Information Brochure

BACHELOR OF TECHNOLOGY (B. Tech)
IN
MECHANICAL ENGINEERING

Department of Mechanical Engineering

Assam Engineering College

Jalukbari, Guwahati – 781013

Assam, India

Website: http://mechanical.aec.ac.in/


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1. ABOUT THE DEPARTMENT

Mechanical Engineering Department of Assam Engineering College, Jalukbari is the pioneer in the state of Assam, offering techno-managerial education under the aegis of State Technical Education, Government of Assam. It was the result of a far-sighted realization of the past leaders to develop technical manpower in the post independent Assam and to raise the standard of living of the people of the whole North Eastern region by way of industrialization. As such the Mechanical Engineering Department came into existence in 1957, after the emergence of Assam Engineering College at Jalukbari in an atmosphere of semi-urban environment. Since then, time has remained as the silent spectator for the relentless service provided by it to the country and other parts of the globe, despite many ups and downs in its stride. The department feels proud that many of its alumni are bringing laurels to the state of Assam, not only in engineering but also in other fields as well.

The following academic courses are offered by the department:

- Undergraduate courses:
  - B. Tech (Mechanical Engineering)
  - B. Tech (Industrial & Production Engineering)
- Postgraduate courses:
  - M. Tech (Mechanical Engineering)
  - Ph. D

The UG programme of Mechanical Engineering Department started way back in 1957 and current intake is 60. Assam Engineering College (AEC) was affiliated to Gauhati University (GU) prior to 2017. With the inception of the Assam Science and Technology University (ASTU), AEC got affiliated to ASTU since 2017. Therefore, the batches enrolled up to 2016 were registered with Gauhati University (GU) and new batches enrolled from 2017 were registered with ASTU. However, for smooth transition of affiliation, 2017 enrolled batch, though registered with ASTU, followed GU syllabus and regulations. From 2018 enrolled batch onwards, ASTU syllabus and regulations are being followed.

The department has continuously strived to provide students with access to well-equipped laboratories and computing facilities. The strength of the department lies in its people. The department continuously stives to gather input and feedback from all its stakeholders for continuous improvement. For more information on the department please visit the department website or contact us. The contact details are provided below:

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Department website: http://mechanical.aec.ac.in/

1.1 Vision and Mission

Institute's vision:

To be an institution for promoting and supporting sustainable development.

Department's vision:

To build professionally competent Mechanical Engineers capable of contributing towards development of the nation and betterment of the society.

Institute's mission:

- To prepare technical manpower with knowledge skills and values of sustainability.
- To take up relevant problems of society & industry as projects, research themes for study and to provide technological solutions.

Department's mission:

- To generate academic atmosphere conducive for developing soft skills, teamwork, leadership & entrepreneurship upheld by professional ethics and committed to development of the nation.
- To provide high quality education for undergraduate programme in Mechanical Engineering and for higher study by adopting strategic approach in curriculum design and teaching methodology.
- To promote acquisition of new knowledge and skill by collaborating with institutes of excellence and industries.
- To generate new knowledge by creative thinking and innovative research targeted at the needs of the society and also North East India.

Program Educational Objectives (PEO)

Program educational objectives describe the expected accomplishments of graduates during the first few years after graduation.

1. Graduate engineers will develop effective technical expertise in Mechanical Engineering upholding ethical & moral values in practice and public life.
2. Graduate engineers will apply their innovative thinking and problem-solving capability in social and professional life, exhibiting leadership by communication and teamwork.
3. Graduate engineers will be proficient in continuing their higher studies, professional development courses and research.
4. Graduate engineers will be capable of mobilizing human and physical resources to their fullest extent in organizations for holistic development.

Program Specific Outcomes (PSO)

1. Graduate Engineers will be able to exhibit excellence in the design of mechanical engineering systems using classical and state-of-the-art tools.
2. Graduate Engineers will be able to exhibit employable skill in the areas of thermal power and modern manufacturing.

2. RULES & REGULATIONS

The B. Tech (Mechanical Engineering) programme offered by the department is governed by rules and regulations framed by ASTU. The syllabus and course structure for the programme has been made by ASTU in consultation of various stakeholders. Please visit the following links on the ASTU website for the detailed syllabus and regulations:

- B. Tech regulation: https://astu.ac.in/?page_id=1188
- Syllabus of B. Tech (Mechanical Engineering): https://astu.ac.in/?page_id=10468

Mentioned below are few important points that we wish to draw your attention to:

- **EVALUATION - Grading System:**
  - As a measure of student's performance, a 9-scale grading system using the following letter grades and corresponding grade points per credit shall be followed:

Internal Assessment	University Evaluation	Grand Total	Grading System			
CE	ESE	Grand Total= CE + ESE	Total Marks (%)	Grade	Description	Grade Point
30	70	100	90 & above	O	Outstanding	10
			80 – 89	A+	Excellent	9
			70 – 79	A	Very Good	8
			60 – 69	B+	Good	7
			50 – 59	B	Above Average	6
			45 – 49	C	Average	5
			35 – 44	P	Pass	4
			Below 35	F	Failed	0
			Absent	Abs	Absent	0

CE – Continuous Evaluation (Internal), both for theory and practical.

ESE – End Semester Examination (Central Evaluation)

(a) The minimum marks of CE should be 11 out of 30 marks for theory subjects which is necessary to become eligible to appear in the End Semester Examination (ESE).

(b) To be eligible to pass in a theory subject with minimum 'P' grade, the followingconditions must be fulfilled

i) Must appear in CE and ESE.

ii) Must obtain 35% marks in CE i.e., 11 marks (rounded) out of 30 marks
iii) Must obtain 35% marks in ESE i.e., 25 marks (rounded) out of 70 marks
iv) Must obtain 35% marks in (CE+ESE) out of 100 marks

(c) To be eligible to pass in a Practical (Laboratory, Seminar, Project, Workshop etc.)subject, a student –

i) Must appear in CE and ESE
ii) Must obtain 35% marks in CE i.e., 5 marks (rounded) out of 15 marks
iii) Must obtain 35% marks in ESE i.e., 12 marks (rounded) out of 35 marks
iv) Must obtain 35% marks in (CE+ESE) i.e., 18 marks (rounded) out of 50 marks

The norms for the award of the letter grade are as follows:

No student can be awarded P or better grade without securing at least 4 GradePoint in any course in End Semester examination

In addition, a student may be assigned the grades 'PS' and 'NPS' for pass marks and non-passing marks respectively, for pass/ No-pass courses, or the transitional grade 'I' (incomplete).

i) A student is considered to have completed a course successfully and earned thecredits if she/he secures a letter grade other than 'F','NPS', 'Ab', 'I'.

ii) A letter grade 'F' or 'NPS' in any course implies a failure in that course.

iii) In exceptional cases, a student is assigned the grade 'I' in a course if the student was compelled to absent himself/herself from the end-semester examination (after registration for End Semester Examination) on account of :

A) Illness or accident which disabled him from appearing at the examination.

B) A calamity in the family at the time of examination which, in the opinionof the College/Institute, required the student to absent himself from the examination.

iv) A student will be eligible for the award of grade 'I' only if his/her attendance atclasses and performance in other components of assessment are complete and satisfactory.

- At the end of each semester, the following measures of the performance of a student in the semester and in the programme up to that semester will be computed and made known to that student together with the grades obtained by the student in each course:

v) The Semester Grade Point Average (SGPA): From the grades obtained by a student in the courses of a semester, the SGPA will be calculated using thefollowing formula:

$$\mathbf{SGPA} = \frac{\sum_{i}^{n} GP_i \times NC_i}{\sum_{i}^{n} NC_i}$$

Where GP_i = Grade points earned in the course

NC_i = Number of credits for the course and

n = the number of courses in the semester.

vi) The Cumulative Grade Point Average (CGPA): From the SGPAs obtained by astudent in the completed semesters, the CGPA will be calculated using the following formula:

$$\mathbf{CGPA} = \frac{\sum_{i}^{n} \mathbf{SGPA_i} \times \mathbf{NSC_i}}{\sum_{i}^{n} \mathbf{NSC_i}}$$

Where SGPAi = Semester Grade Point Average of the i^{th} semester.

NSCi = Number of credits for the i^{th}semester.

n = Number of semesters completed.

vii) Both the SGPA and CGPA will be rounded off to the second place of decimal and recorded as such.

viii) The CGPA may be converted into a percentage, if needed, using the following formula:

Percentage marks = CGPA X 10

- Both the SGPA and CGPA will be rounded off to the second place of decimal and recorded as such. Whenever these CGPA are to be used for the purpose of determining the merit ranking of a group of students, only the rounded off values will be used.
- When a student gets the grade ‘I’ for any course during a semester, the SGPA for that semester and the CGPA at the end of that semester will be tentatively calculated ignoring the ‘I’ graded course(s). After the conversion of ‘I’ grade(s) to appropriate grade(s), the SGPA for that semester and CGPA will finally be recalculated after taking the converted grade(s) into account.
- There are academic and non-academic requirements for the B.Tech. Programme where a student will be awarded the ‘PS’ and ‘NPS’ grades. All non-credit courses (such as NCC/NSO/NSS, industrial training, field visits and Extra Academic Activities) belong to this category. No Grade points are associated with these grades and these courses are not taken into account in the calculation of the SGPA or CGPA. However, the award of the degree is subject to obtaining a ‘PS’ grade in all such courses.
- In the case of an audit course, the letters ‘AU’ shall be written alongside the course name in the Grade Sheet. A student is not required to register again for passing a failed audit course.

➢ ASSESSMENT OF ACADEMIC PERFORMANCE:

- Each theory subject in a semester is evaluated to 100 marks, with the followingweightages:

Sub-components Weightage

Continuous Evaluation (Class tests/ Surprise tests/ Assignments / Quizzes/ Project/ Seminar; at least two class tests for each subject to be conducted in each semester) 30 marks

End-Semester Examination (Entire syllabus) 70 marks

- Each laboratory course in a semester is evaluated for 50 marks, with the followingweightages:

Sub-component Weightage:

Continuous evaluation (Lab report, Viva, Quiz)	15 marks
End Semester examination	35 marks

Based on the above guidelines provided by ASTU, the department has come up with the following evaluation plan for IA/ CE marks w.e.f. AY 2022-23 for all subjects taught by the department:

For Theory subjects:

Component	**Weightage**	
Class Tests* / Surprise test(s)/ Quizzes/ Viva-voce (For practical component if present) * At least 2 numbers of Class Tests in each subject are mandatory	50 %	15 marks
Assignment(s)/ Seminar/ Project/ Lab report (For practical component if present)	50 %	15 marks
Total		30 marks

For Laboratory subjects:

Component	**Weightage**	
Continuous evaluation (Lab reports/ Quizzes/ Viva-voce)	30 %	15 marks
End Semester Examination	70 %	35 marks
Total		50 marks

3. COURSE STRUCTURE AND SYLLABUS

In this section, the detailed course structure for B. Tech (Mechanical Engineering) has been provided semester wise.

3.1 FIRST SEMESTER

As per ASTU course structure, B. Tech (Mechanical Engineering) is included in Group A during the first year (1st and 2nd semesters). Hence, the detailed syllabus for Group A has been provided for the first year.

B.Tech 1st Semester (Group A)

NOTE: Three weeks Mandatory Induction Program need to be done before the commencement of the B.Tech 1st semester classes as per the AICTE mandate

Mandatory Induction Program

3 weeks duration
• Physical activity • Creative Arts • Universal Human Values • Literary • Proficiency Modules • Lectures by Eminent People • Visits to local Areas • Familiarization to Dept./Branch & Innovations

Sl. No.	Sub-Code	Subject	Hours per Week			Credits
			L	**T**	**P**	**C**
Theory						
1	CY181101	Chemistry-101	3	1	0	4
2	MA181102	Mathematics-I	3	1	0	4
3	CS181106	Problem Solving through Programming using C	2	0	2	3
4	EE181107	Basic Electrical Engineering	3	0	0	3
5	HS181108	Communication and Professional Skill	1	0	2	2
Practical						
1	CY181111	Chemistry-101 Lab	0	0	2	1
2	EE181117	Basic Electrical Engineering Lab	0	0	2	1
		TOTAL	12	2	8	**18**
Total Contact Hours per week: 22						
Total Credits: 18						

Course Code	Course Title	Hours per week L-T-P	Credit C
CY181101	**Chemistry-101**	**3-1-0**	**4**

COURSE OBJECTIVES

To introduce specific fundamental as well as applied concepts of Chemistry relevant for the study of topics in different branches of Engineering.

MODULE 1: Atomic Structure (5 Lectures)

Schrodinger's wave equation, Physical significance of Ψ and Ψ^2, Hydrogen atom wave Functions-Radial and Angular wave function, Eigen value, Eigen function, Molecular orbital theory-electronic configurations of molecules in terms of the MO-Homonuclear diatomic molecule, Heteronuclear diatomic molecule. (Eg. CO, NO)

MODULE 2: Polymer Chemistry (6 Lectures)

Classification, Functionality, Determination of molecular weights, Polydispersity index (PDI). Types of polymerization (Addition and Condensation). Structure-property-applicationof few commodity polymers (eg. PE, PP, PS, PMMA, PVC, Isoprene), Biopolymer- properties and its applications (polylactic acid), Conducting polymer-properties and its applications (polyacetylene).

MODULE 3: Nanochemistry (5 Lectures)

Introduction, Synthesis of nanomaterials (Top-down and Bottom-up approach). Fullerenes, Carbon nanotube (Characteristic, properties & application), Nanowire, Application of Nanomaterial in catalysis, Medicine, Energy science, Bio nanomaterials.

MODULE 4: Sustainable Chemistry (6 Lectures)

Principles of green chemistry, Idea of green synthesis, Carbon footprint and sequestration, Carbon trading. Brief idea of alternative solvents–Water, ionic liquids, supercritical fluid system (Carbon dioxide), Waste management**:** Solid, electronic & industrial wastes, Waste management procedures and relevant standards.

MODULE 5: Corrosion Science (6 Lectures)

Definition and scope of corrosion. Dry chemical corrosion and electrochemical corrosion and their mechanisms. Types of electrochemical corrosion (Differential aeration, Galvanic, Concentration cell), Typical electrochemical corrosion like Pitting, Inter-granular, Waterline. Factors affecting corrosion, Protection against corrosion.

MODULE 6: Instrumental Methods of Chemical Analysis (8 Lectures)

Spectroscopy: Principle of spectroscopy, Principle and applications of UV-Visible spectroscopy. Applications of Flame photometry, Atomic absorption spectroscopy, Infrared spectroscopy, NMR spectroscopy, Mass spectroscopy. Principle and applications of different

Chromatographic Techniques-Gas, HPLC, GPC.

MODULE 7: Advanced Engineering Materials (6 Lectures)

Cement (Raw materials, chemical composition, setting and hardening of cement), Refractories (Classification and properties), Lubricants (Types of lubricants, Properties, Mechanism of lubrication)

Text Book/ Reference Books:

1. Engineering Chemistry-Jain & Jain (Dhanpat Rai & Company)
2. Engineering Chemistry-Shashi Chawla (Dhanpat Rai & Company)
3. Industrial Chemistry-B. K. Sharma
4. A text book of Engineering Chemistry-Dr S. Rattan
5. Wiley Engineering Chemistry
6. Atomic Structure and Chemical bond-Manas Chandra (TMH edition)
7. Quantum Chemistry-B.K. Sen
8. Quantum Mechanics-L. Pauling & E. Wilson (McGraw Hill Book Company)
9. Physical Chemistry-P. W. Atkins (Oxford University Press)
10. Advance Inorganic Chemistry- Cotton et. Al. (John Willey)
11. Inorganic Chemistry-Shriver, Atkins, Langford (ELBS)
12. Green Chemistry-Paul T Anastas, John C. Warner
13. Introduction to Polymers-R. J. Young
14. Polymer Science-V.R.Gowarikar (New Age International)
15. Fundamentals of Molecular Spectroscopy-C. N. Banwell & E. N. McCash
16. Atomic & Molecular Spectroscopy-Chatwal & Anand (Himalayan Publishing House)

Course Outcome: After successful completion of the course, the students will be able:

CO1: To apply molecular orbital theory along with electronic configuration on the basis of Schrodinger wave equation for simple homonuclear and heteronuclear diatomic molecules (NO, CO).

CO2: To illustrate the different aspects of polymer chemistry and its uses in differentpurposes along with brief idea of nanomaterials as well as sustainable chemistry with applications.

CO3: To apply the idea of corrosion along with control and preventive measures.

CO4: To apply the fundamental principles and applications of analysis using UV-Visible, Flame photometry, AAS, IR, NMR, mass spectroscopy and chromatography.

CO5: To infer about engineering materials e.g. cement, refractories with lubricants and their properties and applications.

Course Code	Course Title	Hours per week L-T-P	Credit C
MA181102	**Mathematics-I**	**3-1-0**	**4**

CALCULUS AND LINEAR ALGEBRA

MODULE 1: Calculus (8 lectures)

Reduction formulae, applications of definite integrals to evaluate surface areas and volumes of solids of revolution, idea of improper integrals, Beta and Gamma functions and their properties.

MODULE 2: Calculus (8 lectures)

Successive differentiation, standard forms, Leibnitz's theorem (without proof), Taylor's and Maclaurin's theorem with remainders, indeterminate forms and L' Hospital's rule, Curvature and Radius of curvature (both in Cartesian and Polar co-ordinates).

MODULE 3: Sequences and series (6 lectures)

Idea of convergence of sequence and series, Fourier series, Half range sine and cosine series, Parseval's theorem.

MODULE 4: Multivariable Calculus (8 lectures)

Partial derivatives, Euler's theorem, Total derivatives, Maxima, Minima and saddle points, Method of Lagrange multipliers, Double and Triple Integrals and its applications to find areas and volumes.

MODULE 5: Linear Algebra (10 lectures)

Inverse and rank of a Matrix, Linear independence of vectors, rank-nullity theorem, system of linear equations, Symmetric, skew-symmetric and orthogonal matrices, Eigen values and eigen vectors, Diagonalization of matrices, Cayley-Hamilton theorem (without proof), Orthogonal Transformation.

Suggested Text/ Reference Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
3. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
4. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.
5. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.

6. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
7. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Course Outcome: After successful completion of the course, the students will be able to:

CO1: apply the techniques of differential and integral calculus to solve simple Engineering problems.

CO2: Interpret the significance of Beta and Gamma functions.

CO3: apply Rolle's Theorem, power series and Fourier series to Engineering problems.

CO4: apply multi-functional variables, matrices and linear algebra as tools to solve Engineering problems.

Course Code	Course Title	Hours per week L-T-P	Credit C
CS181106	**Problem Solving Through Programming Using C**	**2-0-2**	**3**

MODULE 1: Introduction to Programming (3 Lectures)

Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, system software, application software, compilers, interpreter etc.

Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudo code with examples.

From algorithms to programs; source code, compilation, object and executable code, Syntax and Logical Errors in compilation, storage of data inside program using variables, data types, modular programming, structure of a C program.

MODULE 2: Expressions and precedence (2 Lectures)

Writing C expressions using operators (arithmetic, relational, logical, dereferencing, arrow operator, period operator, conditional operator, subscript operator etc.), identifiers and literals, precedence of operators, evaluation of expressions using precedence and associatively rules.

MODULE 3: Conditional Branching and Loops (4 Lectures)

Writing and evaluation of conditionals and consequent branching using if..else and switch.. case statements, Iteration and loops using for loop, while loop and do..while loop.

MODULE 4: Arrays (2 Lectures)

Arrays (1-D, 2-D), Character arrays and C Strings.

MODULE 5: Basic Algorithms (4 Lectures)

Searching (sequential and binary), Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definitions for asymptotic analysis required).

MODULE 6: Function (3 Lectures)

User defined functions and built in libraries, function prototype, parameter passing in functions, call by value, passing arrays to functions: idea of call by reference (1-D and 2-D), scope rules for C language.

MODULE 7: Recursion (2 Lectures)

Recursion, as a different way of solving problems, example programs, such as Finding Factorial, Fibonacci series.

MODULE 8: Structure (2 Lectures)

Structures, defining structures, Accessing members, Array of Structures.

MODULE 9: Preprocessor Directives (1

Lecture) #define, #include, #ifdef etc.,

conditional compilation.**MODULE 10:**

Pointers (4 Lectures)

Idea of pointers, defining pointers, pointer and arrays, pointer to structure, pointer to function,passing addresses of variables to functions (elementary and user defined), double indirection, Use of Pointers in self-referential structures, dynamic allocation/deallocation of memory blocks data types like elementary data types, arrays, structures, accessing elements of dynamically allocated memory, notion of linked list (no implementation).

Text Books:

(1) Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill

(2) Yashavant Kanetkar, Let us C, BPB Publication

(3) E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill

(4) Yashavant Kanetkar, Understanding Pointers in C, BPB Publication

Reference Books:

(1) Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hallof India

Course Plan:

Units/Topics	Number of Lectures (Hours)	Method of deliver
1. Module 1	4	Both chalk and talk and power point presentation
2. Module 2	2	
3. Module 3	4	
4. Module 4	3	
5. Module 5	3	
6. Module 6	4	

7.	Module 7	3
8.	Module 8	2
9.	Module 9	1
10.	Module 10	4
Total		30

Course Outcome (Theory)

Course Outcome	Statement
CO1	To design, represent and analyze algorithms for logical and numerical problems
CO2	To develop modular programs using functions and recursion
CO3	To create programs using static built-in and user defined data types for storage and processing of data
CO4	To develop programs for dynamic storage and processing of data
CO5	To develop solution for a computing problem through team work

Laboratory - Programming for Problem Solving

Total: 26 contact hours, 2 hours of lab/week

[to be evaluated for Continuous Evaluation (CE): 30 marks]

Lab1: Familiarization with programming environment (editors, compilation, debugging etc.) **(2 hours)**

Lab 2: Simple computational problems using expressions and precedence **(2 hours)**

Lab 3: Problems involving using if-then-else and switch statements (**2 hours)**

Lab 4: Iterative problems e.g., sum of series, factorial, Fibonacci series etc. **(2 hours)**

Lab 5: 1D, 2D Array manipulation: summation, finding odd/even in a set, string handling etc. **(4 hours)**

Lab 6: Matrix problems (addition, multiplication etc.), String operations (finding length, concatenation, comparing etc.) **(4 hours)**

Lab 7: Simple function illustrating the concepts, call by value. **(2 hours)**

Lab 8: Recursive functions for summation, Fibonacci series, and factorial **(2 hours**)

Lab 9: Pointers, call by reference, passing arrays to functions, passing address of structure to function, passing array of structure to function, pointers and arrays, function pointer, dynamic allocation of block of memory and accessing the elements **(4 hours)**

Lab 10: File operations on text files, binary files (**2 hours)**

LIST OF EXPERIMENTS:

INTRODUCTION

Basic Concepts of C:

C was originally developed by Dennis Ritchie between 1969 and 1973 at Bell Labs, and used to re-implement the Unix operating system. It is the most widely used programming languages of all time. C has been standardized by the American National Standards Institute (ANSI) since 1989 and subsequently by the International Organization for Standardization (ISO).

Uses of C language:

- Database Systems
- Language Interpreters
- Compilers and Assemblers
- Operating Systems
- Network Drivers
- Word Processor

Features of C language:

- C is robust language with rich set of built-in functions and operators
- Programs written in C are efficient and fast.
- C is highly portable.
- C is basically a collection of C library functions.
- C is easily extensible.

C Data Types:

Primary Data Types	**Secondary Data Types**
Character	Array
Integer	Pointer
Float	Structure
Double	Union
Void	Enum

C supports following conditional statements:

(i) if statement
(ii) if else statement
(iii) else if statement
(iv) switch statement

C supports following types of loops:

(i) while loops

(ii) do while loops

for loops
C Functions:

C function is a self contained block of statements that can be executed repeatedly whenever we need it.

- Provides modularity.
- Provides reusable code.
- Debugging and editing tasks are easy
- Programs can be modularized into smaller parts

Two types of functions in C:

Built in(Library)

Functions User Defined

Functions

C Arrays:

An array is a data structure in C that can store a fixed size sequential collection of elements of same data type. There are three types of arrays:

- ✓ One-dimensional array
- ✓ Two-dimensional array
- ✓ Multi-dimensional array

C Strings:

In C, the one-dimensional array of characters are called strings, which is terminated by a null character '\0'.

Steps involved in program development:

To develop the program in C language and translate it into machine level language, following steps have to be practiced:
1. Writing and editing the program using suitable compiler
2.Linking the program with required library modules
3.Compiling the program.
4. Executing the program

Ex. No: 1

AREA AND CIRCUMFERENCE OF THE CIRCLE

PROGRAM: To write a C program to find the area and circumference of the circle

ALGORITHM:

Step 1: Start the program.

Step 2: Input the radius of the Circle.

Step 3: Find the area and circumference of the circle using the
formula Area =3.14*r*r
Circum=2*3.14*r

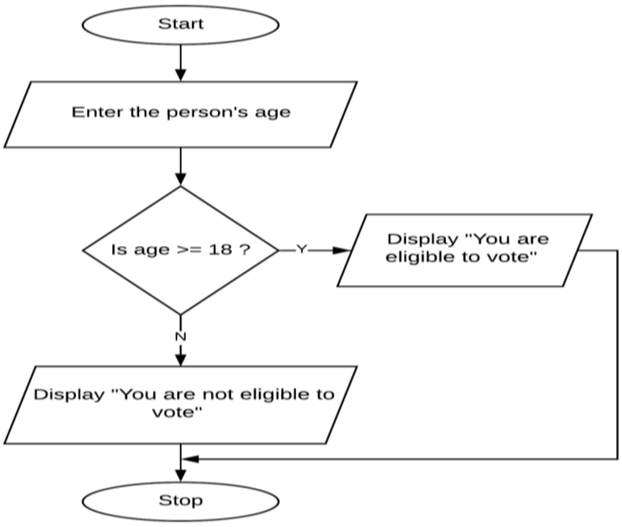
Step 4: Print the area and Circumference

Step 5: Stop the Program

Ex. No: 2

IF STATEMENT

PROGRAM : Write a C program to determine whether a person is eligible to vote.

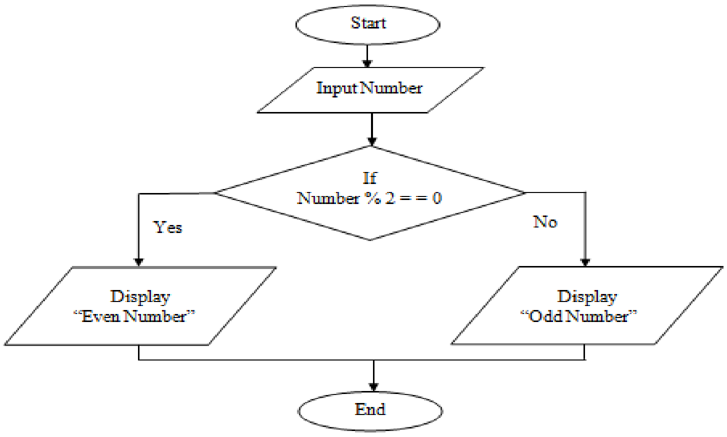


Ex. No: 3

IF ELSE STATEMENT

PROGRAM: Write a C program to find whether the given number is even or odd.

Flowchart:



Ex. No: 4

switch statement

PROGRAM: Write a C program to enter a character and the determine whether it is a vowel or not using switch case.

Algorithm:

Step 1: Start

Step 2: Declare character type variable ch

Step 3: Read ch from User

Step 4: // Checking both lower- and upper-case vowels.

```
IF (ch == 'a' || ch == 'A' ||
        ch == 'e' || ch == 'E' ||
        ch == 'i' || ch == 'I' ||
        ch == 'o' || ch == 'O' ||
        ch == 'u' || ch == 'U' )

  Print "Vowel"

ELSE

  Print "Consonant"
```

Step 5: Stop

Ex. No: 5

for loops

PROGRAM: Write a C program to print first n natural numbers and their sum using for loop.

Algorithm:
Step 1: Start
Step 2: Assign i=1, sum=0
Step 3: Read a number num.
Step 4: Repeat step 5,6 and 7 until i=num reach
Step 5: Print i
Step 6: Print sum.
Step 7: Compute i=i+1
Step 7: Stop

Ex. No: 6

while loops

PROGRAM: C program to print all natural numbers from 1 to n using while loop

Algorithm:
Step 1: Start

Step 2: Assign i=1
Step 3: Read a number num.
Step 4: Repeat step 5&6 until i=num reach
Step 5: Print i
Step 6: Compute i=i+1
Step 7: Stop

Ex. No: 7
do while loops
PROGRAM: A C program to print n natural numbers using do while loop.
Algorithm
Step 1: Start
Step 2: Assign i=1
Step 3: Read a number num.
Step 4: Repeat step 5&6 until i=num reach
Step 5: Print i
Step 6: Compute i=i+1
Step 7: Stop

Ex. No: 8

FUNCTIONS

PROGRAM: Write a C program to find factorial of a number.
Step 1: Start
Step 2: Read a number n
Step 3: Initialize variables:
`i = 1, fact = 1`
Step 4: Call **Factorial** function
Step 5: Print fact.
Step 6: Stop
Factorial
Step 1: if `i <= n` go to step 2 otherwise go to step 4
Step 2: Calculate
`fact = fact * i`
Step 3: Increment i by 1 (`i=i+1`) and go to step 1
Step 4: Return fact.

Ex. No: 9
PROGRAM: Write a C program to find factorial of a number using recursive function.

Algorithm:
Step 1: Start the program
Step 2: Read the variable N.
Step 3: Call the function factorial (N)
Step 4: Print the result.
Step 5: Stop the program

Factorial (N)
Step1: If N is equal to 1 then return 1
Step2: Else set X to N*factorial (N-1)

Step 3: Return the value of X.

Ex. No: 10

1-D ARRAY

PROGRAM:C Program to Copy all elements of an array into Another array

Step1: Start

Step 2: Initialize variable n.

STEP 3: Read the value n

STEP 4: Define arr2[n] and arr1[n]

STEP 5: Set i=0 and repeat step 6 and 7 till i<n

STEP 6: read the elements of arr1[i].

Step 7: Compute i=i+1

STEP 8: Display elements of arr1[].

STEP 9: SET i=0, repeat step10 and step 11 UNTIL (i<n)

STEP 10: arr2[i]=arr1[i]

STEP 11: i=i+1.

STEP 14: SET i=0. repeat step 15 and 16 UNTIL (i<n)

STEP 15: PRINT arr2[i].

STEP 16: i=i+1..

STEP 17: Stop

Ex. No: 11

2-D ARRAY

PROGRAM:C Program to read and display elements of a 2 dimensional array.

```
#include<stdio.
h> int main(){
  /* 2D array
  declaration*/ int
  disp[2][3];
```

```
/*Counter variables for the
loop*/ int i, j;
for(i=0; i<2;
  i++) {
  for(j=0;j<3;j
  ++) {
    printf("Enter value for disp[%d][%d]:",
    i, j); scanf("%d", &disp[i][j]);
  }
}
//Displaying array elements
printf("Two Dimensional array
elements:\n"); for(i=0; i<2; i++) {
  for(j=0;j<3;j++) {
    printf("%d ",
    disp[i][j]); if(j==2){
      printf("\n");
  }
  }
  }
return 0;
}
```

Ex. No: 12

MULTIDIMENSIONAL ARRAY

PROGRAM:C Program to Add Two Matrix Using Multi-dimensional

```
Arrays #include <stdio.h>
int main(){
  int r, c, a[100][100], b[100][100], sum[100][100], i, j;

  printf("Enter number of rows (between 1 and 100):
  "); scanf("%d", &r);
```

```
printf("Enter number of columns (between 1 and 100): ");
scanf("%d", &c);

printf("\nEnter elements of 1st matrix:\n");


for(i=0; i<r;
   ++i) for(j=0;
   j<c; ++j)
   {
      printf("Enter element a%d%d: ",i+1,j+1);
      scanf("%d",&a[i][j]);
   }
printf("Enter elements of 2nd
matrix:\n"); for(i=0; i<r; ++i)
   for(j=0; j<c; ++j)

   {
      printf("Enter element a%d%d: ",i+1, j+1);
      scanf("%d", &b[i][j]);
   }


// Adding Two matrices
for(i=0;i<r;+
   +i)
   for(j=0;j<c
   ;++j)
   {
      sum[i][j]=a[i][j]+b[i][j];
   }
```

```
// Displaying the result
printf("\nSum of two matrix is: \n\n");

for(i=0;i<r;+
  +i)
  for(j=0;j<c
  ;++j)
  {

    printf("%d  ",sum[i][j]);


    if(j==c-1)
    {
      printf("\n\n");
    }

  }

return 0;
}
```

Ex No.13

STRINGS

PROGRAM: C program to read line of text character by character.

```
#include
<stdio.h> int
main()
{
  char name[30],
  ch; int i = 0;
  printf("Enter name: ");
  while(ch != '\n')    // terminates if user hit enter
  {
    ch =
```

```
getchar();
name[i] =
ch; i++;
}
name[i] = '\0';      // inserting null character at
end printf("Name: %s", name);
return 0;
}
```

Syntax of structure

```
struct structure_name
{
   data_type
   member1;
   data_type
   member2;
   .
   .
   data_type memeber;
};
```

Ex no.14

<u>STRUCTURE</u>PROGRAM: Write a C program to add two distances entered by user. Measurement of distance should be in inch and feet. (Note: 12 inches = 1 foot)

```
#include
<stdio.h> struct
Distance
{
```

```
    int
    feet;
    float
    inch;
} dist1, dist2, sum;

int main()
{
    printf("1st distance\n");
    // Input of feet for structure variable
    dist1 printf("Enter feet: ");
    scanf("%d", &dist1.feet);

    // Input of inch for structure variable
    dist1 printf("Enter inch: ");
    scanf("%f", &dist1.inch);

    printf("2nd distance\n");

    // Input of feet for structure variable
    dist2 printf("Enter feet: ");
    scanf("%d", &dist2.feet);

    // Input of feet for structure variable
    dist2 printf("Enter inch: ");
    scanf("%f", &dist2.inch);
    sum.feet = dist1.feet + dist2.feet;
    sum.inch = dist1.inch +
```

```
dist2.inch;

if (sum.inch > 12)
{
      //If inch is greater than 12, changing it to feet.
   ++sum.feet;

   sum.inch = sum.inch - 12;
}


// printing sum of distance dist1 and dist2
printf("Sum of distances = %d\'-%.1f\"", sum.feet, sum.inch);
return 0;
}
```

LIST OS PROGRAMS

1. Write a C program to print the message “Welcome to AEC”.
2. Write a C program to print the value of a variable.
3. Write a C program to print the value of two variables.
4. Write a C program to add two numbers.
5. Write a C program to find the average of three numbers.
6. Write a C program to find the area of a circle.
7. Write a C program to find the area of a rectangle.
8. Write a C program to print the ASCII value of a character.
9. Write a C program to read a character in lower case and then print it in uppercase.
10. Write a C program to read a character in uppercase and then print it in lower case.
11. Write a C program to swap two numbers using a temporary variable.
12. Write a C program to swap two numbers without using a temporary variable.
13. Write a C program to print the digit at one’s place of a number.
14. Write a C program to convert temperature in Fahrenheit to degrees celsius.
15. Write a C program to calculate the total value in a piggybank having coins of Rs 10, Rs.5, Rs.2 and Rs. 1.
16. Write a C program to generate a bill for an item having quantity, value, discount and tax.
17. Write a C program to calculate simple interest.
18. Write a C program to find area and volume of a cube.
19. Write a C program to enter a number and find the years, week and days.

20. Write a C program to determine whether a person is eligible to vote.
21. Write a C program to find the largest of two numbers.
22. Write a C program to find whether the given number is even or odd.
23. Write a C program to enter any character, if the entered character is in lower case then convert it into upper case and if it is in upper case then convert it into lower case.
24. Write a C program to enter a character and the determine whether it is a vowel or not.
25. Write a C program to find whether a given year is leap year or not.
26. Write a C program to test whether an entered number is positive, negative or equal to zero.
27. Write a C program to find greatest of three numbers.
28. Write a C program to display examination result:

    If percentage of marks ≥75----------------- distinction
    If percentage of marks≥60 and<75 ------- 1st division
    If percentage of marks≥50 and<60 ------- 2nd division

    If percentage of marks≥40 and<50 ------- 3rd division
    Otherwise...Fail

    Take the marks for five subjects for each student.
29. Write a C program to Check the category of the entered character.
30. Write a C program to find smallest of three numbers.
31. Write a C program to calculate the roots of a quadratic equation.
32. Write a C program to enter a character and the determine whether it is a vowel or not using switch case.
33. Write a C program to print no. of days in a month using switch case.
34. Write a C program to find out the number of notes required for a given amount of money using switch.
35. Write a C program to to enter a no. from 1 to 7 and display the corresponding day of the week switch case statement.
36. Write a C program that accepts a no. from 1 to 10. Print whether the no. is even or odd using switch case statement.
37. Write a C program to print multiplication table of a given number.
38. Write a C program to print first n natural numbers and their sum using for loop.
39. Write a C program to print first n natural numbers and their sum using while loop.
40. Write a C program to multiply two numbers using Russian peasant method.
41. Write a C program to print first n natural numbers and their sum using do while loop.
42. Write a C program to print first n natural numbers in ascending and descending order using for loop and switch case.
43. Write a C program to calculate the area of either circle or rectangle or triangle depending upon the user's choice.
44. Write a C program to count number of 1's in the binary representation of an integer.
45. Write a C program to find GCD and LCM of two non negative integers.

46. Write a C program to find numbers and their sum between 100 and 200 which are divisible by
47. Write a C program to find area of circle until radius 0 is entered.
48. Write a C program to find sum of even and odd numbers from 1 to N.
49. Write a C program to check an integer for perfect square.
50. Write a C program to find all divisor of a positive number.
51. Write a C program to find sum of digits of a number.
52. Write a C program to reverse a given number and check it for palindrome.
53. Write a C program to find factorial of a number.
54. Write a C program to check a number for a perfect number.
55. Write a C program to check a number for Armstrong.

56. Write a C program to generate Armstrong numbers upto a specific limit.
57. Write a C program to print perfect numbers upto a specific limit.
58. Write a C program to generate first n fibonacci terms.
59. Write a C program to generate fibonacci terms upto a specific limit.
60. Write a C program to check a number for Fibonacci term.
61. Write a C program to check a number for prime.
62. Write a C program to generate first n prime numbers.
63. Write a C program to print the following pattern.

```
1
1  2
1  2  3
--------------------
-------------------------
```

64. Write a C program to print the following pattern

```
1
2  2
3  3  3
4  4  4  4
------------------------------
----------------------------------
```

65. Write a C program to print the following pattern .

```
--------------------------------------
-------------------------------
```

1 2 3 4

1 2 3

1 2

1

66. Write a C program to print the following pattern

----

4 3 2 1

3 2 1

2 1

1

67. Write a C program to calculate simple interest using function.
68. Write a C program to find largest of 3 numbers using function.
69. Write a C program to add three numbers using function.
70. Write a C program to find square of a number using function.
71. Write a C program to find factorial of a number using function.
72. Write a C program to swap two variables using function.
73. Write a C program to calculate area of a circle using function.
74. Write a C program to find whether a number is even or odd using function.
75. Write a C program to find sum the series 1/1! + 4/2! +27/3! +……
76. Write a C program to calculate GCD using recursive function.
77. Write a C program to print the reverse of a positive integer using recursion.
78. Write a C program to print the Fibonacci series using recursive function up to a specific limit.
79. Write a C program to find sum and average of n numbers using array.
80. Write a C program to find largest and smallest of n numbers using array.
81. Write a C program to find sum of array elements.
82. Write a C program to find even numbers among n numbers using array.
83. Write a C program to find sum of even and odd numbers among n integers using array.
84. Write a C program to reverse an array.
85. Write a C program to read and display n numbers using array.
86. Write a C program to read and display n random numbers using array.
87. Write a C program to find the second largest number using an array of n numbers.
88. Write a C program to insert a number at a given location in an array.
89. Write a C program to delete a number from a given location in an array.
90. Write a C program to merge two sorted arrays.
91. Write an algorithm for swapping two values.

92. Write an algorithm to find the larger of two numbers.
93. Write an algorithm to find whether a number is even or odd.
94. Write an algorithm to find sum of first N numbers.
95. Write an algorithm to find Armstrong number.
96. Write an algorithm to find factorial of a number.
97. Draw the flowchart of Fibonacci series .
98. Draw the flowchart to check a number is prime number or not.
99. Draw a flowchart to find the sum of first 50 natural numbers.
100. Draw a flowchart to find all the roots of a quadratic equation $ax^2+bx+c=0$

Course Outcome for Laboratory

Course Outcome	Statement
CO1	To translate a given algorithm to C program and become familiarized with programming environments
CO2	To build programs using modular programming and recursion
CO3	To build programs using built-in and user defined data types for data processing
CO4	To build programs for data processing using dynamic memory management
CO5	To solve a computational problem through team work
CO6	To exhibit self-learning by writing programs for solving problems in differentiation and integration by numerical methods

Course Code	Course Title	Hours per week L-T-P	Credit C
EE181107	**Basic Electrical Engineering**	**3-0-0**	**3**

Objectives:

- To impart the basic knowledge of electric and magnetic circuits and to give idea of the AC fundamentals
- To impart the basic knowledge of working principles and applications of various electrical machines
- To impart the basic knowledge of working principles and applications of various measuring instruments
- To impart the basic knowledge of the electric house wiring and make the students aware of the electrical safety measures.

MODULE 1: DC Circuits (8 Lectures)

Definitions of active, passive, linear, nonlinear circuit elements and networks. Kirchoff's laws, nodal & mesh analysis, voltage & current sources, network theorems- superposition, Thevenin's, Norton's and maximum power transfer theorems.

MODULE 2: AC Circuits (12 Lectures)

Waveforms of alternating voltages and currents, instantaneous, average and RMS values, form factor & peak factor, forms of representation of alternating quantities, concept of phasor & phasor diagrams, Concept of lead & lag, reactances & impedances, AC circuits-resistive, inductive, capacitive, RL, RC & RLC series, parallel and series parallel combination, impedance triangle, admittance, active & reactive power & power factor.

Concepts of 3-phase AC, connections, phase & line values in star & delta connections, solutions of simple 3-phase balanced circuits with resistive & reactive loads, 3-phase power, and phase sequence

MODULE 3: Electrical Machines (12 Lectures)

Single Phase Transformers: Principle of operation, EMF equation, losses and efficiency, Basic idea of an auto-transformer.

DC machines: Electromechanical Energy Conversion, EMF and torque equations, Classification, characteristics and applications of various types of d.c. motors.

Induction Motors: Principle of operation of single phase and three phase induction motors, Application of Induction motors

MODULE 4: Instruments (4 Lectures)

Classification of instruments, essentials of indicating type instruments- deflecting torque, controlling torque, damping; types of indicating instruments, MC & MI type ammeters & voltmeters, extension of range- use of shunt & multipliers.

MODULE 5: Basics of Electrical Installations (4 Lectures)

Basic knowledge of domestic wiring, types of cables (names only), types of wiring; circuit layouts- single phase AC mains to DB; 3 phase connections; accessories- main switch, ceiling rose, fuse, MCB etc. Earthing- purpose & methods.

Text/Reference Books:

1. Basic Electrical Engineering--- Nagrath.
2. Basic Electrical Engineering---Mittle.
3. B.E.E. Science—Sahadev & Rana.
4. Electro-Technology—H. Cotton.
5. A text book of Electro-technology- B.L.Theraja.

Course Outcome: On successful completion of the course, the student will be able to:

CO1: Identify and analyze network theorems / a. c fundamentals and apply them to the solution of electrical engineering problems.

CO2: Gain basic idea of electrical quantities, such as current, voltage, power, energy, phase, frequency etc. and co-relate these concepts in various fields of electrical engineering.

CO3: Understand the principle of operation of different types of electrical machines.

CO4: Understand the basic principle of operation and use of different types of measuring instruments.

CO5: Get concrete idea about electrical installations and importance of the safety measures to be taken in this regard.

Course Code	Course Title	Hours per week L-T-P	Credit C
HS181108	**Communication and Professional Skill**	**1-0-2**	**2**

MODULE 1: Basic Communication (4 Lectures)

Concept and meaning of communication; Importance of communication, Objectives of communication, Process of communication, Characteristics of communication, Forms of communication, Barriers to communication, Communication Breakdown, Effective communication.

MODULE 2: Audience Analysis (3 Lectures)

Audience awareness, Audience analysis, Types of audience, Importance of audience analysis, Audience Profile, Analysing individual and group of audience, Adapting message to audience.

MODULE 3: Job Oriented Communication (5 Lectures)

Introduction to soft skills, Antiquity of soft skills, Classification of soft skills, Combating stage fright, Pre-presentation preparation, Guidance for effective delivery, Creating and designing of Power Point slides, Presentation Delivery, Organizational group discussion, Group discussion as part of selection process, Conferences, Symposia and Seminars, Job Interview, Objectives of interviews, Types of interview, Ground work before interview, Internship and Campus placement.

MODULE 4: Technical report writing (4 Lectures)

Concept of report writing, Importance of report, Characteristics of a report, Categories of report, Formats, Structure of a technical report, Planning, Drafting, Referencing and Styling

MODULE 5: Academic writing and Comprehension skills (3 Lectures)

Précis writing, Presenting Research paper and articles. Miscellaneous grammar.

MODULE 6: Job oriented writing skill (5 Lectures)

Official letters- Formats, Types and Language, Memo writing, Emails, Resume and Curriculum Vitae--the first step forward and Job application.

Reference Books:

1. Effective Technical Communication, M. Ashraf Rizvi. Tata McGraw Hill
2. Technical Communication: Principles and Practice, Meenakshi Raman and Sangeeta Sharma. OUP
3. Personality Development and Soft Skills, B.K.Mitra, OUP
4. Technical Communication for Engineers, S.Verma, VIKAS Publishing House Pvt.Ltd.

Course outcome:

On successful completion of the course the students will be able to:

CO1: Expand and develop basic understanding of the importance of communication.

CO2: Familiarise with different aspects of accurate and effective communication.

CO3: Demonstrate different writing skills i.e. technical, non-technical and other texts.

CO4: Prepare and present technical reports.

CO5: Acquire a basic knowledge of various. job oriented communication skills.

LANGUAGE LABORATORY:

[*to be evaluated for Continuous Evaluation (CE): 30 marks*]

Objectives of the Practical Course:

1. Practical classes in the Language Lab on sounds of English language, its word stress and intonation and on the silent letters in English words attempt to neutralize the learner's accent drawing their attention to the wrong pronunciation commonly made by the non-native speakers while interacting in English and facilitate them to do betterin telephonic interviews conducted in English and have good intelligibility between them and the teachers when they go abroad for higher studies in the medium of English language.
2. Practical classes on Communicative English, Essential English Grammar, Building Vocabulary, Common Errors in English and Reading and Listening exercises attempt to introduce the learners to speech mannerism both formal and informal, strengthen their grammatical knowledge of English, enrich their word stock, make them aware of common mistakes made by non- native speakers while interacting in English and develop their reading, comprehension and listening skills.
3. Interactive sessions in the lab such as Presentation, Group Discussion, JAM, Role Playing and Describe People/Object/Place work as ice-breaking activities, participation in which enables the students to overcome their inhibitions while speaking; invigorate their presence of mind; enhance their critical focus; boost their confidence level; develop their team spirit, leadership quality and problem solving ability; hone their presentation skill and assist them to have effective communication in English (both verbal and non verbal) and be skilled in time management.
4. Writing home assignments with the aid of given guidelines gives the students the scope to enhance their writing skills in English and become aware of various societal issues and problems.
5. The Practical Course aims to develop the communicative skills of the students in English and make a growth of different facets of their personalities to enable them to fare better and have dynamic sustenance in today's academic, social and professional lives.

Syllabus:

Unit – I

Computer/ software aided lessons for practical classes: **Contact Hours: 28**

- Pronunciation: Vowels, Diphthongs and Consonants sounds, Stress and Intonation and Silent Letters in English words.
- Communicative English - Exercises on situational dialogues/ role play in both formal and informal contexts.
- Essential English Grammar
- Building Vocabulary – synonyms, antonyms and phrases and idioms
- Common Errors in English
- Developing reading, comprehension and listening skills with the aid of language lab devices of reading and listening exercises.

Unit – II

Activities/ Interactive sessions for practical:

- Paper Presentation (Manuscript/ Power Point) **Contact Hours: 20**
- Group Discussion
- Just a Minute' Session (JAM)
- Role Playing
- Describing Object/People/Place.

Unit – III

Home Assignments:

- Each student has to submit two home assignments following the guidelines given with a view to enhance their writing skills as well as make them aware of various ethical and environmental issues, social problems, current affairs etc. on the topics of which the writings are to be submitted.

Books recommended in addition to the software installed in the systems with the objective to add to the students' knowledge of the different units of the syllabus and to aid them in interactive sessions:

- Marks, Jonathan. *English Pronunciation in Use: Elementary*. Cambridge: CUP, 2009.
- Hewings, M. *English Pronunciation in Use. Advanced.* Cambridge: CUP, 2009.
- Rottanji. *A Book on Silent Letters in English*. Web
- *English Language Communication Skills (ELCS) Lab Manual- cum-Work Book*. New Delhi: Cengage Learning India Pvt., 2013.
- Murphy, Raymond. *Essential English Grammar: A Self Study Reference and Practice Book for Elementary Students of English 2nd edition*. Cambridge: CUP.

- Hewings, Martin. *Advanced English Grammar: A Self Study Reference and Practice Book for Advanced South Asian Students*. Cambridge: CUP.
- Merriam-Webster. *The Merriam-Webster Dictionary of Synonyms and Antonyms*. US: Merriam-Webster.1984.
- Gulland, Daphne M and David G. Hinds- Howell. *Dictionary of English Idioms 2nd Revised Edition*. UK: Penguin. 2001.
- Kumar, Sanjay and Pushp Lata. *Communication Skills*, *Second* Edition. OUP. 2015.
- Chin, Peter, Samuel Reid et al. *Academic Writing Skills Student's Book 2*. Cambridge: CUP.
- Cholji, Mark. Towards Academic English: Developing Effective Writing Skills. Cambridge: CUP.
- *Spoken English* (CIEFL) in 3 volumes with 6 cassettes, OUP.

Course Code	Course Title	Hours per week L-T-P	Credit C
CY181111	**Chemistry-101 Lab**	**0-0-2**	**1**

List of Experiments:

Choice of 6 experiments from the following:

1. Determination of surface tension of a given liquid at room temperature by Stalagmometer.
2. Determination Co-efficient of viscosity of a given liquid at room temperature by Ostwald's Viscometer.
3. Measurement of conductivity of an Electrolyte.
4. Determination of pH of strong and weak acid & bases by using pH meter.
5. Determination of available chlorine in bleaching powder.
6. Determination of total hardness of water by EDTA method.
7. Estimation of percentage of copper in brass sample.
8. Estimation of iron.
9. Salt analysis.
10. Separation of components of a mixture by paper chromatography.

Reference books

1. Vogels text book of quantitative inorganic analysis, revised by J. Bassett, R.C. Denny, G.H.Jeffery, 4^{th} Ed.
2. Practical Engineering chemistry by Sunitha and Rathna.

Course Outcome

The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will be able to:

CO1 to measure molecular/system properties such as surface tension, co-efficient of viscosity, conductivity of electrolyte, pH of acid and bases, available chlorine content in bleaching powder, hardness of water, copper content in brass, estimation of iron etc.

CO2 to get expose for analysis of basic radicals qualitatively in given salt mixture

CO3 to expose the students to the students to the paper chromatography technique fordetection of components from a mixture of components.

Course Code	Course Title	Hours per week L-T-P	Credit C
EE181117	**Basic Electrical Engineering Lab**	**0-0-2**	**1**

<u>List of Laboratory Experiments/Demonstrations:</u>

1. Basic safety precautions, Introduction and use of measuring instruments.
2. Calibration of measuring instruments.
3. Verification of Thevenin's Theorem.
4. Verification of Maximum Power Transfer Theorem.
5. Measurement of power in a single phase AC circuit using Wattmeter.
6. Measurement of circuit parameters under steady-state condition for RLC circuits.
7. Demonstration of cut-out sections of Electrical Machines.
8. Characteristics of incandescent lamp.
9. Study of balanced three phase circuits.
10. Demonstration of layout of house wiring.
11. Demonstration of measurement of insulation resistance.

Text / References:

1. D. P. Kothari and I. J. Nagrath, ―Basic Electrical Engineering‖, Tata McGraw Hill, 2010.
2. D. C. Kulshreshtha, ―Basic Electrical Engineering‖, McGraw Hill, 2009.
3. L. S. Bobrow, ―Fundamentals of Electrical Engineering‖, Oxford University Press, 2011.
4. E. Hughes, ―Electrical and Electronics Technology‖, Pearson, 2010.
5. V. D. Toro, ―Electrical Engineering Fundamentals‖, Prentice Hall India, 1989.
6. B. L. Theraja, A. K. Theraja, ―A Text Book of Electrical Technology Vol I, II, IV‖, S. Chand & Co., 2015.
7. Abhijit Chakrabarti, Sudipta Nath and Chandan Kumar Chanda, ―Basic Electrical Engineering‖, Tata McGraw-Hill, 2017

Course Outcome: On successful completion of the course, the students will be able to:

CO1: be familiar with switching on and taking precautionary measures while handling electrical equipment.

CO2: apply knowledge of different types of electrical circuits, components and instruments to relate theoretical concepts with experimentation.

CO3: organize and write an engineering report including graphs and tables after performing an experiment.

****

3.2 SECOND SEMESTER

B.Tech 2nd Semester (Group A)

Sl. No.	Sub-Code	Subject	Hours per Week			Credits
			L	T	P	C
Theory						
1	PH181201	Physics-201	3	1	0	4
2	MA181202	Mathematics-II	3	1	0	4
3	CE181103	Engineering Graphics and Design	1	0	4	3
4	ME181104	Engineering Mechanics	3	0	0	3
5	HS181105	Sociology	2	0	0	2
Practical						
1	PH181211	Physics-201 Lab	0	0	2	1
2	ME181114	Engineering Mechanics Lab	0	0	2	1
3	ME181216	Workshop	0	0	4	2
		TOTAL	12	2	12	**20**
Total Contact Hours per week: 26						
Total Credits: 20						

NOTE: Four-weeks mandatory Internship need to be done in the 2nd semester break and the report is to be submitted and evaluated in 3rd semester as per the AICTE mandate

Course Code	Course Title	Hours per weekL-T-P	CreditC
PH181201	Physics-201	3-1-0	4

MODULE 1: Mechanics (17 Lectures)

Conservative & non-conservative forces, Central forces, Conservation of angular momentum, Non-inertial frames of reference; Rotating co-ordinate system- Centripetal and Coriolis acceleration. **(6 Lectures)**

Harmonic Oscillator, damped harmonic motion – over-damped, critically damped and under damped oscillators; forced oscillation and resonance. **(5 Lectures)**

Elasticity, Hooke's law, factors affecting elasticity, Poisson's ratio, Relations in elasticity, twisting couple on a wire, bending of beams with symmetric cross-section, Cantilever. **(6 Lectures)**

MODULE 2: Fluid Mechanics (5 Lectures)

Bernoulli's Theorem and its important applications, Viscosity, Co-efficient of Viscosity, Streamline and Turbulent flow, Reynolds Number, Critical velocity, Poiseuille's equation for flow of liquid through a tube, Motion of a Rigid body in a viscous medium, Rotational viscometer.

MODULE 3: Acoustics (6 Lectures)

Decibel level of sound, Weber–Fetchner law, Reverberation & Reverberation time, Sabine's formula for reverberation time (Derivation not required), Absorption co-efficient, Factors affecting acoustics of buildings and their remedies, Acoustic design of a hall.
Production and properties of ultrasonic waves, Applications of Ultrasonic.

MODULE 4: Optics (3 Lectures)

Aberration in lenses, Spherical and Chromatic Aberration, Method of minimization of Spherical and Chromatic Aberration.

MODULE 5: Nanomaterials and Advanced materials (7 Lectures)

Introduction to Nanomaterials, Properties of Nanomaterials, Potential Well and Quantum Confinement (qualitative), Types of Nanomaterials and their applications. **(4 Lectures)**

Advanced materials: Shape memory alloys and Biomaterials. **(3 Lectures)**

Note: *The syllabus of Physics PH181201 for Group A is designed as per the AICTE directives to teach different topics of Physics to different branches of Engineering to cater to their specific needs. However, in order to give the students a complete essence of Physics, thefollowing topics may be taught in brief (maximum 4 hours) in tutorial classes, or may be encouraged to learn these topics by using online resources e.g. NPTEL lectures etc. and assignments may be* *given to ensure their learning. These topics, however, are not to beincluded in end semester examinations:*

- Principle of production of LASER beams (Qualitative only), properties and uses of LASER beams;
- Classification of magnetic materials (qualitative only) and their properties;
- Definition of Electric Dipole, Dipole moment and Dielectric constant.

Text Books:

1. Engineering Physics – V. Rajendran (Tata McGraw Hill education Pvt. Limited)
2. Engineering Physics – D.K. Bhattacharya and Poonam Tandon (Oxford University Press)

Reference Books:

1. Elements of Properties Matter – D.S. Mathur (S. Chand and Company Pvt. Limited)
2. Applied Physics for Engineers – Neeraj Mehta (PHI Learning Pvt. Limited)

Course Outcomes: After successful completion of the course, the students will be able to:

CO1: Apply the fundamentals of mechanics to solve simple Engineering problems.

CO2: Explain the basic principles of Fluid Mechanics along with their applications.

CO3: Apply the principles of Acoustics to solve related simple Engineering problems.

CO4: Explain the different types of aberration in lenses along with their minimization.

CO5: Explain the fundamentals of nanomaterials and advanced materials.

Course Code	Course Title	Hours per week L-T-P	Credit C
MA181202	**Mathematics-II**	**3-1-0**	**4**

CALCULUS, ORDINARY DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLE

MODULE 1: Vector Calculus (10 lectures)

Differentiation of vectors, Gradient, Divergence and Curl, Directional Derivatives, Line, Surface and volume Integrals; Green, Gauss and Stokes Theorems (without proof) and their applications.

MODULE 2: First order ordinary differential equations (6 lectures)

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

MODULE 3: Ordinary differential equations of higher orders (10 lectures)

Second order linear differential equations with constant co-efficients, Power series solutions: Legendre Polynomials, Bessel functions of first kind and their properties.

MODULE 4: Complex Variable – Differentiation: (6 lectures)

Differentiation, Analytic functions, Cauchy-Riemann equations, Harmonic functions,Finding harmonic conjugate; Elementary analytic functions (exponential, trigonometric,logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

MODULE 5: Complex Variable – Integration: (8 lectures)

Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, CauchyResidue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

Suggested Text/Reference Books

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Erwin kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edn., Wiley India, 2009.
4. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.

5. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
6. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
7. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.
8. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
9. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.

Course Outcomes: After successful completion of the course, the students will be able to:

CO1: Apply techniques for evaluating multiple integrals, ordinary and partial differentiation equations and that of complex variables to deal with varied Engineering problems.

CO2: Make use of advanced level of Mathematics as tools for solving problems related to modelling of physical processes.

Course Code	Course Title	Hours per week L-T-P	Credit C
CE181103	**Engineering Graphics and Design**	**1-0-4**	**3**

MODULE 1: Introduction to Engineering Drawing (8 Lectures)

i. Principles of Engineering Graphics and their significance, usage of Drawing instruments.
ii. Lettering: Single stroke letter – Vertical and inclined capital and small letter,
iii. Scales: Plain scale and Vernier scale.
iv. Curves: Conic sections – Ellipse, parabola, hyperbola, different methods of construction of conic sections, tangents and normal to conics.

MODULE 2: Orthographic Projections (14 Lectures)

i. Principles of Orthographic Projections- Conventions
ii. Projection of points: Introduction of projection, quadrants, 1st, 2nd, 3rd and 4th angle projection of points.
iii. Projection of lines (First angle only): Line parallel to one or both planes, line perpendicular to a plane, line inclined to one plane and parallel to other, line inclined to both plane.
iv. Projections of planes (First angle only): Plane perpendicular to one plane and parallel to other, plane perpendicular to both plane, plane inclined to one plane and perpendicular to other.
v. Projection of solids (First angle only): Axis perpendicular to one plane and parallel to other, axis parallel to both plane, axis inclined to one plane and parallel to other, axis inclined to both plane.

MODULE 3: Sections and Sectional Views of Right Angular Solids (4 Lectures)

Section of solids: Section plane parallel to one plane and perpendicular to other, section plane inclined to one plane and perpendicular to other.

MODULE 4: Isometric Projections (4 Lectures)

Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions.

MODULE 5: Introduction of Computer Graphics (6 Lectures)

Demonstrating knowledge of the theory of CAD software such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen). Drawing simple shapes such as circle, parabola, etc. Drawing geometric solids; Drawing annotation, solid, surface, and wireframe models.

MODULE 6: Demonstration of simple team design (Students Project as group work)(4 Lectures)

Creation of engineering models and their presentation in standard 2D blueprint form, 3D wire-frame and shaded solids; meshed topologies for engineering analysis. Drawing of floor plans, front elevation and sectional elevation showing floor level to ceiling of a simple two storied building with doors and windows.

NOTE:

1. **Assessment of student based on above syllabus comprises of three parts**
    a. Theory examination covering Module 1 to Module 4
    b. Practical Examination covering Module 5
    c. Project covering Module 6

Text/Reference Books:

1. Bhat, N.D.& M. Panchal (2008), Engineering Drawing, Charotar Publishing House
2. Shah, M.B. & B.C. Rana (2008), Engineering Drawing and Computer Graphics, Pearson Education
3. Dhawan, R.K. (2007), A Text Book of Engineering Drawing, S. Chand Publications
4. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, ScitechPublishers.
5. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education
6. User manual of CAD software.

Course Outcome: After successful completion of the course, the students will be able to:

CO1: Explain the basic principles of Engineering Graphics.

CO2: Apply the principles of orthographic and isometric problems to represent simple Engineering objects.

CO3: Apply the principle of sectioning to represent different views of Right Angular Solids.

CO4: Create simple shapes like Circle, parabola, geometric solids etc. using CAD software.

CO5: Demonstrate team work spirit through creation of Engineering models and their presentations.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181104	Engineering Mechanics	3-0-0	3

MODULE 1: Equilibrium of Rigid Bodies (6 Lectures)

Introduction, Free body diagram (FBD), Types of supports and their reactions, System of forces, Resultant of coplanar concurrent forces and non-concurrent force systems, Conditions of equilibrium, (i) concurrent forces in space (ii) non-concurrent forces in space.

MODULE 2: Analysis of Structures (3 Lectures)

Method of joint, method of sections, graphical methods.

MODULE 3: Friction (3 Lectures)

Introduction, laws of Coulombs friction, equilibrium of bodies involving dry friction;inclined plane, ladder friction, wedge friction.

MODULE 4: Centre of Gravity and Moment of Inertia (6 Lectures)

(i) Centre of gravity and centroid; location of centroid and centre of gravity (ii) Moment of inertia of plane area, Parallel axis theorem, perpendicular axis theorem, mass moment of inertia, polar moment of inertia, radius of gyration, product of inertia, M.I. of simple and composite bodies.

MODULE 5: Lifting Machines (4 Lectures)

Introduction, Principles of machines, reversibility of machines, lever, pulley, simple wheeland axle.

MODULE 6: Virtual Work and Energy Method (4 Lectures)

Introduction, virtual displacement, principle of virtual work, application of virtual work.

MODULE 7: Impulse, Momentum, Work and Energy (4 Lectures)

Linear impulse and momentum, Principle of work-energy conservation.

<u>Text Books</u>:

1. Engineering Mechanics by IH Shames, PHI.
2. Engineering Mechanics, Mariam and Craig, Wiley.

<u>Reference Books</u>:

1. Engineering Mechanics by S. Timoshenko and D.H. Young, McGraw Hill Int.
2. Engineering Mechanics by R.K. Banshal, Laxmi Publication (P) Ltd.
3. Engineering Mechanics by K.L. Kumar, McGraw Publishing Co.
4. Engineering Mechanics by Hibbler.

5. Engineering Mechanics by D.P Sharma, Pearson.
6. Engineering Mechanics Statics and Dynamics by A Nelson, McGraw Hill.
7. Engineering Mechanics by S.S. Bhavikatti, New Age International Publishers.

Course Outcome: After successful completion of the course, the students will be able to:

CO1: Explain the construction of Free Body Diagrams of rigid bodies in equilibrium,subjected to coplanar concurrent and non-concurrent forces.

CO2: Analyse structures by the method of joints, sections and graphically.

CO3: Apply the concepts of C.G. and M.I. to find the C.G. and M.I. of simple and composite bodies.

CO4: Explain the working principle of Lifting Machines.

CO5: Apply the principle of Virtual work and Work-Energy Conservation to solve simple Engineering problems.

Course Plan:

Unit No.	Lecture	Topics to be covered
I	1	Introduction to Engineering Mechanics, Concept of FBD
	2	FBD contd.
	3	Different Principles-
	4	Equilibrium of concurrent forces and numerical problems.
	5	Equilibrium of Non-concurrent force system and numerical problems.
	6	Methods of Moments- Numerical problems on equilibrium of non-concurrent forces.
	7	Practice problems Contd.
	8	Practice problems Contd.
II	9	Introduction to plane truss.
	10	Solving problems on truss using method of joints.
	11	Method of section and numerical examples.
	12	Graphical Methods (Maxwell Diagram) and solving problems using graphical Method.
III	13	Friction, types of friction.
	14	Simple friction problems based on sliding of block.
	15	Ladder friction and problems on ladder friction.
	16	Wedge friction and related problems.
IV	17	General cases of parallel forces, centre of parallel forces.
	18	C. G. And centroid of plane figures and curves.
	19	Numerical problems on centroid of plane figures and curves.
	20	Problems contd.

	21	Moment of inertia of plane figures with respect to an axis in its plane, numerical examples on MI of plane figures.
	22	Parallel and perpendicular axis theorem.
V	23	Lifting machine- Introduction to lifting M/c, Types of lifting M/c
	24	System of pulleys- Numerical problem
	25	Simple wheel axle- Numerical problem
	26	Lever- Numerical problem
VI	27	Principles of Virtual work, basic concepts
	28	Numerical problems on virtual work
VII	29	Force , Impulse and momentum
	30	Work power and Energy
	31	Conservation of mechanical Energy
	32	Problems on Impulse, momentum, work and energy.

Beyond the syllabus

Topics to be discussed

1	Kinematics of Rectilinear translation, numerical problems on rectilinear translation
2	Newton’s law, general equation of motion of a particle
3	D’Alembert’s principles- Basic theory and numerical problem.
4	Kinematics of Curvilinear translation numerical problems.
5	Different equations of curvilinear translation, basic theory and numerical problems.
6	Motion of Projectile, numerical problems on projectile.

Course Code	Course Title	Hours per week L-T-P	Credit C
HS181105	Sociology	2-0-0	2

MODULE 1: Understanding of Sociology (5 Lectures)

Introduction to sociology: Meaning and definition of sociology, nature and scope of sociology, significance of sociology; understanding of society and social institutions: family, community, group, culture and civilization, marriage, family, religion.

MODULE 2: Gender and Society (4 Lectures)

Concept of gender, differences between sex and gender, changing gender roles in society, gender equality and inequality, gender and poverty, gender discrimination.

MODULE 3: Social Change (5 Lectures)

Meaning and definition of social change, nature and characteristics of social change, modernization, industrialization, information and technology. Social disorganization and social problems (over population, poverty, unemployment, corruption and black money.

MODULE 4: Industrial Disputes (5 Lectures)

Meaning and definition of industrial disputes, causes and methods of settlement of industrial disputes. Trade union- definition of trade union, functions of trade union, problems of trade union in India. Indian factories Act, 1948.

MODULE 5: Human Resources (5 Lectures)

Meaning of human resources, significance of human resources, meaning of manpower planning, concept of productivity, factors of productivity, factors affecting productivity, workers' participation in management, unilateral and cooperative participation.

Textbooks/ References:

1. C.N. Shankar Rao: Principles of Sociology, New Delhi: S. Chand & Co. Ltd., 2006.

2. Mamoria C.B., Mamoria S and Gankar. Dynamics of Industrial Relations in India,Himalaya Publishing House, New Delhi.

3. John, Mary E. Women's studies in India. New Delhi: Penguin, 2008.

4. Tong, R. Feminist Thought. Colorado: Westview Press, 2009.

5. Ram Ahuja - Social Problems in India, Jaipur: Rawat Publications, 2001.

6. M.N. Srinivas: Caste in Modern India, Oxford University Press, 1992.

7. Principles of Sociology by R.N. Sharma.

8. Labour problems and social welfare by R.C.Saxena.

9. Labour problems and social welfare by U.C.Kulshrestha.

Course Outcome: After successful completion of the course, the students will be able to:

CO1: Develop their sociological thinking to demonstrate sociological understandings of phenomena, for example, how individual biographies are shaped by social structures, social institutions, cultural practices, and multiple axes of difference and/or inequality.

CO2: Identify the major concepts and perspectives of sex-gender systems and practices in contemporary society.

CO3: Develop the ability of critical thinking through the ability to analyze and evaluate social, political, and/or cultural changes in society.

CO4: Exhibit the knowledge of sociological perspective of industry, conflict resolution and labour/management relation in industry.

CO5: Analyse the significance of human resources and its participation in various sectors of society.

Course Code	Course Title	Hours per week L-T-P	Credit C
PH181211	**Physics-201 Lab**	**0-0-2**	**1**

List of Experiments:

1. To find the value of the modulus of rigidity of the material of a rod by using: Vertical Twisting apparatus / Horizontal Twisting apparatus.
2. To find the Moment of Inertia of a given body by using the Moment of Inertia Table.
3. To find the coefficient of viscosity of water by capillary flow method.
4. To find the refractive index of the material of a prism using a spectrometer (by finding the angle of the prism and the angle of minimum deviation of the prism).
5. To find the specific heat of a given liquid by the method of cooling.
6. To find the ratio of two low resistances by using a potentiometer.
7. To find the average resistance of the Meter Bridge wire by Carey Foster's method.
8. To find the refractive index of water by using a convex lens and a mirror.
9. Determination of Planck's constant.
10. To find the velocity of ultrasonic waves in a given liquid.

Text Books:

1. A Text Book on Practical Physics – K.G. Mazumdar and B. Ghosh (SreedharPublishers).
2. A Text book of Practical Physics - Samir Kumar Ghosh (New Central Book Agency).

Course Outcome: After successful completion of the course, the students will be able to:

CO1: Carry out experiments to determine Modulus of rigidity of a rod using VerticalTwisting apparatus/Horizontal Twisting apparatus

CO2: Determine Moment of Inertia and Coefficient of Viscosity of water

CO3: Determine Refractive Index of the material of prism and specific heat of a given liquid

CO4: Determine the ratio of two low resistance using potentiometer and average resistanceof the Meter Bridge wire

CO5: Determine Refractive Index of water using Convex lens and a mirror

CO6: Carry out experiments to determine Plank's Constant and velocity of Ultrasonic wavesin a given liquid.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181114	**Engineering Mechanics Lab**	**0-0-2**	**1**

List of Experiments:

1. To verify the law of polygon of forces for a number of coplanar forces inequilibrium.
2. Parallel Forces Apparatus:
   A. To show experimentally the inverse relationship between reactive forces at support and the distance of the point of application of loads from supports.
   B. To find the reactive forces at the supports using:
   (i) Experimentally, (ii) Analytical method
3. Rolling Friction Apparatus:
   Experimental Computation of Co-Efficient of Friction between an Inclined Plane (Glass) and Trolley (Iron).
4. Square Threaded Screw Jack
   A. To determine the Velocity Ratio, Mechanical Advantage and Efficiency of a Square Threaded Screw Jack
   B. To construct the Curves showing relations of P – W, MA – W, η - W
5. To verify the Law of Moments by using a Bell Crank Lever
6. To verify the equilibrium of forces with the help of force polygon apparatus
7. To determine the co-efficient of friction between the slider and the inclined plane (sliding friction)

Course Outcome: After successful completion of the course, the students will be able to:

CO1: Establish the law of polygon of forces and equilibrium of forces throughexperimentation.

CO2: Determine the reactive forces at support and its relationship with the distance of the point of application of loads from support.

CO3: Determine the co-efficient of Rolling and Sliding friction on an inclined plane through experimentation.

CO4: Determine the velocity ratio, Mechanical advantage and efficiency of a square threaded screw jack.

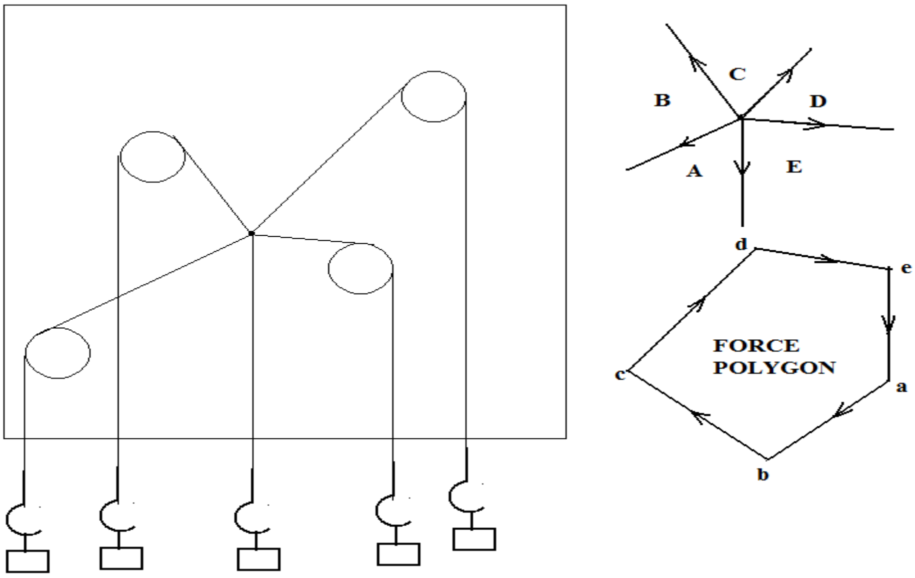
CO5: Verify the law of moments by using a Bell crank lever.

EXPERIMENT NO. 1

TITLE: POLYGON OF FORCES

OBJECTIVE: TO VERIFY THE LAW OF POLYGON OF FORCES

THEORY: A given system of coplanar, concurrent forces will be in equilibrium provided a close polygon can be drawn which shall have its sides respectively parallel and proportional to the forces taken in order.



PROCEDURE:

(1) Fix a sheet on the board

(2) Loading the pans and allow the system to come to rest and note the loads including the weights of pans

(3) Mark the directions of strings on the paper.

(4) Draw force polygon and if the last line meets the starting point, the law is verified

(5) Repeat the procedure by varying the loads

TABLE:

Serial No.	WEIGHTS IN				
	AB	BC	CD	DE	EA

Questions:

1. Define force.
2. What is concurrent force system?
3. Does your vector polygon close? If not, what are the reasons?
4. Do you find any resultant from the vector polygon? Should there be any resultant actually?
5. If there be a resultant in a force system. What should be the effect?

EXPERIMENT NO. 2

TITLE: VERIFICATION OF LAW OF PARALLEL FORCES

OBJECTIVE: TO DETERMINE THE REACTIONS OF A SIMPLY SUPPORTED BEAM LOADED WITH CONCENTRATED LOADS BY OBSERVATION AND BY CALCULATIONS

AND COMPARE THE RESULTS

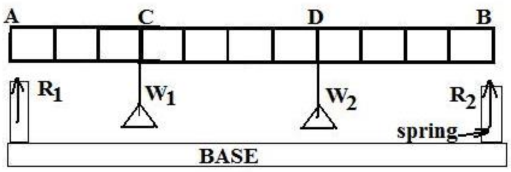
THEORY: By law of parallel forces

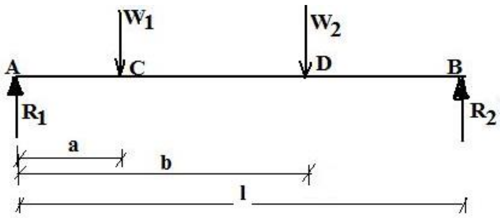
$W_1 + W_2 = R_1 + R_2$ --------------(1)

By taking moment about A

$W_1 x\ a + W_2 x\ b = R_2\ x\ l$ ---------(2)

From equation (1) and (2), R_1 and R_2 can be calculated by knowing a, b, l, W_1 and W_2 . Law can be verified by experiment





PROCEDURE:

1. Calibrate the compression spring separately by removing the bar and putting known load and note the deflection of the spring whereby spring stiffness can be known by dividing load by deflection.
2. Measure span l
3. Put loads W_1 and W_2 at known distance a and b.
4. Calculate reaction R_1 and R_2 using equation (1) and (2).
5. Note spring deflection and convert them into weight units by multiplying by the spring stiffness.
6. Repeat the procedure by varying a, b, W_1 and W_2

TABULATION: Span, l = , Spring stiffness, K_1 = K_2 =

Sl. No	W_1	a	W_2	b	Calculated wt		Observed Value								Inference
					R_1	R_2	Int. def.	Fin. Def.	Def.	R_1	Int. def.	Fin. Def.	Def.	R_2	

Questions:

1. What are the laws of parallel forces?

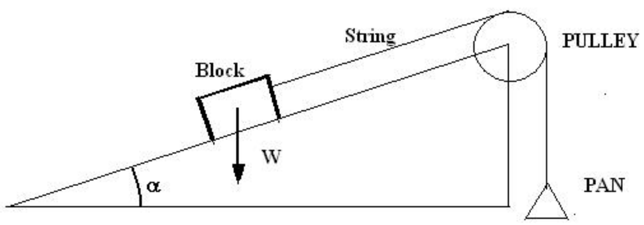
2. Whether loads used by you are masses or weights? What is the difference between mass and weight? Does mass change for a particular substance from place to place? What about weight?
3. Explain what is meant by clockwise and anticlockwise moment?
4. Forces 10 N and 50 N are to be balance at the ends of a lever 1 m long. Where should be the position of the fulcrum?

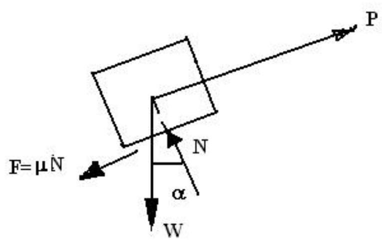
EXPERIMENT NO. 3

TITLE: SLIDER FRICTION ON INCLINED PLANE

OBJECTIVE: TO DETERMINE THE CO-EFFICIENT OF SLIDER FRICTION BETWEEN TWO GIVEN SURFACES

THEORY:





With reference to the figure

μ = co-efficient of friction

N = Normal Reaction

F = Friction force

P = Wt on the pan.

α = inclination of the plane

Resolving the forces along the plane and perpendicular to the plane

$P - \mu N - W \sin\alpha = 0$ -----------(1)

$N - W \cos\alpha = 0$ -----------(2)

From (1) and (2)

$$\mu = P/ W \cos\alpha - \tan\alpha$$

PROCEDURE:

(1) Set the apparatus and note α

(2) Put load W_1 on slider box and check minimum P at which the slider start moving ($W = W_1$ + wt of the box.)

(3) Calculate μ

(4) Repeat for one more set of W and α

TABULATION: Wt of the box = , Wt of the pan =

CONTACT	SERIAL	W	P	α	μ	MEAN

SURFACES	NO.					

Questions:

1. What do you mean by static friction, limiting friction, slider friction and rolling friction?
2. What do you mean by coefficient of friction, angle of friction, angle of repose and cone of friction?
3. “It is easier to pull a body than to push it” Explain
4. For two bodies of the same material resting on the same surface, the body having more weight will experience greater frictional force or the body having less weight will experience greater frictional force?
5. Give some examples indicating the useful and harmful effects of friction

EXPERIMENT NO. 4

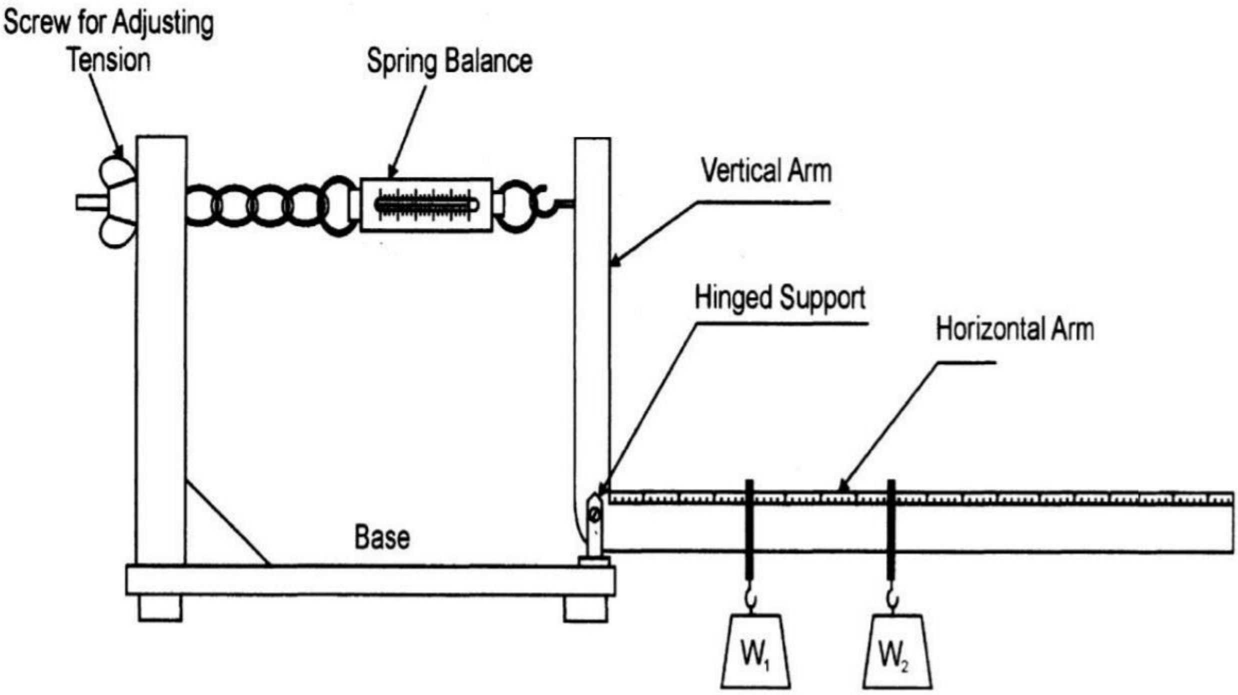
TITLE: VERIFICATION OF THE LAW OF MOMENTS

AIM: TO VERIFY THE PRINCIPLE OF MOMENTS USING THE BELLCRANK LEVER APPARATUS.

THEORY:

Principle of Moments states that ‘the algebraic sum of the moments of a system of coplanar forces about any point in the plane is equal to the moment of the resultant forceof the system about the same point’. This principle would be verified for a bell crank lever arrangement. A lever whose two arms form a right angle, or nearly a right angle and having its fulcrum at the apex of the angle is referred to as a bell crank lever. Theselevers were originally used to operate the bell from a long distance especially where change in direction of bell wires was involved and hence the name.

Now, bell crank levers are used in machines to convert the direction of reciprocation movement.



PROCEDURE:

1. Arrange two hangers at arbitrary locations on the horizontal arm and note thelocations x_1, and x_2, of these hangers from the hinge.
2. Adjust the tension in the spring connected to the vertical arm such that the loadarm becomes horizontal.
3. Note the tensile force in the spring as the initial tension Ti.
4. Hang the weights W_1 and W_2 from the hangers. This will cause the arms to tilt and the pointers to move away from each other. Now again adjust the tension in the spring such that that the arm which has loads comes in horizontal position.
5. Note the tensile force in the spring as the final tension Tf.
6. The tensile force T due to the application of loads on horizontal arm is equals to

$$Tf - Ti.$$

7. Therefore, to verify the principle of moments we need to take moments M of all the external forces (which include the weights of the hangers hanging from the horizontal arm) and the tension in the spring connected to the vertical arm aboutthe hinge.
8. If the total sum is zero, verifies the law of moments since the moment of the resultant is also zero about the hinge.
9. Repeat the above steps by changing the weights and their location on thehorizontal arm

for two more set of observations.

OBSERVATIONS:

Sample calculation:

The total moment about the hinge is given by,

$$\sum M = T \times y - W_1 \times x_1 - W_2 \times x_2$$

Where,

T is the tension in the spring balance

y is the distance of the spring balance from the hinge along the vertical arm

W_1 and W_2 are the loads on the horizontal arms

x_1 and x_2 are the distances of W_1 and W_2 respectively from the hinge alongthe horizontal arm

Sl no.	$T_i(N)$	$W_1(N)$	$W_2(N)$	$x_1(m)$	$x_2(m)$	$T_f(N)$	$T\ (N)$	$\sum M\ (N.m)$

RESULT/ INFERENCE:

Questions:

1. "The total moment in all cases was equal to zero." Is this statement true or false? If false, what are the possible reasons according to you?
2. List some applications of bell crank lever.
3. What is Varignon's theorem?
4. What does the moment of the force measure?

EXPERIMENT NO. 5

TITLE: PERFORMANCE OF A LABORATORY SQUARE THREADED SCREW JACK

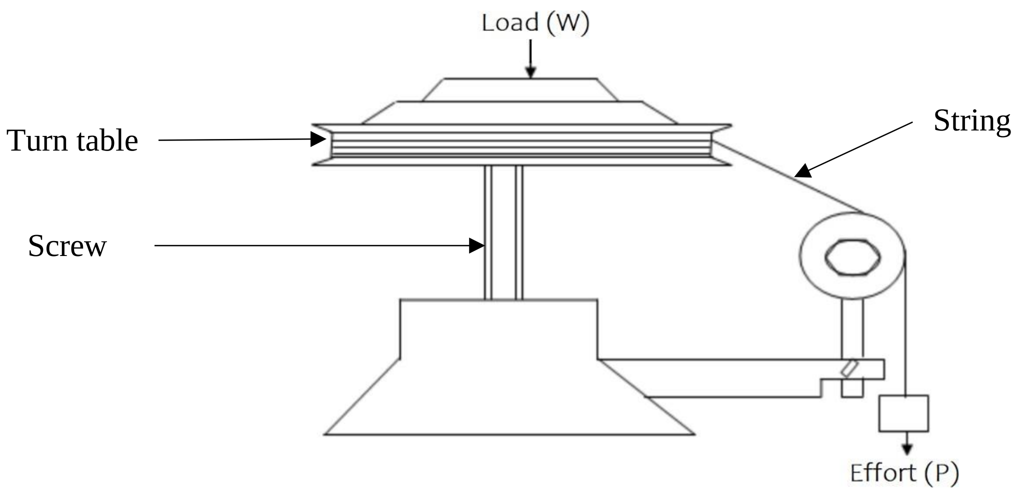
AIM: ANALYSE THE PERFORMANCE OF A LABORATORY SQUARE THREADED SCREW JACK:

A. TO DETERMINE THE VELOCITY RATIO, MECHANICAL ADVANTAGE AND EFFICIENCY OF A SQUARE THREADED SCREWJACK

B. TO CONSTRUCT THE CURVES SHOWING RELATIONS OF *P – W*, *MA – W*, *η- W*

THEORY:

The simple screw jack consists of a screw, which is free to rotate in a nut and effort wheel is fixed to this screw at the top. Nut is fixed with the body. A string is wrapped around the head of screw rod and one end of the string is attached to the effort pan.



The velocity ratio (*VR*) of any lifting machine is given as-

$$VR = \frac{\text{Distance traveled by the effort (y}}{\text{Distance traveled by the load (x}}$$

In case of simple screw jack shown in the figure,

$$VR = \frac{\pi D}{p}$$

where, D = Diameter of the turntable

p = pitch of the screw

Mechanical advantage (*MA*) is given by

$$MA = \text{Load (W)} \big/ Effort\ (P)$$

PROCEDURE:

1. Determine the pitch of the screw thread.
2. Measure the circumference of the turn table.
3. Put some known weight on the turn table and find out the corresponding effortrequired to lift the load by adding the weight on the effort pan.
4. Repeat the experiment for at least five loads.
5. Plot the value in graph papers to construct the following Curves

a. P vs W

b. MA vs W

c. η vs W

OBSERVATIONS:

1. Diameter of load table (turn table): D =
2. Pitch of the screw: P =
3. Circumference of load table: πD =
4. Velocity Ratio: VR =

Sl No.	Load W (N)	Actual effort, Pa (N)	Ideal Effort, Pi (N)	Difference in efforts (N), $Pf = Pa - Pi$	Mechanical Advantage, MA	Efficiency (%), η

From the above observations, the law of machine is _____

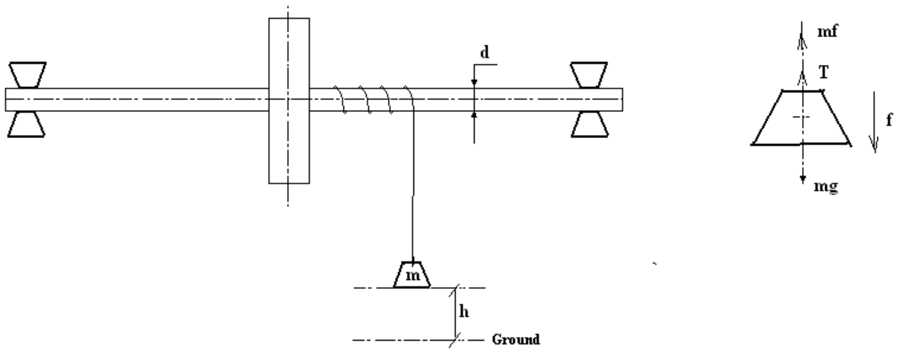
Questions:

1. What is meant by the pitch of a screw? How did you measure the pitch of the screw?
2. List some applications of screw jack. What are the advantages of irreversible machine?
3. What is the nature of the graph of actual effort vs Load?
4. What is the nature of the graph of efficiency vs Load?

Beyond the Syllabus:

EXPERIMENT NO. 1

TITLE: MEASUREMENT OF MOMENT OF INERTIA OF A DISC IN FORM OF FLYWHEEL.



APPARATUS:

Apparatus consists of a flywheel integrated with a shaft. The shaft is mounted on the bearings. A load m is hanged by a thread which is wound around the shaft.

PROCEDURE:

1. Measure the height h, the position of m above ground before it is released.
2. Now from this stationary position the mass is allowed to go down.
3. Record the time of decent (t) over h in sec.
4. Measure the diameter of the shaft

CALCULATIONS:

When the mass m is allowed to fall , the mass falls with increasing velocity at at constant acceleration (f). It can be seen that

Mg = T+ mf

T= mg –mf = m (g-f)----------(1)

Again the disc rotates with increasing angular velocity with an acceleratio θ

Tr - Iθ =0 where I = moment of inertia of the flywheel.

From this we can deduce

$$I= \{m(g – 2h/t^2)\, d^2\, t^2\}/\ 8\, h$$

EXPERIMENTAL RESULTS:

Serial No.	Height Of The Mass From The Ground, H (M)	Time Of Descent, T (Sec)	I (Kg M2)	Average I

Questions:

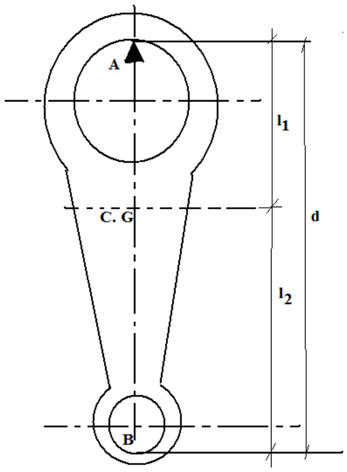
1.The calculated MI also includes the effect of friction in the bearing. Does the bearing friction tend to increase the resistance to rotation?

2. What will be the tension T if the mass is lifted with an acceleration f = 0.4g?

3. What torque will be required to be provided to the shaft?

EXPERIMENT NO.2

TITLE: TO CALCULATE THE CENTRE OF GRAVITY (C.G) DYNAMICALLY USING THE PRINCIPLE OF COMPOUND PENDULAM



PROCEDURE:

1. Measure d
2. Suspend the pendulum from bigger or smaller end.
3. Give a little oscillation (within 4^0)
4. Take the time period for at least 30 oscillations.
5. Now take the readings for the other position.

CALCULATIONS:

Let,

I = Mass moment of inertia through C. G. perpendicular to proper plane (i.e plane of oscillation)

I_A= mass moment of inertia about A.

I_B= mass moment of inertia about B.

m = mass of the connecting rod

l_1 , l_2 = distance of the edge from C. G

ω_1 , ω_2 = frequency of oscillation corresponding to T_1 and T_2.

$$l_2 = (gd/\omega^2_2 - d^2)/ (g/\omega^2_1 + g/\omega^2_2 - 2d)$$

Sl. No	Position	Time of oscillation	No. of oscillation	Time period (sec)	Frequency of oscillation	L_2 (cm)
	A					
	B					

EXPERIMENTAL RESULTS:

Questions:

1.What do you understand by dynamically equivalent system?

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181216	**Workshop**	**0-0-4**	**2**

1. <u>Lathe:</u>

(a) Lathe – Functions, Classification and Specification, Different parts, Drive mechanisms for speed, feed, depth of cut, Taper turning, other operations, Machining time. Lathe accessories and Attachments.

(b) **Semi-Automatics –** Capstan and Turret Lathes – Different parts – Tools – Work and Tool holding devices. Indexing and Bar Feeding mechanism, Tool layout and Tool schedule chart.

2. <u>Shaper, Planar, Slotting and Broaching Operations</u>

(a) **Shaper -** Function, Classification and Specification, Different part of a shaper – Quick return and feed mechanism – Shaper Operations, Cutting speed and Machining time calculations.

(b) **Planar -** Function, Classification and Specification, Difference between shaper and planar - Table drives and field mechanism – Planar operations – Machining time.

(c) **Broaching –** Purpose, Broaching tool and machine

(d) **Slotting Machine –** Purpose, Slotting tool and machine.

