CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET281	MECHANICS OF MATERIALS	VAC	3	1		4

Preamble:

This course helps the students to understand the concept of stress and strain, and practice the methodologies to analyze different types of structures under various loading conditions. The course also covers simple and compound stresses due to forces, stresses and deflection in beams due to bending, torsion of shafts.

Prerequisite: EST100 ENGINEERING MECHANICS

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Discuss the concepts of stress and strain in deformable bodies due to structural and thermal loading
CO 2	Analyse the behaviour of materials under shear stress due to torsional loads acting in simple structural members
CO 3	Analyse beams using graphical and analytical methods to determine slope, deflection and stress
CO 4	Transform stresses and strains for plane stress problems mathematically and graphically and determine the principal stresses and its directions
CO 5	Analyze simple structures subjected to compound stresses, and columns subjected to buckling conditions

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									1
CO 2	3	2	2									2
CO 3	3	3	2									1
CO 4	3	3	2									1
CO 5	3	2	2									1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	50
Apply	20	20	30
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1):

1. Discuss normal strain and shear strain.

2. Determine the deformation of axially loaded bars.

3. State the principle of superposition.

Course Outcome 2 (CO2)

1. Compare the strength of a hollow shaft and a solid shaft.

2. List four important assumptions in the theory of torsion.

3. Determine the shear stress developed in a circular shaft subjected to torsional loading.

Course Outcome 3 (CO3):

1. Draw the Shear Force Diagram and Bending Moment Diagram of a beam.

2. Determine the bending stress and shear stresses in beams.

3. Explain pure bending with example.

Course Outcome 4 (CO4):

1. Estimate the deflection of the beam.

2. Discuss principal planes and principal stresses.

3. Determine principal stresses, maximum shear stress, plane of maximum shear stress and the resultant stress on the plane of maximum shear stress

Course Outcome 5 (CO5):

1. Draw the Mohr's circle.

2. Discuss the behaviour of structures under compound loading.

3. Calculate the safe buckling load.

MODEL QUESTION PAPER

THIRD SEMESTER MECHANICAL ENGINEERING
MET281 MECHANICS OF MATERIALS

Time: 3 hrs **Max. Marks: 100**

PART – A
(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

1. Discuss the significance of Poisson's ratio.
2. Explain Hooke's law for linearly elastic isotropic material.
3. List the important assumptions in the theory of torsion.
4. Explain the term 'point of inflection'.
5. Define i) section modulus and ii) flexural rigidity
6. Explain how shear stress is distributed over the cross section of a rectangular beam.
7. Explain how double integration method can be used to obtain slope and deflection of beams.
8. Define principal stresses and principal planes and explain its significance
9. Draw the Mohr's circle for uniaxial tensile load acting on a mild steel bar.
10. Write a short note on Rankine's crippling load for a column.

PART – B
(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

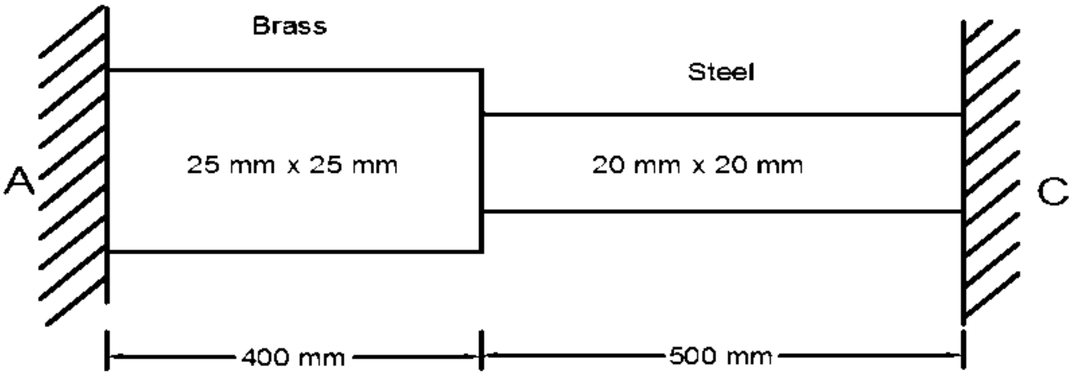
MODULE – 1

11. a) Draw a typical stress strain curve for mild steel under tension, describing briefly the salient points . (7 marks)

    b) A steel bar is fastened between two copper bars as shown in figure. The assembly is subjected to loads at positions as in figure. Calculate the total deformation of the bar and stresses at each section. E_{steel} = 200 GPa and E_{copper} = 110 GPa. (7 marks)

OR

12. a) A bar made of brass and steel as shown in figure is held between two rigid supports A and C. Find the stresses in each material if the temperature rises by 40°C. Take $E_b = 1\times10^5$ N/mm^2; $\alpha_b = 19 \times 10^{-6}$ / °C, $E_s = 2 \times 10^5$ N/mm^2 ; $\alpha_s = 12 \times 10^{-6}$ / °C. (9 marks)



b) A straight bar 450 mm long is 40 mm in diameter for the first 250 mm length and 20 mm diameter for the remaining length. If the bar is subjected to an axial pull of 15 kN, find the maximum and minimum stresses produced in it and the total extension of the bar. Take $E = 2 \times 10^5$ N/mm^2. (5 marks)

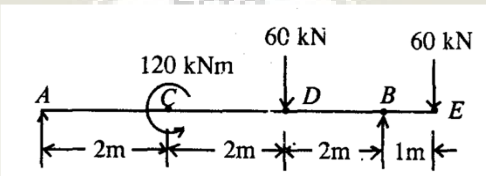
MODULE – 2

13. a) A solid aluminium shaft 1 m long and 50 mm diameter is to be replaced by a tubular steel shaft of the same length and the same outside diameter such that each of the two shafts could have the same angle of twist per unit torsional moment over the total length. What must the inner diameter of the tubular steel shaft be? Modulus of rigidity of the steel is three times that of aluminium. (10 marks)

b) A solid steel shaft transmits 20 kW at 120 rpm. Determine the smallest safe diameter of the shaft if the shear stress is not to exceed 40 MPa. (4 marks)

OR

14. a) Draw shear force and bending moment diagram for the beam given in the figure and mark all the salient points. (10 marks)

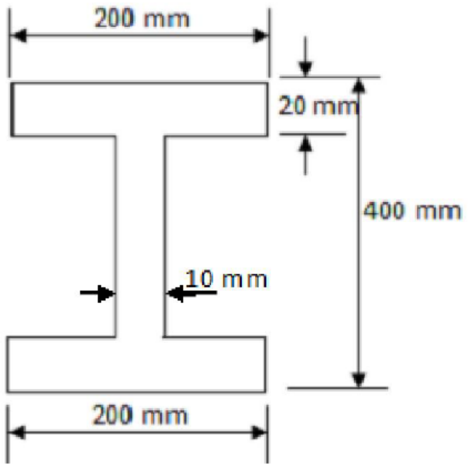


b) Explain the sign conventions used for shear forces and bending moments. (4 marks)

MODULE – 3

15. a) Derive the flexure formula for pure bending of a beam. State the assumptions (9 marks)

b) A rolled steel joist of I section has the dimensions as shown in figure. The beam carries a uniformly distributed load of 40 kN/mm^2 run on a span of 10 m, calculate the maximum stress produced due to bending. (5 marks)



OR

16. a) At the critical section of a beam of rectangular cross section with height 200 mm and width 100 mm, the value of the vertical shear force is 40 kN. Draw the shear stress distribution across the depth of the section. (9 marks)

    b) Derive the expression for shear stress in a beam. (5 marks)

MODULE – 4

17. a) A horizontal girder of steel having uniform section is 14 m long and is simply supported at its ends. It carries concentrated loads of 120 kN and 80 kN at two points 3 m and 4.5 m from the two ends respectively. Moment of inertia for the section of the girder is 16×10^8 mm^4 and E_s = 210 kN/mm^2. Calculate the deflection of the girder at points under the two loads and maximum deflection using Macaulay's method. (10 marks)

    b) A rectangular block of material is subjected to a tensile stress of 110 N/mm^2 on one plane and a tensile stress of 47 N/mm^2 on a plane at right angles, together with shear stresses of 63 N/mm^2 on the same planes. Find the magnitude of the principal stresses and maximum shear stress. (4 marks)

OR

18. a) Derive the transformation equations to determine normal and shear stress on an oblique plane. (10 marks)

    b) Define state of stress at point. Show the components of stress on a 3D rectangular element (4 marks)

MODULE – 5

19. a) At a point in a bracket the stresses on two mutually perpendicular planes are 120 N/mm^2 and 60 N/mm^2 both tensile. The shear stress across these planes is 30 N/mm^2. Find using the Mohr's stress circle i) Principal stresses at the point, ii) Maximum shear stress and iii) resultant stress on a plane inclined at 60° to the axis of the major principal stress. (10 marks)

b) Explain with the help of an example, how to calculate the normal stress when axial and transverse loads act simultaneously. (4 marks)

OR

20. a) Find the crippling load for a hollow steel column 50mm internal diameter and 5mm thick. The column is 5m long with one end fixed and other end hinged. Use Rankine's formula and Rankine's constant as 1/7500 and σ_c = 335 N/mm^2. (9 marks)

b) Derive Euler's formula for a column with both ends hinged. (5 marks)

SYLLABUS

Module 1

Introduction to analysis of deformable bodies – internal forces – method of sections – assumptions and limitations. Stress – stresses due to normal, shear and bearing loads – strength design of simple members. Definition of linear and shear strains.
Material behavior – uniaxial tension test – stress-strain diagrams – Hooke's law for linearly elastic isotropic material under axial and shear deformation, Poisson's ratio, Relationship between Young's modulus, Poisson's ratio and rigidity modulus(no derivations)
Deformation in axially loaded bars – thermal effects – statically indeterminate problems – principle of superposition.

Module 2

Torsion: Shafts - torsion theory of elastic circular bars – assumptions and limitations – polar modulus - torsional rigidity – economic cross-sections – statically indeterminate problems – shaft design for torsional load.
Beams- classification - diagrammatic conventions for supports and loading - axial force, shear force and bending moment in a beam.

Shear force and bending moment diagrams for simply supported, cantilever and overhanging beams (with concentrated loads, moment and uniformly distributed loads only), point of inflection and contraflexure

Module 3

Stresses in beams: Pure bending – flexure formula for beams assumptions and limitations – section modulus – flexural rigidity – economic sections, Problems to calculate bending stress for rectangular and I cross sections.

Shearing stress formula for beams – assumptions and limitations – Problems to calculate shear stress for beams of rectangular cross section.

Module 4

Deflection of beams: Moment-curvature relation – assumptions and limitations - double integration method – Macaulay's method.

Transformation of stress and strains: Definition of state of stress at a point (introduction to stress and strain tensors and its components only) -plane stress – plane strain - equations of transformation (2D) - principal planes and stresses - analogy between stress and strain transformation

Module 5

Mohr's circles of stress (2D)
Compound stresses: Combined axial, flexural and shear loads – combined bending and twisting loads.

Theory of columns: Buckling theory – Euler's formula for long columns – assumptions and limitations – effect of end conditions – slenderness ratio – Rankine's formula for intermediate columns.

Text Books

1. S.S Rattan, "Strength of Materials", McGraw Hill, 2nd edition, 2011.

Reference Books

1. Surya Patnaik, Dale Hopkins, Strength of Materials, Butterworth-Heinemann, 1st edition, 2003.
2. S. H. Crandal, N. C. Dhal, T. J. Lardner, An introduction to the Mechanics of Solids, McGraw Hill, 1999.
3. Mechanics of Materials, Pytel A. and Kiusalaas J. Cengage Learning India Private Limited, 2nd Edition, 2015
4. R. C. Hibbeler, Mechanics of Materials, Pearson Education, 2008.
5. I.H. Shames, J. H. Pitarresi, Introduction to Solid Mechanics, PHI, 2006.
6. James M. Gere, Mechanics of Materials, Brooks/Cole–Thomson Learning, 2004.
7. F. P. Beer, E. R. Johnston, J. T. DeWolf, Mechanics of Materials, Tata McGraw Hill, 2011.
8. MIT Open Courseware web course http://web.mit.edu/emech/dontindex-build/
9. Egor P. Popov, "Engineering Mechanics of Solids", PHI, 2nd edition, 2002.

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1	**Module 1: Introduction to Stress and Strain Analysis**	**9**
1.1	Introduction to analysis of deformable bodies – internal forces – method of sections – assumptions and limitations.	1
1.2	Stress – stresses due to normal, shear and bearing loads – strength design of simple members. Definition of linear and shear strains.	2
1.3	Material behavior – uniaxial tension test – stress-strain diagrams for ductile and brittle materials under axial loading, significance of various points on the diagram	1
1.4	Hooke's law for linearly elastic isotropic material under axial and shear deformation, Poisson's ratio.	1
1.5	Relationship between Young's modulus, Poisson's ratio and rigidity modulus(no derivations)	1
1.6	Deformation in axially loaded bars – thermal effects – statically indeterminate problems – principle of superposition	3
2	**Module 2: Torsion and Introduction to beams**	**9**
2.1	Introduction to Torsion of Shafts – torsion theory of elastic circular bars – assumptions and limitations	1
2.2	Polar modulus - torsional rigidity – economic cross-sections – statically indeterminate problems	2
2.3	Shaft design for torsional load and numerical problems	1
2.4	Introduction to beam bending – sign conventions for supports, loads and moments, classifications of beams, demonstration of the behaviour of beams for various types of loads	2
2.5	Shear force and bending moment diagrams for simply supported, cantilever and overhanging beams (with concentrated loads, moment and uniformly distributed loads only), point of inflection and contraflexure (simple problems to draw the SF and BM diagrams)	3
3	**Module 3: Beam Bending**	**9**
3.1	Stresses in beams: Pure bending – flexure formula for beams assumptions, limitations and derivation	3
3.2	Section modulus – flexural rigidity – economic sections –, numerical problems to analyze the strength of beams (rectangular and I sections only)	3
3.3	Shearing stress in beams – assumptions and limitations – derivation of formula for shear stress, problems to calculate shear stress for beams of rectangular cross section	3
4	**Module 4: Deflection of Beams and Stress-Strain transformations**	**9**
4.1	Introduction to deflection of beams: Moment-curvature relation – assumptions and limitations	1

4.2	Double integration method – Macaulay's method – Simple problems to calculate deflection of cantilever and simply supported beams subjected to point load, moment and UDL	3
4.3	Definition of stress at a point (introduction to stress and strain tensors and its components only), plane stress, plane strain	2
4.4	Stress and strain transformations in 2D – transformation equations - analogy between stress and strain transformation	1
4.5	Determination of principal stresses and principal planes	2
5	**Module 5: Mohr's Circle, Compound Stress and Column Buckling**	**9**
5.1	Mohr's circles of stress (2D) – problems	2
5.2	Compound stresses: Combined axial, flexural and shear loads – discussion of practical situations of combined loading and compound stresses	2
5.3	Combined bending and twisting loads	1
5.4	Introduction to Buckling of columns – Buckling theory – Euler's formula for long columns – assumptions and limitations	2
5.5	Effect of end conditions – slenderness ratio – Rankine's formula for intermediate columns – numerical problems for maximum buckling	2

CODE MET282	COURSE NAME THEORY OF MACHINES	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:

Goal of this course is to expose the students to the fundamentals of kinematics of mechanisms, design of cams, theory and analysis of gears, gear trains, clutches, brakes. The students will also be exposed to velocity and acceleration analysis of different mechanisms. It provides the knowledge on balancing of rotating and reciprocating masses, Gyroscopes, Energy fluctuation in Machines.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Interpret basic principles of mechanisms and machines and Analyse a given mechanism based on velocity and acceleration. List the basic selection requirements of different types of mechanical clutches.
CO 2	Describe the theories of gears and gear trains. List the basic selection requirements of different types of mechanical brakes.
CO 3	Develop the profile of CAMs as per the requirements and to understand cam profile.
CO 4	Explain the dynamic balancing of revolving and reciprocating masses. Describe the fundamentals of gyroscope and its application.
CO 5	Analyse the performance of governors and flywheels.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	2		3						2
CO 2	3	3	2	2		3						2
CO 3	3	3	2	2		3						2
CO 4	3	3	3	2		1						1
CO 5	3	3	3	3		1						3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	**2**	
Remember			
Understand	30	40	80
Apply		10	10
Analyse	20		10
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1): *Interpret basic principles of mechanisms and machines. Analyse a given mechanism based on velocity and acceleration. List the basic selection requirements of different types of mechanical clutches.*

1. Explain the inversions of a four bar mechanism.
2. Explain with neat sketches, the working of single plate clutch.
3. The crank of a slider crank mechanism rotates clockwise at a constant speed of 300 r.p.m. The crank is 150 mm and the connecting rod is 600 mm long. Determine: 1. Linear velocity and acceleration of the midpoint of the connecting rod, and 2. angular velocity and angular acceleration of the connecting rod, at a crank angle of 45° from inner dead centre position

Course Outcome 2 (CO2) *Describe the theories of gears and gear trains. List the basic selection requirements of different types of mechanical brakes.*

1. State and prove the law of gearing
2. In an epicyclic gear train, an arm carries two gears A and B having 36 and 45 teeth respectively. If the arm rotates at 150 rpm in the anticlockwise direction about the centre of the gear A which is fixed, determine the speed of gear B. If the gear A instead of being fixed makes 300 rpm in the clockwise direction, what will be the speed of gear B?
3. Discuss the various types of the brakes.