3. <u>Drilling:</u>

(a) Drilling machines – Classification – Specification – Parts drilling machine – Spindledrive mechanism – tool and work holding devices.

(b) Types of Drills and twist drill nomenclature, drill size and designation of drills.

(c) Deep hole drilling operation.

(d) Speed, feed and depth of cut and machining time in drilling.

(e) Reaming operation, Reaming tools, Reaming allowances.

(f) Tapping operation, tap drill size, difference with die (solid and adjustable).

4. <u>Milling:</u>

Introduction – Classification – Principal parts of a column and knee type Milling machine – Specifications, Spindle drive and feed mechanism, elements of a milling cutter, Milling processes – Up Milling – down milling – face milling – end milling, cutting speed, feed and depth of cut – machining time, indexing and dividing head, indexing methods, spur and helical gear milling operations – Selection of cutter for gear cutting.

5. <u>Grinding:</u>

Introduction – Kinds of Grinding – Grinding processes – Centerless Grinders – Surface Grinders – Tool and cutter Grinder – Specification Grinding wheel – Abrasives – Bonding Processes – Grid , Grade and Structure – Marking System of Grinding wheel – Selection of Grinding wheel, Mounting, Dressing, Truing and Balancing of grinding wheel.

6. <u>Pattern making and Foundry:</u>

Pattern making and sand casting – Pattern materials – Types – Pattern allowances, Coreprints, Moulding sand – Ingredients – Classification – Sand additives – Properties of Moulding sand – Sand preparation and testing, Green sand mould preparations, Cores and core making – Types of Cores.

BOOKS:

1. Elements of Workshop Technology – Vol. I and II, S.K. Hajra Choudhury and A.K. Hajra Choudhury.
2. A course in Workshop Technology (Vol. I and Vol. II) – B.S, Raghuwanshi.
3. Manufacturing Technology – P.N. Rao – Tata McGraw Hill.
4. Workshop Technology – I – P.K. Sapra and R.K. Kapur – Bikas Publishing.
5. Elements of Manufacturing Processes – B.S. Nagendra Parasar and R.K. Mittal –PHI

6. Introduction to Machining Science – G.K. Lal, New Age International Ltd.

Course Outcome: After successful completion of the course, the students will be able to:

CO1: Demonstrate the different types, working principle, different operations andattachments of lathe and semi-automatic lathe.
CO2: Differentiate the different types along with parts, mechanisms and operations ofshaper, planar, broaching and slotting machines
CO3: Differentiate the different types of drilling machines, drills and reamers along with the different operations
CO4: Explain the different types of milling machines, milling cutters, along with milling operations
CO5: Explain the basic principles of grinding, different types of grinding machines, grinding operations, specifications, dressing and truing of grinding wheels.

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3.3 THIRD SEMESTER

B.Tech 3rd Semester: Mechanical Engineering

Sl. No.	Sub-Code	Subject	Hours per Week			Credit	Marks	
			L	T	P	C	CE	ESE
Theory								
1	MA181301A	Mathematics III-A (for branches other than CSE and ECE/ETE)	2	1	0	3	30	70
2	EE181302	Electrical Technology	3	0	2	4	30	70
3	ME181303	Basic Thermodynamics	3	0	2	4	30	70
4	ME181304	Theory of Machines	3	0	0	3	30	70
5	ME181305	Machine and Assembly Drawing	2	0	2	3	30	70
6	MC181306	Constitution of India	2	0	0	0 (PP/NP)	-	100
Practical								
1	ME181314	Theory of Machines Lab	0	0	2	1	15	35
2	SI181321	Internship-I (SAI - Social)	0	0	0	1	-	100
TOTAL			15	1	8	**19**	**165**	**585**
Total Contact Hours per week : 24								
Total Credits: 19								

N.B. **MC181306 is a Mandatory Audit Course (No Credit). It will be evaluated as PP (Pass)or NP (Not Pass)**

Detailed Syllabus:

Course Code	Course Title	Hours per week L-T-P	Credit C
MA181301A	**Mathematics III-A** (For branches other thanCSE and ECE/ETE)	**2-1-0**	**3**

MODULE 1: Partial Differential Equation: (15 Hours)
Formation of Partial Differential equations, Linear partial differential equation of first order, Non-linear partial differential equations of first order, Charpit's method, Method of separation of variables,boundary value problem with reference to the one dimensional heat and wave equation.

MODULE 2: Probability Theory: (15 Hours)
Review of basic probability and Bayes' theorem, Probability distribution, Binomial, Poisson and normal distribution, Joint distribution, Test of significance, fitting of straight line by least square method, Elementary concept of Markov Chain.

MODULE 3: Laplace Transform: (10 Hours)
Laplace transform of elementary function, Properties of Laplace transform, inverse Laplace transform,convolution theorem, Solution of ordinary differential equations with the help of Laplace transform.

Textbooks/References:

1. Advanced Engineering Mathematics: Erwin Kreyszig
2. Higher Engineering Mathematics: B V Ramana
3. Theory and problems of Probability: Seymour Lipschutz
4. A text book of engineering Mathematics: N. P. Bali & M. Goel
5. Statistical Methods: An Introductory Text- J.Medhi, New Age International Publishers

Course Code	Course Title	Hours per week L-T-P	Credit C
EE181302	Electrical Technology	3-0-2	4

COURSE OVERVIEW:

The purpose of the course is to teach principles of AC and DC motors and generators, and AC transformers and how they work. Basic concepts of electromagnetic circuits as they relate to voltages,currents, and physical forces induced in conductors are covered, including application to practical problems of machine design. It also includes the study of alternators, synchronous motors, poly phaseinduction motors and single-phase motors.

Course Objectives

1. Student will be taught the working principle of electric motors/ generators and transformer basedupon fundamental theories after getting detailed knowledge of construction, operating principles.
2. Student will be benefited by acquiring knowledge of construction, operating principles of induction motors and can analyze performance parameters of single as well as three phase induction motors.
3. Students will understand the working principle and behavior of synchronous machines along withvarious area of applications.
4. Students will get the knowledge of power measuring instruments along with their errors.

Motivation:

The objective is to motivate the students in learning electrical machines and strengthening knowledgetowards practical work.

Course Outcome (CO):

After the successful completion of the course student should be able to:

CO1: Apply knowledge to relate the constructional details with the performance analysis of DCmachine.

CO2: Articulate the concept of 1 phase transformer and complete an analysis.

CO3: Analyze and differentiate the working principle of 3 phase and 1 phase Induction Motor alongwith various areas of applications.

CO4: Apply knowledge on operation of synchronous machines and analyze variation of excitationwith power factor under different loading conditions.

CO5: Analyze the performance of the measuring instruments and identify their errors.

MODULE 1: D C Machines:

i. Basic Constructional features, E M F equation of D C generator, Elementary Idea of DC machinewinding-winding pitch, Lap and Wave windings. Types of generators. Characteristics of DC generator-the OCC and the load characteristics. The shunt generator-condition for voltage builds up. Load characteristics. Losses in a DC generator, Efficiency, Applications, Compound generators
ii. Working principle of DC motor. Back EMF, Calculation of torque and power. Types of DC

motors. Characteristics curves. Losses and Efficiency. Speed equation. Method of speed control. Method of starting. The 3 point, 4-point starter (calculations of the star resistors not required)

MODULE 2: Transformer:
Physical description of transformer. Elementary theory of the ideal transformer, EMF equation, Voltage and current transformation ratio. No load and load phasor diagrams. Transformer reactance and impedances. Equivalent resistance & reactance. Simplified equivalent circuit, open and short ckttests. Losses and efficiency. Condition for maximum efficiency. All day efficiency.
Voltage regulation. The auto transformer, basic working principle.

MODULE 3: Induction motor:
Constructional features of 3-ph induction motor-principle of rotating magnetic field (mathematical treatment not required) Principle of operation of the 3-ph induction motor speed. Rotor emf, current and rotor cu loss, Torque, Starting torque. Maximum torque. Condition for maximum torque. Torqueslip curves. Necessity of a starter. Methods of starting of squirrel cage and the slip-ring induction motors.
Introduction to single phase induction motor. Nature of a field and torque produced in single phase induction motors (details of double revolving field not required). Types of motors-split phase, capacitors motors.

MODULE 4: A.C. Synchronous machines:
Principle of operation of alternators. Constructional features of cylindrical generators and salient polealternator, EMF equation.
Principle of operation of the synchronous motor, Synchronous motor on no load, Synchronous motoron load, Behaviour of the Synchronous motor with change of excitation curves. Starting methods of Synchronous Motor. Application of Synchronous motor.

MODULE 5: Measuring Instruments:
Dynamometer type wattmeter. Induction type wattmeter. Single phase induction type energy meter. Errors and compensations.

Textbooks/References:

1. Theraja: A Text book of Electrical Technology.
2. K. Krishna Reddy: Electrical Machines-I, II, III
3. Electrical Technology: Vaidya, Bhagwat, God bole
4. Kothari D.P., and Nagrath, I.J., ‘Electrical Machines’, Tata McGraw Hill
5. Electrical Measurements and Measuring Instruments – A.K. Shawney (Dhanpat Rai)
6. Langsdrof: ‘Theory of Alternating Current Machines’ Tata McGraw Hill
7. Kingsley, Fitzereld: Electric Machinery (McGraw Hill)
8. Ashfaq Husain, Electric Machines, Dhanpat Rai

Suggested Practical:

Course Objectives:

The Electrical Technology Laboratory is designed to provide the students with the practical knowledgeof electrical machines specifically keeping in view the following objectives:

i. to get hands-on experience in performing the basic tests on electrical machines
ii. to reinforce the theoretical concepts with related practical understanding
iii. to know about the various precautionary measures necessary in handling electrical machines
iv. to develop technical report writing skill

Course Outcome (CO):

CO1: Students will be able to apply knowledge on operation of electrical machines (DC motor/generator, transformers) and relate theoretical concepts with experimentation.

CO2: Students will be familiar with the mode of starting, switching-off, and taking pre-cautionarymeasures while handling electrical machines.

CO3: Students will be able to write effective reports and design documentation after performing anexperiment.

LIST OF EXPERIMENTS

1. Open circuit characteristic of a dc generator.
2. Load test on a dc shunt generator.
3. Speed control of dc shunt motor.
4. Open circuit and short circuit test on a single phase transformer
5. Load test on a single phase transformer.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181303	**Basic Thermodynamics**	**3-0-2**	**4**

Objective:

i. To impart knowledge on the laws of thermodynamics and their application along with theknowledge of various cycles.
ii. To give an idea on the mechanism behind the working of different cycles and to develop theability to analyze and solve problems related with thermodynamics
iii. To provide the exposure to fuel and combustion to solve a wide variety of engineering problem.

Motivation:
The knowledge of Basic Thermodynamics has wide application in mechanical engineering. All naturalprocesses are governed by the principles of thermodynamics. Automotive engines, Turbines, Compressors, Pumps, Fossil and Nuclear Power Plants, Propulsion systems for the Aircrafts, Separation and Liquefaction Plant, Refrigeration, Air-conditioning and Heating Devices are some of the engineering devices which are typically designed based on the principles of thermodynamics.

Course Outcomes (CO): At the completion of the course the student will be able
CO1: Illustrate the basic concepts of thermodynamics and its approaches for conversion of heat and work.

CO2: Apply the laws of thermodynamics in steady flow processes in devices, namely nozzles and diffusers, turbines and compressors, throttle device, water turbine, heat exchangers, for energy conversion and employ the concept of irreversibility.

CO3: Relate through diagrams properties of steam for suitable application in the field of energy conversion

CO4: Illustrate graphically and analytically the working of air standard cycles applied in internalcombustion engines, namely, Otto cycle, diesel cycle, dual cycle.

CO5: Examine the various properties of fuel through various experiments to determine their suitabilityfor combustion applications.

MODULE 1: System and Continuum:
Intensive and Extensive properties – Thermodynamic state, pressure, energy, work and heat – processand cycle – Macroscopic and Microscopic points of view – Kinetic theory of gases

MODULE 2: Laws of thermodynamics:
Zeroth law – Concept of equilibrium– Principles of therm. Fixed points. First law of thermodynamicsand its application to open and closed systems Concept of internal energy – Steady flow energyequation – Processes of closed systems. Second law of thermodynamics – Various statements – Carnotcycle – Irreversible and Irreversible processes – Thermodynamic efficiency and temperature scales –Concept of entropy – Entropy changes in various processes.

MODULE 3: Properties of steam:
Latent heat – Saturation pressure and temperature – Dryness fraction – Degree of superheat – Total heat; Rankine cycles (use of steam tables, Mollier chart and other property diagrams).

MODULE 4: Air standard cycles:
Otto, Diesel and dual cycles. Principles of working of two and four stroke SI and CI engines – Representations of processes on T-s and p-v diagrams and comparisons of efficiencies.

MODULE 5: Fuels and Combustions:
Classification of fuels; HCV, LCV, Bomb Calorimeter, Boy's gas calorimeter; Combustion of fuels; Minimum air required (by weight and by volume); Conversion of volumetric analysis into weight analysis and vice versa; excess air and Orsat apparatus.

Textbooks/References:

1. Engineering thermodynamics by P K Nag
2. Fundamentals of Thermodynamics by Cengel and Boles

Prerequisites of the course None (This is a basic course)

Course Time Plan

Units/Topics	Number of Lectures	Method of deliver
Unit I – System and Continuum	8	
Unit II – Laws of thermodynamics	10	
Unit III – Properties of steam	6	Both chalk and talk and power point presentation
Unit IV – Air standard cycles	8	
Unit V – Fuels and Combustions	8	
Total	40	

Expected outcome

On successful completion of the course, the students will have the ability to:

1. Use the knowledge to solve a variety of thermodynamic related practical problems.
2. Gain knowledge of different types of thermodynamic processes and cycles and their practical application.
3. Acquire sufficient knowledge on the combustion process of fuels.
4. Use this knowledge in other engineering subjects like Applied Thermodynamics and further studies.
5. Prepare for a professional career and pursue higher studies.

<u>Practical:</u>

Objective:

i. To impart knowledge on the basic thermodynamic properties.

ii. To give the idea of different types of boilers and its mounting and accessories.
iii. To give the idea of practical knowledge of two stroke and four stroke engines and theirthermodynamic cycles.

Course Outcomes (CO): At the completion of the course the student will be able to:

CO1: Understand the basic concept of thermodynamic properties such as temperature and pressure

CO2: Understand the basic differences of different types of boilers, from the study of cut models, suchas vertical tube boiler, Cochran boiler together with their mountings.

CO3: Understand the working principles of Internal Combustion Engines, from the study of cutmodels, such as 2 stroke and 4 stroke petrol engine, 4 stroke diesel engine

<u>LIST OF EXPERIMENTS</u>

1. To study thermodynamic properties such as temperature and pressure in different condition withthermometer and pressure gauge.
2. To study the mountings and accessories of boilers like vertical tube boiler and Cochran boilerwith the help of cut models.
3. To study the working principle of Internal Combustion Engines such as 2 stroke and 4 strokePetrol Engine and 4 stroke Diesel Engine with the cut models.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181304	**Theory of Machines**	**3-0-0**	**3**

Course Outcomes (CO): At the completion of the course the student will be able

CO1: Analyze the kinematic analysis of a given mechanism.

CO2: Analyze the motion and dynamic forces acting on mechanical motion transmitting element composed of gears, belts, cams

CO3: Apply the concept of mechanical control mechanism to reduce fluctuation of speed and energy.

CO4: Apply the fundamental principles of friction for effective transmission of power and intermittentcontrol of speed.

CO5: Apply the concept of theory of machine in mechanical engineering system for appropriate transmission power and motion.

MODULE 1: SIMPLE MECHANISMS
Link, Pair, chain, mechanism and inversions. Simple mechanism, Slider crank, four bar, straight line steering. Simple velocity and acceleration diagrams,

MODULE 2: GOVERNOR
Watt and Porter governors. Spring controlled centrifugal governor – Hartnell, Hartung, Wilson – Hartnell, Inertia governors. Stability, Effects of friction, Isochronism, Hunting, effort and power.

MODULE 3: CAM
Introduction, classification of cams and followers, Displacement diagram, graphical layout of cam profiles

MODULE 4: FRICTION AND FRICTION DRIVES
Types of friction, Uniform Pressure and Uniform Wear, Friction Clutches, Rolling Friction, Flat Belt,V Belt and Rope Drives, Velocity Ratio in Belt Drives, Law of Belting, Ratio of Friction Tensions inBelts, Power Transmitted by Belts and Ropes, Maximum Power Transmission by Belt, Types of Brakes, Block and Shoe Brake, Band Brake, Internal Expanding Shoe Brake, dynamometer

MODULE 5: TM DIAGRAM AND FLYWHEEL
Fluctuations of energy, Co-efficient of fluctuation of energy and speed, function of flywheel.

MODULE 6: GEAR AND GEAR TRAIN Nomenclature, types – simple, compound, epicyclic geartrain including reverted gear train. Simple description of automobile gear train.

Textbooks/References:

1. Ratan, S.S., Theory of Machines, Tata McGraw Hill Publishing company Ltd., 2nd Edition, 2005.

2. Singh Sadhu, Theory of Machine, Pearson Education
3. Singh V.P., Theory of Machines

Content	Lecture Hours
Unit I: Simple Mechanisms	8
Unit II: Governor	6
Unit III: Cam	4
Unit IV: Friction and Friction Drives	12
Unit V: Tm Diagram and Flywheel	2
Unit VI: Gear and Gear Train	8
Total	40

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181305	**Machine and Assembly Drawing**	**2-0-2**	**3**

Objective:

i. To impart knowledge on various basic mechanical parts and its construction.
ii. To give an idea on functioning of the parts
iii. To proffer knowledge on assembling of the parts of engine and valves

Motivation:
This is a very basic subject which will improve the visualization skill for evolving mechanical parts. It will also provide the knowledge on how the various mechanical parts are to be built by assembling some small elementary parts. Knowledge of the subject will also furnish the better understanding of machine design, workshop theory, theory of machine and IC engine to the students.

Course Outcomes (CO): At the completion of the course the student will be able to:

CO1: Illustrate and draw the profiles of thread and locking devices such as nuts and bolts

CO2: Sketch various joints-key and cotter joints, riveted joints, welded joints, coupling, pipe joints aswell as machine elements.

CO3: Assemble basic engine parts and components such as piston, staffing box, cross head, connecting rod, eccentric

CO4: Assemble elementary mechanical parts to construct valve like feed check valve, stop valve, blow off cock, non-return valve.

CO5: Develop solid models of various machine elements in CAD.

MODULE 1: Screw Fasteners:
Introduction, Screw Thread Nomenclature, Forms of Thread, Thread Profiles- V-Thread, Buttress Tread, British Standard with worth (B.S.W) Thread, Square Thread ACME Thread, Worm Thread, Thread designation, Multistart Thread, left hand thread, right hand thread, Locking devices for nuts, Different types of bolts and nuts.

MODULE 2: Key Cotter and Pin Joints:
Introduction, Saddle Key, Sunk Key, Cotter Joint with Sleeve, Cotter Joint with Socket and Spigot Ends, Cotter Joint with a Gib, Pin Joints-Knuckle joints.

MODULE 3: Riveted and Welded Joints:
Introduction, Rivets and Riveting, Rivet heads, Definitions-Pitch, Margin, Chain Riveting, Zig-Zag Riveting, welded joints and Symbols, Dimensioning of welds, Edge preparation of Welds.

MODULE 4: Coupling and pipe joints:
Introduction, Rigid Coupling-Flanged Coupling, Sleeve or Muff Coupling, Flexible Coupling – Bushed pin type Flanged Coupling, Pipe Joints- Flanged join, Hydraulic Joints.

MODULE 5: Assembly Drawings:

a) Engine Parts: Stuffing Box, Crosshead, Connecting Rod, Eccentric, Piston
b) Valves: Stop Valve, Feed Check Valve, blow off Cock, Non Return Valve

MODULE 6: Computer Aided Drafting:
2D Drawing, Solid Modeling

Textbooks/References:

1. Machine Design by N.D Bhatt
2. Machine Design by K.L. Narayan

Course Code	Course Title	Hours per week L-T-P	Credit C
MC181306	**Constitution of India**	**2-0-0**	**0**

Course Objectives: Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.

2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional roleand entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.

3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in1917 and its impact on the initial drafting of the Indian Constitution.

Course Outcomes: Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP]under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

MODULE 1: History of Making of the Indian Constitution:

a) History
b) Drafting Committee, (Composition & Working)

MODULE 2: Philosophy of the Indian Constitution:

a) Preamble
b) Salient Features

MODULE 3: Contours of Constitutional Rights & Duties:

a) Fundamental Rights
b) Right to Equality
c) Right to Freedom
d) Right against Exploitation
e) Right to Freedom of Religion
f) Cultural and Educational Rights
g) Right to Constitutional Remedies Directive Principles of State Policy FundamentalDuties.

MODULE 4: Organs of Governance:

a) Parliament
b) Composition

c) Qualifications and Disqualifications
d) Powers and Functions
e) Executive
f) President
g) Governor
h) Council of Ministers
i) Judiciary, Appointment and Transfer of Judges, Qualifications
j) Powers and Functions

MODULE 5: Local Administration:

a) District's Administration head: Role and Importance,
b) Municipalities: Introduction, Mayor and role of Elected Representative CEO of Municipal Corporation.
c) Pachayati raj: Introduction, PRI: Zila Pachayat.
d) Elected officials and their roles, CEO Zila Pachayat: Position and role.
e) Block level: Organizational Hierarchy (Different departments),
f) Village level: Role of Elected and Appointed officials,
g) Importance of grass root democracy

MODULE 6: Election Commission:

a) Election Commission: Role and Functioning.
b) Chief Election Commissioner and Election Commissioners.
c) State Election Commission: Role and Functioning.
d) Institute and Bodies for the welfare of SC/ST/OBC and women.

Textbooks/References:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181314	**Theory of Machines Lab**	**0-0-2**	**1**

Course Outcomes (CO): At the completion of the lab, the student will be able to

CO1: Compare analytical results with observed results and infer the cause of variation.
CO2: Determine the stability characteristics of governor for appropriate selection in future engineering applications
CO3: Apply the concept of dynamometer for power measurement.
CO4: Identify appropriate cam for engineering applications.

LIST OF EXPERIMENTS

1. Study of slider crank mechanism
2. Study of gear trains
3. Analysis of porter governor
4. To determine the co-efficient of friction between belt & pulley
5. Power measurement using the principle of dynamometer
6. Cam analysis

Experiment No: 1

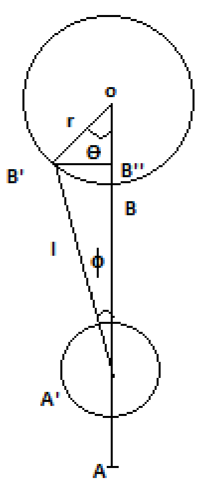
TITLE: SLIDER CRANK MECHANISM

OBJECT: To find piston displacement for crank rotation and verify it by theoretical calculations.

THEORY: For the crank to start motion from the dead centre, there is a corresponding displacement of the piston both being measurable quantities.

Now theoretically, let the piston be at point A, when the connecting rod was along AB, due to a crank of rotation Θ, piston is displaced to A' and the connecting rod is along A'B'.

Piston displacement



AA' = x = AO – A'O = (l + r) – (lcosϕ + rcosΘ)---(i)

Where l=connecting rod length, r=crank radius

B'B''= lsinϕ= rsinΘ

Sinϕ = (r/l) sinΘ ----- (ii)

Cosϕ $=\sqrt{1-(r/l)^2\sin^2\Theta}$ ------(iii)

From (i) and (iii); we get,

$$\mathbf{x = r \{ 1 + n - \cos\Theta - \sqrt{(n^2-\sin^2\Theta)}\}} \text{ where } l/r = n$$

PROCEDURES:

1. Set the apparatus such that the connecting rod is perfectly vertical.
2. Choose a suitable connecting rod length and fix it. Note l and r.
3. Note reading of circular and linear scales.
4. Rotate the crank pulley by ϴ and note corresponding linear scale reading and find the piston displacement.
5. Verify theoretically.
6. Repeat with another connecting rod length

TABULATION:

Serial No.	l	r	ϴ	Theoretical	Practical	Inferences

Answer the following questions:

1. Do you know the practical application of this mechanism? Name some mechanism.
2. What do you mean by dead centres? What are TDC,BDC, IDC and ODC as referred to IC engine?
3. What are External Combustion and Internal Combustion Engine?
4. What is the difference between CI Engine and IC Engine?
5. Can you make l/r ratio less than unity practically?

Experiment No: 2

TITLE: STUDY OF GEAR TRAINS

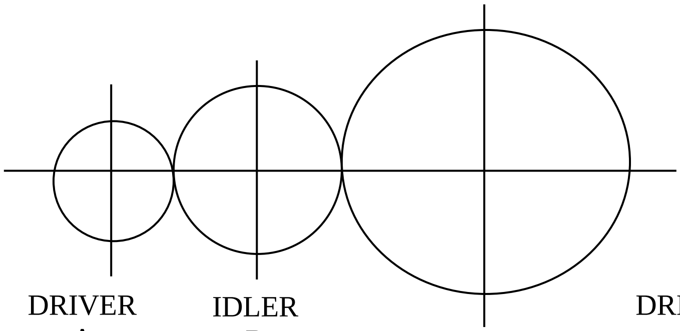
Gear Train: Sometimes two or more gears are made to mesh with each other to transmit power from one shaft to another. Such a combination of gears is called gear train.

TYPES OF GEAR TRAIN: Depending upon the arrangement of the wheels, they may be classified as

(i) Simple gear train (ii) Compound gear train

(iii) Reverted gear train (iv) Epicydic gear train.

CASE I: To verify that the velocity ratio of a simple gear train is independent of the intermediate wheel.



VELOCITY RATIO (VR)

$$= \frac{\text{Speed of the driven gear}}{\text{Speed of the driver gear}}$$

$$= \frac{\text{No of teeth on driver}}{\text{No of teeth on driver}}$$

Taking gear A & B, VR = $N_B / N_A = T_A / T_B$

Taking gears B & C, V.R. is given by VR = $N_C / N_B = T_B / T_C$

Multiplying (i) and (ii) V.R. of gears A and C is = $N_C / N_A = T_A / T_C$

PROCEDURE:

1. Count the number of teeth on gear A, B, C i.e. T_A, T_B, T_C
2. Find out the respective velocity ratios.
3. Check the result by giving one revolution to gear A.

CASE II: To find out the speed of the output shaft of the Epicyclic Gear train using Tabular Method. Here, gear B is fixed and arm A is rotated through known revolution and observe the speed of the speed of the output shaft. Check the value with the help of tabular method.

STEP NO	CONDITION OF MOTION	REVOLUTION OF ELEMENTS			
		ARM A	GEAR B	GEAR C, D	GEAR E
1.	Arm is fixed, gear B rotates through +1 revolution	0	+1	$- T_B / T_C$	$+ (T_B / T_C) \times (T_D / T_E)$

2.	Arm is fixed, gear B rotates through +1 revolution	0	+X	$- X.(T_B/T_C)$	$+ X.(T_B/T_C).(T_D/ T_E)$
3.	Add Y revolutions to all elements	Y	X+Y	$Y- (T_B/T_C)$	$Y+X(T_B/T_C).(T_D/T_E)$

Let the arm make one revolution when B is fixed, then

$$Y = 1, x+ y = 0, x = -1$$

Revolution of gears C, D. $1 – (- 1)\ T_B / T_C = 1 + T_B / T_C$

Revolution of gear E $=1 + (-1). (T_B / T_C). (T_D/ T_E) =1 – (T_B / T_C).(T_D / T_E)$

Check the result experimentally.

Questions:

1. What is an epicyclic gear train? In what manner does it differ from a simple or compound gear train?
2. What advantages does an epicyclic train offer compared to a simple gear train?
3. What is an idler gear train? Explain the use of idler gears.

Experiment No: 3

TITLE: Analysis of Porter Governor

OBJECTIVE: To study the effect of varying the mass of central sleeve for Porter Governor.

AIM: Determination of Characteristics curves of sleeve position against speed and radius of rotation against controlling force for Porter Governor

THEORY: The function of the governor is to maintain the speed of an engine within specific limit whenever there is a variation of load. This is achieved by the principle of centrifugal force. The centrifugal type governors are based on the balancing of centrifugal force on the rotating balls by an equal and opposite radial force known as controlling force.

DESCRIPTION OF APPARATUS: The apparatus is designed to exhibit the characteristics of centrifugal governor of both central sleeve type and spring unit consists of a DC motor connected to the shaft through V-belt. Motor and shaft are mounted on a rigid MS base frame in vertical position. The spindle is supported in ball bearing. The optional governor mechanism can be mounted on spindle. The speed control unit controls the precise speed. A counter sunk has been provided at the topmost bolt of the spindle. A graduated scale is fixed to measure the sleeve lift. The centre sleeve of the Porter governor incorporates a weight sleeve to which weights can be added.

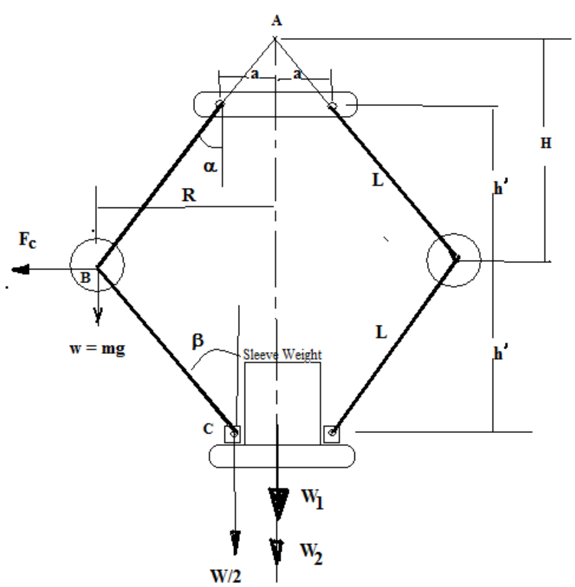
EXPERIMENTAL PROCEDURES:

STARTING PROCEDURE:

1. Assemble the governor to be tested.
2. Complete the electrical connections and switch ON main power.
3. Note the initial reading of pointer on the scale.
4. Switch ON the rotary switch.
5. Slowly increase the speed of Governor until the sleeve is lifted from its initial position by rotating variac
6. Let the governor be stabilized
7. Note down the sleeve's height and relative RPM
8. Increase the speed of governor insteps to get the different positions of sleeve lift at different PRM.

CLOSING PROCEDURE:

1. Decrease the speed of governor gradually by bringing the variac to zero position and then switch OFF the motor
2. Switch OFF all switches and disconnect all the connections.



DATA
a = 52.5 mm
L = 125 mm
h'=100 mm
w=0.750 mm
g=9.81 m/sec2
W1 =2.120 kg
W2=0.763 kg
W3=0.165kg

OBSERVATION TABLE:

X'' =   mm

Sl. No.	X	X=(X' – X'')mm	h= {h'-(X/2)} mm	$\alpha = \cos^{-1}(h/L)$	H	R	H/R	N_{theo}	N_{act}
1									
2									
3									
4									

Calculations

$H = \{(a/tan\alpha) + h\}$, mm $R = \{a + (Lsin\alpha)\}, mm$

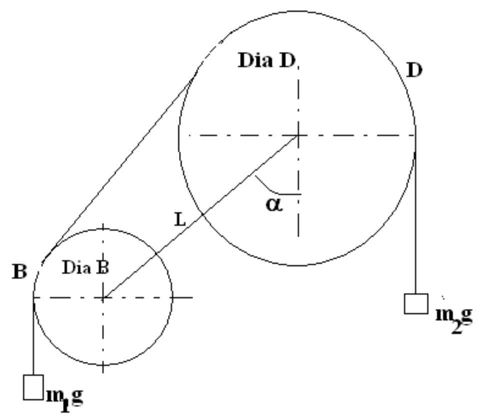
$$N_{theo} = \frac{60}{2\pi}\sqrt{\frac{(w + W)(gX1000)}{wXH}}, RPM$$

Plot the following graphs:

1. R/H Vs N_{theo} , R/H Vs N_{act}
2. X vs N_{theo} , X Vs N_{act}
3. Controlling force diagram

Experiment No: 4

TITLE:TO DETERMINE THE CO-EFFICIENT OF FRICTION BETWEEN BELT & PULLEY



APPARATUS: Pulley D is fixed and pulley B is free. The apparatus permit change of α, the angle made by the centre line of the pulley with the vertical. The belt goes round the two pulleys as shown and at the two ends masses m_1 & m_2 are attached.

PROCEDURE: i) Set desired angle α (00, 200, 300, etc.)

ii) Place nearly equal masses m1 & m2.

iii) Increase m2 slowly until the belt just begin to slide.

iv) Note m1 and m2 for each value of α as set.

v) Measure D, B & L with a scale.

vi) Make a graphical layout of the configuration as per α, D, B & L.

Draw vertical tangent to D and common tangent to D, B.

vii) Measure θ (in radian), the angle of wrap from the graphical construction.

CALCUIATIONS: Now use $m_2g/m_1g = e^{\mu\theta}$, the flat belt relation for the limiting condition to determine μ for the belt and pulley material.

$\mu = 1/_{\theta} \log e \; m_2g/_{m_1g}$

Sl.No	m1	m2	α	θ(in radian)	μ	Average

Questions:

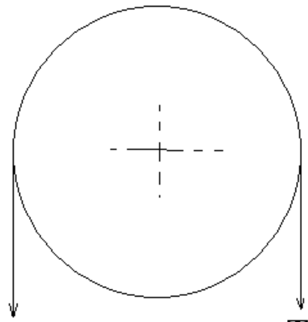
1. What is a flat belt? What is a suitable pulley for flat belt?
2. What is a V- belt and what type of pulley is required for V- belt?

Experiment No: 5

TITLE: POWER MEASUREMENT

OBJECT: TO DETERMINE ONE’S OWN HORSEPOWER.

THEORY: The horse power of the apparatus is given by the equation.



POWER (WATT) = $2\pi R$ (T1 – T2) N / K

R : Radius of pulley   T1 : Tight side tension   T2 : Slack side tension

N : R.P.M.   K : A const. which varies for different systems of unit chosen.

CALCLATIONS: The rate of doing work is known as power. Hence power can be obtained by dividing the total work done by time. The unit of power in S.I. system is Nm/s or watt.

Power = work done per seconds = Force x Distance / time

Say a circular body, which can state about the point A. A tangential force P is applied at point B and the body moves

through a small angle θ. The distance moved by the force P in rotating the body through an angle θ is equal to the length of arc BC.

But length of arc BC = R x θ.

Work done = Force x distance moved = P x R x θ.

Let N = r.p.m. of the pulley

Angle turned in N revolution = $2\pi N/60$ or angle turned in one second = $2\pi N/60$

Therefore, work done in one second = P x R x $2\pi N/60$

(T1- T2) x R x $2\pi N/60$ (Watt)

1 hp = 0.746 kw = 4500 kgm/min = 75 kgm/ sec.

Procedures:

1. Measure effective diameter of pulley and find the radius.
2. Note the dead load used at the end of the rope which is T_2 .
3. Start rotating pulley by the use handle for few seconds and note the no. of revolution completed and spring balance reading which is T_1 .
4. Find revolutions completed per minute.

5. Find H.P.
6. Repeat more and find the mean.

Sl. No.	T_1	T_2	R (m)	N (R.P.M.)	Power (Watt)	Mean

Experiment No: 6

TITLE: CAM ANALYSIS

OBJECT: TO DETERMINE THE JUMP SPEED OF CAM FOLLOWER SYSTEM.

THEORY: The setup is a motorized unit consisting of a camshaft driven by a variable speed motor. The free end of the camshaft has a facility to mount the cam easily. The follower is properly guided in gunmetal bushes and the type of follower can be changed according to the cam under test. Graduated circular protractor is fitted co-axial with the shaft and dial gauge fitted on the follower shaft, is used to note the follower displacement for the angle of cam rotation. A spring is used to provide controlling force to the follower system. Weights on the follower shaft can be adjusted as per the requirement. An arrangement is provided to regulate the speed. The apparatus is very useful for testing the cam performance for jump phenomenon during operation and the effect of change of inertia forces on jump action of cam-follower during operation can be observed.

EXPERIMENTAL PROCEDURES

1. Fix the required cam & follower assembly on the apparatus.

2. Fix the dial gauge at top of follower shaft to get the follower displacement.
3. To find out the angular displacement, rotate the cam manually.
4. Note the angular displacement of cam and vertical displacement of the follower with the help of protractor & dial gauge respectively.
5. Draw the n -θ (follower displacement Vs rotation of cam) curve.
6. Now remove the dial gauge from the follower shaft.
7. Switch on the main power supply.
8. Slowly increase the rpm of the motor with the help of dimmer stat provided at the control panel & check the jump of the follower with the help of stroboscope.
9. If jump of the follower is not appearing then again adjust the speed of the motor. At certain speed jump of the follower will occur. When jump occurs the follower makes a good thumping sound on cam surface. This speed is the jump speed.
10. Decrease the speed of the motor to the minimum value.
11. Now put some weight on the follower shaft plate and keep the spring tension constant.
12. Increase the speed of the motor and find out the jump speed.
13. Now vary the weight on the follower shaft plate and get the two or three jump speeds of the follower at constant spring tension.
14. Plot the curve for follower weight Vs jump speed.
15. Now get the jump speed by varying the spring tension and keeping the follower weight constant.
16. Repeat the procedure for other two cam & follower assemblies.

OBSERVATION TABLE:

Eccentric Cam with Knife Edge Follower		
S.No	θ	n, mm
1	0	
2	20	
3	40	
18	360	

3.4 FOURTH SEMESTER

B.Tech 4th Semester: Mechanical Engineering

Sl. No.	Sub-Code	Subject	Hours per Week			Credit	Marks	
			L	T	P	C	CE	ESE
Theory								
1	ECE181407	Applied Electronics	3	0	2	4	30	70
2	ME181402	Workshop Theory and Practice-I	3	0	2	4	30	70
3	ME181403	Fluid Mechanics-I	3	0	0	3	30	70
4	ME181404	Materials Science	3	0	2	4	30	70
5	ME181405	Mechanics of Materials	3	0	0	3	30	70
6	MC181406	Environmental Science	2	0	0	0 (PP/NP)	-	100
Practical								
1	ME181413	Fluid Mechanics–I Lab	0	0	2	1	15	35
2	ME181415	Mechanics of Materials Lab	0	0	2	1	15	35
TOTAL			17	0	10	**20**	**180**	**520**
Total Contact Hours per week : 27								
Total Credit: 20								

NB: **1. MC181406 is a Mandatory Audit Course (No Credit). It will be evaluated as PP (Pass)or NP (Not Pass)**
2. 2-3-weeks Mandatory Academia Internship need to be done in the 4th semester breakand the report is to be submitted and evaluated in 5th semester

Course Code	Course Title	Hours per week L-T-P	Credit
ECE181407	**Applied Electronics**	**3-0-2**	**4**

Objective: -
To introduce theory and applications of electronic devices and their characteristics, operational principles; knowledge of circuits like power supplies, regulators, amplifiers etc. also combinational and sequential digital circuits, sensors, timers, motors etc. and their uses in various industrial applications.

Outcome: -
Student is expected to understand the basic principle of electronic devices used in various analog and digital circuits and their applications in real life situations.

MODULE 1: Study of Semiconductor Devices
A brief overview of atomic structure, periodic table, chemical bonding and quantum mechanics, Semiconductor - intrinsic & extrinsic, Energy-band, Fermi level, Direct & indirect semiconductor, drift & diffusion current.

MODULE 2: Diodes
PN junction diode, Diode characteristics for forward bias & reverse bias, different characteristic parameters of diode, Rectifiers, DC power supply, Break-down of diode, Zener-diode & its application as voltage regulator, Working principle of LED, LCD, photo-diode & seven segment LED display.

MODULE 3: Transistors
BJT & UJT, BJT characteristics for CB, CE & CC; BJT as switch, Biasing of BJT & operating point, BJT amplifier, Differential amplifier, Op-Amp model and its application as inverting, non-inverting amplifier; unity gain buffer, summing amplifier, comparator, Instrumentation amplifier.

MODULE 4: Digital or Logic Circuits
Number system, Boolean Algebra, combinational logic design using truth tables; Logic simplification: using Boolean laws, rules, De-Morgan's theorem; by Karnaugh Map; combinational logic modules: Adder, Subtractor, Decoder, Encoder, Multiplexer, De Multiplexer;sequential logic components: Latches & flip-flops; applications of flip-flops, Counter & shift- register.

MODULE 5: Clock and Timing Circuits
Rise time, fall time & duty cycle, Positive-edge triggered & negative-edge triggered circuits, IC-555 timer, a stable & monostable multivibrator realisation using IC-555 timer

MODULE 6: Sensors and Robotic System
Introduction to various types of sensors; The engineering design process, introduction to robotic system.

Text/Reference Books:

1. Applied Electronics by Prof. Tushar and Manisha Jadhav; Everest Publishing House.
2. Digital Fundamentals By Floyd and Jain; Pearson Publication
3. Mechatronics Principles and Applications by Godfrey C. Onwubolu; Elsevier Publication.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181402	**Workshop Theory and Practice-I**	**3-0-2**	**4**

Course Outcomes (CO): At the completion of the course the student will be able:

CO1: To analyze motion transmission in machine-fixture-tool-work (MFTW) system for variation in cutting parameters.

CO2: To identify and apply machines and tools for metal removal to produce various metal parts.

CO3: To analyze and evaluate speed, feed, depth of cut for MFTW system and their effect on machining time.

CO4: To apply, analyze and evaluate production economy by semi-automatic system.

CO5: To apply techniques of sand molding and casting for production of metal parts.

MODULE 1: LATHE

(a) Lathe- Functions, Classification and Specification, Different parts, Drive mechanisms for speed, feed, depth of cut, Taper turning, Machining time. Lathe Accessories and Attachments.

(b) Semi-Automatics: Capstan and Turret lathes – Different parts – Tools —Work and Tool holding devices. Indexing and Bar Feeding Mechanisms. Tool layout and Tool Schedule chart.

MODULE 2: SHAPER, PLANER, SLOTTING & BROACHING OPERATIOS

(a) Shaper – Function, Classification and Specification – Quick return and feed mechanisms – Shaper operations – Cutting speed and Machining timecalculations.

(b) Planer - Function, Specification Table drives and feed mechanism

(c) Broaching: Purpose, broaching tool and machine

(d) Slotting machine: Purpose, slotting tool and machine

MODULE 3: DRILLING

(a) Drilling machines – Classification – specifications – Parts drilling machine – spindle drive mechanisms – tool and work holding devices for operation

(b) Types of drills and tool in hand nomenclature, Drill size and designation of drills.

(c) Deep hole drilling

(d) Introduction to reaming and tapping

MODULE 4: MILLING:

Introduction – Classification – Specifications - Principal parts of a milling machine. Elements of a milling cutter, milling processes – Up-milling – Down milling – Face milling – End milling. Cutting Speed, Feed and Depth of Cut – Machining Time. Indexing and Dividing Head

MODULE 5: GRINDING AND SURFACE FINISHING

Grinding:

Introduction – Kinds of grinding – Grinding Processes – Centreless Grinders – Surface Grinders – Tool and Cutter Grinder – Specifications. Grinding Wheel – Composition and specification. Selection of Grinding Wheel. Dressing, and Truing of grinding Wheel.

Surface Finishing:
Introduction – Classification – Principle and Operations of Lapping, Honing, Super finishing, Polishing, Buffing, Tumbling and Burnishing

MODULE 6: PATTERN MAKING AND FOUNDRY
Pattern making and sand casting – Pattern materials – Types – Pattern allowances. Core prints. Moulding sand – ingredients – classification – sand additives – properties of moulding sand – sand preparation and testing. Green sand mould preparation. Cores and core making – Types of cores.

Text/Reference Books:

1. Elements of Workshop Technology (Vol. I & II) – S.K. Hajra Choudhury and A.K. Hajra Choudhury.
2. A course in Workshop Technology (Vol. I & II) – B.S. Raghuwanshi
3. Manufacturing Technology – P.N. Rao – Tata McGraw Hill
4. Workshop Technology-I – P.K. Sapra and R.K. Kapur- Vikas Publishing
5. Elements of Manufacturing Processes – B.S. Nagendra Parashar and R.K. Mittal – PHI.
6. Introduction to machining Science – G.K. Lal, New Age International Limited

Mode of delivery	[1] Chalk & talk, [2] PPT, [3] Numerical problem solution, [4] Practical demo

DETAILS OF TOPICS COVERED	Ref	Mode of delivery	HRS
MODULE 1: LATHE (a) Lathe- Functions, Classification and Specification, Different parts, Drive mechanisms forspeed, feed, depth of cut, Taper turning, Machining time. Lathe Accessories and Attachments. (b) Semi-Automatics: Capstan and Turret lathes – Different parts – Tools —Work and Toolholding devices. Indexing and Bar Feeding Mechanisms. Tool layout and Tool Schedule chart.	1,2,6	1,2,3,4	8
MODULE 2: SHAPER, PLANER, SLOTTING & BROACHING OPERATIOS (a) Shaper – Function, Classification and Specification – Quick (b) return and feed mechanisms – Shaper operations – Cutting speed and Machining timecalculations. (c) Planer - Function, Specification Table drives and feed mechanism (d) Broaching: Purpose, broaching tool and machine (e) Slotting machine: Purpose, slotting tool and machine	1,2,6	1,2,3,4	6

MODULE 3: DRILLING (a) Drilling machines – Classification – specifications – Parts drilling machine – spindle drivemechanisms – tool and work holding devices for operation (b) Types of drills and tool in hand nomenclature, Drill size and designation of drills. (c) Deep hole drilling (d) Introduction to reaming and tapping	1,2,6	1,2,3,4	4
MODULE 4: MILLING: Introduction – Classification – Specifications - Principal parts of a milling machine. Elements ofa milling cutter, milling processes – Up-milling – Down milling – Face milling – End milling. Cutting Speed, Feed and Depth of Cut – Machining Time. Indexing and Dividing Head	1,2,3	1,2,3,4	6
MODULE 5: GRINDING AND SURFACE FINISHING **Grinding:** Introduction – Kinds of grinding – Grinding Processes – Centreless Grinders – Surface Grinders – Tool and Cutter Grinder – Specifications. Grinding Wheel – Composition and specification. Selection of Grinding Wheel. Dressing, and Truing of grinding Wheel. **Surface Finishing:** Introduction – Classification – Principle and Operations of Lapping, Honing, Super finishing, Polishing, Buffing, Tumbling and Burnishing	1,2,3	1,2,4	5
MODULE 6: PATTERN MAKING AND FOUNDRY Pattern making and sand casting – Pattern materials – Types – Pattern allowances. Core prints. Moulding sand – ingredients – classification – sand additives – properties of moulding sand – sandpreparation and testing. Green sand mould preparation. Cores and core making – Types of cores.	2,3,4,5	1,2,3,4	6

<u>Books</u>:

1. Elements of Workshop Technology (Vol. I & II) – S.K. Hajra Coudhury and A.K. Hajra Coudhury.
2. A course in Workshop Technology (Vol. I & II) – B.S. Raghuwanshi
3. Manufacturing Technology – P.N. Rao – Tata McGraw Hill
4. Workshop Technology-I – P.K. Sapra and R.K. Kapur- Vikas Publishing
5. Elements of Manufacturing Processes – B.S. Nagendra Parashar and R.K. Mittal – PHI.
6. Introduction to machining Science – G.K. Lal, New Age International Limited

Suggested Practical: Workshop Theory Practice

Course Outcomes: At the completion of the course the student will be able:

CO1: To use proper metal cutting tools and fixtures for producing desired parts.

CO2: To apply various workshop machines for production of parts according to job design.

CO3: To apply the concept of transmission system in a machine tool fixture work (MFTW) systemfor obtaining desired motion for machine, tool and job.

CO4: To evaluate the effect of machining parameters on quality of machined components.

CO5: To apply techniques of sand molding and casting for production of metal parts.

LATHE MACHINE

1. Demonstration of lathe parts and drive mechanisms.
2. Centering of job by using (i) Scriber (ii) Dial gauge
3. Straight turning, Taper turning, Thread Cutting (External and Internal), Knurling, Grooving, Chamfering in a single job.
4. Parting off the extra material in power saw machine.

PATTERN AND FOUNDRY

1. Making of a split pattern
2. Preparation of green sand mould with the split pattern
3. Casting (Metal- aluminum)

SHAPER AND GRINDER

1. Demonstration of different parts and drives of shaper
2. V – block making
3. Drilling a hole in the V-block
4. Tap internal thread in the drilled hole
5. Grinding of sharp edges.

MILLING MACHINE

1. Demonstration of various parts of a milling machine.
2. Indexing of circular gear blank.
3. Cutting of spur gear and helical gear.

JOB NO – 1

TITLE: LATHE

OBJECTIVE:

1. Demonstration of lathe parts and drive mechanisms
2. Centering of job by using (i) Scriber (ii) Dial gauge

3. Straight turning, Taper turning, Thread Cutting, Knurling, Grooving, Chamfering in a single job
4. Parting off the extra material in power saw machine

INTRODUCTION: Lathe is one of the most versatile and widely used machine tools all over the world. The main function of a lathe is to remove metal from a job to give it the required shape and size. The job is held in the chuck or in between centres on the lathe machine and then turn it against a single point cutting tool which will remove metal from the job in the form of chips. Cutting tool used is a single point cutting tool.

Some common operations carried on lathe are facing, turning, chamfering, parting off, drilling, knurling, boring, thread cutting etc.

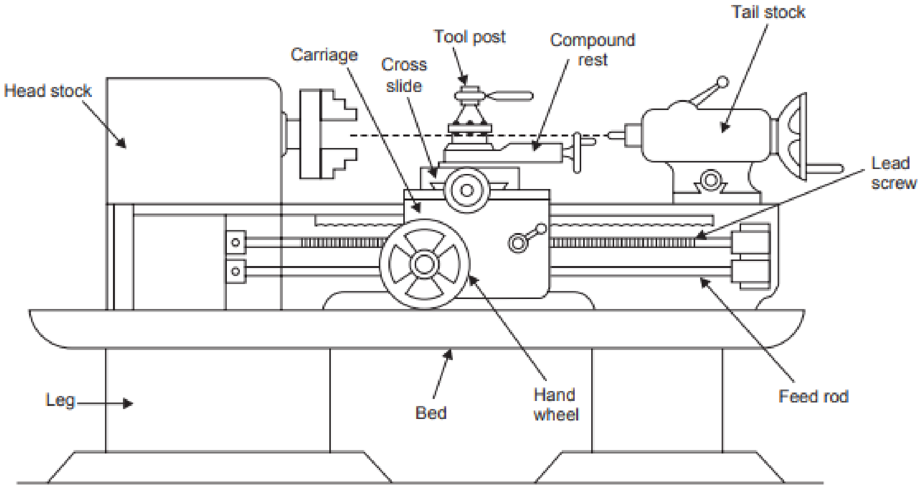


Figure 1: Lathe Machine

PRINCIPAL PARTS OF LATHE MACHINE:

Bed: It is the main body of the machine. All main components are bolted on it. It is usually made by cast iron due to its high compressive strength and high lubrication quality. It is made by casting process and bolted on floor space.

Spindle: The spindle is in the head box which rotates a shaft which is connected to the chuck. This chuck holds a work piece, so the work pieces also rotate.

Gear box: The gear box is in the head stock which rotates the chuck at different speeds.

Carriage: It is situated between the head stock and tail stock. It is used to hold and move the tool post on the bed vertically and horizontally. It slides on the guide ways. Carriage is made by cast iron.

Saddle: It is an “H” shaped casting. It connects the pair of bed guide ways like a bridge. It fits over the bed and slides along the bed between headstock and tailstock. The saddle or the entire carriage can be moved by providing hand feed or automatic feed.

Cross slide**:** Cross-slide is situated on the saddle and slides on the dovetail guide ways at right angles to the bed guide ways. It carries compound rest, compound slide and tool post. Cross slide hand wheel is rotated to move it at right angles to the lathe axis.

Compound slide: Compound slide is on the cross slide which can rotate. It gives support to tool post. It is used in taper turning by giving an angle.

Tool post: It is bolted on the carriage. It is used to hold the tool at correct position. Tool holder is mounted on it.

Chuck: Chuck is used to hold the workspace. It is bolted on the spindle which rotates the chuck and work piece. It is four jaw (independent) and three jaw (self centering) according to the requirement.

Head stock: Head stock is the main body parts which are placed at left side of bed. It is serve as holding device for the gear chain, spindle, driving pulley etc. It is also made by cast iron.

Tail stock: It is placed at right hand side of the bed. The main function of tail stock to support the job when required. It is also used to perform drilling operation.

Live centre: A live centre is a centre placed in the revolving mandrel, it moves and is therefore called live.

Dead Centre: A dead centre is used to support the work piece.

Lead Screw: It is a long threaded rod on the bed which provides an automatic feed to carriage from head stock to tail stock. It is used for giving threads to the work piece.

Legs: Legs are used to carry all the loads of the machine. They are bolted on the floor which prevents vibration.

Apron: The apron is on the front of the saddle which has hand wheel and levers. It is used to control the movement of carriage on the bed.

Tray: Tray is placed lower side of bed. The main function of it to carries all chips removed by the work piece.

Guide ways: Guide ways take care of movement of tail stock and carriage on bed.

Spindle: It is the main part of lathe which holds and rotates the chuck.

SAFETY PRECAUTIONS

1. Always clamp the work and tool properly with the correct size of work and tool holding the device.
2. Always keep the lathe machine clear of tools.
3. Machine should be stopped before making measurements or adjustments on the work piece.
4. Wear an apron or a properly fitted shop coat. Goggles should also be used to avoid chip particles contact with human body.
5. One should remove necktie, wrist watch and jewellery while working on the machine.

6. One should not operate the lathe until he knows the proper procedure to operate.
7. One should check the work frequently when the work piece is being machined.
8. One should check the faceplate or chuck by hand to be sure that there is no danger of the work striking any part of the lathe.
9. Stop the machine and remove chips with pliers. One should not touch remove the chips by hand because they will be hot.

JOB DIAGRAM:

Raw material: Mild steel bar of φ 25 mm

All dimensions are in mm.

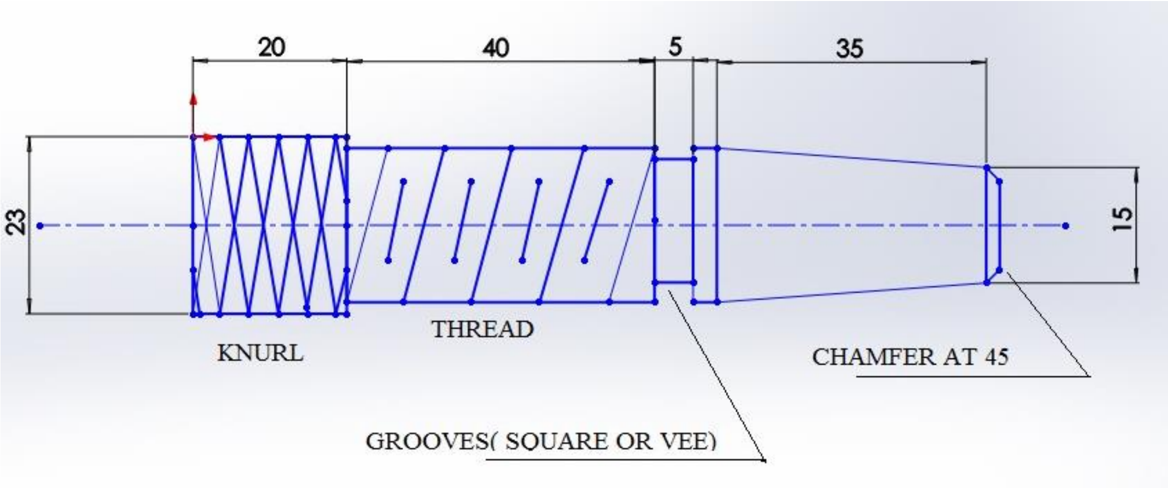


Figure 2: Job diagram

TOOLS AND ACCESSORIES REQUIRED

1. Vernier calipers
2. Scriber
3. Chuck key
4. Facing Tool
5. Knurling tool
6. H.S.S. single point cutting tool
7. Parting tool

WORKING PROCEDURE

a. Select the speed, feed and depth of cut for different operations.
b. Load the job in chuck.
c. Hold the tool in the tool post.
d. Perform facing operation on both ends of the job one after another by a facing tool.
e. Perform centre drilling operation on both ends of the job by a combination drill.
f. Hold the job between the centres.

g. Centre the job by using scriber if four jaw chuck is used.

h. Turn the job to reduce the diameter from 25 mm to 23 mm through the entire length. Then reduce the diameter to 20 mm except the portion where knurling is to be done.

i. Make a groove of width 5 mm

j. Adjust the cutting tool at a particular angle by using swivelling compound slide for taper turning. The angle can be measured by following formula

k. $\tan\alpha = \frac{D-d}{2L}$

l. Use knurling tool to make a particular pattern on the surface.

m. Make a chamfer of 45˚ at the end by adjusting the tool.

n. Cut external thread by using thread dial indicator with following the steps:

i). Change gears of required teeth are fitted to the end of the bed between the spindle and the lead screw for cutting thread of definite pitch.

ii). Depth of cut is given , which is about .05 mm to .2 mm and is applied by advancing tool perpendicular to the axis of the work or at an angle equal to one half of the angle of the thread (e.g. 30˚ for metric thread) by swiveling the compound rest.

iii). Half nut is then engaged.

iv). The tool is withdrawn after producing the groove along the entire length of the work piece and disengaged the half nut

v). Then reverse feed is given

vi). This is repeated until full depth of the thread is obtained

vii). Check with thread pitch gauge.

viii). Remove the job from the machine.

ix). Cut the extra length of the job in a power saw machine.

JOB NO: 2

TITLE: PATTERN AND FOUNDRY

OBJECTIVE:

1. Making of a split pattern
2. Preparation of green sand mould with the split pattern
3. Casting (Metal- aluminium)

INTRODUCTION: Casting in the foundry has to start with a “pattern”. A pattern is a full-size model of the part to cast, patterns can be made from various materials such as mahogany, metal, plastic or Styrofoam. It is very important to have suitable patterns, for the quality of the casting is influenced by the quality of the pattern.

TYPES OF PATTERN: The types of the pattern are

1. One piece or solid pattern 2. Two piece or split pattern 3. Cope and drag pattern 4. Three-piece or multi-piece pattern 5. Loose piece pattern 6. Match plate pattern 7. Follow board pattern 8. Gated pattern 9. Sweep pattern 10. Skeleton pattern 11. Segmental or part pattern.

TOOLS AND EQUIPEMENT USED IN PATTERN SHOP:

Wood Turning Lathe 2.Chisel 3.Slide calliper 4.Files etc.

JOB DIAGRAM OF PATTERN:

All dimensions are in mm

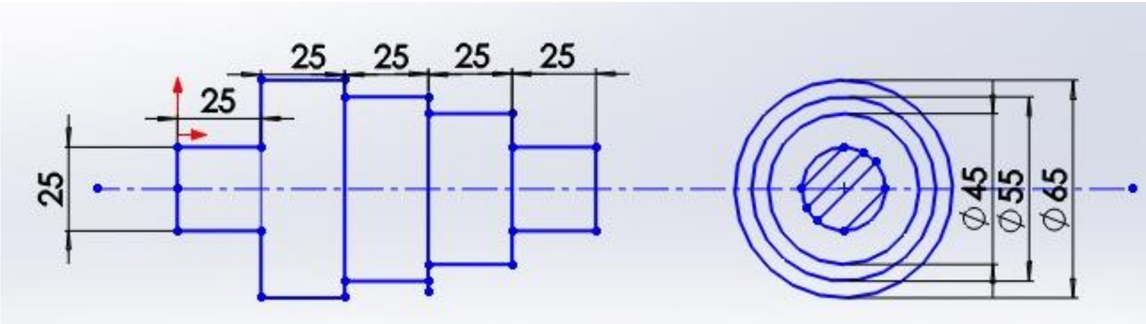


Figure 1: Split pattern

WORKING PROCEDURE FOR MAKING PATTERN:

1. Split the cylindrical wooden block in two equal pieces using saw.
2. Joint the pieces of the block with pin and hold the work piece in between the centres in the wood turning lathe.
3. Turn the job to reduce the diameter to 65 mm through the entire length.
4. Use nose chisel to make the steps of different diameters on the cylindrical block.
5. Cut the extra portion from the work piece to get the required pattern.

MOLDING SAND: The general sources of receiving molding sands are the beds of sea, rivers, lakes, granular elements of rocks, and deserts. Molding sands may be of two types namely natural or synthetic. Natural molding sands contain sufficient binder. Whereas synthetic molding sands are prepared artificially using basic sand molding constituents (silica sand in 88-92%, binder 6-12%, water or moisture content 3-6%) and other additives in proper proportion by weight with perfect mixing and mulling in suitable equipment.

KINDS OF MOULDING SAND:

1. Green sand
2. Dry sand
3. Loam sand
4. Facing sand

5. Backing sand
6. Parting sand
7. Core sand

TOOLS USED IN FOUNDRY SHOP:

1) Hand riddle 2. Drag and cope boxes 3. Molding sand 4. Parting sand 5. Rammer 6. Strike-off bar 7. Bellows 8. Riser and sprue pins 9. Gate cutter 10. Vent rod 11. Draw spike 12. Wire Brush 13. Molding board

WORKING PROCEDURE FOR MAKING MOULD:

1. First a bottom board is placed either on the molding platform or on the floor, making the surface even.
2. The drag molding flask is kept upside down on the bottom board along with the drag part of the pattern at the centre of the flask on the board.
3. Dry facing sand is sprinkled over the board and pattern to provide a non-sticky layer.
4. Freshly prepared molding sand of requisite quality is now poured into the drag and on the split-pattern .
5. Rest of the drag flask is completely filled with the backup sand and uniformly rammed to compact the sand.
6. After the ramming is over, the excess sand in the flask is completely scraped using a flat bar to the level of the flask edges.
7. Now with a vent wire which is a wire of 1 to 2 mm diameter with a pointed end, vent holes are in the drag to the full depth of the flask as well as to the pattern to facilitate the removal of gases during casting solidification. This completes the preparation of the drag.
8. Now finished drag flask is rolled over to the bottom board exposing the pattern.
9. Using a slick, the edges of sand around the pattern is repaired and cope half of the pattern is placed over the drag pattern, aligning it with the help of dowel pins
10. The cope flask on the top of the drag is located aligning again with the help of the pins of the drag box.
11. Dry parting sand is sprinkled all over the drag surface and on the pattern
12. Sprue of the gating system for making the sprue passage is located at a small distance from the pattern. The sprue base, runners and ingates are also located and risers are also placed. Freshly prepared facing sand is poured around the pattern.
13. The moulding sand is then poured in the cope box. The sand is adequately rammed, excess sand is scraped and vent holes are made all over in the cope as in the drag.
14. The sprue and the riser are carefully withdrawn from the flask

15. Later the pouring basin is cut near the top of the sprue.
16. The cope is separated from the drag any loose sand on the cope and drag interface is blown off with the help of the bellows.
17. Now the cope and the drag pattern halves are withdrawn by using the draw spikes and rapping the pattern all around to slightly enlarge the mould cavity so that the walls are not spoiled by the withdrawing pattern.
18. The runners and gates are to be removed or to be cut in the mould carefully without spoiling the mould.
19. Any excess or loose sand is applied in the runners and mould cavity is blown away using the bellows.
20. Now the facing paste is applied all over the mould cavity and the runners which would give the finished casting a good surface finish.
21. A dry sand core is prepared using a core box. After suitable baking, it is placed in the mould cavity.
22. The cope is placed back on the drag taking care of the alignment of the two by means of the pins.
23. The mould is ready for pouring molten metal. The liquid metal is allowed to cool and become solid which is the casting desired.

JOB NO: 3

SHAPER AND GRINDER

OBJECTIVES:

1. Demonstration of different parts and drives of shaper
2. V – block making
3. Drilling a hole in the V-block
4. Tap internal thread in the drilled hole
5. Grinding of sharp edges.

SHAPER**:** The shaper also called shaping machine, is a reciprocating type of machine tool in which the ram moves the cutting tool backward and forward in a straight line to generate the flat surface. The flat surface may be horizontal, inclined or vertical.

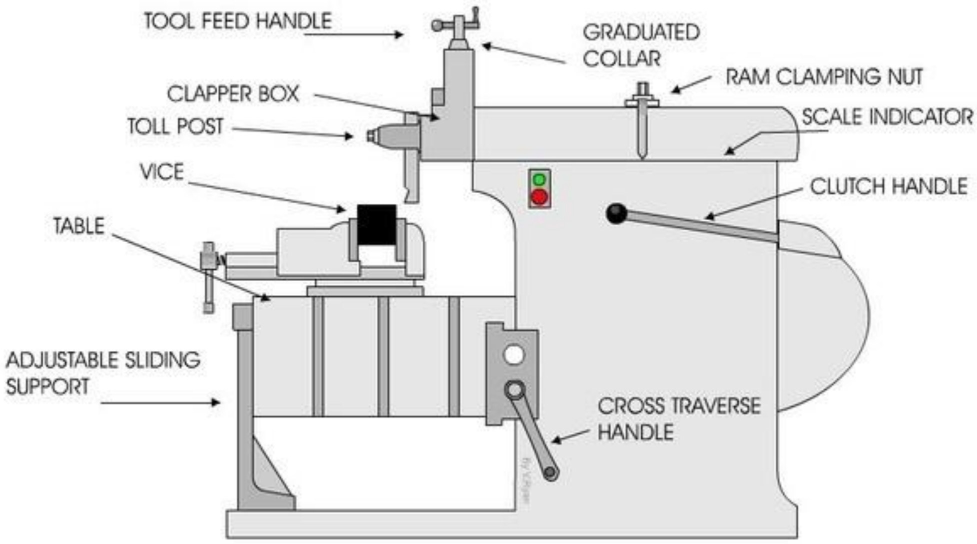


Figure1: Shaper Machine

PRINCIPAL PARTS OF A SHAPER:

i. Base: It is a heavy and robust cast iron body which acts as a support for all other parts of the machine which are mounted over it.

ii. Column (body): it is a box type iron body mounted upon the base. It acts as housing for the operating mechanism of the machine, electrical, cross rail and ram. On the top it is having two guide ways open which the ram reciprocates.

iii. Cross-rail: it is a heavy cast iron construction, attached to the column at its front on the vertical guide ways. It carries two mechanisms, one for elevating the table and the other for cross travel of the table.

iv. Table: it is made of cast iron and used for holding the work piece. T slots are provided on its top and sides for securing the work on to it. It slides along the cross rail to provide feed to the work.

v. Ram: It reciprocates on the guide ways provided above the column. It carries the tool head and mechanism for adjusting the stroke length.

vi. Tool Head: It is attached to the front portion of the ram and is used to hold the tool rigidly. It also provides the vertical and angular movement to the tool for cutting.

WORKING PRINCIPLE AND OPERATION OF A SHAPER:

In a shaper, a single point cutting tool reciprocates over the stationary work piece. The work piece is rigidly held in a vice or clamped directly on the table. The tool is held in the tool head mounted on the ram of the machine. When the ram moves forward, cutting of material takes place. So, it is called cutting stroke. When the ram moves backward, no cutting of material takes place so called idle stroke. The time taken during the return stroke is less as compared to forward stroke and this is obtained by quick return mechanism. The depth of cut is adjusted by moving the tool downward towards the work piece.

PRECAUTIONS:

1. The metal block should be held tightly
2. Marking should be done accurately.
3. Before starting a shaper make sure that the work vise, tool, and ram are securely fastened.
4. Suitable feeds and depth of cut should be maintained uniformly.
5. Apply cutting fluids to the tool and work piece properly.

TOOLS AND APPARATUS USED IN SHAPER:

1. Cutting tool
2. Brush
3. Adjustable Wrench

JOB DIAGRAM:

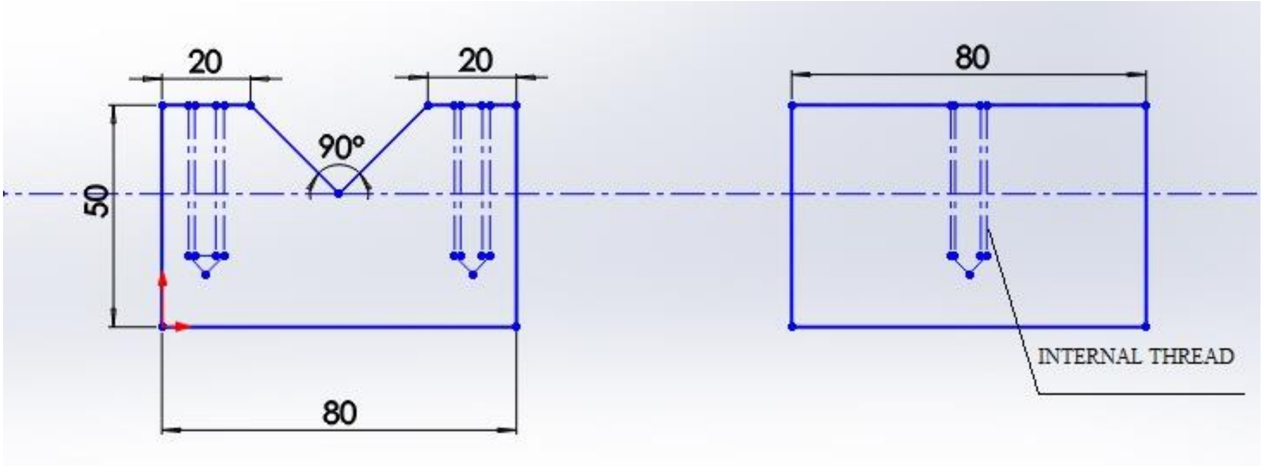


Figure 2: V block and Internal Thread

WORKING PROCEDURE IN SHAPER:

1. The work piece is held in the vice tightly.
2. Tool is set in the tool post such that the tool movement should be exactly perpendicular to the table.
3. Adjust the length of the stroke.
4. Give depth of cut by moving the tool and feed is given to the work piece during return stroke of the ram.
5. Surface planning is done.
6. V groove is made by swivelling the vertical slide of the tool head to the required angle either in left or right of the vertical axis.

DRILLING: In a drilling machine, holes can be drilled quickly and at low cost. The hole is generated by the rotating edge of a cutting tool known as the drill which exerts large force on the work clamped on the table.

RADIAL DRILLING MACHINE: The machine consists of a heavy, round, vertical column mounted on a large base. The column supports a radial arm which can be raised and lowered to accommodate workpieces of different heights. The arm may be swung around to any position over the work bed. The drill head containing mechanism for rotating and feeding the drill is mounted on a radial arm and can be moved horizontally on the guide ways and clamped at any desired position.

PRINCIPAL PARTS OF A RADIAL DRILLING MACHINE:

1) Base 2. Column 3. Radial arm 4. Motor for elevating the arm 5. Elevating screw 6. Guide ways 7. Motor for driving the drill spindle 8. Drill head 9. Drill spindle 10. Table

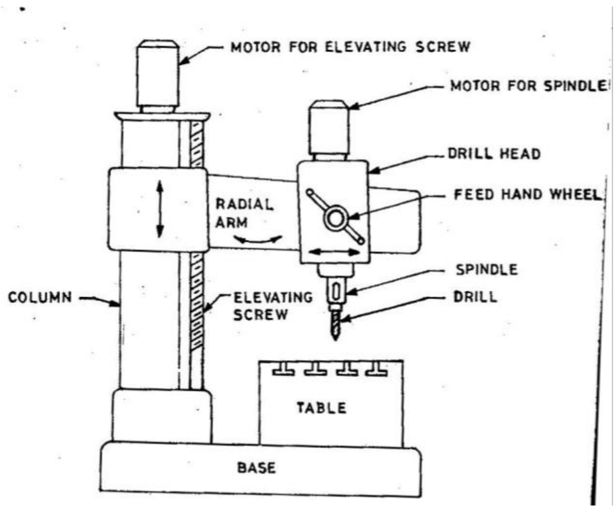


Figure 3: Radial drilling machine

TAPPING: Tapping is the operation of cutting internal threads by means of a cutting tool called a tap. A tap may be considered as a bolt with accurate threads cut on it. The treads act as cutting edges which are hardened and ground. When the tap is screwed into the hole it removes metal and cuts internal threads which will fit into external threads of the same size.

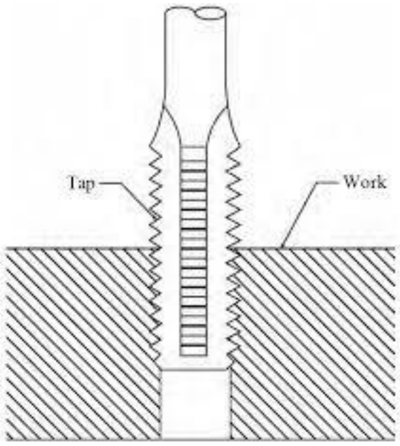


Figure 4: Tapping operation

TAP DRILL SIZE: The size of the tap being outside diameter of its threads, it is evident that the drilled hole must be smaller than the tap by twice the depth of the thread. The amount to be subtracted from the tap diameter depends on the shape of the thread.

Tap drill size, D = T – 2d

Where D is the diameter of tap drill size, T is the diameter of tap to be used and d is the depth of thread.

GRINDING: Grinding is metal cutting operation performed by means of a rotating abrasive wheel that acts as a tool. This is used finish workpieces for high surface quality, accuracy of shape and dimension.

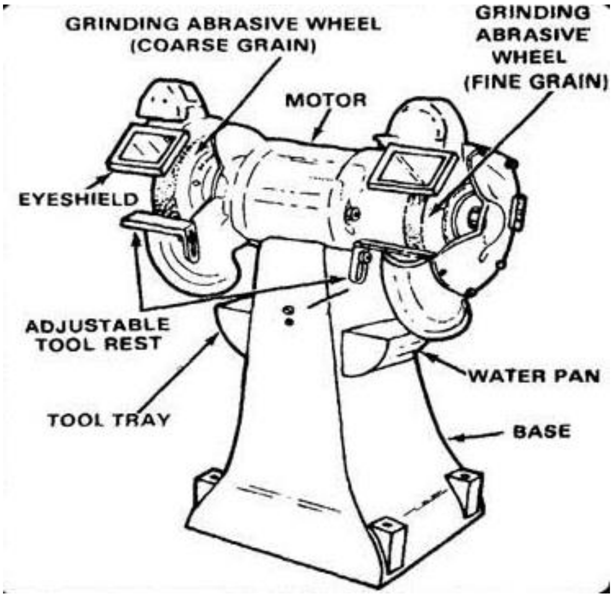


Figure 5: Grinding Machine

PRECAUTIONS FOR DRILLING, TAPPING AND GRINDING:

1. Axis of spindle, adapter, and tool should be coinciding.
2. Work piece must be held rigidly on the drilling machine.
3. Use properly sharpened drills for drilling to the right specifications.
4. Never grind on the side of a grinding machine.

WORKING PROCEDURE FOR DRILLING, TAPPING AND GRINDING:

1. Required diameter of the tap drill size is calculated.
2. The drill bit of required size is chosen and held it by using a chuck with taper shank.
3. The holes are drilled by adjusting the position of the radial arm.
4. Tapping operation is done using first, second and third tap by attaching the taps with tapping wrench.

5. The sharp edges are grinded in grinding machine.

JOB NO: 4

TITLE: MILLING

OBJECTIVE:

1. Demonstration of various parts of a milling machine.
2. Indexing of circular gear blank.
3. Cutting of spur gear and helical gear.

MILLING: Milling is metal cutting operation in which the excess material from the workpiece is removed by rotating multipoint cutting tool called milling cutter. A milling machine is a machine tool that removes metal as the work is fed against a rotating multipoint cutter. The machine can also hold one or more number of cutters at a time. As the workpiece moves against the cutting edges of milling cutter, material is removed in form of chips. Machined surface is formed in one or more passes of workpiece. For better surface finish, accuracy and high production rate it is used more than the other machines.

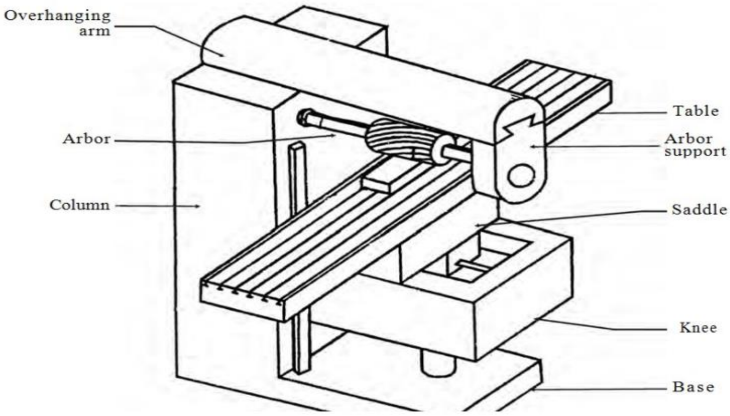


Figure 1: Horizontal Milling machine

PRINCIPAL PARTS OF A COLUMN AND KNEE TYPE MILLING MACHINE

Base – It is made of cast iron and supports all the other parts of the machine tool. A vertical column is mounted upon the base. In some machines, the base serves as a reservoir for cutting fluid.

Column – It is mounted upon the base and is box shaped. It houses the mechanism for providing drive for the spindle. The front vertical face of the column is machined accurately to form dovetail guideways for the knee to move up and down. The top of the column holds an overhanging arm.

Knee – It slides up and down on the guideways of the column. An elevating screw mounted on the base obtains this movement. Saddle is mounted upon the knee and moves in a cross direction.

Saddle – It is mounted on the guideways of the knee and moves towards or away from the face of the column. This movement can be obtained either by power or by hand. The top of the saddle has guideways for the table movement.

Table – The table is moved longitudinally either by power or manually on the guideways of the saddle. The top surface of the table has got 'T' – slots on which the workpieces or other work holding devices are mounted.

Spindle – It is located in the upper part of the column. It receives power from the motor through belt, gears and clutches. The front end of the spindle has got a taper hole into which the cutters are held with different cutter holding devices.

Overhanging arm – It supports the arbor from the top of the column. The arbor is supported by the bearing fitted within the arbor support. It is also useful while using some special attachments.

Arbor- It supports the different types of cutters used in the machine. It is drawn into the taper hole of the spindle by a drawbolt. One or more cutters are mounted on the arbor by placing spacing collars between them. The arbor is supported by an arbor support. The arbor is provided with a Morse taper or self-releasing taper.

TOOLS AND EQUIPEMENTS USED:

1. Milling machine
2. Indexing head
3. Form cutter

TERMINOLOGY OF A SPUR GEAR:

- Pitch surface: The surface of the imaginary rolling cylinder (cone, etc.) that the toothed gear may be considered to replace.
- Pitch circle: A right section of the pitch surface.
- Addendum circle: A circle bounding the ends of the teeth, in a right section of the gear.
- Root (or dedendum) circle: The circle bounding the spaces between the teeth, in a right section of the gear.

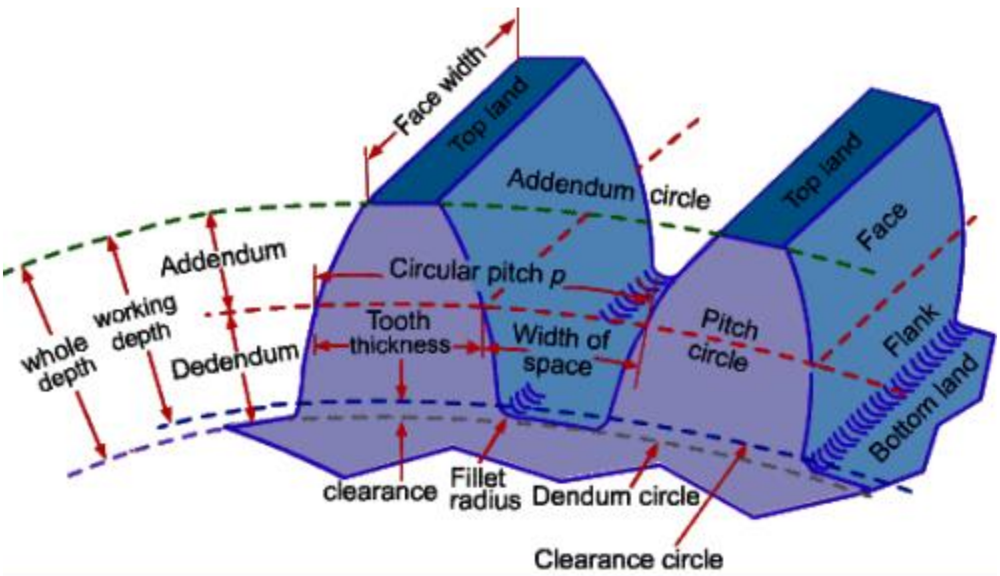


Figure 2: Spur gear

- Addendum: The radial distance between the pitch circle and the addendum circle.
- Dedendum: The radial distance between the pitch circle and the root circle.
- Clearance: The difference between the dedendum of one gear and the addendum of the mating gear.
- Face of a tooth: That part of the tooth surface lying outside the pitch surface.
- Flank of a tooth: The part of the tooth surface lying inside the pitch surface.
- Circular thickness (also called the tooth thickness): The thickness of the tooth measured on the pitch circle. It is the length of an arc and not the length of a straight line.
- Tooth space: The distance between adjacent teeth measured on the pitch circle.
- Backlash: The difference between the circle thickness of one gear and the tooth space of the mating gear.
- Backlash =Space width – Tooth thickness
- Circular pitch p: The width of a tooth and a space, measured on the pitch circle.
- Diametral pitch P: The number of teeth of a gear per inch of its pitch diameter. A toothed gear must have an integral number of teeth. The *circular pitch*, therefore, equals the pitch circumference divided by the number of teeth. The *diametral pitch* is, by definition, the number of teeth divided by the *pitch diameter*.
- Module m: Pitch diameter divided by number of teeth. The pitch diameter is usually specified in inches or millimeters; in the former case the module is the inverse of diametral pitch.
- Fillet : The small radius that connects the profile of a tooth to the root circle.
- Pinion: The smaller of any pair of mating gears. The larger of the pair is called simply the gear.
- Velocity ratio: The ratio of the number of revolutions of the driving (or input) gear to the number of revolutions of the driven (or output) gear, in a unit of time.
- Pitch point: The point of tangency of the pitch circles of a pair of mating gears.
- Common tangent: The line tangent to the pitch circle at the pitch point.
- Base circle: An imaginary circle used in involute gearing to generate the involutes that form the tooth profiles.

INDEXING

Indexing is the process of evenly dividing the circumference of a circular work piece into equally spaced divisions, such in cutting gear teeth.

Indexing Methods: - the following indexing methods are commonly used:

1. Direct indexing
2. Plain indexing or simple indexing
3. Compound indexing
4. Differential indexing
5. Angular indexing

Out of these the direct indexing is the simplest one, but the plain indexing is commonly used.

Plain Indexing: - This method of indexing is used when the direct indexing method cannot be employed for obtaining the required number of divisions on the work. For this indexing method universal indexing head can be used. This method of indexing involves the use of crank, worm, worm wheel and index plate. Worm carries 40 teeth and worm is single start. The worm wheel is directly mounted on the spindle. Since the worm has single start thread and the worm wheel 40 teeth, with one turn of the crank the worm wheel will rotates through one pitch distance, i.e. equal to 1/40 of a revolution. Similarly, 2 turns of the crank will make the work to rotate through 1\20 and a 3 turn through **3**/40 of a revolution. Thus, the crank will have to rotate through 40 turns in order to rotate the work through one complete turn. For n divisions on the work piece, the crank will make 40/n turns. Suppose that the work has to be divided into 23 equal divisions then the corresponding crank movement will be given by: - . _ Crank movement = 40 / 23 = 1 This means that for rotating work piece into 23 equal divisions**,** the crank has to rotate 1 complete revolution and 17/23 of a revolution or will move further 17 holes on 23 hole circle plate. In this fraction the numerator denotes the number of holes to be moved and the denominator the number of holes on the circle to be used.

PROCEDURE FOR CUTTING SPUR GEAR

1. The cutting of spur gear is done after determining gear tooth proportions, selecting the type of indexing to be performed, and finding the correct number of form cutter.
2. The speed should be slightly lower than the plain milling operation and the feed should be normal.
3. The cutter is mounted on the arbor and it is then centered accurately with the diving head spindle by adjusting the position of the table.
4. The gear blank is mounted between the two centers by a mandrel and is connected with the diving head spindle.
5. The proper index plate is bolted on the dividing head the positions of the crank pin and the sector arms are adjusted.

6. For a smaller size gear blank, the depth of cut is given equal to the full depth of the gear tooth.
7. The table is raised to give the required depth of cut by turning the dial through the calculated no of divisions.
8. The machine is started and the feed is applied to finish the first tooth space of the gear.
9. After that blank is positioned by indexing for the next cut and the operation is repeated.

Determination of gear blank and other particulars:

a) Blank diameter = m(Z+2), where, m= module and Z= Number of gear teeth

b) Tooth depth = 2.25m

c) Cutter pitch = 3m

PROCEDURE FOR CUTTING HELICAL GEAR

1. The helical gear milling operation is taken in hand after preparing the gear blank to the required size and calculating the necessary tooth dimensions.
2. The spindle of the dividing head and tailstock are aligned so that they may be perpendicular to the machine spindle.
3. The proper cutter is chosen and mounted on the arbor.
4. The required helix angle is calculated and the table is swiveled to the correct position.
5. Then proper index plate is mounted on the dividing head and the crank pin is pushed into the hole of the required hole circle.
6. The cutter is set to give required depth of cut.
7. After the first cut the index pin is withdrawn from the index plate ,which causes the worm shaft to be disengaged with the table feed gearing.
8. The operation is repeated.

Determination of gear blank and other particulars:

a) Blank diameter = $m(Z/\cos_{\beta}+2)$, where m = module, Z = Number of gear teeth, $_{\beta}$ = Helix angle

b) Tooth depth = 2.25m

c) Cutter pitch = 6m

Selection of table gear train:

Lead of the machine 40×T1, where T1= Pitch of the lead screw of the machine

Lead of the helix is calculated from the formula

$\tan_{\beta} = \pi D/l$ or $l = \pi D/\tan_{\beta}$

$_{\beta}$ = Helix angle

l = lead of the helix

D = diameter of the work

The change gears are

$$\frac{Driver}{Driven} = \frac{Lead\ of\ the\ machine}{Lead\ of\ the\ work} = \frac{40 \times T1}{T2}$$

Selection of cutter

$Zc = Z/cos^3\ \beta$

The selection of is based on Zc

Course Code	Course Title	Hours per week L-T-P	CreditC
ME181403	Fluid Mechanics-I	3-0-0	3

Objective:

i. To provide knowledge on behavior of incompressible fluids both in static as well as in dynamic conditions.
ii. To generate an idea on flow analysis and measurement of incompressible fluid parameters.
iii. To impart knowledge on how to analyze continuity equation, momentum equation, energy equation through better mathematical perspective by vectorial approach

Motivation:
The subject is a very basic subject for mechanical engineering. Knowledge of the subject will helpto understand better about hydraulics, marine engineering flow simulation river dynamics and basics of atmospheric science.

Course Outcomes: At the completion of the course the student will be able:
CO1: Define various fluid properties like viscosity, density, specific gravity and various forces acting on body in a static fluid.
CO2: Classify the flow of fluids like steady unsteady, uniform non-uniform, Rotational Irrotational, Laminar and Turbulent and elementary flow in two dimension- source flow, sink flowand doublet.
CO3: Analyse dynamics of fluid flow using Euler's Equation Bernoulli's equation, momentum equation and also perform dimensional analysis.
CO4: Develop the concept of static and stagnation pressure and flow measurement through Venturimeter, pitot tube and orifice meter
CO5: Evaluate fluid friction, shear stress, pressure gradient for steady and laminar flow in a pipe and two parallel plates.

MODULE 1:

Introductions:
Definition of Fluid, Dimension and Units, Concept of Continuum, No slip condition of viscous liquids, Classification of fluids, Properties of fluids, mass density, specific weight, specific gravity, viscosity, compressibility, compressibility, surface tension and vapor pressure.

Pressure and Fluid Statics:
Define Pressure, The Manometer, pressure at a point, other pressure measuring devices, Hydrostatic forces on submerged plane and curved surfaces, Buoyancy, stability of floating and submerged bodies.

MODULE 2:

Kinematics of Fluids:
Lagrangian and Eulerian description of fluid motion, Acceleration field of a fluid, Differential Equation of Mass Conservation, streamline, path line, streakline, stream tube, steady and unsteady flow, uniform and non-uniform flow, Rotational and Irrotational flows, Vorticity, Stream function, Velocity potential function, Flow net.

Elementary Flows in a two dimensional plane:
Uniform flow, Source and Sink, Vortex Flow, Free and Forced Vortex, Doublet, Continuityequation and its analysis based on integral form.

MODULE 3:

Dynamics of Fluid Flow:
Euler's equation of motion, The Bernoulli's equation and its application, General Energy equation and momentum equation, Dynamic forces on plain and curved surfaces due to impingement of liquid jets.

Flow Measurement:
Concept of static and stagnation pressures, Pitot tube and its application, venturimeter, Orificemeter, Hydraulic co-efficient of an Orifice, Factors affecting the Orifice co-efficients.

Dimensional Analysis and its applications
Introduction, Dimensionless numbers and its significance, Fluid flow problems, drag in immersed bodies.

MODULE 4:

Flow through pipes:
Laminar and turbulent flow, Reynolds number, Pressure drop and head loss in pipe, Darcy Weisbach equation, Steady laminar flow through circular pipes, flow between parallel plates, Couette flow

Text/Reference Books:

1. Fluid Mechanics ----------Dr. A. K. Jain.
2. Fluid Mechanics --------- Cengel &Cimbala.
3. Introduction to fluid mechanics and fluid machines------ Som, Biswas and Chakrabarty
4. Fluid Mechanics ----------Dr. J. Lal
5. Fluid Mechanics and machines------V. L. Streeter.

FLUID MECHANICS-I is one of the most important and basic courses of engineering and has considerable application in fluid flow analysis and measurement of fluid parameters. It basically deals with the properties of fluids, kinematic and dynamic behavior of incompressible fluid, flow measuring devices, fluid friction and open channel flow analysis. The course has been designed in such a way that, analysis of continuity equation, momentum equation, and energy equation can be done in better mathematical perspective through vectorial approach. The course is an important part of the undergraduate syllabi.

Motivation

The knowledge of FLUID MECHANICS-I has wide application and utility in Marine Engineering, Hydraulics, River Dynamics Flow analysis through Numerical simulation. The subject imparts the foundation for the subject FLUID MECHANICS-II. It is a very fundamental subject of many engineering discipline and natural science. It is also involved in medical science like transmission of fluid in arteries, veins and heart. The basic knowledge of this subject helps the UG students to understand the problems that arise in the above mentioned fields.

Course Time Plan:

Units/Topics	Number of Lectures	Method of deliver
1. Module 1	8	Both chalk and talk and power point presentation
2. Module 2	10	
3. Module 3	10	
4. Module 4	7	
TOTAL	35	1 class @1 hours

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181404	**Materials Science**	**3-0-2**	**4**

Course Overview

Materials Science is a very important interdisciplinary course at the undergraduate level. The course includes basic fundamentals of materials science and engineering. The course coverage topics of crystallography and crystal structure determination, dislocations, phase diagrams, heat treatments, oxidation and corrosion, mechanical properties and evaluation, oxidation and corrosion. The Last unit covers a general idea on engineering alloys with their applications.

Selection of materials for various structural applications is an important task for engineers. The growth of science and technology depends on availability of suitable materials. This includes room temperature to high-temperature applications and various environments.. All these applications require different material properties suitable to those conditions. This course provides guidance for selection of material for various applications and to tailor properties of materials according to the requirements. The significance of the course lies on the in-depth knowledge in materials engineering and their selection for manufacturing industries. Prerequisites of the course: UG level physics, chemistry and mathematics.

Course Outcomes

1) Analysis: Determine: -- For a given X-ray diffraction (XRD) pattern for an elemental cubic material, students will be able to index the XRD peaks, determine the crystal structure and lattice parameter.

2) Analysis: Analyze: -- For a given binary phase diagram, students will be able to analyze the microstructure and the phases formed during solidification of the alloy.

3) Synthesis: Design: --For obtaining desired material properties in steels, students will able to design and recommend suitable heat treatment process.

4) Analysis: Determine: -- For a given material, students will be able to determine the tensile, hardness, impact and fatigue properties.

5) Analysis: Determine: --Students will be able analyze the various lattice imperfections and able to determine critical resolved shear stress (CRSS) for a given slip system.

6) Analysis: Analyze: --Students will be able to analyze the various processes of oxidation and corrosion in metals and alloys and apply suitable techniques to protect them.

MODULE 1: (4 Lectures)
Brief review of Crystal Structures- Crystal Directions and Planes. The Bragg Law of X-raydiffraction, Powder method of XRD and the crystal structure determination.

MODULE 2: (12 Lectures)
Mechanical Property measurement: Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress-strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery; Hardness: Rockwell,

Brinell and Vickers and their relation to strength.

Fracture mechanics: Introduction to Stress intensity factor approach and Griffith criterion. Fatigue failure: High cycle fatigue, Stress-life approach, SN curve, endurance and fatigue limits, effects ofmean stress using the Modified Goodman diagram; Fracture with fatigue, Introduction to non-destructive testing (NDT)

MODULE 3: (6 Lectures)

Alloys: substitutional and interstitial solid solutions- Phase diagrams: Interpretation of binary phase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Fe-Fe3C diagram and microstructural aspects of ledeburite, austenite, ferrite and cementite, cast iron.

MODULE 4: (8 Lectures)

Heat treatment of Steel: Annealing and its classifications, tempering, normalising and spheroid sing, isothermal transformation diagrams for Fe-C alloys and microstructure development. TTT diagram, Continuous cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo-nitriding, flame and induction hardening, vacuum and plasma hardening.

MODULE 5: (6 Lectures)

Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critical resolved shear stress. Deformation by twinning, Stacking faults, deformation of polycrystalline materials.