Course Outcome 3 (CO3): *Develop the profile of CAMs as per the requirements and and to understand cam profile.*

1. Explain the different classifications of cam and followers.
2. Draw the displacement, velocity and acceleration diagrams when the follower moves in SHM.
3. A cam with 30 mm as minimum diameter is rotating clockwise at a uniform speed of 1200 r.p.m. and has to give the following motion to a roller follower 10 mm in diameter:
   a) Follower to complete outward stroke of 25 mm during 120° of cam rotation with equal uniform acceleration and retardation;
   b) (b) Follower to dwell for 60° of cam rotation;
   c) (c) Follower to return to its initial position during 90° of cam rotation with equal uniform acceleration and retardation;
   d) (d) Follower to dwell for the remaining 90° of cam rotation.

   Draw the cam profile if the axis of the roller follower passes through the axis of the cam.

Course Outcome 4 (CO4): *Explain the static and dynamic balancing of revolving and reciprocating masses. Describe the fundamentals of gyroscope and its application*

1. Four masses m1, m2, m3 and m4 are 200 kg, 300 kg, 240 kg and 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the angles between successive masses are 45°, 75° and 135°. Find the position and magnitude of the balance mass required, if its radius of rotation is 0.2 m.

2. Explain with neat sketches, the terms Swaying Couple and Hammer Blow.

3. A ship propelled by a turbine rotor which has a mass of 5000 kg and a speed of 2100 r.p.m. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Find the gyroscopic effects in the following conditions:

   a. The ship sails at a speed of 30 km/h and steers to the left in a curve having 60 m radius.

   b. The ship pitches 6 degree above and 6 degree below the horizontal position. The bow is descending with its maximum velocity. The motion due to pitching is simple harmonic and the periodic time is 20 seconds.

   c. The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/s clockwise when viewed from stern.

   Determine also the maximum angular acceleration during pitching. Explain how the direction of motion due to gyroscopic effect is determined in each case.

Course Outcome 5 (CO5): *Analyse the performance of governors and flywheels.*

1. The turning moment diagram for a petrol engine is drawn to the following scales : Turning moment, 1 mm = 5 N-m ; crank angle, 1 mm = 1°. The turning moment diagram repeats itself at every half revolution of the engine and the areas above and below the mean turning moment line taken in order are 295, 685, 40, 340, 960, 270 mm^2. The rotating parts are equivalent to a mass of 36 kg at a radius of gyration of 150 mm. Determine the coefficient of fluctuation of speed when the engine runs at 1800 r.p.m

2. Explain the different types of governors.

3. The arms of a Porter governor are each 250 mm long and pivoted on the governor axis. The mass of each ball is 5 kg and the mass of the central sleeve is 30 kg. The radius of rotation of the balls is 150 mm when the sleeve begins to rise and reaches a value of 200 mm for maximum speed. Determine the speed range of the governor. If the friction at the sleeve is equivalent of 20 N of load at the sleeve, determine how the speed range is modified.

SYLLABUS

Module 1: Kinematics - Links, mechanism, Degrees of freedom, Grashoff's law. Four-bar chain, Slider crank chain- Inversions and practical applications. Velocity and acceleration diagrams of simple mechanisms. Coriolis acceleration (Theory only). Friction clutch - Pressure and wear theories, pivot and collar friction, Single and multiple disc clutches.

Module 2: Gear – Classification of gears- Gear terminology- Law of gearing, Gear trains - Simple, compound gear trains and epicyclic gear trains. Brakes - Block and band brakes, self-energizing and self-locking in braking.

Module 3: Cams- Types of cams, cam profiles for knife edged and roller followers with and without offsets for SHM, constant acceleration-deceleration, and constant velocity

Module 4: Static and dynamic balancing of rotating mass- Single and several masses in different planes. Balancing of reciprocating mass. Gyroscope –Gyroscopic torque, gyroscopic stabilization of ships and aeroplanes.

Module 5: Governors - Types of governors- simple watt governor - Porter governor- Theory of Proell governor - Isochronism, hunting, sensitivity and stability. Flywheel - Turning moment diagrams, fluctuation of energy

Text Books

1. Ballaney P.L. Theory of Machines, Khanna Publishers,1994

2. S. S. Rattan, Theory of Machines, Tata McGraw Hill, 2009

3. V. P. Singh, Theory of Machines, Dhanpat Rai,2013

Reference Books

1. C. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education,2005
2. D. H. Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education,2013
3. G. Erdman, G. N. Sandor, Mechanism Design: Analysis and synthesis Vol I & II, Prentice Hall of India,1984.
4. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press,1988
5. J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, McGraw Hill,2010
6. Holowenko, Dynamics of Machinery, John Wiley, 1995

COURSE PLAN

No	Topic	No. of Lectures
1	**Module 1 (CO1)**	
1.1	Introduction to link, constrained motions, mechanism, machine	1
1.2	Degrees of freedom, Problem, Grashof's law	1
1.3	Inversion – Four Bar chain – Single Slider Chain – Practical Applications	2
1.4	Velocity Analysis – I Centre Methos – Relative Velocity Method	2
1.5	Acceleration Analysis - Four Bar Mechanism – Single Slider Chain	2
1.6	Corriolis Component of Acceleration –Quick Return Mechanisms	2
1.7	Clutches – Theories - Classifications	1
2	**Module 2 (CO2)**	
2.1	Gear – Classifications – Terminology – Law of Gearing – Velocity of Sliding – Interference - Problems	3
2.2	Gear Train –Classifications - Problems on Epi cyclic gear trains	3
2.3	Brake – Theory – Classifications	2
3	**Module 3 (CO3)**	
3.1	Cam – Introduction - Classifications	1
3.2	Velocity and Acceleration Diagrams – Uniform Velocity – Uniform Acceleration and Deceleration – SHM – Calculations	2
3.3	Construction of Cam Profile	4
4	**Module 4 (CO4)**	
4.1	Static and dynamic balancing of rotating masses –Single and several masses in different planes	2
4.2	Balancing of reciprocating masses	3
4.3	Gyroscope – Introduction – Stabilization of Ships	2
4.4	Stabilization of Air Planes	2
5	**Module 5 (CO5)**	
5.1	Governors – Introduction –Classifications	2
5.2	Analytical Problems	2
5.3	Hunting – Sensitivity – Isochronism -Stability	2
5.4	Flywheels – Turning Moment Diagrams –Fluctuation of Energy	2
5.5	Analytical Problems	2

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET282

Course Name : THEORY OF MACHINES

Max. Marks : 100 Duration : 3 Hours

PART – A

(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

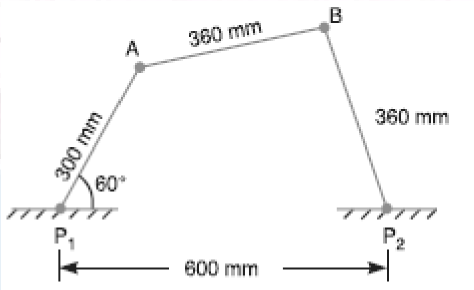
1. Write down the Kutzbach criterion of movability of plane mechanisms. Derive the Grubler's equation from it.
2. Explain the types of constrained motions with neat sketches.
3. With a neat sketch prove the common normal at the point of contact between a pair of teeth must always pass through the pitch point.
4. Explain the terms : (i) Module, (ii) Pressure angle, and (iii) Addendum.
5. Explain the different classifications of followers.
6. Define the following terms as applied to cam with a neat sketch :-(a) Base circle, (b) Pitch circle, (c) Pressure angle
7. Why reciprocating masses is cannot be completely balanced by revolving mass?
8. Derive the formula for the magnitude of gyroscopic couple.
9. Write down the differences between a gyroscope and a flywheel.
10. Explain the term hunting and isochronism.

PART – B

(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

MODULE – 1

11. The dimensions and configuration of the four bar mechanism, shown in Figure, are as follows : P_1A = 300 mm; P_2B = 360 mm; AB = 360 mm, and P_1P_2 = 600 mm. The angle AP_1P_2 = 60°. The crank P_1A has an angular velocity of 10 rad/s and an angular acceleration of 30 rad/s2, both clockwise. Determine the angular velocities and angular accelerations of P_2B, and AB and the velocity and acceleration of the joint B. (14 marks)



OR

12. a) With neat sketches explain the inversions of a four bar mechanism. (7 marks)

b) Derive the equation for the corrioli's component of acceleration. (7 marks)

MODULE – 2

13. An internal wheel B with 80 teeth is keyed to a shaft F. A fixed internal wheel C with 82 teeth is concentric with B. A compound wheel D-E gears with the two internal wheels; D has 28 teeth and gears with C while E gears with B. The compound wheels revolve freely on a pin which projects from a disc keyed to a shaft A co-axial with F. If the wheels have the same pitch and the shaft A makes 800 r.p.m., what is the speed of the shaft F ? Sketch the arrangement.

(14 marks)

OR

14. a) What do you mean by a self-energizing brake and self-locking brake. (4 Marks)

b) A simple band brake operates on a drum of diameter 600 mm that is running at a speed of 200 rpm. The coefficient of friction is 0.3. The brake band has an angle of contact of 270^0. One end of it is fastened to a fixed pin and the other end to the brake arm 125 mm and is placed perpendicular to the line bisecting the angle of contact.

i. What is the effort necessary at the end of brake arm to stop the wheel if 30 kW power is absorbed? What is the direction of rotation of drum for minimum pull?

ii. What is the width of steel band required for this brake if the maximum tensile stress is not to exceed 50 N/mm^2 and the thickness of band is 2.5 mm.

(10 marks)

MODULE – 3

15. A cam rotating clockwise at a uniform speed of 1000 r.p.m. is required to give a roller follower the motion defined below : 1. Follower to move outwards through 50 mm during 120° of cam rotation, 2. Follower to dwell for next 60° of cam rotation, 3. Follower to return to its starting position during next 90° of cam rotation, 4. Follower to dwell for the rest of the cam rotation. The minimum radius of the cam is 50 mm and the diameter of roller is 10 mm. The line of stroke of the follower is off-set by 20 mm from the axis of the cam shaft. If the displacement of the follower takes place with uniform and equal acceleration and retardation on both the outward and return strokes, draw profile of the cam. (14 marks)

OR

16. From the following data, draw the profile of a cam in which the follower moves with simple harmonic motion during ascent while it moves with uniformly accelerated motion during descent : Least radius of cam = 50 mm ; Angle of ascent = 48° ; Angle of dwell between ascent and descent = 42° ; Angle of descent = 60° ; Lift of follower = 40 mm ; Diameter of roller = 30 mm ; Distance between the line of action of follower and the axis of cam = 20 mm. If the cam rotates at 360 r.p.m. anticlockwise, find the maximum velocity and acceleration of the follower during descent. (14 marks)

MODULE – 4

17. a) A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg, 400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 70° and C to D 120°. The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100 mm, between X and Y is 400 mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm, find their magnitudes and angular positions. (10 marks)

    b) Explain the term swaying couple and hammer blow (4 marks)

OR

18. A ship propelled by a turbine rotor which has a mass of 5000 kg and a speed of 2100 r.p.m. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Find the gyroscopic effects in the following conditions: 1. The ship sails at a speed of 30 km/h and steers to the left in a curve having 60 m radius. 2. The ship pitches 6 degree above and 6 degree below the horizontal position. The bow is descending with its maximum velocity. The motion due to pitching is simple harmonic and the periodic time is 20 seconds. 3. The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/s clockwise when viewed from stern. Determine also the maximum angular acceleration during pitching. Explain how the direction of motion due to gyroscopic effect is determined in each case.

(14 marks)

MODULE – 5

19. a) A Porter governor has all four arms 250 mm long. The upper arms are attached on the axis of rotation and the lower arms are attached to the sleeve at a distance of 30 mm from the axis. The mass of each ball is 5 kg and the sleeve has a mass of 50 kg. The extreme radii of rotation are 150 mm and 200 mm. Determine the range of speed of the governor. (10 marks)

b) What is stability of a governor? How does it differ from sensitiveness? (4marks)

OR

20. A three cylinder single acting engine has its cranks set equally at 120° and it runs at 600 r.p.m. The torque-crank angle diagram for each cycle is a triangle for the power stroke with a maximum torque of 90 N-m at 60° from dead centre of corresponding crank. The torque on the return stroke is sensibly zero. Determine : 1. power developed. 2. coefficient of fluctuation of speed, if the mass of the flywheel is 12 kg and has a radius of gyration of 80 mm, 3. coefficient of fluctuation of energy, and 4. maximum angular acceleration of the flywheel. (14 marks)

CODE MET283	COURSE NAME FLUID MECHANICS AND MACHINERY	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble:

This course provides an introduction to the properties and behaviour of fluids. It enables to apply the concepts in engineering. The course also gives an introduction of hydraulic pumps and turbines.

Prerequisite: NIL

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Define Properties of Fluids and Solve hydrostatic problems
CO 2	Explain fluid kinematics and Classify fluid flows
CO 3	Interpret Euler's equation and Solve problems using Bernoulli's equation
CO 4	Explain the working of turbines and Select a turbine for specific application.
CO 5	Explain the characteristics of centrifugal and reciprocating pumps

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2										
CO 2	3	2	1									
CO 3	3	2	1									
CO 4	3	2	1									
CO 5	3	2	1									

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

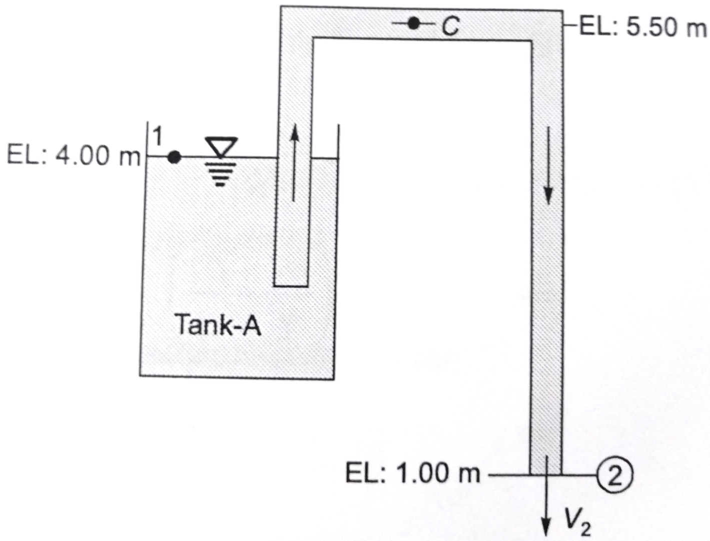
1. Define total pressure on a surface and center of pressure on a surface. What do you understand by the term hydrostatic pressure ?
2. An isosceles triangle of base 3m and altitude 6m is immersed vertically in water with its axis of symmetry horizontal. If the head on its axis is 9m, locate the center of pressure.
3. A triangular plate of 2m base and 2.5m altitude is immersed in water at an inclination of 30°with the base parallel to and at a depth of 2m from the free surface. Find the total hydrostatic force on the side of the plate and the position of its action.

Course Outcome 2

1. Define the following and give one practical example for each of the following:
   (a) laminar flow
   (b) Turbulent flow
   (c) Steady flow
   (d) Uniform flow
2. A two dimensional flow is described by the velocity components, $u = 5x^3; v = -15x^2y$. Evaluate the stream function, velocity, and acceleration at point P(1,2).
3. For the velocity components u = ay sin(xy) and v = ax sin(xy), obtain an expression for the velocity potential function.

Course Outcome 3

1. Derive the Euler's equation of motion along a streamline and from that derive the Bernouli's equation.
2. Oil of specific gravity 0.8 flows through a 0.2 m diameter pipe under a pressure of 100 KPa. If the datum is 5 m below the center line of the pipe and the total energy with respect to the datum is 35 N m/N. Calculate the discharge.
3. A siphon consisting of a pipe of 15 cm diameter is used to empty kerosene oil (relative density=0.8) from tank A. The siphon discharges to the atmosphere at an elevation of 1.00 m. The oil surface in the tank is at an elevation of 4.00 m. The center line of the siphon pipe at its highest point C is at an elevation of 5.50 m. Estimate,



(a) Discharge in the pipe

(b) Pressure at point C.

Course Outcome 4

1. Differentiate between impulse and reaction turbine.

2. Prove that for a single jet Pelton wheel, the specific speed is given by the relation

$$N_s = 219.78\frac{d}{D}\sqrt{\eta_o}$$

3. A Pelton wheel having semicircular buckets and working under a head of 120 m is running at 500 rpm. The discharge through the nozzle is 40 L/s and the diameter of the wheel is 50 cm. Find the following:

    (a) The power available at the nozzle.

    (b) Hydraulic efficiency of the wheel, if coefficient of velocity is 0.96.

Course Outcome 5

1. Distinguis between positive displacement pump and roto dynamic pump

2. Expalin the phenomenon of cavitation and methods to avoid it

3. Explain the significance of NPSH in the installation of a centrifugal pump

SYLLABUS

Module 1

Fundamental concepts: Properties of fluid - density, specific weight, viscosity, surface tension, capillarity, vapour pressure, bulk modulus, compressibility, velocity, rate of shear strain, Newton's law of viscosity, Newtonian and non-Newtonian fluids, real and ideal fluids, incompressible and compressible fluids.

Module 2

Fluid statics: Atmospheric pressure, gauge pressure and absolute pressure. Pascal's Law, measurement of pressure - piezo meter, manometers, pressure gauges, energies in flowing fluid, head - pressure, dynamic, static and total head, forces on planar surfaces immersed in fluids, centre of pressure, buoyancy, equilibrium of floating bodies, metacentre and metacentric height.

Fluid kinematics and dynamics: Classification of flow -1D, 2D and 3D flow, steady, unsteady, uniform, non-uniform, rotational, irrotational, laminar and turbulent flow, path line, streak line and stream line.

Module 3

Continuity equation, Euler's equation, Bernoulli's equation. Reynolds experiment, Reynold's number. Hagen- Poiseuille equation, head loss due to friction, friction, Darcy- Weisbach equation, Chezy's formula, compounding pipes, branching of pipes, siphon effect, water hammer transmission of power through pipes (simple problems) .

Flow rate measurements- venturi and orifice meters, notches and weirs (description only for notches, weirs and meters), practical applications, velocity measurements- Pitot tube and Pitot – static tube.

Module 4

Hydraulic turbines : Impact of jets on vanes - flat, curved, stationary and moving vanes - radial flow over vanes. Impulse and Reaction Turbines – Pelton Wheel constructional features - speed ratio, jet ratio & work done , losses and efficiencies, inward and outward flow reaction turbines- Francis turbine constructional features, work done and efficiencies – axial flow turbine (Kaplan) constructional features, work done and efficiencies, draft tubes, surge tanks, cavitation in turbines.

Module 5

Positive displacement pumps: reciprocating pump, indicator diagram, air vessels and their purposes, slip, negative slip and work required and efficiency, effect of acceleration and friction on indicator diagram (no derivations), multi cylinder pumps.

Rotary pumps: –centrifugal pump, working principle, impeller, casings, manometric head, work, efficiency and losses, priming, specific speed, multistage pumps, selection of pumps, pump characteristics.

Text Books

1. Mahesh Kumar, Fluid Mechanics and Machines, Pearson, 1st edition, 2019.

2. Pati, S., Textbook of Fluid Mechanics and Hydraulic Machines, Tata McGraw Hill, 1st Edition, 2017.

Reference Books

1. Cimbala & Cengel, Fluid Mechanics: Fundamentals and Applications (4th edition, SIE) , McGraw Hill, 2019

COURSE CONTENTS AND LECTURE SCHEDULE

No	Topic	No. of Lectures
1		
1.1	Fundamental concepts: Properties of fluid - density, specific weight, viscosity, surface tension, capillarity, vapour pressure	3
1.2	Bulk modulus, compressibility, velocity, rate of shear strain, Newton's law of viscosity	3
1.3	Newtonian and non-Newtonian fluids, real and ideal fluids, incompressible and compressible fluids.	3
2		
2.1	Fluid statics: Atmospheric pressure, gauge pressure and absolute pressure. Pascal's Law, measurement of pressure - piezo meter, manometers, pressure gauges, energies in flowing fluid	3
2.2	Head - pressure, dynamic, static and total head, forces on planar surfaces immersed in fluids, centre of pressure, buoyancy, equilibrium of floating bodies, metacentre and metacentric height.	3

2.3	Fluid kinematics and dynamics: Classification of flow -1D, 2D and 3D flow, steady, unsteady, uniform, non-uniform, rotational, irrotational, laminar and turbulent flow, path line, streak line and stream line	3
3		
3.1	Continuity equation, Euler's equation, Bernoulli's equation. Reynolds experiment, Reynold's number. Hagen- Poiseuille equation	3
3.2	Head loss due to friction, friction, Darcy- Weisbach equation, Chezy's formula, compounding pipes, branching of pipes, siphon effect, water hammer transmission of power through pipes (simple problems)	3
3.3	Flow rate measurements- venturi and orifice meters, notches and weirs (description only for notches, weirs and meters), practical applications, velocity measurements- Pitot tube and Pitot –static tube	3
4		
4.1	Hydraulic turbines: Impact of jets on vanes - flat, curved, stationary and moving vanes - radial flow over vanes	3
4.2	Impulse and Reaction Turbines – Pelton Wheel constructional features - speed ratio, jet ratio & work done, losses and efficiencies, inward and outward flow reaction turbines- Francis turbine constructional features, work done and efficiencies	3
4.3	Axial flow turbine (Kaplan) constructional features, work done and efficiencies, draft tubes, surge tanks, cavitation in turbines	3
5		
5.1	Positive displacement pumps: reciprocating pump, indicator diagram, air vessels and their purposes	3
5.2	Slip, negative slip and work required and efficiency, effect of acceleration and friction on indicator diagram (no derivations), multi cylinder pumps	3
5.3	Rotary pumps: –centrifugal pump, working principle, impeller, casings, manometric head, work, efficiency and losses, priming, specific speed, multistage pumps, selection of pumps, pump characteristics	3

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

IV SEMESTER B.TECH DEGREE EXAMINATION

MET283: FLUID MECHANICS AND MACHINERY

Maximum: 100 Marks — Duration: 3 hours

PART A

Answer all questions, each question carries 3 marks

1. Define a fluid. What is the difference between ideal and real fluid?
2. Explain the phenomena of capillarity, Obtain the expression for capillary rise of a liquid
3. Distinguish between gauge pressure and absolute pressure.Estimate in meters the depth below the surface of a lake at which the pressure is equal to twice atmospheric pressure.
4. Define and distinguish between Streamline Streak line and path line
5. Water escapes from large storage tank through a small drain hole in the bottom.If the water depth is 2m, what is the exit velocity?If a similar tank contained gasoline what would be the exit velocity?
6. Oil of specific gravity 0.8 flows through a 0.2m diameter pipe under a pressure of 100 kN/m^2. If the datum is 5m below the center line of the pipe and the total energy with respect to the datum is 35m, Calculate the discharge.
7. Differentiate between impulse and reaction turbine
8. Explain the functions of Draft tube
9. Define slip and percentage slip of a reciprocating pump, what are the reasons for negative slip.
10. What are the different classifications of centrifugal pump?

(10×3=30 Marks)

PART B

Answer one full question from each module

MODULE-I

11. (a) Write a short note on surface tension. Derive expressions for the pressure

    i. within a droplet of water

    ii. inside a soap bubble

    (8 marks)

    (b) Define the term viscosity,on what factors does it depend and give the units in which it is expressed. (6 marks)

12. (a) A U-tube is made up of two capillaries of bores 1mm and 2.2mm respectively. The tube is held vertically with zero contact angle. It is partially filled with liquid of surface tension 0.06 N/m. If the estimated difference in the level of two menisci is 15mm, determine the mass density of the liquid. (7 marks)

    (b) A volume of 3.2 m^3 of certain oil weighs 27.5kN. Calculate its

    i. mass denisty

    ii. weight density

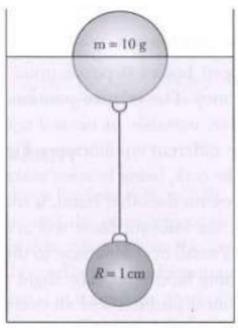
    iii. Specific volume

    iv. Specific gravity

    If the kinematic viscosity of the oil is $7 * 10^{-3}$ Stokes, what would be its dynamic viscosity in centipoises. (7 marks)

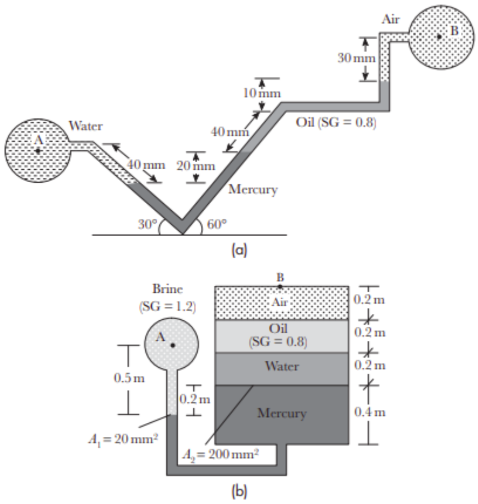
MODULE-II

13. (a) A steel ball of radius 1 cm is hanging inside the water tank by means of a string attached to a hollow plastic ball having raadius 3 cm weighing 10g floating at the free surface, as shown in Fig. Determine the tension in the string and volume of the plastic ball submerged in water. Take density of the steel ball to be 7850 kg/m^2 (7 marks)



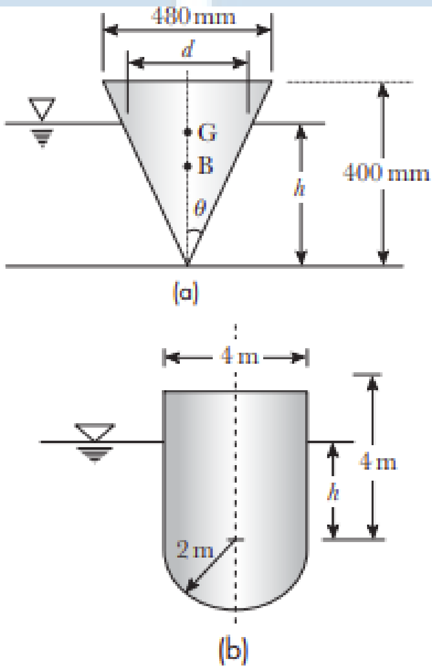
    (b) If the velocity distribution for a 2D ideal flow is given by $u = \frac{x}{2+t}, v = \frac{y}{1+3t}$ Obtain the equation of (a) the streamlines, (b) the pathlines, and (c) the streaklines that pass through point (1, 2) at t = 0. (7 marks)

14. (a) Find out the pressure difference between points A and B for the manometers shown in the figures



(7 marks)

(b) Check whether the floating objects having specific gravity 0.8 shown in Fig. are stable or not.

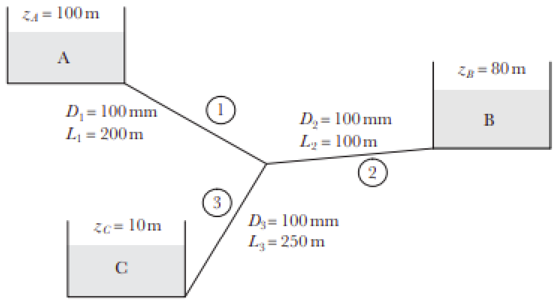


(7 marks)

MODULE-III

15. (a) The maximum velocity for the viscous flow through a 200mm diameter pipe is 3m/s. Determine the average velocity and the radial distance from the pipe axis at which it occurs. In addition, determine the velocity at 25mm from the pipe wall.(7 marks)

    (b) Determine the discharge in each branch of the pipe network shown in Fig. Assume same friction factor f = 0.03 in each pipe. (7 marks)



16. (a) Prove that for power transmission through pipes transmission power is maximum when head loss due to friction is one third of the power available at the inlet.(7 marks)

    (b) A 5km long water pipeline is used to transmit 200 kW of hydraulic power. If the pressure at the inlet is 6MPa and the pressure drop across the pipe length is 2MPa. Determine the pipe diameter and its transmission efficiency. Take the friction factor f = 0.04 (7 marks)

MODULE-IV

17. (a) A double jet Pelton wheel has a specific speed of 16 and is required to deliver 1200 kW. The turbine is supplied through a pipeline from a reservoir whose level is 380m above the nozzles. Allowing 8% for friction loss in the pipe, calculate the following:

      i. Speed in rpm
      ii. Diameter of the jet
      iii. Mean diameter of the bucket

    Assume $C_v = 0.98$, speed ratio = 0.46, and overall efficiency = 85% (10 marks)

    (b) Define the terms unit power, unit speed, ad unit discharge with reference to a hydraulic turbine. (4 marks)

18. (a) Show that the force exerted by a fluid jet in its direction of flow on a semicircular vane is twice that exerted on a flat plate, both plates being fixed in position. (7 marks)

    (b) A Keplan turbine runner is to be designed to develop 9000 kW. The net available head is 5.5m. Assume a speed ratio 2, flow ratio 0.65, and total efficiency 85%. The diameter of the boss is 1/3 the diameter of the runner. Find : (7 marks)

      i. Diameter of the runner.
      ii. Speed of the runner.
      iii. Specific speed of the turbine.