MODULE 6: (4 Lectures)

Alloying of steel, properties of stainless steel and tool steels, maraging steels-cast irons; grey, white, malleable ands pheroidal cast irons- copper and copper alloys; brass, bronze and cupro-nickel; Aluminium and Al-Cu – Mg alloys- Nickel based super alloys and Titanium alloys

Text/Reference Books:

1. Materials Science and Engineering, V. Raghavan, PHI
2. Mechanical Metallurgy, George E. Dieter, McGraw hill Book Company
3. Materials Science and Engineering, V. Raghavan, PHI
4. Heat Treatment-Principles and Techniques, T.V. Rajan, C.P. Sharma and A. Sharma, EasternEconomy Edition
5. Mechanical Metallurgy, George E. Dieter, McGraw hill Book Company
6. Materials Science and Engineering– R.K. Rajput, S.K. Kataria and Sons

Pedagogy: Students should visualize the material science aspects and expertise in material selection for different manufacturing applications.

Expected outcome: At the completion of the course the student will be able to:

1. Identify the general and advanced Engineering materials, their properties and applications.
2. Explain the need of advanced and non-conventional materials.
3. Identify the criteria for selection of materials during design and manufacturing.
4. Correlate material properties with design considerations.
5. Present the outcome carried out in the form of group projects on material characterization and different manufacturing aspects

Suggested Practical:

Course Outcomes: After completion of the course, the students will able to

CO1: Determine the hardness of metals

CO2: Determine the yield strength, ultimate tensile strength and ductility of metals

CO3: Determine the impact strength of metals

LIST OF EXPERIMENTS

1. Brinell Hardness Test
2. Rockwell Hardness Test
3. Impact (Dynamic) Test (Izod and Charpy Test)
4. Uniaxial Tension Test

EXPERIMENT—1:

To determine the hardness of given specimen by Brinell Hardness Testing Machine.

APPARATUS: Brinell hardness testing machine, 5 mm and 10 mm hardened steel ball indenters, Microscope with scale for indentation diameter measurement.

THEORY AND PROCEDURE:

Hardness of a material has been defined in various ways as the resistance of its surface to plastic deformation, cutting, wear, scratching, abrasion, indentation or energy absorption under impact. Hardness depends on crystal structure, dislocations, atomic bonds etc.

Indentation hardness test is one of the most frequently used non-destructive tests for quality control of machine parts or structural components to ensure specific material property in the designed parts or components. It is a quick and inexpensive test and gives information about yield stress. In this type of test, a pyramid, cone or ball is pressed onto a flat surface by gradual application of load to produce a permanent indentation.

There is a very useful correlation between the Brinell hardness and the Ultimate tensile strength (UTS) of heat-treated plain carbon and medium alloy steels.

UTS (S_u), in MPa = 3.4 × BHN

BRINELL HARDNESS TEST: A 5 mm or 10 mm diameter steel or tungsten carbide ball is pressed onto a flat smooth surface free from dirt and scales test specimen at load of 250, 500, 750, 1000 or 3000 kg. For soft materials smaller loads should be used to avoid too deep impression and for very hard metals a tungsten carbide ball is used to minimise distortion of the indenter. The load is applied for a standard time between 10 and 30 s, usually 30 s, and the diameter of the indentation is measured with a low-power microscope after removal of the load. The average of the two readings of the diameter of the impression at right angles should be made. The Brinell hardness number (BHN) is expressed as the load (P) divided by the surface area of the indentation (A_c) (kgf/mm^2).

$$BHN = \frac{2P}{\pi D\left[D - \sqrt{D^2 - d^2}\right]} \text{ kg/mm}^2$$

Where, P = applied load, kg

D = diameter of indenter ball, mm

d = diameter of indentation, mm

The load selection should be made in the following way. For ferrous metals (steel and iron) the load (P) = 30D^2 and for non-ferrous metals like brass, aluminium and soft bearing metals the load (P) = 10×D^2, 5×D^2 and 2.5×D^2 should be used respectively.

TEST PROCEDURE:

1. Operate the machine only in presence of the Instructor.
2. Select proper diameter ball and put the proper weights such that the combination will suite the material being tested.
3. Keep the hand lever at position unload.
4. Start the motor by pushing the green button of the starter and wait until te weight hanger reaches its top position.
5. Place the specimen securely on testing table.
6. Turn the hand wheel in clockwise direction to raise the table so that the specimen gets clamped against the clamping cone with slight pressure.
7. Turn the hand lever from unload position to load position so that the total load is brought into action.
8. When the dial gauge pointer reaches a steady position, the load may be maintained for up to 15 s for accurate work. For releasing the load, take back the lever to unload position.
9. Position the lever to read position to get a projected view of the indentation on the screen.
   - i) Measuring the diameter of the indentation:
   - ii) Turn the knob attached below the screen in such a way that the nearest full division mark should be tangent to the outer edge of the indentation.
   - iii) By means of micrometer movement adjust the other full division mark on the other side in a similar way.
   - iv) Count the number of full divisions in the indentation area. One full division represents one mm.

v) Count the nearest number of divisions with the reference line of micrometer. One division of the micrometer scale represent 0.1 mm.

vi) Count the nearest division on the circular scale of the micrometer. This gives the second decimal value in mm.

vii) Rotate the screen to make the measurement of the diameter of indentation perpendicular to the earlier measurement.

viii) Repeat the above steps.

OBSERVATIONS AND CALCULATIONS:

Diameter of the indenter ball (D) =______mm Material of Specimen—

Sl. No.	Load appll. (P), kgf	Dia of indentation (d), mm			$BHN = \frac{2P}{\pi D\left[D - \sqrt{D^2 - d^2}\right]}$	S_u, MPa
		Horizontal position	Vertical Position	Mean dia.		

Take at least FIVE READINGS at five different places. The impression should not be made very near to the outer edge of the specimen.

Answer the following questions: (To be submitted with report before coming to the next lab)

1) Why is hardness testing used so frequently?
2) Why is it necessary to stipulate different loads for finding BHN of two different classes of materials, say brass and steel?
3) List the advantages and limitations of Brinell hardness test.
4) In a Brinell test on annealed Cu with 5 mm diameter ball, the readings of ‘d” are 2.2, 2.7 and 3.1 mm for loads of 125, 250 and 375 kg. Find BHN. What would be the diameter of impression for a load of 300 kg?

EXPERIMENT—2: HARDNESS TEST

To determine the hardness of given specimen by Rockwell Hardness Testing Machine.

ROCKWELL TEST:

Rockwell hardness test is an indentation hardness test using a verified machine to force a diamond spheroconical indenter or a hard steel ball indenter under specified conditions onto the surface of the material under test in two operations, and to measure the difference in depth of the indentation under the specified conditions of preliminary and total test force.

PROCEDURE OF TEST:

1) Adjust the proper weight on the plunger by weight selection disc according to the Rockwell Scale required as shown in the chart below:

Scale	Indenter	Load, kgf	Dial	Applications	Working range
A	Diamond 120^0	60	Black	Carbides, thin steel, shallow case-hardened steel, case-carburised surfaces.	R_A= 40-90 Harness>C 65
B	Steel ball 1.588 mm (1/16 ″)	100	Red	Al-alloys, Cu- alloys, unhardened steel, rolled, dawn, extruded or cast metals	R_B=0 to 100 Hardness< C 20
C	Diamond 120^0	150	Black	Hard CI, Pearlitic malleable iron steel, deep case hardened steel, Titanium	R_C=20 to 77

2. Keep the lever in position "A"
3. Place the specimen securely on testing table.
4. Turn the hand wheel clockwise so that the specimen will push the indenter to show a reading on dial gauge as small pointer at 3 (RED SPOT) and long pointer close to "0" of outer scale (i.e. B 30 inner scale).
5. Turn the lever from position "A" to "B" slowly so that the total load is brought into action without any jerks.
6. Indentation becomes complete when the long pointer of the dial gauge reaches a steady state. Then take back the lever to position "A" slowly after allowing some time (say 10 s) after the steady state is reached. Read the figure against the long pointer on the proper scale (B or C). This is the direct reading of the Rockwell Hardness of the specimen.
7. Turn back the hand wheel anticlockwise and remove the specimen. Repeat the above procedure for take other readings with spacing three to five times the diameter of the indentation.
8. All standards recommendations are to neglect the first two readings to ensure that the specimen, the indenter and the anvil seat properly. Further readings should be considered.

OBSERVATIONS:

Specimen	Load, kgf	Scale	Indenter	Rockwell Hardness					Average
				(1)	(2)	(3)	(4)	(5)	

Answer the following questions-

(To be submitted along with report before coming to the next lab)

1. What is the need and role of minor load in Rockwell test in contrast to other hardness test?
2. What is wrong with test result "Rockwell hardness of steel is 65"?
3. List the precautions to be taken in this test.

EXPERIMENT No—03: IMPACT (DYNAMIC) TEST (IZOD AND CHARPY TEST)

Objective: To study the toughness (dynamic) or the energy absorbing properties of metals under impact loading.

Background: Under dynamic test the rate of application of load is many order higher than that in quasi-static test such as Uni-axial Tension test where the usual value of strain rate is within the range of ($10^{-1} – 10^{-4}$ per second). The behavior of material may change under the condition of higher strain rate especially in the presence of stress concentrations around notches and at low temperatures. A material which behaves in a ductile manner at relatively low strain rate tends to behave in a brittle manner when the strain rate is higher (about $10^2 – 10^4$ per second).

Fracture: Fracture is the separation of a body under stress into two or more parts. The failure is considered to be brittle if the microcracks propagate rapidly with minimum absorption of energy with negligible plastic deformation. In single crystal materials brittle fracture accompanies cleavage along the weakest crystal plane. In polycrystalline materials the fracture surface is granulated and rough in appearance. According to Griffith, the failure in brittle materials occurs by crack propagation due to stress concentration at the tip of the existing microcracks. Failure in ductile materials occurs after considerable plastic deformation accompanied by slipping at inter-granular boundaries. Such fracture begins with the formation of voids in the materials, usually at non-metallic inclusions. Under continually increasing loads these voids propagate to the surface and cause failure. Brittle fracture and ductile fracture have characteristic appearance which can be easily recognized from the fracture surfaces. In brittle fracture, no apparent plastic deformation takes place before fracture. In brittle crystalline materials, fracture can occur by cleavage as the result of tensile stress acting normal to crystallographic planes with low bonding. In ductile fracture, extensive plastic deformation (necking) takes place before fracture. Rather than cracking, the material "pulls apart," generally leaving a rough surface.

Notch Impact Tests: The ordinary static testing is not satisfactory when it is desirable to determine suitability of a material to resist shock or impact type of loading. In impact tests, the specimen receives a simple shock and the energy absorbed by the specimen is taken as a measure of the resistance of the material to impact or its dynamic toughness. These tests are simple, easy to carry out and rapid to conduct. These are widely used as quality control. The one of the purposes of using impact test to find whether or not the heat treatments have been carried out successfully. Other use of these tests is to determine the ductile to brittle transition temperature range under impact loading.

There are two types of impact tests *viz.*, *Izod* and *Charpy* test. The equipment used for these types of tests is a pendulum type with a fixed weight. The testing machine has the provision to carry out both the two tests by simply altering the support attachment providing different potential energies and the striker head.

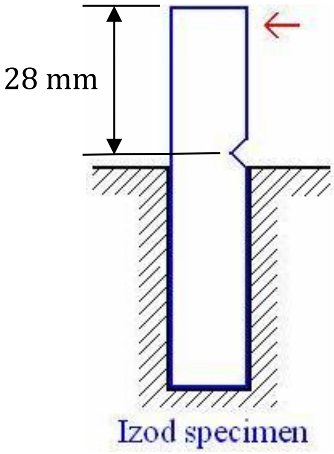


Figure 1: Position of Izod specimen

(a) IZOD Test (Notched cantilever specimen)

This test uses a specimen of square cross-section of size 10 mm × 10 mm and of length 75 mm. A "V" notch is provided at 28 mm from one end. The depth of notch is 2 mm and its angle is 45° with a root radius of 0.25 mm. The specimen is fixed vertically at the clamp at the base of the equipment with the notch facing the striker as shown in Figure 1. The cantilever portion above the notch is 28 mm long. The hammer strikes the specimen at the top portion (below 6 mm from the top) of the specimen and then moves further after the fracture of the specimen. The difference of the potential energy between the initial and final positions of the hammer gives the energy absorbed in the impact. A rotating pointer on the graduated scale records this difference directly.

(b) CHARPY TEST

This test uses a specimen of square cross-section of size 10 mm × 10 mm and of length 55 mm. The specimen has a "U" shaped notch of 2 mm wide and 5 mm deep. The specimen is supported horizontally on the support at the base as shown in Figure 2. The hammer strikes the specimen at its centre opposite face of the notch. Tensile stresses developed at the notch which tends to open up the notch and cause failure.

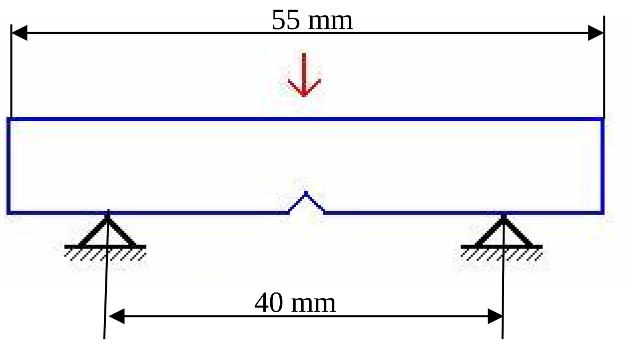


Figure 2: Position of Charpy specimen

Factors affecting Impact Test:

Following are the factors that affect the Impact test:

- Yield strength and ductility
- Notches
- Temperature
- Strain rate
- Fracture mechanism

Yield Strength and Ductility

For a given material the impact energy will be seen to decrease if the yield strength is increased, i.e. if the material undergoes some process that makes it more brittle and less able to undergo plastic deformation. Such processes may include cold working or precipitation hardening.

Notches

The notch serves as a stress concentration zone and some materials are more sensitive towards notches than others. The notch depth and tip radius are therefore very important. High stress concentration in marginally ductile metals, particularly notch-type stress concentration results in the brittle failure. Accuracy of the notch is also an important factor. Small changes in the notch dimensions or shape may result in the latge difference in the test results.

Strain rate

Most of the impact energy is absorbed by means of plastic deformation during the yielding of the specimen. Therefore, factors that affect the yield behaviour and hence ductility of the material will affect the impact energy. High rate of strain rate results in the increase in the yield stress of metals. The increased yield stress and notch-type stress concentration can result in the hydrostatic tension and thereby reducing the fracture stress in tension. Both effects result in the brittle failure. This effect is called notch sensitivity.

Temperature

Temperature is a very important factor which influences the toughness of a material. Generally materials exhibit loss of toughness with decreasing temperature. Yield strength of metals and polymers generally increases with decreasing temperature. Hence the ductile metal fractures like a brittle metal at low temperatures. Generally three regions are observed. At low temperatures, the materials exhibit brittle fracture with a little change in the toughness with temperature. In the transition range, a rapid increase in the toughness with increasing temperature is observed. At high temperatures, metals exhibit little variations in toughness with temperature. The behaviour of materials can change from ductile to brittle abruptly at a temperature which is referred to as ductile-to-brittle transition temperature. This type of behaviour is more prominent in materials with a body centred cubic structure, where lowering the temperature reduces ductility more markedly than face centred cubic materials.

Fracture Mechanism

Metals tend to fail by one of two mechanisms, *viz*., micro-void coalescence or cleavage. Cleavage can occur in body centred cubic materials, where cleavage takes place along the {001} crystal planes. Micro-void coalescence is the more common fracture mechanism. Voids form as strain increases, and these voids eventually join together and cause failure. Cleavage failure involves very less plastic deformation and hence absorbs very low fracture energy.

OBSERVATIONS AND DISCUSSION:

Material:

Dimension of the specimen (mm)

Notch position and type Notch angle

Observations	IZOD Test (J)	CHARPY Test (J)
Initial energy of hammer		
Final energy of hammer		
Energy absorbed		
Type of fracture		

Questions

1. What is the basic difference between Izod and Charpy test?
2. Which one of the two test is advantageous and why?
3. Explain the main reasons for using the notch impact tests.

EXPERIMENT No—04: UNIAXIAL TENSION TEST

Objective

To obtain the stress-strain curve of a metal and determine (1) Young's modulus (E), (2) 0.2% yield stress (σ_O), (3) Ultimate tensile stress, (4) percent elongation, (5) Nominal and true fracture stress.

Apparatus

The name of the machine is called Universal Testing Machine (UTM). Several tests can be performed on this machine *viz*., tension, compression, bending, hardness etc. The movement of the two crossheads is controlled by the flow of hydraulic fluid into the cylinder which drives a piston. The specimen is fixed between the two crossheads. The main hydraulic cylinder is fitted in the centre of the base. The lower table is connected to the main piston in the cylinder with the help of two screwed columns. The two columns can be rotated by a motor driven chain and sprocket fitted in the base of the machine which enables adjustment of the lower crosshead. Two jaws with jaw locking handle are attached on the two crossheads for fitting of tensile specimen.

The main units in control panel are the oil tank which contains the hydraulic oil. The pump is a positive displacement type pump. This assures continuous high nonpulsating oil current for the smooth application of the load on the specimen. Two valves on the control panel one at the right side and other at the left side are used to control the flow of hydraulic fluid into the cylinder. The right valve is a pressure compensated flow control valve. The left one is the return valve for the fluid coming out from the cylinder back to the tank. Pressure compensation of the flow control keeps a constant rate of straining regardless of the total load on the specimen.

Procedure

Tension Test: Adjust the load range according to the capacity of the test specimen. Minimum length of specimen varies with the type of machine. Measure the diameter of the specimen. Mark the gauge length [For cylindrical specimen, a constant ration of gauge length to diameter produces constant percentage elongation provided the specimens are manufactures from the same quality of stock, According to ISO recommendation, the $\frac{L_0}{\sqrt{A_0}}$ ratio is maintained to be 5.65. For other shapes, $L_0 \propto \sqrt{A_0}, i.e., L_0 = k\sqrt{A_0}$].

Select the proper jaw inserts in the chuck assemblies of the two jaws. First, grip fully the upper end of the test piece. Apply the load gradually. The left valve is kept in fully closed position and the right valve in normal open position. Open the right side valve and close it after the lower table is lightly lifted. Operate the lower grip operation handle and lift the lower cross head up and grip fully the lower part of the specimen. Then lock the jaws in this position by operating the jaw locking handle. Then turn the right control valve slowly to open position, (i.e. anti-clockwise) until the desired loading rate is achieved. After this the specimen is under load and then unclamps the locking handle. Now the jaws will not slide down due to their own wt. Then go on increasing the load. When the test piece is broken, close the right control valve, and take out the broken pieces of the test piece. Then open the left control valve to take the piston down.

Compression test: Fix upper and lower pressure plates on the lower cross- head and the lower table respectively. Place the specimen on the lower compression plate. The specimen must be aligned exactly according to the marking on the compression plated in order to give the complete cross action of the specimen a chance to participate equally in the acceptance of load. Then adjust the zero by lifting the lower table and perform the test in the same way as the tension test.

Bending test: Keep the bending table on the lower table in such a way that the central boss of the bending table fits in the central location hole of the lower table. Tapings are provided on the lower table for this purpose. Adjust the bending supports for the required distance and clamp those to the bending table with the screws provided at the side. For adjusting the distance, use the scale marked on bending table. Stoppers are provided which are to be placed at the back of the bending supports. Holes are provided on the bending table for locating the stoppers. The stoppers can be set in five different positions adjusting the centre distance between the supports at an interval of 100 mm. Fix the required bending pane at the lower side of the lower cross-head. Then adjust the zero by lifting the lower table and perform the test in the same way as the tension test.

Observations (Tension Test)

Diameter of the specimen, d_O (mm) =

Gauge length of the specimen, l_O (mm) =

Final deformed Gauge length, l_f (mm) =

Maximum load, P_{max} (N) =

Load at fracture, P_f (N) =

Min. diameter of the neck, d_f (mm) =

Original cross-sectional area, A_O (m^2) =

Area at the fracture (A_f) (m^2) =

From the computer plot calculate

0.2% yield stress = N/m^2

Young's modulus (E) = $\frac{\Delta P L_0}{A_0 \Delta \delta} =$ N/m^2

Ultimate stress = N/m^2

True fracture stress = N/m^2

Nominal average strain at fracture (% elongation) = $\frac{L_f - L_0}{L_0} =$

True strain at fracture = $2 \ln\left(\frac{d_0}{d_f}\right) =$

Result and Discussion

Sources of error: Lack of calibration of the machine, improper alignment, error in the measurement of extension etc., are the sources of error.

1. What is Bauschinger effect? Illustrate with σ–ε Curve.
2. Percent elongation of a material is referred as 17%. What is wrong with this statement?

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181405	**Mechanics of Materials**	**3-0-0**	**3**

Objective:
The course will impart knowledge of mechanics of deformable solids and different types of stresses and strains developed in deformable solids due to various loads. It will help to understand the mechanical behaviour of deformable solids under different types of loads and stresses. Exposure to energy methods will help to solve a wide variety of engineering problems. Ability to analyze and solve strength related practical problems will be developed.

Motivation:
The knowledge of Mechanics of Materials has wide application in mechanical, civil, industrial and production, aeronautical and aerospace engineering. The subject lays the foundation for other engineering subjects like Machine Design, Theory of Structure, Finite Element Analysis, Fracture Mechanics, etc. Engineering aptitude will be incomplete without the knowledge of the subject.

Course Outcomes (CO): At the completion of the course the student will be able:

CO1: Explain stress-strain relationship for homogeneous and isotropic material under axial, torsional, flexural and combined loads.

CO2: Compute principal stresses and strains and maximum shear stress using analytical and graphical methods.

CO3: Analyze radial, hoop and longitudinal stresses for thick cylinders under external and internal loading and analyze stresses in rotating discs.

CO4: Derive stresses in curved beam and estimate the stresses and deflection of helical spring under axial load.

CO5: Apply energy method to estimate the deflection and rotation of beams under flexural loading.

MODULE 1
Complex stresses and strains: Introduction to Cartesian tensors, derivation of Cauchy relations and equilibrium equations in spherical and polar/cylindrical coordinates, principal stresses and directions, stresses on octahedral planes, stress invariants, plane stress, stresses on oblique planes, Mohr's circle for plane and tri-axial stress system. Analysis of strain components, compatibility relations, strain tensor, principal strains and directions, strain invariants, strain on oblique planes, plane strain, Strain Rosette.

MODULE 2:
Combined stresses: Stresses due to combined bending and torsion of circular shafts.

MODULE 3:
Combined stresses: Stresses due to combined bending and torsion of circular shafts. Axisymmetric problems: Application to thick cylinders subjected to internal and external pressures, Lame's equation, compound cylinders, and stresses due to shrunk fit, Stresses in rotating discs of uniform strength and uniform thickness

MODULE 4:
Stresses in non-circular cross-sections/curved beams: crane hooks, rings etc Stresses and deflection of helical springs

MODULE 5:
Computation of slopes and deflection in beams using Double Integration method, Energy method, Theorem of Castigliano, Maxwell Bette reciprocal theorem.

Text/Reference Books:

1. Advanced Mechanics of Solids S Srinath, Tata McGraw Hill
2. Elements of Strength of Materials, S P Timoshenko, CBS Publication
3. Fundamentals of Strength of Materials, D Nag, A Chanda, Wiley India
4. Advanced Mechanics of Solids, L S Srinath, Tata McGraw Hill
5. Fundamentals of Strength of Materials, D Nag, A Chanda, Wiley India
6. Strength of Materials, S S Pathak, Dhanpat Rai Publications
7. Fundamentals of Strength of Materials, D Nag, A Chanda, Wiley India
8. Advanced Mechanics of Solids, L S Srinath, Tata McGraw Hill
9. Strength of Materials, S S Pathak, Dhanpat Rai Publications

Introduction to the Course

Mechanics of Materials is one of the fundamental courses of engineering and has considerable application in solving engineering problems. It basically deals with the behaviour of deformable solids subjected to various loads. Knowledge and analysis of stresses and strains and strength related problems are addressed in detail. The course is an important part of the undergraduate syllabi of many engineering disciplines.

Motivation

The knowledge of Mechanics of Materials has wide application in mechanical, civil, industrial and production, aeronautical and aerospace engineering. The subject lays the foundation for other engineering subjects like Machine Design, Theory of Structure, Finite Element Analysis, Fracture Mechanics, etc. Engineering aptitude will be incomplete without the knowledge of the subject.

Course Objective

The course will impart knowledge of mechanics of deformable solids and different types of stresses and strains developed in deformable solids due to various loads. It will help to understand the mechanical behaviour and failure criteria for deformable solids under different types of loads and stresses. Exposure to energy methods will be provided to solve a wide variety of engineering problems. Ability to analyze and solve strength related practical problems will be developed.

Course Time Plan

Units/Topics	Number of Lectures (Hours)	Method of deliver
11. Module 1	8	Both chalk and talk and power point presentation
12. Module 2	8	
13. Module 3	8	
14. Module 4	8	
15. Module 5	8	
Total	40	

Expected outcome

On successful completion of the course, the students will have the ability to:

1. Use the knowledge of Mathematics and Elementary Strength of Material to solve a variety of strength related practical problems in the field of deformable solids.
2. Gain knowledge of different types of stresses and strains developed in deformable solids due to various loads.
3. Acquire sufficient knowledge on the strength and failure conditions of practical mechanical components used in the industry.
4. Use this knowledge in other fields of engineering, e.g. Machine Design, Theory of Machine, Analysis of Structure, etc.
5. Prepare for a professional career and pursue higher studies.

Course Code	Course Title	Hours per week L-T-P	Credit C
MC181406	Environmental Science	2-0-0	0

MODULE 1: Environment and Ecology

i. Introduction
ii. Environment and Ecology
iii. Objectives of ecological study
iv. Aspects of Ecology
  a) Autecology
  b) Synecology
v. Ecosystem
  a) Structural and functional attributes of an ecosystem
  b) Food chain and food web
  c) Energy flow
  d) Biogeochemical cycles

MODULE 2: Land: Use and Abuse

i. Land use: Impact of land – use on environmental quality
ii. Land degradation
iii. Control of land degradation
iv. Waste land
v. Wet lands

MODULE 3: Water Pollution

a) Introduction
b) Water quality standards
c) Water pollution
d) Control of water pollution
e) Water pollution legislations
f) Water quality management in Rivers

MODULE 4: Air Pollution

i. Introduction
  a) Air pollution system
  b) Air pollutants
ii. Air pollution laws
iii. Control of air pollution
  a) Source correction method
  b) Pollution control equipmentc)

MODULE 5: Noise Pollution

i. Introduction
ii. Sources of noise pollution
iii. Effects of noise
  a) Physical effects
  b) Physiological effects
  c) Psychological effects
iv. controls of Noise pollution

Text / Reference Books:

1. Environmental engineering and management by Dr Suresh Dhameja
2. Environmental studies by Dr B.S. Chauhan
3. Environmental science and engineering by Henry and Hence
4. Environmental studies for undergraduate course by Dr Susmitha Baskar
5. Chemistry for environmental engineering and science by Clair Sawyer

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181413	**Fluid Mechanics–I Lab**	**0-0-2**	**1**

Objective:

i. To impart the knowledge of flow measurement
ii. To give an idea of pressure variation of a fluid in a pipe
iii. To give an idea of dynamic behavior of a fluid

Motivation:
Practical measurement of fluid flow rate, pressure, friction in a pipe etc can be done through this laboratory.

Course Outcomes: At the completion of the course the student will be able:

CO1: Investigate pressure variation, fluid behavior and losses along the flow through a circular pipe

CO2: Compare actual and Standard Cavitation Number of a fluid flow and test the validity of Bernoulli's theorem along a convergent divergent section

CO3: Determine co-efficient of discharge co-efficient of contraction and co-efficient of velocity of flow through and flow rate using Rotameter.

CO4: Determine force exerted on curved vanes by impact of jet

CO5: Compare surface profile of a forced vortex.

LIST OF EXPERIMENTS

1. Determination of a Cavitation number
2. Verification of Bernoulli's equation for incompressible flow
3. Determination of Co-efficient of discharge, co-efficient contraction for orifice meter.
4. Determination of surface profile of vortex apparatus
5. Determination of friction losses in pipes.
6. Determination of force exerted on stationary plate by impact of jet
7. Measurement of discharge through rotameter
8. Determination of pressure in a fluid
9. T verify Darcy's law and to find out the coefficient of permeability of the given medium
10. To find the coefficient of velocity of a pitot tube.

Experiment 01
CAVITATION APPARATUS

OBJECTIVE:

To observe the phenomenon of the cavitation

AIM:

To compare the actual and theoretical cavitation number at cavitation condition.

THEORY:

Low pressure zone can be produced by a local increase in the velocity as in eddies and vortices or by an overall reduction in static pressure. Collapse of the vapor will begin when they are moved into the region where the local pressure is higher than the vapor pressure. Collapse of these cavities may produce objectionable noise, vibration and extensive erosion or pitting of the boundary material in the region of the bubble collapse.In correlating equipment performance data, a useful parameter is the dimensionless grouping called the CAVITATION NUMBER, which may be calculated as:

$$\sigma_v = \frac{p - p_v}{\frac{\rho v^2}{2g}}$$

UTILITIES REQUIRED:

1. Electric Supply: Single phase, 220 V AC, 50 Hz, 5-15 amp socket with connection.
2. Water supply
3. Drain required
4. Floor Area Required: 1.5m × 1

EXPERIMENTAL PROCEDURE

1. Close all the valve
2. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
3. Open by pass valve.
4. Ensure that ON/OFF switch given on the panel is at OFF position.
5. Switch ON the main power supply and then switch ON the pump.
6. Open flow control valve.
7. To release the air from test section, start water supply at maximum flow by operating control valve and by pass valve.
8. Regulate flow of water through test section by control valve and by pass valve.
9. Observe the condition and measure flow rate of water by measuring tank and stop watch provided.
10. Note the pressure at the two points of the test setion.
11. Repeat the experiment for different flow rates.

FORMULA TO BE USED

1. $R = \frac{R_1 - R_2}{100}$, m
2. Q = $\frac{A \times R}{t}$, m^3/s

3. V $=\frac{Q}{a}$, m/s
4. $\sigma_v = \frac{p_1 - p_v}{\frac{\rho v_2{}^2}{2g}}$
5. $\sigma = \frac{p_1 - p_2}{\frac{\rho v_1{}^2}{2g}}$

Where,

A = Area of measuring tank, m2
a_1= Area of pipe,m2
a_2 = Area of throat of venturimeter, m2
d_1 = Diameter of the pipe, m
d_2 = Diameter of throat of venture meter, m
g = Acceleration due to gravity, m/s2
P = Pressure at inlet of test section, kg/cm2
P_V = Vapor pressure of flowing fluid, mm of Hg
Q = Discharge, m3/s
R = Rise of water level in measuring tank, m
R_1 = Final level of water in measuring tank, cm
R_2 = Initial level of water in measuring tank, cm
t = Time taken for R, sec
V_1 = Velocity of the fluid at inlet of test section, m/s
V_2 = Velocity of the fluid at throat, m/s
σ_c = Critical cavitation number
σ = Cavitation number

OBSERVATION:

S No.	P, kg/cm^2	p_2, mm of Hg	R_1,cm	R_2, cm	t, sec	Condition Observed

RESULT & DISCUSSION:

Experiment No. 02

VERIFICATION OF BERNOULLI'S THEOREM

OBJECTIVE:

Study and verify Bernoulli's Theorem in a convergent-divergent pipe.

AIM:

Verification of Bernoulli's Theorem

THEORY:

Bernoulli's law indicates that, if an in viscid fluid is flowing along a pipe of varying cross section, then the pressure is lower at constrictions where the velocity is higher, and higher where the pipe opens out and the fluid stagnates. The well-known Bernoulli equation is derived under the following assumptions:

1. flow is incompressible
2. flow is steady
3. flow is frictionless (□ = 0)
4. along a streamline;

Then, it is expressed with the following equation:

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = h^* = constant$$

Where (in SI units):

p = fluid static pressure at the cross section in N/m^2.

ρ = density of the flowing fluid in kg/m^3

g = acceleration due to gravity in m/s^2(its value is $9.81\ m/s^2 = 9810\ mm/s^2$)

v = mean velocity of fluid flow at the cross section in m/s

z = elevation head of the centre of the cross section with respect to a datum

h^* = total (stagnation) head in m

The terms on the left-hand-side of the above equation represent the pressure head *(h)*, velocity head (h_v), and elevation head *(z)*, respectively. The sum of these terms is known as the total head (h^*). According to the Bernoulli's theorem of fluid flow through a pipe, the total head h^* at any cross section is constant (based on the assumptions given above). In a real flow due to friction and other imperfections, as well as measurement uncertainties, the results will deviate from the theoretical ones.

In our experimental setup, the centreline of all the cross sections we are considering lie on the same horizontal plane (which we may choose as the datum, $z=0$), and thus, all the *'z'* values are zeros so that the above equation reduces to:

$$\frac{P}{\rho g} + \frac{V^2}{2g} + Z = h^* = constant$$

For our experiment, we denote the pressure head as h_i and the total head as h^*_i, where „*i*" represents the cross section we are referring to.

UTILITIES REQUIRED:

1. Supply tank
2. Piezometer
3. Collecting tank

4. Measuring Pipe section
5. scale
6. stopwatch

PROCEDURE:

1. Open the inlet valve slowly and allow the water to flow from the supply tank.
2. Now adjust the flow to get a constant head in the supply tank to make flow in and out flow equal.
3. Under this condition the pressure head will become constant in the piezometer tubes.
4. Measure the height of water level "h" (above the arbitrarily selected plane) in different piezometric tubes.
5. Compute the area of cross-section under the piezometer tubes.
6. Note down the quantity of water collected in the measuring tank for a given interval of time.
7. Change the inlet and outlet supply and note the reading.
8. Take at least two reading as described in the above steps.

OBSERVATION:

S. No	Piezometric head	Duct area, a	Velocity, V	Velocity head	Total head

RESULT & DISCUSSION:

Experiment-03

APPARATUS FOR DETERMINATION OF CO-EFFICIENT OF DISCHARGE, VELOCITY & CONTRACTION OF ORIFICES

OBJECTIVE:

Study the flow of liquid through orifice.

AIM:

The determination of co-efficient of discharge, Velocity, Contraction of Orifices

THEORY:

It works on Bernoulli's principle and device use for measuring the rate of fluid flowing through a pipe. It is a cheaper device as compared to venturimeter. It consists of flat circular plate which has a circular sharp edge hole called as orifice which is concentric with pipe. The orifice diameter is generally kept ½ times the diameter of pipe. An Orifice meter is used to measure the discharge in a pipe. An Orifice meter in its simplest form consists of a plate having a sharp edged circular hole known as an orifice. The plate is fixed inside the pipe.

A mercury U-tube manometer is inserted to know the difference of pressure head between the two tapping. Orifice meter works on the same principle as that of Venturimeter i.e. by reducing the area of flow passage a pressure difference is developed between the two section and the measurement of pressure difference is used to find the discharge.

UTILITIES REQUIRED:

1. Supply Tank
2. Measuring Tank
3. Set of Orifices
4. Scale and sliding apparatus

PROCEDURE:

1. Open the inlet valve and maintain the head constant (at supply tank) over the orifice.
2. Allow water to flow through the orifice and note the maximum head over the orifice that permits the water jet to flow into the measuring tank.
3. Regulate the inlet valve to obtain a constant head of water over the center of orifice and note the time taken for collecting water to a height 'h' in the measuring tank.
4. Note X_0 and Y_1 co-ordinates using the pointer gauge at the center of vena contracta (taken as 0.5 time the diameter outside the orifice opening).
5. Measure the X_2 and Y_2 coordinates at any point on the center of the jet, preferably at the farthest point.
6. Adjust the head over the orifice and repeat the experiment.

FORMULAS TO BE USED:

1. *Co-efficient of discharge*

   C_d = Co-efficient of discharge, $C_d = \frac{Q_{act}}{Q_{th}}$

2. *Co-efficient of Velocity:-*

   C_v = Co-efficient of Velocity, $= \sqrt{\frac{X^2}{4YH}}$

3. *Co-efficient of contraction:-*

   C_c = Co-efficient of Contraction $= \frac{C_d}{C_v}$

Where,

Q_{act} = Actual discharge = A x h / t

Q_{th} = Theoretical discharge = $a \times \sqrt{2gH}$

A = Area of the measuring tank = (29.5×49.5) cm^2

h = Rise of water level (say 10cm) in meters.

t = Time in seconds for raise of water level.

d = Diameter of the orifice = 0.98 mm

a = Area of the Orifice (or Mouthpiece) $= \pi / 4\ d^2$

H = Height of liquid above the centre of the Orifice (or Mouthpiece).

X = Horizontal co-ordinate of the jet at the measuring point.

Y = Vertical co-ordinate of the jet at the measuring point.

H = Height of liquid above the centre of the Orifices.

OBSERVATION TABLE:

Sl.No	Time for rise of water level, t	Head over the orifice, H	Actual discharge, Q_a	Theoretical Discharge, Q_{th}	Co-efficient of discharge, C_d	Horizontal co-ordinate, $X = \lvert X_1 - X_2 \rvert$	Vertical co-ordinate, $Y = \lvert Y_1 - Y_2 \rvert$	Co-efficient of contraction, C_v	Co-efficient of contraction, C_c
1									
2									
3									

RESULT & DISCUSSION:

Experiment No. 04
FORCED VORTEX

OBJECTIVE:

To study rotating mass of fluid in forced vortex condition.

AIM

To determine the surface profile of a vortex apparatus.

THEORY

When a liquid contained in a cylindrical vessel is given the rotation either due to rotation of the vessel about vertical axis or due to tangential velocity of water, surface of water no longer remains horizontal but it depresses at the center and rises near the walls of the vessel. A rotating mass of fluid is called vortex and motion of rotating mass of fluid is called vortex motion. Vortices are of two types viz. forced vortex and free vortex. When a cylinder is in rotation then the vortex is called forced vortex. If water enters a stationary cylinder then a vortex is called a free vortex.

Description of the Apparatus:

The setup consists of an open transparent acrylic cylinder, which is free to rotate about its vertical axis. The cylinder is suitably mounted on a plate. The plate is rotated with the help of a variable speed motor so that cylinder rotates about its vertical axis. A pointer gauge mounted on graduated carriage (in X_Y co-ordinates) is also provided for measuring the RPM of motor.

UTILITIES REQUIRED:

1. Electricity supply: single phase, 220 V AC, 50Hz, 5-15-amp socket with earth connection.
2. Water supply.
3. Drain required.
4. Bench area required: 1m×1m.

PROCEDURE

1. Close the drain valve of the cylindrical vessel. Fill up some water (say 4-5 cm height from bottom) in the vessel.
2. Switch "ON" the supply and slowly increase the motor speed. Do not start the pump. Keep motor speed constant and wait till the vortex formed in the cylinder stabilizes. Once the vortex is stabilized note down the co-ordinates of the vortex and completes the observation table.
3. With the surface speed attachment of the tachometer, measure the outside rotational speed of vessel and note down in the observation table.

OBSERVATIONS:

S.No	N, rpm	Z_r, cm	R_r, cm	Z, cm	R, cm

FORMULAS TO BE USED:

a) $\omega = \frac{2\pi N}{60}$ in rad/sec
b) $r = \frac{R_r - R}{100}$ in m.
c) $Z_c = \frac{\omega^2 r^2}{2g}$ in m.
d) $Z_A = \frac{Z_r - Z}{100}$ in m.
e) $\%\ Error = \frac{Z_A - Z_C}{Z_A} \times 100$

Where,
N =RPM of the cylinder.
R= Horizontal scale reading at particular point on the vortex surface, cm.
R= Difference of horizontal scale reading between particular point & at datum depth of

the vortex, cm.

R_r= Horizontal scale reading of the datum depth point of the vortex, cm

Z= Vertical scale reading at particular point on the vortex surface, cm.

Z_A=Actual height of particular point from the deepest point, m.

Z_C= Calculated height of particular point from deepest point, m.

Z_r= Vertical scale reading of the datum depth point of the vortex, cm.

ω= Angular velocity at particular point on vortex, rad/sec

PRECAUTIONS:

1. While making the experiment of forced vortex, see that water does not spill away from the vessel. Do not increase the speed of rotation excessively.
2. Do not start the pump for forced vortex equipment.

RESULT & DISCUSSION:

Experiment-05

CLOSED CIRCUIT PIPE FRICTION APPARATUS

OBJECTIVE

To study frictional losses in pipes of varying section

AIM

To determine of the co-efficient of friction for a pipe.

INTRODUCTION

The Closed Circuit Self- sufficient portable package system Apparatus for frictional losses in pipes is primarily designed for conducting experiments on the frictional losses in pipes of different sizes. This unit has several advantages like, this does not require any foundation, trench work, etc., and so that you can conduct the experiments keeping the unit anywhere in the laboratory soon after receiving the equipment.

UTILITIES REQUIRED

The unit consists mainly of

Piping System

Measuring Tank

Differential Manometer

Supply pump set

Sump.

EXPERIMENTAL PROCEDURE

BEFORE COMMISSIONING

Check whether all the joints are leak proof and water tight.

Close all the cocks on the pressure feed pipes and Manometer to prevent damage and overloading of the manometer.

Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertical.

Given electrical connections to the switch is internally connected to the meter.

The apparatus is primarily designed for conducting experiments on the frictional losses in pipes sizes. 25mm pipe are provided for wide range of experiments. Pipe can be connected to the Manometer through the pressure feed pipes having individual quick operating cocks.

While taking reading close all the cocks in the pressure feed pipe except the two (upstream and downstream) cocks, which directly connect the manometer to the required pipe for which the loss in head has to be determined. (Make sure while taking readings, that the manometer is properly primed. Priming is the operating of filling the Manometer upper part and the connecting pipes with water venting the air from the pipes).

First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.

The actual discharge is measured with the help of the measuring tank. For each size of the pipe the area of cross section of flow can be calculated from the known diameter of the pipes. From these two valves and the average velocity of from through the pipe can be calculated.

The actual loss of head is determined from the Manometer readings. The frictional loss of head in pipes is given by the Darcy's formula

$$\text{Darcy's formula} = h_f = \frac{4flV^2}{2gd}$$

OBSERVATION TABLE

Sl. No.	Diameter of Pipe (d)	Area of Pipe (a_2)	Time for raise of 10 cm water (t)	Discharge (Q)	Velocity (V)	Head (H)	Loss of head (h_f)	Co-efficient of friction (f)

FORMULA TO BE USED:

$$\text{Darcy's formula} = h_f = \frac{4flV^2}{2gd}$$

Discharge, Q = $(A \times h)/t$ m^3 / sec

Where,

$h_f =$ Loss of head in meter of water = H x 12.6 mm

f = Co-efficient of friction for the pipe

L = Discharge between sections for which loss of head is measured (1 meter)
V = Average velocity of flow in m/sec = Q/a
g = Acceleration due to gravity
d = Pipe diameter in meters
a = Area of the pipe in m^2
A = Area of the measuring tank in meters = 0.3 x 0.3 m^2
h = Rise of water level (say 10 cm) in meters.
t = Time in seconds for raise of water level (say 10 cm)

RESULT & DISCUSSION:

Experiment 06
IMPACT OF A JET

OBJECTIVE

Study of the force exerted by a jet.

AIM:

To study the effect of force on hemispherical vane

THEORY

If a vertical water jet moving with velocity "V" is made to strike a target, which is free to move in the vertical direction, then a force will be exerted on the jet by the impact of the jet. According to momentum equation, this force(Which is also equal to the force required to bring back the target in its original position) must be equal to the rate of change of momentum of the jet flow in the same direction.

Due to impact of the jet on the flat stationary plate, the entire velocity of the jet is destroyed and due to the rate of change of momentum, force acts on the plate. The jet after striking will move along the plate. But the plate is right angles to the jet. Hence the components of the velocity of the jet in the direction of the jet after striking it will be zero. The force exerted by the jet on the plate in the direction of the jet,

F_X =Rate of change of momentum in the direction of force

$=\frac{initial\ momentum - Final\ momentum}{time}$

$=\frac{Mass(initial\ velocity - Final\ velocity)}{time}$

= $\rho AV(V-0)$ for flat plate

= $\rho AV(V-(-V))$ for hemispherical vane

= $2\rho AV^2$

UTILITIES REQUIRED

1. Electricity supply: single phase, 220 V AC,50Hz, 5-15-amp socket with earth connection.
2. Water supply.
3. Drain required.
4. Bench area required: 1.5 m×0.75 m.

PROCEDURE

1. Fill up clean water in the sump tank up to the mark
2. Fix the flat plate to the fixing rod. Fix the nozzle in perspex box at centre and close the top covers.
3. Adjust the balance weight. Locking bolt is provided so that the vane fixing rod is in horizontal position.
4. Connect the electric supply and hose pipe connection to inlet of the nozzle.
5. Fully open the bypass valve. Start the pump.
6. Slowly close bypass valve. The jet strikes the vane.
7. Now, the vane fixing rod gets unbalanced. Put the sliding weight over the rod and adjust its distance such that vane fixing rod is in balanced position.
8. Note down the balance weight and its distance from the centre of the pivot.
9. Close the discharge valve of the measuring tank. Turn the funnel towards the measuring tank so that the water gets collected in the measuring tank. Start stop watch at -0 Lit and measure the time required for 10 Lit.
10. For next reading use same procedure.
11. After completion of experiment drain all the water and tighten the drain plug.

OBSERVATION TABLE

S.No	W_A, kg	R_1, m	R_2, m	t, sec

FORMULA TO BE USED:

$R = \frac{R_1 - R_2}{100}$, in m

Q=$\frac{A \times R}{t}$, in m^3/s

$V = \frac{Q}{a}$, in m/s

$F_X = 2\rho AV^2$,for hemispherical vane

W=$W_{D+R} + W_H + W_A$, in kg

$F_{th} = W \times g, in\ N$

$$Error = \frac{F_x - F_{th}}{F_x} \times 100\ , in\ percnentage$$

Where,
A=Area of measuring tank, m^2
a=Cross section area of nozzle, m^2
d=Diameter of nozzle=0.01 m
F_x = Actual force, N
F_{th} = Theoretical force, N
Q=Actual Discharge,m^3/s
R=Rise of water level in measuring tank, m
R_1 = Final height of water in measuring tank after time t, m
R_2 = Initial height of water in measuring tank, m
t= Time for R, sec
V= Velocity of jet, m/s
W=Total weight, kg
W_A=Weight applied on the disc with rod, kg
W_H=Weight of hemispherical vane, kg = 0.217
W_{D+R}=Weight of aluminium disc with rod, kg = 0.538

RESULT & DISCUSSION:

Experiment 07

ROTAMETER CALIBRATION TEST RIG

OBJECTIVE

Measurement of discharge through rotameter

AIM:

Calibration of Rotameter

THEORY

The rotameter is a variable-area meter that consists of an enlarging transparent tube and a metering "float" (actually heavier than the liquid) that is displayed upward by the upward flow fluid through the tube. The tube is graduated to read the flow directly. Notches in the float cause it to rotate and thus maintain a central position in the tube.

The working principle of rotameter is as follows. When we place a constriction in a closed channel carrying a stream of fluid, there will be increase in velocity and hence increase in Kinetic energy, at the constriction, from an energy balance, as given by Bernoulli's Theorem, there must be a corresponding reduction in pressure. Rate of discharge from the constriction can be calculated by knowing this pressure reduction, the area available for flow at the constriction, the density of fluid, and the co-efficient of discharge.

UTILITIES REQUIRED

1. Electricity supply: single phase, 220 V AC,50Hz, 5-15-amp socket with earth connection.
2. Water supply.
3. Drain required.
4. Floor area required: 1.5 m×0.75 m.

PROCEDURE

1. Open the ball valve provided in the Rotameter pipeline
2. Now switch ON the main power supply and switch ON the pump.
3. Set the flow rate with the help of by pass and flow control valves provided in Rotameter pipline.
4. Measure the discharge with the help of measuring tank and stop watch.
5. The actual discharge, verify the set value of Rotameter..
6. Repeat the same procedure for different flow rates.

OBSERVATION TABLE

S.No	Q_t, LPH	R_1, cm	R_2, cm	t, sec

FORMULA TO BE USED:

$R = \frac{R_1 - R_2}{100}$, in m

$Q_a = \frac{A \times R}{t}$, in m^3/s

Q_t = ______ LPH

$V = \frac{Q}{a}$, in m/s

$Error = Q_t - Q\ , in\ percnentage$

Where,

A=Area of measuring tank, m^2
R=Rise of water level in measuring tank, m
Q_a = Actual discharge for rotameter, m^3/s
Q_t = Theoritical discharge for rotameter, m^3/s
R_1 = Final height of water in measuring tank after time t, m
R_2 = Initial height of water in measuring tank, m
t= Time for R, sec

RESULT & DISCUSSION

Experiment No: 8

PRESSURE MEASUREMENT APARATUS

OBJECTIVE

To study of pressure measurement.

AIM:

To measure the pressure of fluid

THEORY:

Pressure or intensity of pressure may be defined as the force exerted on a unit area. If F represents the total force uniformly distributed over an area A, then the pressure at any point is

$P=\frac{F}{A}$

However, If the pressure is not uniformly distributed, the expression will give the average value only. When the pressure varies from the point to point on an area, the magnitude of pressure at any point can be obtained by the following expression:

$P=\frac{dF}{dA}$

Where dF represents the force acting on the area dA in the normal direction. The unit of pressure can be mentioned as N/m^2.

UTILITIES REQUIRED:

1. Electricity supply: single phase, 220 V AC,50Hz, 5-15-amp socket with earth connection.
2. Water supply.
3. Drain required.
4. Floor area required: 1.5 m×0.75 m.

5. Mercury for manometer(250gm)

PROCEDURE:

1. Apply air pressure by pump.
2. Take the corresponding pressure reading from the pressure gauge.
3. Take the manometric difference reading to calculate the pressure.
4. Now compare the showing value with actual value.
5. Different observations can be taken by varying the air pressure.

OBSERVATION:

S. NO	P_s, Kg/cm^2	h_1,cm	h_2,cm

CALCULATIONS

$P_c=(h_1-h_2)\times \rho_m$, kg/cm^2

NOMENCLATURE

h_1, h_2= Manometer reading, m

P_s= Pressure gauge reading, Kg/cm^2

Pc= Calculated Pressure, Kg/cm^2

RESULTS AND DISCUSSION:

Experiment No:9

DARCY'S LAW APPARATUS

OBJECTIVE:

To Study of fluid flow through porous medium

AIM:

To verify Darcy's Law and to find out the coefficient of permeability of the given medium.

THEORY:

The flow of a fluid through a porous medium follows, under certain limitations, Darcy's law, means

V=ki

Where V is the mean apparent velocity which is equal to the rate of discharge divided by the area of cross-section of the solid mass perpendicular to the flow direction, k the constant of proportionality termed as the coefficient of permeability and "i"(hf/L) is the hydraulic gradient. This law is valid when inertial forces are less than the viscous forces, In general, the law is considered as valid when the Reynolds number is less than unity. Beyond Darcy's range the mean velocity is given by

$V=ki^n$

Where the index n is greater than unity.

It is obvious that the velocity and hydraulic gradient are measured for small velocities of flow and plotted on alog-log paper, the resulting plot will be straight line inclined at an angle of 45^0 . Beyond this range, resulting straight line will have a steeper slope.

PROCEDURE:

1. Clean the apparatus and make all tanks free from dust.
2. Close the drain valves provided.
3. Fill Sump tank $3/4^{th}$ with clean water and ensure that no foreign particles are there.
4. Close Flow control valves given on the water line and open by pass valve
5. Close all pressure Taps of Manometer connected to the bed.
6. Ensure that ON/OFF switch given on the panel is at OFF position.
7. Now switch ON the main power supply and pump.
8. Operate the flow control valve and pressure taps of manometer.
9. Now open the air release valve provided on the Manometer slowly
10. When there is no air in the manometer, close the air release valves
11. Adjust water flow rate in testing section with the help of control valve.
12. Record Manometer reading.
13. Repeat steps for different flow rates

OBSERVATION

L12=0.25 m

L13=0.5 m

S. No	h_1,cm	h_2,cm	h_{12},cm	h_{13},cm	R_1,cm	R_2,cm	t,sec

CALCULATION

1. $R = \frac{R_1 - R_2}{100}$, m
2. $Q = \frac{A \times R}{t}$, m^3/s

3. V =$\frac{Q}{a}$, m/s
4. h_f=h($\frac{\rho_m}{\rho_w}$-1), m of water
5. i= $\frac{h_f}{L_{12}}$
6. i= $\frac{h_f}{L_{12}}$
7. k=$\frac{V}{i}$

Plot the graph between different reading of V &i.

Where,

A= Area of measuring tank

a=Cross sectional area of packed column

d= Inside diameter of column=0.12m

hf=Loss of head

i=Hydraulic gradient

K=Coefficient of permeability

L12=Difference between the manometer taps 1 &2

L13= Difference between the manometer taps 1 &2

Q=Discharge, m^3/s

R= Rise of water level in measuring tank, m

R_1 = Final height of water in measuring tank after time t,m

R_2 = Initial height of water in measuring tank,m

t= Time for R, sec

V= Velocity of jet, m/s

RESULTS AND DISCDUSSION

Experiment No 10

PITOT TUBE APPARATUS

OBJECTIVE

To measure the velocity of flow at different points in apipe.

AIM:

To find the coefficient of velocity of pitot tube

THEORY:

When a pitot tube is used for measuring the velocity of flow in apipw or other closed conduit the pitot tube may be inserted in the pipe as shown in figure. Since a pitot tube measures the stagnation pressure head at its dipped end. The pressure head may determined directly by connecting a suitable differential manometer between the pilot tube and pressure tappings at the pipe surface. Consider two points 1 and 2 at the same level in sucha way that point 2 is just at the inlet of the pitot tube and point 1 is far away from the tube. At point 1 the pressure is Pi and the velocity of the stream is v1. However, at point 2 the fluid is brought to rest and the energy has been converted to pressure energy. Therefore the pressure at 2 is p2, the velocity is zero and since 1 and 2 are in the same horizontal plane, so z1=z2.

Applying Bernoulli's equation at points 1 and 2

$$\frac{P_1}{\omega} + \frac{V^2{}_1}{2g} = \frac{P_2}{\omega} + \frac{V^2{}_2}{2g}$$

V_2=0

$$V_1 = \sqrt{2g\left(\frac{P_2}{w} - \frac{P_1}{w}\right)} = \sqrt{2gH}$$

$$V_{1act} = Cv\sqrt{2gH}$$

PROCEDURE:

1. Close all the valves provided.
2. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
3. Open by pass valve.
4. Switch on the main power supply
5. Open the pressure taps of manometer very slowly
6. Open the air release valve provided on the manometer slowly
7. Adjust water flow rate with control flow valve
8. Record manometer reading
9. Measure flow rate
10. Repeat step for different flow rates

OBSERVATION:

S.No	h_1,cm	h_2,cm	R_1,cm	R_2,cm	t,sec
1					
2					
3					
4					
5					

FORMULAE TO BE USED

6. $R = \frac{R_1 - R_2}{100}$, m
7. Q = $\frac{A \times R}{t}$, $m^3/_s$
8. V = $\frac{Q}{a}$, m/s
9. h=h_1-h_2
10. H=h($\frac{\rho_m}{\rho_w}$-1),
11. V_{th}=$\sqrt{2gH}$
12. C_v=$\frac{V_a}{V_{th}}$

Where

A	=	Area of the measuring tank = (29.5×49.5) cm^2
h	=	Rise of water level (say 10cm) in meters.
t	=	Time in seconds for raise of water level.
d	=	Diameter of thepitot tube=0.028 m
a	=	Area of the Orifice (or Mouthpiece) =π / 4 d^2
H	=	Height of liquid above the centre of the Orifice (or Mouthpiece).
C_v	=	Coefficient of velocity
V_{th}	=	Theoretical velocity
V_a	=	Actual velocity
R	=	Rise of water level in measuring tank, m
R_1	=	Final height of water in measuring tank after time t,m
R_2	=	Initial height of water in measuring tank,m
t	=	Time for R, sec

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181415	**Mechanics of Materials Lab**	**0-0-2**	**1**

Objective:
The laboratory experiments of Mechanics of Materials will impart practical knowledge of mechanics of deformable solids. The students can observe how deformable solids behave under different types of loads and the stresses and strains developed in them. The theoretical knowledge gained can be experimentally verified with practical examples.

Motivation:
Hands on experiments in laboratory to verify the theoretical knowledge make understanding of the subject in a better way. Laboratory experiments impart in-depth understanding and enhance practical knowledge.

Course Outcomes: At completion of the course, the students will able to

CO1: Analyze failure of a given specimen under gradual application of uniaxial tensile load and determine tensile stress, Young's modulus, yield stress, ultimate stress, and percentage elongation.

CO2: Experiment and verify Hook's law, i.e. the relation between stress and strain within elastic limit with the help of a coil spring.

CO3: Compare actual and calculated shear force and bending moment developed in bending of beam under different loads.

CO4: Calculate stiffness of different helical springs in both compression and tension.

Introduction

Mechanics of Materials Laboratory enables to experimentally verify the theoretical knowledge, laws and theorems of the subject through laboratory experiments.

Motivation

Hands on experiments in laboratory to verify the theoretical knowledge make understanding of the subject in a better way. Laboratory experiments impart in-depth understanding and enhance practical knowledge.

Course Objective

The laboratory experiments of Mechanics of Materials will impart practical knowledge of mechanics of deformable solids. The students can observe how deformable solids behave under different types of loads and the stresses and strains developed in them. The theoretical knowledge gained can be experimentally verified with practical examples.

<u>LIST OF EXPERIMENTS</u>

1. UNIAXIAL TENSILE TEST
2. VERIFICATION OF HOOK'S LAW
3. BENDING MOMENT EXPERIMENT

4. COMPRESSION AND EXTENSION OF SPRING

EXPERIMENT 1

UNIAXIAL TENSILE TEST

OBJECTIVE

To obtain the stress-strain curve of a metal and determine (1) Young's modulus, (2) 0.2% yield stress, (3) Ultimate tensile stress, (4) percent elongation, (5) Nominal and true fracture stress.

APPARATUS

The name of the machine is called Universal Testing Machine (UTM). Several tests can be performed on this machine *viz*., tension, compression, bending, hardness etc. The movement of the two crossheads is controlled by the flow of hydraulic fluid into the cylinder which drives a piston. The specimen is fixed between the two crossheads. The main hydraulic cylinder is fitted in the centre of the base. The lower table is connected to the main piston in the cylinder with the help of two screwed columns. The two columns can be rotated by motor driven chain and sprocket fitted in the base of the machine which enables adjustment of the lower crosshead. Two jaws with jaw locking handle are attached on the two crossheads for fitting of tensile specimen. The main units in control panel are the oil tank which contains the hydraulic oil. The pump is a positive displacement type pump. This assures continuous high nonpulsating oil current for the smooth application of the load on the specimen. Two valves on the control panel one at the right side and other at the left side are used to control the flow of hydraulic fluid into the cylinder. The right valve is a pressure compensated flow control valve. The left one is the return valve for the fluid coming out from the cylinder back to the tank. Pressure compensation of the flow control keeps a constant rate of straining regardless of the total load on the specimen.

THEORY

Mechanical testing is carried out to provide information that may be used for the design of engineering components, structures or mechanisms. The tensile test is an important mechanical test that may be used to determine various parameters like tensile stress, Young's modulus, yield stress, ultimate stress, percent elongation, nominal and true fracture stress. A **tensile test,** also known as the **tension test**, is the most fundamental type of mechanical test that can be performed on a material. The results of the test can be used to predict how the material will react to forces being applied in practical situations such as in machine components, bridges, and structures. As the material is stretched until it breaks, a comprehensive tensile profile will result producing a curve showing how it reacted to the forces being applied. This curve is commonly referred to as a "Load-Extension" diagram. The load at which the material fails is of much interest on these diagrams as is the maximum load the material can withstand - the Ultimate Load. A "load-extension" diagram, however has limited use, because its data can only be used to analyze specimens of exactly the same size and shape. To overcome this problem 'load' is converted into 'stress' (load per unit cross sectional area), and extension is converted into a percentage of the original specimen length, or 'strain'. In this way, direct comparisons can be made from the results carried out on different size and shape specimens tested on any machine. It is important to note that the **shape** of the "load-extension" diagram does not change when converted to a stress-strain diagram.

PROCEDURE

Tension Test: Adjust the load range according to the capacity of the test specimen. Minimum length of specimen varies with the type of machine. Measure the diameter of the specimen. Mark the gauge length [For cylindrical specimen, a constant ration of gauge length to diameter produces constant percentage elongation provided the specimens are manufactures from the same quality of stock, According to ISO recommendation, the $\frac{L_0}{\sqrt{A_0}}$ ratio is maintained to be 5.65. For other shapes, $L_0 \propto \sqrt{A_0}, i.e. L_0 = k\sqrt{A_0}$].

Select the proper jaw inserts in the chuck assemblies of the two jaws. First, grip fully the upper end of the test piece. Apply the load gradually. The left valve is kept in fully closed position and the right valve in normal open position. Open the right side valve and close it after the lower table is lightly lifted. Operate the lower grip operation handle and lift the lower cross head up and grip fully the lower part of the specimen. Then lock the jaws in this position by operating the jaw locking handle. Then turn the right control valve slowly to open position, (i.e. anti-clockwise) until the desired loading rate is achieved. After this the specimen is under load and then unclamps the locking handle. Now the jaws will not slide down due to their own wt. Then go on increasing the load. When the test piece is broken, close the right control valve, and take out the broken pieces of the test piece. Then open the left control valve to take the piston down.

Compression test: Fix upper and lower pressure plates on the lower cross- head and the lower table respectively. Place the specimen on the lower compression plate. The specimen must be aligned exactly according to the marking on the compression plated in order to give the complete cross action of the specimen a chance to participate equally in the acceptance of load. Then adjust the zero by lifting the lower table and perform the test in the same way as the tension test.

Bending test: Keep the bending table on the lower table in such a way that the central boss of the bending table fits in the central location hole of the lower table. Tapings are provided on the lower table for this purpose. Adjust the bending supports for the required distance and clamp those to the bending table with the screws provided at the side. For adjusting the distance, use the scale marked on bending table. Stoppers are provided which are to be placed at the back of the bending supports.

Holes are provided on the bending table for locating the stoppers. The stoppers can be set in five different positions adjusting the centre distance between the supports at an interval of 100 mm. Fix the required bending pane at the lower side of the lower cross-head. Then adjust the zero by lifting the lower table and perform the test in the same way as the tension test.

OBSERVATIONS

Tension Test

Diameter of the specimen, d_O (mm) =

Gauge length of the specimen, L_O (mm) =

Final deformed Gauge length, L_f (mm) =

Maximum load, Pmax (N) =

Load at fracture, P_f (N) =

Min. diameter of the neck, d_f (mm) =

Original cross-sectional area, A_O (m^2) =

Area at the fracture (A_f) (m^2) =

From the computer plot calculate

0.2% yield stress = N/m^2

Young's modulus (E) = $\frac{\Delta P L_0}{A_0 \Delta \delta}$ N/m2

Ultimate stress = N/m^2

True fracture stress = N/m^2

Nominal average strain at fracture (% elongation) = $\frac{L_f - L_0}{L_0}$ =

True strain at fracture = $2\ ln\frac{d_0}{d_f}$

RESULT AND DISCUSSION

Sources of error: Lack of calibration of the machine, improper alignment, error in the measurement of extension etc. are the sources of error.

1. What is Bauchinger effect? Illustrate with Stress-Strain Curve.
2. Percent elongation of a material is referred as 17%. What is wrong with this statement?

EXPERIMENT 2

VERIFICATION OF HOOK'S LAW

OBJECTIVE

To study and verify Hooke's law with the help of a coil spring

APPARATUS

1. Table clamp or rod
2. Support rod
3. Crossbar
4. Meter stick/rod clamp
5. Mass hanger
6. Slotted masses (50g, 100g, 200g)
7. Brass spring
8. Collar hook

THEORY

Hooke's law of elasticity is an approximation that states that the extension of a spring is in direct proportion with the load added to it as long as this load does not exceed the elastic limit.

Mathematically, Hooke's law states that $F = -kx$

Where, x is the displacement of the end of the spring from its equilibrium position; F is the restoring force exerted by the material; and k is the spring constant. The negative sign indicates that the force exerted by the spring is in direct opposition to the direction of displacement. It is called a "restoring force", as it tends to restore the system to equilibrium. The potential energy stored in a spring is given by $U = \frac{1}{2}kx^2$

PROCEDURE

1. Arrange the apparatus as shown above.
2. Attach the meter stick vertically in the meter stick clamp it should be arranged in such a position that the pointer of the spring should point the 0.00mm on the scale when there is no load on the hanger.
3. Record the initial location of the hanger (with 0 grams of slotted mass) on the data table.
4. Load mass onto the mass hanger until the spring stretches at least 0.5cm from its unloaded position.
5. Record the mass and new hanger location.

6. Continue loading additional mass and recording the corresponding pointer locations. Proceed in 50g increments For 5 or 6 readings.

OBSERVATIONS

Stretch: This is how much the spring has stretched beyond its unloaded length. Subtract the original pointer position value from the new pointer position value to determine the stretch in centimeters, and then convert this value to meters. The first value of stretch (with 0 grams of slotted mass) is 0 m.

Now draw a load vs stretch graph. Check that it is linear.

$F=-kx$ is Hooke's Law,

PRECAUTIONS

1. The axis of the spring must be vertical.
2. The spring should not be stretched beyond elastic limits.
3. The pointer should move freely on the scale.
4. Load should be placed gently in the scale.
5. The scale should be set vertical. It should be arranged to give almost the maximum extension allowable.

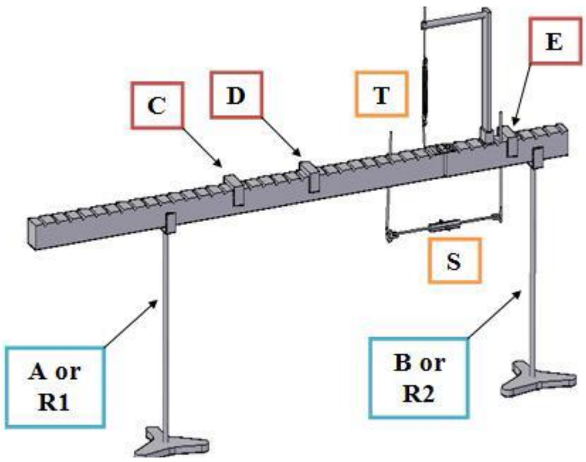
EXPERIMENT 3

BENDING MOMENT EXPERIMENT

OBJECTIVE

To compare the calculated value and the observed value of bending moment at a cross section of the beam supported at its ends.

APPARATUS



1. Shear force apparatus
2. Meter rod
3. Weights

A or R1: Meter Rod 1

B or R2: Meter Rod 2

C: Weight 1

D: Weight 2

E: Weight 3

S: Spring Balance Horizontal

T: Spring Balance Vertical

THEORY

At any cross section of the beam, bending moment due to the forces on the L.H.S. of the cross section is equal to the bending moment due to the forces on the R.H.S. of the cross section. The shear force on the L.H.S. of the cross section of the beam is given by magnitude of resultant of the force on L.H.S. When resultant shear force at a section is known, bending moment at that section can be obtained multiplied by the distance.

PROCEDURE

1. Note the initial reading of the spring balance when the two section AE and EB are made horizontal in the same straight line AB by tightening the screw S (at the and of the spring balance) when the beam is supported at A and B and carries no weight.
2. Suspend weight W1, W2, W3 at three different points say C,D and F of the beam. On suspending weights, AE and EB will try to separate from each other. Bring them in the same line AB by tightening the screw 'S'.
3. Calculate the reaction R1 and R2 at A and B respectively by applying law of parallel forces.
4. Take the spring balance reading and subs tract from it the initial reading. Let this reading be taken as T. This multiplied by the distance from support is the observed bending moment.
5. The resultant of forces on the L.H.S of the cross section E is given by R1-W1- W2, which multiplied by the distance from support gives the calculated bending moment.
6. Find % age error between the calculated and observed value of the bending moment.
7. Take in this way about seven reading for different values of the weights on the beam.
8. Follow the same procedure to verify the bending moment on the R.H.S. by attaching the spring balance on the R.H.S. of the section at E.

OBSERVATIONS

Initial reading of spring balance =   kg

Serial No	Weights			Reactions		BM on LHS/RHS		% error
	W1	W2	W3	R1	R2	Calculated	Observed	

PRECAUTIONS

(1) Zero error of the compression balances must be taken in to account

(2) Weights should not be put on the beam with a jerk.

(3) Slightly press beam to remove any frictional resistance at the supports before taking readings.

(4) Use larger weight to get greater tension to avoid % age error

(5) See that the beam used is very light so that its weight may be neglected.

EXPERIMENT 4:

COMPRESSION AND EXTENSION OF SPRING

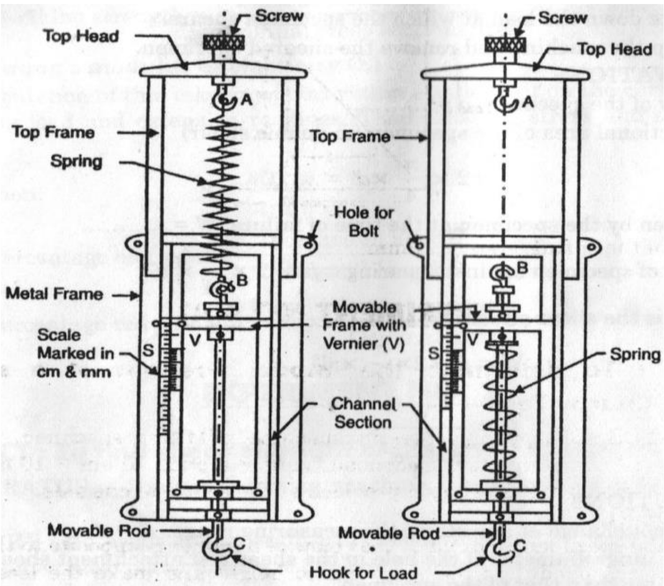
OBJECTIVE

To find the stiffness of different springs in both compression and tension

APPARATUS

Spring testing machine, helical spring, micrometer, weight etc

Spring testing machine consists of a rectangular metal frame with channel sections along both the vertical sides. It is provided with holes in each corner for fixing the apparatus by means of bolts embedded in the vertical support. The nuts are screwed tightly on the bolts. Between the side channels, a movable frame with vernier (V) marked 0-10, attached with a rod moves freely when load is applied at the bottom hook (C). There is a hook (B) on the top of this movable frame. Another frame at the top is fixed with the channel sections of the metal frame. The top frame has a horizontal top head with head with a screw at top and a hook (A) in the centre. When tensile loads are applied at bottom hook (C), the spring is attached between the hooks A and B.



(a) For Tensile Loads (b) For Compressive Loads

THEORY

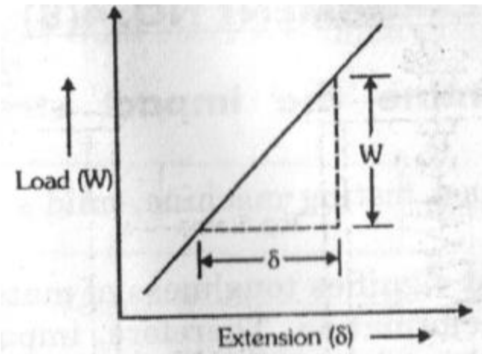
Hooke's law of elasticity as applied to a spring proves that the extension or compression of a spring is in direct proportion with the load added to it as long as this load does not exceed the elastic limit.

Mathematically, Hook's law states that $W = k\,\delta$

Where, δ is the displacement of the spring from its equilibrium position; W is the load added and k is the stiffness of spring.

PROCEDURE

1. Adjust the initial reading to zero. Or note down the initial reading before the application of load.
2. Apply a load W1 on the hook (C).
3. Note down the reading on the scale to measure the extension in mm.
4. Increase the load gradually.
5. Note down the corresponding extensions with the vernier scale (V).
6. Plot the graph between load (W) and extension (δ).



Serial No	Axial Tensile Load W in N	Extension δ in mm

Stiffness of the spring = $k = \frac{W}{\delta}$ N/mm

3.4 FIFTH SEMESTER

B.Tech 5th Semester: Mechanical Engineering

Sl. No.	Sub-Code	Subject	Hours per Week			Credit	Marks	
			L	T	P	C	CE	ESE
Theory								
1	ME181501	Applied Thermodynamics - I	3	0	2	4	30	70
2	ME181502	Machine Design - I	3	0	2	4	30	70
3	ME181503	Mechanisms and Dynamics of Machines	3	0	2	4	30	70
4	ME181504	Heat Transfer - I	3	0	0	3	30	70
5	ME181505	Engineering Inspection and Metrology	3	0	0	3	30	70
6	HS181506	Engineering Economics	3	0	0	3	30	70
Practical								
1	ME181514	Heat Transfer – I Lab	0	0	2	1	15	35
2	ME181515	Engineering Inspection and Metrology Lab	0	0	2	1	15	35
3	SI181521	Internship-II (SAI-Academia)	0	0	0	1	-	100
TOTAL			18	0	10	**24**	**210**	**590**
Total Contact Hours per week: 28								
Total Credits: 24								

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181501	**Applied Thermodynamics - I**	**3-0-2**	**4**

Course Outcomes (CO): On successful completion of this course the student should be able to:

CO1: Apply the various thermodynamic laws and properties of steam for suitable applications in a steam power plant.

CO2: Analyse the Thermodynamic processes involved in the various components of a steam generating plant.

CO3: Evaluate the performance of steam power cycle and select suitable modified methods to improve the efficiency of power cycle.

CO4: Compare the components of a power plant like boiler, nozzle, turbine and condensers in terms of their advantages and disadvantages for selection in industrial applications.

CO5: Explain the concepts of Availability and Irreversibility under various thermodynamic flow systems.

MODULE 1: Availability

Available and unavailable energy, Available energy referred to a cycle, Availability in non-flow or closed system (Non-cyclic), Availability of steady-flow systems, Helmohltz and Gibb's functions, Irreversibility and loss in availability, Effectiveness.

MODULE 2: Boiler

Classification of boilers, mountings, accessories, evaporation capacity, equivalent evaporation, boiler efficiency, selection of a boiler, boiler feed water treatment and boiler troubles.

MODULE 3: Basic Steam Power Cycles

Carnot and Rankine cycles, Modified Rankine cycle, Regenerative and Reheat cycles.

MODULE 4: Steam Nozzles

Expansion of steam through nozzles, velocity and pressure variation in nozzles, Critical pressure ratio, mass flow rate and maximum mass flow rate, Representation of heat drop in nozzles in Mollier diagram, Nozzle efficiency.

MODULE 5: Steam Turbines

Classification, Flow of steam through impulse and reaction turbines, Velocity diagrams, Reheating, Bleeding, Reheat factor, Compounding and governing of steam turbines, Back pressure turbines, Pass out turbines.

MODULE 6: Steam Condensers

Function of steam condenser, Elements of a condenser plant, vacuum production, Delton's law of partial pressure, Classification of condensers, Sources of air leakage in condensers and their effects, Removal of air from the condesers, Vacuum efficiency and condenser efficiency, Determination of cooling water, Cooling towers and cooling ponds.

Textbooks/ Reference Books:

1. A course in thermodynamics and heat engines by Domkundwar, Kothendaraman, Khajuria and Arora, Dhanpat Rai and Sons.
2. Thermal Engineering by Er. R.K.Rajput, Laxmi Publications.
3. Elements of heat engines by Patel, Karamchandani
4. A text book of thermal engineering by Khurmi, Gupta, K Chand Publications.
5. Applied Thermodynamics by P.K. Nag, Mc Graw Hill Education (India) Pvt Ltd.

Lesson Plan and Evaluation Plan:

Lesson Plan

Unit/Topic	Lectures	Methodology/Pedagogy
Unit 1: Availability	5	Chalk and black board and hand notes
Unit 2: Boiler	6	Chalk and black board, also with PPP by LCDP
Unit 3: Basic steam power cycles	7	Chalk and black board, also with PPP by LCDP
Unit 4: Steam nozzles	4	Chalk and black board, also with PPP by LCDP
Unit 5: Steam turbines	6	Chalk and black board, also with PPP by LCDP
Unit 6: Steam condensers	2	Chalk and black board, also with PPP by LCDP

APPLIED THERMODYNAMICS –I (LABORATORY)

List of Experiments:

1. To study various types of boiler models.

2. (a) To study coal fired vertical boiler and their accessories and mountings.

   (b) To study oil fired horizontal boiler and their accessories and mountings.

3. To find dryness fraction of steam by separating and throttling calorimeter.

4. (a) To simulate the performance of boiler and draw efficiency versus pressure curves.

   (b) To simulate the performance of Rankine steam power cycle.

EXPERIMENT NO. 1

Objective: To study various types of boiler models.

Apparatus Used: Cut out sectional models of different components of steam generating unit & steam turbine available in steam power plant mainly within the category of (i) Fire tube and (ii) water tube boiler.

Observation and demonstration:

After minute observation of the cut-out models (sectional) the student will be able to understand the proper functioning of the components in respective steam generating unit. The instructor will provide requisite demonstration on the different models to order to learn the comparison and differences of various types of boilers with their relative merits and demerits.

Step1. Observe different cut out (sectional) models of the boiler and its components.

Step2. Draw the free hand sketch of the models showing proper direction of steam flow.

Step3. Note down the critical points of each component's application in boiler.

Step4. Try to know the properties of material of the component from metallurgical point.

Report writing:

At the end of the observation and complete demonstration, the student will have to submit a report which will contain the followings:

1. Function of each type of boiler with neat sketches and its application.
2. Name of different models of the component of boiler and their function with neat sketch.

EXPERIMENT NO. 2(a)

Objective: - To study coal fired vertical boiler and their accessories and mountings.

Apparatus Used: - Model of Cochran boiler (low pressure boiler).

COCHRAN BOILER: Cochran boiler is a vertical, multi-tublar fire tube, internally fired, natural circulation boiler.

Construction: Cochran boiler consists of a vertical cylindrical shell having a hemispherical top and furnace is also hemispherical in shape. The fire grate is arranged in the furnace and the ash pit is provided below the grate. A fire door is attached on the fire box. Adjacent to the fire box, the boiler has a combustion chamber which is lined with fire bricks. Smoke or fire tubes are provided with combustion chamber. These tubes are equal in length and arranged in a group with wide space in between them. The ends of these smoke tubes are fitted in the smoke box. The chimney is provided at the top of the smoke box for discharge of the gases to the atmosphere. The furnace is surrounded by water on all sides except at the opening for the fire door and the combustion chamber. The smoke tubes are also completely surrounded by water. Different boiler mountings and accessories are located at their proper place.

Working:

The hot gas produced from the burning of the fuel on the grate rises up through the flue pipe and reaches the combustion chamber. The flue gases from the combustion pass through the fire tubes and the smoke box and finally are discharged through the chimney. The flue gases during their travel from fire box to the chimney gives heat to the surrounding water to generate steam.

Report writing:

Step1. Write the make, model and specification of the boiler under observation.

Step 2. Identify and name the different components of the coal fired vertical boilers.

Step 3. Explain the functions of each component in brief with suitable sketch.

Step 4. Classify the components under mountings and accessories and give justification.

Step 5. Sketch the boiler clearly depicting the line of feed water, oil flow , flue gas flow and steam flow.

Step 6. Observe minutely the oil fired mechanism and draw the water heating process.

Step 7. Classify the boiler on the basis of heating and write proper justification.

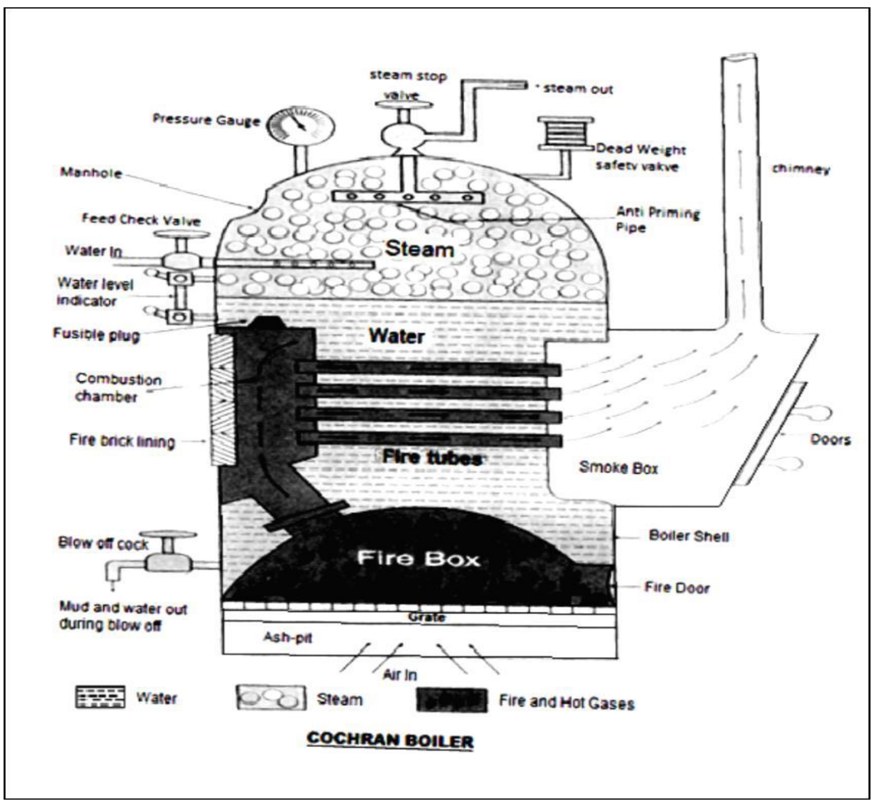


Fig 5.1: Cochran Boiler

EXPERIMENT NO. 2(b)

Objective: - To study oil fired horizontal boilers and their accessories and mountings.

Apparatus Used: - Model of Westerwork horizontal oil fired fire tube 3 pass boiler.

Theory: Boiler is an apparatus to produce steam. Thermal energy released by combustion of fuel is used to make steam at the desired temperature and pressure. The steam produced is used for producing mechanical work by expanding it in steam engine or steam turbine, heating the residential and industrial buildings and performing certain processes in the sugar mills, chemical and textile industries.

Observation and demonstration: -This experimentation will give the students an real exposure on the study of steam generating unit by observing and identifying the different components of the oil fired horizontal boiler.

Report writing:

Step 1. Identify and name the different components of the oil fired horizontal boilers.

Step2. Explain the functions of each component in brief with suitable sketch.

Step3. Classify the components under mountings and accessories and give justification.

Step4. Sketch the boiler clearly depicting the line of feed water, oil flow and steam flow.

Step 5. Observe minutely the oil fired mechanism and draw the water heating process.

Step 6. Classify the boiler on the basis of heating and write proper justification.

Fig 5.2: Fire tube boiler

EXPERIMENT NO. 3

Separating and Throttling Calorimeter

Objective: The objective of this experiment is to determine the dryness fraction of wet steam.

Apparatus:

a. Ward steam bench
b. Steam boiler plant (unit 1).
c. Separating and throttling calorimeter (unit 3)
d. Measuring
e. Beaker

Theory:

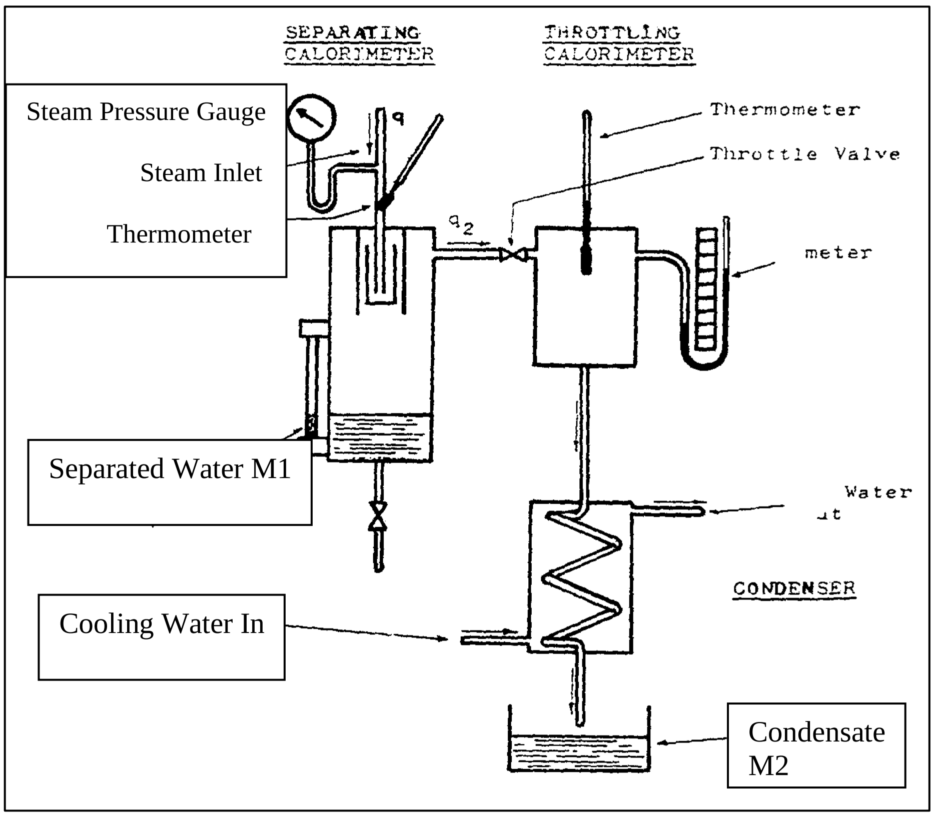


Fig 5.3: Schematic diagram for the separating and throttling Calorimeters.

The separating calorimeter is a vessel used initially to separate some of the moisture from the steam, to ensure superheat conditions after throttling. The steam is made to change direction suddenly; the moisture droplets, being heavier than the vapor, drop out of suspension and are collected at the bottom of the vessel.

The throttling calorimeter is a vessel with a needle valve fitted on the inlet side. The steam is throttled through the needle valve and exhausted to the condenser. Suppose M kg of wet steam with a dryness fraction of x (state A) enters the separating calorimeter. The vapor part will have a mass of xM kg and the liquid part will have a mass of (1-x)M kg. In the separating calorimeter part of the liquid, say M_1

kg will be separated from the wet steam. Hence the dryness fraction of the wet steam will increase to x1 (state B) which will pass through the throttling process valve. After the throttling process the steam in the throttling calorimeter will be in superheated state (state C).

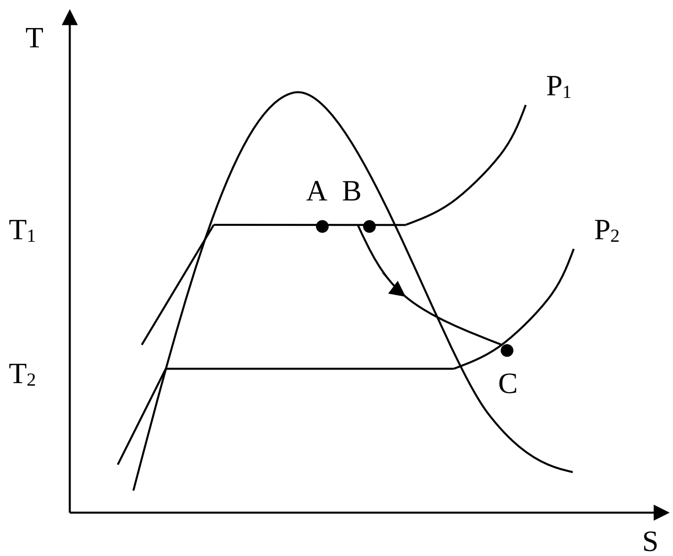


Fig 5.4: T-S diagram of the separating and throttling calorimeter

From the steady flow energy equation;

$$Q - W = h_C - h_B$$

Since throttling takes place over a very small distance, the heat transfer is negligible, i.e., Q = 0. Then the steady flow energy equation for the throttling process becomes,

$$h_C = h_B$$

Hence, enthalpy after throttling = enthalpy before throttling

$$h_C = h_{f1} + x_1 h_{fg1}$$

If the pressure of the steam before throttling, the pressure and temperature of the steam after throttling, are known the value of x_1 can be calculated using steam tables.

$$\text{Dryness Fraction} = \frac{\text{Mass of dry steam}}{\text{Mass of mixture}}$$

Therefore, $$X = \frac{x_1 M_2}{M_1 + M_2}$$

Where, M_2 is the mass of condensate.

Experimental Procedure:

1) Fill the boiler chamber by filtered water around 75% of its capacity (must be more than 50%). The glass tube attached to the boiler chamber will indicate the water level. During water filling both the valves of the boiler should kept open position and at the end of filling of water close both the valves. Now, on the power supply to the unit.
2) Set the boiler temperature in the control panel (Right side Digital Indicator, DTI_R) in and 125^0C. To set the temperature, there are three push buttons in the DTI_R: left one to lower temp., middle to up temp., right one to set (fixing) the temp. by pressing the push button.
3) Start the boiler by switching on heater-1 or heater -2 or both the heaters. Switch of heaters are in the control panel. In this position wait for few minutes until the boiler pressure raise to desired level (may be 0.5, 1.0, 1.5, 2.0 bar or Kg/cm^2). The boiler pressure is indicated by the pressure gauge attached to the boiler.
4) Start the flow of condenser cooling water. Input of water is lower port.
5) Open the steam valve (V3) and allow the steam to flow from boiler section to separating chamber, which separates wet vapor from steam, for a time period of in between 1 to 2 minutes.
6) Open the throttle valve (V4) and adjust to give a pressure at exhaust of about 5cm Hg or water measured on the manometer or 2 division in the outer scale of the pressure gauge (0.1 kg/cm^2) attached with red coloured throttling chamber.
7) As soon as pressure is stable start the stop-watch and wait for 3 (or 4) minutes.
8) After 3 (or 4) minutes note the temperature of dry steam (T_2) indicating at the left DTI of the control panel. Also note the pressure (P_1) from the pressure gauge attached at the top of throttling chamber (i.e pressure after separating and before throttling) and pressure P_2 (from the manometer) after throttling. Temperature (T_1) indicated in the DTI_R, is the temp. of steam in the boiler which is not use here.
9) Open the drain valve of the separating chamber and take the weight (M_1) of the drained water.
10) Take the weight of the water coming out from the steam condenser and take the weight (M_2) of the drained water. The valve of the steam condenser should kept open during experimentation and collect the condensate in a pot.

Results and Calculations:

Using the average values, obtain the specific enthalpy of steam at (state C) hence calculate the dryness fraction of incoming steam. Also calculate the specific enthalpy of incoming steam.

Table Of Observations

Reading #	1	2	3	4	5	6	Ave
Steam pressure in main P_1 (bars)							
Steam pressure after throttling P_2 (bars)							
Temperature of main T_1 (^oC)							
Temperature after throttling T_2 (^oC)							
Quantity of Separated water M1 (kg)							
Quantity of condensate M_2 (Kg)							
Atmospheric pressure P_a (bars)							

EXPERIMENT NO: 4(A)

Objective: To simulate the performance of boiler and draw efficiency versus pressure curves.

Theory: A boiler is a closed vessel in which steam is produced from water by combustion of fuel.

Let M is mass of steam (in Kg) generated at a certain pressure P (in Bar) by combustion of one Kg of fuel having caloric value C kJ/Kg.

T_0 is the feed water temperature in degree C.

X is the quality of steam produced at pressure P in Bar.

Heat required to produce unit Kg of steam (H) $=h_f + x*h_{fg}$

Initial heat content in feed water $(H_f)=mc\Delta T$

Heat utilized in generation of steam unit kg $(H_U)=H-H_f$

Heat utilized in generation of M steam unit kg $(H_U)=M(H-H_f)$ kJ

Heat supplied by burning one kg of fuel=C kJ

The boiler efficiency is the ratio between Heat utilized in generation of M kg of steam and Heat supplied by burning one kg of fuel. Thus, Boiler efficiency is expressed as

$\eta= [M (H-H_f)]/C$

Assumption of computer simulation:

10 kg of steam having quality x=0.98 is to be generated by burning one kg of fuel of caloric value 32,000 kJ/kg from feed water temperature 30^0C by varying pressure from 1 Bar to 8 bar. It is required

to draw boiler efficiency versus pressure curves manually as well as through computer simulation by using steam table.

Experimental Results

Pressure of steam generation	P1 1Bar	P2 2 Bar	P3 3 Bar	P4 4 Bar	P5 5 Bar	P6 6 Bar	P7 7 Bar	P8 8 Bar
Boiler Efficiency, η	η_1	η_2	η_3	η_4	η_5	η_6	η_7	η_8

Draw the efficiency versus pressure curves as shown below.

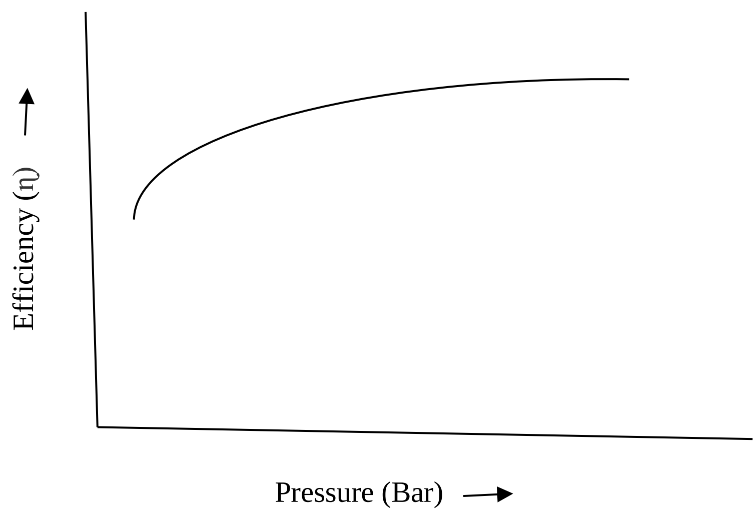


Fig 5.5: Efficiency vs pressure curve

EXPERIMENT NO: 4(B)

Aim: To simulate the performance of Rankine steam power cycle.