MODULE-V

19. (a) Draw the performance curves of a centrifugal pump. Also discuss the effect of blade outlet angles (7 marks)

(b) A centrifugal pump discharges 0.2 m^3/s of water at a head of 25 m when running at a speed of 1400 rpm.The manometric efficiency is 80%. If the impeller has an outer diameter of 30 cm and width of 5 cm, determine the vane angle at the outlet. (7 marks)

20. (a) A single acting reciprocating pump of 200 mm bore and 300 mm stroke runs at 30 rpm. The suction head is 4 m and the delivery head is 15 m. Considering acceleration determine the pressure in the cylinder at the beginning and end of suction and delivery strokes. Take the value of atmospheric pressure as 10.3 m of water head. The length of suction pipe is 8 m and that of delivery pipe is 20 m. The pipe diameters are 120 mm each (7 marks)

(b) The construction details of a centrifugal pump is as follows; Impeller diameter= 50 cm Impeller width=2.5 cm Speed= 1200 rpm Suction head= 6 m Delivery head= 40 m Outlet blade angle= 30°. Manometric efficiency : 80% Overall effrciency :75%. Determine the power required to drive the pump. Also calculate the pressures at the suction and delivery side of the pump. assume the frictional drop in suction is 2 m and in the delivery 8m and inlet swirl as zero (7 marks)

CODE MET284	COURSE NAME THERMODYNAMICS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	-	4

Preamble:

Thermodynamics is the study of energy. Without energy life cannot exist. Activities from breathing to the launching of rockets involves energy transactions and are subject to thermodynamic analysis. Engineering devices like engines, turbines, refrigeration and air conditioning systems, propulsion systems etc., work on energy transformations and must be analysed using principles of thermodynamics. So, a thorough knowledge of thermodynamic concepts is essential for a mechanical engineer. This course offers an introduction to the basic concepts and laws of thermodynamics.

Prerequisite: NIL

Course Outcomes:

After completion of the course the student will be able to

CO1	Understand basic concepts and laws of thermodynamics
CO2	Conduct first law analysis of open and closed systems
CO3	Determine entropy changes associated with different processes
CO4	Understand the application and limitations of the ideal gas equation of state
CO5	Determine change in properties of pure substances during phase change processes
CO6	Evaluate properties of ideal gas mixtures

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										2
CO2	2	2	1	1								1
CO3	3	3	2	2								1
CO4	2	2	2	2								1
CO5	3	3	2	1								1
CO6	3	3	2	2								1

Assessment Pattern

Blooms Category	CA			ESA
	Assignment	Test - 1	Test - 2	
Remember	25	20	20	10
Understand	25	40	40	20
Apply	25	40	40	70
Analyse	25			
Evaluate				
Create				

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

Mark distribution & Duration of Examination :

Total Marks	CA	ESE	ESE Duration
150	50	100	3 Hours

End semester pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1

1. Discuss the limitations of first law of thermodynamics.

2. Second law of thermodynamics is often called a directional law . Why?

3. Explain Joule-Kelvin effect. What is the significance of the inversion curve ?

Course Outcome 2

1. A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston – cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process.

2. Carbon dioxide enters an adiabatic nozzle steadily at 1 MPa and 500°C with a mass flow rate of 600 kg/hr and leaves at 100 kPa and 450 m/s. The inlet area of the nozzle is 40 cm^2. Determine (a) the inlet velocity and (b) the exit temperature

3. Water is being heated in a closed pan on top of a range while being stirred by a paddle – wheel. During the process, 30 kJ of heat is transferred to the water and 5 kJ of heat is lost to the surrounding air. The paddle – wheel work amounts to 500 N-m. Determine the final energy of the system, if its initial energy is 10 kJ.

Course Outcome 3

1.An adiabatic vessel contains 2 kg of water at 25˚C. B paddle – wheel work transfer, the temperature of water is increased to 30˚C. If the specific heat of water is assumed to be constant at 4.186 kJ/kg.K, find the entropy change of the universe.

2. Two kilograms of water at 80°C is mixed adiabatically with 3 kg of water at 30°C in a constant pressure process at 1 atm. Find the increase in entropy of the total mass of water due to the mixing process.

3. An iron block of unknown mass at 85^{o}C is dropped into an insulated tank that contains 0.1 m3 of water at 20^{o}C. At the same time a paddle-wheel driven by a 200 W motor is activated to stir the water. Thermal equilibrium is established after 20 minutes when the final temperature is 24^{o}C. Determine the mass of the iron block and the entropy generated during this process.

Course Outcome 4

1. Discuss the limitations of ideal gas equation.

2. Discuss law of corresponding states and its role in the construction of compressibility chart.

3. A rigid tank contains 2 kmol of N_2 and 6 kmol of CH_4 gases at 200 K and 12 MPa. Estimate the volume of the tank, using (a) ideal gas equation of state (b) the compressibility chart and Amagat's law

Course Outcome 5

1.Steam is throttled from 3 MPa and 600˚C to 2.5 MPa. Determine the temperature of the steam at the end of the throttling process.

2. Determine the change in specific volume, specific enthalpy and quality of steam as saturated steam at 15 bar expands isentropically to 1 bar. Use steam tables

3. Estimate the enthalpy of vapourization of steam at 500 kPa, using the Clapeyron equation and compare it with the tabulated value

Course Outcome 6

1. A gaseous mixture contains , by volume, 21%nitrogen, 50% hydrogen and 29 % carbon dioxide. Calculate the molecular weight of the mixture, the characteristic gas constant of the mixture and the value of the reversible adiabatic expansion index - γ. At 10˚C, the C_p values of nitrogen, hydrogen and carbon dioxide are 1.039, 14.235 and 0.828 kJ/kg.K respectively.

2. A mixture of 2 kmol of CO_2 and 3 kmol of air is contained in a tank at 199 kPa and 20˚C. Treating air to be a mixture of 79% N_2 and 21% O_2 by volume , calculate (a) the individual mass of CO_2 , N_2 and O_2, (b) the percentage content of carbon by mass in the mixture and (c) the molar mass , characteristic gas constant and the specific volume of the mixture

3. A gas mixture in an engine cylinder has 12% CO_2, 11.5 % O_2 and 76.5% N_2 by volume. The mixture at 1000˚C expands reversibly, according to the law $PV^{1.25}$ = constant, to 7 times its initial volume. Determine the work transfer and heat transfer per unit mass of the mixture.

SYLLABUS

Module 1: Role of Thermodynamics and it's applications in Engineering and Science –Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.

Module 2: Energy - Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity. Joule's Experiment- First law of Thermodynamics - First law applied to Non flow Process- Enthalpy- specific heats- PMM1, First law applied to Flow Process, Mass and Energy balance in simple steady flow process. Applications of SFEE, Limitations of the First Law.

Module 3: Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements, Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale. Clausius Inequality, Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process- isentropic process, Third law of thermodynamics.

Module 4: Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface, Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables. The ideal Gas Equation, Characteristic and Universal Gas constants, Limitations of ideal Gas Model: Equation of state of real substances, Compressibility factor, Law of corresponding state, Compressibility charts.

Module 5: Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law Equivalent Gas constant and Molecular Weight, Properties of gas mixtures: Internal Energy, Enthalpy, specific heats and Entropy. General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions - Maxwell's Relations, Tds Equations. The Clapeyron Equation, equations for internal energy, enthalpy and entropy, specific heats, Throttling process, Joule Thomson Coefficient, inversion curve.

Text Books

1. P. K. Nag, Engineering Thermodynamics, McGraw Hill, 2013

2. E. Rathakrishnan Fundamentals of Engineering Thermodynamics, PHI, 2005

3. Y. A. Cengel and M. A. Boles, Thermodynamics an Engineering Approach, McGraw Hill, 2011

Reference Books:

1. Moran J., Shapiro N. M., Fundamentals of Engineering Thermodynamics, Wiley, 2006

2. R. E. Sonntag and C. Borgnakke, Fundamentals of Thermodynamics, Wiley, 2009

3. Holman J. P. Thermodynamics, McGraw Hill, 2004

4. M. Achuthan, Engineering Thermodynamics, PHI, 2004

COURSE PLAN

Module	Topics	Hours Allotted
1	Role of Thermodynamics and it's applications in Engineering and Science – Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe	2L
	Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function.	2L
	Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.	2L + 1T
2	Energy - Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity.	2L + 1T
	Joule's Experiment- First law of Thermodynamics - First law applied to Non flow Process- Enthalpy- specific heats- PMM1	2L + 1T
	First law applied to Flow Process, Mass and Energy balance in simple steady flow process. Applications of SFEE, Limitations of first law	2L + 1T
3	Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – Kelvin-Planck and Clausius Statements, Equivalence of two statements	3L
	Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale.	2L + 1T
	Clausius Inequality, Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process- isentropic process, Third law of thermodynamics	2L + 2T
4	Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface,	3L
	Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables	2L + 1T

	The ideal Gas Equation, Characteristic and Universal Gas constants, Limitations of ideal Gas Model: Equation of state of real substances, Compressibility factor, Law of corresponding state, Compressibility charts.	2L +1T
5	Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law.	2L
	Equivalent Gas constant and Molecular Weight, Properties of gas mixtures: Internal Energy, Enthalpy, specific heats and Entropy	2L +1T
	General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions - Maxwell's Relations	2L
	Tds Equations. The Clapeyron Equation, equations for internal energy, enthalpy and entropy, specific heats, Throttling process, Joule Thomson Coefficient, inversion curve.	2L + 1T

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET284

Course Name : THERMODYNAMICS

(Permitted to use Steam Tables and Mollier Chart)

Max. Marks : 100 Duration : 3 Hours

Part – A

Answer all questions.

1. Define thermodynamics. List a few of its applications

2.Differentiate between intensive and extensive properties.

3. Differentiate between heat and work.

4. Explain system approach and control volume approach as applied in the analysis of a flow process.

5. An inventor claims to have developed an engine that delivers 26 kJ of work using 82 kJ of heat while operating between temperatures 120°C and 30°C. Is his claim valid ? Give the reason for your answer.

6. Show that two reversible adiabatics cannot intersect

7.Define (i)critical point and (ii) triple point, with respect to water

8. Why do real gases deviate from ideal gas behaviour? When do they approach ideal behaviour?

9. Define Helmholtz function and Gibbs function and state their significance

10. State Dalton's law and Amagat's laws for ideal gas mixtures.

(3 x 10 = 30 marks)

Part – B

Answer any two full questions from each module.

Module - 1

11.a] Explain macroscopic and microscopic approach to thermodynamics . (7 marks)

b] With the aid of a suitable diagram, explain the working of constant volume gas thermometer. (7 marks)

OR

12.a] What is meant by thermodynamic equilibrium ? What are the essential conditions for a system to be in thermodynamic equilibrium ? (7 marks) b] Express the temperature of 91^{0}C in (i) Farenhiet (ii) Kelvin (iii) Rankine. (7 marks)

Module – 2

13.a] A mass of 2.4 kg of air at 150 kPa and 12°C is contained in a gas – tight, frictionless piston – cylinder device. The air is now compressed to a final pressure of 600 kPa . During this process, heat is transferred from the air such that the temperature inside the cylinder remains constant. Calculate the work input during this process. (7 marks)

a] Air enters a 28 cm diameter pipe steadily at 200 kPa and 20°C with a velocity of 5m/s. Air is heated as it flows, and leaves the pipe at 180 kPa and 40°C. Determine (i) the volume flow rate of air at the inlet (ii) the mass flow rate of air and (iii) the velocity and volume flow rate at the exit. (7 marks)

OR

14.a] A turbine operates under steady flow conditions, receiving steam at the following conditions : pressure 1.2 MPa, temperature 188°C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3m. The steam leaves the turbine at the following conditions : pressure 20 kPa, enthalpy 25kJ/kg, velocity 100 m/s, and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW ? (7 marks)

b] Derive the steady flow energy equation, stating all assumptions. (7 marks)

Module – 3

15.a]State the Kelvin-Planck and Clausius statements of the second law of thermodynamics and prove their equivalence. (7 marks)

b]A heat engine operating between two reservoirs at 1000 K and 300 K is used to drive a heat pump which extracts heat from the reservoir at 300 K at a rate twice that at which the engine rejects heat to it. If the efficiency of the engine is 40 % of the maximum possible and the COP of the heat pump is 50 % of the maximum possible, what is the temperature of the reservoir to which the heat pump rejects heat ? What is the rate of heat rejection from the heat pump, if the rate of heat supply to the engine is 50kW ? (7 marks)

OR

16.a] A house is to be maintained at 21°C during winter and at 26°C during summer. Heat leakage through the walls, windows and roof is about 3000 kJ/hr per degree temperature difference between the interior of the house and the environment. A reversible heat pump is proposed for realising the desired heating and cooling. What is the minimum power required to run the heat pump in the reverse, if the outside temperature during summer is 36°C? Also find the lowest environment temperature during winter for which the inside of the house can be maintained at 21°C consuming the same power. (8 marks)

b] Give the Nernst statement of the third law and explain its significance. (6 marks)

Module – 4

17.a] Show the constant pressure transformation of unit mass of ice at atmospheric pressure and -20^oC to superheated steam at 220^oC on P-v , T-v and P-T coordinate systems and explain their salient features . (8 marks)

b] Nitrogen enclosed in a piston cylinder arrangement is at a pressure of 2 bar and temperature 75°C. Calculate the specific volume of Nitrogen using ideal gas equation. What would be the specific volume of this Nitrogen , if its compressibility factor at the prevailing condition is 0.9.
. (6 marks)

OR

18.a] Steam at 25 bar and 300^oC expands isentropically to 5 bar. Calculate the change in enthalpy, volume and temperature of unit mass of steam during this process using steam tables and Mollier chart and compare the values (8 marks)

b] Explain law of corresponding states and its significance to the generalized compressibility chart. (6 marks)

Module – 5

19.a] Derive the expressions for the equivalent molecular weight and characteristic gas constant for a mixture of ideal gases. (6 marks)

b] 0.5 kg of Helium and 0.5 kg of Nitrogen are mixed at 20^oC and at a total pressure of 100 kPa. Find (i) volume of the mixture (ii) partial volumes of the components (iii) partial pressures of the components (iv) the specific heats of the mixture and (v) the gas constant of the mixture. Take ratio of specific heats for Helium and Nitrogen to be 1.667 and 1.4 respectively. (8 marks)

OR

20.a] 2 kg of carbon dioxide at 38°C and 1.4 bar is mixed with 5 kg of nitrogen at 150°C and 1.03 bar to form a mixture at a final pressure of 70 kPa. The process occurs adiabatically in a steady flow apparatus. Calculate the final temperature of the mixture and the change in entropy during the mixing process. Take specific heat at constant pressure for CO_2 and N_2 as 0.85 kJ/kgK and 1.04 kJ/kg respectively. (7 marks)

b]Derive the Maxwell relations. Explain their significance? (7 marks)

MET 285	MATERIAL SCIENCE AND TECHNOLOGY (MINOR)	CATEGORY	L	T	P	Credits	Year of Introduction
		VAC	4	0	0	4	2019

Preamble:

Understanding the correlation between the chemical bonds and crystal structure of metallic materials.

Recognize the importance of crystal imperfections including dislocations in plastic deformation.

Understanding the mechanisms of materials failure through fatigue and creep.

Understanding the fundamental characteristics of conductors and resistors.

Understanding the fundamental characteristics of semi and super conductors.

Prerequisite: PHT 110 Engineering Physics and CYT 100 Engineering Chemistry

Course Outcomes - At the end of the course students will be able to

CO 1	Understand the basic chemical bonds, crystal structures and their relationship with the properties.
CO 2	How to quantify failure of materials
CO 3	Given a hypothetical or real problem with an electronic materials device or process, explain the cause of the problem and propose solutions.
CO 4	Understand how materials interact at the nanoscale
CO 5	Define and differentiate engineering materials on the basis of structure and properties for engineering applications

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	-		-	-
CO 2	-	3		-	-	-	-	-	-	-	-	-
CO 3		-	-	2	-	-	-	-	-	-	-	-
CO 4		-	-	-	3	-	-	-	-	-	-	-
CO 5	-	-	-	-		-	-	-	-	-	-	2

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test I (Marks)	Test II (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
Regular class work/tutorials/assignments	15 marks
Continuous Assessment Test (Minimum 2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand the basic chemical bonds, crystal structures and their relationship with the properties.

1. Why ionic and covalent bonded materials are poor conductors? Draw electronic configurations.
2. Correlate the strength of an element with atomic number.
3. What kind of bonding you expect in the following materials: NaCl, Cadmium Telluride and Bronze.
4. Explain how grain size influences the strength of a metal

Course Outcome 2 (CO2): How to quantify failure of materials.

1. Explain the factors affecting the fatigue strength?
2. Explain the effects of crystalline and non-crystalline structure on strength of a metal.
3. What are the roles of surface defects on crack propagation?
4. A small hole is drilled through a steel plate ahead of a crack, whether it can stop the crack's progress until repairs can be made or not? Explain in detail and derive the equation
5. Explain the effect of impact loading on ductile materials

Course Outcome 3 (CO3): Given a hypothetical or real problem with an electronic materials device or process, explain the cause of the problem and propose solutions.

1. Explain why nichrome and not copper is used as a heating element.
2. Why does the conductivity of a semiconductor change with impurity content? Compare this with the behavior of metallic conductors.
3. Explain why lead and zinc with an even number of electrons in the outer shell and a full valence band are conductors.
4. When ice melts into water, the dielectric constant increases, in contrast to the decrease observed during the melting of HCl. Explain why this is so.

Course Outcome 4 (CO4): Understand how materials interact at the nanoscale

1. What is the concept of nano? Correlate the significance of dislocation density to single crystal silicon ICs used in electronic industry.
2. Explain touch screens
3. Explain flexible electronic circuits

Course Outcome 5 (CO5): Define and differentiate engineering materials on the basis of structure and properties for engineering applications

1. Explain the slip systems of BCC, FCC and HCP. Why BCC and HCP exhibit brittle nature and FCC ductile nature?
2. Explain in detail the different strengthening mechanisms of metallic crystals
3. Explain why Aluminum used in long distance transmission lines cannot be strengthened by solid solution.
4. Explain the attributes of surface breakdown of an insulator

SYLLABUS

MODULE - 1

Earlier and present development of atomic structure- primary bonds: - secondary bonds - earlier and present development of atomic structure- primary bonds: - secondary bonds - classification of engineering materials- levels of structure- crystallography- structure–property relationships in materials - classification of engineering materials.

MODULE - II

Miller indices: - modes of plastic deformation - structure determination by X-ray diffraction - Classification of crystal imperfections- Diffusion in solids, fick's laws - dislocation density - mechanism of crystallization: homogeneous and heterogeneous nuclei formation - Hall - Petch theory.

MODULE - III

Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - strengthening mechanisms- Fatigue: - Stress cycles – fatigue tests, S-N curve - Ductile to brittle transition temperature (DBTT) in steels - Creep: Creep curves – creep tests - Super plasticity - introduction to super alloys.

MODULE - IV

Composites:- fiber and composite phase - polymer matrix composites - metal matrix composites - ceramic matrix composites - dielectric materials- conductors - resistor materials.

MODULE - V

Superconducting phenomenon - semi conductors- fabrication of integrated circuits - semiconductor devices.

Text Books

1. Callister William. D., Material Science and Engineering, John Wiley, 2014
2. Raghavan V, Material Science and Engineering, Prentice Hall, 2004

Reference

1. Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill, 2009
2. Anderson J.C. *et.al*., Material Science for Engineers, Chapman and Hall, 1990
3. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill, 1976

MODEL QUESTION PAPER

MATERIAL SCIENCE & TECHNOLOGY - MET 285

Max. Marks : 100 **Duration : 3 Hours**

Part – A

Answer all questions.

Answer all questions, each question carries 3 marks

1. NASA's *Parker Solar Probe* will be the first-ever mission to "touch" the Sun. The spacecraft, about the size of a small car, will travel directly into the Sun's atmosphere about 4 million miles from the earth surface. Postulate the coolant used in the parker solar probe with chemical bonds.
2. Distinguish between crystal and non crystalline materials.
3. What is the driving force for diffusion?
4. What are the roles of surface imperfections on crack initiation?
5. What is the grain size preferred for creep applications? Why
6. Explain the attributes of DBTT
7. Make a list of at least four different sports implements that are made of or contain composites
8. What is the distinction between matrix and dispersed phases in a composite material?
9. Specify three elements that you would add to pure silicon to make it an extrinsic semiconductor of (i) the *n*-type, and (ii) the *p*-type.
10. Explain why nichrome and not copper is used as a heating element

PART -B

Answer one full question from each module.

Module -1

11. Calculate the APF of SC, BCC and FCC (14 marks).

OR

12. Distinguish between characteristics of ionic, covalent ad metallic bonds (14 marks).

Module -2

13. Explain the effect of: (i) Grain size; (ii) Grain size distribution and (iii) Grain orientation (iv) Grain shape on strength and creep resistance with neat sketches. Attributes of Hall-Petch equation and grain boundaries (14 marks).

OR

14. Distinguish between homogeneous and heterogeneous nuclei formation (14 marks).

Module -3

15. Postulate with neat sketches, why 100 % pure metals are weaker? What are the primary functions of alloying? Explain the fundamental rules governing the alloying with neat sketches and how is it accomplished in substitution and interstitial solid solutions? (14 marks).

OR

16. Explain fatigue test and attributes of S-N curve (14 marks).

Module -4

17. For a polymer-matrix fiber-reinforced composite, (a) list three functions of the matrix phase; (b) Compare the desired mechanical characteristics of matrix and fiber phases; and (c) cite two reasons why there must be a strong bond between fiber and matrix at their interface (14 marks).

OR

18. The dielectric constant of polyethylene is independent of temperature, while that of polyvinylchloride is not. Explain this difference in behavior on the basis of their monomer structures (14 marks).

Module -5

19. (a) Derive the kinetic energy of free electrons as a function of their wave number (7 marks).
 (b) The resistivity of silver at room temperature is 1.6 x 10^{-8} ohm m. Calculate the collision Time for electron scattering (7 marks).

OR

20. (a). Explain why lead and zinc with an even number of electrons in the outer shell and a full valence band are conductors (7 marks).
 (b). Calculate the fraction of holes present at 300 K in silicon doped with indium. The acceptor level is 0.16 eV above the top of the valence band (7 marks).

Course content and lecture schedules.

Module	TOPIC	No. of hours	Course outcomes
1.1	Earlier and present development of atomic structure; correlation of atomic radius to strength; electron configurations; - Primary bonds: - characteristics of covalent, ionic and metallic bond - properties from bonding.	2	CO1
1.2	Secondary bonds: - classification- hydrogen bond and anomalous behavior of ice float on water, application- specific heat, applications.	2	
1.3	Classification of engineering materials- levels of structure-crystallography:- crystal, space lattice, unit cell- APF of BCC, FCC, HCP structures.	2	
1.4	short and long range order - non crystalline - structure–property relationships in materials.	1	
2.1	Miller indices: - crystal plane and direction - attributes of miller indices for slip system, brittleness of BCC, HCP and ductility of FCC - modes of plastic deformation: - slip and twinning - structure determination by X-ray diffraction.	3	CO1 CO2
2.2	Classification of crystal imperfections: - types of point and dislocations.- Diffusion in solids, fick's laws, mechanisms, applications - dislocation density and attributes of nano structures.	3	

2.3	Mechanism of crystallization: Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity.	1	CO1 CO2
2.4	Effects of grain size, grain size distribution, grain shape, grain orientation on dislocation/strength and creep resistance - Hall - Petch theory.	2	
3.1	Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions, Hume Rothery`s rule - strengthening mechanisms.	3	CO2 CO5
3.2	Fatigue: - Stress cycles – Primary and secondary stress raisers - Characteristics of fatigue failure, fatigue tests, S-N curve attributes.	2	
3.3	Factors affecting fatigue strength: stress concentration, size effect, surface roughness, change in surface properties, surface residual stress - Ways to improve fatigue life.	2	
3.4	Ductile to brittle transition temperature (DBTT) in steels -Creep: Creep curves – creep tests - Super plasticity - introduction to nickel based super alloys, characteristics and applications.	2	CO1 CO2
4.1	Composites:- fiber and composite phase - polymer matrix composites - metal matrix composites - ceramic matrix composites	2	
4.2	Dielectric materials:- polarization, temperature and frequency effects, electric breakdown, ferroelectric materials.	3	CO1 CO2
4.3	Conductors: - the resistivity range, free electron theory.	2	
4.4	Conduction by free electrons, conductor and resistor materials.	2	
5.1	Superconducting phenomenon, Type I and Type II superconductors, potential applications.	3	CO3
5.2	Semi conductors:- energy gap in solids, intrinsic and extrinsic semiconductors, semiconductor materials.	2	
5.3	Fabrication of integrated circuits: - production of metallurgical grade silicon, semiconductor grade silicon, single crystal growth, wafer manufacture, oxidation, photolithography, doping.	3	CO4
5.4	Ion implantation, epitaxial growth, metallization.	1	
5.5	Some semiconductor devices: - junction diodes, lasers and transistor, photon detectors.	2	CO4

MET 286	MANUFACTURING TECHNOLOGY (MINOR)	CATEGORY	L	T	P	Credits	Year of Introduction
		VAC	3	1	0	4	2019

Preamble:

1. To understand basic manufacturing processes of casting and welding
2. Provide a detailed discussion on the welding process and the physics of welding.
3. To understand mechanisms of material removal in LBM and EBM process
4. To introduce the different forming process of forging, extrusion and drawing.
5. To introduce the different fabrication of microelectronic devices

Prerequisite: MET 255 - Material Science & Technology (Minor)

Course Outcomes - At the end of the course students will be able to

CO 1	Illustrate the basic principles of foundry practices and special casting processes, their advantages, limitations and applications.
CO 2	Categorize welding processes according to welding principle and material.
CO 3	Understand the advantages of LBM and EBM over fusion welding process.
CO 4	An ability to understand the principles of the basic microelectronic processing technology.
CO 5	Learn about key aspects of the microelectronics industry, from device design, to processing, to photolithography, to manufacturing and packaging. Students will come out knowing the core processes of ion implantation, diffusion, oxidation, deposition, etching, including the fundamental physical mechanisms, and the necessary understanding for using these processes in a manufacturing environment.

Mapping of course outcomes with program outcomes (Minimum requirements)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
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CO 2	-	-	-	-	-	-	-	-	-	-	-	2
CO 3	-	-	3	-	-	-	-	-	-	-	-	-
CO 4	-	-	-	3	-	-	-	-	-	-	-	-
CO 5	-	4	-	-	-	-	-	-	-	-	-	-

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test I (Marks)	Test II (Marks)	
Remember	25	25	25
Understand	15	15	15
Apply	30	25	30
Analyze	10	10	10
Evaluate	10	15	10
Create	10	10	10

Mark distribution

Total Marks	CIE marks	ESE marks	ESE duration
150	50	100	3 Hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	10 marks
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Continuous Assessment Test (2 numbers)	25 marks

End semester pattern:- There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): - Illustrate the basic principles of foundry practices and special casting processes, their advantages, limitations and applications.

1. Explain Why casting is an important manufacturing processes
2. Name the important factors in selecting sand for molds.
3. Why does die casting produce the smallest cast parts?
4. What is the difference between sand-mold and shell mold casting?

Course Outcome 2 (CO2): Categorize welding processes according to welding principle and material.

1. Describe the functions and characteristics of electrodes. What functions do coatings have? How are electrodes classified?
2. Describe the role of filler metals in welding.
3. Explain the significance of the stiffness of the components being welded on both weld quality and part shape.

Course Outcome 3 (CO3): Understand the advantages of LBM and EBM over fusion welding process.

1. What is the power of LBM and EBM used for welding?
2. Why LBM and EBM are better quality than fusion welding?
3. What is the HAZ of LBM as compared to fusion welding process.

Course Outcome 4 (CO4): An ability to understand the principles of the basic microelectronic processing technology.

1. Why is silicon the semiconductor most used in IC technology?
2. Define selectivity and isotropy and their importance in relation to etching.
3. Explain the differences between wet and dry oxidation.
4. How is epitaxy different from other techniques used for deposition? Explain.

Course Outcome 5 (CO5): Learn about key aspects of the microelectronics industry, from device design, to processing, to photolithography, to manufacturing and packaging. Students will come out knowing the core processes of ion implantation, diffusion, oxidation, deposition, etching, including the fundamental physical mechanisms, and the necessary understanding for using these processes in a manufacturing environment.

1. Describe bulk and surface micromachining.
2. Lithography produces projected shapes, so true three dimensional shapes are more difficult to produce. What lithography processes are best able to produce three-dimensional shapes, such as lenses? Explain.
3. Explain how you would produce a spur gear if its thickness was one-tenth of its diameter and its diameter was (a) 10 um, (b) 100 um, (c) 1 mm, (d) 10 mm, and (e) 100 mm.

SYLLABUS

Module I

Metal casting:-sand casting:- shell molding, evaporative pattern casting, investment casting, permanent mold casting, vacuum casting, slush casting, pressure casting, die casting, centrifugal casting, squeeze casting, semi solid metal forming, casting for single crystal, casting defects.

Module II

Powder metallurgy:-powder production methods; powder characteristics; blending, mixing; compaction of metal powders; sintering fundamentals and mechanisms; infiltration and impregnation - Welding: arc welding: non consumable electrodes; heat affected zone; quality; case study and weld ability of metals.

Module III

Consumable electrodes; electron and laser beam welding; heat affected zone; power density; weld quality; case study; applications - Brazing:- filler metals, fluxes, joint strength; brazing methods, applications -Soldering:- solders and fluxes - soldering methods - solder ability, case study, typical joint designs, applications.

Module IV

Metal forging: quality, defects -Metal extrusion: process, defects, applications - Metal drawing process, drawing practice, defects, applications - Fabrication of microelectronic devices - crystal growing and wafer preparation - Film deposition - oxidation - Photo lithography

Module V

Different lithography methods - Etching, wet etching, dry etching- diffusion and Ion implantation-metallization and testing - wire bonding and packing - yield and reliability - fabrication of micro electro mechanical devices.