Theory: The Rankine cycle on which the steam turbine works is shown below:

1-2 isentropic pump   2-3 constant pressure heat addition

3-4 isentropic turbine   4-1 constant pressure heat rejection

$Q_{in}=h_3-h_2$ heat added in boiler (positive value)

$Q_{out}=h_4-h_1$ heat removed from condenser (here h_4 and h_1 signs have been switched to keep this a positive value)

$W_{turbine}=h_3-h_4$ turbine work

Now, neglecting pump work, the efficiency of the Rankine power cycle can be written as

$\eta_{rankine}$ = Turbine work/Heat added in boiler

$\eta_{rankine} = (h_3-h_4)/(h_3-h_{4f})$

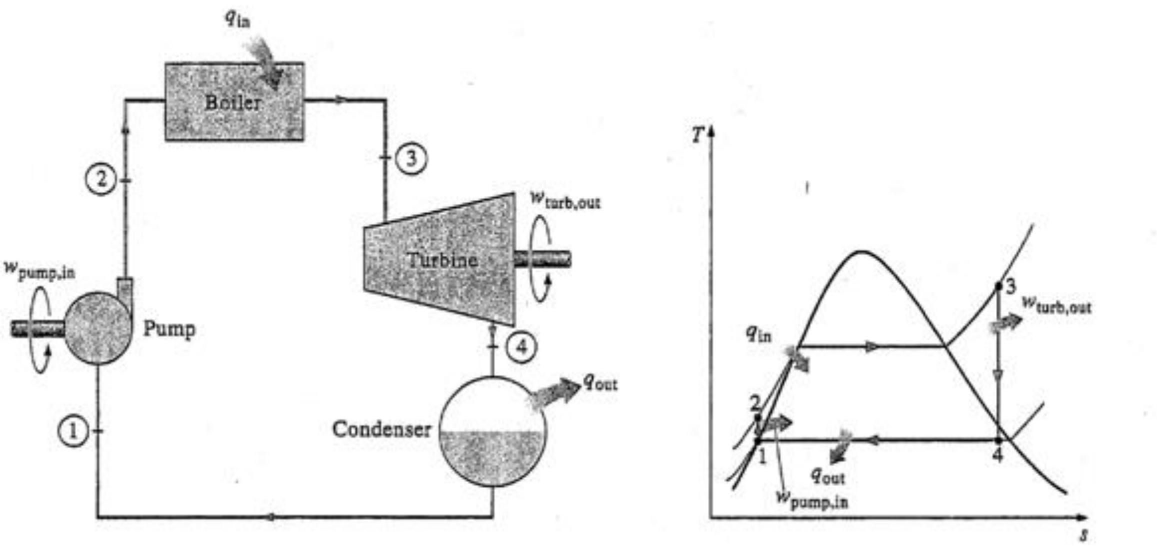


Fig 5.6: Rankine steam power cycle

The Rankine cycle efficiency can be improved by increasing the boiler pressure of steam generation.

Assumption on computer simulation problem:

In a Rankine steam power cycle dry and saturated steam is produced at different pressure keeping the condenser pressure fixed at 0.5 Bar. Compute the Rankine efficiency at different pressure and draw the Efficiency versus pressure curves both manually and through computer simulation.

Step1. Vary the steam generating pressure from 6 Bar to 18 Bar and find the values of h_3.

Step2. Compute value of h_4 at condenser pressure after knowing x_4 i.e. $h_4=h_{4f}+x*h_{4fg}$

Step3. Calculate the value of $\eta_{rankine}$ and repeat above steps and draw the curves.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181502	**Machine Design - I**	**3-0-2**	**4**

Course Outcomes: On successful completion of the course, the student will be able to:

CO1. Describe the design process, material selection, calculation of stresses and stress concentrations under variable loading. Know different types of Mechanical Failures, different Modes of failure and different theories of failure.

CO2. Design and Analyze bolted joints, standardization, Design different types of riveted joints for various Engineering applications like structural joints, boiler joints etc, Design various types of Welded Joints

CO3. Design solid and hollow shafts for different design considerations, Design of Cotter and Knuckle joints for Alternating/Tensile loads

CO4. Differentiate between rigid and flexible couplings, Design Rigid Couplings and checks against failure,

CO5. Design Belt Drive, Rope Drive and Chain Drive, Applications of these drives in Industry

MODULE 1:
Introduction, General considerations and procedure for designing, types of Loads, Designed stress and factor of safety, stress concentration, selection of materials, codes for design-BIS codes, Modes of Failure, Failure theories, Fits and Tolerance.

MODULE 2: Joints
a) Detachable joints: Design of threaded fasteners, thread forms and threaded fastener types and materials, bold tightening and initial tension, Power screws.
b) Permanent Joints: Design of Riveted joints and welded joints – eccentric loading.

MODULE 3: Shafting
Design of shaft subjected to bending, torsion, axial and combined loading Keys, Cotter and Knuckle joint

MODULE 4: Coupling
Rigid and Flexible coupling.

MODULE 5: Power Transmission Elements:
Belt and Chain Drives, design of Flat and V-belts.

Textbooks/ Reference Books:

1. Machine Design by Black and Adams (TMH)
2. Design of machine elements by M F Spott

3. Design of machine elements by B V Bhandari (TMH)
4. Machine Design by Hall
5. Machine Design by Khurmi and Gupta
6. Machine Design by Bahl and Goel
7. Machine Design by Shigley

Course Time Plan:

Units/Topics	Number of Lectures	Method of delivery
Unit I: Introduction, General considerations and procedure for designing, types of Loads, Designed stress and factor of safety, stress concentration, selection of materials, codes for design-BIS codes, Modes of Failure, Failure theories, Fits and Tolerance	8	Both chalk and talk, Demonstrations, power point presentation
Unit II: Joints a) Detachable joints: Design of threaded fasteners, thread forms and threaded fastener types and materials, bold tightening and initial tension, Power screws. b) Permanent Joints: Design of Riveted joints and welded joints – eccentric loading.	10	
Unit III: Shafting: Design of shaft subjected to bending, torsion, axial and combined loading Keys, Cotter and Knuckle joint	10	
Unit IV: Coupling. Rigid and Flexible coupling.	6	
Unit V: Power Transmission Elements: Belt and Chain Drives, design of Flat and V-belts.	6	
Total	40	1 class = 1 Hour

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181503	**Mechanisms and Dynamics of Machines**	**3-0-2**	**4**

Course Outcomes (COs) are:

CO1: To illustrate Kinematic analysis of plane motion graphically and analytically and to draw velocity and acceleration diagram; to understand the concept of Coriolis acceleration used in solving problems in kinematics.

CO2: To synthesize mechanisms to generate the desired motions by combination of different machine elements using analytical and graphical approaches.

CO3: To understand different types of mechanisms used in engineering applications and their working principles.

CO4: To estimate gyroscopic action in certain machine elements using principle of gyroscope and their practical applications.

CO5: To analyze balancing of rotating and reciprocating masses, single and multi-cylinder engines, importance of firing order and study of balancing instruments

MODULE 1: Kinematic Analysis of Plane Motion

Velocity diagram, Acceleration diagram, Coriolis component of acceleration, Analytical method of kinematic analysis.

MODULE 2: Kinematic Synthesis of Linkages

Introduction, number synthesis, basic features, analytical methods, graphical methods.

MODULE 3: Mechanisms

Mechanism, Mobility, Inversion, Test for 4 bar mechanism by Grashoff's law, Straight line mechanism, Oscillatory mechanism, Quick return mechanism, Steering mechanism, Spatial mechanism
– Hook's joints.

MODULE 4: Gyroscopic Action in Machines

Gyroscopic action and force, method of analysis, Gyroscopic action in certain machine elements, use of gyroscopic principles in instruments.

MODULE 5: Balancing

Balancing of rotating masses, two plane balancing, balancing of reciprocating masses, Graphical solution, balancing of single cylinder and multi-cylinder engines, firing order, Balancing of rotors, Field balancing, Balancing instruments.

Textbooks/ Reference Books:

1. Theory of Machines: Kinematics and Dynamics by Sadhu Singh, Pearson
2. Theory of Machines by V P Singh, Dhanpat Rai & Co
3. Theory of Machine By Rattan, Tata McGraw Hill

Mechanisms and Dynamics of Machines Laboratory:

Experiments:

Exp-1: Determination of Coriolis Component of Acceleration

Exp-2: Study of Balancing of Rotating Masses

Exp-3: Study of Balancing of Reciprocating Masses

Exp-4: Determination of Angle of Precision Using Principle of Gyroscope

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181504	**Heat Transfer - I**	**3-0-0**	**3**

Course Outcomes: At the completion of the course the student will be able:

CO1: Classify the various modes of heat transfer processes and discuss their applications.

CO2: Define various terms related to heat and mass transfer specifically Diffusion.
CO3: Discuss the mechanisms of heat transfer under steady and transient conditions and describe various examples.
CO4: Choose suitable methodology for solving wide variety of practical heat transfer problems involving Conduction and Radiation heat transfer.
CO5: Design various heat transfer systems such as Fins, Radiation shields and define related parameters.

MODULE 1: Introduction: Concept of Modes of Heat Transfer

Conduction Heat Transfer: General 3-D differential equation for heat conduction, Boundary conditions and their types.

MODULE 2: One Dimensional Steady State Heat Conduction

System with or without heat generation: slab, cylinder, sphere, Concept of thermal resistance and electrical analogy, Variable thermal resistance and electrical analogy, Composite systems: slab, co-axial cylinder, concentric sphere, Critical radius of insulation, Fins.
One Dimensional Unsteady State Heat Conduction: Lumped system analysis, Response time of a temperature measuring instrument, Mixed boundary condition.

MODULE 3: Radiation Heat Transfer

Nature of thermal radiation, emissive power, Absorption, Reflection and Transmission, Concept of a black body, Intensity of radiation, Laws of black body radiation, Radiation to and from real surfaces.

MODULE 4: Radiative Heat Exchange Between Surfaces

Radiation between two black bodies, Radiation shape factor (View factor) and its properties. Shape factors for different geometries, Radiation between two infinite parallel places, Radiation between two infinitely long concentric cylinders, Radiation between grey bodies, Electric network analogy for thermal radiation, Radiation shields, Radiation combined with convection.

MODULE 5: Diffusion Mass Transfer

Concentrations, Velocities and Fluxes, Fick’s law of diffusion, the diffusion co-efficient, Species conservation equation and the boundary equation, Steady state molecular diffusion.
Textbooks/ Reference Books:

1. A basic approach to heat transfer – by M N Ožišik, McGow Hills.
2. Fundamentals for heat transfer – by Sachdeva, Wiley Eastern.
3. Heat transfer, by P.S. Ghoshdastidar, Oxford University Press

Introduction to the Course

From study of Thermodynamics students have learned about the process of energy interactions of system and surroundings. Different energy interactions in the form of Work and Energy was dealing with the end states of the process. The course HEAT TRANSFER-I deals with the nature of heat interaction or the time rate at which this heat interactions taking place. HEAT TRANSFER-I is one among the many important and basic courses of mechanical engineering and has considerable application in relevant fields of technology and society.

This subject basically covers different modes of heat transfer specifically Conduction and Radiation and their applications. It also thermodynamically analyzes the different modes of heat transfer in various cases are and expressions for heat transfer rate are derived. Since the process of Mass transfer has many similarities with the process of Heat transfer, finally this course discusses about different modes of mass transfer specifically Diffusion. In overall this course gives a reasonable overview of several modes of transfer and their physical origins.

Motivation

Heat transfer is an important subject in the Mechanical engineering curriculum and also taught in other disciplines like Chemical engineering, Aeronautical engineering etc. The knowledge of HEAT TRANSFER-I has wide application and utility in Refrigeration and air conditioning systems, Conventional oven, IC Engine, Power plants etc. Study of the laws, which govern the process of heat transfer, the students will be in a position to design equipment in which the heat transfer process occurs. For a Mechanical engineering UG student, the basic knowledge of this subject along with the first law of Thermodynamics (conservation of energy) can be used to understand and solve the problems relevant to technology and society.

Course Time Plan:

Units/Topics	Number of Lectures	Method of deliver
Unit I – Introduction: Concept of Modes of Heat Transfer	7	Both chalk and talk and power point presentation
Unit II – One Dimensional Steady and Unsteady State Heat Conduction	14	
Unit III – Radiation Heat Transfer	5	
Unit IV – Radiative Heat Exchange Between Surfaces	6	
Unit V – Diffusion Mass Transfer	3	

TOTAL	35	1 class @ 1 hour

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181505	**Engineering Inspection and Metrology**	**3-0-0**	**3**

Course Outcomes (CO): At the completion of the course the student will be able:

CO1: To apply proper instruments for dimensional measurements according to level of precision.
CO2: To apply necessary standards for obtaining desired fit and design appropriate limit gauges.
CO3: To develop analytical and experimental techniques for precise measurement of thread and gear parameters.
CO4: To design appropriate control charts for statistical process control.
CO5: To estimate texture of machined surface by stylus equipment and optical interferometry.

MODULE 1: Introductory Concept
(a) Meaning of engineering metrology. Precision, Accuracy, Sources of errors in measurement.
(b) Meaning of engineering inspection, types of inspection, merit/demerit of 100% inspection.
(c) Sampling inspection – Representative sample.
Standards of measurement and sub-division of standards.

MODULE 2: Statistical Process Control
(a) Dimensional variations during manufacture, Chance causes and Assignable causes.
(b) Control chart and its significance in statistical process control, Meaning of process under statistical control. Examples of control charts.
(c) Computer implementation of control charts.

MODULE 3: Tolerance, Limits of Size and Fits
(a) Concept of tolerance, allowance and clearance
(b) Natural tolerance limits, Process capability and Specification limits.
(c) Hole and shaft basis systems of specifying limits of size and tolerances.
(d) Indian Standard for fits and tolerances.
(e) Limit gauges – Meaning of gauge, Taylor's principle of limit gauging, Design of hole/ring gauge and plug gauge and their use, Type I and Type II statistical errors.
(f) Interchangeability – its importance in production, techniques of achieving interchangeability during manufacture of industrial products.
Comparators – Features of comparators, classification of comparators, different comparators and their uses in mass production.

MODULE 4: Tool Room Measuring Instruments
Vernier Calliper, Micrometer screw gauge, Height gauge, Depth gauge, V blocks, Straight edges, Radius gauge, Feeler gauge, Wire gauge, Thread pitch gauge, Bevel protractor, Combination set, Bore gauge, Sine bar and slip gauges, Dial indicator with magnetic base, Surface plate, Profile projector (PP), Tool maker's microscope (TMM), Diameter measuring machine (DMM) and

Coordinate measuring machine (CMM): Types of CMM, Role of CMM, and applications of CMM.

MODULE 5: Measurement of Screw Threads

(a) Parameters for measurement of screw threads.
(b) Measurement of various parameters of screw thread such as diameter, thread angle, effective diameter and pitch.
(c) Use of screw thread micrometer and Thread pitch gauge
(d) One wire, Two wire and Three wire methods.
(e) Use of TMM, PP, DMM in thread measurement.

MODULE 6: Measurement of Gears

(a) Profile of gear tooth and Involute function.
(b) Spur gear measurements by functional and analytical tests. Parkson gear tester.
(c) Measurement of tooth thickness – chordal thickness method, constant chord method, base tangent method.
(d) Check for pitch circle diameter and tooth spacing.

MODULE 7: Surface Texture

(a) Meaning of surface texture, Elements of surface texture.
(b) Meaning of roughness and Waviness.
(c) Roughness width cut-off (Sampling length) and its significance
(d) Representation of surface roughness.
(e) Procedure of estimation of surface roughness.
(f) Measurement of surface roughness by stylus equipment.

MODULE 8: Interferometry

(a) Condition for constructive and destructive interference of monochromatic light waves.
(b) Sources of monochromatic light for lab use.
(c) Use of optical flat.
(d) Principle of Gauge length interferometer and Laser interferometer.

MODULE 9: Alignment Testing

(a) Optical methods for alignment testing
(b) Laser alignment testing.
(c) Alignment tests on machine tools

Textbooks:

1. Metrology and Measurement, Anand Bewoor, Vinay A. Kulkarni, TMH
2. Engineering metrology – M Mahajan
3. Engineering Metrology – R K Jain
4. Dimensional metrology – M K Khare and S Vajpayee, OXFORD-IBH Publishers

Reference Books:

1. Handbook of industrial metrology – ASTME publication
2. Engineering Metrology – K J Hume, Published by Macdonald & Co.(1968)
3. Practical Engineering Metrology – K W B Sharp, Sir Isaac Pitman & Sons
4. Engineering Precision measurements – A W Judge, Chapman and Hall publishing (1957)
5. Dimensional Metrology – L Miller,Edward Arnold publishing Co
6. Precision Measurements – Jack Johnson – Pitman publishing Co.

Mode of delivery	[1] Chalk & talk, [2] PPT, [3] Numerical problem solution, [4] Practical demo

DETAILS OF TOPICS COVERED	Ref	Mode of delivery	Hrs
Unit 1. Introductory concept Meaning of engineering metrology. Precision, Accuracy, Sources of errors in measurement. Meaning of engineering inspection, types of inspection, merit/demerit of 100% inspection. Sampling inspection – Representative sample. Standards of measurement and sub-division of standards.	[1] [2]	[1] [2]	3
Unit 2. Statistical Process Control Dimensional variations during manufacture, Chance causes and Assignable causes. Control chart and its significance in statistical process control, Meaning of process under statistical control. Examples of control charts. Computer implementation of control charts.	[3]	[1] [2] [3]	5
Unit 3.Tolerance, Limits of size and fits Concept of tolerance, allowance and clearance Natural tolerance limits, Process capability and Specification limits. Hole and shaft basis systems of specifying limits of size and tolerances. Indian Standard for fits and tolerances. Limit gauges – Meaning of gauge, Taylor's principle of limit gauging, Design of hole/ring gauge and plug gauge and their use, Type I and Type II statistical errors. Interchangeability – its importance in production, techniques	[2]	[1] [2] [3]	5

of achieving interchangeability during manufacture of industrial products. Comparators – Features of comparators, classification of comparators, different comparators and their uses in mass production.			
Unit 4. Tool room measuring instruments: Vernier Calliper, Micrometer screw gauge, Height gauge, Depth gauge, V blocks, Straight edges, Radius gauge, Feeler gauge, Wire gauge, Thread pitch gauge, Bevel protractor, Combination set, Bore gauge, Sine bar and slip gauges, Dial indicator with magnetic base, Surface plate, Profile projector (PP), Tool maker's microscope (TMM), Diameter measuring machine (DMM) and Coordinate measuring machine (CMM): Types of CMM, Role of CMM, and applications of CMM.	[1] [2] [3] [4] [11]	[2] [4] [5]	5
Unit 5. Measurement of screw threads Parameters for measurement of screw threads. Measurement of various parameters of screw thread such as diameter, thread angle, effective diameter and pitch. Use of screw thread micrometer and Thread pitch gauge One wire, Two wire and Three wire methods. Use of TMM, PP, DMM in thread measurement.	[3] [4] [7] [8]	[2] [4] [5]	5
Unit 6. Measurement of gears Profile of gear tooth and Involute function. Spur gear measurements by functional and analytical tests. Parkson gear tester. Measurement of tooth thickness – chordal thickness method, constant chord method, base tangent method. Check for pitch circle diameter and tooth spacing.	[3] [4] [9]	[2] [4] [5]	5
Unit7. Surface texture Meaning of surface texture, Elements of surface texture. Meaning of roughness and Waviness. Roughness width cut-off (Sampling length) and its significance Representation of surface roughness. Procedure of estimation of surface roughness.	[3] [4] [9]	[2] [4] [5]	5

Measurement of surface roughness by stylus equipment.			
Unit 8. Interferometry Condition for constructive and destructive interference of monochromatic light waves. Sources of monochromatic light for lab use. Use of optical flat. Principle of Gauge length interferometer and Laser interferometer.	[3] [4] [10]	2,3	4
Unit 9. Alignment testing Optical methods for alignment testing Laser alignment testing. (c) Alignment tests on machine tools	[3] [5] [6]	2	3

TextsMetrology and Measurement, Anand Bewoor, Vinay A. Kulkarni, TMH

1. Engineering metrology – M Mahajan
2. Engineering Metrology – R K Jain
3. Dimensional metrology – M K Khare and S Vajpayee, OXFORD-IBH Publishers

References

4. Handbook of industrial metrology – ASTME publication
5. Engineering Metrology – K J Hume, Published by MacDonald & Co. (1968)
6. Practical Engineering Metrology – K W B Sharp, Sir Isaac Pitman & Sons
7. Measuring instruments – Yu G. Gorodetsky – MIR publishers
8. Engineering Precision measurements – A W Judge, Chapman and Hall publishing (1957)
9. Dimensional Metrology – L Miller, Edward Arnold publishing Co.
10. Precision Measurements – Jack Johnson – Pitman publishing Co

Course Code	Course Title	Hours per week L-T-P	Credit C
HS181506	Engineering Economics	3-0-0	3

Course Outcomes (COs):

The students will be able to

1. Acquire knowledge about economics its nature, scope and importance.
2. Understand the economic laws, principles, and theories and their relevance in present day situation.
3. Develop the ability of critical thinking to meet the challenges at the national and global problems.
4. Apply knowledge in finding out socio-economic problems and appropriate measures to deal with them.
5. Equip students with vital knowledge to run government and non-government institutions and bodies.
6. Assemble knowledge which is vital for industry and research and evolve proper policy for economic development.

MODULE 1: Introduction to Economics (3 Lectures)

Meaning and Definition of Economics, Nature and Scope of Economics, Concept of Micro and Macro Economics.

MODULE 2: Utility Analysis (3 Lectures)

Meaning of Utility, Utility Function, Consumers Equilibrium, Concept of Indifference Curve, properties of Indifference Curve, Equilibrium under Indifference Curve.

MODULE 3: Demand and Supply Analysis (4 Lectures)

Law of Demand, Demand Function, Elasticity of Demand, Types of Elasticity of Demand, Measurement of Elasticity of Demand, Demand Forecasting, , Law of Supply, Supply Function.

MODULE 4: Revenue, Production & Cost Analysis (4 Lectures)

Average, Marginal and Total Revenue, Revenue Function, Average, Marginal and Total Cost, Cost Function, Short and Long Run Cost Curves. Break Even Point, Managerial Uses of Cost Function, Cobb Douglas Production Function.

MODULE 5 : Market Structure (4 Lectures)

Concept of Market, Price-Output Determination under Perfect Competition, Monopoly Market and Monopolistic Competition.

MODULE 6: Money, Banking and National Income (8 Lectures)

Definition of Money, Function of Money, Index Numbers, Construction of Index Numbers, value of Money, Causes of Inflation, Functions of Commercial and central bank, Central bank and its monetary policy, Money Market and Capital Market, Functions of Stock exchange, Concept of National Income, Measurement of National Income, Concept of Investment.

MODULE 7: Introduction to Environmental Economics (5 Lectures)

Concept of Environmental Economics, Cost -Benefit Analysis, Social Cost, Externalities, Concept of Pareto Equilibrium, Externality, Market Failure.

MODULE 8: Public Finance (3 Lectures)

Introduction to Public Finance, Concept of Budget, Types of Budget, Budget Receipts, Concept of Goods and services Tax (GST).

Textbooks/Reference Books:

1. Managerial Economics by V. Agarwal: Pearson Pvt. Limited, New Delhi.
2. Engineering Economics by Dr. A. Ahmed & G. Begum: Chandra prakash, Guwahati
3. Principles of Engineering Economics with Application by Dr. Z. A. Khan, A. N. Siddiquee, B. Kumar, M. H. Abidi: Cambridge University Press.
4. Public Finance and Public Policy by Dr. R. K Choudhury: Kalayani publishers.
5. Quantitative Methods for Economics by R. Veerachamy: New Age International Publication Ltd.
6. Micro and Macro Economics by Dr. M. L. Seth: Educational Publishers, Agra -3
7. A Koutsoyiannis: Modern Microeconomics
8. Environmental Economics by R. N. Bhattacharya: Oxford Publication.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181514	Heat Transfer – I Lab	0-0-2	1

Course Outcomes: After successful completion of the course, the student will be able to:

CO1: Estimate physical properties like thermal conductivity of different liquids and solids and compare its variation.

CO2: Demonstrate the pin-fin apparatus, draw the temperature curve and predict its efficiency and deduce the practical applications of a fin.

CO3: Conduct experimental research in radiation heat transfer and determine various related parameters specifically Stefan-Boltzmann constant and Emissivity of solid surface.

List of Experiments

Experiments on Conduction

1. Determination of thermal conductivity of guarded hot plate
2. Determination of thermal conductivity of liquid
3. Determination of thermal conductivity of insulating powder
4. Study of temperature distribution in a pin-fin
5. Experimentation with unsteady heat transfer apparatus

Experiments on Radiation

1. Determination of Stefan Boltzmann constant
2. Determination of emissivity of the test plate surface at various temperatures

ABOVE SYLLABUS:

Experiments on Convection

1. Calculation of Heat Transfer Coefficient of Forced Convection in Internal Pipe Flow
2. Calculation of Heat Transfer Coefficient of Natural Convection for A Vertical Tube
3. Determination of Heat Transfer Coefficient in Drop and Film Condensation Phenomenon
4. Heat Pipe Demonstration

Experiment 1:

Determination of thermal conductivity of guarded hot plate

Introduction:

The significant mode of heat transfer in solids is by conduction and the heat flow rate by conduction depends upon the Thermal Conductivity (k) of the material. Metals possess high value of k, while Non-Metallic solids or Insulating materials possess low value of k. Losses of Thermal energy can be reduced by using different types of Insulating materials. Few of their applications includes: -

- Walls of Refrigerator.
- Walls of Cold Storages.
- Steam Pipes.
- Refrigerant Pipes.
- Chilled water lines & Hot water lines.
- Ice Plant brine tank walls.

Theory:

Two slab guarded hot plate method is based on the principle of one-dimensional heat flow through an insulating Slab. The Thermal Conductivity, k is determined using the basic law of heat conduction i.e., Fourier Law. For one dimensional, steady state heat conduction process, this law can be expressed in the following forms-

$q = k\,A\,(T_h - T_c) / \Delta x$

where q = the heat flow rate in Watts.

A = Area of Heat Flow.

T_h = Hot side temperature.

T_c = Cold side temperature.

Δx = Thickness of insulation layer.

Two slab arrangement makes the apparatus symmetrical in direction of heat flow and Guarded plate prevents the heat flow in radial direction and makes it possible to have the Unidirectional heat flow possible. Hence this Two Slab Guarded Hot Plate method has become a standardized method and is adopted in standards.

Apparatus:

The apparatus consists of a Nichrome heater wounded on mica former and cladded by mica sheet as insulation with top and bottom circular copper supporting plates forming the central heater assembly. This is surrounded by guard heater plate assembly.

Two insulating slabs are placed on both side of the guard (Heater-1) and central (Heater-2) clamped together with two cooling plates, through which the circulating water under constant head and temperature is circulated. The whole assembly is placed on a vertical supporting structure of suitable clamps. The whole apparatus is mounted in a box.

The temperature at various locations is measured with the help of calibrated Cr/Al constantan Thermocouples with a digital Temperature Indicator of 1 ºC least count. Heater input to central heater and guard heater is controlled with separate dimmerstats and measured with digital Ammeter and

Voltmeter and selector switch.

Specifications:

- Central Heater Diameter = 90 mm
- Guard Heater Ring ID = 95 mm
- Guard Heater Ring OD = 180 mm
- Cooling Plate Diameter = 180 mm
- Thermocouples = T_1 to T_6
- Cooling water circulation for top and bottom plates.
- Test Specimen material = Dia. 180 mm, Thickness 20 mm (Δx), Material: Press Wood, and Bakelite
- Control Panel consisting of-
    - Digital Temperature Indicator with selector switches with 1 ℃ least count.
    - Dimmerstat – 2 No.s, 230 Volts to control heater input
    - Digital Voltmeter and Ammeter to measure Central Heater input (q) and Guard heater input.
    - Necessary switches.

Procedure:

1. The apparatus is assembled properly and the Test Specimens are clamped properly.
2. Adjust cooling water supply and checked for any leakages if any.
3. The central heater is given an heat input of q Watts and is always to be kept constant.
4. The Guard heater is given an heat input of q watts and is adjusted properly so that a close balance of temperature is obtained between T_1 and T_3 and T_2 and T_4
5. Wait sufficiently for steady state and after obtaining a satisfactory steady state the observations are recorded in the following observation table.

Observation Table:

I. Specimen Thickness = Δx = 0.02 m.
II. Central Heater dia.(D) = 0.09 m.

T_1 ℃	T_2 ℃	T_3 ℃	T_4 ℃	T_5 ℃	T_6 ℃	T_7 ℃	T_8 ℃	For Central Heater		
								Voltage (V)	Current (I)	Heat Input, q Watt

Calculations:

- Hot side temperature $T_h = (T_1 + T_2) / 2 =$ ℃
- Cold side temperature $T_c = (T_5 + T_6) / 2 =$ ℃
- Since half the heat flow rate is passing through upper side and half through the lower side,

  $q/2 = k.A\,(T_h - T_c)/\Delta x$

  $k = q/2 \times \Delta x/A \times 1/(T_h - T_c)$

  $= q.4\Delta x/2.\pi D^2(T_h - T_c)$

  $=$ W/m- ℃

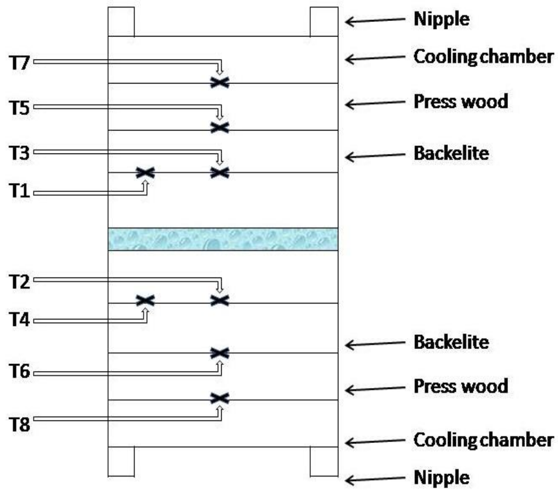


Fig 5. : GUARDED HOT PLATE ASSEMBLY

Experiment No 2

Determination of thermal conductivity of liquid

Introduction:-

Thermal conductivity of solids, liquids and gases is one of the important physical properties and its evaluation is of prime importance to engineers in different fields, especially mechanical and chemical engineers require this knowledge for determining the heat flow range in a given situation.

Thermal conductivity defines the easiness with which heat flows through given material and it appears in Fourier law of heat conduction as given below;

q / A (heat flux) = $-k\, dT / dx$ ------------------------------ (1)

Where dT / dx is a temperature gradient in (℃) / m and k is the Thermal conductivity, its SI units is

W/m-K .

Like solids, thermal conductivity of liquid varies with temperature. However it is not a very strong function of temperature. It may be noted that K values varies with the composition of liquids and comparison with the reference values shows a deviation due to commercially available liquids have composition beyond the control of the user. This apparatus is designed and developed according to the principle of guarded hot plate method. The apparatus is useful for the determination of K of some commonly used liquids like water, oils etc. over a temperature range from 30 ℃ to 80 ℃

Apparatus: -

Apparatus mainly consists of two parts-

1. Guarded hot plate assembly mounted on three studs in a box and provision of water circulation connections.
2. Instruments and control unit with all the necessary instruments mounted on front panel.

- Guarded hot plate Assembly-
    1. Cooling jacket and inlet and outlet connections.
    2. Cold plate.
    3. Supporting studs with leveling nuts.
    4. Main heater assembly.
    5. Ring heater assembly.
    6. Top guard heater assembly.
    7. Thermocouples and gaskets.
- Instruments and control units-

1. Ammeter
2. Voltmeter
3. Ammeter and Voltmeter selector switch
4. Dimmerstat-03 Nos.
5. Main switch
6. Digital temperature indicator

Procedure: -

1. Start the supply.
2. Switch on the main switch.
3. Start the circulating water system and adjust a flow rate accordingly.

4. Give supply to main heater.
5. Give supply to ring guard heater & top guard heater.
6. After getting the proper steady state all the observation are recorded.

Observations: -

1. Main heater diameter = 110mm
2. Liquid space diameter = 120mm
3. Mean diameter of (1) and (2) = 115mm
4. Mean area of heat flow (Am) pi/4.d^2 = 0.01038 m^2
5. Thickness of liquid layer. (s) = 5mm

INPUT TO HEATERS---

Heater	Voltage (V)	Current (I)	Heat Input q, (Watt)
Main (W)			
Guard ring			
Top Guard			

TEMPERATURE LOCATION: -

Location	Temperature (°C)
Cold plate	T1= T2= T3=
Main heater plate	T4= T5= T6=
Guard ring	T7= T8=
Top guard plate	T9= T10= T11=

Calculations: -

1. Average cold plate temperature = (Tc)

   i. =T1+T2+T3 / 3 =

2. Average hot plate temperature (Th) = T4+T5+T6 / 3 =

3. Heat flux, q / A = -k dT/dx

Thermal conductivity, k =

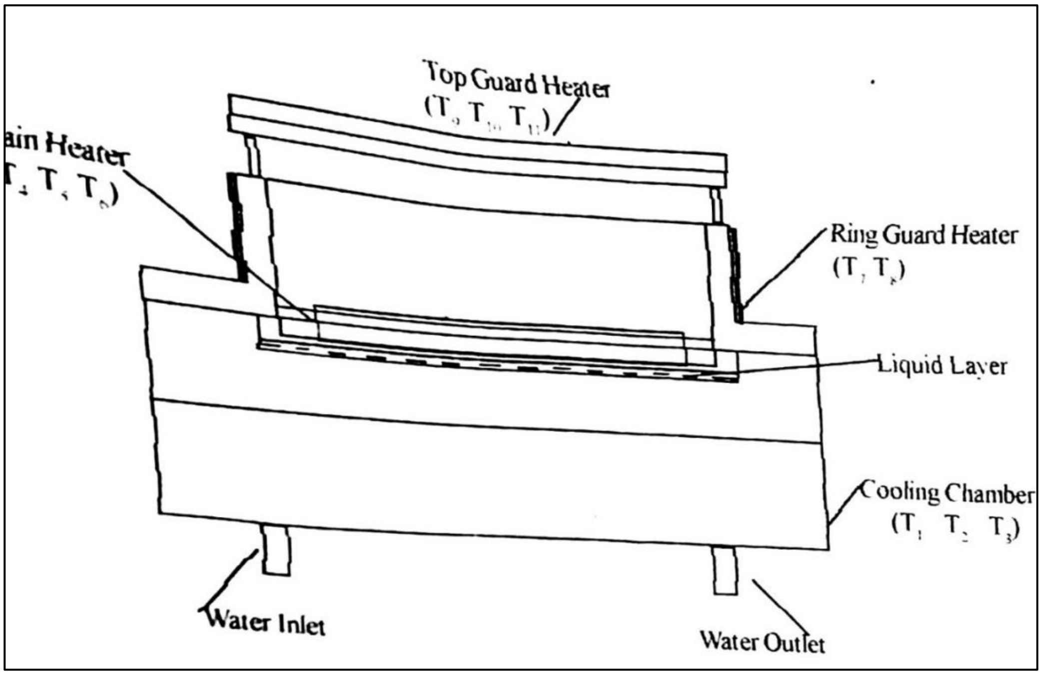


Fig 5. Schematic Diagram of thermal conductivity of liquid apparatus

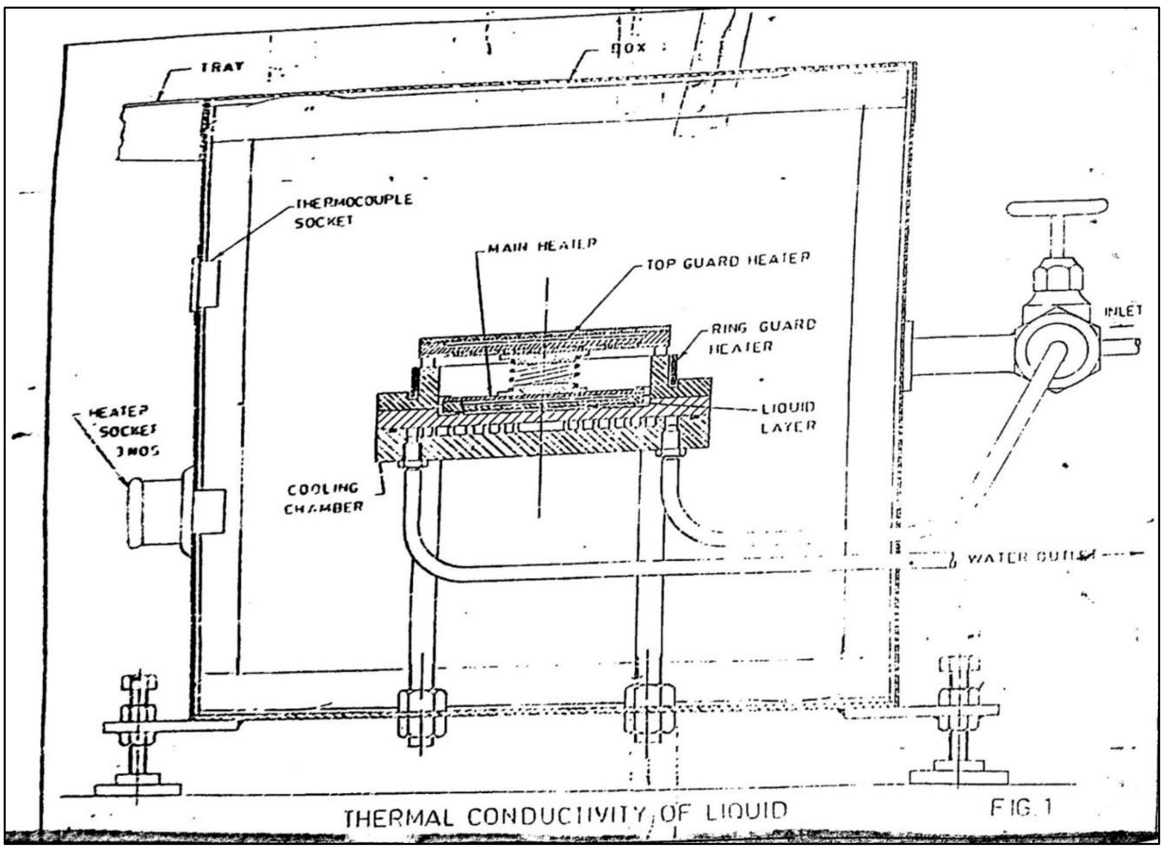


Fig 5. Thermal conductivity of liquid apparatus

Experiment No. 3

Determination of thermal conductivity of insulating powder

Introduction:

Thermal conductivity is one of the important properties of the material and its knowledge is required for analysing heat conduction problems. Physical meaning of thermal conductivity is how quickly heat passes through a given material. Thus the determination of this property is of considerable engineering significance.

Apparatus:

The apparatus consists of two thin halved concentric copper spheres. The inner sphere houses the heating coil. The insulating powder (Asbestos powder / plaster of paris-legging material) is packed between the inner & outer sphere. The power supply to the heating coil is adjusted by using a dimmerstat and is measured by a voltmeter and ammeter. Iron – constant thermocouples are used to measure the temperature.

Thermocouples No.1 to 4 are embedded on inner sphere and No. 5 to 10 are embedded on the outer sphere. Under steady state condition the temperatures T_1 to T_{10} are noted and also the voltmeter and ammeter readings are recorded. These readings in turn enable to find out the thermal conductivity of the insulating powder packed between the two spheres.

Specifications:

- ★ Radius of the inner copper sphere - r_i - 50 mm
- ★ Radius of the outer copper sphere - r_o - 100 mm
- ★ Voltmeter - (0-100) V
- ★ Ammeter - (0-5) A
- ★ Dimmerstat - 2 A
- ★ Heater - Mica Type
- ★ Temperature indicator - (0-300) ºC
- ★ Thermocouple No. 1 to 4 on inner sphere to measure T_i

Thermocouple No. 5 to 10 on outer sphere to measure T_o

- ★ Insulating powder

Procedure:

1) Start the power supply.

2) Increase the input to heater slowly by Dimmerstat and adjust equal to (60-100) V.
3) Take the temperature readings T_1 to T_{10} after time interval of 10 minutes.
4) Take the readings till steady state is reached.
5) Note down the readings T_1 to T_{10}.

Precautions:

- ✓ Keep the dimmerstat to zero position before starting the unit.
- ✓ Operate selector switch of temperature indicator gently.
- ✓ Never exceed the heater input to 100 volts.

Observations:

1. Radius of the inner copper sphere - r_i - 50 mm
2. Radius of the outer copper sphere - r_o - 100 mm
3. Input voltage -
4. Input current -

Observation Table:

Temperatures	Time in Minutes							
T_1								
T_2								
T_3								
T_4								
T_5								
T_6								
T_7								
T_8								
T_9								
T_{10}								

Calculations:

- Power input to heater Q

  Q = V. I watts
- Average surface temperature of inner sphere T_i

  $T_i = (T_1 + T_2 + T_3 + T_4) / 4$ ℃=
- Average surface temperature of outer sphere T_o

  $T_o = (T_5 + T_6 + T_7 + T_8 + T_9 + T_{10}) / 6$ ℃ =
- Thermal conductivity of insulating powder k

  $k = Q\ (1/R_i – 1/R_o) / 4\pi\ (T_i – T_o)$ W/m^{2}K

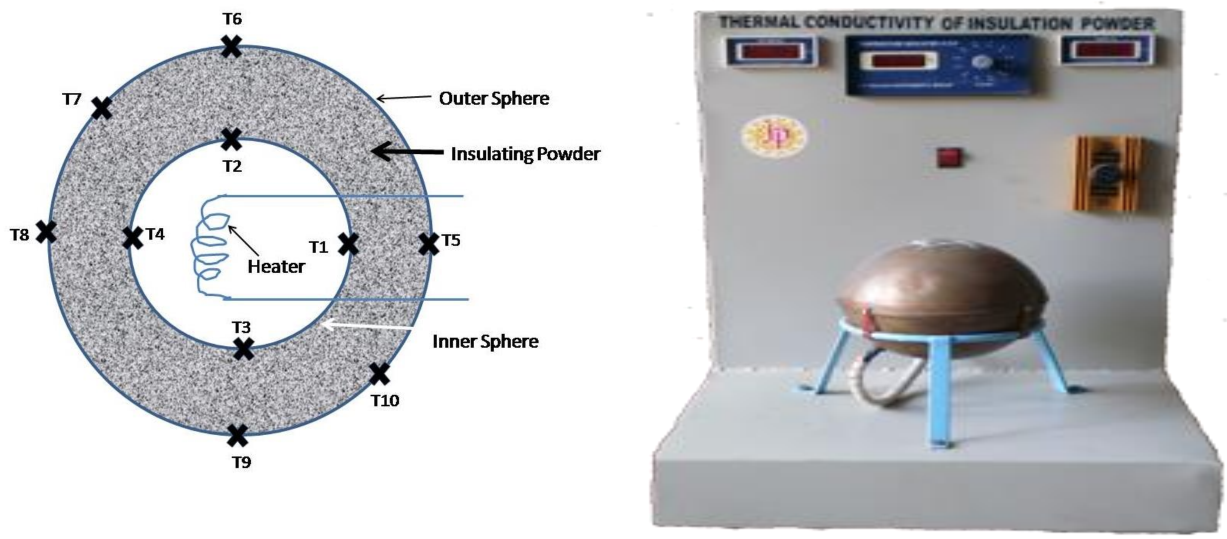


Fig 5. (a) Location of Thermocouples in Spherical Shell; (b) Apparatus of Thermal Conductivity of Insulating Powder

Experiment no. 4

Study of temperature distribution in a pin-fin

INTRODUCTION: -

Extended surfaces or fins are used to increase the heat transfer rate from a surface to another medium, whenever it is not possible to increase the value of the surface heat transfer coefficient or the temperature difference between the surface and the fluid. The use of this is very common and they are fabricated in variety of shapes. Fins attached to the engine cylinder of motor cycle, condenser tubes of refrigerator are few familiar examples. It is obvious that a fin surface strikes out from the primary heat transfer surface. The temperature difference with surrounding fluid will steadily diminish as one move out along the fin. The design of the fins therefore requires knowledge of the temperature distribution in the fin. The main objective of this experiment is to study the temperature distribution in a simple pin-fin.

APPARATUS: -

A brass fin of circular cross section is fitted in a long rectangular duct. The other end of the duct is connected to the suction side of a blower and the air flows past the fin perpendicular to its axis. One end of the fin projects outside the duct and is heated by a heater. Temperatures at five points along the length of the fin are measured by Nickel-Chromium / Nickel-Alumel thermocouples connected along the length of the fin. The air flow rate is measured by an orifice meter fitted on the delivery side of the blower Schematic diagram of the set-up is shown in fig. no. 2, while the details of pin fin are as per fig. no. 3.

SPECIFICATIONS: -

- Diameter of the fin: 12. 7 mm
- Diameter of orifice: 14 mm
- Diameter of delivery pipe: 36 mm (Int)
- Coefficient of discharge (orifice meter): 0.65
- Centrifugal blower: 0.5 H. P single phase motor
- Thermocouples on fins 1 to 5
- Ambient temperature in side of the duct 6 Nos.
- Fin material: Brass
- Temperature Indicator: 0- 300^{o} C
- Dimmerstat for heat input control
- Heater suitable for mounting at the fin end outside the duct
- Voltmeter: 0- 300 V
- Ammeter: 0-5 A

PROCEDURE: -

1. Switch on main switch.
2. Start heating the fin by switching on the heater and adjust dimmerstat voltage equal to 60V to 90V.
3. Start the blower and adjust the difference of level in manometer H= m with the help of valve.
4. When the steady state is reached, record the final readings 1 to 5 and also record the ambient temperature reading by 6

PRECAUTIONS: -

- ✓ See that dimerestat is at zero position before switching on heater.
- ✓ Operate change over switch of temperature indicator gently.
- ✓ Be sure the steady state is reached before taking the final readings.

OBSERVATIONS: -

1. Diameter of the fin = 12.7 mm
2. Length of the fin = 150 mm
3. Diameter of the orifice = 14 mm
4. Diameter of the delivery pipe=(int) = 36mm
5. Coefficient of discharge (Orifice meter) Cd =065
6. Ambient temperature = ^{o} C
7. Input voltage =
8. Input current =
9. Manometer readings = m of water

OBSERVATION TABLE:

Time In Minutes	Temperatures (°C)					
	T_1	T_2	T_3	T_4	T_5	T_6

CALCULATIONS:

1) Average fin temperature (t_m)

$$t_m = \frac{T_1+T_2+T_3+T_4+T_5}{5} \text{°C} =$$

2) Mean Fin Temp , $T_{mf} = \frac{T_m+T_6}{2}$ °C =

3) Air ftow rate (Q) where, C_d= 0.56

$$Q = \frac{C_d X a_1 X a_2 \sqrt{2gh\left(\frac{\rho_w}{\rho_a}\right)}}{\sqrt{a_1^2 - a_2^2}}$$

Where

a_1= area of delivery pipe in m^2 = $1.01X10^{-3}$ m^2

a_2= area of orifice in m^2 = $1.54X10^{-4}$ m^2

g= 9.81 m^2/s

h=Manometer reading in m

ρ_w= density of water = 1000 Kg/m^3

ρ_a= density of air = 1.207 Kg/m^3

4) Velocity of ambient temperature (T_6)

V= m/s area of duct (A = 0.0165 m^2)

5) Velocity of air at Tmf ρ_a = Kg/m^3

T_{mf}= V X $[\frac{T_{mf}+273}{T_6+273}]$ m/s

k_{air}= W/mK

υ_a = m/s

6) Reynolds Number (R_e) Take these values from chart which is provided at the end at T_{mf}

Re = $\frac{V_{mf}\ X\ d}{\upsilon_a}$

7) Nusselets Number (N_u)

N_u= 0.615 x $(R_e)^{0.466}$

8) Heat Transfer coefficient (h)

h = $\frac{N_u\ X\ k_{air}}{d}$

= w/m^2K

9) Fin parameter (m)

m= $\sqrt{a(h.c)/(k.A)}$ m^{-1}

Where,

C= Circumference of fin (πd) = 0.0398

k = Thermal conductivity of fin material Brass 110.71 W/mK

A= Area of fin = $1.266x10^{-4}$

10) Fin efficiency, η= tan h(ml) = $\frac{e^{+ml} - e^{-ml}}{e^{+ml} + e^{-ml}}$

= %

Experiment No 5

To obtain the specimen temperature at any interval of time by practical by theoretical observing the heating cooling curve of unsteady state.

INTRODUCTION:

Unsteady state designates a phenomenon which is time dependent. Conduction of heat in unsteady state refers to transient coefficient where in heat flow and temperature conditions where in heat flow and temperature distribution at any point of the system vary continuously with time.

Transient condition occurs in heating or cooling of metal billets, cooling of I C engine cylinder, Brick burning & vulcanization of rubber.

APPARATUS:

Unsteady state heat transfer equipment has water heater located at bottom of the equipment .Specimen to be hold in chuck which is at the top of water heater. Thermocouple NO.1 is located inside the specimen No.3 is thermocouple measures the atmospheric temperature.

Digital temperature indicator indicates respective temperatures of thermocouples as we select it by selector switch, Heater ON/OFF switched is provided on control panel.

SPECIFICATIONS:

★ Heater	1Kw
★ Digital temperature Indicator	0-300^{o}C
★ Thermocouple `	Al-Cr type
★ Specimen material	Copper
★ Dimmerstat	2 Amp
★ Voltmeter	0-300volts
★ Ammeter	0-5 Amp

PROCEDURE

1) Fill the water pot up to 3/4th of its height
2) Put “ON” the mains switch
3) Insert the thermocouple in jar having tag
4) Keep the thermocouple near to the specimen inside the transparent chamber to ambient temp(T_3)
5) Start the water heater by putting heaters switch in downward directions
6) Keep the selectors switch and observe the water temperature (T_2)

7) When the water temperature reaches up to boiling point temp, put off the heater switch and put on the buzzer switch, insert the specimen in the jar. At the same time note down the specimen temperature and start noting the time (buzzer beeps at every; 5 seconds interval).
8) Note down the specimen reading (T_1) check the temperature by selector switch
9) Take the readings of specimen temperature till it comes nearly to hot water temperature
10) Now take out specimen from water jar and keep inside the transparent chamber.
11) Take the atmospheric temperature (T_3) by selecting selector switch and specimen temperature at the each interval of 5 seconds of interval. Note down the specimen temperature reading till it becomes closer to atmospheric temperature.
12) Put off buzzer switch & main switch.

OBSERATION TABLE

1. Specimen material : Copper
2. Thermal conductivity of copper, K =383.559 W/m^0k
3. Coefficient of diffusivity of copper, α = 412.0 m^2/hr.
4. Specimen diameter, d = 0.127 m r=0.00635m
5. Specimen length, L =0.07 m

SR. NO.		COOLING /HEATING	
	Water Temperature T_2 in ℃	Specimen Temperature in ℃ at Interval of 't' Sec T_1	Time in Sec (t)

- Grashoff's No: $Gr = \beta g\, L^3 \Delta T / \upsilon^2$

For the following values, refer enclosed chart of water for heating and air for cooling where,

β = 1/T (For cooling only)

T = Maximum temp in ^{0}K

(In case of water β (heating) is to be taken from the table)

g = 9.81m^2/sec

ΔT = Temperature difference between surrounding temperature and specimen temperature in^{0}K

υ = Dynamic viscosity of medium at mean film temperature from table in N-s/m^2.

Pr = Prandtl number of medium at mean film temperature from table

K = Thermal conductivity of medium at mean film temperature from table in W/m^0K

L = Length of the specimen in m

- Mean film temp = Tmf = $T_{abm}+(T_{si}+T_{so})/2$

ΔT = $(T_{si}+T_{so})/2 - T_{amb}$[T_{si} = initial Temperature , T_{so} = Final temperature]

- Ra = Gr.Pr (Correlations for vertical cylinder)
- $Nu = 0.59(Ra)^{1/4}$ $1x\ 10^4 <= Ra < 1\ x\ 10^8$
- $Nu= 0.13(Ra)^{1/3}$ $1x\ 10^8 <= Ra < 1x\ 10^{12}$
- $h = Nu.\ K_{medium}/\ K_{specimen}$
- $Bi= hLc\ /K_{specimen}$

CALCULATIONS

Characteristic dimension for cylinder L_c

$L_c=r/2$

because the cylinder is vertical

Case 1) If the Biot no. is less than 0.1 then go for the following equation

Case 2) If the Biot no. more than 0.1 then go to for HEISLER'S CHART given

$t\text{-}t_{total}\ /t_{initial}\text{-}t_{final}$ =e^-(h.t/C.L.ρ)

Where

ρ =density of copper =8800Kg/m^3

h= heat transfer coefficient =W/m^2K

t=time in sec

Cp= specific heat =381J/kgK

(Above values are taken as per enclosed chart).

Obtain the temperature at any desired interval of time OR the time at any desired temperature.

Plot the graph of temperature difference v/s time for heating and for cooling.

REASONS FOR THE DEVIATION IN THE GRAPHS

Case1 HEATING: The thermocouple is located at the center and the surface is outer side sp surface temperature earlier than the center i.e. it requires more time to reach the temperature at the center. The same thing is shown in the graphs.

Case2) COOLING: The specimen is taken out of the jar; the surface is still not dry so, the latent heat is taken from the inside of the material itself to cool the surface. This causes the increased rate of heat transfer at the Centre which is at higher side than that of the surface. So at the center that temp. is low.

The same thing is shown in the graph.

Experiment 6

Determination of Stefan Boltzmann Constant

INTRODUCTION:

The apparatus consists of a flanged copper hemisphere fixed to a flat backelite plate, the outer surface of which forms the jacket to heat it. Thermocouples are used to measure the temperature of the enclosure. Water heating tank is provided to supply hot water.

A disc about 2 cm in diameter is introduced from the backelite base & its temperature is measured by thermocouples. The inner surface of the enclosure, base & disc are blackened to make their absorptivity equal to unity.

When the enclosure is in equilibrium at temperature T, the radiant energy absorbed by disc equals the radiant energy it emits,

$Q= \sigma A_d T^4$

$Q \quad - Q_1 = \sigma A_D (T^4 - T_1^4)$

If disc D has mass m and specific heat Cp then after a short time Disc is inserted.

$m.\ Cp\ dT/dt= \sigma\ A_d\ (T^4 - T_1^4)$

$\sigma = m\ Cp\ (dT/dt) / A_d\ (T^4 - T_1^4)$

Where dT is the rise of temperature of disc at the instant when its temperature is T and it will be tangent at t=0 of the curve between T and $T_{1.}$

SPECIFICATIONS:

- ★ Hemisphere dia. – 0.2 m
- ★ Base backelite plate - 0.3 m
- ★ Test disc dia. -0.02m
- ★ Thickness of test disc - 0.002m
- ★ Thermocouples on hemisphere - 4 Nos.
- ★ Water tank capacity with immersion heater.
- ★ Thermocouple on test disc - 1 No.
- ★ Temperature indicator

PROCEDURE

1. First boil the water in the water tank with the help of immersion heater up to boiling
2. Then insert test disc in the backelite, if not inserted (test disc is blackened totally)

3. Drop the boiled water on the hemisphere
4. Take the readings of test disc. i.e. T_5 when it starts increasing ; with the help of the stop watch after every 10 sec. till the steady state is reached i e. 5 consequent readings should indicate same temp.
5. Immediately take the readings of thermocouples on the hemisphere i e. T_1, T_2, T_3, T_4upto steady state.

PRECAUTION: -

- ✓ Operate the selection switch of the temperature indicator gently.
- ✓ Stir the water with stirrer before taking the reading .(Inside the water tank).

OBESERVATIONS: -

1. Diameter of the test disc d= 0.020 m
2. Mass of the test disc m = 0.007 Kg
3. Specific heat of test disc (Brass) C= 877 J/Kg K
4. Area of Test Disc A_d= 3.14 x $10^{-4}$$m^2$

OBSERVATION TABLE: -

1. For Hemisphere: -

Sl No.	Water temperature, T_6	Temperature of the hemisphere			
		T_1	T_2	T_3	T_4

2. For Test Disc:

Thermocouple Location	Time in Sec.								
	10	20	30	40	50	60	70	80	90

CALCULATIONS: -

For calculating the Stefan-Boltzmann Constant following equation is used:

mCp(dT/dt)

σ =

$A_d (T^4 - T_1^4)$

Where

σ= Stefen Boltzman Constant

m = Mass of the test disc in Kg = .007kg

Cp = Specific heat of test disc (Brass) = 877 J/kgK

d = diameter of the test disc = 0.02m

A_d= Area of the test disc ($\frac{\pi}{4} \times d^2$) = 3.14×10^{-4} m^2

T= Mean temp. of hemisphere i.e $T = T_1 + T_2 + T_3 + T_4/4$ is calculated.

dT= T_{final}-$T_{initial}$

Where T_{final}= Steady state temp. reading of test disc $T_{initial}$= Temp. of disc from which it starts increasing.

dt = Total time required for achieving the steady state from the time when temp, of the disc starts increasing.

σ=

REASONS FOR LOW VALUE OF STEFEN BOLTZMANN CONSTANT

- There is no vacuum provided for the experiments.

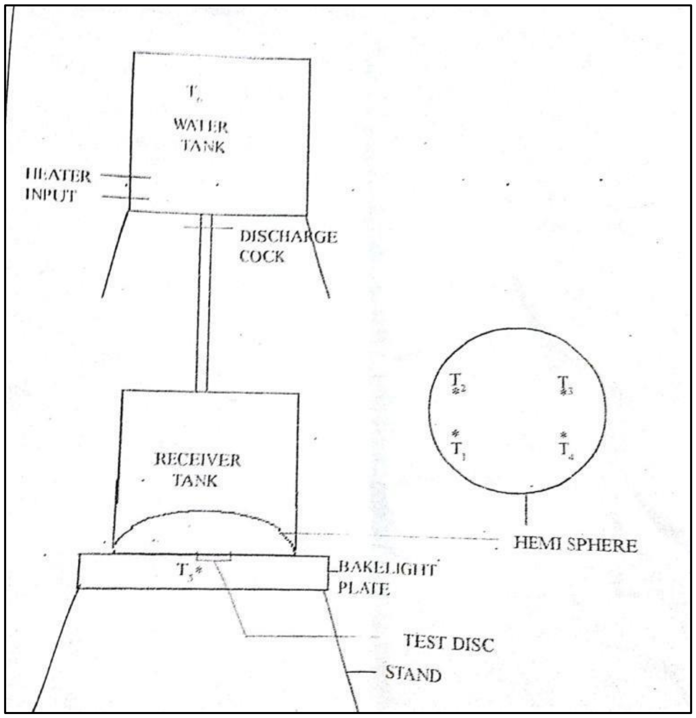


Fig 5. Apparatus for Measuring Stefan Boltzmann Constant

Experiment No 7

Emissivity Measurement Apparatus

INTRODUCTION

All substance at all temperature emits thermal radiations. Thermal radiation is an electromagnetic wave and does not require any material medium for propagation. All bodies can emit radiation and have also the capacity to absorb all or a part of the radiation coming from the surrounding towards it.

An idealized black surface is one which absorbs all the incident radiations with reflectivity and transmissivity equal to zero. The radiant energy per unit time per unit area from the surface of the body is called as the emissive power and is usually denoted by 'e'. The emissivity of the surface is the ratio of the emissive power of the surface to the emissive power of the black surface at the same temperature.

$$\text{Thus } \varepsilon = E/E_b$$

For a black body absorptivity and emissivity is unity.

Emissivity being a property of the surface depends on the nature of the surface and temperature.

It is obvious from Stefan-Boltzmann Law that the prediction of emissive power of a surface requires knowledge about the value of its emissivity and therefore much experimental research in radiations has been on measuring the values of emissivity as function of surface temperature. The present experimental setup is designed to measure the property of emissivity of test plate surface at various temperatures.

APPARATUS: -

The experimental consists of two circular aluminum plates of identical in size and are provided with heating coils sandwiched. The plates are mounted on brackets are kept in enclosure so as to provide undisturbed natural convection surroundings.

The heat input to the heater is varied by separate dimmerstats and is measured by using an ammeter and voltmeter, with the help of double plate toggle switches. The temperatures of the plates are measured by temperature indicator. Another thermocouple is kept in enclosure.

Plate one is blacked whereas plate two is the test plate whose emissivity is to be determined.

The heater inputs to two plates are dissipated from the plates by conduction, convection and radiation. The experimental set up is designed in such a way that under steady state conditions the heat dissipation by conduction & convection is same for both the plates, where the surface temperature are same & the differences in the heater input readings are because of the differences in radiation characteristics due to their different emissivity's.

PRECAUTION: -

- ✓ Keep heater at preferred location.
- ✓ Take readings until steady state is reached.
- ✓ Use stabilized AC single phase supply.
- ✓ Always keep the dimmerstats at zero position before start.
- ✓ Gradually increase the heater inputs.
- ✓ See that the black plate is having a layer uniformly.

NOTE: - There is possibility of getting absurd results if the supply voltage fluctuating.

SPECIFICATIONS: -

- Test plate = 170 mm
- Black plate = 170 mm
- Heater-Nichrome strip wound on mica sheet.
- Dimmerstat
- Voltmeter = 0-300 V
- Ammeter = 0-5 A
- Enclosure = with one side of perpex sheet.
- Thermocouple = ChromelAlumel – 3 Nos.

- Thermocouple indicator = 0-300℃

We shall now define a number of terms concerned with the emission characteristics of surfaces. It is useful to introduce first the concept of an ideal surface called black body or a black surface. A black surface is one which absorbs all radiation falling on it regardless of its wavelength and direction. For a given temperature and wavelength, it emits the maximum amount of energy. It thus serves as a standard on which to base the emission characteristics of real surfaces. The radiant flux emitted from the surface of a body is called the total hemispherical emissive power and will be denoted by the symbol 'e' (unit – W/m2). The total hemispherical emissive power of a black surface will be denoted by e_b. The adjectives total and hemispherical indicate that the quantity being defined is a summation of radiation emitted over all wavelengths and over all directions.

PROCEDURE: -

1. Start the supply.
2. When both the toggle switches are in downward direction black plate dimmerstat operate whereas when both the toggle switches are in upward direction test plate dimmerstat operate.
3. Gradually increase the input to the heater to black plate and to adjust the heater input to test plate slightly less than the black plate.
4. Check the temperatures of the two plates with small time intervals and adjust the input to test plate only by the dimmerstat so that the two plates will be maintained at the same temperature.
5. This will require some time to obtained steady state condition.
6. After attaining the steady state condition, the temperatures and voltmeter and ammeter readings for both plates are recorded.

OBSERVATIONS: -

1. Heater input to black plate

V=

I=

2. Heater input to test plate

V= .

I =

OBSERVATION TABLE :-

TEMPERATURES	STEADY STATE READINGS
BLACK PLATE(T_1)	
TEST PLATE (T_2)	

ENCLOSURE (T_3)	

CALCULATION: -

To determine the emissivity of test plate following equation is used.

$W_b - W_T = A \times (T_S^4 - T_E^4) \times (1-E) \times \sigma$

Where,

W_b = Heat input to black plate (watts) = V×I=93×0.94=87.42 watt

W_t = Heat input to test plate (watts) = V×I=60×0.58=34.8 watt

d =170 mm

t = 6 mm

A = Area of plates =[2. π/4.d^2]+[π.d.t] = 0.0486 m^2

T_S =Temperature of plates after steady state = $T_1 = T_2$ = 201˚C = 474K

T_E =Temperature of enclosure = T_3 = 49˚C = 322K

E =Emissivity of test plate which has to be determine.

σ =Stefan Boltzmann constant = 5.667 x 10^{-8} W/m^2-K^4

CONCLUSION: -

The Emissivity of test plate was found to be ………….. at the temp of ……….K

THERMOCOUPLE POSITIONS: -

BALCK PLATE (T1)

TEST PLATE (T2)

ENCLOSURE (T3)

BEYOND SYLLABUS:

Experiment 1:

Calculation of Heat Transfer Coefficient of Forced Convection in Internal Pipe Flow

APPARATUS:

The apparatus consists of blower unit fitted with the test pipe. The test section is surrounded by nichrome band heater. Six thermocouples are placed in the air system at the entrance & exit, of the test section & two thermocouples are embedded on the test section to measure the air temperature. Test pipe is connected to the delivery side of the blower along with the orifice to measure flow of air through the pipe. Input to the heater is given through a dimmerstat & measured by voltmeter & ammeter. A temperature indicator is provided to measure temperatures of pipe wall in the test section. Air flow is measured with the help of orifice meter & the water manometer fitted on the panel.

SPECIFICATIONS:

- Delivery pipe diameter D_i = 0.036 m
- Length of test section L= 0.45 m
- Blower 0.5 H. P., Single phase with motor.
- Orifice diameter 0.014 m
- Dimmerstat 2 Amp.
- Voltmeter *0 - 300 V*
- Ammeter 0 - 5A
- Thermocouples Chromel – Alumel
- Temperature Indicator 0 - 300°C
- Heater Nichrome wire heater wounded on test pipe (Band type)

PROCEDURE:

1) Start the supply.

2) Start the blower & adjust the flow by means of valve to some desired difference in manometer level. (Preferably open control valve fully)

3) Start the heating of the test section with the help of dimmerstat & adjust desired heater input with the help of voltmeter & ammeter (60 V)

4) Take the readings of all 8 thermocouples at an interval of 5 minutes until the steady state is reached.

THERMOCOUPLE POSITONS: -

$T_1 – T_6$ = Temperature of pipe wall in the section

T_7 = Air inlet temperature

T_8 = Air outlet temperature

PRECAUTIONS: -

- ✓ Keep the dimmerstat at zero position before switch on the power supply.
- ✓ Increase the voltage gradually.
- ✓ Do not stop the bowler in between the testing period.
- ✓ Operate selector switch of temperature indicator gently.
- ✓ Do not exceed 80 volts so as to avoid fluctuating results.

OBSERVATIONS: -

1) Input voltage = volts
2) Input current = Amp
3) Manometer reading H = m

OBSERVATIONS TABLE: -

Temperature	Time				
T_1					
T_2					
T_3					
T_4					
T_5					
T_6					
T_7					
T_8					

CALCULATIONS: -

1) Bulk mean temperature of air

T_{Bm} $= (T_i – T_0)/2$

$=$ ^oC

We have following properties of air at T_{Bm}

ρ_a $=$ kg/m^3

$C\rho_a$ $=$ $kJ/kg\ ^0K$

Take these values from chart which is provided at the end

2) Calculation for discharge of air

$$Q_a\,(Air) = C_d\, a_1\, a_2\, \sqrt{2gh_a}\, (\rho_w\, \rho_a)/\sqrt{(a_1^2 - a_2^2)}$$

Where a_1 = area of delivery pipe in m^2 = $1.01x\ 10^{-3} m^2$, C_d = 0.65

a_2 =Area of orifice in m^2 = $1.54x10^{-4}\ m^2$

h_a = manometer reading in m, $g=9.8m^2/s$

ρ_w = Density of water 1000 kg/m^3

ρ^B = Density of air at t_{bm}

3) Mean mass flow rate of air(m)

$$m = Q_a \times \rho_a$$

4) Heat of air(q) (KW)

$$q = m\, Cp_a\, (T_0 - T_i)$$

5) Heat transfer coefficient (h)

$$h = q/\ \{A(T_0 - T_i)\} \quad Watt/m^2K$$

Where

A = Area of section = $\pi.d.L$

d = 36 mm

L = 450 mm

T_s = $(T_1+T_2+T_3 \ldots\ldots\ldots.. T_6)/6$ ^0C

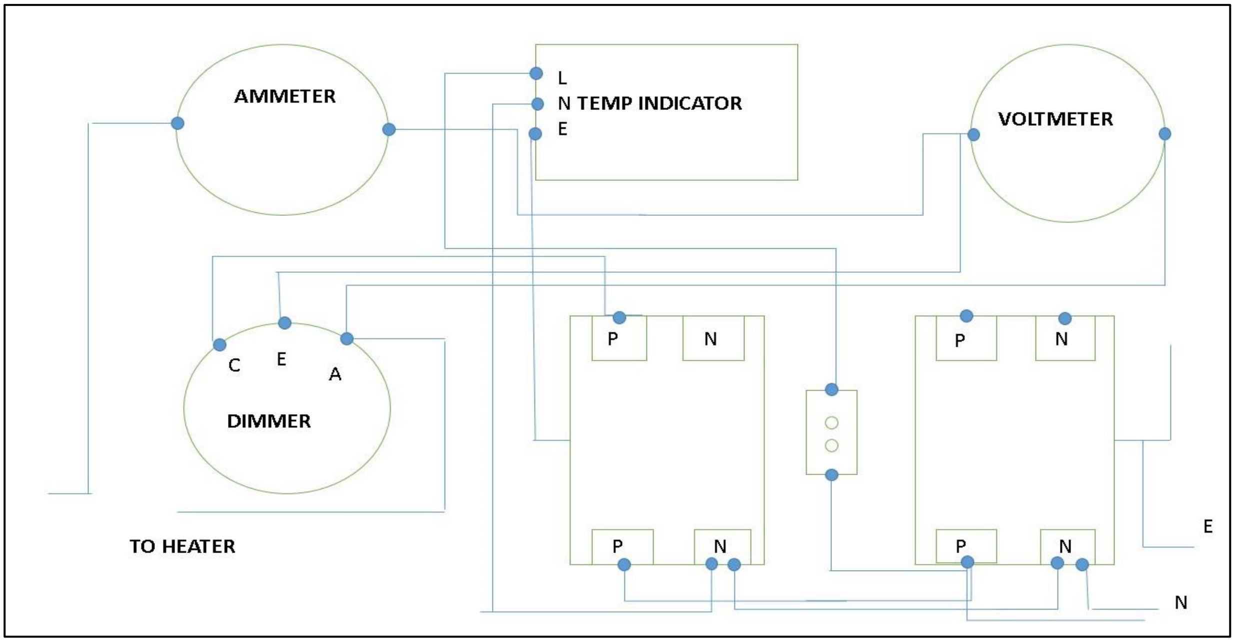


Fig 5. Forced Convection Apparatus Wiring Diagram

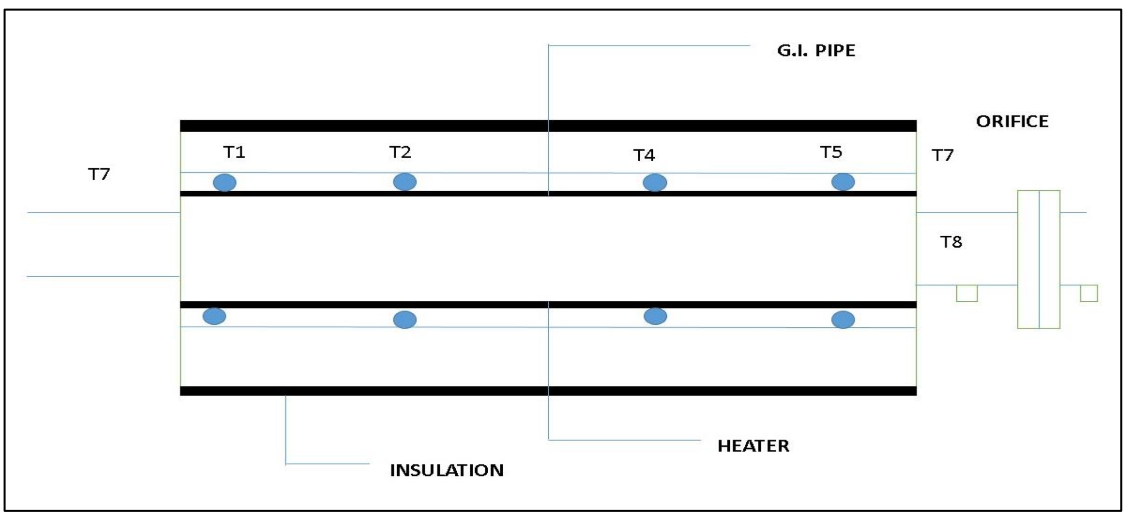


Fig 5. Schematic Diagram Forced Convection Showing Thermocouple Location

T1 –T6 = Temperature of pipe wall in the test section

T7 = Air inlet temperature

T8 = Air outlet temperature

Distance between each thermocouple is =0.08

Experiment no 2

Calculation of Heat Transfer Coefficient of Natural Convection for a Vertical Tube

INTRODUCTION: -

Heat, a form of kinetic energy, is transferred in three ways: Conduction, Convection and Radiation. Heat transfer (also called thermal heat transfer) can occur only if a temperature difference exists, and that too only in the direction of decreasing temperature.

Conduction is the heat transfer within any solid. This mode of heat transfer is accomplished by two mechanisms, i.e., molecular lattice vibrations and free electron movement. Molecules at a relatively high energy level (temperature) impart energy to the adjacent molecules at lower energy levels. This type of energy transfer exists so long as there is a temperature gradient in a system comprising molecules of a solid, liquid or gas. The drift of 'free' electrons is mainly present in case of metallic solids. The metallic alloys have a different concentration of free electrons, and their ability to conduct heat is directly proportional to the concentration of free electrons in them. The free electron concentration of non-metals is very low. Hence, materials that is good conductors of heat too. Pure conduction is found only in solids.

Convection is possible only in the presence of a fluid medium. When a fluid flows inside a duct or over a solid body and the temperature of the fluid and the solid surfaces are different, heat transfer between the fluid and the solid surface will take place. This is due to the motion of fluid relative to the surface. This type of heat transfer is called convection.

If two bodies at different temperatures are placed in an evacuated adiabatic enclosure so that they are not in contact through a solid or fluid medium, the temperature of the two bodies will tend to ecome equal. The mode of heat transfer by which this equilibrium is achieved is called thermal radiation. Radiation is an electromagnetic wave phenomenon, and no medium is required for its propagation.

APPARATUS: -

The apparatus consists of a brass tube fitted in rectangular duct in vertical fashion. The duct is open at top and bottom and forms an enclosure and serves the purpose of undisturbed surrounding. One side of duct is made up of Perspex for visualization. An electrical heating element is kept in vertical tube which in turns heats the tube surface. The heat loss by tube to surrounding air is by natural convection. The temperature of vertical tube is measured by seven thermocouples which are fixed on the tube by drilling holes along the tube wall. The heat input to the heater is measured by an ammeter and voltmeter and is varied by a dimmerstat. The schematic diagram of the experimental setup with thermocouple position is shown in Fig2.1. The voltage regulator, ammeter and digital voltmeter have been used to control and measure the input power to the working pipe. The readings of all thermocouples have been recorded every 10 minutes until the reading became constant and a steady state is reached and then the final reading has been recorded.

SPECIFICATIONS: -

- ★ Diameter of the tube (d) 38mm
- ★ Length of the tube (l) 530mm
- ★ No. of thermocouples 8 (1-7 measures temperature on the tube and 8 measures the ambient temperature)
- ★ Temperature indicator 0-300˚C
- ★ Ammeter 0-5 A
- ★ Voltmeter 0-300 V

PRECAUTIONS: -

- ✓ Before starting the unit keep dimmerstate to zero-volt position & increase it slowly.
- ✓ Operate selector switch of temperature indicator gently.
- ✓ Never exceed 100 volts.
- ✓

PROCEDURE:-

1. Start the supply and adjust the dimmerstat to obtain the required heat input.
2. Wait until steady state condition i.e., there is no further change in temperature.
3. Note down the surface temperature at various points i.e., T_1-T_7.
4. Note down the ambient temperature, T_8.

OBESERVATIONS: -

1. O.D of the cylinder (d) – 38 mm
2. Length of the cylinder – 530 mm
3. Input Voltage –
4. Input Current –

OBSERVATION TABLE: -

Thermocouple Location	Time in Minute											

1												
2												
3												
4												
5												
6												
7												
8 (ambient)												

CALCULATIONS: -

Average heat transfer coefficient, h_a in W/m^2-K

$h_a = q/A \times (T_s - T_a)$

Where,

h_a	Heat transfer coefficient
Q	V X I (watts)
A	Surface area of cylinder in $m^2 = (\pi dl)$
T_s	Average of surface temperature T_1-T_7.
Ta	Ambient temperature, T_8.

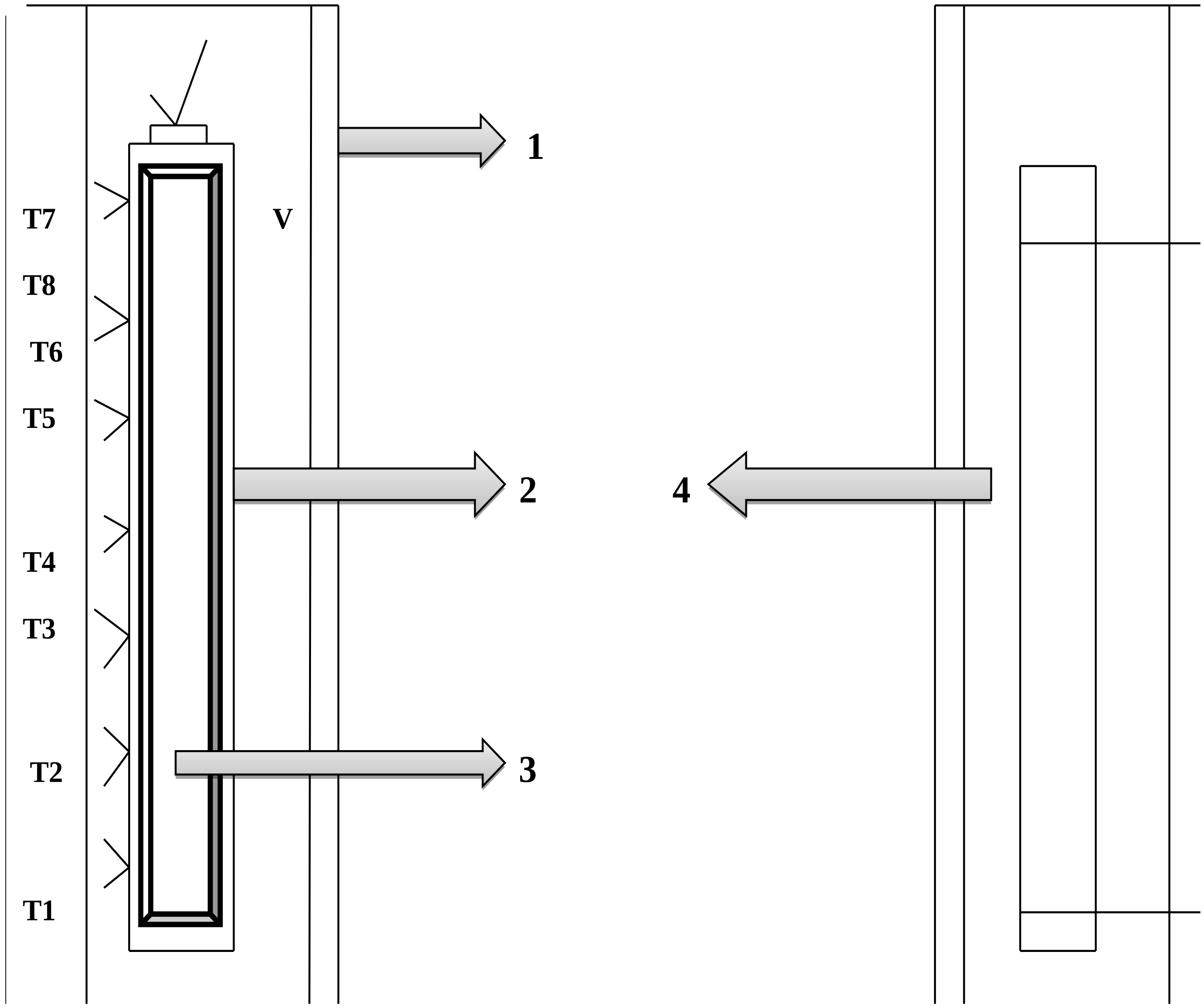


Fig 5. Schematic diagram for Natural Convection Apparatus
(1. Duct, 2. Test tube, 3. Heater, 4. Acrylic Sheet)

Experiment no 3

Determination Of Heat Transfer Coefficient in Drop and Film Condensation Phenomenon

AIM

To Determine Heat Transfer Coefficients in drop and film Condensation Phenomenon.

INTRODUCTION

Condensation is a phase change heat transfer process which occurs in mechanical and chemical engineering applications.

Condensation of vapour on surface is of two types.

1. Drop condensation
2. Film condensation

FLIM AND DROP CONDENSATION

Condensation occurs wherever a vapour comes into contact with a surface at a temperature lower than the saturation temperature corresponding to its vapour pressure. The nature of the condensation depends upon whether the liquid thus formed wets or does not wet the solid surface. If the liquid wets the surface the condensate flows on the surface in the form of a film and the process is called FLIM CONDENSATION. If on the other hand, the liquid does not wet the solid surface, the condensate collects in the form of droplets, which either grow in size or coalesce with neighbouring droplets and eventually roll off the surface under the influence of gravity. This process is called DROP CONDENSATION.

APPARATUS

The apparatus is developed for finding heat transfer coefficients in drop and film condensation phenomenon. The two condensers made of copper tubes. One of the tube is chrome placed and the other is placed is polished. Cooling water is circulated through each tube. These two are enclosed in a glass cylinder to observe the phenomenon of condensation. Steam from a cooker enters the glass cylinder and comes in contact with outer surface of the copper tube. A pressure gauge shows the pressure of steam entering the cylinder.

A Rotameter is used prior to the tube to note sown the rate of flow of cooling water. A temperature indicator 300^0C range and multichannel is used to measure condensers. A thermocouple left in the glass cylinder measures the temperature of steam. Each copper tube carries a thermocouple to note down the tem of surface. In all 6 (six) thermocouple are used.

However, depending upon the type of tube we have to note down only 4(four) temperatures. Flow control valves are used after the Rotameter to control or stop low temperatures. Flow control valves are used after the Rotameter to control or stop low through the copper tube.

PRECAUTIONS

- ✓ Before switching on the heater for steam cooker, confirm that sufficient level is there.
- ✓ Operate the valves properly.
- ✓ Operate the selector switch of T.I. properly gently.
- ✓ After the experiment is over put off the heater switch and allow the cooling water to flow through both condensers for 10- 15 min and then stop the flow.

PROCEDURE

1) Open the lid of cooker and if necessary fill sufficient water in it. Generally, the water level should be 0.03-0.035 m above the heater surface. If water levels is sufficient close the lid.
2) Now put on the heater so that water will start boiling. Select the valves and start flow through either copper tube. Close the steam admitting valve and condenser drain valve. Note down the flow rate and see that there is no much variation
3) Put on the temp indicator and see that the thermocouples show proper temperature initially.
4) Wait for 10-15 min until steam generates and its pressure is shown on the pressure gauge .If the desired pressure is achieved then admit the steam to the glass cylinder and note down the temperatures, when the steady state can be confirmed by the temp no T-3 which is the steam temperature.
5) Open the drain valve and let the condensate be drained. Close the valve.
6) After the readings are noted repeat the experiment for other copper tube.

When the experiment is over put off the heater switch and let water seen through both the copper tube (condensers) for about 10-15 minutes. Close the cooling water supply.

NOMENCLATURE: -

1) Steam pressure - Kg/cm
2) Water flow rate - LPH
3) Temperatures - ^{0}C

T_1 Surface temperature of plated condenser.

T_2 surface temp of plain (copper) condenser.

T_3 Steam temp in glass cylinder.

T_4 Temp of water leaving plated condenser

T_5 Temp of water leaving plain (copper) Condenser

T_6 Temp of water inlet to condenser.

So while testing plate condenser we have to note temperatures T_1 ,T_3, T_4 and T_6, and while testing plain condenser we have to not down temperature T_2, T_3,T_5 ,T_6 Only

OBSERVATION TABLE: -

Type of Condenser	Steam pressure Kg/cm^2	Rotameter Readings LPH	Temperature					
			T	T	T	T	T	T_6

Plated Condenser								
Plain (Copper) condenser								

SPECIMEN CALCULATIONS

Plated Condensers Bulk Mean Temp Inner Surface $T_{bm} = (T_4 + T_6)/2\ ^0C$

1. Reynolds Number:

$Re = 4m_w/\pi\ D_i\ \rho_w\ \upsilon_w$

Where,

M_w = Mass flow rate of water

D_i = Inner diameter of condenser 0.017m

ρ_w = Density of water kg/m^3

υ_w = kinematic viscosity m^2/s

Take ρ_w, υ_w, K_w, P_r, T_{bm} from chart provided at end.

2. Nusselt number: (Nu)

$Nu = 0.023(R_c)^{0.8} x (P_r)^{0.4}$

Use Re calculated from 1 and P_r for properties of water table

3. Inner heat transfer coefficient

$h_i = Nu\ x\ K_w / L$

K_w = Thermal Conductivity of water w/m-K

L = length of condenser = 0.15m

4. Bulk Mean Temp:

$T = T_1 + T_3/2$

h_0 = outer heat transfer coefficient at bulk mean temp

$= 0.943[\lambda\ \rho^2\ g\ \ k^3 / (T_s - T_w)\mu\ x\ L]^{0.25}$

ρ_w = Density of water Kg/m^3

K_w = Thermal Conductivity of water w/m-K

μ =Viscosity of Condensate $N\text{-}s/m^2$

λ	= Heat of Evaporation	J/Kg
T_S	= T_3	^0K
T_W	= T_1	^0K
L	= Length of condenser	m

Take ρ_w K_w μ λ From chart provided at end

5. OVERALL HEAT TRANSER COEFFICIENT:

$1 / U = 1/h + D_i/ D_0 \times 1/ h_0$ $_{w/m}{}^2K$

Where ,

D_i = 0.017m D_o = 0.020m

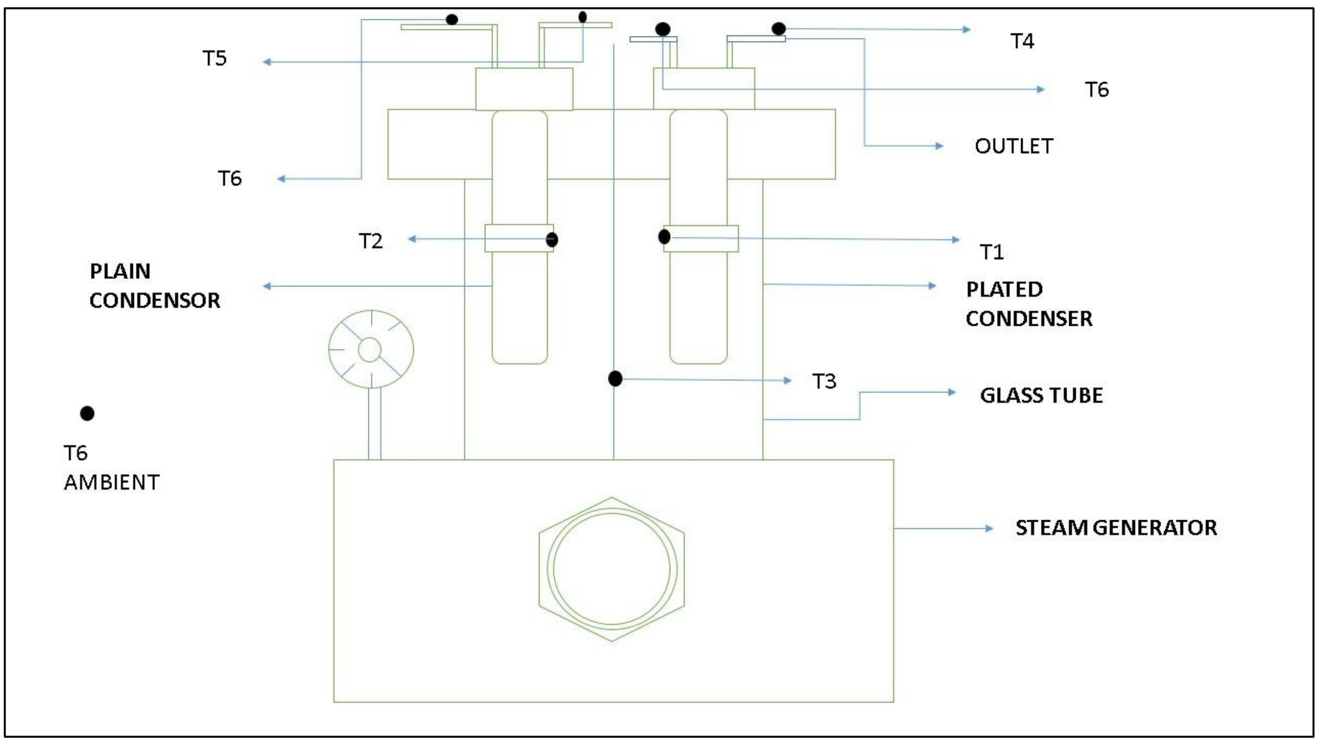


Fig 5. Drop and Film Condensation Apparatus

Experiment no. 4

Heat Pipe Demonstration

INTRODUCTION: -

Heat pipe is a device which transfers heat by boiling a fluid at one end and condensing on other end of pipe. The evaporation and condensation processes are responsible for nearly isothermal working of heat pipe. The condensed liquid is transferred back to boiling area by capillary action through a weak structure in a pipe. Thus, use of capillary action for pumping the liquid back is unique characteristics of heat pipe.

DESCRIPTION: -

The demonstrate consists of heat pipe, a stainless tube & copper pipe of identical physical properties such as diameter, lengths Heat pipe is made up of galvanised pipe. In heat pipe wire of suitable size inserted Circumferential layers of this mesh have been used. Calculated quantity of distilled water as working fluid is introduced in heat pipe after cleaning the pipe and mesh with hydrochloric acid, acetone & distilled water making perfect vacuum as far as possible. The pipe is filed after filling distilled water. A stainless-steel pipe & copper pipe are taken for comparison.

The lengths for three members are kept equal and band type heaters are used and mounted on heating section. The surface temperature along the lengths of pipe are measured by chromelalumel thermocouples while temperature of water in condenser tank is measured by thermometers.

SPECIFICATIONS: -

- OD of Copper pipe = ϕ 32mm
- OD of Stainless steel pipe = ϕ 32 mm
- OD of Heal Pipe = ϕ 32 mm
- Length of the pipes = 430 mm
- Condenser tank = 3 nos.
- Condenser tank capacity = 1 ltr
- Voltmeter = 0-300 V
- Ammeter = 5 amp
- Heater = 3 nos.
- Thermometer = 3 nos
- Temperature indicator

PRECAUTIONS: -

- ✓ Operate the selector switch of the temperature indicator gently.
- ✓ Stir the water with stirrer before taking the reading with thermometer
- ✓ Do not exceed 120 volts
- ✓ Do not disturb valve position of the heat pipe

PROCEDURE: -

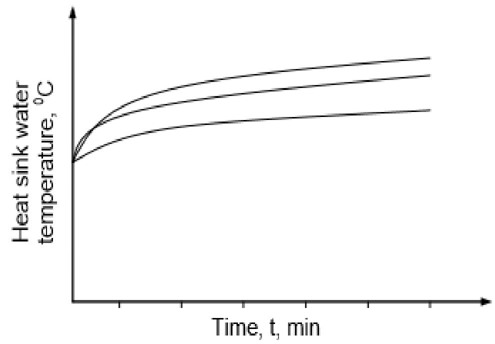
1. Before using the demonstrator, evacuate the heat pipe if necessary.
2. Fill equal amount of water in three condenser tanks so that the pipes are submerged completely in the water.
3. Start the supply.
4. Give known steady input to all the three heaters with the help of demerstat.
5. Check the input to the three heaters with selector switch, voltmeter & ammeter
6. Allow an initial beating period of about 15 minutes. Before starting up the demonstrator
7. Note down all the temperature along the lengths of pipe & also of water in the tank at the interval of 10 minutes.
8. This procedure is to be followed for steady heat pipe demonstrator working

OBSERVATION TABLE: -

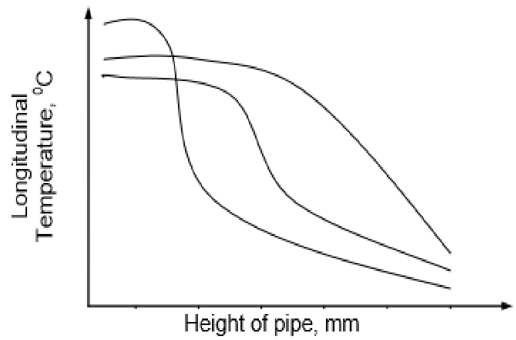
Unit	Temperature of Water in Condenser Tank	Thermocouple Locations			
HEAT PIPE		T_1	T_2	T_3	T_4
S.S.PIPE		T_5	T_6	T_7	T_8
Cu PIPE		T_9	T_{10}	T_{11}	T_{12}

GRAPHS

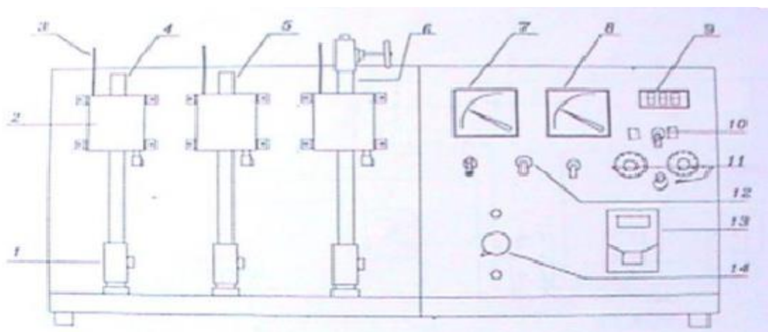
1. Plot the graph of heat sink water temperature rise up with respect to time.
2. Plot longitudinal temperature distribution for pipes.



Variation of water temperature in three sinks with increase in time.