Text Books

1. Serope Kalpakjian, Steven R. Schmid - Manufacturing Engineering and Technology, seventh edition, Pearson.

Reference

1. https://nptel.ac.in/courses/103106075/
2. Principles of Metal Casting – Hine and Rosenthal
3. Materials and Processes in Manufacturing - Paul Degarma E and Ronald A. Kosher
4. Manufacturing Technology Foundry, Forming and Welding – P. N. Rao

MODEL QUESTION PAPER

MANUFACTURING PROCESS - MET 286 Max. Marks : 100 **Duration : 3 Hours**

Part – A

Answer all questions.

Answer all questions, each question carries 3 marks

1. What are composite molds? Why are they used?
2. What are the advantages of pressure casting over other processes?
3. Describe what occurs to metal powders during sintering.
4. Explain the basic principles of arc-welding processes.
5. Are fluxes necessary in brazing? If so, why?
6. Soldering is generally applied to thinner components. Explain Why.
7. Why is control of the volume of the blank important in closed-die forging?
8. Define selectivity and isotropy and their importance in relation to etching.
9. Describe the difference between isotropic etching and anisotropic etching.
10. What is the difference between chemically reactive ion etching and dry-plasma etching?

PART -B

Answer one full question from each module.

MODULE -1

11. Explain why squeeze casting produces parts with better mechanical properties, dimensional accuracy, and surface finish than do expendable-mold processes (14 marks).

OR

12. Explain different types of casting defeats in detail (14 marks).

MODULE -2

13. a.Explain the difference between impregnation and infiltration. Give some applications of each (7 marks).
 b.Describe the relative advantages and limitations of cold and hot isostatic pressing (7 marks).

OR

14. Explain the factors that contribute to the differences in properties across a welded joint (14 marks).

MODULE -3

15. a.What are the principles of (a) wave soldering and (b) reflow soldering? (7 marks).
 b.It is common practice to tin-plate electrical terminals to facilitate soldering. Why is it tin that is used? (7 marks).

OR

16. Examine various household products and describe how their components are joined and assembled. Explain why those particular processes were used and not others (14 marks).

MODULE -4

17. a.Describe the factors involved in precision forging (7 marks).
 b.Explain why cold extrusion is an important manufacturing process (7 marks).

OR

18. a.A common problem in ion implantation is channeling, in which the high-velocity ions travel deep into the material via channels along the crystallographic planes before finally being stopped. How could this effect be avoided? Explain (7 marks).
 b.Describe your understanding of the important features of clean rooms and how they are maintained (7 marks).

MODULE -5

19. a.List the advantages and disadvantages of surface micromachining compared with bulk micromachining (7 marks).
 b.What is the difference between chemically reactive ion etching and dry-plasma etching? (7 marks).

OR

20. a. What is the main limitation to successful application of MEMS? (7 marks).
 b. What is the purpose of a spacer layer in surface micromachining? (7 marks).

Course content and lecture schedules.

Module	TOPIC	No. of hours	Course outcomes
1.1	Metal casting:-sand casting:- sand, types of sand mold, pattern, cores, casting operations.	2	CO1
1.2	Shell molding, plaster and ceramic mold casting; evaporative pattern casting, investment casting,	3	CO1 CO5
1.3	Permanent mold casting, vacuum casting, slush casting, pressure casting, die casting,	2	

1.4	Centrifugal casting, squeeze casting, semi solid metal forming - applications of each process.	2	CO1
1.5	Casting for single crystal, applications of each process, casting defects.	1	
2.1	Powder metallurgy:-powder production methods, atomization, reduction, electrolytic deposition, carbonyls, comminution.	2	CO2
2.2	Powder characteristics:- particle size, shape and distribution	1	CO2 CO5
2.3	Blending, mixing and compaction of metal powders, isostatic pressing	2	CO2
2.4	Sintering: fundamentals and mechanisms - infiltration and impregnation.	1	
2.5	Welding: arc welding non consumable electrodes, heat transfer in arc welding, gas tungsten arc, plasma arc and atomic hydrogen welding; heat affected zone, weld ability, weld quality, applications of each processes.	3	CO4 CO5
3.1	Consumable electrodes:-shielded metal, submerged, gas metal arc welding, heat affected zone, weld ability, weld quality, applications of each processes.	3	CO4
3.3	Electron and laser beam welding, heat affected area, power density, weld quality, heat affected zone, case study, applications of each processes.	1	
3.4	Brazing:- filler metals, fluxes, joint strength; brazing methods, torch, furnace, induction, resistance, dip brazing, applications of each processes.	2	CO4
3.5	Soldering:-types of solders and fluxes - different soldering methods - solder ability, case study, typical joint designs, applications of each processes.	2	CO4
4.1	Metal forging:-open die, impression die, closed die, precision die, quality, defects.	3	CO4
4.2	Metal extrusion:-process, hot, cold, impact and hydrostatic extrusion; defects, applications - Metal drawing process- drawing practice- defects, applications of each processes.	3	
4.3	Fabrication of microelectronic devices:-clean rooms-semiconductors and silicon- crystal growing and wafer preparation	2	CO4
4.4	Film deposition - oxidation - Photo lithography	1	
5.1	electron beam lithography, X-ray, Ion beam, photo resistant lithography, scattering with angular limitations projection electron beam lithography.	1	CO4
5.2	Etching:- wet etching:- isotropic etchants, anisotropic etching - dry etching:-sputter, reactive plasma, physical chemical and cryogenic dry etching.	2	CO4
5.3	Diffusion and Ion implantation- metallization and testing- Wire bonding and packing-yield and reliability - printed circuit boards	3	CO4 CO5
5.4	Fabrication of micro electro-mechanical devices:-micromachining of MEMS devices: bulk and surface micro machining, single crystal silicon reactive etching and metallization, silicon micromachining by single step plasma etching, etching combined with diffusion bonding with suitable example and applications.	3	CO4

CODE	Course Name	CATEGORY	L	T	P	CREDIT
MET381	DYNAMICS OF MACHINES	VAC	3	1	0	4

Preamble: This course mainly covers the topics namely force analysis of engines, turning moment diagrams, balancing of rotating and reciprocating machines and stability analysis of vehicles. Analysis of free and forced vibration of single degree of freedom systems are included.

Prerequisite: EST100 Engineering Mechanics

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Analyse forces in a four bar mechanism
CO 2	Draw turning moment diagrams for a steam engines and internal combustion engines.
CO 3	Calculate the unbalanced masses in rotating and reciprocating machines.
CO 4	Calculate gyroscopic couple and do stability analysis of vehicles
CO 5	Analyse free and forced vibrations of single degree of freedom systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	3	2									
CO 5	3	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain D' Alembert's principle.
2. Determine analytically the forces such as piston effort, force in the connecting rod and side thrust on the cylinder walls of a reciprocating engine.
3. Draw the force polygon of a four bar mechanism.
4. Use virtual work and determine the external torque required to be applied in the case of a slider-crank engine.

Course Outcome 2 (CO2)

1. Define coefficient of fluctuation of energy
2. Draw turning moment diagrams for single cylinder double stroke steam engine.
3. Find the centrifugal stress in a flywheel for a given tangential speed.
4. Determine the maximum fluctuation of energy for a multi cylinder engine.

Course Outcome 3 (CO3)

1. Distinguish between static balancing and dynamic balancing.
2. What is single plane balancing? Explain.
3. Draw the force polygon and couple polygon when several masses rotate in different (parallel) planes.
4. Explain i) hammer blow ii) variation in tractive effort and iii) swaying couple in locomotives
5. What do you mean by primary and secondary unbalanced forces?

Course Outcome 4 (CO4):

1. Derive an expression relating the stress in a flywheel and its linear speed.
2. Describe with neat sketches the effects of gyroscopic couple on pitching, rolling and steering of a ship
3. Find an expression for the angle of heel for a two wheeler

4. Define coefficient of fluctuation of energy and maximum fluctuation of energy.

Course Outcome 5 (CO5):

1. Explain the energy method and Newton's method to determine the natural frequencies of a single degree of freedom system.
2. Derive an expression for the logarithmic decrement.
3. Find the forced response of a damped single degree of freedom vibrating system subjected to a harmonic excitation.
4. Distinguish between motion transmissibility and force transmissibility.
5. What is whirling? Derive an expression for the critical speed of a shaft.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

V SEMESTER BTECH DEGREE EXAMINATION

MET381: DYNAMICS OF MACHINES

Maximum:100 Marks Duration:3 hours

PART A

Answer all questions, each question carries 3 marks

1. Explain virtual work method of force analysis of a four-bar mechanism.
2. What is meant by equivalent dynamic systems?
3. Define coefficient of fluctuation of energy and coefficient of fluctuation of speed.
4. Why flywheels are required?
5. Distinguish between static and dynamic balancing.
6. What is meant by partial balancing? List the effects of partial balancing.
7. Describe the effect of gyroscopic couple on the stability of a two-wheeler while negotiating a curve.
8. Define coefficient of fluctuation of speed and coefficient of fluctuation of energy.
9. Explain the energy method of obtaining the natural frequency of a single degree of freedom vibrating system.
10. Explain transmissibility. (10×3=30Marks)

PART B

Answer one full question from each module

MODULE 1

11. a) A slider crank mechanism of crank radius 60 mm and connecting rod length 240 mm is acted upon by 2 kN gas force at its piston. Calculate the torque to be applied on the crank to make the mechanism in static equilibrium when the crank makes 60° with the line of stroke. Use graphical method. (9 marks)

    b) Distinguish between static and dynamic force analyses. (5 marks)

12. a) State and explain D' Alembert's principle. (4 marks)

b) The ratio of connecting rod length to crank length of a vertical gasoline engine is 4. The engine bore and stroke are 8 cm and 10 cm respectively. The mass of the reciprocating parts is 1 kg. The gas pressure on the piston is 6 bar, when it has moved 40° from the inner dead centre during the power stroke. Determine:

i. net load on the piston

ii. net load on the gudgeon pin and the crank pin

iii. thrust on the cylinder walls

iv. thrust on the crank bearing

MODULE 2

13. a) Derive an expression for the centrifugal stress in a flywheel as a function of the tangential velocity. (5 marks)

b) A machine is coupled to a two stroke engine which produces a torque of 800+180 sin 3θ Nm where θ is the crank angle. The mean engine speed is 400 rpm. The flywheel and the other rotating parts attached to the engine have a mass of 350 kg at a radius of gyration of220 mm. Calculate: i) the power of the engine and ii) the total fluctuation of speed of the flywheel. (9 marks)

14. . a) Draw the turning moment diagram for a 4 stroke diesel engine. (4 marks)

b) The turning moment diagram for a multi cylinder engine has been draw to a scale of 1 cm to 5000 Nm torque and 1 cm to 60° respectively. The intercepted areas between output torque curve and mean resistance line taken in order from one end are: -0.3; +4.1; -2.8; +3.2; -3.3; +2.5; -3.6; +2.8; -2.6 square cm when the engine is running at 800 rpm. The engine has a stroke of 30 cm and the fluctuation of speed is not to exceed 2% of the mean speed. Determine a suitable diameter and cross-section of the flywheel rim for a limiting value of shaft centrifugal stress of 280 x 10^5 N/m^2. The material density may be assumed as 7.2 g/cm^3 . Assume thickness of the rim to be ¼ of the width.

(10 marks)

MODULE 3

15. a) Four masses 200 kg, 300 kg, 240 kg and 260 kg with radii of rotation are positioned at 20 cm, 15 cm, 25 cm and 30 cm respectively. Their corresponding angular positions with respect to mass 200 kg are 45°, 75° and 135°. Find the

magnitude and position of the balancing mass required if the radius of rotation is 20 cm. (10 marks)

b) Dynamically balanced system is statically balanced, but not vice versa. Give your comments. (4 marks)

16. a) Describe the effects of partial balancing of reciprocating engines. (9 marks)

b) Four masses are attached to shaft at planes A, B, C and D at equal radii. The distance of planes B, C and D from A are 50 cm, 60 cm and 130 cm respectively. The masses at A, B and C are 60 kg, 55 kg and 80 kg respectively. If the system is in complete balance, determine the mass at D and the position of masses B, C and D with respect to A.

(10 marks)

MODULE 4

17. a) Explain spin vector, precession vector, gyroscopic applied torque vector and gyroscopic reactive torque vector. (4 marks)

b) Explain the effects of gyroscopic couple on the stability of a four wheeler while it negotiates a curve. (10 marks)

18. a) What is the function of a flywheel? (4 marks)

b) Determine the maximum and minimum speeds of a flywheel of mass 25 kg and radius of gyration of 10 cm when the fluctuation of energy is 54.5 Nm. The mean speed of the engine is 1000 rpm. (10 marks)

MODULE 5

19. a) A machine of mass 1000 kg is acted upon by an external force of 2450 N at a speed of 1500 rpm. To reduce the effect, vibration isolators made of rubber having a static deflection of 2 mm under the machine load and an estimated damping factor of 0.2 are used. Determine the following:

i. Force transmitted to the foundation
ii. Amplitude of vibration of machine
iii. Phase lag between the transmitted force and the displacement of mass.

(10 marks)

b) Distinguish between motion transmissibility and displacement transmissibility.

(5 marks)

20. a) A damped spring mass system has mass 3 kg, stiffness 100 N/m and damping coefficient 3 Ns/m. Determine the following:

i. Damping ratio
ii. Damped natural frequency
iii. Logarithmic decrement
iv. Ratio of two successive amplitudes (8 marks)

b) Describe briefly Newton's method and energy method used for obtaining the natural frequencies. (6 marks)

Syllabus

Module 1

Static and dynamic force analysis of mechanisms (four bar linkages only)-graphical method-virtual work method -D'Alembert's principle-equivalent dynamic systems-reciprocating engine force analysis

Module 2

Flywheels-turning moment diagrams for steam engines-four stroke internal combustion engine and multi cylinder engines-coefficient of fluctuation of speed-coefficient of fluctuation of energy-design of flywheels.

Module 3

Balancing: static balancing-dynamic balancing-balancing of several masses revolving in a single plane-several masses in different parallel planes-balancing of single cylinder reciprocating engines-partial balancing and its effects-balancing of multi cylinder inline engines

Module 4

Gyroscopic couple-effects on the stability of automobiles-two wheeler and four wheeler, stability of ships and air crafts-Flywheels-turning moment diagrams-coefficient of fluctuation of energy, coefficient of fluctuation of speed

Module 5

Vibration-free vibration of single degree of freedom systems-equation of motion-Newton's method-energy method-natural frequency-undamped and damped systems-logarithmic decrement-forced vibration-response of SDOF systems to harmonic excitation-whirling of shaft-vibration absorber-transmissibility

Text Books

1. Ballaney, P. L. Theory of machines and mechanisms. Khanna Publishers, 2010.

2. Rattan S S, Theory of Machines, Tata McGraw-Hill Education, 2005.

Reference Books

1. Charles E Wilson and J Peter Sadler, Kinematics and Dynamics of Machinery, Tata McGraw-Hill Education, 2008.

2. Amithabha Ghosh and Asok Kumar Malik, Theory of Mechanisms and Machines, East West Press, 2011

3. Thomas Bevan, Theory of Machines, Pearson, 2013.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Static analysis of mechanisms-graphical method-four bar mechanisms	3
1.2	Virtual work method -D'Alembert's principle-equivalent dynamic systems	3
1.3	Reciprocating engine force analysis	2
2		
2.1	Flywheels, turning moment diagrams-steam engines-four stroke internal combustion engines and multi cylinder engines	4
2.2	Multi cylinder engine-coefficient of fluctuation of speed-coefficient of fluctuation of energy-design of flywheels	4
3		
3.1	Static and dynamic balancing- balancing of several masses in a single plane-force polygon	3
3.2	Balancing of several masses in parallel planes-couple polygon	3
3.3	Balancing of reciprocating masses-effects of partial balancing	2
3.4	Balancing of multi cylinder in-line engines	2
4		
4.1	Gyroscopic couple-introduction-spin, precession and applied couple vectors	2
4.2	Effects of gyroscopic couple on the stability of two wheeler and four wheeler	2
4.3	Effects on the stability of sea vessels and air crafts	3
4.4	Flywheels-turning moment diagrams-coefficient of fluctuation of energy, coefficient of fluctuation of speed	3
5		
5.1	Vibration-free vibration of single degree of freedom systems-equation of motion-Newton's method-energy method-natural frequency	3
5.2	Damped systems-logarithmic decrement-forced vibration-response of SDOF systems to harmonic excitation	3
5.3	Whirling of shaft-vibration absorber- transmissibility	3

CODE MET382	Course Name MACHINE DESIGN	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course mainly covers elementary topics of strength of materials such as stresses, strains, stress concentration, etc. Failure theories to predict the failure of machine elements subjected to static and fatigue loading are also covered. Design of bolts, riveted joints, welded joints, springs and shafts are also incorporated in this syllabus.