Variation of surface temperature along the length of the pipe



Heat pipe demonstrator

1. Heater
2. Water container
3. Thermometer
4. Heat pipe
5. S.S. pipe
6. Copper pipe
7. Voltmeter
8. Ammeter
9. Temperature indicator
10 selector switch
11. Temperature selector switch
12 Pipe toggle switches (only one switch is to be put in upward direction at time)
13. Main switch
14. Heater control

Fig 5. Schematic of Heat Pipe Demonstrator

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181515	**Engineering Inspection and Metrology Lab**	**0-0-2**	**1**

Course Outcomes (CO): At the completion of the course the student will be able:

CO1: To apply proper instruments for dimensional measurement according to level of precision.

CO2: To utilize setting gauge for calibration of instrument during precision measurement.

CO3: To apply necessary tolerances on limit gauges for quality control.

CO4: To compare results of theoretical analysis with practical measurement in threads and gears.

CO5: To estimate precisely surface roughness of machined surface texture

LIST OF EXPERIMENTS

(***to select experiments from the list and add similar experiments to address the COs***)

1. To use vernier caliper and standard setting gauge for precision measurement.
2. To use micrometer screw gauge to measure major diameter and minor diameter of thread
3. To measure the height of an object by using height gauge
4. To measure the depth of a hollow cylinder by using depth gauge
5. To measure the internal diameter of a hollow cylinder by using bore gauge
6. To use feeler gauge to set clearance between mating parts
7. To use radius gauge to check the radius of a fillet
8. To use plug gauge/ring gauge/snap gauge as GO/NOGO gauge
9. To use dial indicator as comparator
10. To use thread pitch gauge to estimate the pitch of screw thread
11. To use screw thread micrometer to estimate effective diameter of screw thread
12. To use standard wire method to estimate effective diameter of screw thread
13. To use profile projector in measuring linear and angular dimensions of engineering components
14. To use Tool Maker's Microscope for linear and angular measurements
15. To use bevel protractor for angular measurement
16. To use gear tooth vernier caliper in the measurement of spur gear parameters
17. To estimate roughness of a machined surface by surface roughness testing instrument.

BEYOND THE SYLLABUS:

1. To determine surface configuration using a optical flat.
2. To use sine bar for angular measurement.

Experiment no 1

To use vernier caliper and standard setting gauge for precision measurement.

Objective: To check a vernier caliper with the help of slip gauge (end standard) and ready it for

other measurements
Items needed: Slip gauge, vernier caliper, Gudgeon pin
The instrument:

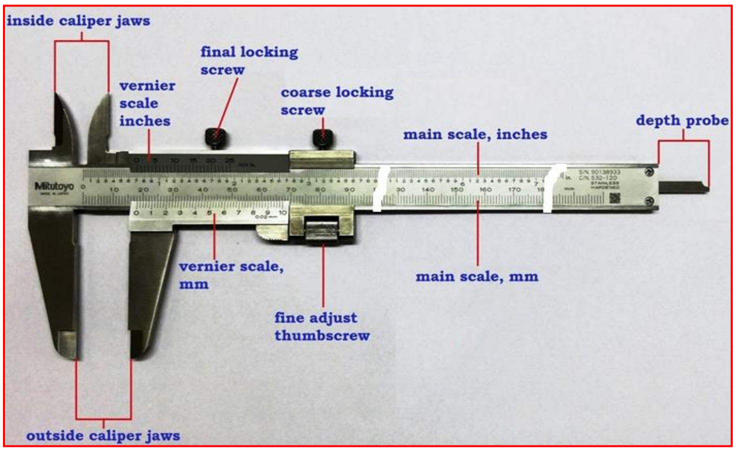


Fig 5. The parts of a vernier calliper is shown labelled in figure above.

Procedure:

1. Determine vernier constant (VC) = Smallest division of main scale - Smallest division of vernier. Explore using common sense to determine VC.
2. Remember, this is the least count (LC) of the instrument.
3. Determine the error (E) of the instrument. E can be either positive or negative. Explore using common sense whether to add or subtract in Eq.1.
4. During measurement, the formula for the observed reading (M_O) in the vernier caliper is given by:-

$$M_O = MSR + (No. of\ vernier\ division\ matching) * (VC) \pm E \qquad \text{Equation 1}$$

Where, *MSR* = main scale reading

(1) The formula for any other measurement (M) is given by

$$M = S \pm (M_{O1} \sim M_{O2}) \qquad \text{Equation 2}$$

where

S = Nominal size of Slip gauge standard, approximately equal in size to the measured item.

M_{O1} = observed reading on slip gauge standard

M_{O2} = observed reading on the part being measured

The sign "~" is used to denote difference of bigger and lower value.

For the "±" sign:- (1) Use "+" sign when $M_{O2}>M_{O1}$ (2) Use "-" sign when $M_{O2}<M_{O1}$.

Measurement: Take at least five measurements of length of a gudgeon pin and tabulate the results.

Experiment no 2

To use micrometer screw gauge to measure major diameter and minor diameter of thread.

Experiment No.2

Objective: (1) To check a screw gauge with the help of slip gauge (end standard) and ready it for other measurements (2) To measure the major and root diameter (using V piece)

Items needed: Slip gauge, Micrometer screw gauge, Gudgeon pin, V piece

The instrument:

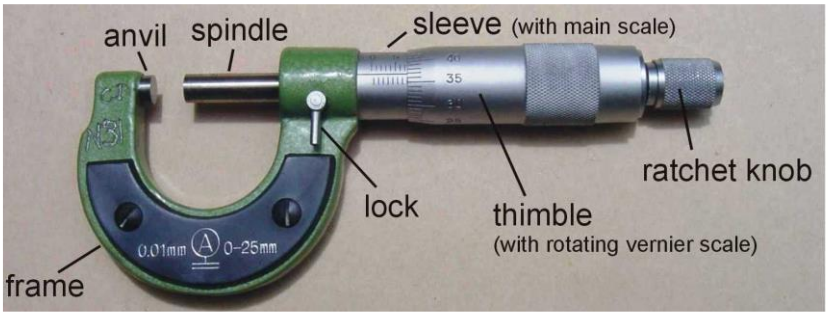


Fig 5. The parts of a screw gauge is shown labelled in figure above.

Procedure:

1. Determine the least count (LC) of the instrument.
2. Determine the error (E) of the instrument. E can be either positive or negative. Explore using common sense whether to add or subtract E in Eq.1.
3. During measurement, the formula for the observed reading (M_O) in the vernier caliper is given by:-

$$M_O = MSR + (No.of\ division\ matching) * (LC) \pm E$$ Equation 1

where MSR = main scale reading

4. The formula for any other measurement (M) is given by

$$M = S \pm (M_{O1} \sim M_{O2})$$ Equation 2

Where S = Nominal size of Slip gauge standard, approximately equal in size to the measured item.

M_{O1} = observed reading on slip gauge standard

M_{O2} = observed reading on the part being measured

The sign "~" is used to denote difference of bigger and lower value.

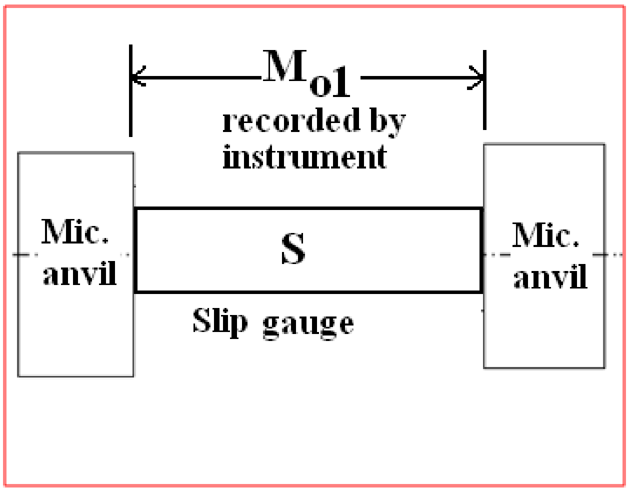
For the "±" sign:- (1) Use "+" sign when $M_{O2}>M_{O1}$ (2) Use "-" sign when $M_{O2}<M_{O1}$.

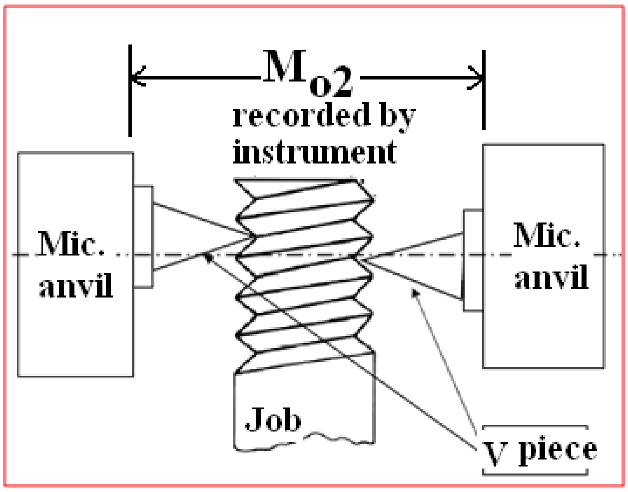
Measurement:

(1) Take at least five measurements of diameter of a gudgeon pin and tabulate the results.

(2) Use the same principle to measure the Major diameter of a metric thread of a bolt

(3) Use the same principle to measure the Minor diameter of a metric thread of a bolt, using V piece. The formula is Observed reading = 'M' minus 2(size of V piece). See the figures in next page.





Experiment no 3

To measure the height of an object by using height gauge.

Items needed: Surface plate, spirit level, vernier height gauge

HEIGHT MEASUREMENT

1. Determine vernier constant (VC)
2. Determine the error (E) of the instrument.
3. During measurement, the formula for the observed reading (M_O) in the height gauge is given by:-

$$M_O = MSR + (No. of\ vernier\ division\ matching) * (VC) \pm E$$

where MSR = main scale reading

Equation 1

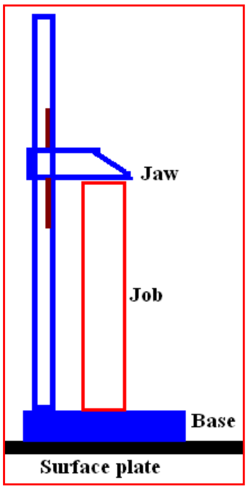


Fig 5. Vernier Height gauge

1. Level the surface plate in two orthogonal horizontal directions by the spirit level.
2. Place the height gauge over the surface plate and insert the sleeve height vertical between the base and the jaw.
3. Take at least five readings and tabulate the result.

Experiment no 4

To measure the depth of a hollow cylinder by using depth gauge

Items needed: Surface plate, spirit level, micrometre depth gauge

DEPTH MEASUREMENT

1. Determine least count (LC) of the instrument.
2. Determine the error (E) of the instrument.
3. During measurement, the formula for the observed reading (M_O) in the depth gauge is given by:-

$$M_O = MSR + (No. of\ circular\ scale\ division\ matching) * (LC) \pm E$$

where MSR = main scale reading

Equation 2

1. Level the surface plate in two orthogonal horizontal directions by the spirit level.
2. Place the depth gauge over the surface plate.
3. Select a standard rod which is relatively little longer than the depth of the sleeve.
4. Fit this rod into the depth gauge and ensure that the end of the rod stands on the surface plate. At this position, the anvil of the gauge shall not touch the upper face of the sleeve.
5. Now rotate the thimble of the screw gauge ACW until the anvil touches the upper brim *with the standard rod still standing on the surface plate*.
6. Take the reading M_O.

7. The depth of the hole (D) = Length of standard rod minus the screw gauge reading (M_O).
8. Take at least five measurements (D) and tabulate the results.

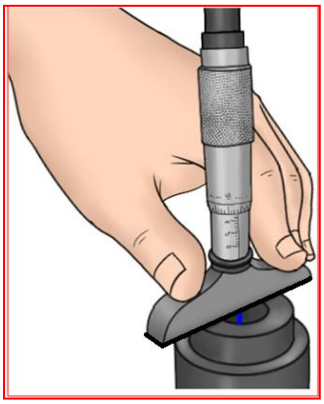


Fig 5. Micrometre depth gauge

Experiment no 5

To measure the internal diameter of a hollow cylinder by using bore gauge

Items needed: Bore gauge and bored cylinder sleeve

The instrument:

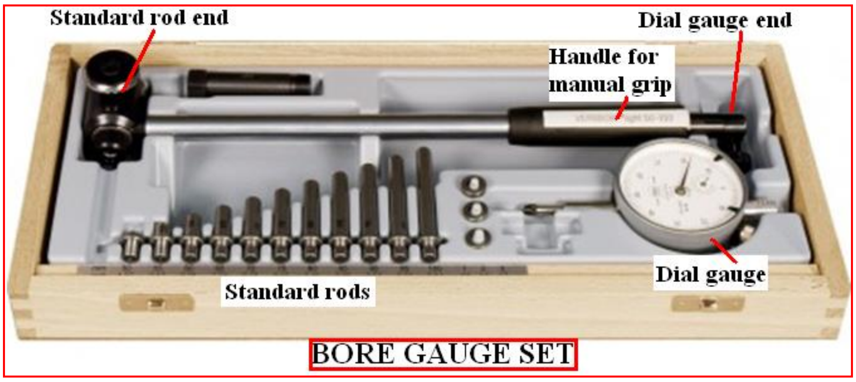


Fig 5. Bore Gauge set

The parts of a bore gauge is shown labelled in figure above.

Procedure:

1. Determine least count (LC) of the dial gauge (usually 0.01mm) and learn how to read the main scale (one or part rotation of the clock hand).
2. Fit the dial gauge on the dial gauge end of the measuring instrument and set it to zero marker by rotating the dial.
3. Select and fit a rod which is marked as little longer than the diameter of the bore.
4. Check the plunger at the end of the grip rod by touching it whether this action deflects the dial gauge or not. If it is found satisfactory, then proceed.

5. Insert the standard rod end, with the rod fitted, into the cylinder bore. Ensure to keep the grip rod upright while taking readings.
6. Take the reading of the dial gauge.
7. The size of the bore (Diameter) = Standard rod size MINUS dial gauge reading.
8. Repeat this procedure at several random places inside the bore.
9. Tabulate the results.

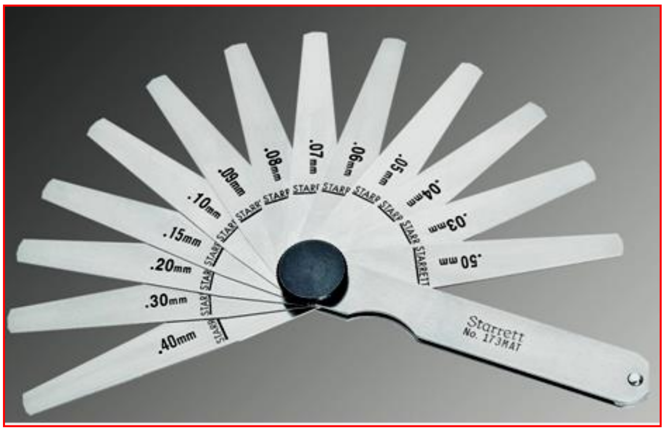
Fig 5. Measurement using Bore Gauge

Experiment no 6

To use feeler gauge to set clearance between mating parts

Items needed: Feeler gauge and engine

The instrument:



The parts of a feeler gauge is shown labeled in figure above.

Procedure:

1. Observe carefully the instrument and learn what the marked readings on the feeler gauge mean.
2. Go to the engine and remove the tappet cover.
3. Rotate the flywheel slowly and manually check to see if one of the rockers is becoming loose.

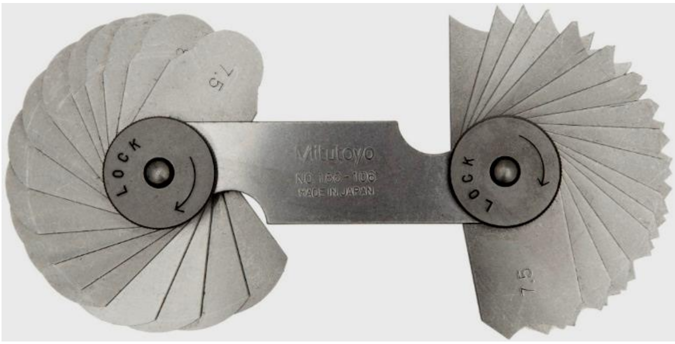
4. By slight adjustments, ensure that the gap between the rocker and valve is the highest.
5. Try using either single or multiple sets of feeler foils by inserting them into the gap so created. Note that the fit between the feeler foils and the clearance should be sliding fit.
6. Take the reading (s) of the feeler gauge. Tabulate it.

Experiment no 7

To use radius gauge to check the radius of a fillet

Items needed: Radius gauge, round file and mild steel piece

The instrument:



The parts of a radius gauge is shown labeled in figure above.

Procedure:

1. Go to the workshop and take the round file to make a deep cut.
2. Try using the radius gauge foils and observe against light so that it fits into the groove nicely.
3. Take the reading and that gives the radius of the cut made into the mild steel piece.

Experiment no 8

To use plug gauge/ring gauge/snap gauge as GO/NOGO gauge

Items needed: Snap gauge, slip gauges

The instrument:

The parts of a snap gauge is shown labelled in figure above.

Procedure:

1. Decide the Minimum Metal Limit (LML) and Maximum Metal Limit (MML) to act as quality control limits.
2. Obtain a sets of slip gauges and use procedure of wringing to set the piles to act as standards of GO and NOGO. Unscrew the movable anvils to get sliding fit of slip gauge piles into the anvils.
3. It shall make the snap gauge ready for inspection. GO must allow the item to pass through it and NOGO must not. Then accept the product. If this rule is broken by an item, the item is rejected.

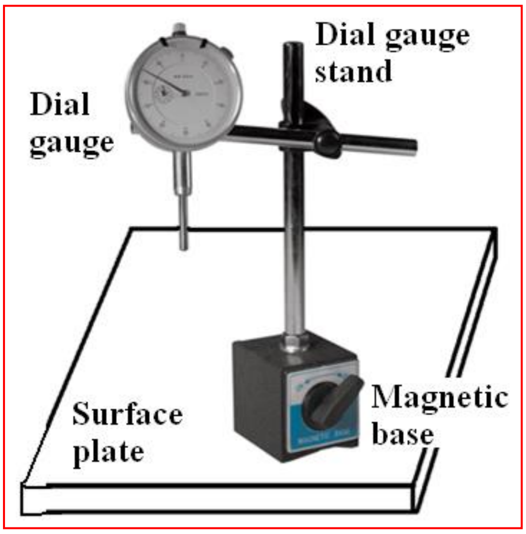
Experiment no 9

To use dial indicator as comparator

Items needed:

Dial gauge, Stand and magnetic base, Surface plate, Slip gauges, Spindle of φ25mm

The instrument:



The parts of a dial gauge is shown labeled in figure above.

Procedure:

1. Fit the dial gauge on the stand with magnetic base as shown.
2. Level the surface plate and fix the dial gauge stand on it.
3. Assume that you are to inspect a lot with natural variation of dimensions in it. For that purpose, fix a range of limits (USL and LSL) so that you shall accept those items within the LSL and USL, and reject all those outside this range. LSL and USL refer to lower and upper specification limits. Since the LC of the dial gauge is 0.01mm, hence the deviations must be multiples of 0.01mm, say $25 \pm 0.45\ mm$.
4. Now make a pile of slip gauges for a height of (25-0.45) mm and another of (25+0.45) mm.

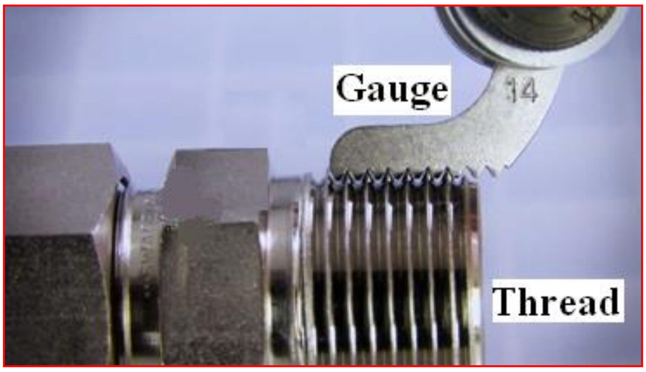
5. Set the first pile under the dial gauge plunger and observe the reading. Rotate the dial to set this value to zero in the dial. Fetch the cursor available on the dial gauge to this zero position. Take the second pile and it should make the dial gauge to record the same value. If there are discrepancies, then there must be measurement errors (eliminate it). Set the second cursor to this position of reading.
6. Take the spindle as an example and insert it under the dial plunger. If it has to be accepted, the dial gauge hand must be within the cursor positions, else rejected.

Experiment no 10

To use thread pitch gauge to estimate the pitch of screw thread

Items needed: Thread pitch gauge and bolt/nut with metric thread

The instrument:



The parts of a thread pitch gauge is shown labeled in figure above.

Procedure:

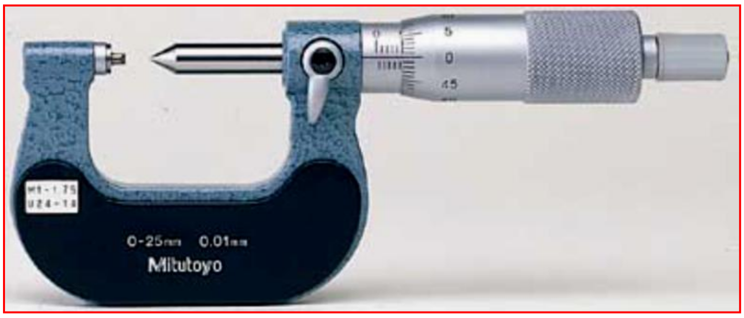
1. Go to the workshop and take a metric bolt or nut at random.
2. Try using the pitch gauge to fit into the thread and observe against light so that it fits into the grooves nicely.
3. Take the reading marked on the gauge foil and that gives the pitch of the thread.

Experiment no 11

To use screw thread micrometer to estimate effective diameter of screw thread

Items needed: Screw thread Micrometer, threaded spindle with known pitch

The instrument:



The parts of a screw gauge is shown labelled in figure above.

SPECIFICATIONS

Metric

Range	Order No.	Thread to be measured (Metric/Unified)
0 - 25mm	125-101	0.4 - 0.5mm/64 - 48TPI
	125-102	0.6 - 0.9mm/44 - 28TPI
	125-103	1 - 1.75mm/24 - 14TPI
	125-104	2 - 3mm/13 - 9TPI
	125-105	3.5 - 5mm/8 - 5TPI
25 - 50mm	125-106	0.4 - 0.5mm/64 - 48TPI
	125-107	0.6 - 0.9mm/44 - 28TPI
	125-108	1 - 1.75mm/24 - 14TPI
	125-109	2 - 3mm/13 - 9TPI
	125-110	3.5 - 5mm/8 - 5TPI

Range	Order No.	Thread to be measured (Metric/Unified)
50 - 75mm	125-111	0.6 - 0.9mm/44 - 28TPI
	125-112	1 - 1.75mm/24 - 14TPI
	125-113	2 - 3mm/13 - 9TPI
	125-114	3.5 - 5mm/8 - 5TPI
	125-115	5.5 - 7mm/4.5 - 3.5TPI
75 - 100mm	125-116	0.6 - 0.9mm/44 - 28TPI
	125-117	1 - 1.75mm/24 - 14TPI
	125-118	2 - 3mm/13 - 9TPI
	125-119	3.5 - 5mm/8 - 5TPI
	125-120	5.5 - 7mm/4.5 - 3.5TPI

Procedure:

1. Determine the least count (LC) of the instrument.
2. Determine the error (E) of the instrument. E can be either positive or negative. Explore using common sense whether to add or subtract E in Eq.1.
3. During measurement, the formula for the observed reading (M_O) in the vernier caliper is given by:-

$$M_O = MSR + (No. of\ division\ matching) * (LC) \pm E \quad \text{Equation 1}$$

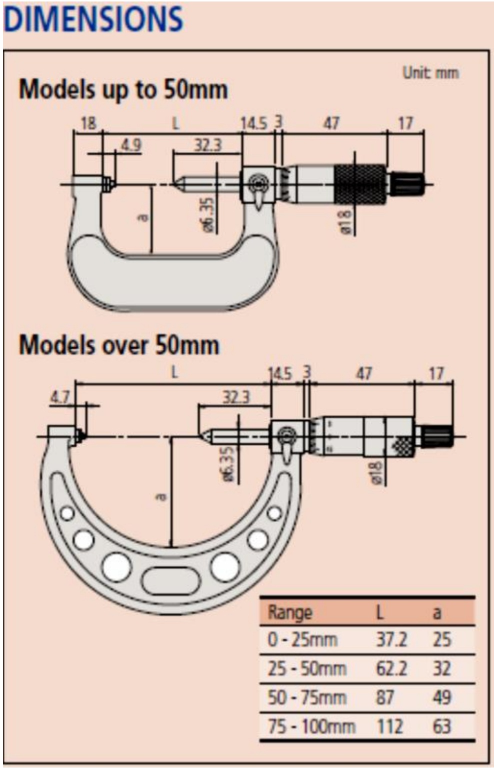
where MSR = main scale reading

If a setting gauge (S) is given, then use the formula

$$M = S \pm (M_{O1} \sim M_{O2}) \quad \text{Equation 2}$$

Measurement:

1. Take at least five measurements of pitch diameter of a thread and tabulate the results.



Experiment no 12

To use standard wire method to estimate effective diameter of screw thread

Experiment no 13

To use profile projector in measuring linear and angular dimensions of engineering components

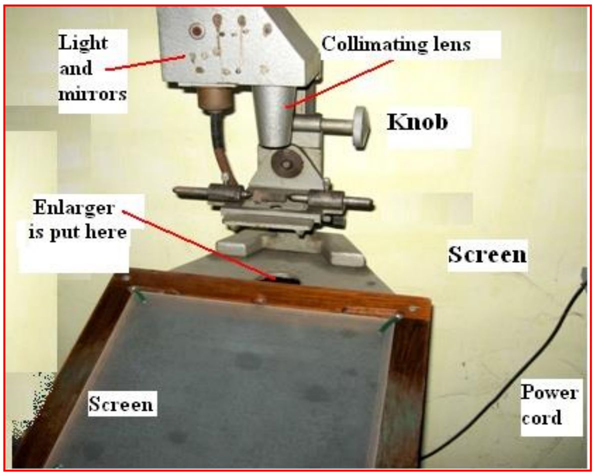
Items needed: Screw thread, Profile projector, Protractor

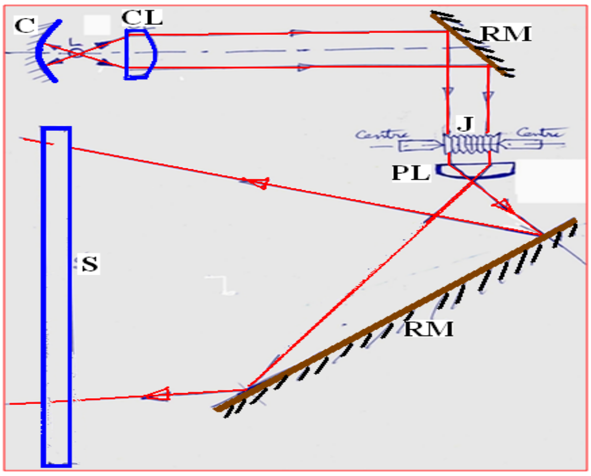
The instrument:

A simple arrangement of light source, lenses, reflecting mirrors and projector screen is also available which is described below:-

where,

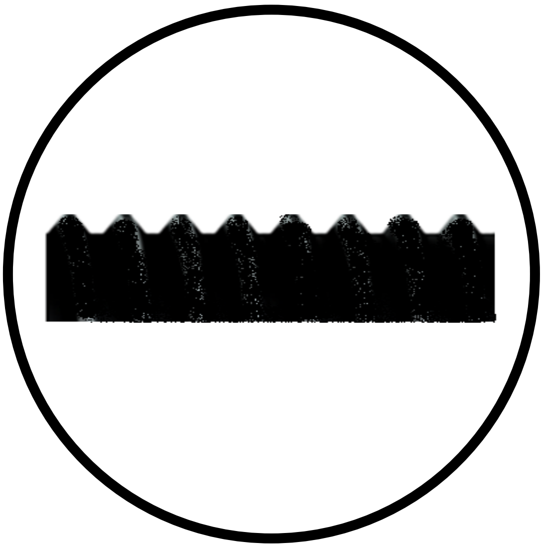
C = Concave mirror, CL = collimating lens, RM = Reflecting mirror, J = Job, P = projecting or Enlarging mirror, S = Semi transparent screen



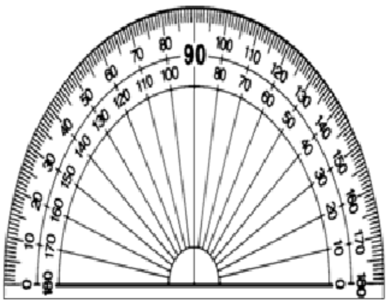


The light source is a powerful light bulb from which the rays are incident upon the curved mirror. Upon reflection from the curved mirror, the rays pass through the collimating lens and they become parallel. These parallel rays are reflected by a plane mirror to the profile of the job and pass by its profile. After that the rays pass through an enlarger and fall upon another plane mirror which reflect the enlarged image shadow on a semi transparent screen.

On the screen, the measurements are taken such as linear and angular measurements with the help of scales and protractors. Only linear measurements are then divided by the magnification power (10X, 20X, 50X, 100X etc) of the enlarging lens to get the actual dimension of the job. During measurements, the protractor or the scale may be positioned against a steel parallel shown below:



A view of the thread profile on projector screen



Protractor

Procedure:

1. Place the thread between the two centers.
2. Select proper magnification
3. Switch ON the instrument and adjust the column to focus the shadow of thread on the screen.
4. After receiving a sharp shadow, take the measurements.
5. Linear measurements are to be divided by the magnification to get the actual measured value. Angular measurements are to be accepted as they are.
6. Make at least five trials to average the readings of major, minor diameters and thread angle.
7. Tabulate the results.

Procedure for the PP having digital read out

Profile projector with digital micrometer

The profile projector is an optical device for getting the shadow (image) of the object in a larger scale on a semi-transparent screen. At present sophisticated profile projectors are becoming available. The projection of thread profile shadow is available on the screen and the measurements can be made by rotation of the table feed screws, which in turn, provide the readings in digital format.

1. Let us test an angle gauge which is to be used as a standard. The angle value is marked over the gauge.
2. Put the angle gauge over the table and switch ON the apparatus.
3. By lifting/lowering the table, the shadow of the angle gauge can be obtained on the screen.
4. Using the knobs for the table and also by the knob for the screen, one of the cross wires can be made parallel to the side of the angle gauge.
5. Take the initial reading (degrees).

6. Now rotate the cross wire so that it becomes parallel to the other edge of the angle gauge. Take this final reading.
7. The difference of reading shall give the value of measured angle for the angle gauge.

Experiment no 14

To use Tool Maker's Microscope for linear and angular measurements

Items needed: Tool maker's microscope, cutting tool having flank wear more than 10µm, fixture with protractors

The instrument

Tool Maker's microscope is an opto-mechanical (Optical & Mechanical) device for various linear and angular measurements. The light source is used to illuminate the job placed over the table in V-piece or between two centers. The knob is used to adjust the ocular head in the vertical column for focusing on the job seen through the eye-piece. For fine adjustment, the eye piece can be rotated.

The ocular head consists of a microscope tube in which several lenses are arranged to get the enlarged view of the job and its surface. Also, several cross wires can be seen in the graticule inside the microscope. Four of them are parallel to one another and two of them are at 60^{O} to each other. The TMM shown below has no rotary movement for the table. It has only linear movement of the table in two orthogonal (perpendicular) directions by the use of the two micrometers. The one having rotary movement of the table is shown in another figure 1 below.

In the above figure 2 (model not available in lab), knob 1 is used for lifting or lowering the ocular head & to focus the job. Knob 2 is used to rotate the glass table where angular divisions with vernier scale are present. Micrometers are in mutually perpendicular directions. The light source gives out illumination which passes through a filter and gets reflected from a mirror placed at 45^{O} so that the job placed over the glass table is illuminated. As you see through the eye piece, few cross wires (hairs) are seen inside. Once the job is focused by moving the ocular head, the cross wires can be placed in suitable position on the image to measure linear and angular dimensions.

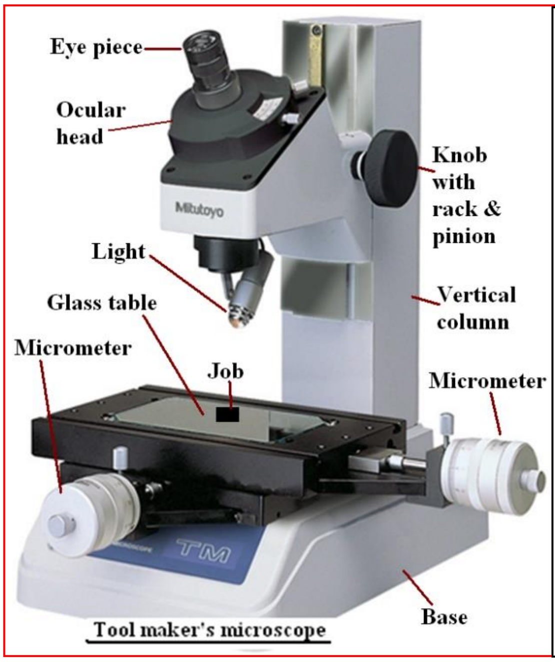


Figure 1

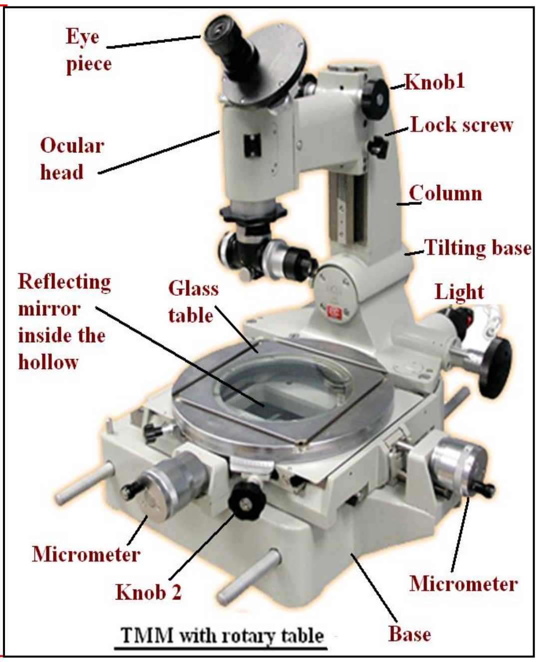
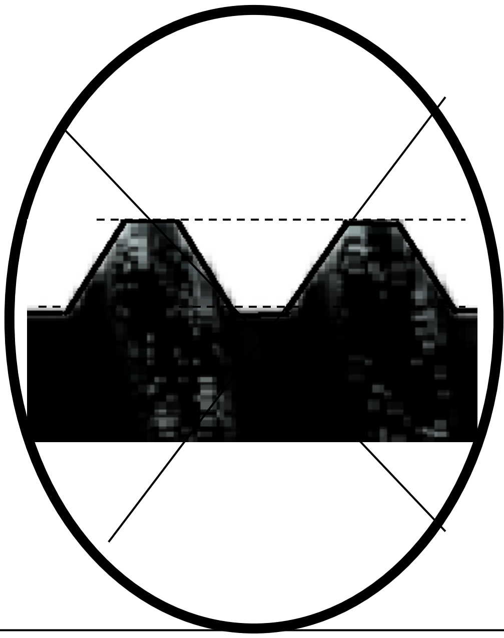


Figure 2



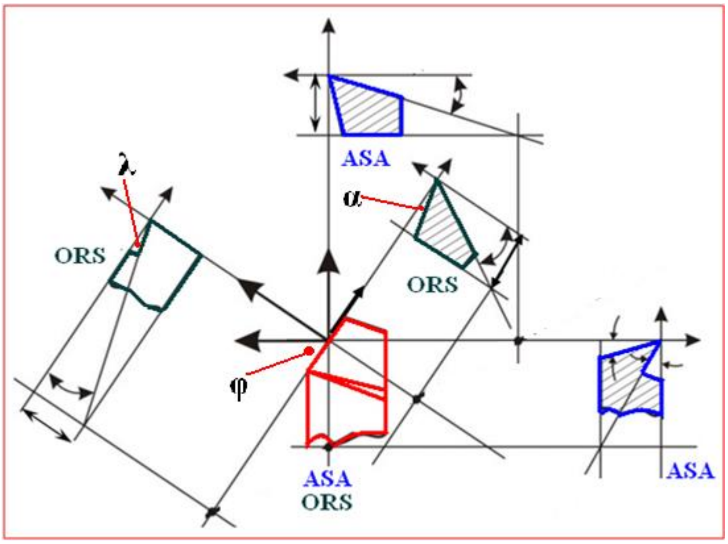
A view of the thread profile in TMM

Procedure:

1. For measuring tool wear, the tool flank has to be made perpendicular to the line of vision, i.e., perpendicular to the axis of microscope tube.
2. Place the single point tool on the fixture with main cutting edge facing upwards and tilt it by the inclination angle (λ) so that the cutting edge becomes parallel to the one of the two horizontal axes of the TMM table (say Y).

3. Now tilt the tool to make the cutting edge parallel to the table. For this, the main cutting edge angle has to be known that can be measured with the help of bevel protractor. If main cutting edge angle is φ, then the tool has to be tilted by an angle φ.
4. Next, the main flank has to be made parallel to the table of TMM. For this the clearance angle (α) of the main flank has to be known. It also can be measured with the help of bevel protractor. Now tilt the tool, with cutting edge still parallel to the table, until the flank becomes parallel to the table.

TO UNDERSTAND THESE, the figures in ORS system of nomenclature have to be known.



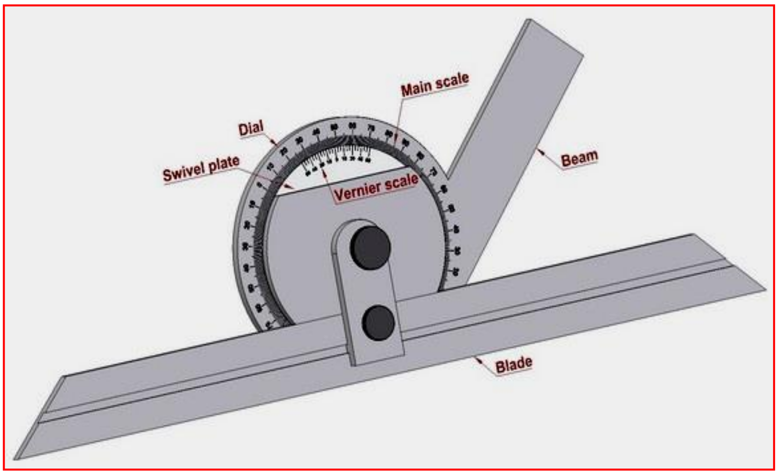
1. Once the flank is made parallel to the table OR perpendicular to the axis of microscope, the measurements can be made as usual.
2. Make one of the cross wires parallel to the cutting edge. Use the micrometer that gives the movement perpendicular to the cutting edge. Take the initial reading. Now move the cross wire to the desired location on the flank wear and take the final reading. Difference of reading gives the amount of wear.
3. Take at least 10 readings to get V_B (average flank wear) and express it in microns.

Experiment 15

To use bevel protractor for angular measurement

Items needed: Bevel protractor, tailstock center

The instrument:



The parts of a bevel protractor is shown labeled in figure above. The tailstock center is shown above.

Procedure:

1. Determine the vernier constant (VC) which is also the least count (LC) of the instrument.
2. Set the blade and beam of the caliper against the sides of the cone of the tailstock center.
3. The observed measurement is given by (in degrees)

$$M_O = MSR + (No.of\ vernier\ division\ matching) * (VC) \pm E$$

where MSR = main scale reading

E = Error of the instrument.

1. If you use an angle gauge standard, then the observed measurement is given by

$$M = S \pm (M_{O1} \sim M_{O2})$$

where,

S = Nominal size of angle gauge standard, approximately equal in size to the measured item.

M_{O1} = observed reading on angle gauge standard

M_{O2} = observed reading on the part being measured

The sign "~" is used to denote difference of bigger and lower value.

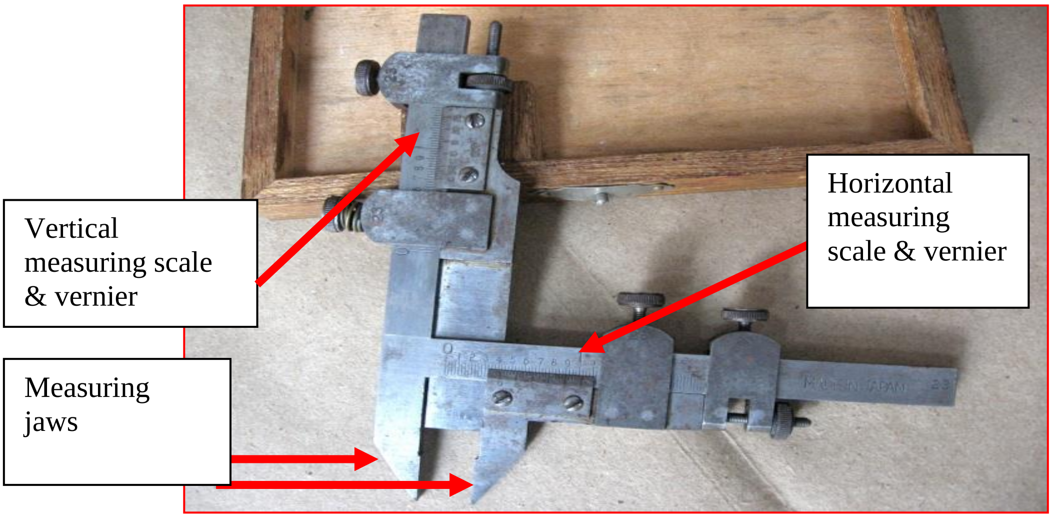
For the "±" sign: - (1) Use "+" sign when $M_{O2}>M_{O1}$ (2) Use "-" sign when $M_{O2}<M_{O1}$

Experiment no 16

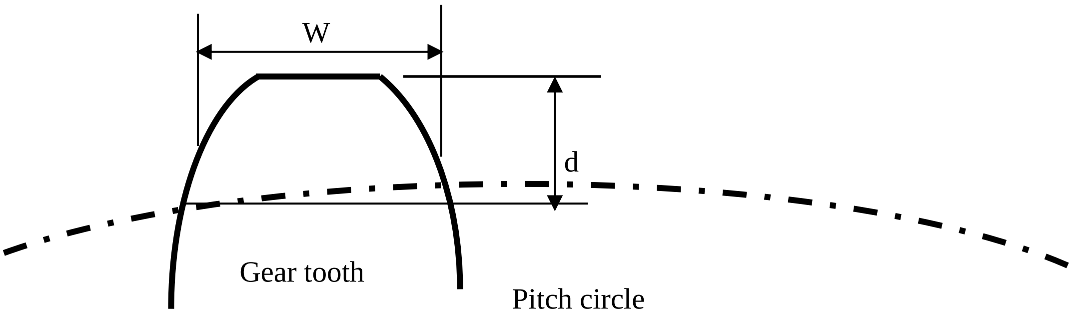
To use gear tooth vernier caliper in the measurement of spur gear parameters

Items needed: Spur gear, Gear tooth vernier caliper

The instrument:



The parts of a gear tooth vernier caliper are shown labeled above.



Theory & procedure:

d = Chordal depth

W = Chordal thickness (our parameter of interest) which must be same for all the teeth.

1. Calculate the chordal depth (d) using the formula

$$d = (mT/2) + m - (mT/2)\ \mathrm{Cos}\ (90^{o}/T)$$

2. Calculate the chordal thickness (W) using the formula

$$W = mT\ \mathrm{Sin}\ (90^{o}/T)$$

Here m = module = (DP/T), where DP = PCD and T = Number of teeth

Since these are not known, therefore, use the formula to calculate ‘m’ from

$$m = D_O/(T+2)$$

where D_o is the addendum circle diameter or outside diameter (OD) assuming addendum as one module (m), to be measured by a vernier calliper,

3. Now set the value of ‘d’ in the vertical arm of the caliper and fix its movement.
4. Now measure ‘W’ by using the other arm of the caliper.
5. Finally compare the values of ‘Calculated W’ and ‘Measured W’
6. Take at least five readings to get an average. Also determine the variation of measured W among all the teeth.

Experiment no 17

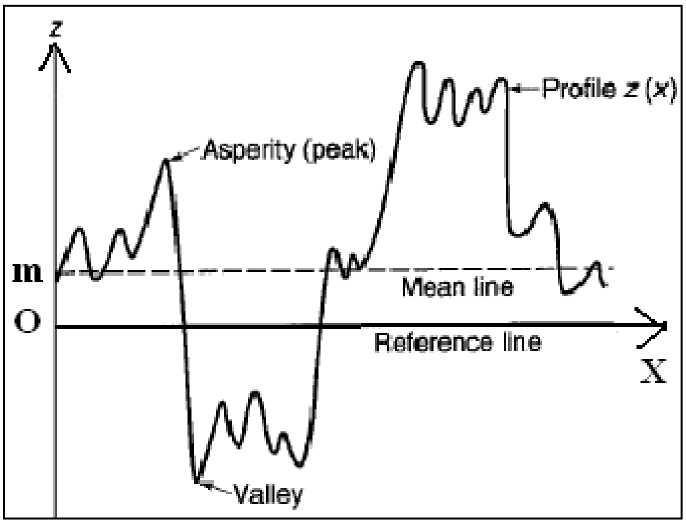
To estimate roughness of a machined surface by surface roughness testing instrument.

Items needed: Surface plate, Pocket surf, calibration specimen, spirit level.

Theory:

Estimation of surface roughness

There are various parameters used for the estimation of surface roughness using the recommended sampling length. However, the following are popularly followed by instrument designers who provide the necessary set-up for the collection of data points and presentation of results. The user is not in a position to collect the data and assess the roughness unless an instrument is designed by him/her.



Amplitude Parameters for estimating roughness:

Surface roughness most commonly refers to the variations in the height of the surface relative to a reference plane. It is measured either along a single line profile or along a set of parallel line profiles (surface maps). It is usually characterized by one of the two statistical height descriptors advocated by the American National Standards Institute (ANSI) and the International Standardization Organization (ISO) (Anonymous, 1975, 1985). These are (1) Ra, CLA (center-line average), or AA (arithmetic average) and (2) the standard deviation or variance (σ), Rq or root mean square (RMS). Two other statistical height descriptors are skewness (Sk) and kurtosis (K); these are rarely used. Another measure of surface roughness is an extreme-value height descriptor Rt (or Ry, Rmax, or maximum peak-to-valley height or simply P–V distance). Four other extreme-value height descriptors in limited use, are: Rp (maximum peak height, maximum peak-to-mean height or simply P–M distance), Rv (maximum valley depth or mean-to-lowest valley height), Rz (average peak-to-valley height), and Rpm (average peak-to-mean height).

We consider a profile, z(x), in which profile heights are measured from a reference line figure above. We define a center line or mean line such that the area between the profile and the mean line (above the reference) line is equal to that below the mean line. Ra, CLA, or AA is the arithmetic mean of the absolute values of vertical deviation from the mean line through the profile. The standard deviation 'σ' is the square root of the arithmetic mean of the square of the vertical deviations from the mean line. In mathematical form, we write

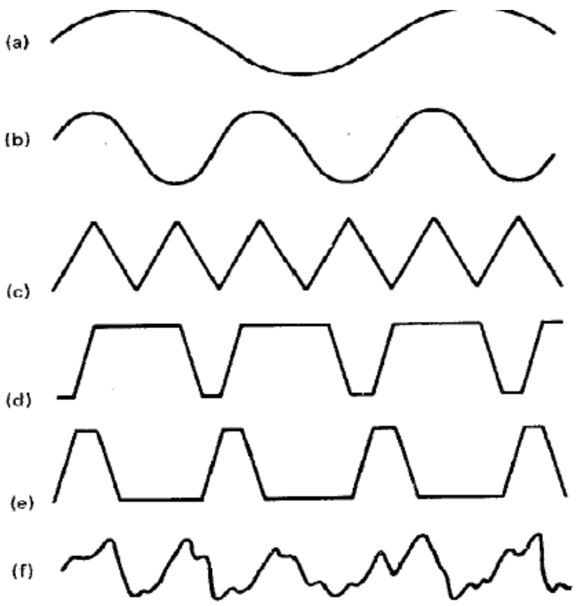
$$Ra = CLA = AA = \frac{1}{L}\int_0^L |z - m| dx$$

and m = $\frac{1}{L}\int_0^L z\, dx$, where L is the sampling length.

The variance is given by $\sigma^2 = \frac{1}{L}\int_0^L (z-m)^2\, dx = R_q^2 - m^2$

where 'σ' is the standard deviation and Rq is the square root of the A.M. of the square of the vertical deviations from a reference line.

$$R_q^2 = RMS^2 = \frac{1}{L}\int_0^L z^2\, dx$$



Various surface profiles having the same R_a value.

Standardized sampling lengths for machining processes

Process	*Symbol*	*Suitable length in 'mm'*				
Milling	M		0.8	2.5	8.0	
Turning	T	0.25	0.8	2.5		
Grinding	G	0.25	0.8	2.5		
Planning	P			2.5	8.0	25.0
Reaming	R		0.8	2.5		
Scraping	S			2.5	8.0	25.0
Diamond turning	DT	0.25	0.8			
Honing	H	0.25	0.8			
Lapping	LP	0.25	0.8			
Superfinishing	SF	0.25	0.8			
Buffing	BF			2.5		
Polishing	PO			2.5		

The instruments have a provision of a traverse mechanism (adjustable, say for 25, 50, 75, 100mm etc) for the stylus to move a larger distance within which it captures peaks and valleys many a times, keeping in view the cut-off length, and averages them to provide the roughness estimate through the average meter (Ra or CLA value).

Lay: It is the direction of the predominant surface patterns left over by the machining process. For example, the feed marks left by the sharp single point cutting tool in shaping operation are readily visible to the eye. Note that surface roughness is measured across the direction of lay. In case there is no definite directional characteristics (such as in lapped surface: what are honing, lapping, super-finishing?), then the measurements are to be done in two mutually perpendicular directions.

The roughness average (Ra) is the mean height between the mean line and the roughness profile.

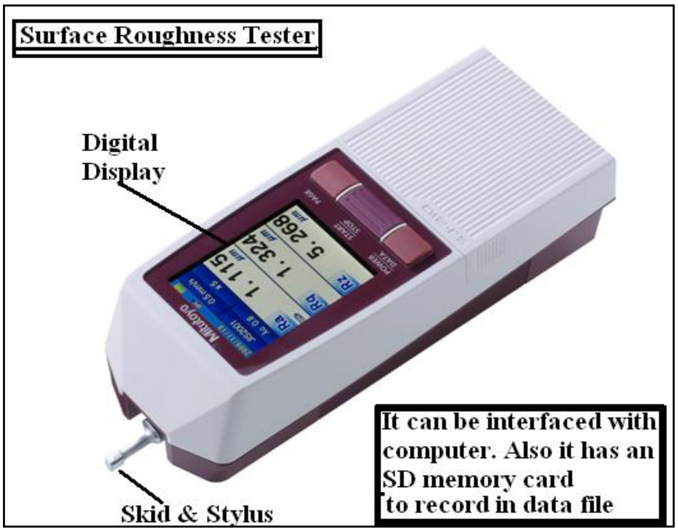
Rp = Maximum peak height from mean line

Rv = Maximum valley depth from mean line

Rz = Rp + Rv = maximum peak to valley height

P and V respectively denote peak and valley heights from a reference line.

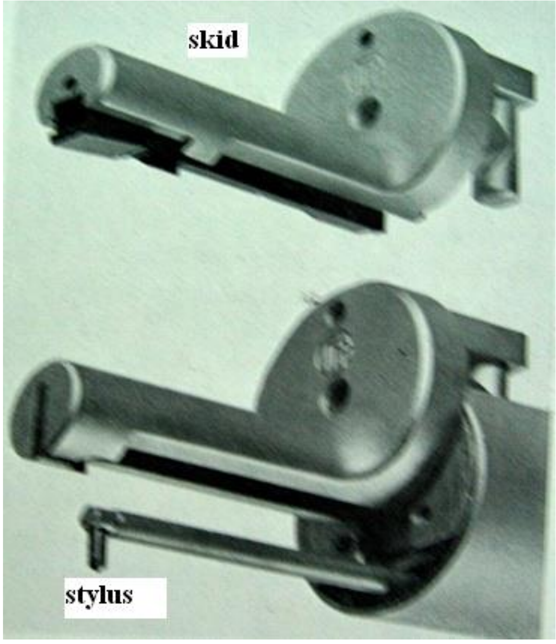
INSTRUMENTATION for ESTIMATION OF SURFACE ROUGHNESS

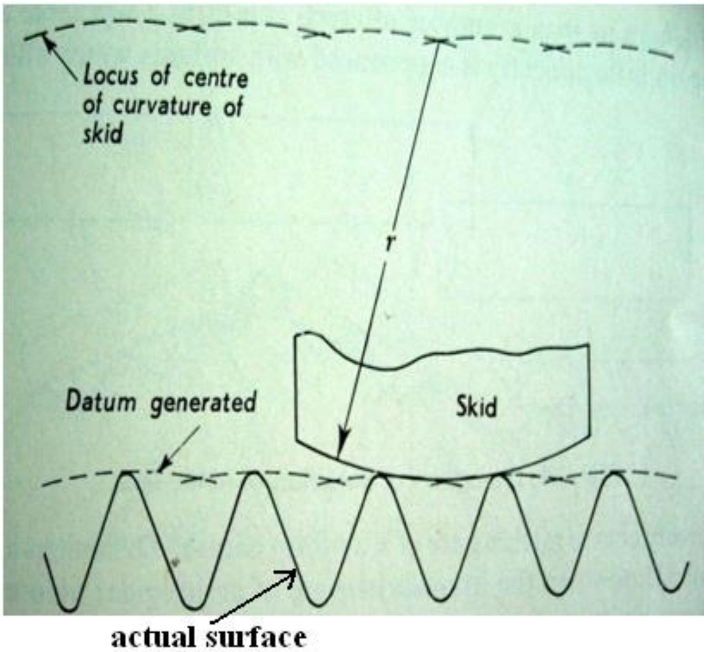


There are several types of instruments for the estimation of surface roughness. Among these, Optical, stylus type (with electrical amplifier) and interferometer are mostly used. Examples are Zeiss-Smaltz surface finish microscope, Tomlinson surface recorder (National physical Laboratory), Talysurf (Rank Taylor Hobson, UK), Johansson surface finish indicator, Philips roughness indicator, Profilograph (designed by Dr E J Abbott, USA), Brush surface analyzer (A C Wickman Ltd, UK), Electron microscopy, Surface texture interferometer, Topograph indicator (Pneumatic instrument) etc. Among these, Talyusrf is the most common and popularly used (different models available). The portable version is the pocketsurf.

The datum from which the curves or profiles are drawn

The datum, from which the profile is drawn or the data are collected by the probe or stylus, is generated by a mechanical foot or shoe called the 'skid' which may be flat or rounded in shape. These are shown in the figures below. With the arrangement of the skid, the displacement is recorded with respect to the shoe. In the other figure, a skid of radius 'r' is shown to move over a surface of uniform irregularities. The datum shall then be generated with respect to the locus of the centre of curvature of the skid moving over the surface. Note that this datum generated shall be approximately a straight line if the radius (r) of the skid is well chosen. Even then the radius (r) is a debatable issue. As such, the radius (r) has been standardized according to standards (such as British standard) followed by instrument manufacturers. See advanced literature if additional information is needed by you.





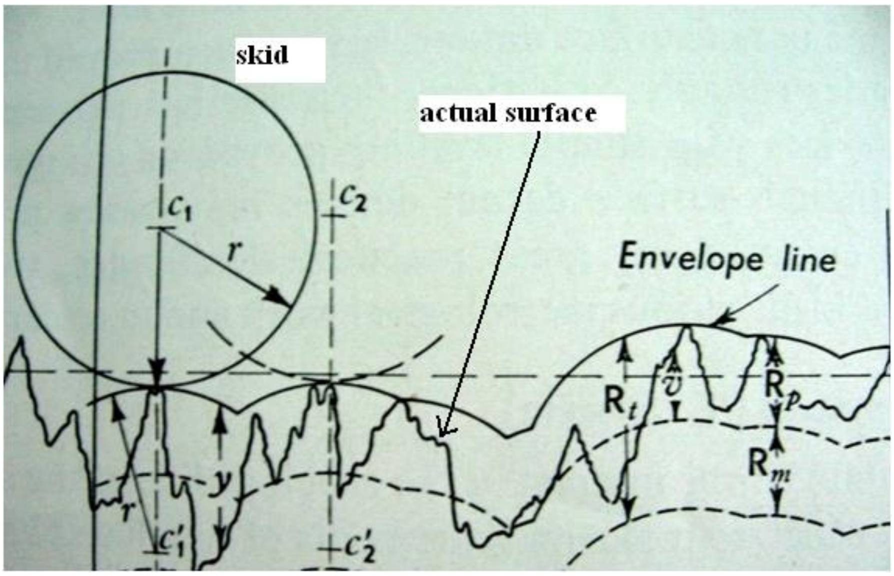
The M-system and the E-system

We have already explained the concept of the Center line system of measurement of surface roughness. The above discussions relate to this system. The Center line system is also known as 'M-system' or Mean line system.

But there is another system, called the Envelope system or E-system, where the datum from which the measurements are made constitute an envelope of the actual surface. The envelope line is defined as a line touching the effective profile at the highest peaks so that it depicts the errors of form and errors of roughness. This envelope line is congruent with the center line path of a circle of radius 'r' rolling over the actual profile touching at the highest peaks. The concept is shown in the figure below. (For details, see Engg. Dimensional Metrology by L Miller).

The datum attachment

The purpose of the datum attachment is to enable profile graphs and average readings of straight and curved surfaces to be obtained with reference to a datum generated within the instrument, independently of the surface under test. Special attachments are available that can be replaced for assessing surface roughness on straight and curved surfaces.



Note on table of sampling length [A W Judge]

Shortest cut-off are used for very finely finished surfaces and on short parts. The middle values are used for finer finishing processes such as fine turning and final grinding, honing, lapping etc. The longest cut-off are used for coarser grades of precision grinding, better grades of milling, shaping etc.

Measurement

In this instrument, a sharply pointed stylus is made to trace the profile of the surface irregularities, and the oscillatory movements of the stylus are converted into changes in an electrical current. The instrument, excepting the recorder, can be considered as a wave form analyzer which first prepares the surface for measurement by removing from its true representation those wavelengths that are not to be included, and then measures the resulting waveform. By this, the instrument is made selective in such a way that general departures from the true shape are satisfactorily eliminated, and the center line becomes zero current or zero voltage line of the waveform operative in displacing the mechanical part of the indicating instrument.

The graph recorder

The pen recorder has the feature of providing A/D conversion as data file in SD card so that graphs with rectilinear coordinates (mutually perpendicular axes and linear scales) can be drawn.

Procedure:

First of all charge the battery of the instrument and at the same time prepare a job sample.

Now switch ON the instrument and modify the setting for the sampling length and range of travel.

Place the stylus gently on the job surface in such a way that during travel the pickup does not go out of the job.

Next press the switch for measure and the pattern would be drawn and the value of roughness would be displayed.

TABULATE THE RESULTS FOR SEVERAL TRIALS.

<u>BEYOND THE SYLLABUS</u>

Experiment 1

To determine surface configuration using a optical flat.

Items needed: Optical flat, Polished (mirror finish) surface, Monochromatic light source

Theory:

Optical flat

It is round piece of glass with two mutually parallel flat ends which are polished to a high degree of flatness. Various sizes are available up to 25cm, generally used in the range of 25mm-75mm

Material: Inexpensive glass for low cost, Sapphire or high quality optical quartz.

Flatness: (a) Working flats have flatness in the order of 4μm or less. It means that no point deviates in height from other points by more than this value. (b) Master flat: flatness in the order of 2 μm or less (c) Reference flat: flatness is in the order of 1 μm or less.

Other commercial grades of optical flats are available in the flatness range of 8 μm. The surfaces of optical flats are coated with TiO_2 to reduce light lost by reflection so that clearer interference bands are available. The finished surface is shown by an arrow if only one surface is ground.

Fig. Optical flat and its use over slip gauges to test the flatness of the surfaces

TEST DURFACE CONFIGURATIONS:

1. Ideal flat surface: The fringes are parallel to one another. The reference contact is found by giving slight pressure at one end: if the fringes move, the surface if inclined that way; if no response, the reference contact is found.

2. Concave surface: The fringes are curve away from the reference contact. If by pressing at the ends, the fringes do not move but they move when pressed at the middle, the surface is concave.
3. Convex surface: The fringes centre around a reference contact. If by pressing at the ends fringes move and there is no response because of pressure at the middle, then surface is convex.

Procedure

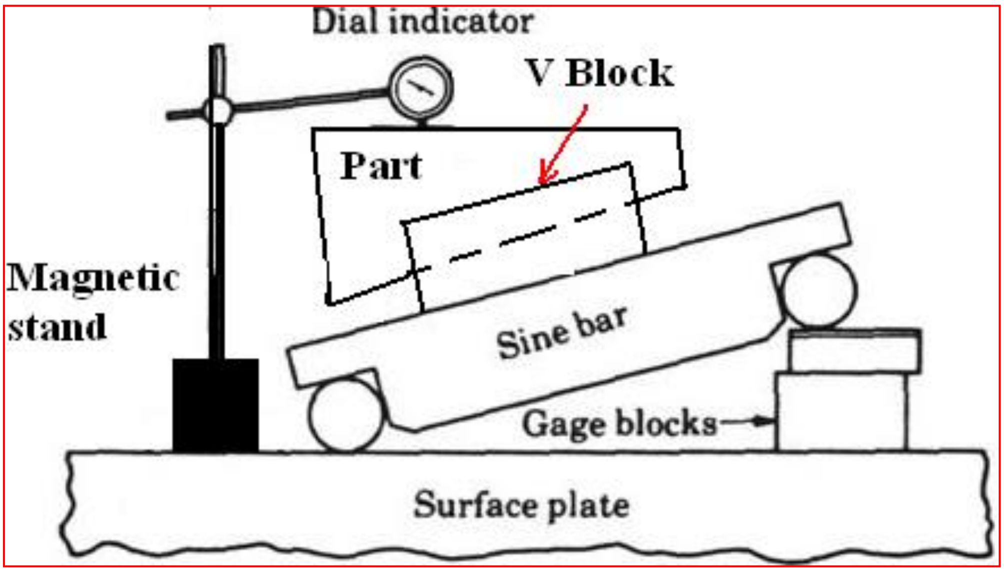
1. Use a dark room and switch ON the monochromatic light source.
2. Clean the finished surface and hold, by pressure, the optical flat over the test surface.
3. Observe the pattern and comment on the surface configuration.
4. If possible, determine the approximate value of the concavity/convexity.

Experiment 2

To use sine bar for angular measurement.

Items needed: Surface plate, Tailstock center, slip gauges, V block, Sine bar, dial indicator with magnetic base stand, spirit level.

The instrument set up:



The components of the set up are shown labelled in figure above.

Procedure:

1. First of all, level the surface plate with the help of spirit level.
2. Put the V block over the sine bar (its length “L” must be known in advance).
3. Put the part being measured over the V block.

4. Raise one end of the sine bar rollers using slip gauges such that the top surface of the part becomes horizontal. This can be ensured by taking two readings at the two extremities of the part with the help of the dial gauge.
5. Now determine the height of slip gauge pile (h).
6. The half taper of the part would be given by

$$\beta = Sin^{-1}\left(\frac{h}{L}\right)$$

7. The measured taper would be 2β (full taper).
8. Take at least five readings by rotating the part for various positions and tabulate the results.

3.6 SIXTH SEMESTER

B.Tech 6th Semester: Mechanical Engineering

Sl. No.	Sub-Code	Subject	Hours per Week			Credit	Marks	
			L	T	P	C	CE	ESE
Theory								
1	ME181601	Machine Design-II	3	0	2	4	30	70
2	ME181602	Fluid Mechanics-II	3	0	0	3	30	70
3	ME181603	Mechanical Measurements and Instrumentation	3	0	0	3	30	70
4	ME181604	Workshop Theory and Practice-II	3	0	2	4	30	70
5	ME181605	Heat Transfer-II	3	0	0	3	30	70
6	HS181606	Accountancy	2	0	0	2	30	70
Practical								
1	ME181612	Fluid Mechanics-II Lab	0	0	2	1	15	35
2	ME181613	Mechanical Measurements and Instrumentation Lab	0	0	2	1	15	35
3	ME181615	Heat Transfer-II Lab	0	0	2	1	15	35
Total			**17**	**0**	**10**	**22**	**225**	**525**
Total Contact Hours per week: 27								
Total Credits: 22								

N.B. 4-6 weeks Mandatory Industry Internship need to be done in the 6th semester break and thereport is to be submitted and evaluated in 7th semester

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181601	**Machine Design-II**	**3-0-2**	**4**

Course Outcomes (COs): On successful completion of this course the student should be able to:

CO1: Identify the modes of fatigue failure in materials in cases of axial, torsional, flexural and combined loading conditions with stress concentration criteria

CO2: Distinguish between cases of static and dynamic loading conditions to test the theories of failurein design of simple mechanical elements like plates, bars, beams and shafts

CO3: Design gears, springs by selecting and analyzing engineering materials and considering designcriterions of failure under static and dynamic loading conditions using design data hand book(s)

CO4: Utilize the principles of tribology to design sliding contact bearing and select antifriction-bearings under static and dynamic loading conditions using design data hand book(s)

CO5: Design and analyze brakes and clutches under the consideration of power transmission usingdesign data hand book(s)

MODULE 1: **(10 Lectures)**

Design against static load
Different types of loads and stresses-
ReviewDesign against fluctuating load
Stress concentration, fluctuating stresses, Fatigue failure, endurance limit, Notch sensitivity, cumulative damage in fatigue, Soderberg and Goodman Diagrams, Fatigue design under combined stresses

MODULE 2: **(10 Lectures)**

Design of Mechanical Springs – helical spring, Gears: Spur and Helical gear

MODULE 3: **(10 Lectures)**

Design of Friction clutches – single and multidisc clutch, cone clutch, Brakes – Disc, cone, band andinternal expanding shoes

MODULE 4: **(10 Lectures)**

Tribology, Design of Bearings – radial and Thrust journal bearings, Selection of Rolling ContactBearings

Textbooks/ Reference Books:

1. Machine Design by Black and Adams (TMH)
2. Design of machine elements by M F Spott
3. Design of machine elements by B V Bhandari (TMH)
4. Machine Design by Hall
5. Machine Design by Khurmi and Gupta
6. Machine Design by Bahl and Goel
7. Machine Design by Shigley
8. Design Data Handbook: Mahadevan and Reddy

Course Time Plan:

Units/Topics	Number of Lectures	Method of deliver
Unit I: Design against static load Different types of loads and stresses- Review	4	Both chalk and talk, Demonstration, power point presentation
Design against fluctuating load Stress concentration, fluctuating stresses, Fatigue failure, endurance limit, Notch sensitivity, cumulative damage in fatigue, Soderberg and Goodman Diagrams, Fatigue design under combined stresses.	12	
Unit II: Design of Mechanical Springs – helical spring, Gears: Spur and Helical gear	8	
Unit III: Design of Friction clutches – single and multidisc clutch, cone clutch, Brakes – Disc, cone, band andinternal expanding shoes	8	
Unit IV: Tribology, Design of Bearings – radial and Thrust journal bearings, Selection of Rolling ContactBearings	8	
Total	40	1 class = 1 Hour

MACHINE DESIGN LAB

Experiment 1: Analytical Modelling of Spur Gears

Aim: A 5KW motor drives a spur pinion at 700rpm which transmits power to another spur gear on the driven shaft. The required rpm on the driven shaft is 175 rpm. The transmission drive is to be placed in a space not more than 20cm in width. Design a suitable transmission drive for the above condition. Justify the design using analytical analysis.

Theory: The algorithm to develop an analytical model in C++ is as follows:

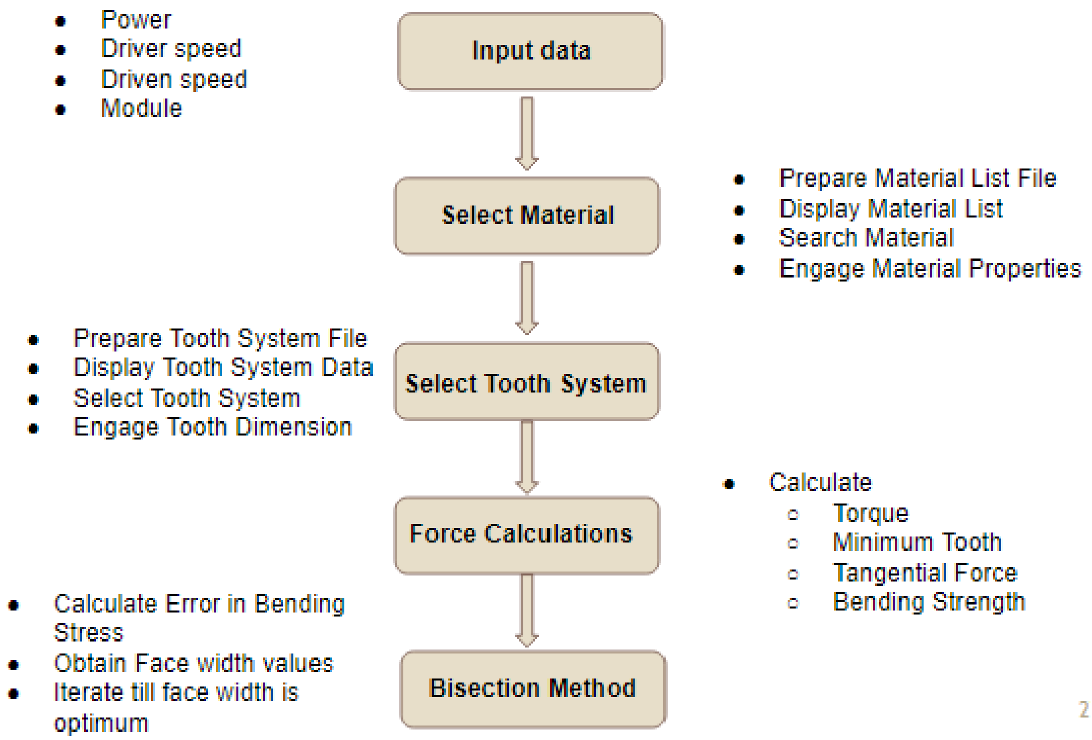


Fig: 6.1 Algorithm of Gear Design

Code:

*****Please put the code that you have developed here******

Results:

Table 1.1-Data Obtained from Analytical Model

Input Parameters	Power Transmitted	Input RPM	Output RPM	Center Distance	Module	Tooth System Selected	Material Selected
Output Parameters	Pitch Circle Diameter of Pinion and Gear	Addendum and Dedendum Circle Diameter of Pinion & Gear	Whole Depth	Tooth Thickness	The face width	Maximum Tangential Force	Maximum bending stress

Experiment 2: Numerical Modelling of Spur Gears

Aim: A 5KW motor drives a spur pinion at 700rpm which transmits power to another spur gear on the driven shaft. The required rpm on the driven shaft is 175 rpm. The transmission drive is to be placed in a space not more than 20cm in width. Design a suitable transmission drive for the above condition. Justify the design using numerical analysis.

Solid Modelling:

I. Create the base circle(c1) and pitch circle(c2) of the gear.

II. Draw dedendum circle(c3) and addendum circle(c4)

III. From the center draw a vertical line(L1), draw another line(L2) from the center of the circle at an angle (anticlockwise) with value of that of the pressure angle, α .

IV. Taking point 1 as a center (intersection between base circle(c1) and line(L2)) draw a circle(c5) with radius equal to the distance between point 1 and point 2(Intersection between circle(c2) and line(L1)).

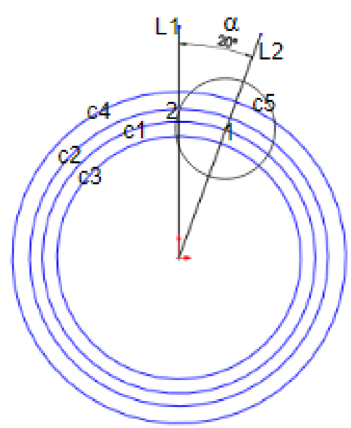


Fig 6 Geometric Circles for Reference

V. Using the trim command from the modify menu, obtain the involute profile between point 3(Intersection between c5 and c4) and point 4(Intersection between c5 and c3) from circle (c5).

VI. Draw a line of length equal to the tooth thickness from point 2 and draw a perpendicular bisector on it.

VII. Obtain a mirror image of the original tooth profile. Join the tip of the tooth profile by a horizontal line

VIII. Incorporate fillet radius at the bottom of the teeth on both the sides with appropriate fillet radius at the dedendum circle. Draw circle(c6) with the dimension of the shaft.

IX. Convert all sketches to the construction line except the dedendum circle and tooth profile.

X. Extrude the sketch and apply circular pattern to develop the 3-D model of the gear.

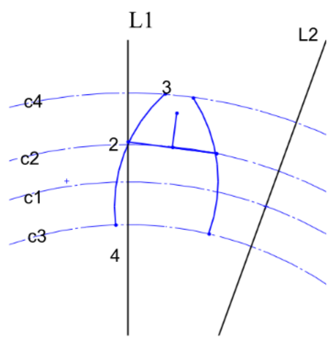


Fig 6 Tooth Profile

XI. Generate the mating gear on the same geometry modeler as per the problem.

XII. Save the file in .iges/.igs format.

Numerical Modelling:

I. Open ANSYS Workbench. Click on import and select the ".igs" file for spur pinion.

II. Create a "Static Structural" standalone system by dragging the module into the workspace.

III. Connect the Geometry(A) and the Geometry (B) under the "Static Structural" module by dragging a click from each tab

IV. Check if Engineering Data is updated.(If not double click on it and select a material)

V. Double click on the "Geometry(A)" and "Design Modeler" will open. Select dimensions in "Millimeter". Click "Ok".

VI. Open the "Design Modeller" on the Imported geometry and right click on "Geometry" and click on "Generate".

VII. Minimize the "Design Modeller" and go to the Workbench Window. Right Click on "Model" and then click on "edit". The "Static Structural" module will open.

VIII. Generate a generic mesh by right clicking on it and clicking on generate mesh. (In case the mesh is not appropriate, method sizing, mapping etc can be added)

IX. Right click on "Static Structural" tab and then go to "Insert" under which select "Fixed Support". Before selecting inner faces(green) of the Gear, please make sure cursor select is "face" type. After which, select the inner face(s) and click on "Apply".

X. Right click on "Static Structural" tab and then go to "Insert" under which click on "Force". Please make sure cursor select is "line" type as the load is supposed to be put at the tip of the tooth. Select face edge of the tooth that is almost or exactly parallel to the vertical axis. Click on "Apply ".

XI. Select "Component" instead of "Vector" and according to the direction and magnitude enter the details of force.

XII. Similarly, on the "Solution" tab, select the quantities to be calculated by right clicking and selecting from the menu.

XIII. Right click on "Solution" and then click on "Solve" or simply click on "solve" at the top of the window. Click on individual results to view.

XIV. Click on print preview and report preview to generate report.

XV. Save the project.

Results:

*****Put results as generated in ANSYS (put the results of mesh, results like stress, deformation, material used only and final diagram) ******

Experiment 3: Analytical Modelling of Anti-Friction Bearings

Aim: For the same motor specification and gear drive of experiment 1, select a suitable anti-friction bearing for the gear and justify the design. Select the bearings from reliable suppliers.

Theory: Algorithm

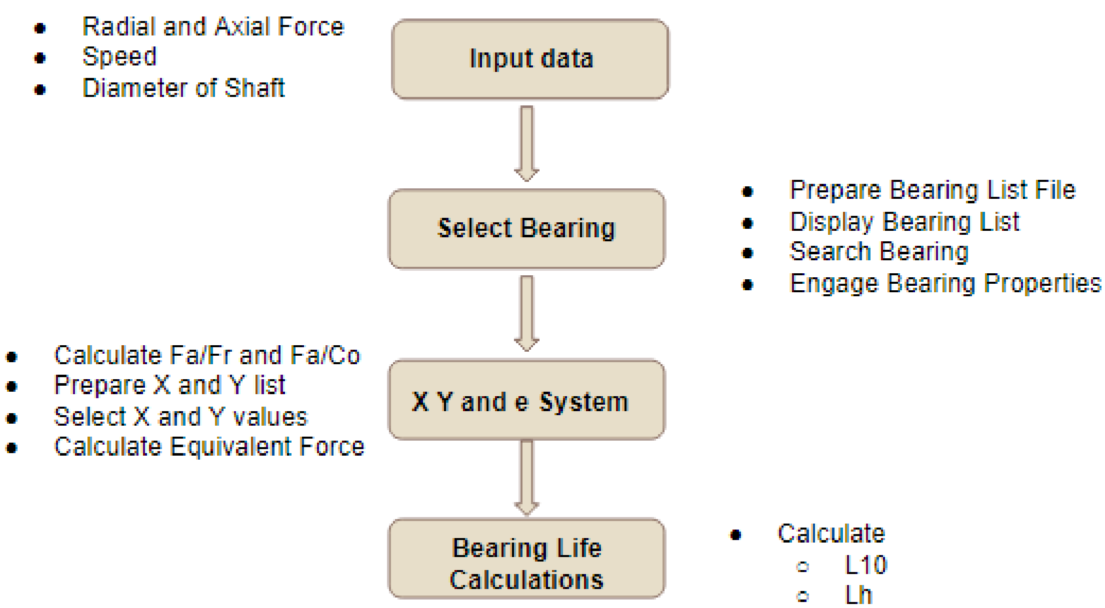


Fig 3.1 Algorithm of Anti Friction Bearing Selection and Analysis

Code:

*****Please put the code that you have developed here******

Results:

Table 3.1

Bearing No	Bore Diameter(d)	Outside Diameter(D)	Width (B)	Inner Land Diameter (Li)	Outee Land Diameter (Lo)	No. of Balls (z)	Ball Diameter (do)	Static Load Capacity (Co)	Bearing Life in hours

Experiment 4: Numerical Modelling of Anti Friction Bearings

Aim: For the same motor specification and gear drive of experiment 1, select a suitable anti-friction bearing for the gear and justify the design and develop a numerical model. Select the bearings from reliable suppliers.

Solid Modelling:

1. Obtain the bearing dimensions of selected bearing from: https://nhbb.com/files/catalog_pages/HiTech_Catalog.pdf
2. Draw an axis (A1) from which all the dimensions are measured upwards.

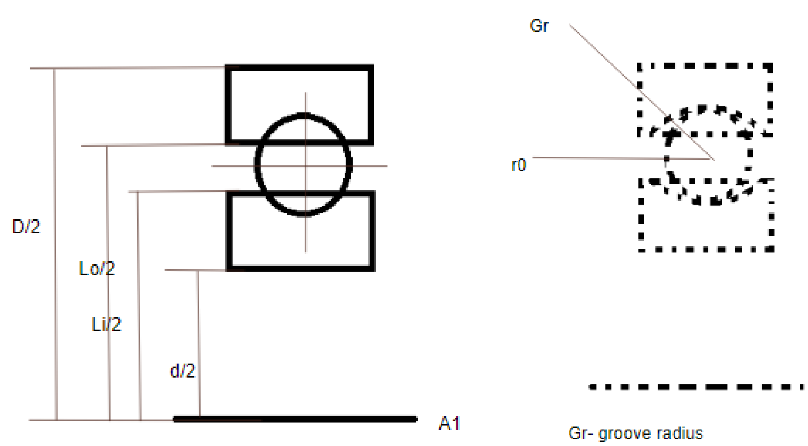


Fig 6. (a) 2D Sketch of Inner race, Outer race and Balls of an antifriction Bearing. (b) Construction of Groove lines.

3. In a solid modelling software, draw the following following 2D sketch as per dimensions obtained from the catalogue.
4. Draw a perpendicular bisector between the inner race and outer race and find the mid-point of the perpendicular bisector.
5. Draw a circle with the diameter equal to the ball diameter.
6. Draw the grooves as per dimension decided manually and convert the whole sketch into constructions lines.
7. Convert the sketch to from construction to geometric lines for the inner race. Make sure the sketch is closed.
8. Exit sketch and use the revolve command. Select the axis A1 for revolution and inner race geometry as the contour. Make sure the revolve angle is 360 degrees.
9. In a different sketch and plane, draw a circle circumscribing a square. Measure the diameter of the circle.
10. Save the file as inner race.
11. Save the file again by using the “Save As” option. Use a different name this time.
12. Convert the sketch from construction to geometric lines of the outer race. Make sure the sketch is closed.
13. Exit sketch and use the revolve command. Select the axis A1 for revolution and outer race geometry as the contour. Make sure the revolve angle is 360 degrees.
14. Save the file.
15. Save the file again by using the save as command. Use a different name this time.
16. Go to the same sketch and sketch a semicircle over the full circle
17. Exit sketch and use the revolve command. Select the axis A1 for revolution and outer race geometry as the contour. Make sure the revolve angle is 360 degrees.
18. In a separate sketch plane, draw an axis through the origin. Select Circular pattern and in bodies to pattern, select the ball.
19. Select equal spacing and angle as 360. Put the number of instances as the number of balls required.
20. In a different sketch and plane, draw a circle circumscribing a square. Keep the diameter of the drawn on the inner race.
21. Save the file.

22. Open Assembly in any solid modelling software and load all the parts of the bearing. Make sure all the parts are in float mode and not in fix mode.
23. Fix the outer race.
24. Apply concentric mate between the inner race and outer race.
25. Apply face coincidence if the inner race and outer race are offset.
26. Now, apply parallel mating between the two squares on the inner race and balls respectively. Set the distance between the two as 0mm.
27. Save the assembly.

Numerical Modelling:

1. Open ANSYS Workbench, and import the geometry as shown in the figures below.
2. Open the Geometry and check if the imported geometry is alright.
3. Add Transient Structural standalone system and link the geometry to the geometry of the standalone system as shown in figure by simply dragging and dropping it.
4. Open the Model tab on the standalone system. Open Connection in which open Contacts.
5. Select all the contact regions and set the type of definition to "No Separation" type.
6. Generate Mesh.
7. From the Body- Ground Drop down menu select "Revolute".
8. Select the face option and then select the bearing face. Click on Apply.
9. Create another revolute joint and select all the bearing. Click on Apply.
10. Check if the axis orientation is correct and if not click on reference geometry.
11. Click on the axis to be changed and then on the axis to which the new direction is to be set.
12. Click on Apply.
13. In the "Transient" menu, select on "Analysis"
14. Set the initial time step to 0.1, Minimum Time Step to 0.01 and Maximum Time Step to 0.1.
15. In the "Transient" menu, Inset a Fixed Support and select the face of the outer race. Click on Apply.
16. In the "Transient" menu, Inset a Force and select the face of the inner race. Click on Apply.
17. Change the "Defined By" to Components and put the magnitude of force along whichever direction is required.
18. Insert a Joint Load and select "Ground to Inner Race". Set type to rotational velocity and enter the magnitude.

19. Right click on Solution and Click on Solve.
20. Insert any result and over which right click and select Evaluate all results to view the parameter.

Results:

*****Please put results generated in ANSYS (put the details of material used, mesh generated (nodes and elements), results like stress, deformation, material used only and final diagram) ******

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181602	**Fluid Mechanics-II**	**3-0-0**	**3**

Course Outcomes (COs): At the completion of the course the student will be able:

CO1: To familiarize with behaviour of compressible gas flow and to understand the difference between subsonic and supersonic flow

CO2: Illustrate the effect of Mach number on wave pattern, and do analysis for Fanno flow, Rayleigh flow and isothermal flow

CO3: Determine integral thicknesses, wall shear stresses, and skin friction coefficient using the concepts of viscous boundary layers and the momentum integral

CO4: Justify the cause of boundary layer separation in viscous and turbulent flows, deduce velocity distribution, shear velocity, and intensity in turbulent flows and derive the governing equations for the respective flows

CO5: Solve turbulent fluid flow problems with the application of turbulent theories and boundary conditions, differentiate between hydraulically smooth and rough boundaries

MODULE 1: Compressible Flow

Introduction to Compressible Flow, Propagation of elastic waves, wave pattern under varying Mach number, one dimensional steady Isentropic flow, Irreversible discontinuity in supersonic flow, Shock Waves-Normal shock, Impossibility of shock in subsonic flow, Moving normal shock waves, Fanno flow, Rayleigh flow, Isothermal flow

MODULE 2: Viscous Flow

Characteristics of laminar flow, governing equation, Boundary layer equation, Blasius flow over flat plate, Wall shear and boundary layer thickness, Momentum integral equation for boundary layer, Separation of boundary layer, Control of boundary layer separation, Mechanics of boundary layer transition, Several events of transition, Form drag and skin friction drag

MODULE 3: Turbulent Flow

Characteristics, Classification, Theories of Turbulent, Mean Motion and Fluctuations, derivation of Governing equation for turbulent flow, boundary conditions, Prandtl's mixing length, universal velocity distribution Law and Friction factor in Duct flow for very large Reynold Numbers, velocity distribution, shear velocity, hydraulically smooth and rough boundaries, velocity distribution in rough pipes, Nikuradse's Experiment on artificially roughened pipes, Karman-Prandtl resistance equation

Textbooks/ Reference Books:

1. Fluid Mechanics (Tata McGraw Hill) --------- V. L. Steeter
2. Fluid Mechanics (Prentice Hall India) --------- A. Mohanti
3. Fluid Mechanics (ELBS) ------------------------ Massey
4. Gas Dynamics (PHI) -------------------------- E. Rathakrishnan
5. Introduction to Fluid Mechanics and Fluid Machines ---- S K Som & G Biswas

Introduction to the Course

FLUID MECHANICS-II requires basic knowledge from the subject FLUID MECHANICS-I. This course introduces the core topics of FM like compressible flow, viscous and laminar flow. The course framework is hence designed giving importance to the basics of the above mentioned topics, thus enabling the students to build strong fundamentals in the area of Fluid Mechanics. It has application related more towards aerodynamics flow and industrial fluid flow. It mainly discusses the characteristics, classification and theoretical background of the governing equations of compressible, viscous and turbulent flows. This course is designed to lay a foundation for advanced studies and research in the field of Fluid Mechanics.

Motivation

The study of compressible flow has its applications in the field of supersonic aircrafts, supersonic wind tunnels, natural gas pipeline etc. Viscous and turbulent flow studies find its application throughout the globe where fluid flow exists. Practical examples of turbulent flow are blood flow, oil transport, lava flow, atmosphere and ocean currents, the flow through pumps and turbines, and the flow in boat wakes and around aircraft-wing tips. This subject helps the under graduate students to appreciate how natural flow phenomenon's can be modelled theoretically and motivates them to further extend their studies in this field.

Course Time Plan:

Units/Topics	Number of Lectures	Method of deliver
Unit I – Compressible Flow	12	Both chalk and talk and power point presentation
Unit II – Viscous Flow	11	
Unit III – Turbulent Flow	12	
TOTAL	35	1 class @1 hours

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181603	**Mechanical Measurements and Instrumentation**	**3-0-0**	**3**

Course Outcomes (COs):

This course aims to improve students understanding of the concepts, principles, problems, and practices of mechanical measurement systems. After completing this course, students should be able to:

CO1: Apply the principles of static and dynamic characteristics of the instruments for their calibration

CO2: Apply transducers and sensors for measuring mechanical parameters

CO3: Apply modulation and demodulation for mechanical signals and different conversion techniques

CO4: Apply the concept of measurement and identify the errors involved in the control systems

CO5: Select and apply measuring instruments for industrial manufacturing systems

MODULE 1: General Concept of Measurement and Instrumentation (2 Lectures)

Definition of Measurement and Instrumentation, Precision, Accuracy in measurements, Sources oferrors in measurement. Standards of measurement and sub-division of standards

MODULE 2: Static and Dynamic Characteristics of Instruments (4 Lectures)

Static and dynamic characteristics of instruments and instrumentation system, Linear and non-linearsystems, Electrical networks, Mechanical systems, Analogous systems, Thermal systems, First andsecond order systems

MODULE 3: Primary Sensing Elements and Transducers (8 Lectures)

(i) Introduction
(ii) Mechanical Devices as Primary Detectors
(iii) Mechanical Spring Devices: Cantilever, Helical Spring, Spiral Spring, Proving Rings, Loadcells, Spring Flexure Pivot
(iv) Pressure sensitive primary devices: Bourdon Tubes, Diaphragms, Bellows
(v) Classifications of transducers: Primary and Secondary transducers, Passive and Active Transducers, Analog and Digital transducers, Transducers and Inverse transducers
(vi) Transducers for linear displacement measurement: Resistive transducers, Potentiometers, Variable inductance transducers, Linear variable differential transducers (LVDT), Capacitive transducers, Piezo electric transducers, Rosettes

MODULE 4: Strain Gauges (3 Lectures)

Measurement of strain and applications of strain gauges

MODULE 5: Measurement of Pressure with Secondary Transducers (2 Lectures)

(i) Resistive, (ii) Inductive, (iii) Capacitive, (iv) Piezo-electric transducers

MODULE 6: Measurement of Torque (3 Lectures)

(i) Strain gauges, (ii) Torque meters, (iii) Inductive torque transducers, (iv) Digital method,

(v) Magneto-stricture transducers

MODULE 7: Measurement of Angular Velocity **(2 Lectures)**
(i) AC and DC tachometer generators (ii) Drag cup rotor AC (iii) Photo-electric tachometer(iv) Stroboscopic methods

MODULE 8: Measurement of Vibrations **(2 Lectures)**
Seismic transducers (ii) LVDT accelerometers (iii) Piezo-electric accelerometers

MODULE 9: Measurement of Temperature **(2 Lectures)**
(i) Platinum resistance thermometers (ii) Thermocouples (iii) Thermistors (iv) Optical pyrometers

MODULE 10: Measurement of Flow **(2 Lectures)**
(i) Turbine meter (ii) Electro-magnetic flowmeter (iii) Hot wire anemometer

MODULE 11: Miscellaneous Measurements **(6 Lectures)**
Measurement of sound using microphone, Cathode ray oscilloscope: Observation of wave forms,measurement of voltage and current, Lissajous patterns for measurements of phase and frequency

MODULE 12: Display Devices and Recorders **(4 Lectures)**
Electrical Indicating Instruments, Analog Ammeters and Voltmeters, Strip chart recorders,
X-Y recorders, Ultra-violet recorders, Magnetic tape recorders

Textbooks/ Reference Books:

1. Mechanical Measurement and Instrumentation by Er R.K Rajput. S.K.Kataria & sons
2. Mechanical Measurement and Instrumentation, A.K Sawhney
3. Doebelin's Measurement System Ernest O Doebelin/Dhanesh N Manik Mc Graw Hill Education

Course Time Plan

Units/Topics	Number of Lectures	Method of delivery
Unit I: General concept of Instrumentation.	2	Both chalk and talk and power point presentation
Unit II: Static and Dynamic Characteristics of instruments	4	
Unit III: Primary Sensing Elements and Transducers	8	
Unit IV: Strain gauges	3	
Unit V: Measurement of pressure with secondary transducers	2	

Unit VI: Measurement of torque	3	Both chalk and talk and power point presentation
Unit VII : Measurement of angular velocity	2	
Unit VIII: Measurement of vibrations	2	
Unit IX: Measurement of temperature	2	
Unit X: Measurement of flow	2	
Unit XI: Miscellaneous Measurements	6	
Unit XII: Display Devices and Recorders	4	
Total	40	

Pedagogy: Students should visualize the instrumentation aspects and expertise in instrument selection for different measurement applications in engineering.

Expected outcome

On successful completion of the course, the students will have the ability to:

Select the proper instrumentation for making measurements of physical quantities (e.g., pressure, temperature etc.) commonly encountered in mechanical engineering.

1. Handle the instruments and also to calibrate it.
2. Differentiate between the analog and digital instruments.
3. Deal with different types of sensors and transducers in the measurement of various physical quantities.
4. Build up basic idea for signal conditioning and data acquisition system.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181604	Workshop Theory and Practice-II	3-0-2	4

THEORY

Course Outcomes (COs): At the completion of the course the students will be able to:

CO1: Choose a suitable welding process for a given application under specific conditions demonstrating an understanding of the principle, advantages and limitations of several welding and allied processes

CO2: Predict chip characteristics, estimate tool life and evaluate cutting forces for known process parameters in machining with single point cutting tool specified in ASA or ORS and justify changes in tool design and process parameters to improve tool life by reducing tool wear and cutting forces

CO3: Distinguish between Jigs and Fixtures and select the appropriate work holding device for a givenmanufacturing operation

CO4: Justify the selection of additive manufacturing (AM) over conventional manufacturing for a given application and choose a suitable AM technology based on consideration of material and productdesign

CO5: Classify and compare non-conventional machining processes and use this knowledge to identify suitable technology for a given machining application

MODULE 1: Welding and Allied Processes

(a) Overview of Welding technology and its classification
(b) Oxyfuel gas welding: Oxy-acetylene welding – welding equipment – Types of flames – Alternative fuels – Oxyfuel gas cutting
(c) Non-consumable electrode arc welding: Processes viz. GTAW, PAW, – Principle – Powersource – Polarity – Equipment – Electrodes – Applications; Arc Cutting
(d) Consumable electrode arc welding: Processes viz. SMAW, GMAW, FCAW, SAW– Principle –Power source – Polarity – Forces on droplet and droplet transfer across the arc – Equipment – Electrodes – Applications
(e) Resistance welding: Processes – Principle – Applications
(f) Soldering and Brazing
(g) High energy beam welding: Laser Beam and Electron Beam
(h) Solid State Welding: Friction Welding; Friction Stir Welding; Explosive Welding; UltrasonicWelding
(i) Weldability and its factors
(j) Inspection and testing of welds

MODULE 2: Cutting Tool Specification and Mechanics

(a) Single point cutting tools – Reference planes – System of axes. Tool specifications – ASA &ORS systems
(b) Mechanics of metal cutting: Mechanism of chip formation – Type of chips.