Prerequisite: EST100 Engineering Mechanics

Course Outcomes: After the completion of the course the student will be able to:

CO 1	To calculate the different types of stresses in a structural member.
CO 2	To apply failure theories and predict the failure of components.
CO 3	To design bolts subjected to fatigue loads.
CO 4	To design riveted and welded joints.
CO 5	To design close coiled helical compression springs and shafts subjected to static and fatigue loads.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2									
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	3	2									
CO 5	3	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment Test (2 numbers)	: 25 marks
Assignment/Quiz/Course project	: 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define stress concentration factor and factor of safety.
2. Calculate the principal stresses in a structural member subjected to loads in two directions.
3. Draw stress strain diagram and explain its significance in the design of machine elements.
4. Calculate the equivalent stress due to combined axial, bending and torsional loads.

Course Outcome 2 (CO2)

1. Explain the steps in the design process.
2. Distinguish between codes and standards.
3. Describe with neat sketches the different types of fits.
4. What are the different failure theories? What is the significance in design?

Course Outcome 3 (CO3)

1. Define endurance limit. What are the factors affecting it?
2. Explain Soderberg's and Goodman's criteria.
3. Derive an expression for the impact stress in terms of static stress.
4. What is meant by preloading or initial tension in a bolt?
5. Design a bolted joint subjected to eccentric loading.

Course Outcome 4 (CO4):

1. What are the advantages of riveted joint over welded joint?
2. Describe the different modes of failure of a riveted joint.
3. Find the various efficiencies of a riveted joint.

4. Describe the different AWS welding symbols.
5. Design a welded joint subjected to axial loading, twisting moment and bending moment.

Course Outcome 5 (CO5):

1. Design a close coiled helical compression spring subjected to axial loading.
2. Explain surge in spring.
3. What are the different types of end constructions for a close coiled helical compression spring? How do they affect the performance of the spring?
4. What is critical speed of a shaft?
5. Why hollow shafts are preferred in certain applications compared to solid shafts?

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

VI SEMESTER BTECH DEGREE EXAMINATION

MET382 : MACHINE DESIGN

Maximum: 100 Marks Duration:3 hours

PART A

Answer all questions, each question carries 3 marks

1. Define stress concentration and factor of safety.
2. Distinguish between normal stress and principal stress.
3. What are standards and codes?
4. Explain Haigh's and Rankine's theories of failures.
5. Why preloading of bolts is required?
6. Define endurance limit. What is its significance in design of machine elements?
7. Describe the different modes of failure of a riveted joint.
8. Explain with a neat sketch the AWS welding symbols
9. Derive an expression for the stress in a closed coiled helical compression spring.
10. What is meant by the critical speed of a shaft?

PART B

Answer one full question from each module

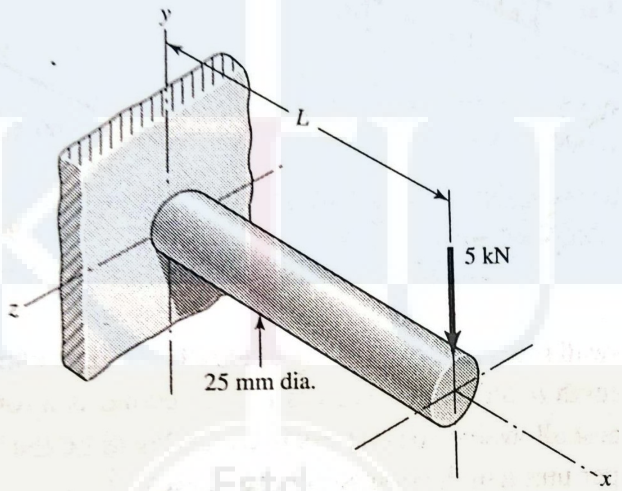
MODULE 1

11. a) An element in plane stress is subjected to stresses σ_{xx} = 85 MPa, σ_{yy} = -30 MPa and τ_{xy} = -32 MPa. Determine the principal stresses and the maximum shear stress (9 marks)

b) Draw the shear stress, bending stress, axial stress and torsional shear stress in a shaft of circular cross-section. (5 marks)

12. a) Draw the stress-strain diagram for mild steel and show all the significant regions. (5 marks)

b) Find the maximum stress in the cantilever beam shown below. The material is aluminium. The rod length L = 15 cm. The permissible tensile and shear stresses are 70 N/mm^2 and 50 N/mm^2 respectively. (10 marks)



MODULE 2

13. a) Explain allowances and tolerances. (5 marks)

b) A mild steel shaft having yield stress σ_{yp}= 200 MPa is subjected to the following stresses. $\sigma_x = 120$ MPa, $\sigma_y = -60$ MPa , $\tau_{xy} = 36$ MPa. Find the factor of safety using

a. Rankine's theory
b. Guest's theory (10 marks)

14. a) With neat sketches explain clearance fit, interference fit and transition fit. (6 marks)

b) What are the steps in the design process. (6 marks)

c) Explain preferred sizes. (2 marks)

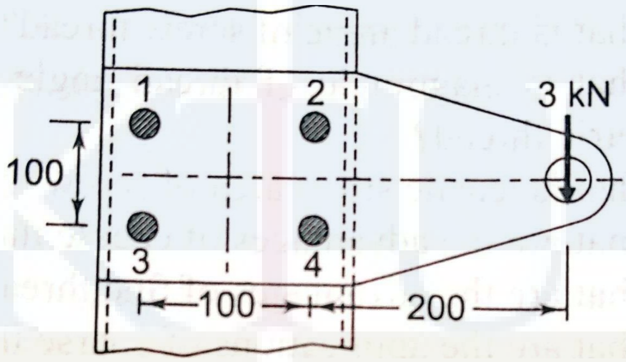
MODULE 3

15. a) A round prismatic steel bar (E = 210 GPa) of length 2 m and diameter 15 mm hangs vertically from a support at its upper end. A sliding collar of mass 20 kg drops from a height of 150 mm onto a flange fixed at the lower end of the bar without rebounding. Calculate the maximum elongation of the bar due to impact. Also, determine the maximum tensile stress in the bar and the corresponding impact factor (10 marks)

b) Explain the Gerber criterion used in the design for fatigue loading. (4 marks)

16. a) With a neat sketch explain the nominal diameter, root diameter and pitch diameter and pitch of a screw thread. (3 marks)

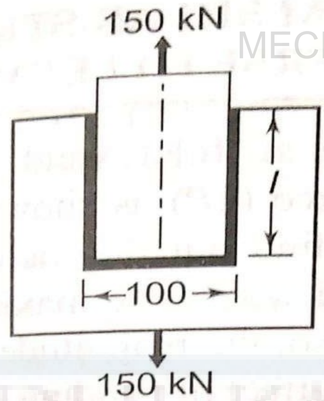
b) Find the diameter of the bolt for a bracket loaded as shown below. The allowable shear stress for bolt material is 60 MPa. (11 marks)



MODULE 4

17. a) What are the advantages of welded joint over riveted joint? (9 marks)

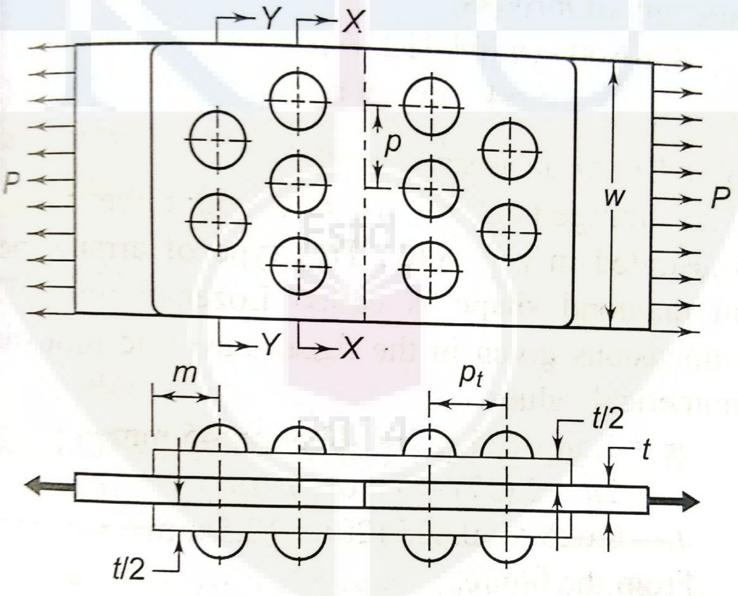
b) Two plates are joined together by means of a single transverse and double parallel fillet welds are shown in figure. The size of the fillet weld is 5 mm and allowable shear load per mm of weld is 330 N. Find the length of each parallel fillet weld. (10 marks)



18. a) Draw a zig-zag-double riveted double covered (equal) butt joint and mark all the details. (4 marks)

b) Two flat plates of width w = 200 mm, subjected to a tensile force P = 250 kN are connected together by means of a double-strap butt joint as shown below. The rivets and the plates are made of the same steel and the permissible stresses in tension, compression and shear are 70, 100 and 60 N/mm^2 respectively. Calculate the i) diameter of the rivets, ii) thickness of the plates and iv) the efficiency of the joint.

(10 marks)

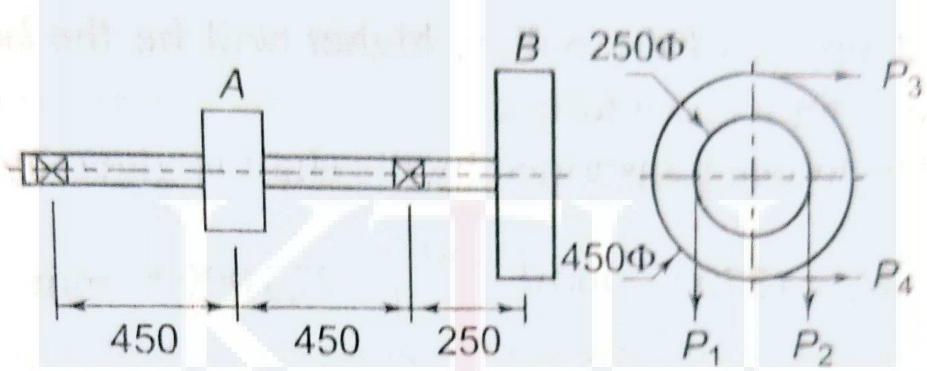


MODULE 5

19. a) Explain surge in springs. (4 marks)

b) It is required to design a helical compression spring subjected to a maximum force of 1250 N. The deflection of the spring corresponding to the maximum force should be approximately 30 mm. The spring index can be taken as 6. The ultimate tensile strength and modulus of rigidity of the spring material are 1090 and 81370 N/mm^2 respectively. The permissible shear stress for the spring wire should be taken as 50% of the ultimate tensile strength. Design the spring and calculate: i) wire diameter, ii) mean coil diameter, iii) number of active coils, iv) total number of coils, v) free length of the spring and pitch of the coil. (10 marks)

20. a) A line shaft supporting two pulleys A and B is shown in figure. Power is supplied to the shaft by means of a vertical belt on the pulley A, which is then transmitted to the pulley Bcarrying a horizontal belt. The ratio of belt tensions on tight and loose sides is 3:1. The limiting value of tension in the belt is 2.7 kN. The permissible shear stress is 86 N/mm^2. Pulleys are keyed to the shaft. Determine the diameter of the shaft according to the ASME code, if K_b = 1.5 and K_t = 1.0. (10 marks)



b) Two shafts ; one solid and the other hollow, have the same weight and transmit the same torque. Calculate the ratio of the maximum shear stress induced in the solid shat to that in the hollow shaft. The inner diameter of the hollow shaft is 50% of the outer diameter. (5 marks)

Syllabus

Module 1

Tension, compression, shear: Introduction, Internal force, stress, strain, elasticity, stress-strain diagram, working stress, stress concentration, factor of safety, bending and torsional stresses, eccentric loading, stresses due to combined axial, bending and torsional loads, principal stresses

Module 2

Machine design, steps in the design process, standards and codes, preferred sizes, tolerances, allowances, fits, selection of materials

Theories of elastic failures- Guest's theory, Rankine's theory, St. Venant's theory, Haigh's theory, and Von Mises and Hencky Theory.

Module 3

Shock and impact loads, fatigue loading, endurance limit stress, factors affecting endurance limit, design for fatigue loading, Soderberg and Good man criteria.

Threaded joints, types of threads, stresses in screw threads, bolted joints, initial tension, design of bolts for static and fatigue loading, power screws

Module 4

Design of riveted joints- material for rivets, modes of failure, efficiency of joint, design of boiler and tank joints, structural joints

Design of welded joints- AWS welding symbols, stresses in fillet and butt welds, butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet wed under bending, eccentrically loaded welds.

Module 5

Springs- classification, spring materials, stresses and deflection of helical springs, axial loading, , static and fatigue loading, surging, critical frequency, concentric springs, end construction.

Shafting- material, design considerations, causes of failure in shafts, design based on strength, rigidity, critical speed, design for static and fatigue loads, repeated loading, reversed bending

Text Books

1. Bhandari V B, Design of Machine Elements, Tata McGraw-Hill Education, 2010.
2. James M Gere, Mechanics of Materials, Thomson, 2007

.