Orthogonal andoblique machining, Chip thickness ratio and velocity relationship, Stress, Strain and Strain rate,
Merchant Theory of metal cutting, Measurement of cutting forces

(c) Cutting variables and factors affecting them, Selection of tool angles

(d) Tool wears and Tool life – Basic causes – Progressive tool wears – Tool life – Variablesaffecting tool life – Specifications and criteria for tool life. Machinability – Factors – Criterion

(e) Tool materials and Cutting Fluids

MODULE 3: Jigs and Fixtures
Introduction – Elements of Jigs and Fixtures – Principle of Location – Locating Methods and Devices –Design Principle for Location. Clamping – Principles for Clamping – Clamping Devices. Indexing Jigs and Fixtures – Indexing devices. Fool- Proofing

MODULE 4: Additive Manufacturing (AM)
Overview – Basic principle need and advantages of AM – Comparison of conventional manufacturing and AM – Procedure of product development in AM – Classification of AM processes – Materials used, applications and challenges of AM technologies viz. 3D-printing, Stereolithography (SLA), Fused Deposition Modeling (FDM), Laminated Object Manufacturing (LOM), Selective Deposition Lamination (SDL), Ultrasonic consolidation, Selective Laser Sintering (SLS), Laser Engineered Net Shaping (LENS), Electron Beam Free Form Fabrication (EBFFF), Electron Beam Melting (EBM), Arc based AM: Plasma transferred arc, Tungsten inert gas and Metal inert gas

MODULE 5: Non-Conventional Machining
Need for Non-Conventional Machining. Principles of operation, Machine setups, Applications, Merits and Demerits of – (a) Abrasive Jet Machining, (b) Ultrasonic Machining, (c) Electrochemical Machining, (d) Electro-discharge Machining, (e) Laser Beam Machining, (f) Electron Beam Machining. Comparative study of the above processes

Textbooks/ Reference Books:

1. Elements of Workshop Technology (Vol. I & II) – S.K. Hajra Coudhury and A.K. HajraChoudhury.
2. A course in Workshop Technology (Vol. I & II) – B.S. Raghuwanshi
3. Manufacturing Technology – P.N. Rao – Tata McGraw Hill
4. Introduction to Machining Science – G.K. Lal, New Age International Limited
5. Jigs and Fixtures – P.H. Joshi, Tata McGraw Hill
6. Manufacturing Science – Amitabha Ghosh and Asok Kumar Mallick, East West Press
7. Non-Conventional Machining – P.K. Mishra, Narosa Publishing House.
8. Fundamentals of modern manufacturing: materials, processes and systems – Mikell P. Groover,John Wiley & Sons, Inc.
9. Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing – IGibson, D W Rosen and B Stucker, Springer, 2010

DETAILS OF TOPICS COVERED	Ref	Mode of delivery	HRS
Unit-I - Welding and Allied Processes	1,2,3	1,2,3	10
Unit- II - Cutting Tool Specification and Mechanics	1,2,4,6	1,2,3	8
Unit-III - Jigs and Fixtures:	1,5	1,2,3	6
Unit IV- Additive Manufacturing (AM)	8	1,2	6
Unit-V – Non-conventional Machining: Need for Non-conventional Machining. Principles of operation, Machine setups, Applications, Merits and Demerits of – (a) Abrasive Jet Machining, (b) Ultrasonic Machining, (c) Electrochemical Machining, (d) Electro-discharge Machining, (e) Laser Beam Machining, (f) Electron Beam Machining. Comparative study of the above processes.	7	1,2,3	8
Mode of delivery	[1] Chalk & talk, [2] PPT, [3] Numerical problem solution		

Books:

1. Elements of Workshop Technology (Vol. I & II) – S.K. Hajra Coudhury and A.K. Hajra Choudhury.
2. A course in Workshop Technology (Vol. I & II) – B.S. Raghuwanshi
3. Manufacturing Technology – P.N. Rao – Tata McGraw Hill
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7. Non-Conventional Machining – P.K. Mishra, Narosa Publishing House.
8. Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing – IGibson, D W Rosen and B Stucker, Springer, 2010

PRACTICAL

Course Outcomes (COs): At the completion of the course the students will be able to:

CO1: List the general safety precautions required in different shop floors and point out any deficiencies in a given setup
CO2: Identify the general tools and equipment used in machine shop and welding shop
CO3: Prepare simple butt joints using gas welding or arc welding and lap spot welds using resistancespot welding
CO4: Experiment to determine suitable process parameters to improve surface finish for

machiningmild steel using single point cutting tool
CO5: Plan the required operations involving machining and welding to produce a simple product for agiven job design

MODULE 1: Welding and Allied Processes

(a) Demonstration of arc welding equipment, tools and personal protective equipment (PPE)
(b) Study of OAW equipment, gas flame types, Types of Torches and Gas welding (OAW) of MS flat after edge preparation
(c) Study of SMAW set up and weld MS plate
(d) Study of GTAW set up and welding of MS plate
(e) Study of GMAW welding set up and welding of MS plate
(f) Resistance spot welding of MS sheet
(g) Demonstration of Friction Stir Welding

Experiment No 1: Demonstration of arc welding equipment, tools and personal protective equipment (PPE)

Experiment No. 2: Study of OAW equipment, gas flame types, Types of Torches and Gas welding (OAW) of MS flat after edge preparation.

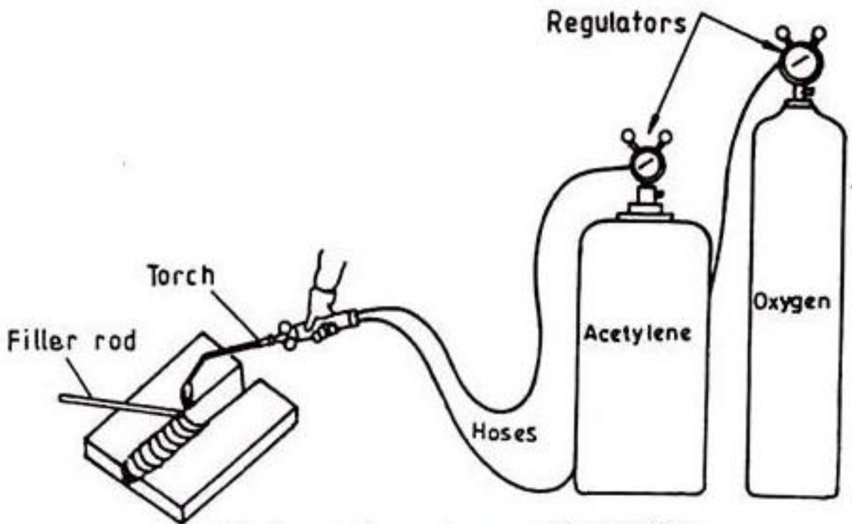
OBJECTIVES: TO WELD MS PLATE BY USING OAW

EQUIPMENTS NEEDED

1. Acetylene cylinder 12. Safety valve valve wrench 13. Oxygen cylinder cap 2. Cylinder pressure gauge 14. Line pressure (acetylene) adjusting screw (oxygen) 3. Line pressure gauge 15. Oxygen cylinder 4. Line pressure adjusting 16. Torch body screw 17. Welding tip 5. Acetylene hose 18. Acetylene torch 6. Acetylene cylinder valve 7. Acetylene cylinder cap 19. Oxygen torch valve 8. Fusible plugs 20. Oxygen hose 9. Line pressure gauge 21. Cylinder support 10. Cylinder pressure gauge 11. Oxygen cylinder valve

Oxy-acetylene flames

Characteristics of the oxy-acetylene flame Oxy-acetylene blowpipes utilise the Bunsen burner principle of mixing gases together before they reach the point at which combustion is to take place. This prior mixing of the gases produces a much hotter and shorter flame than when fuel gases are simply allowed to flow out into the air and burn. For example, acetylene when premixed and burnt with pure oxygen produces the highest temperature gas flame that is safe and convenient for welding. Theoretically it requires two volumes of oxygen to burn one volume of acetylene, but the blowpipe is designed to only supply the oxygen necessary to form the luminous or incandescent cone for which the volume is 1:1. When the flame is adjusted to neutral, the extra one and a half volumes of oxygen are obtained from the atmosphere.



A standard setup for oxy-acetylene welding.

Flame adjustment

Three types of flame adjustment can be obtained when using the gas welding plant:

Neutral

Carburizing

Oxidizing

Neutral flame: A neutral flame is produced when acetylene and oxygen burn in the proper proportions, ie equal volumes. It is made up of a distinct and clearly defined incandescent cone or jet surrounded by a faint secondary flame or envelope. The length of the inner cone should be between three to five times its own width.

Temperature is about 3000 °C and the uses the following. Fusion welding of: • mild steel and alloys • cast iron • aluminium and alloys • stainless steel • chrome-nickel alloys • copper and alloys • lead etc.

Carburising flame: This flame is produced when there is an excess of acetylene and can be readily recognised by a luminous intermediate cone or ‘feather’ around the inner cone caused by unburnt particles of carbon which are burnt and disappear as they reach the outer edge of the feather. The carburising flame has an excess of carbon and will add carbon to the surface of the material. It is also sometimes referred to as a ‘reducing flame’. A reducing flame is one that, because of its need for oxygen, will reduce oxides such as iron oxide. The temperature of the carburising flame is lower than that of the neutral flame. It causes mild steel to seemingly sweat or look greasy. (This is brought about by the unburnt particles of carbon in the flame reacting on the steel’s surface and lowering the melting point of the steel before it melts to any depth). Temperature is about 2800 °C and the uses the following:- Fusion welding high carbon steels, Hard surfacing operations.

Oxidising flame: This flame is produced when there is an excess of oxygen in the flame, so named because of its oxidising effect on the molten metal. The effect of too much oxygen is to decrease the length and width of the outer envelope and to shorten the inner cone. It is very harmful in certain welding applications, such as the welding of mild steel, aluminium and stainless steels. When welding mild steel excess oxygen can be detected by the intense sparking of the melted metal and the appearance of a whitish scum. Temperature is about 3300 °C and the uses the following: 1. Fusion welding of: • brass • bronze • zinc die castings. 2. Bronze welding of: • cast iron • galvanised iron • mild steel.

Welding technique

The flame is directed at a point to form a molten weld pool. The filler rod is held within the outer envelope to raise it to a welding temperature. On formation of the weld pool, the filler rod is lowered into the centre of the molten pool in a constant dipping action regulated by the amount of filler metal required. Do not allow the molten metal from the rod to drop into the weld pool. Keep the flame on the line of the weld moving forward without excessive weaving motion. Increased angle of the blowpipe slows progress and increases the size of the molten pool. It is important that the filler rod be withdrawn from the molten pool so that the heat build up can occur to re-establish the correct pool depth for full penetration.

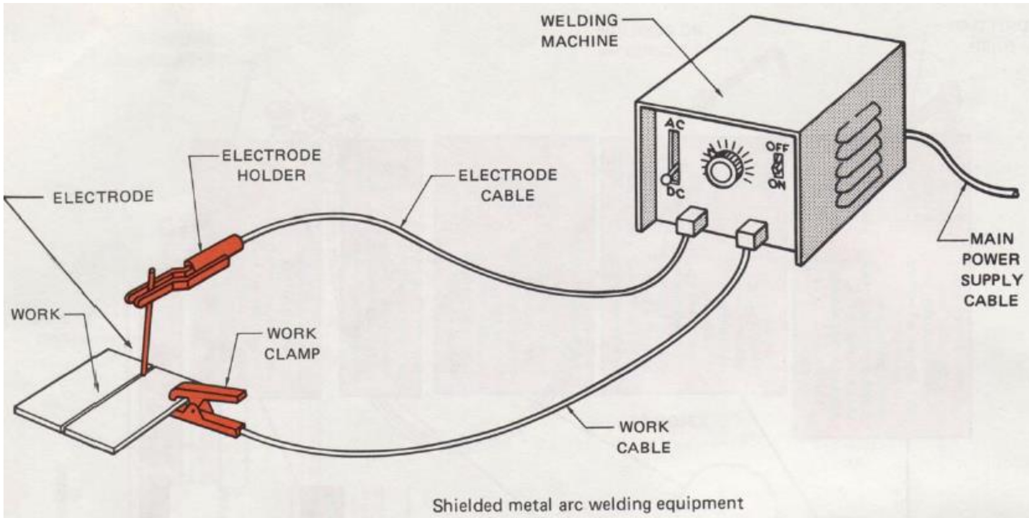
Experiment No 3: Study Of Shielded Metal Arc Welding (SMAW) set Up And weld MS Plate

OBJECTIVE: To prepare a V – Butt Joint Using SMAW Welding.

RESOURCES REQUIRED: MS flat 50 x 60 X 10 mm^3, Tong, Chipping Hammer, goggles, THEORY: SMAW is a welding process that uses a flux covered metal electrode to carry an electrical current. The current forms an arc that jumps a gap from the end of the electrode to the work. The electric arc creates enough heat to melt both the electrode and the base material(s). Molten metal from the electrode travels across the arc to the molten pool of base metal where they mix together. As the arc moves away, the mixture of molten metals solidifies and becomes one piece. The molten pool of metal is surrounded and protected by a fume cloud and a covering of slag produced as the coating of the electrode burns or vaporizes. Due to the appearance of the electrodes, SMAW is commonly known as ‘stick’ welding.

SMAW is one of the oldest and most popular methods of joining metal. Moderate quality welds can be made at low speed with good uniformity. SMAW is used primarily because of its low cost, flexibility, portability and versatility. Both the equipment and electrodes are low in cost

and very simple. SMAW is very flexible in terms of the material thicknesses that can be welded (materials from 1/16” thick to several inches thick can be welded with the same machine and different settings). It is a very portable process because all that's required is a portable power supply (i.e. generator). Finally, it's quite versatile because it can weld many different types of metals, including cast iron, steel, nickel & aluminum. Some of the biggest drawbacks to SMAW



Shielded metal arc welding equipment

are (1) that it produces a lot of smoke & sparks, (2) there is a lot of post-weld cleanup needed if the welded areas are to look presentable, (3) it is a fairly slow welding process and (4) it requires a lot of operator skill to produce consistent quality welds.

PROCEDURE:

- Prepare the edges of the work pieces to be joined to the required V shape.
- Finish the edges using emery paper.
- Place the work pieces on the work table in the required position.
- Set the required current of the machine
- Fix the electrode to the electrode holder.
- Touch the electrode to the work, so that current flow will be established and then separated by a small distance and the arc will be generated.
- First tack weld is done on the work pieces.
- Move the electrode slowly along the length of the joint with the filler rod, so that the filler metal will be deposited in the joint.
- Repeat the operation for the second pass, so that required amount of filler metal will be deposited on the work pieces.

PRECAUTIONS:

1. Never look at the arc with the naked eye. Always use a shield while welding.

2. Always wear the safety hand gloves, apron and leather shoes.
3. Ensure proper insulation of the cables and check for openings.
4. Select the parameters of the machine properly based on the metals to be welded.
5. Set these parameters properly before performing the operation.
6. Inflammable and combustible materials are removed from the vicinity of welding operations.

Experiment No 4: Study of GTAW and preparation of Butt-Welding Using Tungsten Inert Gas (TIG) Welding

OBJECTIVE: To prepare a V – Butt Joint Using TIG Welding.

RESOURCES REQUIRED: MS flat 50 x 60 X 10 mm^3, Tong, Chipping Hammer, goggles, Tungsten Electrode, Ceramic Nozzle and Filler rod, Argon gas cylinder.

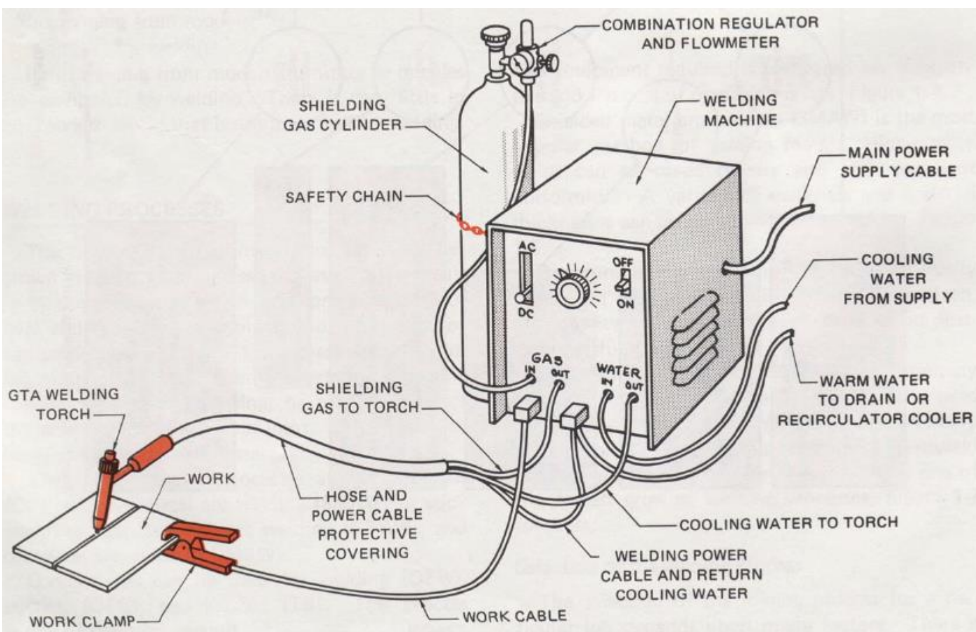
THEORY:

The endeavour of welder is always to obtain a joint which is as strong as the base metal and at the same time, the joint is as homogeneous as possible. To this end, the complete exclusion of oxygen and other gases which interfere with the weld pool to the detriment of weld quality is very essential. In manual metal arc welding, the use of stick electrodes does this job to some extent but not fully. In inert gas shielded arc welding processes, a high-pressure inert gas flowing around the electrode while welding would physically displace all the atmospheric gases around the weld metal to fully protect it. The shielding gases most commonly used are argon, helium, carbon dioxide and mixtures of them. Argon and helium are completely inert and therefore they provide completely inert atmosphere around the puddle, when used at sufficient pressure. Any contaminations in these gases would decrease the weld quality. Argon is normally preferred over helium because of a number of specific advantages. It requires a lower arc voltage, allows for easier arc starting and provides a smooth arc action. A longer arc can be maintained with argon, since arc voltage does not vary appreciably with arc length. It is more economical in operation. Argon is particularly useful for welding thin sheets and for out of position welding. The main advantage of Helium is that it can with stand the higher arc voltages. As a result it is used in the welding where higher heat input is required, such as for thick sheets or for higher thermal conductivity materials such as copper or aluminium. Carbon dioxide is the most economical of all the shielding gases. Both argon and helium can be used with AC as well as DC welding power sources. However, carbon dioxide is normally used with only DC with electrode positive.

TUNGSTEN INERT GAS (TIG) WELDING: Tungsten inert gas (TIG) welding is as inert gas shielded arc welding process using non consumable electrode. The electrode may also contain 1 to 2%

thoria mixed along with core tungsten or tungsten with 0.15 to 0.4% zirconia. The pure tungsten electrodes are less expensive but will carry less current. The thoriated tungsten electrodes carry high currents and are more desirable because they can strike and maintain stable arc with relative ease. The zirconia added tungsten electrodes are better than pure tungsten but inferior to thoriated tungsten electrodes.

A typical TIG welding setup is shown in fig. It consists of a welding torch at the centre of which is the tungsten electrode. The inert gas is supplied to the welding zone through the annular path surrounding the tungsten electrode to effectively displace the atmosphere around the weld puddle. The TIG welding process can be used for the joining of a number of materials though the most common ones are aluminium, magnesium and stainless steel. The power sources used are always the constant current type. Both DC and AC power supplies can be used for TIG welding. When DC is used, the electrode can be negative (DCEN) or positive (DCEP). With DCEP is normally used for welding thin metals where as for deeper penetration welds DCEN is used. An Ac arc welding is likely to give rise to a higher penetration than that of DCEP.



Gas tungsten arc welding equipment

PROCEDURE:

- Prepare the edges of the work pieces to be joined to the required V shape.
- Finish the edges using emery paper.
- Place the work pieces on the work table in the required position.

- Set the required current of the machine
- Fix the tungsten electrode to the electrode holder.
- Required size of the nozzle is selected and it is fixed to the torch.
- Adjust the inert gas flow rate to the required rate.
- Select the filler rod (same as base metals) of required diameter.
- Touch the electrode to the work, so that current flow will be established and then separated by a small distance and the arc will be generated.
- First tack weld is done on the work pieces.
- Move the electrode slowly along the length of the joint with the filler rod, so that the filler metal will be deposited in the joint.
- Repeat the operation for the second pass, so that required amount of filler metal will be deposited on the work pieces.

PRECAUTIONS:

1. Never look at the arc with the naked eye. Always use a shield while welding.
2. Always wear the safety hand gloves, apron and leather shoes.
3. Ensure proper insulation of the cables and check for openings.
4. Select the parameters of the machine properly based on the metals to be welded.
5. Set these parameters properly before performing the operation.
6. Inflammable and combustible materials are removed from the vicinity of welding operations.

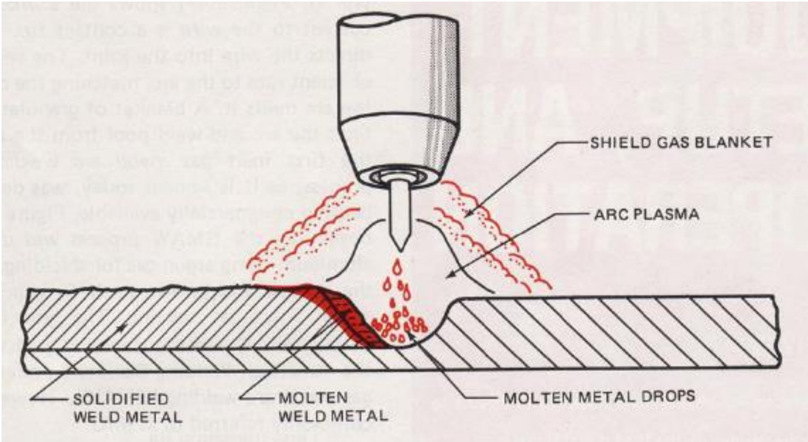
Experiment No 5: Study of GMAW and weld a MS plate

OBJECTIVE: To prepare a V – Butt Joint Using MIG Welding.

RESOURCES REQUIRED: MS flat 50 x 60 X 10 mm^3,Tong, Chipping Hammer, goggles, MS Electrode Coil.

THEORY

Gas Metal Arc Welding (GMAW) In the GMAW process, an arc is established between a continuous wire electrode (which is always being consumed) and the base metal. Under the correct conditions, the wire is fed at a constant rate to the arc, matching the rate at which the arc melts it. The filler metal is the thin wire that's fed automatically into the pool where it melts. Since molten metal is sensitive to oxygen in the air, good shielding with oxygen-free gases is required. This shielding gas provides a stable, inert environment to protect the weld pool as it solidifies. Consequently, GMAW is commonly known as MIG (metal inert gas) welding. Since fluxes are not used (like SMAW), the welds produced are sound, free of contaminants, and as corrosion-resistant as the parent metal. The filler material is usually the same composition (or alloy) as the base metal.



Gas shielded metal arc welding (GMAW)

PROCEDURE:

- Prepare the edges of the work pieces to be joined to the required V shape.
- Finish the edges using emery paper.
- Place the work pieces on the work table in the required position.
- Set the required current of the machine
- Fix the electrode to the electrode holder.
- Adjust the inert gas flow rate to the required rate.
- Touch the electrode to the work, so that current flow will be established and then separated by a small distance and the arc will be generated.
- First tack weld is done on the work pieces.
- Move the electrode slowly along the length of the joint with the filler rod, so that the filler metal will be deposited in the joint.
- Repeat the operation for the second pass, so that required amount of filler metal will be deposited on the work pieces.

PRECAUTIONS:

1. Never look at the arc with the naked eye. Always use a shield while welding.
2. Always wear the safety hand gloves, apron and leather shoes.
3. Ensure proper insulation of the cables and check for openings.
4. Select the parameters of the machine properly based on the metals to be welded.
5. Set these parameters properly before performing the operation.

6. Inflammable and combustible materials are removed from the vicinity of welding operations.

Experiment No 6: Resistance Spot Welding of MS plate

OBJECTIVE: TO WELD TWO MS SHEETS BY RESISTANCE SPOT WELDER

THEORY

Resistance spot welding (RSW) is a process in which faying surfaces are joined by the heat generated by resistance to the flow of electric current through work pieces that are held together under force by electrodes. The contacting surfaces in the region of current concentration are heated by a short-time pulse of low-voltage, high amperage current to form a fused nugget of weld metal. When the flow of current ceases, the electrode force is maintained while the weld metal rapidly cools and solidifies. The electrodes are retracted after each weld, which usually is completed in a fraction of a second. Compared to arc welding, this process uses no shielding gases, flux or filler material and the electrodes conducts very high electric power at the interface. The process is typically used to obtain a lap joint of sheet metal parts of low thickness using a series of spot welds, in situations where gas-tight or liquid-tight assembly is not required. Spot welding is the most widely used joining technique for the assembly of sheet metal products such as automotive body assemblies, domestic appliances, furniture, building products, enclosures and containers. The attachment of braces, brackets, pads, or clips to formed sheet-metal parts such as cases, covers, bases, or trays is another common application of RSW. Major advantages of spot welding include high operating speeds and suitability for automation and inclusion in high production assembly lines. The heat energy supplied to the welding operation depends on the current flow, resistance of the circuit and length of time the current is applied.

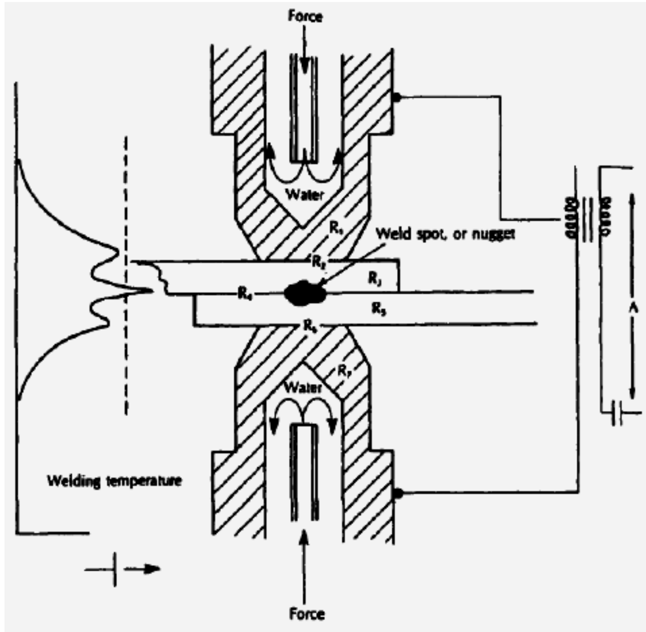
Resistance welding cycle

• Squeeze Time: Time interval between timer initiation and the first application of current needed to assure that electrodes contact the work and establish full force

• Weld time: The time for which welding current is applied (in single impulse welding) to the work

• Hold Time: The time during which force is maintained on the work after the last impulse of welding current ends to allow the weld nugget to solidify and develop strength.

• Off Time: The time during which the electrodes are off the work and the work is moved to the next weld location for repetitive welding.



Resistance spot welding setup

Experimental Procedure

1. Prepare a pair of pieces of MS sheet metals, mild steel of about 1 mm thickness,

2. Spot weld the pairs of the prepared specimens by following the standard procedure

3. Check the weld quality after cooling

Experiment No 7: Demonstration of Friction Stir Welding

MODULE 2: Cutting Tool Specification and Mechanics

(a) Prepare a single point cutting tool by grinding from square rod blank
(b) Study the effect of speed, feed, DOC and environment on finish and chip pattern

Experiment No. 2: Study of effect of speed, feed, DOC and environment on finish and chip pattern

Materials required:

1. Engine Lathe 2. Carbide Turning Inserts 3. Work piece: Aluminum or steel

Procedure: (refer to figure)

1. Set up the lathe

2. Fit the carbide insert tool in the tool holder

3. Hold the job in the chuck and centre it by using scriber

4. Adjust the speed (RPM), feed and depth of cut of the machine tool according to these specifications of the machine. If you set two levels for the factors, there shall be (2x2x2) eight experiments.

5. Now give a initial cut for the whole length of the job

6. After that, select lengths of about 10cm for the above eight sets of experiments.

7. Run the machine and turn the jobs at required cutting parameters

8. Collect chips at the end of each experiment and later classify them

8. Compare the surface finish of the job and infer the effect of speed, feed and depth of cut.

MODULE 3: JIGS and Fixtures

Demonstrate work holding devices in the workshop and machine tools

MODULE 4: Additive Manufacturing (AM)

Demonstration of an additive manufacturing set up

MODULE 5: Non-Conventional Machining

Demonstration of equipment in non-conventional machining shop

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181605	**Heat Transfer-II**	**3-0-0**	**3**

Course Outcomes (COs): At the completion of the course the student will be able:

CO1: Classify the various types of Convective heat transfer problems and discuss their applications

CO2: Apply dimensional analysis in convective heat and mass transfer to derive empirical equations

CO3: Compare different types of boundary layers formed in various flow problems and evaluatevarious parameters of hydrodynamic and thermal boundary layers

CO4: Design different types of heat exchangers by deducing sizing and thermal analysis methods andanalyze two-phase flow problems

CO5: Evaluate the heat transfer rate in forced and free convection modes using corresponding empirical correlations

MODULE 1: Fundamentals of Convective Heat Transfer
Introduction; The basic equations, the convective heat transfer co-efficient.
Forced convective systems: Forced convection over a flat-plate (External flow), Heat transfer and temperature distribution for flow between parallel plates, Forced convection in circular tubes (Internal flow)

MODULE 2: Free Convection
Laminar boundary layer equations of free convection on a vertical flat-plate, concept of Grashoff number, Empirical correlations for vertical plates, horizontal plates, inclined surface, vertical and horizontal cylinders, spheres

MODULE 3: Heat Exchanger Analysis & Design
Types; Overall heat transfer co-efficient. Fouling factor, LMTD methods of analysis, Effectiveness –NTU method. Pressure drop and pumping power, Aspects of design.
Double pipe heat exchanger Shell and tube heat exchanger; Condensers, Optimization of heat exchangers

MODULE 4: Boiling and Condensation
Boiling heat transfer phenomena, Boiling correlations, Laminar film-wise condensation on a vertical plate.
Flow Measurement Concept of static and stagnation pressures, application of Pitot tube in Flow Measurements, Pitot Static tube, Hot wire anemometer, Venturimeter, Loss of head in a venturimeter, Orificemeter and its classification, the phenomenon of jet contractions, Hydraulic co-efficient of an Orifice, Factors affecting the Orifice co-efficients

MODULE 5: Convective Mass Transfer
Convective mass transfer co-efficient; the concentration boundary layer. Analogy between momentum,heat and mass transfer, Convective mass transfer correlation, evaporation of water into air.
Dimensional analysis: Application to free and forced convection; application to convective masstransfer

Reference Books:

1. A basic approach to heat transfer – by M N Ožišik, McGraw Hills
2. Fundamentals for heat transfer – by Sachdeva, Wiley Eastern
3. Heat transfer, by P.S. Ghoshdastidar, Oxford University Press

Introduction to the Course

From study of course, HEAT TRANSFER-I students have learned about the process and origins of various heat and mass transfer between system and surroundings. The subject Heat Transfer-II covers different aspects of Convective heat transfer and its applications. It thermally and empirically analyzes the different modes of convective heat transfer namely forced and free convection. This course also discusses about different types of boundary layer formed in various flow problems. Using the concepts of Conductive and Convective heat transfer this subject analyze various practical situations and assimilates the principles of heat exchanger system and phase change process (Boiling and Condensation).

This course is aimed to learn about different flow measuring instruments and their basic principles. It also discusses about convective mode of mass transfer and its analogy with other processes. Finally, this course introduces dimensional analysis and discusses its application in convective heat and mass transfer problems.

Motivation

The fundamental knowledge gained from HEAT TRANSFER-I course will increase the importance of learning advanced principles of heat transfer process and HEAT TRANSFER-II will impart further understanding of the subject. The topics of this subject are designed in such a way that students can demonstrate different measurement technologies and use of them in Industrial applications. Understanding importance of dimensional analysis will give confidence to solve more complex problems in the field of convective heat and mass transfer. Upon completion of this course, the students can able to understand and apply different heat and mass transfer principles of different applications.

Course Time Plan:

Units/Topics	Number of Lectures	Method of delivery
Unit I Fundamentals of Convective Heat Transfer	7	
Unit II – Free Convection	4	

Unit III – Heat Exchanger Analysis & Design	11	Both chalk and talk and power point presentation 1 class @1 hours
Unit IV – Boiling and Condensation	6	
Unit V– Convective mass transfer	7	
TOTAL	3	
	35	

Course Code	Course Title	Hours per week L-T-P	Credit C
HS181606	**Accountancy**	**2-0-0**	**2**

MODULE 1:
Concept and classification of Accounts, Transaction, Double Entry system of Book Keeping, Golden rules of Debit and Credit, Journal- Definition, advantages, Procedure of Journalising, Ledger, advantages, rules regarding Posting, Balancing of Ledger accounts, Trial Balance- Definition, objectives, procedure of preparation

MODULE 2:
Name of Subsidiary Books, Cash Book-definition, advantages, objectives, types of Cash Book, preparation of different types of cash books, Bank Reconciliation Statement, Regions of disagreement between Cash Book with Pass Book balance, preparation of Bank Reconciliation Statement

MODULE 3:
Final Account: Preparation of Trading Account, Profit and Loss Account with adjustments

MODULE 4:
Concept of Capital Expenditure and revenue Expenditure, Bad debts, Provision for Bad and Doubtful debts, Provision for discount on Debtors, Outstanding expenses, Prepaid expenses, Accrued Income

MODULE 5:
Introduction to Depreciation Accounting- Meaning, causes, factors, methods of charging depreciation etc.

Textbooks/Reference Books:

1. Theory and Practice of accountancy- KR Das, KM Sinha, KS Pal Choudhury, Dr. A Rahman,PK Pujary
2. Book- Keeping & Accountancy- C Mohan Juneja, J R C Chawla, KK Sakseena
3. Double Entry Book- Keeping & Accountancy- JR Batliboi

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181612	**Fluid Mechanics–II Lab**	**0-0-2**	**1**

Course Outcomes (COs):

1. Students will be able to Categorize different regimes in a pipe flow, visually and theoretically using Reynolds Apparatus
2. Students will be able to Estimate laminar boundary layer thickness over a flat plate at differentpositions, provided with a wind tunnel setup

LIST OF EXPERIMENTS

Exp-1. Reynolds Apparatus with Storage Tank
Exp-2. Calibration of Wind Tunnel
Exp-3. Boundary Layer Growth Over Flat Plate

Experiment No: 1

Reynolds Apparatus with Storge Tank

Aim:

1. To visualize different flow conditions.
2. To obtain the Reynolds number in different flow conditions.

Equipment:

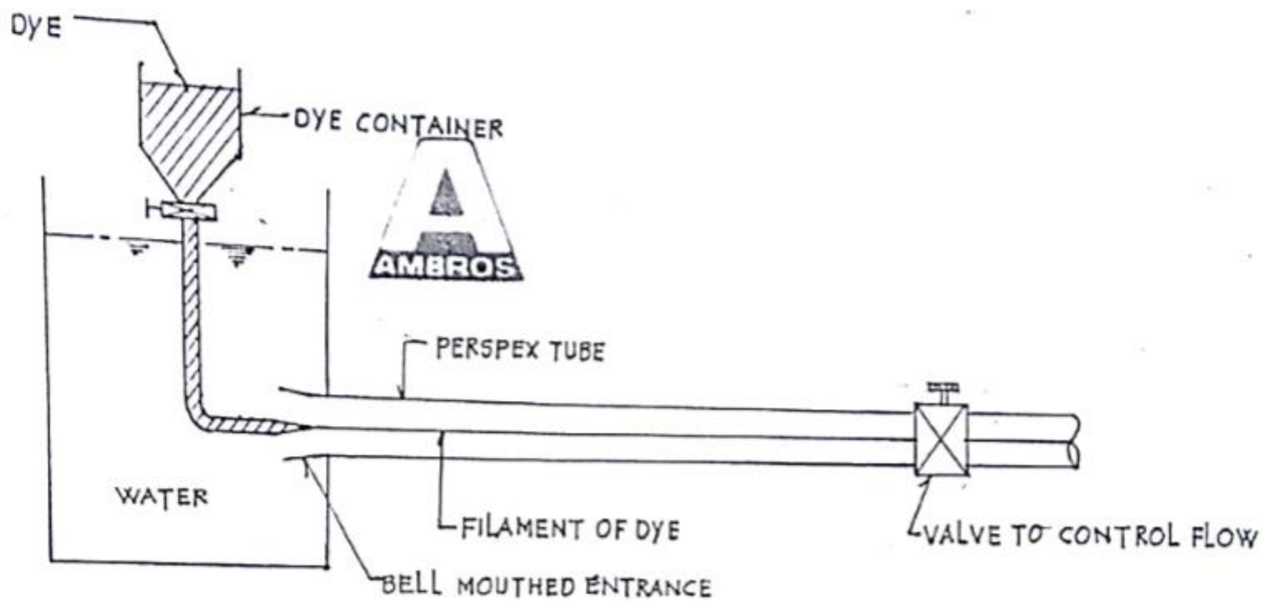
Supply tank with Elliptical bell mouth entry, coloured dye injector arrangement, Perspex tube with means of varying flow rate and collecting tank.

Introduction and Theory:

Depending upon the relative magnitudes of viscous and inertial forces, flow can occur in two different manner viz. laminar flow and turbulent flow. In laminar flow viscous effect are more predominant than the inertial effects. But when shear and normal stresses are added with the increase in velocity of flow the flow is turbulent. To identify the laminar and turbulent ranges of flow a dimensionless parameter is being utilized which is a measure of the relative importance of inertial force and viscous force prevailing in the flow of a fluid, which is known as Reynolds number. It is equal to the ratio of the inertial force to the viscous force per unit volume. This mean that a large value of Reynolds number signifies less viscous effects and vice versa. For determining different flow conditions, equipment first used by Professor Osborne Reynolds after whose name Reynold's number exist.

The motion is laminar or turbulent according as the value of Re is less than or greater than a certain value. If a liquid such as water is allowed to flow through a glass tube, and if one of the liquid filament is made visible by means of dye, then by watching this filament we may get insight into the actual behavior of the liquid as it moves along. After reaching steady state the out1et va1ve is s1ightly opened. The central thread of dye carried along by the slow stream of water in the glass tube is seen to be nearly as steady and well defined as the indicating column. But when, as a result of further opening of the valve, the water velocity passes a specific limit, a change occurs, the rigid thread of dye begins to break up and to group momentarily ill-defined. The moment the dye deviates from its straight 1ine pattern corresponds to the condition when the flow in the conduit is no longer in laminar conditions. The discharge, Q flowing in the conduit at this moment is measured and the Reynolds number is calculated. This is the lower critical Reynolds number. Finally, at high velocities the dye mixes completely with the water and the coloured mixture fills the tube.

Experimental Setup:



REYNOLDS APPARATUS

Apparatus consists of a storage cum supply tank which has the provision for supplying coloured dye through jet. A Perspex tube is provided to visualize the different flow condition. The entry of water in perspex tube is through elliptical bell mouth to have smooth flow at the entry. A regulating valve is provided on the downstream side of the tube to regulate the flow. The discharge must be varied very gradually from a smaller to larger value. A collecting tube is used to find the actual discharge of the perspex tube.

Experimental Procedure:

1. Note down the relevant dimensions as diameter of Perspex tube, area of collecting tank etc.
2. By maintaining suitable amount of steady flow or nearby steady flow in Perspex tube, open inlet of the dye tank so that dye stream moves as a straight line in the tube representing laminar flow.
3. The discharge of Perspex tube is recorded.
4. Increase the flow rate gradually by maintaining steady flow.
5. Record the discharge for each flow rate where the flow changes gradually from laminar to transition and then to turbulent flow.

Observations and Calculations:

Inner diameter of Perspex tube D =

Kinematic viscosity of water υ =

Area of Perspex tube A=

Observation Table:

S.No	Volume of water collected (V)	Time taken (t)	Flow rate (Q)	Velocity (V)	Reynolds No. (Re)	Type of flow
	m^3	sec	m^3/sec	m/sec		

Sample Calculation: (Take one reading and write down the calculation steps)

Discussion: (write few lines about the observations made in this experiment)

Experiment No 2. Calibration of Wind Tunnel

Experiment No: 3

Boundary Layer Growth Over Flat Plate

Aim:

1. To visualize boundary layer growth over flat plate.
2. To calculate the boundary layer thickness at various location with in laminar flow range.

Introduction and Theory:

It is well known that in real fluids as opposed to the ideal fluid that is of the subject of potential flow theory, shear forces as well as pressure forces are encountered. Viscous forces are proportional to the velocity gradient transversely to the general direction of flow and the early workers estimated that these shear forces must be very small relative to the pressure forces, and they consequently expected potential flow to approximately close to the real fluid pattern.

Prandtl was first to recognize that even in fluids of very low viscosity the shear forces are significant, since in a thin layer adjacent to the surface, the fluid velocity must fall from that in the free stream to zero in contact with the surfaces.

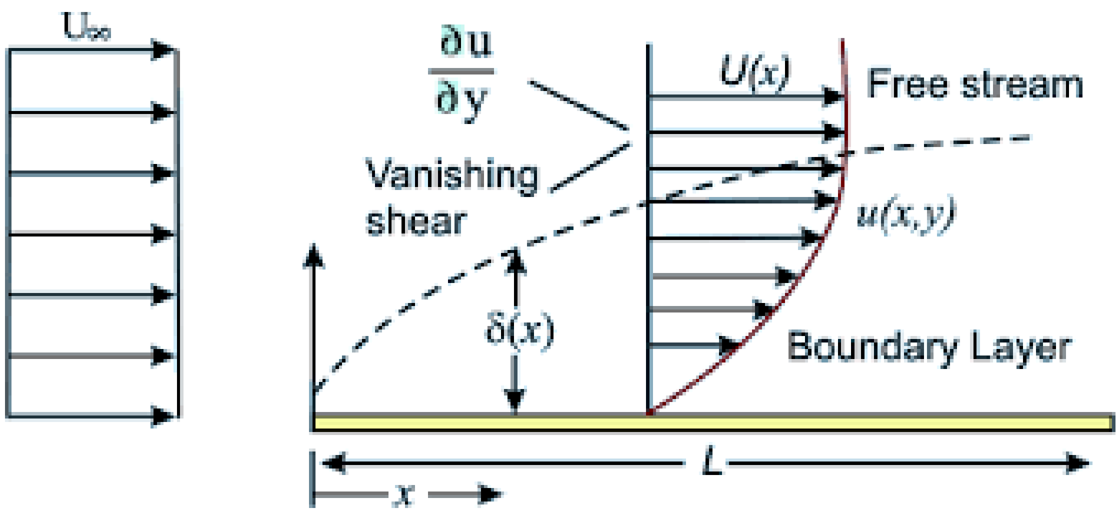
This thin layer adjacent to the surface is called boundary layer. In the boundary layer the velocity gradient dv/dx is necessarily very great, and the shear stresses are accordingly very large. Outside the boundary layer and the wake, the velocity gradient and hence the frictional effects are small. We can therefore divide the whole field of fluid flow into two regions.

1. Areas occupied by the water and the boundary layer
2. The remainder in which shear stresses are small and maybe neglected.

The potential flow theory maybe applied till second region, but difficulties arise because location of boundary layer between a & b cannot be determined on theoretical basis, experimental observations are necessary.

The development of boundary layer is much influenced by presence of positive or negative pressure gradient in the direction of flow.

In our experiment, the arrangement is ideally of flat plat plate in the region of constant pressure.



Experimental Setup:

The cross section of wind tunnel is constant (305×75) and as a result boundary layer grows in the walls but this not affect badly the experimental condition of constant pressure because the plate in traversed in horizontal direction and readings are taken at a particular place with respect to the terminal body. The readings of dynamic head are indicated in the inclined manometers attached with the wind tunnel.

Experimental Procedure:

1. Level the wind tunnel setup by spirit level.
2. Ensure the reading to be zero when the fan is not running.
3. Start the fan after switching on the mains.
4. Measure the dynamic head (h1,h2) in the undisturbed stream(to be observed at a distance of 20mm from the plate), by the pitot tube arrangement. This head can be adjusted according to ones choice by the control valve set at the outlet of the tunnel.
5. The pitot tube is then moved in contact with the plate and successive readings of the manometer are taken, starting initially with steps of 0.2 mm (by screwing the micrometer head) until dynamic head reaches the dynamics head of the free stream.

Precautions:

Before starting the experiment, the vertical location of the pitot tube in the micrometer head must be carefully adjusted so that the micrometer reads 0.25mm when the end of the tube is just in contact with the plate surface; the micrometer readings then corresponds to the distance of the central line of the tube from the surface. The correct position maybe judged carefully screwing the micrometer down while observing the reflection of the tube in the surface of plate. The pitot tube should be withdrawn from contact with plate before traversing the latter, otherwise the tube or plate maybe damaged. The experiment observations are rather tedious as, owing to the small bore of the tube, the manometer readings take several minutes to stabilize.

Observations and Calculations:

Density of manometric liquid $\rho_l =$

Density of air $\rho_a =$

Inclination of manometer $\Theta = 22.21^0$

Necessary Formulae:

Dynamic Pressure $P_d = \rho_l \times g \times \Delta h \times \sin(22.21)$

$= \frac{1}{2} \times \rho_a \times u^2$

Velocity $u = \sqrt{\frac{2 \times P_d}{\rho_a}}$

Calculation for u_∞:

Observation Table:

X	Y	Δh	Dynamic Pressure	Velocity (u)	u/u_∞	δ
(mm)	(mm)	(mm)	(N/m^2)	(m/sec)		(mm)
1.0	0					
	0.2					
	0.4					
	0.6					
	0.8					
	1.0					
	1.2					
	1.4					
	1.6					
	1.8					
	2.0					
2.0	0					
	0.2					
	0.4					
	0.6					
	0.8					
	1.0					
	1.2					
	1.4					
	1.6					
	1.8					
	2.0					
3.0	0					
	0.2					
	0.4					
	0.6					
	0.8					
	1.0					
	1.2					
	1.4					
	1.6					
	1.8					
	2.0					

Sample Calculation: (Take one reading and write down the calculation steps)

Discussion: (write few lines about the observations made in this experiment)

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181613	**Mechanical Measurements and Instrumentation Lab**	**0-0-2**	**1**

Course Outcomes (COs):

This course aims to improve students understanding of the concepts, principles, problems, and practices of mechanical measurement systems. After completing this course, students should be able to:

CO1: Understand the methods and devices for mechanical measurements
CO2: Formulate objective(s) and identify key factors in designing experiments for a given problem
CO3: Apply the concepts of calibration, traceability and uncertainty for accurate and reliable measurements
CO4: Identify and estimate measurement errors and suggest suitable techniques to minimize them
CO5: Analyze and discuss the results to draw valid conclusions

LIST OF EXPERIMENTS

Exp-1: Experiment for displacement measurement

Exp-2: Experiment for speed measurement

Exp-3: Experiment for force measurement

Exp-4: Experiment for torque measurement

Exp-5: Experiment for strain measurement

Exp-6: Experiment for temperature measurement

Exp-7: Experiment for pressure measurement

Exp-8: Experiment for flow measurement

Exp-9: Experiment for study of control valves

Exp-10: Experiment for process control study

EXPERIMENT NO: 1
DISPLACEMENT MEASUREMENT

OBJECTIVE: To understand use of various transducers sensors to measure displacement you will be able to compare, decide their accuracies and draw graphs of displacement vs. output voltage.

Transducers used are

a) LVDT
b) Inductance
c) Capacitance (Linear Displacement)
d) Capacitance (Angular displacement)

e) Variable Resistance / potentiometer (Linear displacement)

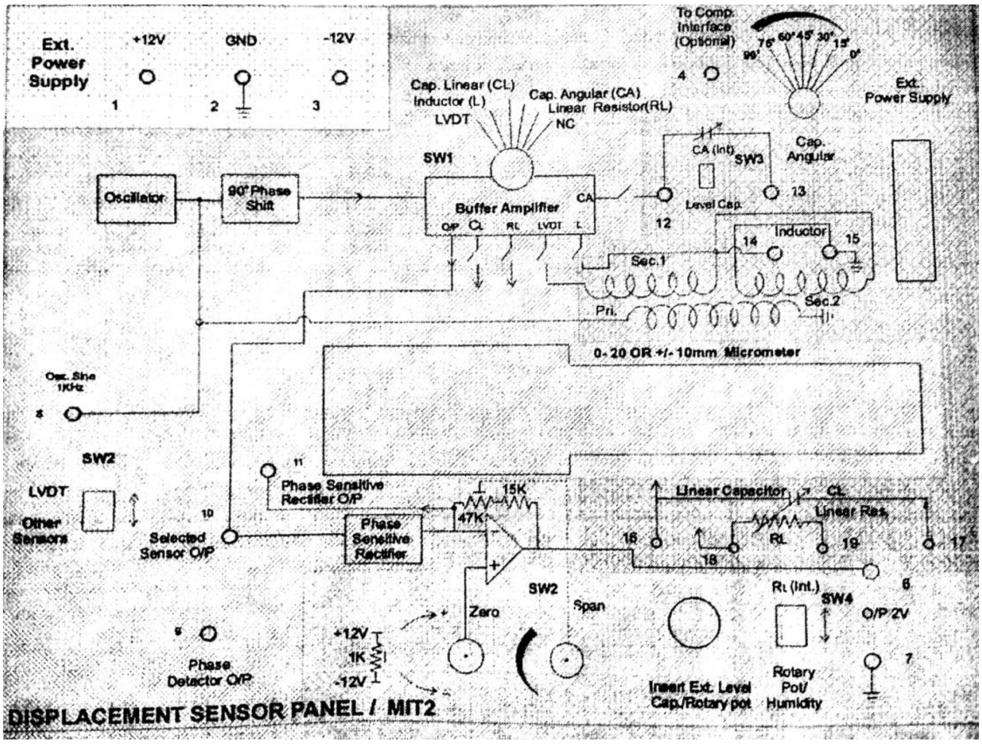


Figure 1.1: Displacement Sensors panel (MIT2) Overlay view

Equipment required:

1. Power supply ±12V
2. Voltmeter
3. Panel – MIT 2

a) LVDT

Objective: Study LVDT as displacement transducer and observe displacement versus output voltage.

Theory: Linear variable differential transformer LVDT is a transducer. Basically it is passive inductive transformer similar to a potential transformer.

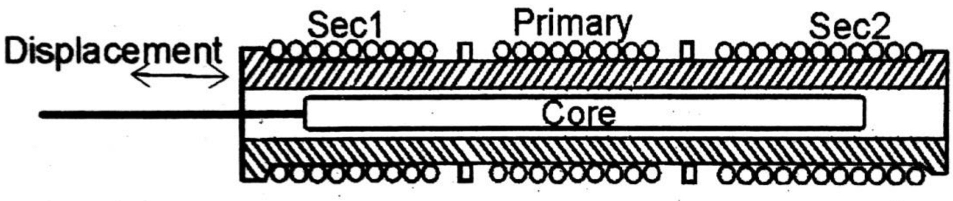


Figure 1.2: Construction of LVDT

LVDT consists of three windings, one primary and two secondaries of equal turns. Primary is wound centrally between two secondaries. All three windings are wound on a hollow tubular former through which magnetic core slides.

Core affects magnetic coupling between primary and the secondaries while primary is connected to AC signal.

Normal/null position of core causes equal induced voltage in both the secondaries. Hence the total difference voltage of both the secondaries becomes zero. Any deviation in core position from its null position induces unequal voltage from both secondaries and hence the difference signal of it is a non zero quantity. This non zero quantity varies with core position. Ideally displacement versus change in difference signal should be linear.

Procedure:

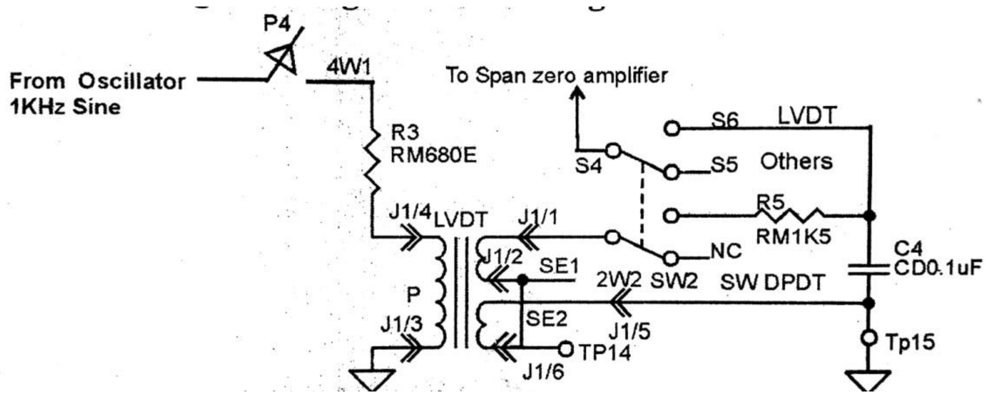


Figure 1.3: Signal conditioning circuit LVDT9

Wiring sequence: +12V-1, -12V-3, GND-2, VM(+)-6, VM(-)-7

1. Connect ±12 V DC to the respective terminals on the panel.
2. Set DPDT to LVDT
3. Set SW1 at LVDT
4. Adjust micrometer to near zero mark and adjust zero adjustment pot for zero output voltage on voltmeter.
5. Now move the micrometer to right i.e., 20mm position and adjust output to 2V with the help of span adjust potentiometer.
6. Move the micrometer towards left & note down the output voltage on voltmeter for various displacements.

Table No. 1.1: Observation table

Micrometer reading distance in mm	Output Voltage [x10 = displacement (mm)]
0	
5	
10	
15	
20	

Plot the graph of distance versus output voltage.

Conclusion:

b) Inductive Transducer

Objective: To become familiar with displacement transducer using transducer and you will be able to compare inductance transducer with other displacement transducers.

Theory:

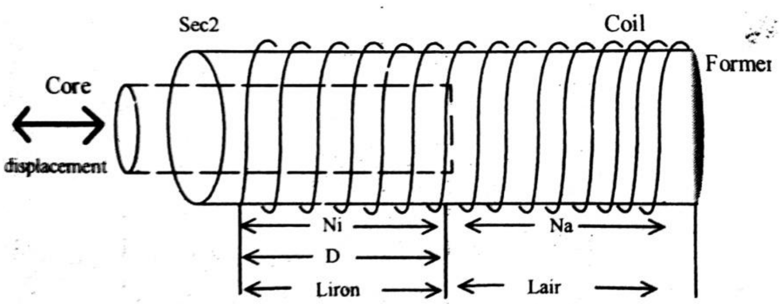


Figure 1.4: Construction of inductive transducer

Inductive transducer provided is based on variation in permeability which causes change in self inductance. Inductance coil is wound on a tubular former. A sliding core inside the coil former causes change in self inductance.

Procedure:

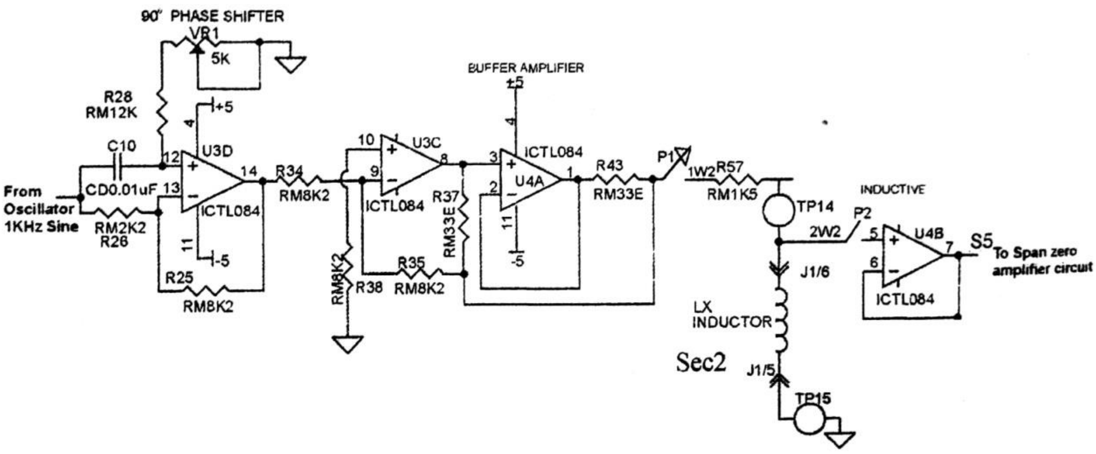


Figure 1.5: Inductance Measurement

Wiring sequence: +12V-1, -12V-3, GND-2, VM(+)-6, VM(-)-7

1. Connect ±12 V DC to the respective terminals on the panel.
2. Set DPDT at other sensors.
3. Switch SW1 at LVDT
4. Adjust micrometer to near zero mark and adjust zero adjustment pot for zero output voltage on voltmeter.
5. Now move the micrometer to right i.e. 20mm position and adjust output to 2V with the help of span adjust potentiometer.

6. Move the micrometer towards left & note down the output voltage on voltmeter for various displacements.

Table No. 1.2: Observation table

Micrometer reading distance in mm	Output Voltage [x10 = displacement (mm)]
0	
5	
10	
15	
20	

Plot the graph of distance versus output voltage.

Conclusion:

c) Linear Displacement measurement using Capacitance

Theory:

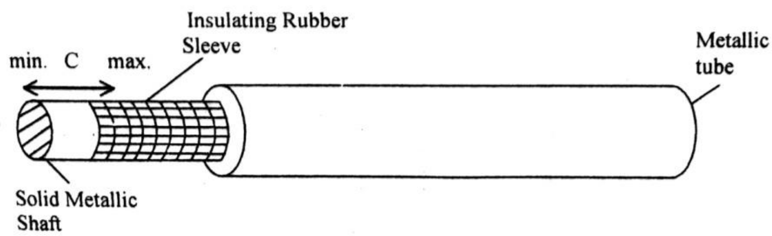


Figure 1.6: Construction of Linear capacitance

The capacitance used is formed by an aluminium hollow tube through which a brass rod fully covered by rubber sleeve(insulating) slides. Brass rod outer surface and aluminium tube inner surface becomes parallel to each other and are separated by rubber sleeve. Capacitance will be more when the maximum surface areas are in parallel. This is possible when rod is fully inserted (micrometer at 20mm postion) in the hollow aluminium tube, capacitance is minimum (0mm position) when minimum areas are in parallel infront of each other. Then amount of capacitance is dependent of position of brass rod (slider) and is proportional to the displacement.

Capacitance measurement circuit is basically based on

Ic = C$\frac{dv}{dt}$ If we maintain $\frac{dv}{dt}$ constant then ic ∝ C

By measuring current drop across a resistor connected in series, we can calibrate for capacitance in terms of displacement.

Procedure:

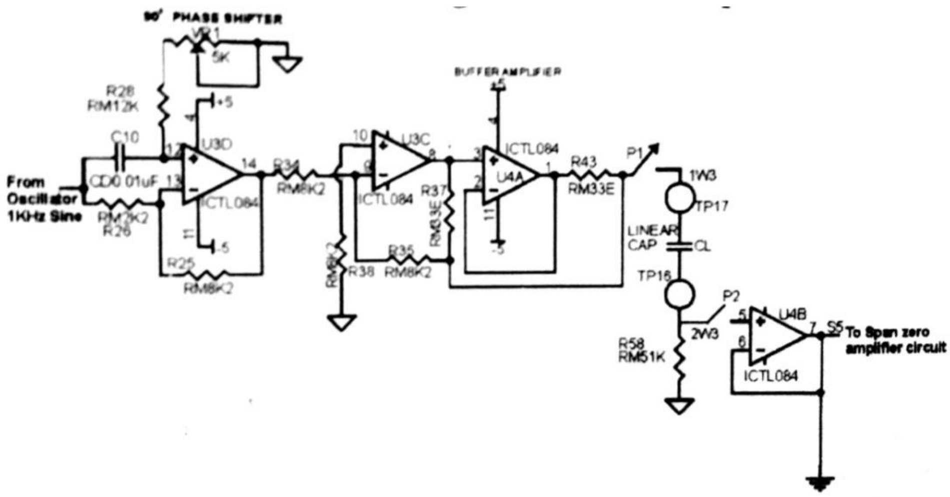


Figure 1.7: Signal conditioning circuit Linear capacitance

Wiring sequence: +12V-1, -12V-3, GND-2, VM(+)-6, VM(-)-7

1. Connect ±12 V DC to the respective terminals on the panel.
2. Set DPDT to other sensors.
3. Set SW1 at linear capacitance.
4. Adjust micrometer to near zero mark and adjust zero adjustment pot for zero output voltage on voltmeter.
5. Now move the micrometer to right i.e., 20mm position and adjust output to 2V with the help of span adjust potentiometer.
6. Move the micrometer towards left & note down the output voltage on voltmeter for various displacements.

Table No. 1.3: Observation table

Micrometer reading distance in mm	Output Voltage [x10 = displacement (mm)]
0	
5	
10	
15	
20	

Plot the graph of distance versus output voltage.

Conclusion:

d) Angular displacement measurement

Objective: To understand the technique of angular displacement measurement.

Theory: A variable capacitor is used as sensor of angular movement i.e. capacitance value varies with angular displacement of its shaft. However, it does not vary linearly over complete range of its angular movement. As you rotate the knob the change in capacitance with angular displacement detected, converted into DC voltage as output. This output voltage is proportional to the angular displacement.

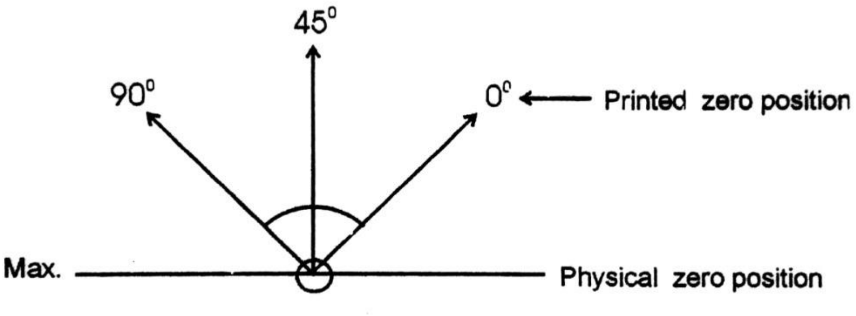


Figure 1.8: Angular capacitance

Procedure:

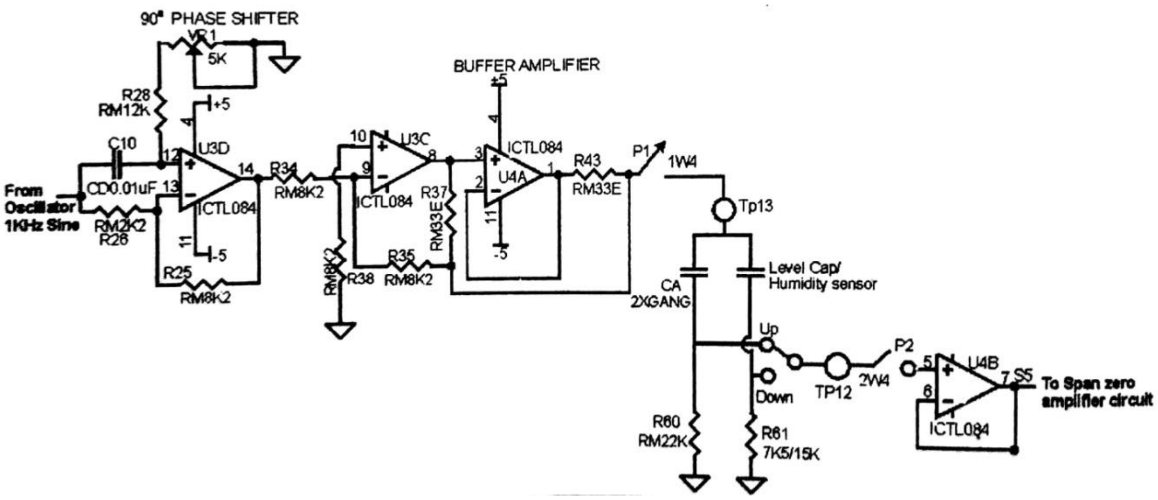


Figure 1.9: Signal conditioning circuit of angular displacement

Wiring sequence: +12V-1, -12V-3, GND-2, VM(+)-6, VM(-)-7

1. Connect ±12 V DC to the respective terminals on the panel.
2. Set DPDT to other sensors.
3. Set switch SW1 at angular capacitance.
4. Adjust capacitor knob to 0˚ and set output voltage to zero with the help of zero adj. potentiometer.
5. Now set capacitor knob to 90˚ and adjust O/P voltage to 0.9V with the help of span potentiometer.
6. Recheck zero and full scale i.e. range setting twice or thrice for confirmation.
7. Now adjust capacitor knob to various angles as in table no.1.4 and note down the corresponding output voltages.

Table No. 1.4: Observation table

Capacitor Knob angle	Output Voltage Volt[x100 = Angle (degree)]
0	0
15	.
30	.
45	.
60	.
90	0.9

Plot the graph of angle versus output voltage.

Conclusion:

e) Displacement measurement using Linear potentiometer

Objective: To understand simple method of displacement measurement using linear potentiometer (variable resistance).

Theory: An element which resistance changes due to change in some physical phenomenon is called as resistive transducer. A potentiometer (variable resistance) can be used as resistive transducer. Displacement of wiper (variable arm) of potentiometer gives variation in resistance. A linear motion variable resistance (potentiometer or linear motion volume control) is simple transducers that can be used for linear displacement measurement

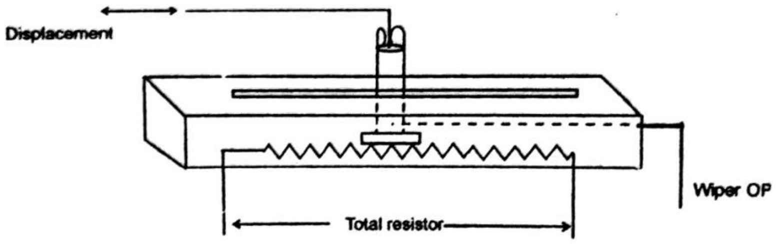


Figure 1.10: Construction of linear resistor

Panel provides linear potentiometer connected to a micrometer on board. Also electronic circuitry to convert variation in resistance to proportional DC voltage is constructed on the panel.

Procedure:

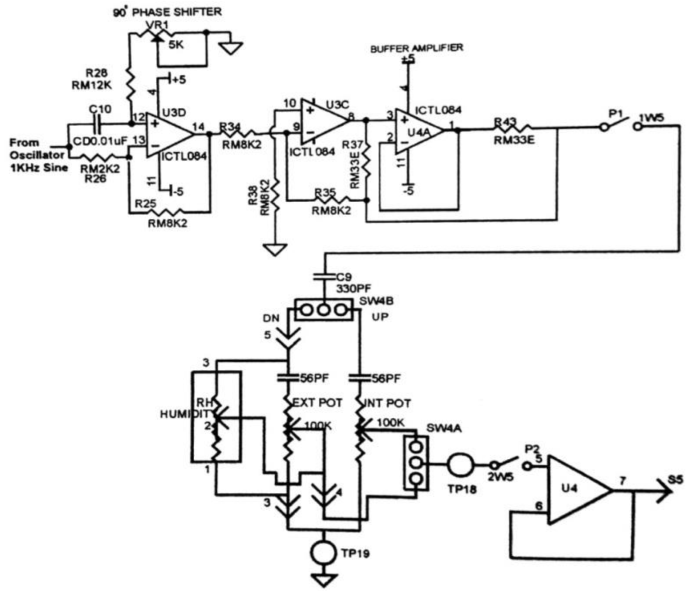


Figure 1.11: Signal conditioning circuit of linear potentiometer

Wiring sequence: +12V-1, -12V-3, GND-2, VM(+)-6, VM(-)-7

1. Connect ±12 V DC to the respective terminals on the panel.
2. Set DPDT to other sensors.
3. Set SW1 at linear resistor.
4. Adjust micrometer to near zero mark and adjust zero adjustment pot for zero output voltage on voltmeter.
5. Now move the micrometer to right i.e. 20mm position and adjust output to 2V with the help of span adjust potentiometer.
6. Move the micrometer towards left & note down the output voltage on voltmeter for various displacements.

Table No. 1.5 Observation table

Micrometer displacement	Output Voltage volt[x10 = displacement (mm)]
0	0
5	.
10	.
15	.
20	2

Plot the graph of distance versus output voltage.

Conclusion:

EXPERIMENT NO: 2

SPEED MEASUREMENT

OBJECTIVE: To understand and describe various sensors used in speed measurement application (non contact type sensors)

a) Magnetic pick up
b) Hall effect sensor
c) Inductive sensor
d) Photo reflective method
e) Photo interruptive method
f) Stroboscope method.

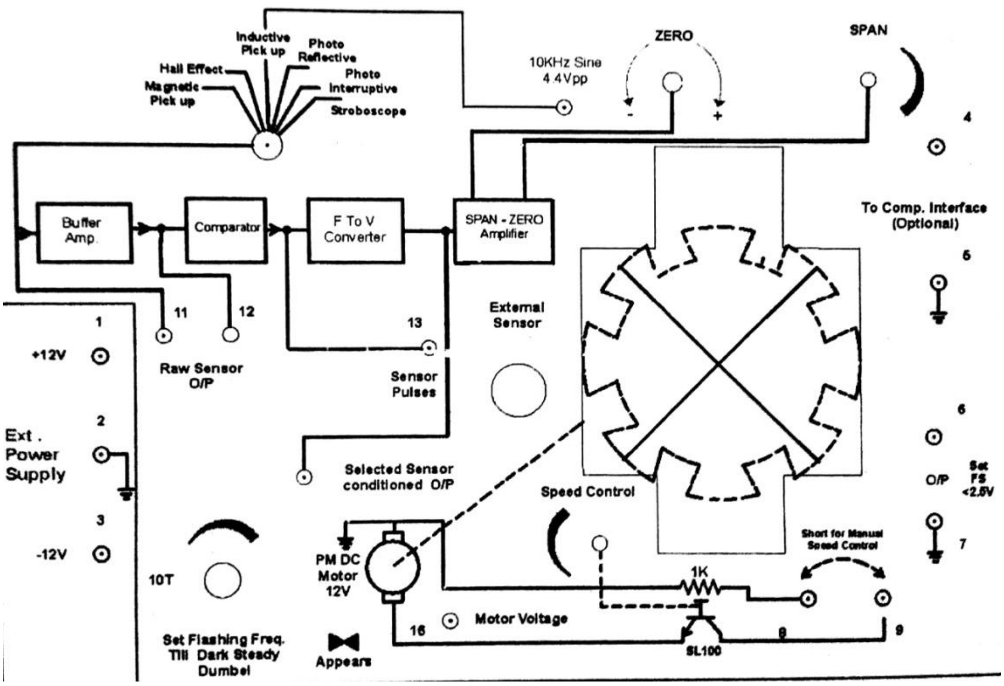


Figure 2.1: Speed measurement sensor panel

Equipment required:

1. Voltmeter
2. Power supply ±12V
3. CRO
4. Panel No. – MIT 3

a) Magnetic Pick up

Objective: To understand the behaviour of Magnetic pickup and to observe the magnetic pick up as motor speed sensor.

Theory: A magnetic pickup is a coil placed in magnetic field. Variation in magnetic field induces a voltage pulse in the coil. Amplitude and frequency of induced voltage pulse depends upon rate of change of magnetic flux.

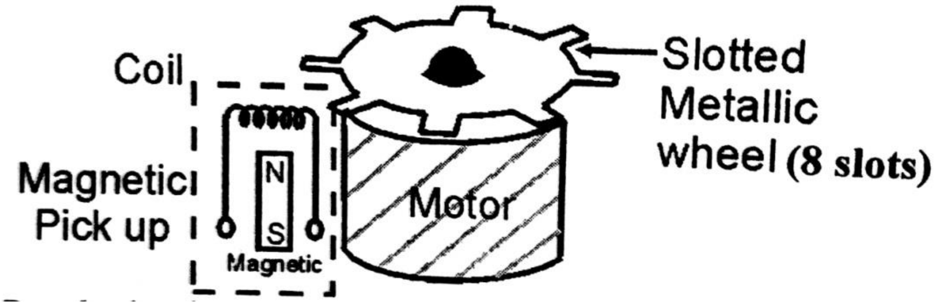


Figure 2.2: Magnetic pickup used to measure motor speed

Magnetic flux produced by magnet can be altered by bringing any external magnetic material near to the magnetic field of magnet which will induce voltage in coil placed in it. The voltage pulses from magnetic pick up are proportional to the rate of change of flux. Every time the tooth of wheel reaches over magnet it will cut magnetic lines and hence induction of a voltage pulse. Hence divide the frequency obtained at the O/P of sensor (tp13) by 8 to get shaft rotation frequency.

Procedure:

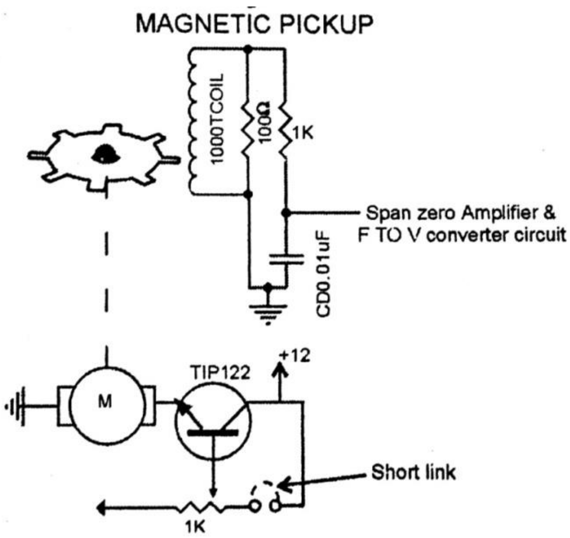


Figure 2.3: Magnetic pick up circuit

Wiring sequence: +1V-1, -12V-3, GND-2, 8-9, VM(+)-6, VM(-)-7

1. Connect ±12V supply to the panel.
2. Short the terminals as shown in wiring diagram by patch cord for manual speed control of motor through potentiometer on panel.
3. Select the magnetic pick up sensor by setting rotary 6 position switch at correct location.
4. Connect voltmeter to the output terminals to monitor the speed.
5. Connect 16 to VM(+) and VM(-) to ground for measure input voltage of motor.
6. Adjust zero pot for zero output voltage when motor is stand still and adjust span potentiometer output at 2V when motor is running at input voltage 10V.
7. Repeat the procedure for two or three times to confirm zero and full scale adjustment.

8. Vary the speed of motor by potentiometer and note down the output voltge for each position of the potentiometer.
9. Verify output voltage = [(f/8)×60]/2000 V

Table No. 2.1: Observation table

Motor Volt	Frequency at Tp13 F(Hz)	RPM using above formula	(Speed RPM=) OP volt × 2000
0			0
.			.
.			.
.			.
10			2

Conclusion:

b) Hall effect sensor

Objective: To understand the hall effect and its use for motor speed measurement.

Theory: Hall effect switch is a semiconductor switch and activates on presence of Magnetism around it and deactivates on removal of magnetic field. This property of hall effect switch is useful for motor speed measurement.

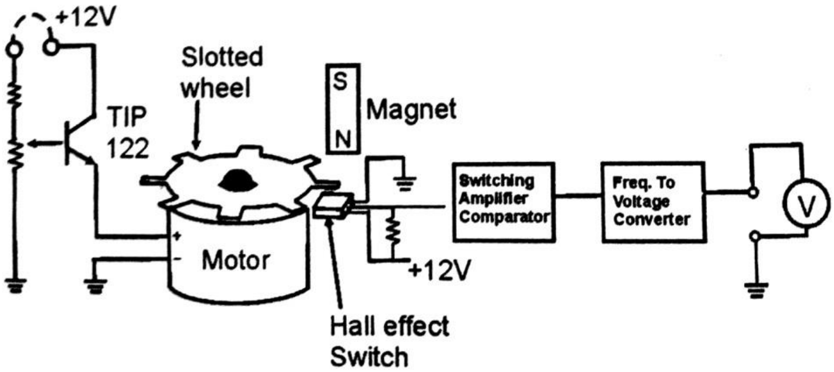


Figure2.4: Hall effect switch for speed measurement

Hall effect switch is placed just below the teeth of the wheel. A permanent magnet is mounted just above the wheel height. Permanent magnet produces permanent magnetic field around hall effect switch and open collector output of it switches to zero. On rotation of motor slotted wheel rotates. When tooth of wheel appears in between magnet and hall switch magnetic field weakens and hall effect switch output changes its state (becomes high). Thus hall effect gives one pulse per tooth of the wheel. These pulses are amplified and converted into sharp pulses by comparator. Further these pulses are converted into DC voltage by frequency to voltage converter.

Procedure:

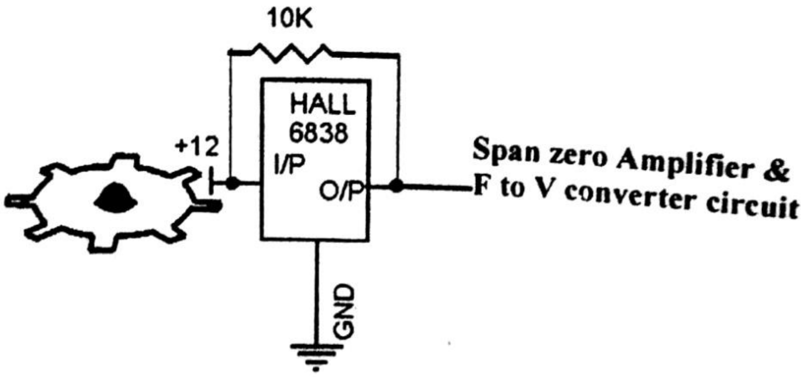


Figure 2.5: Hall effect switch circuit

Wiring sequence: +1V-1, -12V-3, GND-2, 8-9, VM(+)-6, VM(-)-7

1. Connect ±12V supply to the panel.
2. Short the terminals as shown in wiring diagram by patch cord for manual speed control of motor through potentiometer on panel.
3. Select the hall effect sensor by setting rotary 6 position switch at correct location.
4. Connect voltmeter to the output terminals to monitor the speed.
5. Connect 16 to VM(+) and VM(-) to ground for measure input voltage of motor.
6. Adjust zero pot for zero output voltage when motor is stand still and adjust span potentiometer output at 2V when motor is running at input voltage 10V.
7. Repeat the procedure for two or three times to confirm zero and full scale adjustment.
8. Vary the speed of motor by potentiometer and note down the output voltage for each position of the potentiometer.
9. Verify output voltage = $[(f/8)\times 60]/2000$ V

Table No. 2.2: Observation table

Motor Volt	Frequency at Tp13 F(Hz)	RPM using above formula	(Speed RPM=) OP volt × 2000
0 . . . 10			0 . . . 2

Conclusion:

c) Inductance

Objective: To study and test motor speed measurement using inductance.

Theory: value of inductance (effectively inductive resistance) if kept in magnetic field changes when magnetic field is disturbed. This property is used for motor speed measurement.

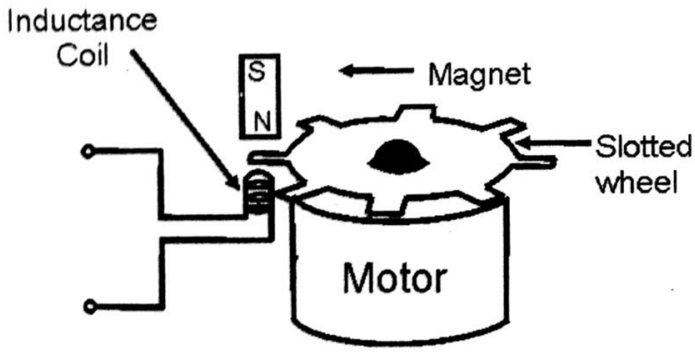


Figure 2.6: Inductance coil for speed measurement

Permanent magnet establishes a magnetic field around inductance coil. It offers certain reactance to a sine wave signal applied and drops some output voltage across it. When motor rotates, a slotted wheel connected to the motor shaft also rotates and disturbs magnetic field by its each tooth. This causes change in value of inductive resistance. Hence voltage across coil changes each time as magnetic field disturbed. This voltage change can be converted into pulses for speed measurement of motor.

Procedure:

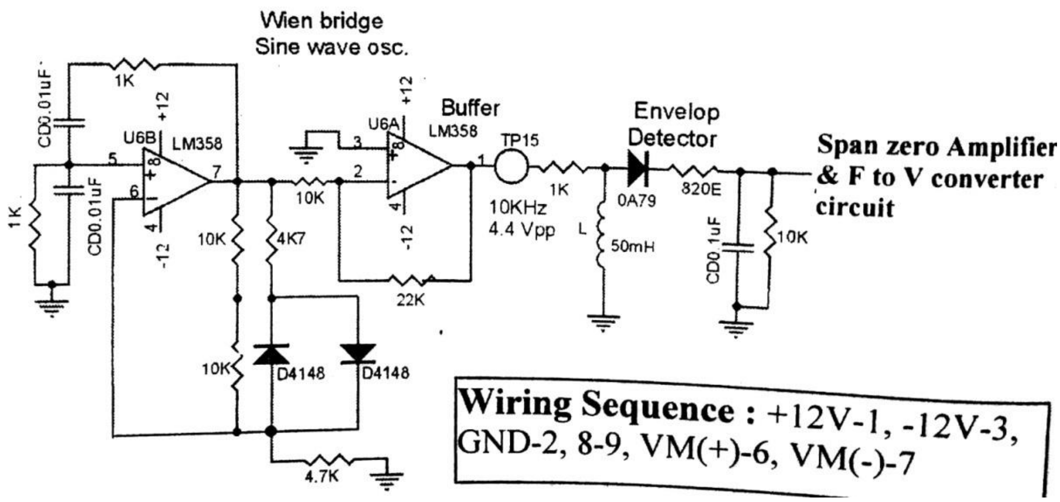


Figure 2.7: Inductance circuit

Wiring sequence: +1V-1, -12V-3, GND-2, 8-9, VM(+)-6, VM(-)-7

1. Connect ±12V supply to the panel.
2. Short the terminals as shown in wiring diagram by patch cord for manual speed control of motor through potentiometer on panel.
3. Select the inductive sensor by setting rotary 6 position switch at correct location.
4. Connect voltmeter to the output terminals to monitor the speed.
5. Connect 16 to VM(+) and VM(-) to ground for measure input voltage of motor.
6. Adjust zero pot for zero output voltage when motor is stand still and adjust span potentiometer output at 2V when motor is running at input voltage 10V.
7. Repeat the procedure for two or three times to confirm zero and full scale adjustment.

8. Vary the speed of motor by potentiometer and note down the output voltage for each position of the potentiometer.
9. Verify output voltage = [(f/8)×60]/2000 V

Table No. 2.3: Observation table

Motor Volt	Frequency at Tp13 F(Hz)	RPM using above formula	(Speed RPM=) OP volt × 2000
0 . . . 10			0 . . . 2

Conclusion:

d) Photo reflector sensor

Objective: To become familiar with photo sensor with reflection technique.
Theory: A slotted wheel connected to the motor shaft may be used as reflector for infrared signal. If an infrared transmitter transmits light, it will be reflected by the teeth of the slotted wheel. This reflected light can be detected using photo transistor whose O/P made available for speed measurement purpose.

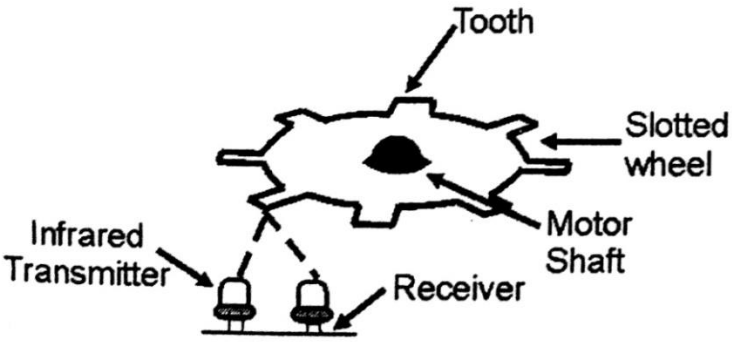


Figure 2.8 : Photo reflector for speed measurement

Infrared transmitter and receiver (detector) are placed, just below the tooth area of slotted wheel. Transmitter when applied +ve DC voltage transmits infrared light (invisible). Slotted wheel tooth reflects this light back and detector (receiver) receives this reflected light $ give current flow. When slotted wheel rotates due to coupling with motor shaft, each tooth of wheel passes over transmitter receiver pair and each time receiver detects light and gives voltage output. This voltage will appear as pulses. If this voltage is further processed to obtain the pulses of sufficient amplitude which can be measured by counter or by frequency to voltage converter.
Procedure:

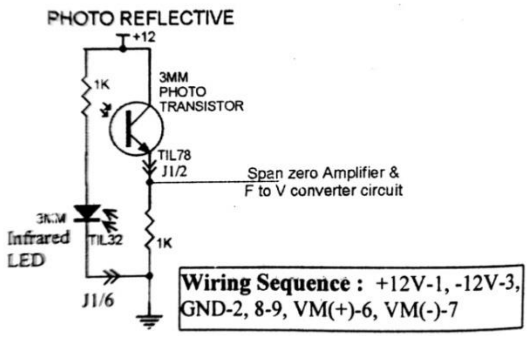


Figure 2.9: Photo reflective sensor circuit

Wiring sequence: +1V-1, -12V-3, GND-2, 8-9, VM(+)-6, VM(-)-7

1. Connect ±12V supply to the panel.
2. Short the terminals as shown in wiring diagram by patch cord for manual speed control of motor through potentiometer on panel.
3. Select the photo reflector sensor by setting rotary 6 position switch at correct location.
4. Connect voltmeter to the output terminals to monitor the speed.
5. Connect 16 to VM(+) and VM(-) to ground for measure input voltage of motor.
6. Adjust zero pot for zero output voltage when motor is stand still and adjust span potentiometer output at 2V when motor is running at input voltage 10V.
7. Repeat the procedure for two or three times to confirm zero and full scale adjustment.
8. Vary the speed of motor by potentiometer and note down the output voltage for each position of the potentiometer.
9. Verify output voltage = [(f/8)×60]/2000 V

Table No. 2.4: Observation table

Motor Volt	Frequency at Tp13 F(Hz)	RPM using above formula	(Speed RPM=) OP volt × 2000
0 . . . 10			0 . . . 2

Conclusion:

e) Photo Interruptive Method

Objective: To understand the photo interruptive action used for motor speed measurement.

Theory: Any optical transmitter can transmit light rays (visible or invisible) those travel axially or in straight line. A detector if placed in its path can detect light travelling and can give voltage output. If this light is interrupted by any means, detector output ceases. On removal of interruption detector voltage output recovers. Hence each interruption between transmitter and receiver causes dip in output voltage from the detector(receiver) and can be treated as pulses.

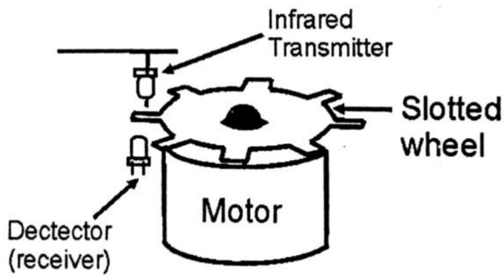


Figure 2.10: transmitter detector arrangement

A transmitter is mounted just above tooth area of slotted wheel and receiver mounted just below tooth area. Rotation of slotted wheel (due to motor) causes passing of teeth between transmitter and receiver path and hence interruption. The rate of interruption depends upon motor speed and no of teeth of wheel. The output of detector (pulses) may not be suitable for direct measurement hence requires processing circuit which includes amplifier/comparator, counter or frequency to voltage converter. Hence after processing the detector signal it can be used for direct speed measurement.

Procedure:

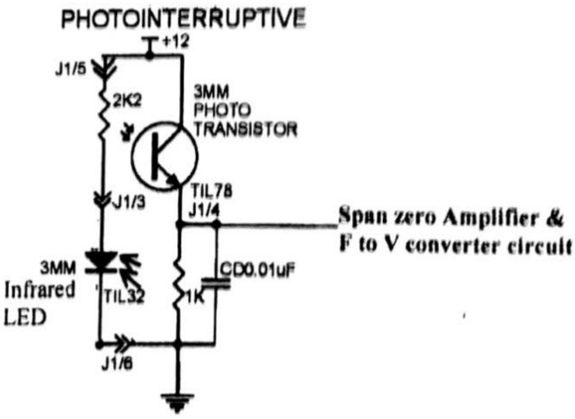


Figure 2.11: Photo Interruptive sensor circuit

Wiring sequence: +12V-1, -12V-3, GND-2, 8-9, VM(+)-6, VM(-)-7

1. Connect ±12V supply to the panel.
2. Short the terminals as shown in wiring diagram by patch cord for manual speed control of motor through potentiometer on panel.
3. Select the photo interruption sensor by setting rotary 6 position switch at correct location.
4. Connect voltmeter to the output terminals to monitor the speed.
5. Connect 16 to VM(+) and VM(-) to ground for measure input voltage of motor.
6. Adjust zero pot for zero output voltage when motor is stand still and adjust span potentiometer output at 2V when motor is running at input voltage 10V.

7. Repeat the procedure for two or three times to confirm zero and full scale adjustment.
8. Vary the speed of motor by potentiometer and note down the output voltge for each position of the potentiometer.
9. Verify output voltage = [(f/8)×60]/2000 V

Table No. 2.5: Observation table

ɔtor Volt	ɛquency at Tp13 Hz)	ꞌM using above formula	ɔeed RPM=) ꞌ volt × 2000

Conclusion:

f) Stroboscopic Method

Objective: To understand the method of motor speed measurement using stroboscope.

Theory: Stroboscope is basically a flashing high intensity lamp, flashing at precise intervals. Flashing rate is controllable and calibrated. When this light directed on vibrating or rotating object a steady pattern may be visible if the vibration / rotation rate of an object match in frequency to that of flashing lamp.

This unit is designed on same principles but uses flashing LEDs instead of lamp. An oscillator built around IC555 drives LED ON $ OFF. Oscillator frequency can be varied by potentiometer.

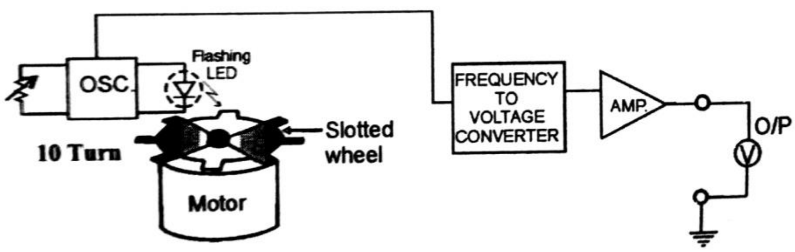


Figure 2.12: Stroboscope arrangement for speed measurement

To achieve stable pattern always start Stroboscope frequency at highest frequency and then start slowing down. You will get steady pattern whenever Stroboscope frequency is related to shaft frequency in ratios of two. As you begin slowing down you will see +type figure which is when flashing rate is 4 times. Then further down, you will get dark shade dumbbell when frequency is 2 times. This the correct pattern which has darkest dumbbell. Further down you will get a faint dumbbell where frequency is exactly matching but faint picture will be difficult to judge when speed is low.

Procedure:

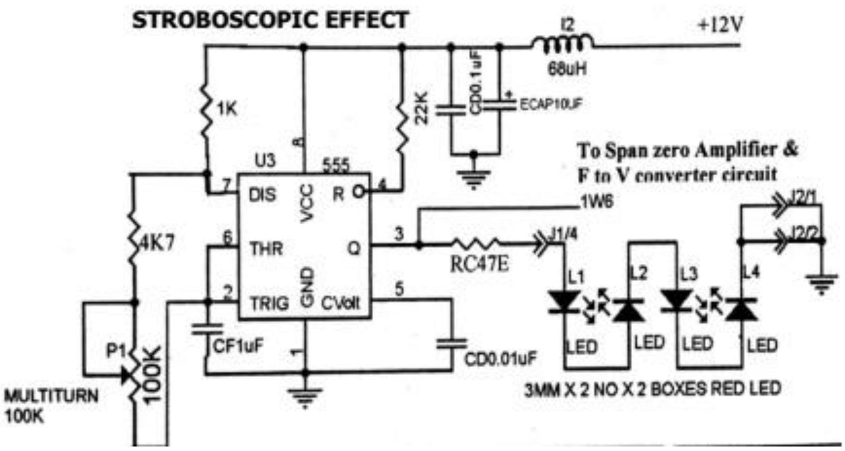


Figure 2.13: Stroboscopic flasher circuit

Wiring sequence: +12V-1, -12V-3, GND-2, 8-9, VM (+)-6, VM(-)-7

1. Connect ±12V supply to the panel.
2. Short the terminals as shown in wiring diagram by patch cord for manual speed control of motor through potentiometer on panel.
3. Select stroboscope by setting rotary 6 position switch at correct location.
4. Connect voltmeter to the output terminals to monitor the speed.
5. Connect 16 to VM(+) and VM(-) to ground for measure input voltage of motor.
6. Set 3V (approx) with speed control potentiometer on panel and make steady pattern and adjust output voltage to 0.15V with zero adj. pot.
7. Now set 10V as maximum speed on panel and make steady pattern and adjust output voltage at 1.05V.
8. Repeat the procedure for two or three times to confirm zero and full-scale adjustment.
9. Vary the speed of motor by potentiometer and note down the output voltage for each position of the potentiometer by making steady pattern.
10. Verify output voltage = [(f/2) ×60]/4000 V

Table No. 2.6: Observation table

Motor Volt	Frequency at Tp13 F(Hz)	RPM using above formula	(Speed RPM=) OP volt × 4000
3			0.15
.			.
.			.
.			.
10			1.05

Conclusion:

EXPERIMENT NO: 3

FORCE MEASUREMENT

Objective: Graphical representation of sensor/Transducer output voltage vs weights (load).

Theory:

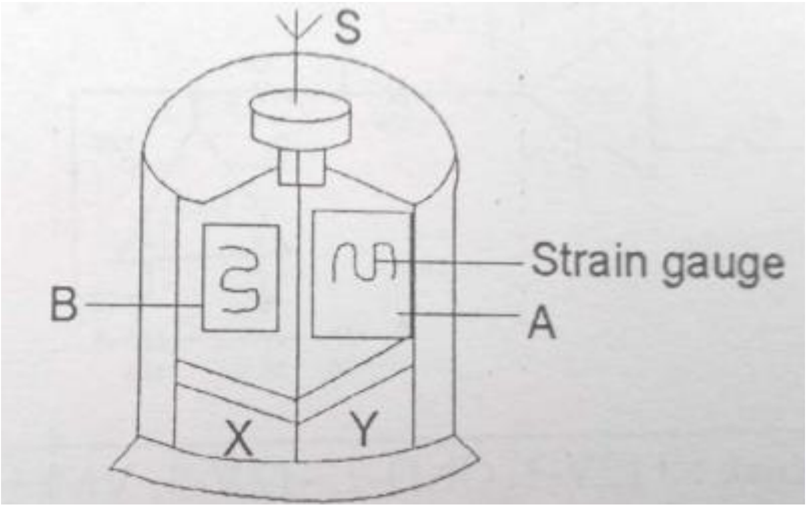


Figure 3.1: Load Cell

Stress in the direction of A as shown in fig. 1 causes compression along the axis and expansion in the X & Y axes. This results decrease in the resistance of gauge A & increase in the resistance of gauge B. Gauges on all four sides of bar if connected n bridge form gives high sensitivity and thus measurement of small loads as well as heavier loads is possible.

Equipments required:

1. Voltmeter - 2V or 20V
2. Power supply- ±12 V
3. Load cell- 20kg
4. Weights- 1, 2, 5, 10 kg
5. Panel- MIT 1

Procedure:

Wiring Sequence: +12V-1, GND-2, -12V-3, VM(+)-4, VM(-)-5

1. Connect ±12 V DC to the panel terminals connect external load cel to the panel through "D" connector.
2. Connect the load cell for placing different loads (weights).
3. Connect a voltmeter across output terminals.
4. Adjust output to zero volts by zero adjust potentiometer for no load (weight) condition.
5. Place 10 kg weight/load in the pass of load cell and adjust output to 1V DC by span potentiometer.

6. Repeat the above produce for "0" output and 1V output condition twice or thrice to ensure correct range adjustment.
7. Now note down the output voltage against different weights as indicated in observation table.

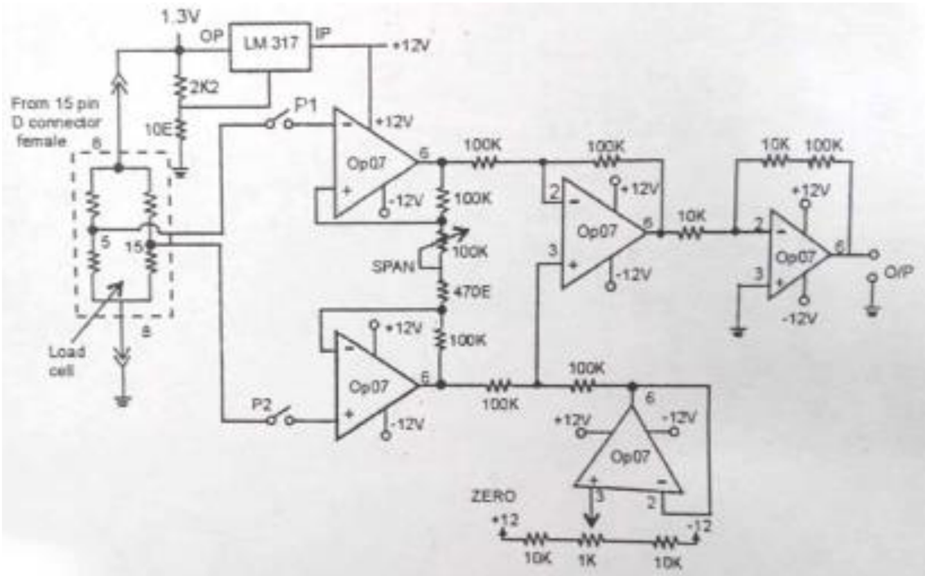


Figure 3.2: Signal Conditioning circuit of load cell

Table No. 3.1: Observation table

Load/Weight in kg	Output voltage in Volt
1	0
2	
3	
4	
5	
6	
7	
8	
9	
10	1

Plot a graph of load (weight) versus output voltage and calculate slope of it.

Conclusion:

EXPERIMENT NO: 4

TORQUE MEASUREMENT

Objective: Measurement of torque generated by Universal motor.

Theory:

The AC/DC universal motor supported on pedestal (trunion) at both axial ends will have its rotor as well as stator free to move. By Newton's law of motion (action and reaction), the torque being applied at the shaft rotor gets transmitted to stator & stator will trend to move in opposite direction. This action is very similar to driver driving into the water from spring board above by first pressing it downward to jump upwards and ahead before getting in to spin for drive.

Spread Rubber gasket (10mm) no table so that the chasis with mounted motor will not move away from its place also avoid under vibrations.

A. Torque measurement: The movement of stator is restricted by

$$T = F \times r \tag{1}$$

Where F is the force at the shaft periphery & r is the radius (typically $11\emptyset$). Since we are able to measure the force (f) being applied at the local cell, which are located at the distance of R (50 mm in this case), we have another equation for the shaft torque

$$T = f \times R \tag{2}$$

As (1) and (2) being same torque, by measuring f through load cell in kg wt., knowing R (50mm) we can determine T.

$$T = Force \times Distance$$

$$= Force\ (kg) \times 0.05\ meter \times 9.9\ m/sec^2$$

$$= kg \times 0.49$$

Where 0.49 is Dynamometer constant.

Whose unit is $N - m/kg$.

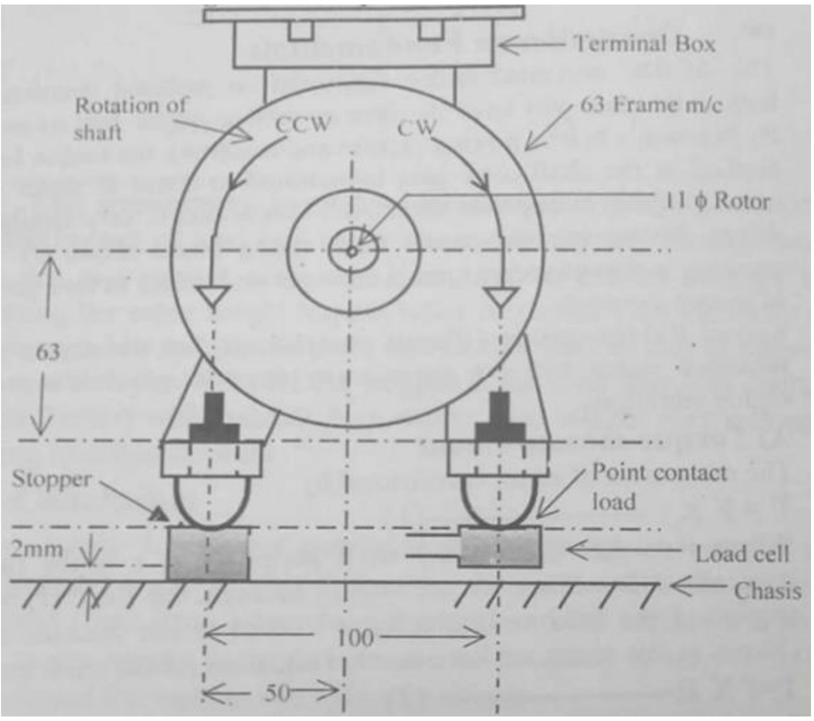
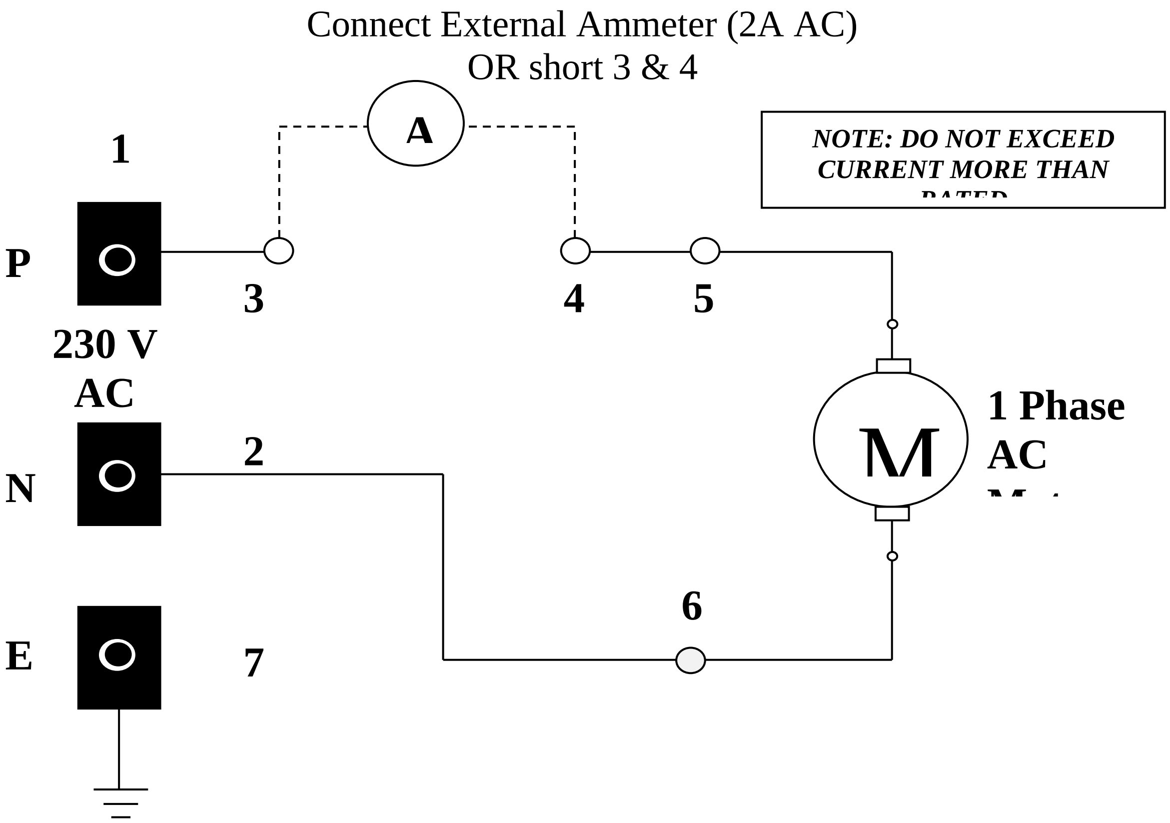


Figure 4.1: Torque measurement



B. Full scale determination:

To identify full-scale range of force measuring sensor, assuming fully loaded motor with full speed. Actually, speed will drop on load.

Now power is $P = 2\pi NT/60$ (where P=120 W)

$$T = 60 \times P/2\pi N$$

Substitute values of speed when fully loaded. Use hand held tacho from lab stock to measure speed in RPM when fully loaded. Here you will observe the motor will rotate with 1280 RPM at full load. (You can fully load the motor by observing full load rotate current through it)

$$T = \frac{60 \times 120}{2\pi N}$$

$$T = (60 \times 120)/2\pi \times 1280$$

$$T = 0.896\ N - M$$

Therefore force $= T/0.49$

$$= \frac{0.896}{0.49} = 1.83\ kg$$

=Full load force to be measured

Hence let us use 3 kg sensor calibrated for 2V output for 2kg. Therefore, multiplication factor is 1> So during experiment the O/P voltage reading is the corresponding load in kg (Fwt in kg).

C. Loading of motor:

To apply torque on shaft of motor a belt pulley, spring balance arrangement is made. As you tighten wing Nut there by tightening belt of shaft pulley through two no. of spring balances, motor speed drops. Maintain rough surface outside. It draws more current to support torque. The rotor rotates in CCW direction, stator rotates in CW direction.

$$Applied\ torque, T_a = (F_1 - F_2) \times {}^{d}/_{2}$$

Where d=diameter of pulley= 25 mm= 0.025 meters

$$= \Delta F \times {}^{d}/_{2} \times 9.8 \frac{m}{sec^2} = applied\ torque\ in\ N\text{-}m$$

D. Zeroing/tare:

If you rotate motor without belt pulley loading, still motor will exert residual torque/force on force sensor which needs to be subtracted from measured observations.

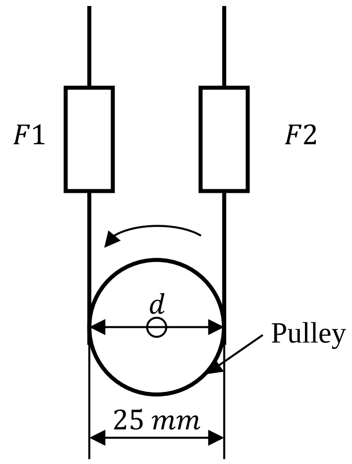


Figure 4.2: Loading arrangement

Equipment required:

1. Voltmeter- 2V or 20V
2. Power supply- ±12 V
3. Motor assembly with belt pulley and Load cell (3kg), motor- 1 ph. Induction, 1500rpm.
4. Panel- MIT 1

Procedure:

Panel provides all circuitry needed to perform experimentation on torque measurement. Load cell is fixed on a motor chasis assembly under its foot and should be connected to MIT 1 panel through

15 pin D connector. On board circuitry consist of instrumentation amplifier and single ended amplifier. Zero adjustment and span adjustments potentiometer are provided.

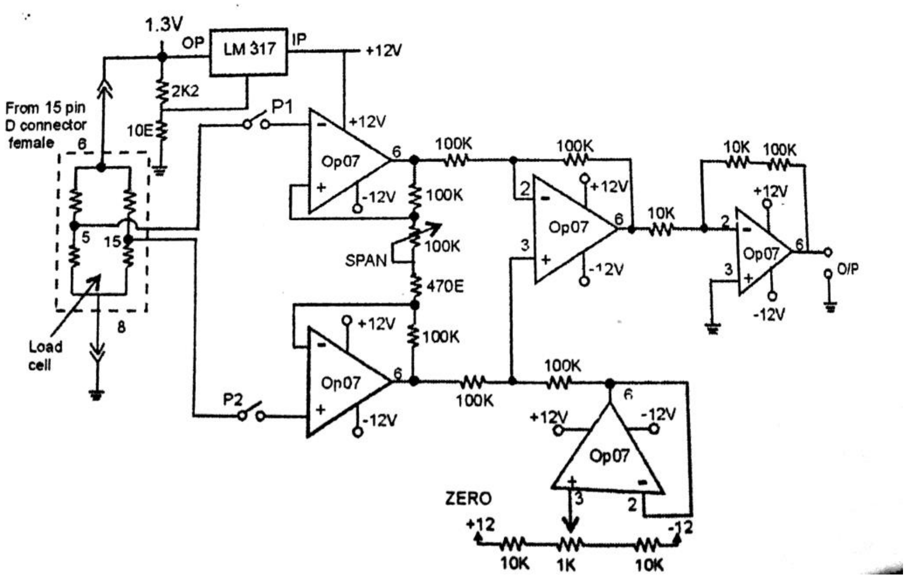


Figure 4.3: Signal conditioning circuit of Load cell

Wiring sequence:

A) panel wiring: +12V-1, GND-2, -12V-3, VM (+)-4, VM (-)-5

B) Motor wiring: 230VAC(L) -1 ph. AC motor (1), 230VAC(N)-1 ph. AC motor (2), 230VAC(E)-1 ph.AC motor (7), AC ammeter (+ve)-1 ph.AC motor (3), AC ammeter (-ve) -1 ph. AC motor (4)

1. Select the sensor by selecting rotary 6 position switch at correct location.
2. Connect ± 12 V DC to the panel terminals connect external load cell to the panel through "D" connector.
3. Connect a voltmeter across O/P terminal.
4. Keep the span pot to minimum position before starting the motor.
5. Adjust O/P to zero volts by zero adjust potentiometer under no load (Foot of motor should not be pressing on the sensor).
6. Start the motor by connecting its 3 pin socket to 230 V AC.
7. Load the motor by tightening both wing nuts such that the motor takes its maximum rated full load current (by observation on AC Ammeter).
8. Note down $F1$ and $F2$ in kg.
9. Set voltage at O/P terminals=ΔF in kg.
10. Calculate $\Delta F = F1 - F2$ (in kg).
11. Set voltage at O/P terminals =ΔF in kg. This is the span adjustment.
12. Repeat the above procedure for "0" O/P and V O/P condition twice or thrice to ensure correct range adjustment.

Another way of zeroing/tare.

13. Run the motor at no load (no belt).
14. Keep span potentiometer to minimum, zero the output using zero potentiometer.

15. Put on belt, load the motor by tightening wing nuts such that the motor rotates at its maximum full load current.
16. Now set the span such that O/P volt =ΔF in kg-F_Z. (E.g., if ΔF=1.4 and F_Z=0.7, set O/P=1.4-0.7=0.7 V.
17. After calibration take different set of readings as shown in Table.

Table No. 4.1: Observation Table for torque measurement

Sr.	F1 kg	F2 kg	$F1 - F2 = \Delta F$ kg	I (A)	T_a N.m	F_{wt} in Volts	$F_{wt}.F_Z = F_{wt}$ in kg	$F_{wt} \times 0.49 = T_m$ in N.m	$\frac{T_a - T_m}{T_a} \times 100$
1.									
2.									
3.									
4.									
5.									

T_a= Applied torque and T_m= Measure torque

Conclusion:

EXPERIMENT NO - 5
STRAIN MEASUREMENT

OBJECTIVE: To study the linearity characteristics of strain gauge displacement sensor versus electrical output.

THEORY: Strain gauge is a passive electrical transducer. It gives variation in electrical resistance between its two terminals as effect of strain on sensor (gauge) on application of external force.

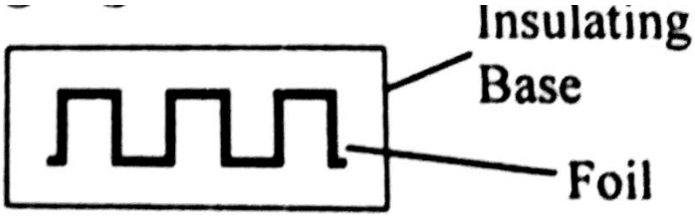


Figure 5.1: Strain gauge construction

Foil type strain gauges are flexible and can be mounted on curved surfaces. Resistive strain gauges are normally connected in full bridge or half bridge form and a constant voltage or constant current source drives it. The difference voltage available from bridge circuit is required to be amplified to measure it easily. Panel provides strain gauge mounted on a spring steel strip. The strip is fixed at one end and the other end is kept free to move. Movement of free end strip is connected to a micrometer. Strain gauges are connected to the strip from both the surfaces, two from each side. Thus, on application of force, strip bends and offers elongation on one side and compression from other side. Thus, gauges are connected in full bridge and half bridge as shown below

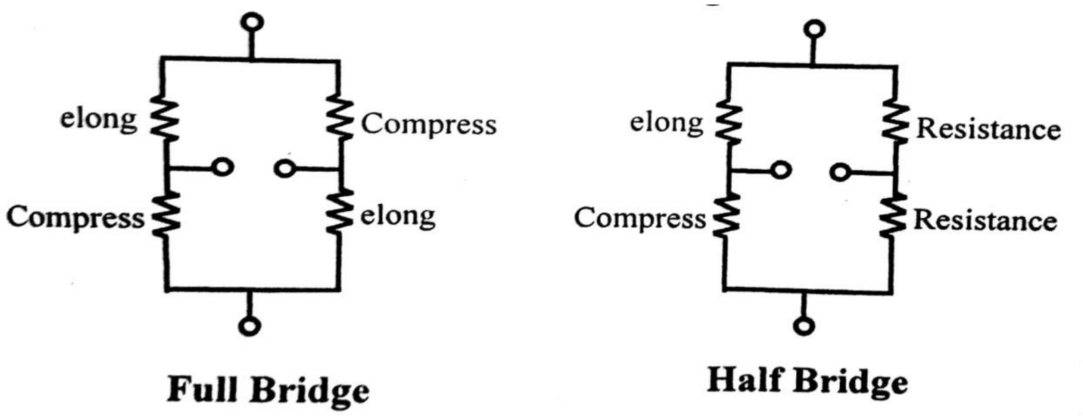


Figure 5.2: Full bridge and half bridge

Equipment required:

1. Voltmeter
2. Power supply: ±12V
3. MIT 1

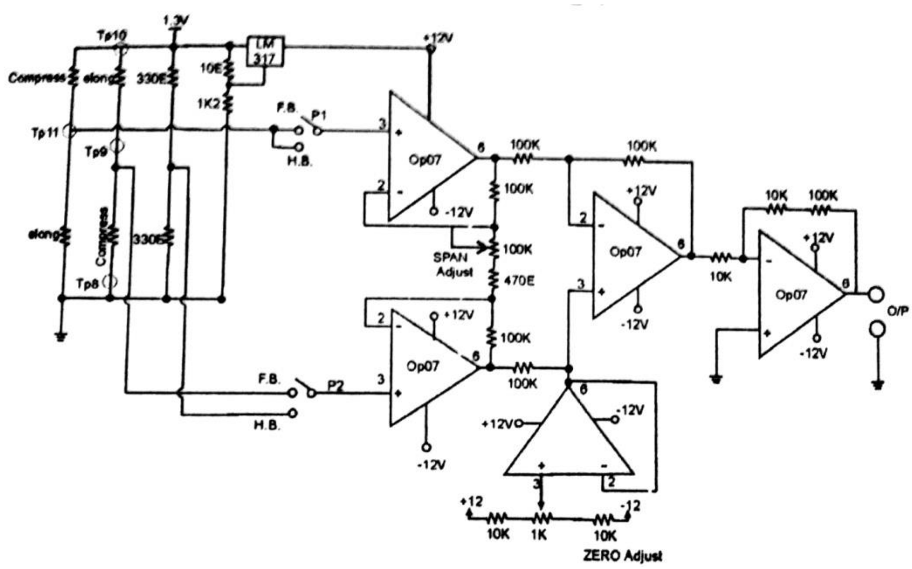


Figure 5.3: Signal conditioning circuit of Strain

PROCEDURE:

Wiring sequence: +12V-1, -12V-3, GND-2, VM(+)-4, VM(-)-5.

1. Connect ±12 V to the supply terminal of the panel.
2. Select the full bridge sensor by setting rotary 6 position.
3. Connect voltmeter at DC output terminals.
4. Adjust micrometer to the marking of 5 mm (zero strain) $ adjust the output voltage to zero with the help of zero adjust pot.
5. Now adjust the micrometer to zero (0mm) mark (full strain) and adjust output voltage to 2.5 V with the help of span adjust pot.
6. For strain half bridge select the sensor by setting rotary 6 position switch.
7. Then repeat the procedure.

Table No. 5.1: Observation table

Displacement micrometer reading mm	Output DC volts
0	2.5V
2	.
4	.
.	.
.	.
25	0

Plot a graph of displacement versus output voltage.

CONCLUSION:

EXPERIMENT NO: 6
TEMPERATURE MEASUREMENT

OBJECTIVE: To understand and use following sensors and transducers used in temperature measurement:

a) IC sensor
b) RTD
c) Thermistor

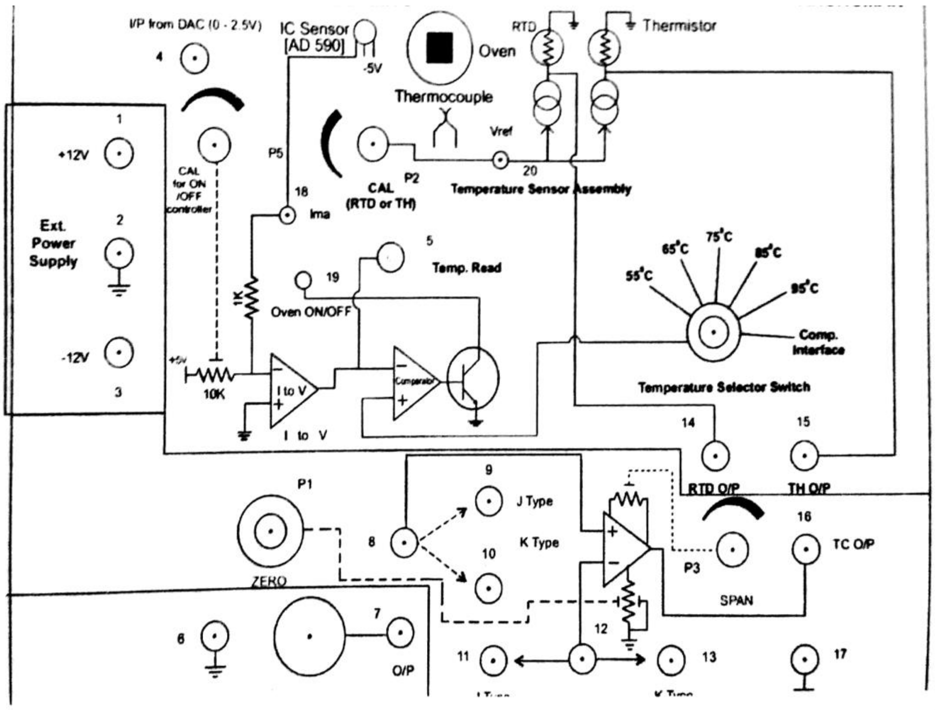


Figure 6.1: Temperature sensors panel (MIT6) PCB view

Equipment required:

1. DC power supply ±12V
2. Voltmeter -2V
3. Panel No- MIT 6

a) IC Sensor

Objective: To understand working of IC sensor as temperature transducer and also plot the graph of characteristic property against temperature.

Theory: IC sensor is a semiconductor sensor and acts as a temperature dependent current source. The IC sensor is placed in closed vicinity of the oven so as to sense the temperature easily. As the temperature rises the sensor draws more current from the supply. The output is compared with the voltage set across the set point resistors, which varies as per rotary switch selected for different temperatures.

Procedure:

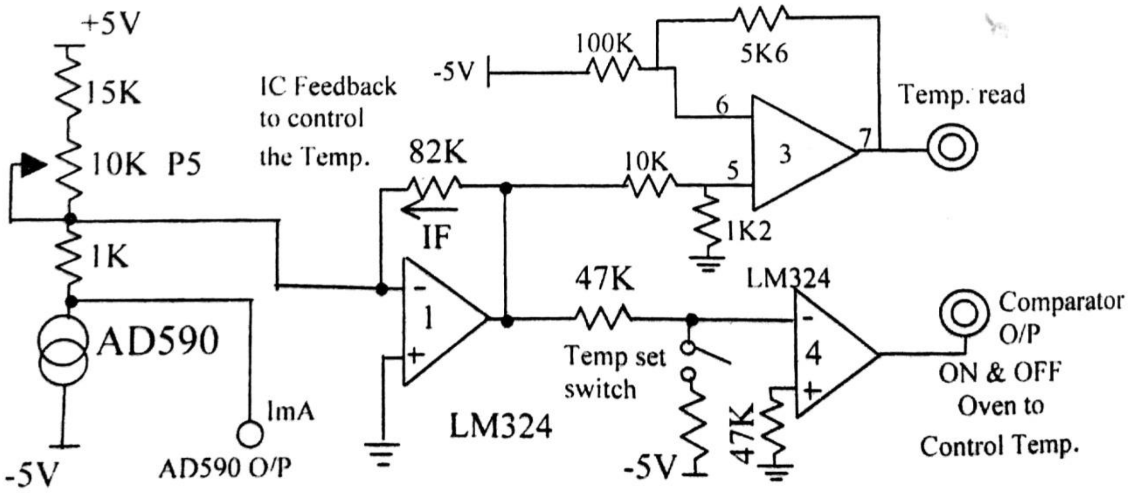


Figure 6.2: IC sensor and digital closed loop control

Wiring sequence: +12V-1, -12V-3, GND-2, VM(+)-5, VM(-)-6, VM(+)-18, VM(-)-17

1. Make the wiring connections as given in wiring schedule.
2. Before making “ON” the MIT- panel ensure that pot P5 (CAL for ON/OFF Controller) $ P2 (CAL for RTD or TH) are in at (CCW) minimum position.
3. Put on the power supply to the panel.
4. Adjust V_{ref} = 10.3 V at tag no. 20 using pot P2.
5. Adjust pot P5 such that the oven just turns on indicated by red LED glowing.
6. Above setting is required to calibrate IC sensor, Thermistor and RTD.
7. Now measure temperature (in the form of voltage) at temperature read tag with DMM on 20V range.
8. It will be observed that the voltage at temp read tag is increasing $ will reach up to the set point selected (±02V is allowable range) i.e., for 55˚ C set point the temperature read tag may show 0.53V or 057V. Within this range of voltage, the oven becomes off indicating set point temperature $ ac
9. Actual oven temperature are nearly equal.
10. At this point measure voltages at O/P s of different sensors i.e., RTD output, Thermistor output, IC sensor output.
11. Take reading at different set points 65˚C, 75˚C, 85˚C, 95˚C etc.

Table No. 6.1: Observation table

Switch position.	Set temp. in 0˚C	Voltage at Ima tag	Temp. read Volt ×100 C	
			Min	Max
Posn.1	55			
Posn.2	65			
Posn.3	75			
Posn.4	85			
Posn.5	95			

CONCLUSION:

b) RTD

Objective: To understand the working of the RTD (PT100) temperature transducer and also plot the graph of characteristic property against temperature.

Theory: Resistance temperature detector transducer is made up of thin film of platinum deposited on a ceramic substrate and having gold contact plates at each end that make contact with film. The resistance of this thin film increases as the temperature increases i.e. the sensor has positive temperature coefficient (PTC).

The increase in resistance is linear with temperature and the relationship between the change in resistance with temperature rise is given as 0.385Ω/˚C.

$R_t = R_0 + 0.385T$

Where, R_t = resistance at temperature T˚C

R_0 = resistance at 0˚C (100 Ω)

As the temperature goes on increases resistance of RTD increases which can be measure in terms of voltage at the o/p further converted in corresponding resistance using formula.

Using the equation, $R(t) = 100 + t \times 0.39$oms/˚C

Calculate the theoretical resistance value for various temperature and note down in the table.

Procedure:

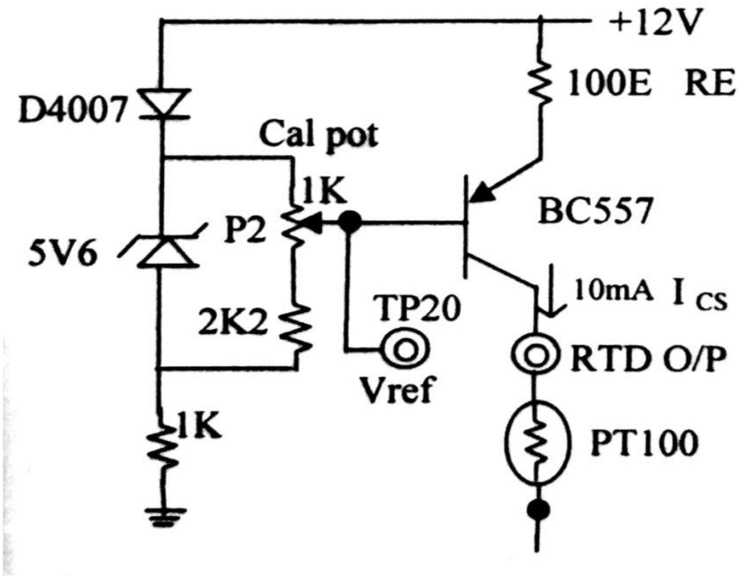


Figure 6.3 : RTD circuit

Wiring sequence: +12V-1, -12V-3, GND-2, VM(+)-5, VM(-)-6, VM(+)-14, VM(-)-17

1. Make the wiring connections as given in wiring schedule.
2. Before making "ON" the MIT- panel ensure that pot P5 (CAL for ON/OFF Controller) $ P2 (CAL for RTD or TH) are in at (CCW) minimum position.
3. Put on the power supply to the panel.
4. Adjust V_{ref} = 10.3 V at tag no. 20 using pot P2.
5. Adjust pot P5 such that the oven just turns on indicated by red LED glowing.
6. Above setting is required to calibrate IC sensor, Thermistor and RTD.
7. Now measure temperature (in the form of voltage) at temperature read tag with DMM on 20V range.
8. It will be observed that the voltage at temp read tag is increasing $ will reach up to the set point selected (±02V is allowable range) i.e. for 55˚ C set point the temperature read tag may show 0.53V or 057V. Within this range of voltage, the oven becomes off indicating set point temperature & actual oven temperature are nearly equal.
9. At this point measure voltages at O/P s of different sensors i.e. RTD output, Thermistor output, IC sensor output.
10. Take reading at different set points 65˚C, 75˚C, 85˚C, 95˚C etc.

Table No. 6.2: Observation table

Switch posn.	Set temp. in 0˚C	O/P in mV	Resistanceof RTD(ohm)	
			Using equation	Voltage mV/10
Posn.1	55			
Posn.2	65			
Posn.3	75			
Posn.4	85			

Posn.5	95			

Coclusion:

c) Thermistor

Objective: To understand the working of the thermistor temperature transducer and also plot the graph of characteristic property against temperature.

Theory: The resistance of the thermistor changes with change in temperature. In the given panel the thermistor used is of NTC (negative temperature coefficient) type i.e., its resistance decreases with increase the temperature. Panel provides Thermistor fitted in a mini oven arrangement. The oven gives the required temperature with a selector switch for particular temperature. As the temperature goes on increasing resistance of Thermistor decreases which can be measure in terms of voltage at the o/p further converted in corresponding resistance.

Procedure:

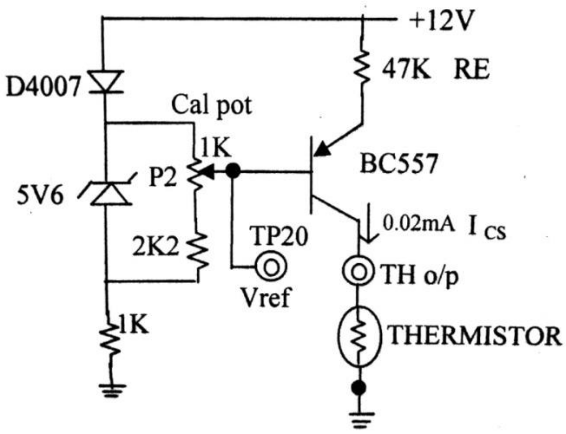


Figure 6.4: Thermistor circuit

Wiring seq: +12V-1, -12V-3, GND-2, VM(+)-5, VM(-)-6, VM(+)-15,VM(-)-17

1. Make the wiring connections as given in wiring schedule.
2. Before making "ON" the MIT- panel ensure that pot P5 (CAL for ON?OFF Controller) $ P2 (CAL for RTD or TH) are in at (CCW) minimum position.
3. Put on the power supply to the panel.
4. Adjust V_{ref} = 10.3 V at tag no. 20 using pot P2.
5. Adjust pot P5 such that the oven just turns on indicated by red LED glowing.
6. Above setting is required to calibrate IC sensor, Thermistor and RTD.
7. Now measure temperature (in the form of voltage) at temperature read tag with DMM on 20V range.

8. It will be observed that the voltage at temp read tag is increasing & will reach up to the set point selected (±02V is allowable range) i.e. for 55˚ C set point the temperature read tag may show 0.53V or 057V. Within this range of voltage the oven becomes off indicating set point temperature & actual oven temperature are nearly equal.
9. At this point measure voltages at O/P s of different sensors i.e. RTD output, Thermistor output, IC sensor output.
10. Take reading at different set points 65˚C, 75˚C, 85˚C, 95˚C etc.

Table No. 6.3: Observation table

Switch position	Temp(0˚C)	O/P in mV	Resistance of Thermistor (KΩ) = Voltage mV/20	
Posn.1	55			
Posn.2	65			
Posn.3	75			
Posn.4	85			
Posn.5	95			

Conclusion:

EXPERIMENT NO: 7
PRESSURE MEASUREMENT

OBJECTIVE: To understand pressure sensor (Piezo resistive/strain) working and find out its behaviour against pressure.

THEORY: Piezo resistive sensor (Strain gauge sensors) are fabricated in wafer form. Four strain sensitive resistors are diffused in silicon wafer mounted on thin pressure diagram. These four resistors are connected in wheatstone bridge form. Thus, the value of two resistors increases with positive pressure and decreases that of remaining two opposite resistors. Sensors in bridge form is shown below.

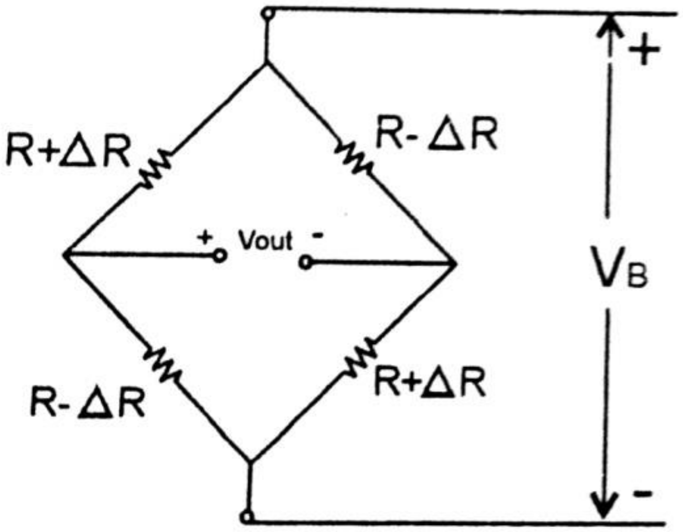


Figure 7.1: Pressure sensor

Alignment of resistors on silicon determines the increase or decrease in resistance value when applied with pressure. The resultant differential O/P $V_o = V_B \times \Delta R/R$ since the change in resistance ΔR is directly proportional to the applied pressure.

Equipment Required:

1. Voltmeter -2V or 20V (DMM)
2. Power supply ±12V
3. Hand Air pump
4. Pressure Gauge (20 PSI/30PSI)
5. Panel No. MIT 1

PROCEDURE:

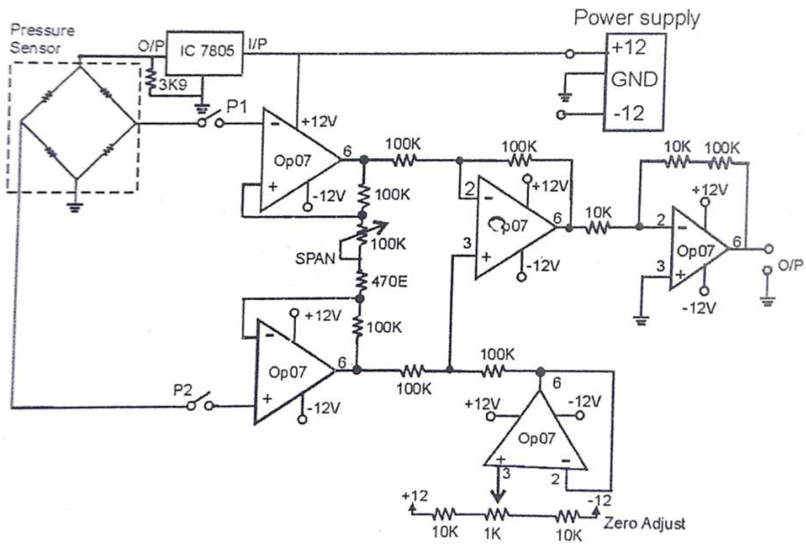


Figure 7.2: Signal conditioning circuit pressure

Wiring sequence: +12V-1, -12V-3, GND-2, VM(+)-4, VM(-)-5

1. Connect ±12V supply to the panel.

2. Connect a voltmeter at output.
3. Connect air pump to the panel socket.
4. Switch on the power supply.
5. Adjust output voltage to zero with the help of zero adj.
6. Apply pressure through air pump and increase the pressure to 15 psi.
7. Set output voltage 1.5 V using span.
8. Repeat zero and span adj. procedure twice or thrice.
9. Now apply pressure and observe corresponding output voltage.

Table No. 7.1: Observation table

Air Pressure(psi)	O/P voltage (V)
0	0V
2	
4	
.	
.	
15	1.5V

Plot graph of air pressure versus output voltage.

CONCLUSION:

EXPERIMENT NO - 8

FLOW MEASUREMENT

Objective: Graphical presentation of pressure sensor output voltage vs flow rate using

a) Venturimeter
b) Turbine Interruptive type flow meter

a) Venturimeter

Theory:

The Venturimeter is a device used to determine the discharge (rate of flow) of a liquid flowing in a pipeline. It has three main parts. They are convergent cone, throat and divergent cone.

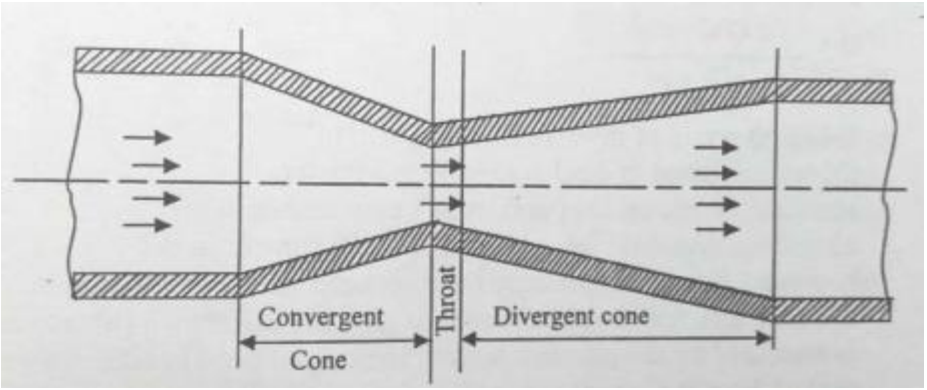


Figure 8.1 Venturimeter

Convergent Cone:

The diameter of this cone gradually decreases towards the throat. The taper angle will be 20°. The slop of taper will be $1/4$ to $1/5$. Since the area of flow is decreasing, the velocity of flow increases and it will be maximum at throat. Due to this, the pressure decreases to minimum at the throat.

Throat:

It is the cross section of Venturimeter where the diameter is minimum. The ratio of throat diameter, to inlet diameter is between $1/4$to $3/4$. But most suitable value will be around $1/3$ to $2/3$.

Divergent Cone:

Diameter of this cone gradually increases to original inlet diameter. Length of divergent cone is nearly four times greater than that of convergent cone, the taper angle of divergent cone will be around 5° to 10°.

In divergent cone, diameter gradually increases causing pressure also to increase to original. But, if this recovery of pressure is rapid, there is possibility that the liquid may breakaway the walls of Venturimeter. This is the reason for having the length of divergent cone more.

By using the following equation, we can determine the discharge of liquid which is flowing through the Venturimeter,

$$Q = \frac{C_d a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

Where Q= rate of flow (or Discharge) in m^3/S.

C_d= Coefficient of discharge of Venturimeter.

a_1= Cross sectional area at inlet of Venturimeter in m^2.

a_2= Cross sectional area at throat of Venturimeter in m^2.

h= the difference in pressure head between inlet and throat in m.

Observe that flow is proportional to pressure difference (h) which is measured by the pressure sensor. Hence it is need to take square root of the signal condition sensor O/P to obtain flow rate.

Procedure:

1. Connect to pressure sensor on MIT panel as shown in fig. 2.
2. Select the sensor by selecting rotary 6-position switch at connect location 5th location.
3. Connect $\pm$12 V supply to the 4 panel connect power cord of motor.
4. Connect voltmeter across the O/P.
5. Keep the manual valve at close position.
6. Read the LHP reading on the Rotameter.
7. Set O/P to 0V at close position of manual valve.
8. Set O/P to 2.5V at fully open position i.e., 200 LPH of manual valve.
9. Again, set O/P to 0V at close position of manual valve.
10. Set again O/P to 2.5V at fully open position.
11. Repeat the span zero adjustment procedure for correct measurement range.

12. Now keep the manual valve open at various position & note down the sensor voltage readings in the table below.

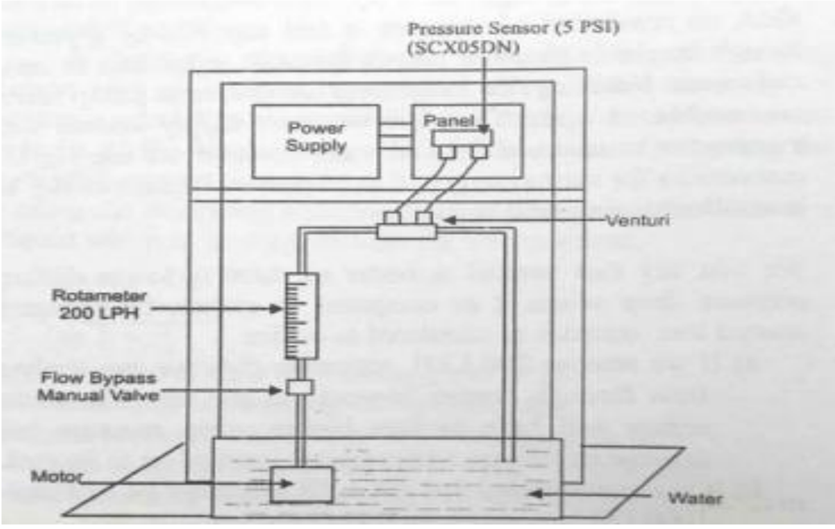


Figure 8.2 Pressure sensor on MIT panel

Table No. 8.1: Observation Table

Sr. No.	Rotameter LPH	Output voltage (±0.05) V	Square root of Voltage $\sqrt{V}$
1.	0		
2.	20		
3.	40		
4.	60		
5.	80		
6.	100		
7.	120		
8.	140		
9.	160		
10.	180		
11.	200		

Plot a graph of

1. Sensor output voltage versus flow (LPH).
2. Square root of sensor output voltage versus flow (LPH).

Conclusion:

b) Turbine Interruptive type flow meter

Theory: Figure 8.3 shows the circuit inside the turbine type flow sensor used in flow measurement assembly.

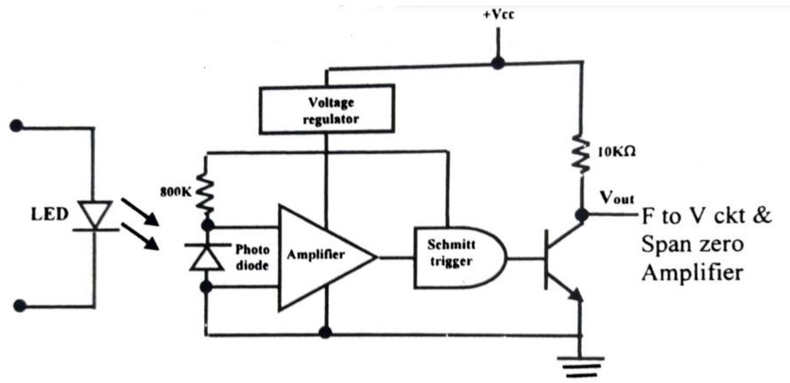


Figure 8.3: Flow Sensor

Inside the housing of flow sensor there is an infra-red light emitting diode. The LED is directed at the receiver which has a built-in voltage regulator, photo diode, amplifier, schimit trigger and output stage. Every turbine blade passage blocks the light beam and so reduces the level of the output signal to typically 200mV (maximum 40 mV). The 'unblocked' level is the supply voltage and the output is tied to this through a 10 K resistor.

The turbine inside the sensor will work as a interrupter between the LED & photo diode. The rate of interruption will depend on the rate of flow of liquid passing through the sensor. This flow can be controlled using a valve.

The pulses provided due to interruption at the O/P are further converted into DC voltage by freq. to voltage converter. Converter O/P passed through zero & span amplifier can be measured as water per LPH.

Specification of turbine flow sensor.

Flow range 0.25-6.5 lit/m

Pulses per liter- 4600 pulses/lit approximately

Approximately full scale- 500 Hz

Linearity at FSD frequency- +/- 10 %

Procedure:

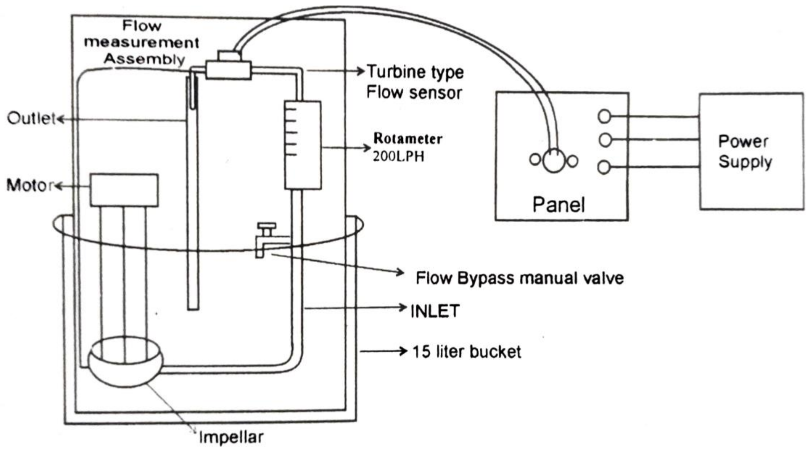


Figure 8.4: Mechanical arrangement for flow measurement

Wiring sequence: +12V-1, -12V-3, GND-2, VM(+)-6, VM(-)-7

1. Connect +/- 12V supply to the panel and connect power cord of motor.
2. Select the flow measurement sensor by setting rotary 6 position switch at correct location.
3. Connect voltmeter across the output. Keep the manual valve at fully close position. No flow of water will be observed. Hence the water flow is ‘0’ LPH.
4. Set 0 V at output using zero adjustment pot.
5. Now fully open the valve and again read the LPH level. If it is 140 LPH then set 1.4 V at O/P using span adjustment pot. Always set this span adjustment according to LPH level. E.g. for 140 LPH, set 1.4V at output for 160 LPH, set 1.6V at output etc.
6. Again close the valve check for zero position voltage and repeat the span zero adjustment procedure for correct measurement range.
7. Now keep the manual valve open at various positions & note down the readings in the table below.

No	Rotameter Reading (LPH)	LPH=O/P(Volt) × 100

Conclusion:

Experiment 9: Study of control valves

Experiment 10: Process control study

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181615	**Heat Transfer-II Lab**	**0-0-2**	**1**

Course Outcomes (COs): After successful completion of the course, the student will be able to:

CO1: Estimate convective heat transfer coefficient for forced and free convection and compare thevalues under steady state condition
CO2: Determine various related parameters in drop and film condensation process
CO3: Demonstrate the heat pipe and deduce its practical applications

LIST OF EXPERIMENTS:

Experiments on Convection

1. Calculation of heat transfer coefficient of forced convection in internal pipe flow
2. Calculation of heat transfer coefficient of natural convection for a vertical tube
3. Determination of heat transfer coefficient in drop and film condensation phenomenon
4. Heat pipe demonstration

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3.7 SEVENTH SEMESTER

B.Tech 7th Semester: Mechanical Engineering

Sl. No.	Sub-Code	Subject	Hours per Week			Credit	Marks	
			L	T	P	C	CE	ESE
Theory								
1	ME181701	Vibration of Mechanical Systems	3	0	0	3	30	70
2	ME181702	Applied Thermodynamics - II	3	0	0	3	30	70
3	ME181703	Industrial Engineering and Management	3	0	0	3	30	70
4	ME181PE1*	Program Elective -1	3	0	0	3	30	70
5	ME181OE1*	Open Elective -1	3	0	0	3	30	70
6	HS181704	Principles of Management	3	0	0	3	30	70
Practical								
1	ME181722	Project-1	0	0	8	4	50	50
2	ME181723	Grand Viva Voce-I	0	0	0	1	0	50
3	SI181721	Internship-III (SAI - Industry)	0	0	0	2	0	200
TOTAL			18	0	8	**25**	**230**	**720**
Total Contact Hours per week: 26								
Total Credit: 25								

Program Elective-1

Sl No	Code	Subject
1	ME181PE11	Hydraulic Machines
2	ME181PE12	Machine Tools
3	ME181PE13	Power Plant Technology
4	ME181PE14	Quality Engineering
5	ME181PE15	Refrigeration
6	ME181PE16	Rotordynamics
7	ME181PE1*	Any other subject offered from time to time with the approval of the University

Open Elective-1

Sl No	Code	Subject
1	ME181OE11	Operation Research
2	ME181OE12	Renewable Energy Sources
3	ME181OE13	Solid Waste Management
4	ME181OE1*	Any other subject offered from time to time with the approval of the University

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181701	Vibration of Mechanical Systems	3-0-0	3

Introduction to the Course

Vibration is the study of oscillatory motion and it is one of the most fundamental applied topics of engineering. Understanding, measurement, monitoring and control of vibration is very important as vibration occurs in almost all spheres of life, viz. in machines, cars, structures, sound propagation, etc. The course introduces basics concepts of vibration of free and forced, undamped and damped vibration, single and multi degree of freedom, seismic instruments and noise engineering with applications.

Motivation

The knowledge of vibration is essential for a designer. Vibration of Mechanical Systems imparts a strong background to the students for further advanced studies. Study of vibration is important for mechanical, civil and aeronautical engineers.

Course Objective

The objective of the course is to provide fundamental knowledge and concepts of vibration to formulate mathematical models of mechanical systems, examine vibration response, establish relation between real system and physical model and determine a complete solution to the modeled vibration system.

Course Outcomes (COs):

CO1: Construct free body diagram and formulate the equation of motion for free vibration of mechanical system under damped and undamped conditions.

CO2: Develop mathematical models of physical systems under forced vibration using Newton's laws of motion and principles of conservation of energy and solve.

CO3: Analyze results of seismic instruments to estimate vibration parameters.

CO4: Evaluate vibration parameters and noise for multi degrees of freedom system and estimate the critical speed of a shaft for whirling motion.

CO5: Develop mathematical model using MATLAB for mechanical vibrating system.

MODULE 1:

Basic Concepts: Introduction, importance, main causes of vibration, characteristics of vibration, harmonic analysis, beats, periodic and non-harmonic excitation, mathematical models, elements of a vibratory system, lumped or discrete parameter system, continuous or distributed parameter systems, equivalent springs and dashpots.

MODULE 2:

Undamped Free Vibration: Introduction, derivation of differential equation of motion-energy method, Newton’s 2nd law method, Rayleigh’s method, solution of differential equations of motion, angular oscillation, compound pendulum.

MODULE 3:

Damped Free Vibration: Introduction, viscous damping, free vibration with viscous damping – over damped, critically damped and under damped systems, critical damping coefficient, logarithmic decrement, Coulomb damping, structural damping, interface damping: comparisons.

MODULE 4:

Forced Vibration SDOF (Single Degree of Freedom System): Introduction, forced harmonic vibration, magnification factor, resonance, excitation due to rotating and reciprocating unbalance, vibration isolation, force transmissibility, motion transmissibility.

MODULE 5:

Two Degrees of Freedom System (2DOF): Introduction, principal modes of vibration, modes shapes, torsional Vibration, coordinate coupling static and dynamic, dynamic vibration absorber, torsional vibration absorber, pendulum type vibration absorber, generalized co-ordinates.

MODULE 6:

Seismic Instruments: Introduction, vibrometer, accelerometer, phase distortion.

MODULE 7:

Multi Degree of Freedom Systems (MDOF): Introduction, equation of motion, matrix methods, orthogonality and principal modes of vibration, approximate method of determining fundamental frequencies- Dunkerley's method, Rayleigh's method, Holzer's methods, method of matrix iteration.

MODULE 8:

Introduction to Whirling Motion and Critical Speed, critical speed of a single rotor, multiple rotors. Introduction to Noise Engineering.

Textbooks/ Reference Books:

1. Mechanical Vibrations, Singiresu S Rao, Pearson
2. Vibration Theory & Application, W T Thomson, Prentice–Hall
3. Mechanical Vibrations, V P Singh, Dhanpat Rai & Co
4. Mechanical Vibration & Noise Engineering, A G Ambekar, Prentice–Hall

Prerequisites of the course

Engineering Mechanics, Linear algebra, Calculus, Differential Equations

Course Time Plan

Units/Topics	Number of Lectures (Hours)	Method of delivery
Unit I – Basic Concepts	4	
Unit II – Undamped Free Vibration	6	
Unit III – Damped Free Vibration	6	

Unit IV – Forced Vibration SDOF	6	Both chalk and talk and power point presentation
Unit V – Two Degrees of Freedom System	6	
Unit VI – Seismic Instruments_	2	
Unit VII – Multi Degree of Freedom Systems	6	
Unit VIII –_Whirling Motion and Critical Speed	2	
Total	38	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181702	**Applied Thermodynamics - II**	**3-0-0**	**3**

Course objectives:

The course is designed to give students scope to learn applied thermal science with cycle working fluids other than water, mostly air. Here a good knowledge of the basics of thermodynamics and fluid mechanics is a prerequisite. The course aims at providing information related to air compressors of all types, gas turbines, jet and rocket engines, basics of refrigeration and psychrometry. The course further aims at developing skills in the students to apply information to practical problems. The teacher should give emphasis on both theories of the topics and their applications.

Motivations:

It is expected that the students will be motivated to acquire knowledge that will help them in applying themselves to practical fields of compressors, gas turbine plants, refrigeration plants, air-conditioning plants etc. It will further motivate them to acquire the basic knowledge, which is considered as prerequisite for learning subjects like internal combustion engines, air-conditioning.

Course Outcomes (COs): On successful completion of this course the student should be able to:

1. Analyse the thermodynamic processes and cycles involved in compressors, gas turbines, jet engines and refrigerator systems using air/gas as working fluid to reduce them to solvable mathematical models.
2. Estimate all the design parameters of the components used in thermodynamic devices using thermofluidic considerations.
3. Estimate the effects of irreversibility on the design of the single-process thermodynamic devices from thermodynamic properties.
4. Compare the performances in terms of efficiency, power and COP of each of the thermodynamic devices for selection in domestic and small industrial applications.
5. Evaluate the positive and negative aspects of space heating and cooling technology with reference to environment using psychrometric properties.

MODULE 1: Air Compressors

Introduction; Reciprocating type – Single stage and multi-stage, Compression ratio and volumetric efficiency, effect of clearance, compressor efficiencies. Methods for improving thermal efficiencies. Compressor work and power. Intercooler and after-cooler. Rotary compressors – Classification, Centrifugal compressors – theory of operations, impeller and diffuser, impeller work; efficiency. Rotary Vs Reciprocating compressor. Introduction to axial flow compressors, charging and choking of compressors.

MODULE 2: Gas Turbine

Introduction – gas turbine cycles – open and closed, Ideal and Actual cycles. Isentropic efficiencies and thermal efficiencies. Power output. Methods to improve thermal efficiencies; Gas turbine vs I C Engines.

MODULE 3: Jet and Rocket Propulsion
Introduction. Types of jet engines – turbojet, turboprop, ramjet, pulsejet. Analysis of turbojet engine cycle, thrust, jet thrust, propeller thrust, effective speed ratio, specific fuel consumption, thrust, impulse, performance. Types of rocket engines – solid propellants rockets, liquid propellants rockets, hybrid rockets, analysis of rocket propulsion, performance, comparison between jet and rocket propulsion.

MODULE 4: Refrigeration
Introduction – Reversed Carnot cycle and air refrigeration cycles; COP; Capacity of a refrigerating unit. Vapour compression and vapour absorption cycles. Properties of refrigerants. Heat pump.

MODULE 5: Psychrometry Introduction; Psychrometric terms; Delton's law of partial pressures. Psychrometric processes. Psychrometric Chart. Psychrometry.

Textbooks/ Reference Books:

1. Engineering Thermodynamics (Principles and Practices, Dr D S Kumar, Kataria and sons, First Edition, 2012.
2. Applied Thermodynamics, T. D. Eastor and A McConkey, 5th Edn (18th impression), Pearson Education, 2015.
3. Engineering Thermodynamics, P K Nag, 5th Edn, McGraw Hill Publications, 2013.
4. Thermodynamics – An Engineering Approach, Cengel and Boles, 5th Edn, Tata McGraw Hill Publications, 2006.
5. Thermal Engineering, R Rajput, Laxmi Publications, 2014.
6. Engineering Thermodynamics, Rogers and Mayhew, 4th Edn (2nd impression), Pearson Education, 2007.

Course Plan:

Sl No	Courses to be covered	No of classes		
		Theory	Tutorial	Mode of delivery
1	Revisions of cycles – Carnot, Rankine, Otto, Diesel etc.	1		PPT
2	Air Compressors: Introduction; Reciprocating type – Single stage, Compression ratio and volumetric efficiency, effect of clearance, compressor efficiencies. Compressor work and power.	3	1	Talk & chalk
3	Multi-stage compressors, Intercooler and after-cooler.	2	1	Talk & chalk
4	Rotary compressors – Classification, Centrifugal compressors – theory of operations, impeller and diffuser, impeller work; efficiency	1	1	Talk & chalk

5	Introduction to axial flow compressors, charging and choking of compressors.	1	1	
6	Gas Turbine Introduction – gas turbine cycles – open and closed, Ideal and Actual cycles.	2	1	Talk & chalk
7	Methods to improve thermal efficiencies; Gas turbine Vs I C Engines	2	1	Talk & chalk
8	Jet and Rocket propulsion Introduction. Types of jet engines – turbojet, turboprop, ramjet, pulsejet.	2		Talk & chalk
9	Analysis of turbojet engine cycle, thrust, jet thrust, propeller thrust, effective speed ratio, specific fuel consumption, thrust, impulse, performance.	3	1	Talk & chalk
10	Types of rocket engines; analysis of rocket propulsion; performance; comparison of rocket propulsion and jet propulsion.	1	1	PPT
11	Refrigeration: Introduction – Reversed Carnot cycle and air refrigeration cycles;	1	1	Talk & chalk
12	COP; Capacity of a refrigerating unit		1	Talk & chalk
13	Vapour compression cycle	1	1	Talk & chalk
14	Vapour absorption cycle	1		Talk & chalk
15	Refrigerants; heat pump	1		Talk & chalk
16	Psychrometry: Introduction; Psychrometric terms; Delton’s law of partial pressures.	1		Talk & chalk
17	Psychrometric chart; Psychrometer	1	1	Talk & chalk

Plans for class test: (Course duration July to Dec)

Class Test	Course	Tentative Date
I	Compressors – reciprocating and rotary.	Mid- August
II	Gas turbines & Jet propulsion engines	End- September
III	Refrigeration & Air-conditioning.	Early-November

Plans for seminars:

Groups comprising of 4 students will be formed from the batch and each group will be allotted a topic from the topics listed below. They will present their findings in seminars arranged once a week.

Sl no	Topic
1	Air leaks in compressed air lines
2	Motors used in compressors
3	Uses of waste heat from the compressors
4	Jet engines for Boeing 777
5	Turbine blades with TBC and CMC
6	Second law analysis of gas power cycles
7	Rocket launching stations in India
8	Missile technology
9	Thermoelectric power generator
10	Liquefaction of gases
11	Two-stage refrigeration system with a flash chamber
12	Heat pump systems
13	Selection of right refrigerant
14	Evaporative cooling – various examples
15	Wet cooling towers
16	Human comfort and air-conditioning

Topics beyond the course:

The following out-of-the-syllabus topics will be dealt in seminars:

Topics
Air leaks in compressed air lines
Motors used in compressors
Uses of waste heat from the compressors
Jet engines for Boeing 777
Heat pump systems
Second law analysis of gas power cycles
Rocket launching stations in India
Missile technology
Thermoelectric power generator
Evaporative cooling – various examples
Wet cooling towers

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181703	**Industrial Engineering and Management**	**3-0-0**	**3**

Learning Objectives:

The primary objective of the course is scientific decision making process under industrial environment with the help of various decision support systems. It aims to present needful exposure for better understanding of various types industry, its organizational structure and management principles. The course aims to develop understanding of project management and control by network analysis. The other objectives are (i) to provide knowledge in work study for improving performance rating of workers, (ii) to impart requisite knowledge about plant location, layout analysis, product design & production planning under different manufacturing system and (III) To develop knowledge about plant maintenance, significance of total quality management with better understanding of environmental and social issues surrounding enterprises.

Course Outcomes (COs): After the completion of the Course, the students will be able to:

1. Explain the concept of Organization, functions of Management and Organization types
2. Analyze the problems to related to Plant Location and Layout for optimal solutions
3. Utilize the concept of Project Management to solve various problems related to time optimization of Projects
4. Explain the concepts of Work Study, Product Design, Production Planning and Control and Inventory Management
5. Explain the concepts of Maintenance and Quality Control Techniques practice in Organizations

MODULE 1: Introduction to Organization **(2 Lectures)**
Definition of organization, organizational structure, types of organization, span of control, delegation of authority and responsibility.

MODULE 2: Plant Location and Layout **(4 Lectures)**
Objectives, Locational factors, Economics of plant location; Meaning, objectives and types of plant layout and their relevance to mass, batch and job-order production systems.

MODULE 3: Network Analysis **(6 Lectures)**
Objectives, Network development technique, Network computations – Critical Path and its significance, Earliest and Latest dates, calculation of float. Deterministic and probabilistic network models, Assumptions and computations related to PERT model, Crashing of jobs for minimum cost-time schedule for CPM models

MODULE 4: Work Study **(6 Lectures)**
Meaning and scope, subdivisions of work study – Method/Motion study and Work Measurement; Method/Motion study- its meaning and scope, steps in method/motion study, Tools and techniques of method/motion study, Principles of motion economy; Micro-motion study – Meaning and scope, therbligs, use of motion camera in micro-motion study; Work measurement – concept of observed

time, rating factor, average worker and standard time for jobs. Use of stop watch and work sampling techniques in the determination of standard time.

MODULE 5: Product Design and Development (6 Lectures)

Meaning of product, Product life cycle (PLC) and Product mix; Decisions to be taken during product development and design, Procedure for product development and design, Value of a product – its meaning, Value Analysis

MODULE 6: Production Planning and Inventory Control (6 Lectures)

Meaning and Objectives, Effects of types of production, steps in Production Planning and Control, Use of Gantt chart, Machine Scheduling Problems, Make/Buy decision and Break-even analysis and Inventory Control: EOQ Model, ABC, VED, FSN analysis.

MODULE 7: Maintenance Management (6 Lectures)

Meaning and Types of maintenance, and their suitability, Standards of maintenance, Total Productive Maintenance (TPM).

MODULE 8: Quality and Quality Control Engineering (6 Lectures)

Meaning of Quality, Inspection, Quality Control, Process Control, Control Charts, Acceptance Sampling, Total Quality Management Philosophy

Textbooks/ Reference Books:

1. Industrial Engineering and Management - O P Khanna.
2. Industrial Engineering – M Telsang
3. Essentials of Management – Koontz O' Donnel
4. Industrial engineering – M Mahajan
5. Operations Management – Panneerselvam
6. Motion and Time study – R M Barnes
7. Network and project management – Punmia
8. Total Quality Management – Besterfield et.al.

Prerequisites of the course: Basic knowledge on Engineering Economics, Accountancy, and Management Practices are preferable.

Lesson Plan

Unit/Topic	Lectures	Methodology/Pedagogy
Unit 1: Organization	2	Discussion and interaction also PPP
Unit 2: Network Analysis	6	Chalk and black board.
Unit 3: Work Study	6	Discussion along with chalk and board.
Unit 4: Plant Location and layout	4	PPP and Chalk and black board.
Unit 5: Product design and Development.	6	Discussion and interaction also PPP
Unit 6: Production Planning and Control	6	PPP and Chalk and talk and hand notes.
Unit 7: Maintenance Management	6	PPP and interaction.
Unit 8: Total Quality Management	6	Discussion and interaction also PPP

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181PE11	Hydraulic Machines	3-0-0	3

Introduction to the Course

This is an introductory course in Hydraulic Machines. The subject Hydraulic Machines has a wide scope and is of prime importance in almost all fields of engineering. The course emphasizes the basic underlying fluid mechanical principles governing energy transfer in a hydraulic machine and also description of the different kinds of hydraulic and air machines along with their performances. There is a well-balanced coverage of physical concepts, mathematical operations along with examples and exercise problems of practical importance.

Motivation

The use of hydraulic machines is very wide in industrial applications. The major applications pertain to electric power generations, aircraft and rocket propulsions and in varieties of medium and small scale industries. In electric power generations turbines are used which are the main components or power producing component of the unit. For aircraft propulsion, compressors are used.

Again, for industries where high pressure air is required, the centrifugal compressors are used. Similarly for transmission and distribution of water or liquid, circulation of liquid, pumps are incorporated in industrial applications and almost all industrial applications are involved in such applications or such operations of transmission and distribution and circulation of liquid. Therefore hydraulic machines are used starting from a very routine industrial application to a very high-tech industrial application.

Course Objective

The course will build a strong foundation on Hydraulic Machines. It will help to apply the basic principles, the laws, and the pertinent equations to engineering design of the machines for required applications. It will help to understand the mechanism behind the working of hydraulic machines. Exposure to different types of turbines and pumps will be provided to solve a wide variety of engineering problems.

Course Outcomes (COs):

1. Students will be able to extend knowledge of fluid mechanics to understand working of different types of hydraulic machines namely turbines and pumps.
2. Students will be able to recognize different types of turbines based on their working principles and calculate the work output and efficiency to draw the characteristic curves.
3. Students will be able to differentiate the principles of operation of different types of pumps to draw a comparison between them.
4. Students will be able to illustrate the performance characteristics of pumps.
5. Students will be able to deduce problems related to the various types of hydraulic machines, and calculate their working parameters and estimate the optimum working conditions.

MODULE 1:

Eular equation for turbo machines, Radial, axial and mixed flow machines. Impulse and Reaction machines

MODULE 2:
Impulse turbine- Pelton wheel, wheel diameter, jet diameter, bucket shape, size and number, speed control of Pelton wheel. Use of Pelton wheel and efficiency, specific speed and specific diameter range

MODULE 3:
Reaction Hydraulic turbine- Francis turbine – runner, flow and speed ratio, casing guide, vanes, flow control, speed control, runner shape variation with the change of specific speed. Draft tube, surge tank, penstock, cavitation. Axial flow turbine and Kaplan turbine. Blade profile, specific speed, diameter change of blade, pitch, guide vane, flow control, cavitation characteristics, draft tube, speed control of Kaplan turbines.

MODULE 4:
Centrifugal Pump and Reciprocating pump- Centrifugal pumps-single and multistage, radial and mixed flow pumps, vane pump, volute casing pump. Pump efficiencies-hydraulic efficiency, overall efficiency, loss in pump, speed ratio, efficiency. Pump characteristics- surging, cavitation on pump. Priming of centrifugal pumps, self-priming of pumps, multi stage pumps, runner, casing and stationary vanes. Axial pump-specific speed, flow ratio, speed ratio characteristics, applications. Propeller pump, blade-shape and aerofoil analysis-lift and drag estimate of pressure rise and power requirements

MODULE 5: Fluid System- Fluid couplings, Hydraulic dynamometer, Gear pumps

Textbooks/ Reference Books:

1. A Textbook of Fluid Mechanics and Hydraulic Machines by Dr. R.K. Bansal, Laxmi Publications (P) Ltd.
2. Introduction to Fluid Mechanics and Fluid Machines by S.K. Som, Gautam Biswas and Suman Chakraborty, Tata McGraw Hill Publication
3. A Textbook of Fluid Mechanics and Hydraulic Machines by Er. R.K. Rajput, S Chand Publications

BEYOND THE SYLLABUS

HYDRAULIC MACHINES LABORATORY (To supplement the Theory course)

FRANCIS TRIBUNE TEST RIG (1kW)

OBJECTIVE:

To study the operation of a Francis Turbine.

AIM:

To determine the output of Francis Turbine.

To determine the efficiency of the Francis Turbine.

INTRODUCTION:

Francis turbine, named after James Bichens Francis, is a reaction type of turbine for medium high to low heads and medium small to large quantities of water. The reaction turbine operates with its wheel submerged in water. The water before entering the turbine the pressure as well as kinetic energy. The moment on the wheel is produced by both kinetic and pressure energies. The water leaving the turbine has still some of the pressure as well as kinetic energy.

Theory:

Originally the Francis turbine was designed as a purely radial flow reaction turbine but modern Francis turbine is a mixed flow type in which water enters the runner radially inwards towards the centre and discharge out axially. It operates under medium heads and requires quantity of water.

DESCRIPTION:

The present set-up consists of a runner. The water is fed to the turbine by means of Centrifugal Pump, radially to the runner. The runner is directly mounted on the end of a central SS shaft and other end is connected to a brake arrangement. The circular window of the turbine casing is provided with a transparent acrylic sheet for observation of flow on to the runner. The runner assembly is supported by thick cast iron pedestal. Load is applied to the turbine with the help of the brake arrangement so that the efficiency of the turbine can be calculated. A draught tube is fitted on the outlet of the turbine. The set-up is complete with guide mechanism. Pressure and vacuum gauges are fitted at the inlet and outlet of the turbine to measure the total supply head on the turbine.

UTILITIES REQUIRED:

Electricity Supply: 3 Phase, 440 V AC, 50 Hz,15 kW with earth connection.

Water supply (400 liters)

Drain required.

Bench Area Required: 2 m x 1 m

Tachometer to measure RPM

Experimental Procedure:

STARTING PROCEDURE:

1. Clean the apparatus and make Tank free from Dust,
2. Close the drain valve provided.
3. Fill Sump tank ¾ with clean Water and ensure that no foreign particles are there.
4. Fill manometer fluid i.e., Hg. In manometer.
5. Ensure that there is no load on the brake drum.
6. Switch ON the pump with the help of starter.
7. Open the Air release Valve provided on the Manometer, slowly to release the air from manometer. This should be done very carefully.
8. When there is no air in the manometer, close the air from manometer. This should be done very carefully.
9. Now turbine is in operation.
10. Apply load on load pan.

11. Note the manometer reading, pressure gauge reading and vacuum gauge reading.
12. Now regulate the guide vanes position with the help of a hand wheel provided for this purpose.
13. Regulate the discharge by regulating the guide vanes position.
14. Note the maximum RPM of the turbine obtained by regulating the position of the guide vanes.
15. Note the spring balance readings.
16. Repeat the same experiment for different load.

CLOSING PROCEDURE:

1. When the experiment is over, First remove load on dynamometer.
2. Open the by-pass valve.
3. Close the ball valves provided on manometer.
4. Switch OFF Pump with the help of starter.
5. Switch OFF main power supply.

OBSERVATION CALCULATION:

DATA:

g = 9.8 m/s2

ρw = 1000 kg/m3

ρm = 13600 kg/m3

Cv = 0.98

D = 0.08 m

dB = 0.183 m

dR = 0.012 m

W3 = _ _ _ _ _ _kg

W3 = _ _ _ _ _ _kg

OBSERVATION TABLE

S. No.	N, RPM	P_d , kg/cm^2	P_s , Mm Hg	h_1 , cm	h_2 , cm	W_1 , kg	W_2 , kg

CALCULATIONS:

$H = 10\ (P_d + \frac{\rho_s}{760})$, m of water = _ _ _ _ _ _ _ _ _ _ _m of water

$Q = V \times A$, m^3/sec = _ _ _ _ _ _ _ _ _ _ _ m^3 / sec

$A = \frac{\pi}{4} d^2$, m^2 = _ _ _ _ _ _ _ _ _ _ _ _ m^2

$h = \frac{h_1 - h_2}{100}$, m = _ _ _ _ _ _ _ _ _ _ _ _ m

$V = C_v \times \sqrt{(2gh(\frac{\rho_m}{\rho_w} - 1)}$, m/sec = _ _ _ _ _ _ _ _ _ m/sec

$E_i = \frac{\rho_w \times g \times Q \times H}{1000}$, kW = _ _ _ _ _ _ _ _ _ _ _ _ _ m

T = $(W_1 + W_2 + W_3 - W_4) \times g \times R_e$, Nm =_ _ _ _ _ _ _ _ _ _**Nm**

$R_e = \frac{d_B + 2d_r}{2}$, m = _ _ _ _ _ _ _ _ _ _ _ _ _ m

$E_a = \frac{2 \times \pi \times N \times T}{60 \times 1000}$, kW = _ _ _ _ _ _ _ _ _ _ _ _ _ kW

$\eta_1 = \frac{E_a}{E_1} \times 100\%$ = _ _ _ _ _ _ _ _ _ _ _ _ _%

NOMENCLATURE:

A	=	Cross-section area of pipe, m^2
C_v	=	Co-efficient of pitot tube
D	=	Diameter of pipe, m
d_B	=	Diameter of brake drum, m
d_R	=	Diameter of pipe
E_i	=	Input power, kW
E_o	=	Output power, kW
g	=	Acceleration due to gravity, m/s^2
H	=	Total head, m
h	=	Different pressure of manometer, m
h_1, h_2	=	Manometer reading at both points, cm
N	=	RPM of runner shaft
P_d	=	Delivery pressure, Kg/cm^2
P_s	=	Suction pressure, mmHg
Q	=	Discharge, m^3/sec
Re	=	Equation Radius, m
T	=	Torque/N m
V	=	Velocity of water, m/s
W_1	=	Applied weight, kg
W_2	=	Dead weight (obtained from spring balance), kg
W_3	=	Weight of hanger, kg
W_4	=	Weigh of rope, kg
ρ_w	=	Density of water, kg/m^3
ρ_m	=	Density of Manometer fluid i.e. Hg, kg/m^3
η_t	=	Turbine efficiency %

PRECAUTIONS & MAINTANENCE INSTRUCTION:

1. Never run the apparatus if power supply is less than 390 volts and above 420 volts.
2. To prevent clogging of moving arts, Run Pump at least once in a fortnight.
3. Always use clean water.
4. If apparatus will not in use for more than half a month, drain the apparatus completely.
5. Always keep apparatus free from dust.

TROUBLESHOOTING:

1. If pump does not lift water, the revolution of the motor may be reverse. Change the electric connection to change the revolution
2. If plane is not showing input, check the main supply.

REFERENCE:
1. Streeter, Wylie, Bedford, “Fluid Mechanics”, 9th ed., Mc Graw Hill., NY, 2007, Page 518-520.
2. Y.A. Cengel, J.M. Cimbala, “Fluid Mechanics”, 2nd ed., McGraw-Hill, ND,2007, Page 786-795.

HYDRAULIC RAM TESTING RIG

OBJECTIVE:

Study the working of Hydraulic Ram.

AIM:

To determine the efficiency of Hydraulic Ram.

INTRODUCTION:

The Hydraulic Ram is a contrivance utilizing the water hammer principle. Ram is used when a natural source of water like a spring or stream at low head is available at a nearby place to pump a part of water to higher heads. The Ram requires no external energy. The work done by a large quantity of water in falling through a small height is used to raise a small part of water to a greater height.

THEORY:

A quantity of water is first allowed to pass through a long column of pipe connected to the Hydraulic Ram and discharged through a waste valve. The momentum of the water flowing through the pipe is then suddenly destroyed by the automatic closing of the waste valve which pumps a small quantity of water to high head tank. When the moving column of water is brought to rest, the waste valve opens and the cycle is repeated automatically.

The efficiency of the Hydraulic Ram can be determined by following formulae:

1. D’Aubuisson’s Effeciency

$$\eta_A = \frac{q h_d}{(q+Q) h_s}$$

2.Rankine’s Effeciency

$$\eta_R = \frac{q h_d}{Q h_s}$$

The Hydraulic Rams are most widely used in hilly regions where natural water streams are available. It requires no external energy, and the running and maintenance expenditure is practically nil.

DESCRIPTION:

The experimental set up consists of a Hydraulic Ram having a cylindrical air vessel connected to a small rectangular chamber through a non-returning valve.A waste vavle is also provided in the rectangular chamber to discharge the excessive water to the collecting.The chamber is connected to an elevated supply tank.A delivery pipe is connected to the foot of air chamber to deliver the water to measuring tank to measure the discharge deliverd by the Ram.A pressure gauge is provided for measuring the pressure.

Utilities Required:

Electricity Supply: Single Phase,220V AC,50 Hz,5-15amp socket with earth connection.

Water supply

Drain required.

Bench Area Required:1.5m × 0.75m

Experimental Procedures:

STARTING PROCEDURES:

1. Clean the apparatus and make free from dust.
2. Close all the drain valves provided.
3. Fill Sump tank ¾ with clean water and ensure that no foreign particles are there.
4. Close all control valves provided.
5. Ensure that all ON/OFF switches given on the panel are at OFF position.
6. Now switch ON the main power supply.
7. Switch ON the pump.
8. Fill overhead tank with water.
9. Adjust the ram stroke at minimum.
10. When overhead tank overflows,open control valve of ram.
11. Now Ram is in operation.
12. Adjust stroke of ram to vary the head developed by the ram.
13. Open slightly the control valve provided at useful water discharge line of Air Vessel.
14. Record pressure gauge reading in air vessel.
15. Measure flow rate of useful water and waste water discharged by the ram using stop watch and measuring tanks.
16. Repeat experiment at different flow rates of useful water discharged by the Ram by regulating the control valve provided at useful water discharge line of Air Vessel.

CLOSING PROCEDURE:

When experiment is over, switch OFF pump first.

Switch OFF power supply to panel.

OBSERVATIONS & CALCULATIONS:

DATA:

h_s= 1m

A= 0.1215m^2

OBSERVATION TABLE:

S.NO	Useful water	Waste water	P, kg/cm^2			
	V, ml	t_1,sec	R_1,cm	R_2,cm	t_2,sec	

CALCULATIONS:

$R = \frac{R_1 - R_2}{100}, m = \ldots\ldots\ldots\ldots\ldots m$

$Q = \frac{R \times A}{t_2}, m^3/sec = \ldots\ldots. m^3/sec$

$q = \frac{V}{t_1} \times \frac{1}{10^6}, \frac{m^2}{sec} = \ .... m^3/sec$

$h_d = 10 \times P, m\ of\ Water = \ ...... m$

$\eta_A = \frac{qh_d}{(q+Q)h_s} = \ ....$

$\eta_R = \frac{qh_d}{Qh_s} = \ ....$

NOMENCLATURE:

h_d = Delivery head of ram, m

h_s = Head of water supplied to Ram, m

P = Pressure gauge reading, kg/cm^3

q = Discharge of useful water lifted up, m^3/sec

Q = Discharge of waste water, m^3/sec

R = Rise in water level in measuring tank of waste water, m

R_1= Final level of water in measuring tank, m

R_2= Initial level of water in measuring tank, m

t_1 = Time taken for collecting useful water, sec

t_2 = Time taken for R, sec

V = Volume of useful water, ml

η_A= D' Aubussion's Effeciency

η_R= Rankine's Effeciency

PRECAUTION & MAINTENANCE INSTRUCTIONS:

1. Never run the apparatus if power supply is less than 180 volts and above 230 volts.
2. To prevent clogging of moving parts, Run Pump at least once in a fortnight.
3. Always use clean water.
4. It apparatus will not in use for more than one month, drain the water completely.
5. Always keep apparatus free from dust

TROUBLESHOOTING:

1. If pump gets jam,rotate the impeller of the pump by means of a scerwdriver.
2. If panel is not showing input,check the fuse and main supply.

REFERENCES:

1. R.S. Khurmi, "Hydraulics,Fluid Mechanics And Hydraulic Machines'',11th ed., S.Chand & Company LTD.,ND,2008,Page 645-646.
2. Dr. P.N. Modi, Dr. S.M. Seth,''Hydraulics &Fluid Mechanics'',15th ed., Standard Book House, ND,2005, Page1131-1133.

PELTON TURBINE TEST RIG (1 kW)

OBJECTIVE:

To study the operation of a Pelton Turbine.

AIM:

1. To determine the output power of a pelton turbine.
2. To determine the efficiency of the pelton turbine.

INTRODUCTION:

A turbine is a machine which converts the fluid energy into mechanical energy which is then utilized to run the electric generator of a power plant. Fluid used can be water or stream. The Pelton wheel is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. The energy available at the inlet of the turbine is only kinetic energy. The pressure at the inlet and outlet of the turbine is atmosphere. The turbine is used for high head.

THEORY:

Pelton turbine is an impulse turbine. In an impulse turbine, all the available energy of water is converted into kinetic energy or velocity head by passing it through a contracting nozzle provided at the end of penstock. The water coming out of the nozzle is formed into a free jet, which strikes on a series of buckets of the runner thus causing it revolve. The runner revolves freely in air. The water is contact with only a part of the runner at a time, and throughout its action on the runner.

DESCRIPTION:

The set up consists of centrifugal pump, turbine unit, and sump tank, arranged in such a way that the whole unit works as re-circulating water system. The centrifugal pump supplies the water from sump tank to the turbine. The loading of the turbine is achieved by rope brake drum connected with weight balance. The turbine unit can be visualized by a large circular transparent window kept at the front. A bearing pedestals rotor assembly of shaft, runner and brake drum, all mounted on suitable caste iron base plate.

UTILITIES REQUIRED:

Electricity supply: Three phase, 420 V AC, 50Hz, 5kW with earth connection.

Water supply (initial fill)

Drain Required.

Floor area required: 1.5m x 0.75m.

Mercury (Hg) for manometer 250 gms.

Tachometer for RPM measurement.

EXPERIMENTAL PROCEDURE

Starting procedure:

1. Close all the valve provided.
2. Fill sump tank 3/4th with clean water and ensure that no foreign particles are there.
3. Fill manometer fluid i.e., Hg. In manometer by opening the valves of manometer and one PU pipe from pressure measurement point of pipe.
4. Connect the PU pipe back to its position and close the valves of manometer.
5. Open the by-pass valve and ensure that there is no load on the brake drum.
6. Switch ON the pump with the help of starter.
7. Close the bypass valve.
8. Open pressure measurement valves of the manometer.
9. Open the air release valve provided on the manometer, slowly to release the air from manometer. (This should be done very carefully).
10. When there is no air in the manometer, close the air release valves.

11. Now turbine is in operation.
12. Load the turbine with the help of hand wheel attach on the top of weight balance.
13. Note the manometer reading and pressure gauge reading.
14. Measure the load applied and RPM of the turbine.
15. Repeat the experiment at different load.
16. Repeat the experiment for different discharge by regulating the nozzle position by the hand wheel provided for same.

Closing procedure:

1. When the experiment is over, first of all remove the load on dynamometer.
2. Open the by-pass valve.
3. Close the ball valves provided on manometer.
4. Switch OFF pump with the help of starter.
5. Switch OFF main power supply.
6. Drain the sump tank by the drain valve provided.

OBSERVATION & CALCULATIONS

DATA:

$g = 9.81$ m/sec^2

$\rho_w = 1000$ kg/m^3

$\rho_m = 13600$ kg/m^3

$C_v = 0.98$

D = 0.052m

$d_B = 0.2$ m

$d_R = 0.012$ m

W_3 = _ _ _ _ kg

OBSERVATION TABLE

S.No.	N	P, kg/cm^2	h_1 , cm	h_2 , cm	W_1 , kg	W_2 , kg
1.						
2.						
3.						

CALCULATIONS

$H = 10 \text{ x } P$, m of water = _ _ _ _ _ _ _ _ _ _ _ m

$A = \frac{\pi}{4} D^2$, m^2 = _ _ _ _ _ _ _ _ _ _ m^2

$h = \frac{h_1 - h_2}{100}$, m = _ _ _ _ _ _ _ _ _ _ m

$V = C_v \text{ x } \sqrt{2gh \text{ x } \left(\frac{\rho_m}{\rho_w} - 1\right)}$, m/sec = _ _ _ _ _ _ _m/sec

$Q = V \text{ x } A$, m^3/sec = _ _ _ _ _ _ _ _ m^3/sec

$E_i = \frac{\rho_w \text{ x g x Q x H}}{1000}$, kW = _ _ _ _ _ _ _ _ _ kW

$R_e = \frac{d_B + 2d_R}{2}$, m = _ _ _ _ _ _ _ _ _ _ m

$T = (W_1 + W_3 – W_2) \text{ x g x } R_e$, Nm = _ _ _ _ _ _ _ _ N m

$E_o = \frac{2 \times \pi \times N \times T}{60 \times 1000}$, kW =_ _ _ _ _ _ _ _ _ _ kW

$\eta_t = \frac{E_o}{E_i} \times 100\%$ = _ _ _ _ _ _ _ _ _ _ %

NOMENCLATURE:

A = Cross-sectional area of pipe, m^2

C_v = Co-efficient of pitot tube.

D = Diameter of pipe, m.

d_B = Diameter of brake drum, m.

d_R = Diameter of rope, m.

E_i = Input power, kW.

E_o = Output power, kW.

g = Acceleration due to gravity, m/sec^2

H = Total head, m.

h = Manometer difference, m.

h_1 , h_2 = Manometer reading at both points, cm.

N = RPM of runner shaft,

P = Pressure gauge reading, kg/cm^2

Re = Equivalent radius, m.

Q = Discharge, m^3/sec.

T = Torque, N m.

V = Velocity of water, m/sec

W_1 = Spring balance weight, kg.

W_2 =Adjustable weight, kg.

W_3 = Weight of Rope, kg.

ρ_w = Density of water, kg/m^3

ρ_m = Density of manometer fluid i.e. Hg, kg/m^3

η_t = Turbine efficiency.

Precautions & Maintanance Instructions:

1. Never run the apparatus if power supply is less than 390V and above 420V.
2. To prevent clogging of moving parts, run pump atleast once in a fortnight.
3. Always keep apparatus free from dust.

Troubleshooting:

1. If pump doesn't lift the water, the revolution of the motor may be reversed. Change the electric connection to change the revolutions.
2. If panel is not showing input, check the main supply.

References:

1. Streeter, Wylie, Bedford, "Fluid Mechanics", 9th ed., McGraw Hill., NY, 2007, Page 529-532.

2. Y.A.Cengel, J.M. Cimbala, “Fluid Mechanics”, 2nd ed., Tata McGraw-Hill, ND,2007,Page 783-785.

RECIPROCATING PUMP TEST RIG
(WITH D.C. MOTOR & SWINGING FIELD DYNAMOMETER)
OBJECTIVE:
Study of reciprocating pump characteristics
AIM:
To determine;

- Pump input
- Shaft input
- Total head
- Discharge
- Pump input
- Pump efficiency
- Overall efficiency
- Volumetric efficiency

To plot the following performance characteristics
Head vs Discharge
Pump efficiency vs Discharge
INTRODUCTION

A pump is a device which lifts water from a lower level to a higher level at the expense of mechanical energy. Pump can be broadly classified into two categories,positive displacement & rotodynamic or dynamic pressure pump.In a positive displacement pump a small quantity of liquid is taken inside the pump and is bodily displaced and forced out of the pump under pressure. The liquid inside a positive displacement pump may be subjected either to a reciprocating motion (reciprocating pump) or to a rotary/circular motion (gear pump, screw pumps etc.).

THEORY

Reciprocating pump consists a piston having a reciprocatory motion inside a cylinder with the help of connecting rod and a crank rotated by a electric motor, I.C. engine,or any another suitable means. The cylinder is connected to the sump by the suction pipe. Values are provided at suction and delivery side and are non-returnable so that to allow the fluid in direction only. These pumps are applied where the fluid is required in a small quantity but at a higher pressure. Reciprocating pumps are applied for vehicle washing,for the watr supply for the multi-stories buildings, industries etc.

DESCRIPTION

The apparatus consists of a double acting-single cylinder reciprocating pump is operated in closed circuit. A DC motor is provided to regulate the rpm of the pump. Suction and delivery head can be varied by the values provide and Pressure & Vacuum gauges can measure it.To find out the power

Input to the pump swinging field dynamometer is provided. Sump tank, measuring tank and stop-watch is provided. Sump tank, measuring tank and stop-watch is provided with the set-up. Discharge can be calculated with the help of measuring tank and stop watch.

UTILITIES REQUIRED

1. Electricity supply; Single phase,220 V AC, 50Hz, 5-15 amp socket with earth connection.
2. Water supply
3. Drain required
4. Bench Area Required : 1.5×0.75 m

EXPERIMENTAL PROCEDURE

STARTING PROCEDURE

1. Clean the apparatus and make tanks free from dust.
2. Close the drain values provided.
3. Fill Sump Tank 3/4th with clean water and ensure that no foreign particles are there.
4. Open flow control valve given on the water discharge line and control valve given on suction line.
5. Ensure that all ON/OFF switches given on the panel are at OFF position.
6. Set the required RPM of motor / pump with the speed control knob provided at the control panel.
7. Operate the flow control valve to regulate the flow of water discharged by the pump.
8. Operate the control valve to regulate the suction of the pump.
9. Record discharge pressure by means of pressure gauge, provided on discharge line.
10. Record suction pressure by means of vacuum gauge, provided at suction of the pump.
11. Note down the time required for 10 pulses of energy meter with the help of stop watch to calculate the power consumption y motor.
12. Measure the discharged by using measuring tank and stop watch.
13. Repeat the same procedure for different speed of pump.
14. Repeat the same procedure for different discharge with constant speed.

CLOSING PROCEDURE:

1.When experiment is over,open the gate valve properly,provided on the discharge line.
2. Reduce the RPM of the pump with the help of DC drive.
3. Switch OFF the pump first.
4. Switch OFF power supply to panel.

OBSERVATION & CALCULATION:

DATA:

EMC = 3200 Pulses/Kw hr

η = 0.7

d = 0.055

L = 0.04

A = 0.121 m^2

ρ = 1000 kg/m^3

r = 0.135 m

g = 9.81 m^2

h_{pg} = 1 m

OBSERVATION TABLE:

S.No	N, RPM	P_d, kg/cm^2	p^s, mmHg	R_1, cm	R_2, cm	t, sec	t_p, sec	F, kg

To plot head vs discharge & Pump efficiency vs Discharge

CALCULATIONS:

$E_i = \frac{P}{t_p} \times \frac{3600}{EMC}$, kW = ------------Kw

$E_s = \frac{2 \times \pi \times N \times \eta \times T}{60000}$, kW= ------------kW

T = F×g×r , Nm=--------------- Nm

$Q_t = \frac{2 \times a \times L \times N}{60}$, m^3/sec =--------------- m^3/sec

a = $\frac{\pi}{4}d^2$, m^2=-----------------m^2

R = $\frac{R_1 - R_2}{100}$, m =_ _ _ _ _ _ _ _ _ m

$Q_a = \frac{A \times R}{t}$, m^3/sec = _ _ _ _ _ _ _ _ _ _ _m^3/sec

H = 10 x $\left[P_d + \frac{P_s}{760}\right]$+ h_{pg} , m of water = _ _ _ _ _ _ _ _ _ m of water

$E_o = \frac{\rho \times g \times Q \times H}{1000}$, kW = _ _ _ _ _ _ _ _ _ kW

$\eta_o = \frac{E_o}{E_i}$x 100% = _ _ _ _ _ _ _ _ _ %

$\eta_p = \frac{E_o}{E_s}$x 100% = _ _ _ _ _ _ _ _ _ %

$\eta_v = \frac{Q_a}{Q_t}$x 100% = _ _ _ _ _ _ _ _ _ %

NOMENCLATURE

A = Area of measuring tank, m^2

a = Cross-sectional area of the cylinder, m^2

d = Diameter of the cylinder, m

E_i = Pump input, kW

E_s = Shaft output, kW

E_o = Pump output, kW

EMC = Energy meter constant, pulses/kW hr

F = Force in spring balance, kg

g = Acceleration due to gravity, m/s^2

H = Total head, m

$h_{\rho g}$ = Height of pressure gauge from vacuum gauge, m

L = Length of the stroke, m

N = Speed of pump, r.p.m.

P = Pulses of energy meter

P_d = Delivery pressure, kg/cm^2

P_s = Suction pressure, mmHg

Q_a = Actual Discharge, m^3/s

Q_t = Theoretical discharge, m^3/s

R = Rise of water level in measuring tank, m

R_1 = Final level of water in measuring tank, cm

R_2 = Initial level of water in measuring tank, m

r = Radius of swinging field arm, m

T = Torque, N m

t = Time taken by R, sec

t_p = Time taken by P, sec

ρ = Density of fluid, kg/m^3

η_o = Overall efficiency %

η_p = Pump efficiency %

η_v = Volumetric efficiency %

η = Efficiency of transmission %

PRECAUTIONS & MAINTENANCE INSTRUCTION

1. Never run the apparatus if power supply is less than 180 volts and above 230 volts
2. Never fully close the delivery valve and By-pass Valves at a time.
3. To prevent clogging of moving parts, Run Pump at least once in a fortnight
4. Always use clean water.
5. If apparatus is not in use for more than half month, drain the apparatus completely.
6. Always keep apparatus free from dust.

TROUBLESHOOTING

1. Reverse the electric connection of motor to change the revolutions.
2. If panel is not showing input, check the fuse and main supply.
3. If field failure (FF) indicates on the control panel and the motor is not moving, check the fuses, if burnt, change it.
4. If overload (OL) indicates on the panel and motor stop moving, reduce the load.

REFERENCES

1. R.S Khurmi, "Hydraulics, Fluid Mechanics And , Hydraulic Machines", 11th ed., S.Chand & Company LTD., ND, 2008, Page 602-604, 605, 606.

2. Dr. P.N. Modi, Dr S.M. Seth, "Hydraulics & Fluid Mechanics", 15th ed., Standard Book House, ND, 2005, Page 1020-1022.

SUBMERSIBLE PUMP TEST RIG

OBJECTIVE:

Study of submersible pump characteristics.

AIM: To determine:

- Pump input
- Shaft output
- Total head
- Discharge
- Pump Output
- Overall efficiency
- Pump efficiency

To plot the following performance characteristic:-

- Head vs. Discharge
- Pump efficiency vs. Discharge.

INTRODUCTION:

In general, a pump may be defined as a Mechanical Device which interposed in a Pipe Line, converts Mechanical Energy supplied to it from some external source into Hydraulic Energy thus resulting in the flow of liquid from a lower to a higher potential/head.

THEORY:

Submersible pumps are mainly used for lifting water from greater depths. These are of coupled type, consisting of pump and submersible motor, which is freely suspended in the bore-well with the help of discharge pipe. Only cable and discharge pipe. Only cable and discharge pipe comes out of the well.

Submersible pumps are also used for mine dewatering circulating water, surface water pumping etc. In order to ensure for longer life and optimum efficiency of the bore-well, it is recommended that the rated discharge of the pump should be taken as approximately 85% of the yield of the bore-well

DESCRIPTION:

The present submersible pump test rig is a self contained unit operated on closed circuit basis containing a sump tank. The set up consists of a Submersible Pump, which is mounted horizontally with a starter. Flow of fluid is measured by using measuring tank and stop watch.

UTILITIES REQUIRED:

1. Electricity Supply: Single Phase,220 VAC,50 Hz,5-15 amp socket with earth connection.
2. Water Supply.
3. Drain required.

4. Bench Area Required: 1.7m x 0.75m

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Clean the apparatus and make all tanks free from dust.
2. Close the drain valve.
3. Fill Sump tank ¾ with clean water and ensure that no foreign particles are there.
4. Open flow control valve given on the discharge line.
5. Ensure that all ON/OFF switches given on the panel are at OFF position.
6. Now switch ON the main power supply and switch ON the Pump.
7. Operate the flow control valve to regulate the flow of water discharged by the pump.
8. Record discharge pressure by means of pressure gauge,provided,on discharge line.
9. Note down the time required for 10 pulses for the calculation of power input.
10. Measure the discharge by using measuring tank and Stop Watch.
11. Repeat the same procedure for different pressure.

CLOSING PROCEDURE:

1. When experiment is over switch off pump first,
2. Switch off power to panel.

OBSERVATION AND CONCLUSION:

DATA:

A = $0.128\ m^2$

EMC = 3200 Pulses/kW hr

ρ = $1000\ kg/m^3$

η_m = 0.8

h_{pg} = 1 m

OBSERVTION TABLE:

S.No	P_d,kg/cm^2	R_1, cm	R_2, cm	t, sec	t_p, sec

CALCULATIONS:

$E_i = \frac{P}{t_P} \times \frac{3600}{EMC}$, kW = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ kW

$E_s = E_i \times \eta_m$ x , kW = _ _ _ _ _ _ _ _ _ _ _ _ _ _ kW

$R = \frac{R_1 - R_2}{100}$, m = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ m

$Q = \frac{A \times R}{t}$, m^3/sec = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _m^3/sec

$H = 10 \times [P_d] + h_{pg}$, m of water = _ _ _ _ _ _ _ _ _ _ m f water

$E_o = \frac{\rho \times g \times Q \times H}{1000}$, kW = _ _ _ _ _ _ _ _ _ _ _ _ _ _kW

$\eta_o = \frac{E_o}{E_i}$ x 100% = _ _ _ _ _ _ _ _ _ _ _ _ _%

$\eta_p = \frac{E_o}{E_s}$ x 100% = _ _ _ _ _ _ _ _ _ _ _ _ _ %

Nomenclature:

A	=	Area of measurement tank, m^2
EMC	=	Enegy meter constant, Pulse/kW hr
E_i	=	Power input, kW
E_o	=	Pump output,kW
E_s	=	Shaft output, kW
g	=	Acceleration due to gravity, m/s^2
H	=	Total head, m of water
h_{pg}	=	Height of pressure gauge from vacuum gauge, m
P	=	Number of pulses
P_d	=	Delivery pressure, kg/cm^2
Q	=	Discharge, m^3/sec
R	=	Rise of water level in measurement tank,m
R_1	=	Final level of water in measuring tank, cm
R_2	=	Initial level of water in measuring tank, cm
t_p	=	Time required for P pulse , sec
ρ	=	Density of water, kg/m^3
η_m	=	Efficiency of motor%
η_p	=	Pump efficiency%
η_o	=	Overall efficiency%

PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

1. Never run the apparatus if power supply is ess tan 180 volts
2. Always keep apparatus free of dust.
3. Use clean water.

TROUBLESHOOTING:

The major trouble which takes place with their probable reasons are listed below:

1. Water level is sup tank is not adequate.
2. Low speed of motor due to low voltage
3. Gate valve not fully open.

NO DISCHARGE:

1. Pump not properly submerged in water.
2. Strainer/Impeller chocked.
3. Coupling broken.

JAMMING OF PUMP:

1. Dry running of pump.
2. Bend in shaft.
3. Improper alignment.

EXCESSIVE VIBRATION:

1. Inadequate water level.
2. Bearings worn out.
3. Shaft bends.

REFERENCES:

G.K Sahu, “Pumps”,1st ed., New Age International (P) Ltd, ND,2007, Page 211-212.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181PE12	**Machine Tools**	**3-0-0**	**3**

Objective	To impart knowledge on machine and machining system, the drives & their kinematics and the need for automation			
Motivation	Manufacturing of engineering products by mechanical engineers need good knowledge on machine and its sub systems. Also, economy of production is a never-ending effort by engineers.			
Prerequisite	Engineering Mechanics, Graphics, Theory of machines, Workshop theory I & II			
Weekly Contact hours	Lecture = 03	Tutorial = 0	Practical = 0	Credit = 3
Mode of delivery	[1] Chalk & talk, [2] PPT, [3] Numerical problem solution			

Course Outcomes (COs): At the completion of the course the students will be able to:

1. Apply principles of mechanics of machining in determination of force, torque, power etc. in metal cutting
2. Apply the concept of kinematic principles in design of machine tool drive
3. Apply the basic principles in design of hydraulic and also electrical drive
4. Apply the concept of machine tools for semi-automatic or automated production
5. Apply the principles of machine tools in economics of production

MODULE 1:
Metal cutting fundamental principles. Forces acting on the cutting tools. Merchant's theory of metal cutting. Vibration and chatter during metal cutting processes. Tool wear, tool life in relation to speed and surface.

MODULE 2:
Design and constructional principles of machines tools. Basic features of construction and fundamental kinetics requirements of machine tools.
Kinematic drives of machine tools – selection of range of speeds and feeds; layout in G P. – Ray diagrams for machine tools, gear boxes sliding and clutches drives. Feed gear-box analysis.

MODULE 3:
Considerations affecting the design of machine tools (Lathe, Milling and drilling machines) with reference to their purpose, strength, rigidity and accuracy. Single purpose and general purpose machine tools – effect on design.

MODULE 4: Application of hydraulic drives – circuit diagram, pumps and valves. Effect on power consumption and surface finish.

MODULE 5: Electric equipment for machine tools. Characteristics demanded from the machine tools.

MODULE 6: Automation in machine tools – Capstan and Turret lathe and their operation lay out. Single spindle automatic screw cutting machine tools and their cam lay out. Swiss type automatics.

MODULE 7: Economics of automation, Elementary principle of numerical control of machine tools, Acceptance tests for machine tools.

Textbooks/ Reference Books:

1. Principles of machine tools, Vol I & II, by G C Sen and A Bhattacharyya.
2. Design of machine tools by S K Basu
3. Design of machine tools by S K Basu and D K Pal
4. Production Technology, Vol II, by Dr. O P Khanna

Theory:70, Sessional: 30 **ESE 70 marks, Time: 3 hours**			
DETAILS OF TOPICS COVERED	**Ref**	**Mode of delivery**	**HRS**
Unit–I: Metal cutting fundamental principles. Forces acting on the cutting tools. Merchant's theory of metal cutting. Vibration and chatter during metal cutting processes. Tool wear, tool life in relation to speed and surface.	1,2	1,2,3	6
Unit – II: Design and constructional principles of machines tools. Basic features of construction and fundamental kinetics requirements of machine tools. Kinematic drives of machine tools – selection of range of speeds and feeds; layout in G P. – Ray diagrams for machine tools, gear boxes sliding and clutches drives. Feed gear-box analysis.	2,3	1,2,3	6
Unit – III: Considerations affecting the design of machine tools (Lathe, Milling and drilling machines) with reference to their purpose, strength, rigidity and accuracy. Single purpose and general purpose machine tools – effect on design.	2,3	1,2	5
Unit – IV: Application of hydraulic drives – circuit diagram, pumps and valves. Its effect on power consumption and surface finish.	1,2,3	1,2	5
Unit V: Electric equipments for machine tools. Characteristics demanded from the machine tools.		1,2	4

Unit VI: Automation in machine tools – Capstan and Turret lathe and their operation lay out. Single spindle automatic screw cutting machine tools and their cam lay out. Swiss type automatics. Economics of automation. Elementary principle of numerical control of machine tools.	2,3,4	1,2	4
Unit VII: Acceptance tests for machine tools.	4	1,2	4

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181PE13	**Power Plant Technology**	**3-0-0**	**3**

Introduction to the Course

From study of course POWER PLANT TECHNOLOGY, students can learn about the various power plants with their functioning. This subject covers different aspects of various power plant's fuel sources, its processing, working methodologies, various parts of the plant and applications with various limitations. It thermally and diagrammatically explains various plants. This course also discusses about different types of instruments, pollution and some non-conventional power producing plants in details. This course is aimed to learn about different power generating principles and their future scope in countries economy and industrial growth. It also discusses about power plant economics and various aspects for computing plant performances. Finally, this course introduces into students mind about various options for future possibilities, modifications and alternatives for power generations.

Motivation

The fundamental knowledge gained from this course will increase the importance of learning advanced principles power generation processes and non-conventional power plants will impart further scopes of various other alternatives for energy sources. The topics of this subject are designed in such a way that students can demonstrate different thermal energy production technologies and use of them in commercial purposes globally. Understanding of various power plant pollutions will give confidence to solve more challenging socio-political issues. Upon completion of this course, the students can understand and apply their knowledge to the improvements for the existing various power producing installations.

Course Outcomes (COs): At the completion of the course the student will be able:

CO1: Identify the different components of power plants and understand local and global energy scenario.
CO2: Evaluate the performance of steam power plant and its different components.
CO3: Compare the working and performance of diesel and gas turbine power plant.
CO4: Differentiate the working and relative merits between different non-conventional power plants.
CO5: Analyse the economics of power generation in different power plant.

Pre-requisite of the Course:

Fluid mechanics-I, II Thermodynamics & Heat transfer- I, II

MODULE 1:

Introduction of local and global Energy Scenario, history of power plant technology, key terminologies, various components and basic concepts of power plant, Resources and development. Concepts of captive power plant and co-generation Types of power plants

MODULE 2:
Steam turbine, Site selection, General lay-out of thermal power plants, Energy losses in steam turbine, Steam Generator- High Pressure Boiler, Economiser, Superheater, Reheater, Regenerator, Air preheater, coal firing furnace, fluidised bed combustion, waste heat boiler

MODULE 3:
Diesel Electric power plant, Plant layout, Engine performance, Gas Turbine Power Plant, Site selection, layout, fuels, materials, combined cycle

MODULE 4: Hydro Electric Power Plant, Classification, Hydro turbine, Principles of Nuclear Energy, Nuclear power plant, Fast breeding reactors

MODULE 5: Non-Conventional Power Plants- Geothermal, Wind, Solar power plants and Direct Energy Conversion Systems, Economics of power generation

Textbooks/ Reference Books:

1. Power Plant Technology Author: M.M. El-Wakil Publisher: McGraw-Hill Education
2. Power Plant Engineering Author: Domkundwar, Arora, Domkundwar Publisher: Dhanpat Rai & Co
3. Thermal Engineering Author: R.K.Rajput Publisher : Laxmi Publication
4. Steam Turbine Theory and Practice Author: William J. Kearton Publisher: CBS Publication
5. Gas Turbines Author: V Ganeshan, Publisher: McGraw Hill Education

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181PE14	**Quality Engineering**	**3-0-0**	**3**

Course Outcomes (COs): At the completion of the course the student will be able:

1. Recall and explain the basic concepts of Quality, Evolution of Quality, Variations, Quality Characteristics, classification of Quality Characteristics, Internal and External Customers, Juran's Quality Trilogy, Cost of Quality
2. Explain Statistical Process Control, Statistical Aspects of Quality Control, Type I and Type II Error in Statistical Analysis, Shewart Control Charts for Variables and Attributes. Interpretation of the Charts
3. Develop Sampling plans: Single, double, multiple and Sequential Sampling Plans
4. Explain Sampling Schemes and Sampling Systems, application of Dodge and Romig Tables
5. Explain and apply the Concepts of TQM, the salient contributions of Quality Gurus like Deming, Juran and Crosby, Deming's Philosophy leading to TQM, philosophy of Continuous Improvement, Quantification of Quality, Quality Scales, Six Sigma Approach, Reliability

MODULE 1: Introduction **(8 Lectures)**

The history and Background of Quality Control, Need for Quality Control, Evolution of Quality Control and different Quality Management Philosophies (Overview), Quality Assurance - Phases of Quality Assurance. Quality Definition: Characteristics / dimensions of quality, Juran's Quality Trilogy Quality
Spiral, Causes of Variation change and Assignable Causes. Quality Costs: Reason for Quality Costs Analysis, Categories of Quality Costs (Cost of poor Quality), Concept of Optimum Quality Cost Model

MODULE 2: Statistical Concepts **(7 Lectures)**

Sample Parameters and Universe Parameters, Central Tendency and Dispersion and their measures, Data Representation Frequency Distribution Curves, Continuous and Discrete Distributions, Normal curve and its characteristics, Normal Table, Hypothesis Testing, Chi-square distribution. Inspection: Types of Inspection, Inspection Error, Inspection and Quality, Samples Inspections- Its Importance and Application Theory of Sampling: Population and Sample, Sample Statistics and Population Parameters, Rational Sub Grouping, Stewart Normal Bowl Experiment.

MODULE 3: Statistical Process Control **(10 Lectures)**

Statistical Aspects of Quality Control, Type I and Type II Error in Statistical Analysis, Shewart Control Charts-Variable and Attribute Charts (X, R-charts, b-chart, c-chart, up-chart) Control Charts for Variables: X Bar and R Charts, X Bar and Sigma Charts construction of the charts. Interpretation of the Charts. Manufacturing and Non-Manufacturing Application of the Charts. Control Charts for Attributes:
p Chart, 100p Chart, n-p Chart, c Chart, U chart Interpretation of the Charts, Application

MODULE 4: Acceptance Sampling Plans for Attributes **(10 Lectures)**

Introduction, Importance, Situation leading to Economic Use Sampling Plans, Concept of AQL and relevant terms, OC Curves-Type A and Type B OC Curves, Different types of Sampling Plans, ASN

Curve, ATI Curve. Sampling Schemes-MIL STD105D-Rules for Switching, Dodge and Romig Tables: Acceptance Sampling Plans for Variables: Introduction, Sampling Plans for Sigma Known and Sigma Unknown, Application.

MODULE 5: Concept of Total Quality Management (7 Lectures)

Introduction, Tools and Techniques of TQM, Brief Introduction Reliability: Distinction between Reliability and Quality, Relevant Terms, The Characteristics Curve (Bath-Tub Curve), Failure-Types, Causes of Failure, Reliability Function in terms of Failure Rate and its characteristics, Reliability improvement- Series and parallel Systems

Textbooks/ Reference Books:

1. Principles of Quality Control: Jerry Banks: Publisher: John Wiley & Sons
2. Introduction to Statistical Quality Control: Douglas Montgomery: Publisher: John Wiley & Sons
3. Statistical Quality Control: Eugene Grant and Richard Leavenworth: Publisher: Mc Graw Hill
4. Total Quality Management: Dale H., Besterfield, Glen H. Besterfield, Mary Besterfield-sacre: Publisher: Pearson

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181PE15	**Refrigeration**	**3-0-0**	**3**

Course Outcomes (COs): At the completion of the course the student will be able:

1. Students will be able to *describe* refrigeration process and *illustrate* different related thermodynamic cycles.
2. Students will be able to *list* different applications of refrigeration and *analyse* the respective processes.
3. Students will be able to *categorise* and *compare* different types refrigerants used for various applications.
4. Students will be able to *explain* various refrigeration equipment used in VCRS and VARS.
5. Students will be able to *explain* and *analyse* practical refrigeration systems namely Vapour compression (VCRS) and Vapour absorption refrigeration cycles (VARS) and other nonconventional refrigeration systems.

MODULE 1: Refrigeration
Introduction, history, methods of refrigeration, Ice, Evaporation expansion of air, throttling of gas, vapour compression and absorption, steam jet, liquid gas, dry ice, units of refr. Difference between engine, refrigerator and heat pump.

MODULE 2: Gas Cycle Refrigeration
Simple cycles – Carnot and Bell-Coleman; Regenerative & reduced ambient system; Air-craft refrigerating system - simple boot-strap, reduced ambient; Actual cycles, ramming; Advantages and disadvantages of DART.

MODULE 3: Vapour Compression Systems
Analysis of simple cycles, representation of TS, pH plans; methods of improving COP; Deviations of actual cycles from theoretical cycles. Compound compression with liquid flash cooler, flash inter-cooler multiple systems – COP, power required, Ewing diagram.

MODULE 4: Vapor Absorber Ref. System
Thermodynamical analysis of systems, Advantages and disadvantages, Components, Practical systems NHe Watt. Water LiBr, Electrolux systems, Calculations based on concentration; Properties of binary mixtures.

MODULE 5: Non – Conventional Ref. System
Steam jet ref. Thermoelectric, Vortex tube refr. – merits and demerits and applications.

MODULE 6: Refrigerants
Nomenclature, classification, desirable properties. Important refrigerants and their comparisons, selection of refrigerants.

MODULE 7: Ref. Equipment
Brief introduction to compressors, condensers, expansion devices, evaporators; Piping, line valves, solenoid valves, oil separators, driers, filters, moisture indicators, purging and controls.

MODULE 8: Application of Refrigeration
Production of dry ice, cascading, multi-staging domestic, commercial, industrial and medical, preservator of food-spoilage, methods of preservation, cold storage, preparing of insulating materials using in ref. Systems.

Textbooks/ Reference Books:

1. Refrigeration and Air-Conditioning by Ahmedul Ameen, PHI
2. Refrigeration and Air-Conditioning by C.P.Arora, Tata McGraw Hill Publication.
3. Refrigeration and Air-Conditioning by M.Prasad

Pre-requisites of the course

Thermodynamics, Fluid mechanics

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I - Refrigeration	4	1. Lecture using board and chalk. 2. Discussion/ Interaction. 3. Demonstration using presentations.
Unit II - Gas cycle refrigeration	6	
Unit III - Vapour Compression Systems	4	
Unit IV - Vapor Absorber Ref. System	4	
Unit V - Non – Conventional Ref. System	4	
Unit VI - Refrigerants	4	
Unit VII - Ref. Equipment	6	
Unit VIII - Application of Refrigeration	3	
Total	35	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181PE16	Rotordynamics	3-0-0	3

Course Outcomes (COs): At the completion of the course the student will be able:

1. Predict rotor system dynamic characteristics for design of any type of machinery.
2. Develop knowledge of problems relating to rotating machineries during operation such as unbalances, misalignment, gyroscopic effect
3. Analyze torsional vibration of rotor for high power transmission and high speed application
4. Identify rotor bearing system parameters and apply in futuristic model based condition monitoring
5. Develop knowledge about recent development in active magnetic bearing.

MODULE 1: Simple Rotor System (6 Lectures)
Basic transverse vibration of Single DOF rotor model, Jeffcott Rotor with central and offset disc, calculation of natural frequencies

MODULE 2: Transverse Vibration of Simple Rotor Bearing Foundation System (4 Lectures)
Symmetrical rigid and flexible shaft on Anisotropic bearing, unbalance forces, bearing forces

MODULE 3: Gyroscopic Effect in Rotor System (6 Lectures)
Effect of spinning disk, synchronous whirl of an overhang rotor, asynchronous rotational motion

MODULE 4: Tranverse Vibration of Multi Dof Rotors (3 Lectures)
Influence co-efficient method for static and dynamic case

MODULE 5: Torsional Vibration of Rotors (8 Lectures)
Direct and transverse matrix method, TMM for geared and branched system.

MODULE 6: Balancing of Rotors (4 Lectures)
Rigid rotors balancing single and two plane balancing, flexible rotor balancing

MODULE 7: Active Magnetic Bearings in Rotors (6 Lectures)
Basics of active magnetic bearing, block diagram and transfer functions, tuning of the controller parameters

MODULE 8: Signal Processing in Rotating Machineries and Condition Monitoring (3 Lectures)

Textbooks/ Reference Books:

1. J. S. Rao, Rotor Dynamics, Third Ed., New Age, New Delhi.
2. M. J. Goodwin, Dynamics of Rotor Bearing System, Unwin Hyman, Sydney.
3. Rajiv Tewari, Rotor Systems, Analysis and Identification, CRC Press.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181OE11	**Operation Research**	**3-0-0**	**3**

Objective	To impart knowledge on optimization with limited skill and research and to show how cost reduction & profit maximization are possible in real life problems			
Motivation	A subject of creative solutions for engineering & business problems. Plays significant role for developing alternate economic and effective solution to problems			
Prerequisite	Higher secondary Maths., Basic Engineering Maths			
Weekly Contact hours	Lecture = 03	Tutorial = 0	Practical = 0	Credit = 3
Mode of delivery	[1] Chalk & talk, [2] Numerical problem solution			

Course Outcomes (COs): At the completion of the course the student will be able:

1. To analyze techno-managerial problems for effective use of resources in professional life.
2. To analyze & solve engineering and managerial problems by classical methods and interpret results.
3. To identify technical and managerial situations needing effective, economic and efficient methods for problem solution.
4. To formulate mathematical models for optimization of engineering & business problems for quantitative analysis, solution and interpretation of results.
5. To formulate and solve problems by simulation technique in engineering problems to verify and validate the model

MODULE 1:
Introduction to OR, Engineering applications, Statements of an OR problems, Types of problems handled in OR

MODULE 2:

a) Linear programming (deterministic)- Problem formulation, Feasibility and optimality, Basic and Non-basic solutions.
b) Graphical methods of solving LPP, Simplex Algorithm and problem solution, use of slack, surplus and Artificial variables and their meanings.
c) Big-M method and 2-phase method.
d) Dual Simplex algorithm.
e) Meaning and examples of unique, Alternate/Multiple, unbounded and Infeasible solutions.
f) Degeneracy and cycling

MODULE 3:

Special Linear Programming Problems – their formulations and solutions in such cases as Integer Programming Problems (IPP), Transportation problem (TP) and Assignment Problem (AP). Discussion on method extended to Travelling Salesman Problem (TSP)

MODULE 4:
Classical Optimization – Introduction, single and Multi-variate problems, Lagrangean method, KarushKuhn Tuker (KKT) conditions.

MODULE 5:
Inventory modelling – Classification of inventory, Deterministic versus Stochastic problems situations, Formulation and solution of Deterministic inventory problems.

MODULE 6:
Simulation – Meaning, Monte-Carlo simulation, generation of random observations, use of digital computers in simulation, Discussion on Simulation examples such as inventory, queuing etc.

Textbooks/ Reference Books:

1. Operations Research –H A Taha
2. Operations Research –Gupta and Hira
3. Operations Research –Billy E Gillet
4. Operations Research –Panneerselvam
5. Optimization – S S Rao
6. Operations Research – N G Nair
7. System Simulation by digital computers – N Deo

Theory:70, Sessional (CE): 30 **ESE 70 marks, Time: 3 hours**			
DETAILS OF TOPICS COVERED	**Ref**	**Mode of delivery**	**HRS**
Unit 1: Introduction History of Operations Research Engineering applications General Statement of an OR problem	2,3,4	1,2	1
Unit 2: Linear Programming (a) Deterministic Linear programming Problems (LPP): Problem formulation, Feasibility and Optimality, Basic and Non-Basic solutions (b) Solution of LPP by (i) Graphical method: (1) Corner point method (2) Iso-profit (cost) method (ii) Simplex Algorithm: Use of Slack, Surplus and Artificial variables and their meanings, Condition for starting solution	2,4,6	1,2	10

and limitation of simplex method, Meaning and significance of Big-M (Charnes method of penalty) and 2-phase method (iii) Meaning and examples of Unique, Alternate/Multiple, Unbounded and Infeasible solutions, Degeneracy and Cycling			
Unit 3: Special LPPs Integer Programming Problem (IPP) and solution by Simplex and Dual Simplex algorithms Transportation Problem (TP): Solution steps as (i) Initial Basic Feasible Solution (IBFS), (ii) Check for degeracy and (iii) Moving towards optimality Assignment Problem (AP) and Degeracy. Discussion on method extended to Travelling Salesman Problem (TSP).	2,4,6	1,2	10
Unit 4: Analytical methods for Classical Optimisation Formulation of Single and Multi-variate problems with and without constraints Necessary and sufficient conditions for solving unconstrained problems; Lagrangean method Karush-Kuhn-Tucker (KKT) conditions and limitations	2,5	1,2	8
Unit 5: Inventory modeling and simulation: Classification of inventory, Distinction between Deterministic and Stochastic inventory problems, Costs involved in inventory system, Formulation and Solution of simple and basic deterministic inventory problems. Introduction and meaning of simulation, Monte Carlo simulation and random numbers, Example of simulation applied to inventory problems, Use of digital computer for simulation.	1,2,3,6,7	1,2	8

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181OE12	**Renewable Energy Sources**	**3-0-0**	**3**

Course Outcomes (COs): At the completion of the course the student will be able:

1. Identify energy demand and relate with available energy resources and also explain the Nonconventional energy sources & systems
2. Analyze harnessing of solar energy
3. Analyze harnessing of wind energy
4. Analyze harnessing of Biomass energy
5. Analyze harnessing of Geothermal and Ocean energies
6. Analyze Magneto hydrodynamics and Fuel cell technology

MODULE 1:
Different forms of non-conventional energy sources: Solar, Bio-gas, wind, tidal, geothermal etc.

MODULE 2: Basic Bio-Conversion Mechanism
Source of waste, simple digesters; composition and calorific value of biogas, Bio-mass as a source of energy, energy plantation, production of fuel from wood, agricultural and municipal solid and animal wastes, sludge and waste water, bio-gas generation and utilization

MODULE 3: Solar Option
Energy from sun – availability of solar radiation, technique of collection, storage and utilization; Types of solar collectors; selective surfaces; solar thermal processes – heating, cooling, drying, power generation etc. Thermoelectric conversion and thermal storage. Introduction to photoelectric conversion

MODULE 4: Wind and Tidal Energy Generation
Special characteristics, turbine parameters, optimum operation, electric power generation from wind/tidal energy; Types of wind mills, Elementary design principles, Principle of ocean thermal energy conversion; Power plant based on OTEC

MODULE 5: Geothermal Energy
System. Extent of available resources. Heat transport in geothermal systems. Hot springs and steam injections

MODULE 6: The Nuclear Options
Fission, fusion technology fundamentals. Thermal and fast reactors. State of art Breeder reactors, prospect and limitations, economics. Fusion energy – controlled fusion of H_2, He etc. Energy release rate, future possibilities

MODULE 7: Direct Conversion Methods
Thermo-ions, MHD, electrochemical devices, fuel cells etc. Intrigated energy packages using solar, biomass, wind etc.

MODULE 8: Comparative study of non-conventional energy source, cost consideration and economic

Textbooks/ Reference Books:

1. Waste water Engineering - by MetCaff, Eddy – McGrow Hills
2. Solar Energy - by SP Sukhatme – TMG
3. Solar Energy Utilization - Duffie & Beckman – Wiley Int. Ltd.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181OE13	**Solid Waste Management**	**3-0-0**	**3**

Course Outcomes (COs): At the completion of the course the student will be able:

CO1: Explain the principles of Solid Waste Management
CO2: Apply modern techniques at different stages of waste processing
CO3: Design solid waste management system for any area
CO4: Understand the environmental problems relating to solid waste management
CO5: Cater to the needs of the society for implementing scientific waste management

MODULE 1: Introduction to Solid Waste Management
Introduction to Solid Waste, 4-R Principle in waste minimization, Concept of Zero Waste, Types and Sources of Solid Waste, Characteristics & Quantification technique of Solid Waste, Legislation & Regulations

MODULE 2: Collection Systems of Solid Waste
Refuse collection: Primary collection system, secondary collection system, transfer to disposal site, Commercial wastes, Transfer stations

MODULE 3: Processing of Municipal Solid Waste
Storing, Conveying, Compacting, Shredding, Material separation, Trommel screens, magnets & electromechanical separators

MODULE 4: Biochemical Processes
Fundamentals of Composting, Different techniques of Composting, anaerobic digestion, Bio-gas production

MODULE 5: Combustion and Energy Recovery
Incineration, Waste to energy combustors, Pyrolysis, Plasma Gasification, Undesirable effects of combustion

MODULE 6: Current Issues in Solid Waste Management
Life cycle analysis & management, social stigma associated with waste management, public or private ownership, financing solid waste facilities, role of solid waste engineer

Textbooks/ Reference Books:

1. P. Aarne Vesilind, William Worrell, Reinhart, Solid Waste Engineering, Thomson Publishing House
2. Prasad Modak, Waste Minimization- A Practical Guide to Cleaner Production & Enhanced Profitability, Centre for Environment Education, Ahmedabad

Course Code	Course Title	Hours per week L-T-P	Credit C
HS181704	**Principles of Management**	**3-0-0**	**3**

MODULE 1: Introduction **(6 Lecture)**

Definition and meaning of management, Characteristics of management, importance of management, functions of management-planning, organising, directing, staffing, coordination and controlling etc., principles of management, Difference between administration and management

MODULE 2: Financial Management **(6 Lecture)**

Definition and management of financial planning, importance and characteristics of sound financial plan, concepts of capital- fixed capital and working capital, source of finance, fund flow statement

MODULE 3: Marginal costing **(6 Lecture)**

Definition and meaning of marginal costing, advantages, marginal cost equation, contribution, profitvolume ratio, break even analysis, margin of safety

MODULE 4: Cost Accounting **(6 Lecture)**

Cost Accounting- Concept and benefit, elements of cost, preparation of cost sheet with adjustment of raw materials, work-in-progress and finished goods

MODULE 5: Capitalisation **(4 Lecture)**

Definition and meaning of capitalisation, over and under capitalisation

MODULE 6: Motivation **(6 Lecture)**

Introductory observation, definition of motivation, motivational technique, features of sound motivational system

MODULE 7: Leadership **(6 Lecture)**

Concept of leadership, principles of leadership, functions of leadership, qualities of leadership, different styles of leadership

Textbooks/Reference Books:

1. Principle of Business Management: RK Sharma, Shashi K.Gupta
2. Business Organisation and Management: SS Sarkar, RK Sharma, Shashi K.Gupta
3. Industrial Organisation and Management: SK Basu, KC Sahu, B Rajviv
4. Principles of Management by Dr. A. K. Bora: Chandra Prakash, Guwahati.
5. Management Accounting: RK Sharma, Shashi K Gupta
6. Cost Accounting: SP Jain, K I Narang
7. Cost Accounting, RSN Pillai, V Bhagawati
8. Principles of Management: RN Gupta
9. Principles of Management: RSN Pillai, S. Kala
10. Principles of Management: Dipak Kumar Bhattacharjee

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181722	**Project-1**	**0-0-8**	**4**

Evaluation Plan for 7th Semester B. Tech Project
Marks: CE=50, ESE=50

CO 1: Choose mechanical and allied problems having engineering and present day importance
CO 2: Analyze mechanical and allied engineering problems for meaningful data extraction, presentation and interpretation
CO 3: Show skill for project management and effective solutions for mechanical and allied engineering problems
CO 4: Evaluate solutions in the context of practical utility, sustainability and environment impact
CO 5: Develop leadership skill and personality for team work

Out of 5 COs, four COs (CO1, CO2, CO4 and CO5) will be attained in two progress seminars as CA component [Total=50 marks] and CO3 will be attained in ESE [50] marks.

Progress Seminar-I

COs	Components	Marks
CO-1	Novelty of Idea (Title)	5
CO-2	Literature Survey	5
	Objectives & Methodology	5
	Progress of work	5
	Total marks	20

Progress Seminar-II

COs	Components	Marks
CO-4	Results and Discussion	15
	Conclusions and Future Scope	5
CO-5	Communication skill	5
	Leadership/Personality	5
	Total marks	30

ESE (Viva Voce + Supervisor)

COs		Components	Marks
CO-3	Supervisor	Knowledge and Contribution	15
		Participation/Discipline	5
	Viva Voce (External + Internal)	Thesis	10
		Engineering Knowledge	20

		Total marks	50

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181723	**Grand Viva-voce - I**	**0-0-0**	**1**

COURSE OUTCOMES

A successful student in the grand viva will be able to demonstrate knowledge in the following domains:

CO1: Applied Mechanics

CO2: Thermal & Fluid Engineering

CO3: Design Engineering

CO4: Manufacturing & Management

EVALUATION PLAN

The students would appear before a board of examiners during the end of the semester. The schedule of examination will be notified to the students at least 7 days prior to the examination.

Course Code	Course Title	Hours per week L-T-P	Credit C
SI181721	**Internship-III (SAI - Industry)**	**0-0-0**	**2**
GUIDELINES WILL BE ISSUED BY THE UNIVERSITY (ASTU) FROM TIME TO TIME			

COURSE OUTCOMES

- CO 1 Demonstrate the ability to apply engineering knowledge in practical industrial situation
- CO 2 Identify and analyze engineering problems for giving meaningful solution.
- CO 3 Synthesize engineering knowledge coupled with practical ideas for improved decision making.
- CO 4 Demonstrate capability to work effectively individually or in teams for tech report writing/presentation
- CO 5 Specify technical and behavioural standards needed for industries.

EVALUATION PLAN

After the completion of internship/training, the students have to give presentations on their work and submit a report. Guidelines for report preparation will be provided by the department from time to time. A panel of internal examiners assess their learning outcomes using the respective rubrics given below based on the report, presentation and viva-voce examination. The reports consist of the practical knowledge the students gained though the internships.

Rubrics & assessment sheet

Roll No	CO1 General technical knowledge after industry visit (10)	CO2 Capability for Problem ID & Analysis (10)	CO3 Problem solving capability (Tech & Managerial) (5)	CO4		CO5 Tech/Behavioural standard used (5)
				Report Quality as per format (10)	Presentation/ Communication skill (10)	

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3.8 EIGHTH SEMESTER

B.Tech 8th Semester: Mechanical Engineering

Sl. No.	Sub-Code	Subject	Hours per Week			Credit	Marks	
			L	T	P	C	CE	ESE
Theory								
1	ME181801	Manufacturing Methods	3	0	0	3	30	70
2	ME1818PE2 *	Program Elective - 2	3	0	0	3	30	70
3	ME1818PE3 *	Program Elective - 3	3	0	0	3	30	70
4	ME1818OE2 *	Open Elective - 2	3	0	0	3	30	70
Practical								
1	ME181822	Project -2	0	0	12	6	100	50
2	ME181823	Grand Viva Voce-II	0	0	0	1	-	50
TOTAL			**12**	**0**	**12**	**19**	**220**	**380**
Total Contact Hours per week: 24								
Total Credits: 19								

Program Elective-2 Subjects		
Sl. No.	**Subject Code**	**Subject**
1	ME1818PE21	Air Conditioning
2	ME1818PE22	Mechatronics
3	ME1818PE23	Robotics and Applications
4	ME1818PE24	Compressors and Gas Turbines
5	ME1818PE25	Computational Fluid Dynamics

6	ME1818PE2*	Any other subject offered from time to time with the approval of the University

Program Elective-3 Subjects		
Sl. No.	**Subject Code**	**Subject**
1	ME1818PE31	Computer Integrated Manufacturing
2	ME1818PE32	Operations Management
3	ME1818PE33	Internal Combustion Engines
4	ME1818PE34	Composite Materials
5	ME1818PE35	Tribology
6	ME1818PE3*	Any other subject offered from time to time with the approval of the University

Open Elective-2 Subjects		
Sl. No.	**Subject Code**	**Subject**
1	ME1818OE21	Noise and Vibration Control
2	ME1818OE22	Industrial Safety Engineering
3	ME1818OE23	Engineering Economic Analysis
4	ME1818OE24	Automotive Mechanics
5	ME1818OE25	Machining and machine tools
6	ME1818OE2*	Any other subject offered from time to time with the approval of the University

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181801	**Manufacturing Methods**	**3-0-0**	**3**

Course Outcomes (COs): At the completion of the course the student will be able to:

CO1: Determine mould filling time, total solidification time and design riser for vertical and bottom gating sand moulds.
CO2: Determine the maximum draft possible in a single pass rolling, number of stages (passes) required and rolling torque and power for given roll diameter, reduction required and coefficient of friction in cold working operation.
CO3: Determine the forging force required in a forging operation for a given material (defined by a flow curve) and reduction.
CO4: Determine the ram pressure (force) using Johnson equation in an extrusion process for a given reduction and given material (defined by a flow curve).
CO5: Determine the drawing force in a wire drawing operation for a given reduction and material (defined by a flow curve).
CO6: Design blanking and piercing die and punch for a given sheet metal.
CO7: Determine blank size, number of draws, die and punch size for a given sheet metal in a drawing operation.

MODULE 1: Melting of metals, gases in metals
Different furnaces used in melting. Gating system, Design for sand Casting –Vertical and bottom gating moulds, total solidification time, riser design, aspiration effect. Solidification behaviour of pure metals and alloy metals, Centerline shrinkage. Special casting methods – Permanent mould casting – Pressure Die casting – Hot chamber, Cold chamber and Air blown methods – Low-pressure die casting, Continuous casting. Non-metallic mould casting – Centrifugal casting, Investment casting. Casting defects, their causes and remedies, Fettling of casting and Inspection.

MODULE 2: Behaviour of metal in metal in forming
Flow curve and average flow stress, Hot, Cold and Warm working – Variables affecting mechanical working process. Rolling – Principle – Condition for continuous rolling and maximum draft possible, Forces and power in rolling – Methods for reduction of roll separating force – Rolling mills – Roll pass design – Thread rolling, ring rolling, gear rolling and Roll Piercing – rolling defects.
Forging – Forge ability – Metallurgy of Forging – Open die forging operations, analysis of open die forging, forging force, forging hammers and presses, closed die forging – Drop forging, Press forging, machine forging – Forging die design factors – Forging Defects. Extrusion – Classification – Analysis of extrusion process, determination ram pressure – Variation of ram pressure with ram travel – Principle of operations of Hydrostatic extrusion, side extrusion, impact and Hooker’s extrusion – Defects in extrusion. Wire, Rod and Tube drawing – Principle and Operation – drawing equipment, drawing die – preliminary operations – tube drawing methods – Analysis of drawing, drawing force, maximum reduction per pass.

MODULE 3: High Energy Rate Forming
Reasons that prompted transition to HERF – Classification – Principles and operations of Explosive Forming, Electro-hydraulic Forming, and Electromagnetic Forming – High Velocity Forming, Principles and Operations of Petro-forging, Dynapak.

MODULE 4: Press working and sheet metal operations

Classification, forming limit diagram – Different types of Press and Selection of Presses – Pattern layout and allowances – Various cutting and forming operations – Principles and Operations of Cutting/Shearing, design for blanking and piercing operations – Methods of reduction of cutting forces. Deep drawing operations – Design for deep drawing – Methods for redrawing – Defects in sheet metal formed parts.

MODULE 5: Surface Finishing Operations
Classification – Principle and Operations of Lapping, Honing, Super finishing, Polishing, Buffing, Tumbling and Burnishing.

MODULE 6: Manufacture of threads and gears
Threads manufacturing – Different methods – Casting, Thread Chasing, Thread Rolling, Die and Tapping, Milling and grinding.
Gear manufacturing - Different Methods – Casting, Forming and Metal removal. Gear Cutting and Gear Generation Processes. Gear Finishing Operations.

MODULE 7: Powder Metallurgy
Advantages and applications of P/M – Powder Characteristics – Powder production methods – Mixing and Blending, Briquetting techniques – Sintering and presintering – Secondary Processes, Infiltration and Impregnation – Production of Cemented carbides.

Textbooks/ Reference Books:

1. Elements of Workshop Technology (Vol. I & II) – S.K. Hajra Choudhury and A.K. Hajra Choudhury.
2. Manufacturing Science–Amitabha Ghosh and Ashok Kumar Mallick, East West Press
3. Production Engineering – P.C. Sharma, S. Chand & Company Ltd.
4. Metal Forming Technology – Dr. R. Narayanasamy, Ahuja Book Co. Pvt. Ltd
5. Mechanical Metallurgy – G.E. Dieter, McGraw Hill

Time-Plan

Unit/Topics	Lectures
Unit–I: Melting and Casting of metals	5
Unit–II: Mechanical working of metals	10
Unit–III: High Energy Rate Forming	2
Unit–IV: Press Working	5
Unit–V: Surface Finishing Operations	2
Unit–VI: Manufacturing of threads and gears	3
Unit–VII: Powder Metallurgy	4
Total	31

Pedagogy: Students should visualize the manufacturing Methods aspects and gain expertise in material selection, manufacturing processes and industrial applications.

Expected outcome: At the completion of the course the student will be able to:

1. Know the general and advanced manufacturing processes, their selection and applicability of the processes.
2. Know the limitations and advantages of the manufacturing techniques.

3. Identify the criteria for selection of manufacturing processes for production of structural parts and components.
4. Correlate material properties and design considerations with the corresponding manufacturing techniques.

TOPICS BEYOND THE SYLLABUS:

Black pipe manufacturing and galvanisation

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818PE21	Air Conditioning	3-0-0	3

Course Outcomes (COs):

CO1: Given any three psychrometric properties of air students will be able to calculate all other psychrometric properties using equations and/or psychrometric chart.
CO2: Students will able to define human thermal comfort, its indices and comfort charts and also able to demonstrate the relationship between thermal comfort and human health based on thermodynamics of human body.
CO3: Students will be able to illustrate different psychrometric processes on the psychrometric charts. Students will be able to calculate the psychrometric properties of air after undergoing a psychrometric process or a combination of more than one psychrometric process.
CO4: Students will be able to design an air conditioning system for a room for given indoor and outdoor design conditions.
CO5: Students will be able to design a duct system using any one of the different duct design methods namely equal friction method, velocity reduction and static regain method.

MODULE 1: Psychrometry
Psychrometric properties, representations of properties in charts, preparation of charts

MODULE 2: Psychrometric processes
Constant sensible heat and latent heat processes, adiabatic saturation and enthalpy deviation. Adiabatic mixing of air stream. Humidification, Dehumidification water spray processes, sensible heat factors, grand sensible heat ratio lines, apparatus dew points, Bypass factors, Air washer-humidifying efficiency

MODULE 3: Comfort A/C
Air temperature, human health, body temperature regulation, comfort indices, comfort charts and their limitations

MODULE 4: Load analysis
Inside and outside design conditions, load classification, summer cooling loads, solar heat gain and transmission and radiation. Flywheel effect of building materials, equipment temperature differential loads due to human beings, load due to electric light, equipment and appliances. Infiltrator and ventilator loads, product loads, miscellaneous loads such as duct heat gain, duct air leakage, fans, pumps etc. Winter heat load – computation of loads

MODULE 5: Duct design and Air distribution
Different methods of duct design such as velocity reduction, equal friction and static regain, aspect ratio duct losses, distribution of air in rooms, nature and supply grill; duct arrangement and air handling system

MODULE 6: A/C System
Unitary control system, special features of residential, commercial and industrial A/C system, Year-round a/c zoning

MODULE 7: Equipment

(1) Fans – types of fans, characteristics, curves, fan selection. (2) Air filter and cleaner. (3) Cooling towers, evaporators, condensers (4) Cooling coils and water capacity, (5) Chemical dehumidifiers, (6) Heaters, radiators, Convection coils

MODULE 8: Instruments and controls
Temperature, humidity, air velocity measuring instruments, Thermostat, humidistat. By pass and damper control. Dew point control, noise control, Pneumatic control

Textbooks/ Reference Books

1. Refrigeration and Air-Conditioning by Ahmedul Ameen, PHI
2. Refrigeration and Air-Conditioning by C.P. Arora, Tata McGraw Hill Publication.
3. Refrigeration and Air-Conditioning by M. Prasad

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I - Psychrometry	4	1. Lecture using board and chalk. 2. Discussion/ Interaction. 3. Demonstration using presentations.
Unit II - Psychrometric processes	6	
Unit III - Comfort A/C	4	
Unit IV - Load analysis	4	
Unit V - Duct design and Air distribution	4	
Unit VI - A/C System	4	
Unit VII - Equipment	6	
Unit VIII - Instruments and controls	3	
Total	35	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818PE22	**Mechatronics**	**3-0-0**	**3**

Course Outcomes (COs):

After successful completion of this course, student will be able to:

CO1: Critically evaluate components of integrated systems

CO2: Design complete systems by justifying the use of sensors, actuators, control circuits

CO3: Code logics into PLC and develop closed loop control processes.

CO4: Utilize Computer Numerical Control to automate manufacturing processes.

CO5: Learn about Robot hardware and functioning

MODULE 1: Basic concepts
Definition of Mechatronics, Mechatronics in manufacturing, products and design.

MODULE 2: Review of fundamentals of electronics
Data conversion devices, sensors, transducers, signal processing devices, relays, microprocessors, and PLCs.

MODULE 3: Drives
Stepper motors, servo drives, ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.

MODULE 4: Hydraulic systems
Flow, pressure and direction control valves, actuators, hydraulic pumps, design of hydraulic circuits.

MODULE 5: Pneumatics
Production, distribution and conditioning of compressed air, system components and graphic representations, design of systems.

MODULE 6: Controllers
Description of proportional, integral and derivative (PID) controllers.

MODULE 7: CNC machines and part programming

MODULE 8: Industrial Robotics

Textbooks/ Reference Books:

1. Mechatronics-Electronic Control Systems in Mechanical and Electrical Engineering, W. Bolton, Pearson Education Ltd, 2006.
2. Mechatronics-Principles and Applications, Godfrey and Onwubolu, Butterworth-Heinemann, 2006.

3. Computer Automation in Manufacturing - an Introduction, T. O. Boucher, Chapman and Hall, 1996

Course Time Plan

Sl No	Unit	L-T-P	Hours	Method of Deliver
1	Basic concepts	2-0-1	3	Both Chalk and Talk with presentation
2	Review of fundamentals of electronics	10-0-2	12	
3	Drives	3-0-1	4	
4	Hydraulic systems	3-0-1	4	
5	Pneumatics	3-0-1	4	
6	Controllers	1-2-0	4	
7	CNC machines and part programming	1-0-3	4	
8	Industrial Robotics	3-1-0	4	
	Total		39	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818PE23	**Robotics and Applications**	**3-0-0**	**3**

Course Outcomes (COs):

After completion of the course the student will be able to:

CO1: Relate basic concepts of robotics for robot classification, anatomy, coordinate systems, degrees of freedom, work envelope, and robot specification to understand its operation.
CO2: Apply the knowledge of drive systems, actuators, sensors, and control methods to understand the design and working of robots.
CO3: Model forward and inverse kinematics of robot manipulators and analyze forces in links and joints of a robot.
CO4: Develop the knowledge of robot vision for image processing, analysis and object recognition.
CO5: Develop robot programming to perform tasks in industrial applications and extend the knowledge of artificial intelligence (AI) in robotics.

MODULE 1: Overview of Robotics
Definition and classification of robot manipulators, coordinate frames, robot configuration, motion and degrees of freedom, work envelope, uses, field of applications, robot specifications.

MODULE 2: Structure and Control of Robotic System
Robot anatomy, mechanical design of robot end-effectors (grippers), gripper mechanism and fingers, robot drive systems, electric drives and servo control in robotics, hydraulic and pneumatic actuators.

MODULE 3: Robot Arm Kinematics
Introduction to direct and inverse kinematics, geometric representation of rotation matrices, Euler angle representation, links and joints parameters, homogeneous transformation and D-H representation, arm matrix and kinematic equation for robot manipulator.

MODULE 4: Robot Arm Dynamics
Jacobian and force vectors, joint velocities, kinetic energy and potential energy of a robot manipulator, Lagrange-Euler formulation for motion, dynamic equation of a robot manipulator, planning of manipulator trajectory.

MODULE 5: Introduction to Sensors and Robot Vision
Classification of sensors and their functions, overview of computer vision and robotic applications of vision, elements of a vision system, lighting techniques and devices, image processing and analysis, object recognition.

MODULE 6: Robot Programming
Introduction to robot programming, application of robot programming for simple functions, introduction to artificial intelligence in robotics, mobile robotics and distributed robotics.

Textbooks/ Reference Books:

1. Robotics: Control, Sensing, Vision and Intelligence – K.S. Fu, R.C. Gonzalez and C.S.G. Lee, McGraw-Hill.

2. Introduction to Robotics – J. J. Craig, Addision-Wesley.
3. A Textbook on Industrial Robotics – Ganesh S. Hegde, University Science Pres

Course Time Plan

Units/Topics	Number of Lectures (Hours)	Method of deliver
Unit I – Overview of Robotics	8	Both chalk and talk and power point presentation
Unit II – Structure and Control of Robotic System	8	
Unit III – Robot Arm Kinematics	6	
Unit IV – Robot Arm Dynamics	6	
Unit V – Introduction to Sensors and Robot Vision	6	
Unit VI – Robot Programming	6	
Total	40	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818PE24	Compressors and Gas Turbines	3-0-0	3

Course Outcomes (COs):

CO1: Explain different parts of compressors, gas turbines and jet engines
CO2: Explain basic details of Turboprop, Turbofan, Turbojet and Ramjet systems.
CO3: Analyze turbomachines by applying Euler's equation.
CO4: Perform thermodynamic analysis for turbines and compressors.
CO5: Choose appropriate blading material for particular applications of turbine and compressor.

MODULE 1: Introduction
Classification of Turbo machines, Application of Euler equation to radial and axial flow turbomachines.

MODULE 2: Centrifugal Compressors
Impeller, blade shape, diffuser, velocity diagram, inlet guide vane and pre-whirl, slip, work done, pressure rise, temperature rise, enthalpy-entropy diagram, efficiency, characteristics, surging.
Axial-flow Compressors: Stage, stage blading arrangement, velocity diagram, blade angles, thermodynamics of the compressor stage, enthalpy-entropy diagram, efficiency, degree of reaction, stage pressure and temperature rise, work done factor, stage loading, pressure ratio of a multistage compressor, surging and stall, characteristics curve.

MODULE 3: Axial-flow Turbines
Impulse Turbines: Single stage and multi stage turbine, blading, velocity diagram, blading efficiency, Thermodynamics of stage, stage enthalpy-entropy diagram, efficiency.
Reaction Turbine: Stage, blading, stage velocity diagram, Thermodynamics of the stage, enthalpy entropy diagram, efficiency, degree of reaction, free vortex design, variation of degree of reaction with radius, flow characteristics of multistage turbine.
Gas Turbine: Combined cycles, compounding and governing of gas turbine.

MODULE 4: Combustion system
Types of combustion chambers, the combustion chamber performance.
Blading material: Influence of blading material on the maximum temperature of the cycle, desirable properties of a gas turbine blading material, various blading material and their strength and weakness

MODULE 5: Jet Propulsion
Turboprop, turbofan, turbojet and ramjet systems, matching of turbine and compressor.

Textbooks/ Reference Books:

1. Gas Turbine Theory – H.Cohen, G.F.C. Rogers and H.T.H. Saravanemuttoo (Longman Scientific and Technical)
2. Turbines, Compressors and Fans- S.M.Yahava (Tata McGraw-Hill)
3. Gas Turbines and Propulsive system- P.P. Khajuria and S.P. Dubey (Dhanpat Rai and Sons)

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818PE25	**Computational Fluid Dynamics**	**3-0-0**	**3**

Course Outcomes (COs):

CO1: Explain the approaches used in computational fluid dynamics and heat transfer.

CO2: Illustrate the major theories used in computational fluid dynamics and heat transfer

CO3: Analyze and apply the methodologies used in computational fluid dynamics and heat transfer

CO4: Formulate and solve the simple problems involving governing equations of parabolic type, hyperbolic type and elliptic type with incorporation of boundary conditions/ initial condition.

CO5: Justify the methods for evaluating physical problems like heat conduction in bars, plates, fluid flow of simple nature by applying CFD & HT tools.

MODULE 1: The Basic Equations of Fluid Dynamics
General form of a Conservation law: equation of mass conservation, conservation law of momentum, conservation equation of Energy.

MODULE 2: The dynamic levels of approximation
The Navier-Stokes (NS) equation: The Reynold's averaged NS equation, The thin layer NS approximation, The parabolized NS approximation, The boundary layer approximation, the distributed loss model, The inviscid flow model, Euler equations, steady inviscid rotational flow, The potential flow model, small disturbance approximation of the potential equation, Linearised potential flow, singularity methods, mathematical nature of flow equations.

MODULE 3: Basic discretization techniques
(a)The finite difference method, (b)The finite volume method and conservative discretization.

MODULE 4: Analysis and application of Numerical schemes
Consistency, stability, convergence, Fourier and Von Neumann stability analysis, modified equation, application of finite difference methods, to wave, heat. Laplace and Burger's equation.

MODULE 5: Solution methods
Solution of 1D heat conduction equation, wave equation, Laplace equation using various schemes.

MODULE 6: Heat Transfer
Basics of finite difference and finite element methods: Numerical methods for conduction heat transfer, Numerical methods for convection heat transfer, Numerical methods for radiative heat transfer.

Textbooks/ Reference Books:

1. Computational Fluid Mechanics and Heat Transfer—Hemisphere-Anderson, Tannehill, Pletcher.

2. Computational Heat Transfer-Hemisphere and Springer-Verlag-Jaluria and Torrance
3. Computational techniques for Fluid Dynamics-Verlag-Fletcher and Springer

Course Description	• This course introduces computational fluid dynamics (CFD) and numerical heat transfer (NHT) modelling technology for thermo-fluid related applications. • This course provides core knowledge of the fundamentals of CFD for engineers, and an introduction to the methods and analysis techniques used in CFD.
Objectives/Learning Outcomes/Capability Development	• Conceptual understanding of the numerical analysis which underpin the engineering discipline. • Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline. • Application of established engineering methods to complex engineering problem solving.

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I - The Basic Equations of Fluid Dynamics	4	1. Lecture using board and chalk. 2. Discussion/ Interaction. 3. Demonstration using presentations.
Unit II - The dynamic levels of approximation	8	
Unit III - Basic discretization techniques	5	
Unit IV - Analysis and application of Numerical schemes:	8	
Unit V - Solution methods	7	
Unit VI - Heat Transfer	5	
Total	37	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818PE31	**Computer Integrated Manufacturing**	**3-0-0**	**3**

Course Outcomes (COs):

CO1: Apply the concept of CIM in automated manufacturing systems.
CO2: Apply the concept of computer aided design in manufacturing and assembly.
CO3: Apply the knowledge of production and process planning in manufacturing systems.
CO4: Design flexible manufacturing cell by applying concept of Group Technology and FMS.
CO5: Apply data management for decision making in CIMS.

MODULE 1: Introduction
Introduction to Automation: Automated Manufacturing system; Need of automation, Basic elements of automation, Levels of automation, Advantages & disadvantages of automation, Concept of CIM, information flow in CIM, elements of CIM, benefits and limitations.

MODULE 2: CAD/CAM
Product Design and CAD, application of computers in design, scope of CAD / CAM and CIM, concurrent engineering, design for manufacturing and assembly.

MODULE3: Production Planning and Control
Process planning – Computer Aided Process Planning (CAPP), Logical steps in Computer Aided Process Planning, Aggregate Production Planning and the Master Production Schedule, Material Requirement planning, Capacity Planning, Control Systems, Shop Floor Control, Inventory Control, manufacturing resource planning and enterprise resource planning.

MODULE 4: Group Technology
Concept, design and manufacturing attributes, part families, composite part, methods of grouping, PFA, classification and coding system- OPITZ– Relevance of GT in CIM, GT and CAD, benefits and limitations of GT.

MODULE 5: Flexible Manufacturing Systems
Flexible & rigid manufacturing cell and FMS structure, types, components of FMS, Building Blocks of FMS, Flexible Assembly System

MODULE 6: Data Acquisition and Database Management Systems
Data acquisition system, type of data, automatic data identification methods, bar code technology, Data and database management system, database design requirements, types of DBMS models-hierarchical, network and relational models and their applications.

Textbooks/ Reference Books:

1. CAD/CAM (Dhanpat Rai & Sons.) ------ S. Kumar and A.K. Jha

2. Computer Integrated Manufacturing (PHI) ------ S. K. Vajpayee.

3. Mechatronics, HMT Ltd., (Tata Mc Graw Hills)

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I - Introduction	5	1. Lecture using board and chalk.
Unit II - CAD/CAM	6	

Unit III - Production Planning and Control	5	2. Discussion/ Interaction. 3. Demonstration using presentations.
Unit IV - Group Technology	5	
Unit V - Flexible Manufacturing Systems	5	
Unit VI - Data Acquisition and Database Management Systems	5	
Total	30	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818PE32	**Operations Management**	**3-0-0**	**3**

Course Outcomes (COs):

This course aims to improve students understanding of the concepts, principles, problems, and practices of operations management. After completing this course, students should be able to:

- CO1: To anticipate the importance of productivity and competitiveness to both organizations and nations.
- CO2: To recommend the various production and operations design decisions and to relate them for the overall strategies of organizations.
- CO3: To analyze the relationship of the various planning practices of capacity planning, project planning and scheduling.
- CO4: To summarize the roles of inventories and basics of managing inventories in various demand settings.
- CO5: To relate the contemporary operations and manufacturing organizational approaches and the supply-chain management activities in organizational strategy.

MODULE 1: Operations Management
Introduction, Operations Management and Strategy, Tools for Implementation of Operations.

MODULE 2: Forecasting
Introduction, The Strategic Importance of Forecasting, Benefits, Cost implications and Decision-making using forecasting, Classification of Forecasting Process, Methods of Forecasting, Forecasting and Product Life Cycle, Selection of the Forecasting Method, Qualitative Methods of Forecasting, Quantitative Methods, Accuracy of Forecasting

MODULE 3: Inventory Management
Need for holding stock, Planning and controlling stock levels, Product Classification, Demand analysis, ABC analysis, Product Coding. Inventory Cost and Service, Lead Time, Management of Stock Levels, Replenishment Methods

MODULE 4: Layout Planning
Introduction, Objectives of Layout, Classification of Facilities, Why Layout decisions are important, Nature of layout problems, redesigning of a layout, Manufacturing facility layouts, Types of Layouts, Layout Planning, Evaluating Plant Layouts

MODULE 5: Total Quality Management
Introduction, Meaning and Dimensions of Quality, Quality Control Techniques, Quality Based Strategy, Total Quality Management (TQM), Towards TQM – ISO 9000 as a Platform

MODULE 6: Supply Chain Management
Introduction, Domain Applications, Views on Supply Chain, Bullwhip Effect in SCM, Collaborative Supply Chain, Inventory Management in Supply Chain, Financial Supply Chain

MODULE 7: Operations Scheduling
Introduction, Purpose of Operations Scheduling, Factors Considered while Scheduling, Scheduling Activity under PPC, Scheduling Strategies, Scheduling Guidelines,

MODULE 8: Value Engineering
Introduction, Value Engineering/Value Analysis, Relevance of VE in Modern Manufacturing, Process of Value Analysis, VE– Approaches and Aim, Providing Value to the Customers, Benefits

MODULE 9: Project Management
Planning Process: Introduction, need, Project Management Principles, Essentials of Project Management Philosophy, Project Planning, Project Process Flows.

Textbooks/ Reference Books:

1. Heizer, Render, Principles of Operations Management 7th Edition, Prentice Hall, 2008.
2. Heizer, Render, Principles of Operations Management 8th Edition, Prentice Hall, 2011.
3. David Collier and James Evans, OM, 2nd Edition. Upper Saddle River, NJ: South-Western Cengage Learning, 2010/2011. ISBN-13: 978-0538745567
4. Jacobs, F.R. & R. B. Chase. Operations and Supply Chain Management 13th Edition, Boston: McGraw-Hill Irwin, 2010.

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I - Operations Management	4	1. Lecture using board and chalk. 2. Discussion/ Interaction. 3. Demonstration using presentations.
Unit II - Forecasting	6	
Unit III - Inventory Management	4	
Unit IV - Layout Planning	4	
Unit V - Total Quality Management	4	
Unit VI - Supply Chain Management	4	
Unit VII - Operations Scheduling	6	
Unit VIII - Value Engineering	3	
Unit IX - Project Management	5	
Total	40	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818PE33	**Internal Combustion Engines**	**3-0-0**	**3**

Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1: Analyze and compare the real cycles with ideal air standard cycles to estimate the losses occurring during the run of an I.C. Engine.
CO2: Apply the properties of fuels and analyses the combustion processes in automotive IC engines including the state-of-the-art technologies of MPFI, CRDI and DGI engines to understand their effect on engine efficiency and emissions.
CO3: Estimate the primary design parameters, namely, stroke, bore, compression ratio, air-fuel ratio and rated speed of components of internal combustion engines from required performance parameters.
CO4: Critically examine the causes of unwanted exhaust emissions, their effects on the environment and measures to reduce such emissions from the study of chemistry of combustion and emission control technologies.
CO5: Estimate the performance of I C engines under various load conditions and throttle positions in a suitable test rig and compare the results for single cylinder and multi-cylinder of I.C. engines, namely SI and CI engines.

MODULE 1:
Fuel Air cycle – effect of variation of specific heats, fuel-air ratio, compression ratio and dissociation. Actual cycle – losses in actual cycle.

MODULE 2:
Exhaust gas analysis – its interpretation and use in determination of combustion characteristics; Pollution norms

MODULE 3:
I C engines fuels - - Petrol, Diesel, natural gases and some other alternative fuels and their characteristics and use in engines. Combustion process in S. I. And C. I. engines, abnormal combustion, detonation and fuel knock – additives. Rating of I. C. engine fuel.

MODULE 4:
Design features of combustion chambers used in S I and C I engines, some important types of combustion chambers.

MODULE 5:
Carburetion – desirable characteristics – compensation for simple jet carburetor, calculation for air-fuel ratio.

MODULE 6:
Injection processes – requirements and methods –mechanical, electronic and MPF injection system. Ignition processes in petrol engines – requirements and types – battery magneto and electronic.

MODULE 7:
Performance characteristics of petrol and Diesel engines. Part load and full load characteristics in

respect to thermal efficiency, mechanical efficiency, fuel consumption, bmep and torque. I C engine ratings and volume capacity compression ratio and weight to power output ratio and its trends in power – weight characteristics. Supercharging of I C engines – effect of supercharging on Diesel and petrol engines – performance characteristics for supercharged engines.

MODULE 8:

Supercharger – types, principles of dual-fuel and multi-fuel engines and Stratified combustion engines.

Textbooks/ Reference Books:

1. A course in Internal Combustion engines, M. L. Mathur and R. P. Sarma, 5th edn, 2014
2. Internal Combustion Engine fundamentals, John B. Heywood, 5th edn, McGraw-Hill international edition, 1988.
3. Internal Combustion Engines, V Ganesan, Tata McGraw Hill Publication, 2nd edn, 2003.
4. Engineering Fundamentals of Internal Combustion Engine, W W Pulkrabek, Pearson Education, 5th Edn. 2013.
5. Fundamentals of Internal Combustion Engine, H.N.Gupta, 2nd Edn, PHI Pvt Ltd, 2013. 6. A textbook of Internal Combustion Engines, S S Thipse, 2nd Rev Edn, Jaico Publishing house, 2014.

Introduction:

The course aims at providing information needed for basic understanding of the operation of internal combustion engines. The course covers topics of applied thermo-science. The teacher is expected to deliberate on the topics right from the fundamentals so as to build an understanding of concepts and emphasis the relationship between conceptual understanding and problem-solving approaches. They will also learn about the pollutions caused by the emissions, ever-changing international regulations on pollution, various pollution control mechanisms. However, students are assumed to have knowledge of fundamental thermodynamics, heat transfer and fluid dynamics as a prerequisite to get maximum benefit.

Motivations:

The course aims at motivating the students to have the fundamentals of most types of internal combustion engines, particularly of reciprocating engines. They are expected to develop concept that will help them to stay knowledgeable of all future advancements in internal combustion engine technology, specifically in engine design, materials, fuels, controls. The course further aims at motivating the students to approach for solutions related to enhancement of performance of the engine, reduction in emissions etc.

Course Plan:

Courses to be covered	No of classes

Sl No		Theory	Tutorial	Mode of delivery
1	Introduction to IC engines, Revisions of cycles – Air standard cycle	1		Chalk & talk
2	Revisions of cycles – Otto, diesel and Dual cycles and their comparison	1		PPT
3	Air-fuel cycle	2	1	Chalk & talk
4	Actual cycle	2		Chalk & talk
5	Fuels for IC engines: SI engines, properties, ASTM curves, CI engine fuels – properties	3		Chalk & talk
6	Ratings of IC engine fuels	1		Chalk & talk
7	Alternate fuels			PPT
8	Combustion in SI engines, knock	2		Chalk & talk
9	Combustion in CI engines, diesel knock	3		Chalk & talk
10	Combustion chamber designs	3		PPT
11	Carburetion	1		Chalk & talk
12	Ignition in SI engines	2	1	Chalk & talk
12	Fuel injection in CI engines	3		Chalk & talk
13	Performance testing and performance characteristics of CI engines, Exhaust gas analysis	2	1	Chalk & talk
14	Supercharging, stratified charge engines, multi-fuel engines.	2	2	Chalk & talk

Plans for class test: (course duration Jan – June)

Class Test	Course	Tentative Date
I	Air standard cycle, Air-fuel cycle, actual cycle, Fuels for IC engines, Ratings.	Mid- February
II	Combustion in SI & CI engines, knock, CC design, Carburetion	End- March
III	Ignition in SI engines, Fuel injection, Performance testing, Supercharging and rest.	Early-May

Plans for seminars:

Groups comprising of 3 students will be formed from the batch and each group will be allotted a topic from the topics listed below. They will present their findings in seminars arranged once a week.

Sl no	Topic

1	History of IC Engines
2	Classifications of IC engines
3	Starting and charging of IC engines
4	Cooling systems
5	Lubricating systems
6	Transmission
7	Lightings and accessories
8	Breaking system
9	Steering
10	Chassis
11	Suspension
12	Fuel supply systems
13	Ignition systems
14	Gasoline as fuel and its emission control systems
15	Diesel as fuel and its emission control systems
16	Cylinder head and valve guides
17	Cam-shaft and valve-timing diagrams
18	Engine balancing and balance shafts
19	Scavenging
20	Crank-shafts and bearings
21	Car driving, fuel saving, safety
22	Fluidised bed combination consideration
23	Dual-fuel and multi-fuel engines

Topics beyond the course:

The following out-of-the-syllabus topics will be dealt in seminars:

Sl no	Topics
1.	charging of IC engines
2.	Cooling systems
3.	Lubricating systems
4.	Transmission
5.	Lightings and accessories
6.	Breaking system

7. Steering
8. Chassis
9. Suspension
10. Fuel supply systems
11. Cylinder head and valve guides
12. Cam-shaft and valve-timing diagrams
13. Engine balancing and balance shafts
14. Scavenging
15. Crank-shafts and bearings
16. Car driving, fuel saving, safety
17. Fluidised bed combination consideration

Laboratory Manuals:

(1) Performance testing of SI engine:

Description of the test rig:

Engine type	four-stroke single cylinder Honda G 300 SI engine, Swept volume 272 cm^3, air-cooled, Max power 7 HP.
Other components	electric dynamometer, digital torque-meter, tachometer, fuel flow-meter, 15 x 200 W bulbs for measuring load, exhaust gas analyser, electronic timer.

Test Procedures:

1. Connect the torque-meter, flow-meter, exhaust gas analyser and start the engine.
2. Run the engine at definite rpm for no load condition. Measure rpm, flow rate, torque and emissions.
3. Switch on one bulb, i.e., apply a load of 200 W and measure rpm, flow rate , torque and emissions.
4. Continue the experiment by switching on the other bulbs one by one, i.e., by increasing the load gradually and take readings.
5. Repeat the test (from 2 to 4) by changing the initial rpm.

Results and discussions:

Obtain the following table:

Sl	No of bulbs	V	I	Load kW	RPM	Torque	BHP	Fuel consumption	CO	HC	NO

Draw the following performance**:**

RPM = F (Load); BHP = f (Load); Fuel Consumption = f (Load); BHP = f (RPM); Fuel Con = f (RPM); Emissions = f (Load)

(2) Performance testing of CI engine:

Description of the computerised engine test rig:

Engine type	four-stroke single cylinder CI engine, Kirloskar made, 5 HP at 1500 rpm, water-cooled, Max power 317 kW.
Other components	Fully computerised rig with sensors for mean effective pressure, temperatures, air flow, fuel flow and dynamometer. It is equipped with eddy current dynamometer, exhaust heat exchanger, air flow-meter, fuel flow-meter, water flow system with a rotameter.

Test Procedures:

1. Connect the computer with the software with the engine system.
2. Start the software.
3. Keep the load knob at zero load.
4. Manipulate the rotameter to maintain water flow for the engine at a rate of 100 ml/s and 80 m/s for the heat exchanger.
5. Start the engine.
6. Increase the load and take data from the computer system.
7. Data obtained are then used by the computer to calculate IP, BP, BFSC.
8. Computer provides data for the variations of MEP with swept volume and also with crank angle. It depicts the variations in p-θ diagram and in p-V diagram. Read the graphs and compare with theoretical graph.
9. Change the load by turning the load-knob and repeat the test from 5 to 7.

10. Repeat 8 for two or three more loads.

Results and discussions:

1. Obtain performance graphs for various loads.
2. Compare the graphs.
3. Study the p-θ diagrams obtained for different loads and compare.

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818PE34	**Composite Materials**	**3-0-0**	**3**

Course Outcomes (CO's): After completion of the course, students will be able to

CO1: Identify different materials to design composites structures.
CO2: Compare the set of technological properties of the advanced materials with the conventional materials.
CO3: Use different techniques to process different types of composites and know the limitations of each process.
CO4: Understand various applications of composite materials in modern industries such as aerospace, automotive, bio-medical etc.
CO5: Understand different composite testing methods to obtain its material properties.

MODULE 1: Introduction to Composites
Fundamentals of composites, need for composites, enhancement of properties classification of composites, Reinforcement, particle reinforced composites, Fibre reinforced composites. Applications of various types of composites. Fiber production techniques for glass, carbon and ceramic fibers

MODULE 2: Polymer Matrix Composites
Polymer resins- thermosetting resins, thermoplastic resins, reinforcement fibres- various types of fibres. PMC processes- hand layup, spray up, compression moulding, injection moulding, resin transfer moulding, Pultrusion, Filament winding. Fibre reinforced plastics (FRP), Glass Fibre Reinforced Plastics (GFRP), Laminates- Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Applications of PMC in aerospace, automotive industries

MODULE 3: Metal Matrix Composites
Characteristics of MMC, various types of metal matrix composites, advantages of MMC, limitations of MMC, Reinforcements – particles – fibres. Effect of reinforcement – volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process, diffusion bonding, stir casting, squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface-measurement of interface properties. applications of MMC in aerospace, automotive industries

MODULE 4: Testing of Composites
Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter laminar shear testing, Fracture testing etc.

Textbooks/ Reference Books:

1. Bhargava, A. K., Engineering Materials: Polymers, Ceramics and Composites, Prentice Hall India. 2. Chawla K. K., "Composite materials", Second Edition, Springer.

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I - Introduction to Composites	8	1. Lecture using board

Unit II - Polymer Matrix Composites	8	and chalk.
Unit III - Metal Matrix Composites	8	2. Discussion/ Interaction.
Unit IV - Testing of Composites	8	3. Demonstration using presentations.
Total	32	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818PE35	Tribology	3-0-0	3

Course Outcomes (COs): After completion of the course, students will be able to

CO1: Understand the fundamentals of tribology and associated parameters.
CO2: Apply concepts of tribology for the performance analysis and design of components experiencing relative motion.
CO3: Analyze the requirements and design hydrodynamic and hydrostatic journal and plane slider bearings for a given application.
CO4: Select proper bearing materials and lubricants for a given tribological application. 5. Apply scientific information and knowledge about tribological problems and solutions to industry.

MODULE 1: Introduction
Introduction, history of tribology, Viscosity, flow of fluids, viscosity and its variation absolute and kinematic viscosity, temperature variation, viscosity index determination of viscosity, different viscometers, Tribological considerations, Nature of surfaces and their contact

MODULE 2: Friction and Wear
Role of friction and laws of static friction, causes of friction, theories of friction, Laws of rolling friction; Friction of metals and non-metals; Friction measurements, Friction Instability. Definition of Wear, mechanism of Wear, types and measurement of wear, friction affecting wear, Theories of wear; Wear of metals and non-metals.

MODULE 3: Hydrodynamic theory of lubrication
Principle of hydrodynamic lubrication, Various theories of lubrication, Petroff's equation, Reynold's equation in two dimensions, Effects of side leakage, Reynolds equation in three dimensions, Friction in sliding bearing, hydro dynamic theory applied to journal bearing, minimum oil film thickness, oil whip and whirl, anti-friction bearing, hydrodynamic thrust bearing.

MODULE 4: Hydrostatic lubrication
Principle of hydrostatic lubrication, General requirements of bearing materials, types of bearing materials., Hydrostatic step bearing, application to pivoted pad thrust bearing and other applications, Hydrostatic lifts, hydrostatic squeeze films and its application to journal bearing, optimum design of hydrostatic step bearing.

MODULE 5: Lubrication and Lubricants
Importance of Lubrication, Boundary Lubrication, Mixed Lubrication, Full Fluid Film Lubrication, Hydrodynamic, Elasto-hydrodynamic lubrication, Types & Properties of Lubricants, Lubricants Additives, bearing materials, bearing constructions, oil seals, shields and gaskets

Textbooks/ Reference Books:

1. Basu, Sengupta and Ahuja, "Fundamentals of Tribology", PHI
2. Majumdar, B. C, "Tribology", S. Chand Co.

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I - Introduction	6	1. Lecture using board and chalk. 2. Discussion/ Interaction. 3. Demonstration using presentations.
Unit II - Friction and Wear	6	
Unit III - Hydrodynamic theory of lubrication	6	
Unit IV - Hydrostatic lubrication	6	
Unit V - Lubrication and Lubricants	6	
Total	30	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818OE21	**Noise and Vibration Control**	**3-0-0**	**3**

MODULE 1: Noise and Its Measurement
Wave Propagation, Decibel level, Frequency Analysis, Sound pressure level and its measurement, Noise Pollution regulation and control rules, Sound Level Meter.

MODULE 2: Vibration and Its Measurement
Vibration of single and multiple degree(s) of freedom system, Transmissibility, Critical Speed, Dynamical Analogies, Vibration of Beams and plates, Vibration Measurement

MODULE 3: Vibration Control
Vibration control at source, vibration Isolators, Dynamic vibration Absorber

MODULE 4: Acoustics of Rooms, Partitions, Enclosures ad Barriers
Sound field in a room, Acoustics of a Partition wall ad enclosures

MODULE 5: Noise Control Strategies
Control of Noise at source, Control of Noise in the path Control of Noise at the receiver end, Control of Noise of an existing facility

Textbooks/ Reference Books:

1. "Noise and Vibration Control", by M L Munjal, IISc Press, World Scientific Publishing Co. Pte Ltd., Singapore.
2. "Engineering Noise Control" by D.A. Bies, C.H. Hansen, Spon press London
3. Industrial Noise and Vibration Control, by J.D. Irwin, E.R. Graf, Prentice Hall, Englewood Cliffs
4. Notifications issued, time to time, by of GOI regarding Noise/Sound and vibrations

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I - Noise and Its Measurement	6	1. Lecture using board and chalk. 2. Discussion/ Interaction. 3. Demonstration using presentations.
Unit II - Vibration and Its Measurement	6	
Unit III - Vibration Control	6	
Unit IV - Acoustics of Rooms, Partitions, Enclosures ad Barriers	6	
Unit V - Noise Control Strategies	6	
Total	30	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818OE22	**Industrial Safety Engineering**	**3-0-0**	**3**

Course Outcomes (COs):

On successful completion of this course the student should be able to:

CO1: Understand the basic concepts and terminologies in industrial safety engineering.
CO2: Apply various techniques to analyses failure modes.
CO3: Assess industrial risk and losses.
CO4: Identify unsafe components in industry and conduct safety audit.
CO5: Develop fire protection systems in industry.

MODULE 1: Key concepts and basic terminologies
History of Industrial Safety Movement in India and abroad. Basic concepts and importance of industrial safety, key concepts and basic terminologies like safety, risk, accidents, incidents, mishaps, hazards, hazard-mishap entity, examples of hazard components and its description, hazard theory, hazard triangle and hazard analysis, causal factors, hazard actuation, hazard causal factors. Fundamental concepts in safety domain ontology and accident causation.

MODULE 2: Failure modes and effects analysis
Failure modes and effects analysis (FMEA), its history and importance, identification of failure modes, system breakdown concept, methodology and example of a case study of identifying failure modes of compressor sub system.

MODULE 3: Failure tree analysis
Failure tree analysis (FTA), its history and importance, different measures, primary failures, secondary failures, command failures, event symbols, gate symbols with application, failure tree construction concept, P-S-C concept of failure analysis, example of fault tree construction and analysis of gas oven burner system.

MODULE 4: Industrial risk and losses

Concept and definition of industrial risk, risk profile, risk assessment process, risk contour map, individual risk assessment, industrial losses, identification and classification of losses, framework for consequence assessment, loss estimation, safety function deployment and steps of stakeholders concerns about safety.

MODULE 5: Safety audit
Introduction, Components of safety audit, types of audit, audit methodology, non conformity reporting (NCR), audit checklist and report – review of inspection, remarks by government agencies, consultants, experts – perusal of accident and safety records, formats – implementation of audit indication - liaison with departments to ensure co-ordination – check list – identification of unsafe acts of workers and unsafe conditions in the shop floor.

MODULE 6: Industrial Fire Prevention and Protection
Sources of ignition – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E – types of fire extinguishers – fire stoppers – hydrant pipes – hoses – monitors – fire watchers – layout of stand pipes – fire station-

fire alarms and sirens – maintenance of fire trucks – foam generators – escape from fire rescue operations – fire drills – notice first aid for burns.

Textbooks/ Reference Books:

1. NPTEL course on “Industrial safety engineering” by Prof. J. Maiti, Department of Industrial and systems engineering, IIT, Kharagpur.
2. Derek, James, “Fire Prevention Hand Book”, Butter Worths and Company, London, 1986.
3. R.K. Jain and Sunil S. Rao, Industrial Safety, Health and Environment Management Systems, Khanna publishers, New Delhi (2006).
4. Risk Assessment and Environmental Management: D. Kofi Asvite-Dualy, John Willey & Sons, West Sussex, England (1998).
5. Gupta, R.S., “Hand Book of Fire Technology” Orient Longman, Bombay 1977.
6. GREEN, A.E., “High Risk Safety Technology”, John Wiley and Sons, 1984.
7. Lees, F.P. “Loss Prevention in Process Industries” Butterworths and Company, 1996.

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I-Key concepts and basic terminologies	5	1. Lecture using board and chalk. 2. Discussion/ Interaction. 3. Demonstration using presentations.
Unit II - Failure modes and effects analysis	6	
Unit III - Failure tree analysis	5	
Unit IV - Industrial risk and losses	5	
Unit V - Safety audit	5	
Unit VI - Industrial Fire Prevention and Protection	5	
Total	30	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818OE23	**Engineering Economic Analysis**	**3-0-0**	**3**

Course outcomes (COs):

After completion of the course, the students will be able to

CO1: Apply the concept of time value of money in managerial decision making.
CO2: Make decisions on economic equivalence of physical assets for selection of alternatives.
CO3: Make decisions on economic replacement of physical assets for acquiring new ones.
CO4: Apply the concept of depreciation for economic decisions on the life of an asset.
CO5: Make decisions on economically viable optimum quantity of production for manufacturing

MODULE 1: Introduction
Introduction to Engineering Economy, Physical & Economic Environment, Phases in Engg. process, Some economic concepts, Value and utility; Interest and Interest rate, Time value of money; Interest formulas: - Simple and compound interest, Cash flow diagrams, Interest formulas for discrete compounding and discrete payments: Single payment (CAF & PWF), Interest formulas for discrete compounding and discrete payments: Equal payment series (CAF, CRF & PWF).

MODULE 2: Problem solving by compounding
Problem solving on discrete compounding, discrete payment; Interest formulas for Uniform gradient series; Interest formulas for geometric gradient series; Compounding frequency of Interest: Nominal and Effective interest rates; Problem solving on frequency compounding of interest and gradient series factors.

MODULE 3: Economic equivalence
Economic equivalence: Meaning and principles of equivalence; Equivalence calculations involving cash flows; Methods of comparison of alternatives: Present worth, Annual equivalent, Future worth, Internal rate of return; Comparison of alternatives: - Capitalized equivalent amount, Capital recovery with return Problem solving on equivalence and comparison of alternatives.

MODULE 4: Replacement analysis
Replacement analysis: Reason, Concept of defender and challenger; Proper treatment of sunk cost in replacement; Replacement because of improved efficiency, inadequacy, demand etc.; Problem solving on replacement analysis; Economic life of the asset.

MODULE 5: Depreciation
Depreciation: Definition, Reasons, Types of property, Value time function and book value; Basic depreciation methods: S-L method, declining balance method; Depreciation: Declining balance switching to S-L, SOYD Method; Modified accelerated cost recovery system (MACRS) method of depreciation, Depletion; Depreciation: Units of production method, Depletion.

MODULE 6: Break even and EOQ
Breakeven analysis, Effect of fixed and variable cost on BEP; Economic order quantity; Problem solving based on Break-even analysis and EOQ.

Textbooks/ Reference Books:

1. Engineering Economics – H G Thuesen and W J Fabryky and G J Thuesen
2. Panneer Selvam, R, ―Engineering Economics‖, Prentice Hall of India Ltd, New Delhi, 2001.
3. Degarmo, E.P., Sullivan, W.G and Canada, J.R, ―Engineering Economy‖, Macmillan, New York, 1984

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I-: Introduction	5	1. Lecture using board and chalk. 2. Discussion/ Interaction. 3. Demonstration using presentations.
Unit II - Problem solving by compounding	6	
Unit III - Economic equivalence	5	
Unit IV - Replacement analysis	5	
Unit V - Depreciation	5	
Unit VI - Break even and EOQ	5	
Total	30	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818OE24	**Automotive Mechanics**	**3-0-0**	**3**

Course Outcomes (COs): At the completion of the course the student will be able:

CO1: To apply the concept of internal combustion of fuel air mixture for energy production and subsequent controlled use.
CO2: To apply various types of engines and sub-systems with respect to desired objective and performance.
CO3: To examine various, dis-assembled components and assess their condition of components for replacement/repair.
CO4: To choose primary and peripheral components of an automobile needed for control, safety, comfort, economy and efficiency.
CO5: To apply new technology in automotive systems for environmental sustainability.

MODULE 1: Introduction
History of automotive systems and operations, components of an automobile, Basic Engine terminology, Classification of different types of engines.

MODULE 2: Power Unit
Principles of Engine operation, Engine parts and their functions, Multiple cylinder Engines, Engine trouble and repairs.

MODULE 3: Fuel Systems
Fuel used systems for delivery of fuel to the engine, carburetor, fuel pump and injector, common rail system for diesel injection, CRDI.

MODULE 4: Intake and Exhaust Systems
Cylinder head and valves, valve actuation & lubrication, manifold for intake and exhaust, connecting rod, piston, piston rings, gudgeon pin, crankcase, crankshaft and bearings, camshaft and OHC, Timing chains and actuations of valves, VVT engine.

MODULE 5: Power Transmission System
Manual and automatic transmission systems; meaning and functioning. **The clutch**- construction and operation, mechanical versus hydraulic clutch. **Gear box:** types, gear system and gear box, process of speed changing and reversing. **Propeller shaft:** strength consideration and coupling used. **Differential gear box:** need, construction and operation. **Axle and Wheel assembly**: solid/liquid lubrication in bearings, wheel alignment and balancing (castor/camber/toe/ offset). **Tyres-** types, specification, rotation of tyres.

MODULE 6: Chassis and Suspension system
Position of Engine; balance and road holding. Springs (coil and leaf) and dashpots. Steel and rubber bushes and mountings for engine. Chassis construction and types.

MODULE 7: Steering systems
Rack and pinion system, tie rod and wheel pivot, turning radius & safety arrangement. Types: Mechanical system versus hydraulic systems (power steering), Electronic Power Steering (EPS).

MODULE 8: Braking system
Types of Brakes: drum and disc. Brake system: mechanical, pneumatic and hydraulic, and their operation. Components: shoe materials, size and replacement, drum/disc repair and replacement, Antilock Braking system (ABS)

MODULE 9: Recent trends in automobile engineering

Textbooks/ Reference Books:

1. Automotive Mechanics by Crouse and Anglin
2. I C Engines by V Ganeshan
3. Automotive electronics handbook by Ronald K Jurgen, McGraw Hill Professional Publication.
4. Understanding Automotive Electronics by William B. Ribbens, Butterworth-Heinemann, 225 Wildwood Avenue, Woburn, MA 01801-2041.
5. Automobile Electrical and Electronic Systems by Tom Denton, Elsevier Publication

Course time plan:

DETAILS OF TOPICS COVERED	HRS
Unit 1. Introduction: Introduction	2
Unit 2. Power Unit:	2
Unit 3. Fuel Systems	2
Unit 4: Intake and Exhaust Systems—	4
Unit 5: Power Transmission Systems	8
Unit 6: Chassis and Suspension systems	3
Unit 7: Steering systems	5
Unit 8: Braking system	5
Total	33

Course Code	Course Title	Hours per week L-T-P	Credit C
ME1818OE25	**Machining and Machine Tools**	**3-0-0**	**3**

Course outcomes (COs):
After completion of the course, the students will be able to:

CO1: Apply cutting tool reference systems in determining tool signatures.
CO2: Apply mechanics of machining as well as chip formation for determination of force, power, toque etc.
CO3: Evaluate tool life as well as suggest strategies for economic tool life.
CO4: Apply concept of kinematic analysis in machine tool applications.
CO5: Apply design considerations in machine tool applications.

MODULE 1: Introduction and Reference Systems
Machining, definition and objectives. Geometry of cutting tools; turning, milling and drilling - in different reference systems like machine reference system, tool reference system and work reference system.

MODULE 2: Chip Formation and Mechanics
Mechanism of chip formation, Types of chips and their characteristics, Effective rake. Mechanics of machining

MODULE 3: Materials and Failure of Cutting Tools
Cutting tools materials and methods of failure; Assessment of tool life

MODULE 4: Measurement by Dynamometry
theoretical estimation and experimental determination of cutting forces and power consumption. Dynamometers; types, design, construction and use.

MODULE 5: Economics of Machining
Economics of machining and its principal objectives;
Main parameters and their role on cutting forces, cutting temperature, tool life and surface quality, selection of optimum combination of parameters.

MODULE 6: Kinematics of Machine Tools
Basic considerations in the design of drives – Speed and structure program, Ray diagram. Transmission in the systems of stepped regulation. Spindle speed and design of all geared headstock – intermediate shaft diameter calculation. Stepless drives and hydraulic drive. Feed gear boxes.

MODULE 7: Design Considerations
Various types of beds and columns, their materials, construction and design features and principles. Guides, spindle materials and their lubrication Temperature deformation.
Static and Dynamic rigidity, forced damped, self, excited and stick slip vibration., Vibration isolators.

Textbooks/ Reference Books:
1. Metal cutting: Theory & Practice by Amitabha Bhattacharyya
2. Manufacturing Science by Ghosh and Mallik

3. Metal cutting by E. M. Trent
4. Fundamentals of machining and machine tools**:** Geoffrey Boothroyd
5. Principles of Machine Tools: Sen and Bhattacharya.
6. Design of Machine tools: S. K. Basu.
7. Machine Tool Engineering: G. R. Nagpal.
8. The Design and construction of M/C tools: H. C. Town.
9. Machine Tools Design Hand Books: C.M.T.I.

Course time plan

Units/ Topics	Number of Lectures (Duration = 1 hour)	Methods of delivery
Unit I-: Introduction and Reference Systems	4	1. Lecture using board and chalk. 2. Discussion/ Interaction. 3. Demonstration using presentations.
Unit II - Chip Formation and Mechanics	5	
Unit III - Materials and Failure of Cutting Tools	4	
Unit IV - Measurement by Dynamometry	4	
Unit V - Economics of Machining	4	
Unit VI - Kinematics of Machine Tools	5	
Unit VII - Design Considerations	4	
Total	30	

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181822	**Project-2**	**0-0-12**	**6**

Evaluation Plan for 8th Semester B. Tech Project
Marks: CE = 100, ESE = 50

CO 1: Choose mechanical and allied problems having engineering and present day importance
CO 2: Analyze mechanical and allied engineering problems for meaningful data extraction, presentation and interpretation
CO 3: Show skill for project management and effective solutions for mechanical and allied engineering problems
CO 4: Evaluate solutions in the context of practical utility, sustainability and environment impact
CO 5: Develop leadership skill and personality for team work

Out of 5 COs, four COs (CO1, CO2, CO4 and CO5) will be attained in two progress seminars as CA component [Total=100 marks] and CO3 will be attained in ESE [50] marks.

Progress Seminar-I

COs	Components	Marks
CO-1	Novelty of Idea (Title)	10
CO-2	Literature Survey	10
	Objectives & Methodology	10
	Progress of work	10
	Total marks	40

Progress Seminar-II

COs	Components	Marks
CO-4	Results and Discussion	30
	Conclusions and Future Scope	10
CO-5	Communication skill	10
	Leadership/ Personality	10
	Total marks	60

ESE (Viva Voce + Supervisor)

COs		Components	Marks
CO-3	Supervisor	Knowledge and Contribution	20
	Viva Voce (External + Internal)	Thesis	10
		Engineering Knowledge	20
		Total marks	50

Course Code	Course Title	Hours per week L-T-P	Credit C
ME181823	**Grand Viva-voce - II**	**0-0-0**	**1**

COURSE OUTCOMES

A successful student in the grand viva will be able to demonstrate knowledge in the following domains:

CO1: Applied Mechanics

CO2: Thermal & Fluid Engineering

CO3: Design Engineering

CO4: Manufacturing & Management

EVALUATION PLAN

The students would appear before a board of examiners during the end of the semester. The schedule of examination will be notified to the students at least 7 days prior to the examination.

Contact us:

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