Reference Books

1. S P Timoshenko and D H Young, Elements of Strength of Materials, East West Pvt Ltd.,2011

3. Robert L Norton, Design of Machinery, Tata Mc Graw-Hill, 2005

4. P C Sharma and D K Aggarwal, Machine Design, S K Kataria & Sons, 2007.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures (Hrs.)
1		
1.1	Tension, compression, shear-Introduction, internal force, stress, strain, elasticity	3
1.2	Stress-strain diagram, working stress, stress concentration, factor of safety	2
1.3	Bending and torsional stresses, eccentric loading, stresses due to combined axial, bending and torsional loads, principal stresses	3
2		
2.1	Machine design, steps in the design process, standards and codes	3
2.2	Preferred sizes, tolerances, allowances, fits, selection of materials	2
2.3	Theories of elastic failures- Guest’s theory, Rankine’s theory, St. Venant’s theory, Haigh’s theory, and Von Mises and Hencky Theory.	3
3		
3.1	Shock and impact loads, fatigue loading, endurance limit stress, factors affecting endurance limit	2
3.2	Design for fatigue loading, Soderberg and Goodman’s criteria.	2
3.3	Threaded joints, types of threads, stresses in screw threads, bolted joints, initial tension	2
3.4	Design of bolts for static and fatigue loading, eccentric loading, power screws	2
4		
4.1	Design of riveted joints- material for rivets, modes of failure, rivet and butt joints, efficiency of joint, design of structural joints	3
4.2	Design of welded joints- AWS welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension,	3
4.3	Fillet joint under torsion, fillet wed under bending, eccentrically loaded welds.	3
5		
5.1	Springs- classification, spring materials, stresses and deflection of	3

	helical springs, axial loading	
5.2	Static and fatigue loading, surging, critical frequency, concentric springs, end construction	3
5.3	Shafting- material, design considerations, causes of failure in shafts, hollow and solid shafts, design based on strength, rigidity,	3
5.4	Critical speed, design for static and fatigue loads, repeated loading, reversed bending	3

CODE MET383	COURSE NAME THERMAL SCIENCE AND ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course involve the application of principles studied in thermodynamics to different energy conversion systems like steam turbine, steam powerplant, IC engines and refrigeration systems. This course also covers the methods for improving and evaluating the performance of different energy conversion systems. This course also helps to understand the combustion phenomenon in IC engines.

Prerequisite: MET284 Thermodynamics (Minor)

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the working of steam power cycle and related components
CO 2	Discuss the working of steam turbines and methods for evaluating the performance
CO 3	Illustrate the performance testing and evaluation of IC engines
CO 4	Explain the combustion phenomenon and pollution in IC engines
CO 5	Discuss the principles of refrigeration and air-conditioning and basic design considerations

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**	3	2									
CO 2	**3**	3	2									
CO 3	**3**	3	2									
CO 4	**3**	3	2									
CO 5	**3**	3	2									

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination**
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. In a reheat Rankine cycle, steam at a pressure of 40 bar and 300°C is expanded through a turbine to a pressure of 4 bar. It is then heated at a constant pressure to 300ºC and then expanded to 0.1 bar. Estimate the work done per kg of steam flowing through the turbine, the amount of heat supplied during the reheat process and the cycle efficiency. Neglect pump work.
2. Explain the term boiler mountings and accessories
3. With the help of a figure explain the working of Babcock and Wilcox boiler.

Course Outcome 2 (CO2):

1. In an impulse steam turbine, steam issues from the nozzle with a velocity of 1200 m/s. The nozzle angle is 20^{o} and the mean blade velocity is 400 m/s. The inlet and outlet blade angles are equal. The blade velocity coefficient is 0.8. The mass of steam flowing through the turbine per hour is 950 kg. Calculate: (i) Blade angles. (ii) Relative velocity of steam entering the blades (iii) Tangential force on the blades. (iv) Power developed. (v) Blade efficiency.
2. Derive the conditions for maximum efficiency of a Parsons reaction turbine.
3. Discuss the means of improving the performance of a steam turbine.

Course Outcome 3(CO3):

1. A 4-cylinder four stroke petrol engine is working based on the following data: Air-fuel ratio by weight = 15:1, calorific value of the fuel = 45000 kJ/kg, mechanical efficiency = 80 %, air- standard efficiency = 54 %, relative efficiency = 70 %, volumetric efficiency = 75 %, stroke/bore ratio = 1.25, suction conditions = 1 bar and 30 ^{o}C, r.p.m. = 2500, brake power = 70 kW. Calculate: (i) Compression ratio. (ii) Indicated thermal efficiency. (iii) Brake specific fuel consumption. (iv) Bore and stroke.
2. Discuss the working of a rotary engine and its merits and demerits over conventional IC engines.
3. Explain the performance testing of IC engines

Course Outcome 4 (CO4):

1. Explain equivalence ratio and its significance in IC engine combustion.
2. Explain different stages of SI engine combustion with the help of pressure-crank angle diagram.
3. Discuss detonation in SI engine, cause and effects and the engine variable influencing the same.

Course Outcome 5 (CO5):

1. Derive the expression for COP of an ideal air refrigeration cycle.
2. Explain the factors affecting human comfort
3. Write brief note on summer air conditioning

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

V SEMESTER BTECH DEGREE EXAMINATION

MET383: THERMAL SCIENCE AND ENGINEERING

Maximum: 100 Marks Duration:3 hours

Use of Steam tables, Refrigeration tables, Charts and Psychrometric chart is permitted.

PART A

Answer all questions, each question carries 3 marks

1. Explain Rankine cycle with help of a T-S diagram.
2. Differentiate between fire tube boiler and water tube boiler.
3. List the difference between throttle governing and nozzle governing.
4. Explain degree of reaction of a steam turbine.
5. Explain the term MEP
6. Explain the meaning of Specific Fuel
7. Explain the term Preignition
8. What do you meant by Octane number?
9. Why reversed Carnot cycle is practically impossible to execute?
10. Differentiate between specific humidity and relative humidity (10×3=30 Marks)

PART B

Answer one full question from each module

MODULE 1

11. a) Steam at a pressure of 15 bar and 250 ^{o}C is expanded through a turbine to a pressure of 4 bar. It is then reheated at constant pressure to initial temperature of 250 ^{o}C and finally expanded to condenser pressure of 0.1 bar. Calculate efficiency of the cycle. Pump work can be neglected. (8 marks)

    b) Explain in detail different boiler mountings and accessories. (6 marks)

12. a) With the help of a neat figure explain the working of a Benson boiler. What are its merits over other boilers? (8 marks)

    b) With the help of T-s and p-h diagram explain the significance of binary vapour cycle. (6 marks)

MODULE 2

13. a) Derive the condition for maximum efficiency of a reaction turbine. (6 marks)

    b) With the help of figures enumerate the difference between pressure compounding and velocity compounding of steam turbines. (8 marks)

14. a) What do you meant by reheat factor? List the parameters influencing the value of reheat factor. (4 marks)

    b) In an impulse steam turbine, steam issues from the nozzle with a velocity of 1200 m/s. The nozzle angle is 20^o and the mean blade velocity is 400 m/s. The inlet and outlet blade angles are equal. The blade velocity coefficient is 0.8. The mass of steam flowing through the turbine per hour is 950 kg. Calculate: (i) Blade angles. (ii) Relative velocity of steam entering the blades. (iii) Tangential force on the blades. (iv) Power developed. (v) Blade efficiency. (10 marks)

MODULE 3

15. a) Discuss the terms a) Mechanical efficiency b) Volumetric Efficiency c) Thermal efficiency of an IC engine (9 marks)

    b) Discuss the effect of variable specific heat in actual cycle of IC engines. (5 marks)

16. The following observations were recorded during a trial of a four stroke single cylinder diesel engine for a trial duration of 30 min. Fuel consumption is 4 liters, Calorific value of fuel 43 MJ/kg, specific gravity of the fuel = 0.8, average area of indicator diagram = 8.5 cm^2, length of indicator diagram = 8.5 cm, spring constant= 5.5 bar/cm, brake load = 150 kg, spring balance reading = 20 kg, effective brake wheel diameter = 1.5 m, speed = 200 rpm, cylinder diameter = 30 cm, stroke = 45 cm. Calculate i) indicate power ii) brake power iii) mechanical efficiency iv) specific fuel consumption in kg/kWh and v) indicated thermal efficiency. (14 marks)

MODULE 4

17. a) With the help of pressure-crank angle diagram explain different stages of CI engine combustion. (8 marks)

    b) Explain the phenomenon of detonation in SI engine based on autoignition theory.

    (6 marks)

18. With the help of figures compare different types of SI and CI engine combustion chambers. (14 marks)

MODULE 5

19. a) A freezer of 20 TR capacity has evaporator and condenser temperature of -30 ^oC and 25 ^oC respectively. The refrigerant R-12 is sub-cooled by 4 ^oC before entering the expansion valve and is superheated by 5 ^oC before entering the evaporator. If a six cylinder single acting compressor with stroke equal to bore running at 1000 rpm. is used. Determine i) COP ii) Theoretical piston displacement per minute iii) Theoretical bore and stroke. (9 marks)

    b) Derive an expression for COP of a Reversed Brayton cycle for air refrigeration system. (5 marks)

20. a) Explain the concept of summer air conditioning (10 marks)

    b) Define i) DPT ii) RH ii) SHF and iv) ADP. (4 marks)

Syllabus

Module 1

Steam engineering- Rankine cycle, Modified Rankine cycle, Relative efficiency, Improvement in steam cycles-Reheat, Regenerative and Binary vapour cycle. Steam Boilers: Types of boilers, Cochran boiler, Babcock and Wilcox boiler, Benson boiler, La Mont boiler, Boiler Mountings and Accessories.

Module 2

Steam turbines: classification, compounding of turbines-pressure velocity variation, velocity diagrams, work done, efficiency, condition for maximum efficiency, multistage turbines-condition line, stage efficiency. Steam turbine performance-reheat factor, degree of reaction, cycles with reheating and regenerative heating, governing of turbines.

Module 3

Actual cycle analysis of IC engines- Deviation of actual engine cycle from ideal cycle, Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque, Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency, relative efficiency and Specific fuel consumption.

Module 4

Combustion in I.C. Engines- Analysis of fuel combustion-A/F ratio, equivalence ratio, excess air. Combustion phenomena in S.I. engines; Ignition limits, stages of combustion in S.I. Engines, Ignition lag, velocity of flame propagation, auto ignition, detonation; effects of engine variables on detonation; theories of detonation, octane rating of fuels; pre-ignition; S.I. engine combustion chambers. Combustion in C.I. Engines; delay period; variables affecting delay period; knock in C.I. engines, Cetane rating; C.I. engine combustion chambers.

Module 5

Refrigeration– Reversed Carnot cycle, Air refrigeration system- Reversed Joule cycle. Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams. Psychometric properties – specific humidity, relative humidity and degree of saturation, thermodynamic equations, enthalpy of moisture, DBT, WBT and DPT, psychrometers, psychometric chart. Comfort and industrial air conditioning, Comfort air conditioning-factors affecting human comfort, Effective temperature, comfort chart, Summer air conditioning

Text Books

1. Rudramoorthy , Thermal Engineering, McGraw Hill Education India, 2003.

2. R.K Rajput, Thermal Engineering, Laxmi publications, 2010.

3. Arora C. P, Refrigeration and Air-Conditioning, McGraw-Hill, 2008.

4. Arora S. C. and Domkundwar, Refrigeration and Air-Conditioning, Dhanpat Rai, 2010.

Reference Books

1. V. Ganesan, Fundamentals of IC engines, Tata McGraw-Hill, 2002.

2. J.B.Heywood, I.C engine fundamentals. McGraw-Hill, 2011.

3. Rathore, Thermal Engineering, McGraw Hill Education India, 2010.

4. Dossat. R. J, Principles of Refrigeration, Pearson Education India, 2002.

5. Stoecker W.F, Refrigeration and Air-Conditioning, McGraw-Hill Publishing Company, 2009.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Steam engineering- Rankine cycle, Modified Rankine cycle, Relative efficiency, Improvement in steam cycles-Reheat, Regenerative and Binary vapor cycle.	4
1.2	Steam Boilers: Types of boilers, Cochran boiler, Babcock and Wilcox boiler, Benson boiler.	3
1.3	La Mont boiler, Boiler Mountings and Accessories.	2
2		
2.1	Steam turbines: classification, compounding of turbines-pressure velocity variation, velocity diagrams.	3
2.2	Work done, efficiency, condition for maximum efficiency, multistage turbines-condition line, stage efficiency.	3
2.3	Steam turbine performance-reheat factor, degree of reaction, cycles with reheating and regenerative heating, governing of turbines.	3
3		
3.1	Actual cycle analysis of IC engines- Deviation of actual engine cycle from ideal cycle	2
3.2	Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque	2
3.3	Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency	3
3.4	Relative efficiency, Specific fuel consumption.	2
4		
4.1	Combustion in I.C. Engines- Analysis of fuel combustion-A/F ratio, equivalence ratio, excess air.	1
4.2	Combustion phenomena in S.I. engines; Ignition limits, stages of combustion in S.I. Engines, Ignition lag, velocity of flame	3

	propagation, auto ignition, detonation; effects of engine variables on detonation; theories of detonation,	
4.3	Octane rating of fuels; pre-ignition; S.I. engine combustion chambers. Combustion in C.I. Engines; delay period; variables affecting delay period;	3
4.4	knock in C.I. engines, Cetane rating; C.I. engine combustion chambers.	2
5		
5.1	Refrigeration– Reversed Carnot cycle, Air refrigeration system- Reversed Joule cycle.	2
5.2	Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams.	2
5.3	Psychometric properties – specific humidity, relative humidity and degree of saturation-	1
5.4	Thermodynamic equations- enthalpy of moisture- DBT, WBT and DPT–psychrometers, psychometric chart.	2
5.5	Comfort and industrial air conditioning, Comfort air conditioning-factors affecting human comfort, Effective temperature, comfort chart, Summer air conditioning,	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET 384	**HEAT TRANSFER**	VAC	3	1	0	4

Preamble:

The objectives of the course are:

- To introduce the heat transfer by conduction, convection and radiation modes.
- To provide useful information for solving the heat transfer problems across the plane and cylindrical sections
- To give enough ideas to solve the heat transfer problems involving convection heat transfer
- To determine the performance of heat exchangers
- Present and solve the various types of radiation heat transfer problems

Prerequisite: MET203 Mechanics of fluid

Course Outcomes: After the completion of the course the student will be able to

CO 1	To understand the basics of heat transfer.
CO 2	To estimate heat transfer through plane wall, cylindrical surface and fins for various conditions.
CO 3	To solve problems involving heat convection.
CO 4	To solve the problems of heat exchangers and to determine its performance.
CO 5	To estimate radiation heat transfer between two bodies.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											1
CO 2	2	3	2								1	1
CO 3	2	2	2								1	1
CO 4	2	3	2								1	1

Assessment Pattern

Bloom's Category	**Continuous Assessment**			**End Semester Examination**
	Assignment (%)	**Test 1 (%)**	**Test 2 (%)**	
Remember	30	20	20	10
Understand	30	40	40	20
Apply	40	40	40	70
Analyse				
Evaluate				
Create				

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain Fourier's law of heat conduction?
2. Derive the equation of general heat conduction equation in Cartesian coordinates?

Course Outcome 2 (CO2)

1. The interior temperature of a refrigerator is maintained at 7°C. The walls are constructed with two mild steel sheets 3 mm thick with 5 cm of glass wool insulation between them. The heat transfer coefficients on inner and outer surface of refrigerator are 10 W/m2°C and 12.5 W/m2 °C respectively. Find the rate of heat leaked the refrigerator in watts when it is kept in a kitchen room. Also find inter wall temperatures. The temperature in kitchen room is 28°C.Take K (mild steel) =40 W/m-°C K (glass wool) = 0.04 W/m-°C3. Demonstrate the operation of stack and stack pointer through push and pop Instructions.

2. Derive an equation for one dimensional heat conduction through a plane wall and represent it in a form of electrical analogy?

Course Outcome 3(CO3):

1. Explain Newton's law of convective heat transfer?

2. Explain hydrodynamic boundary layer with the help of a neat diagram.

3. Define Reynolds Number, Prandtl Number and Nusselt Number.

Course Outcome 4 (CO4):

1. What is LMTD? What is the need of determine the LMTD?

2. In a double pipe heat exchanger hot water flows at a rate of 14 kg/s and gets cooled from 370K to 340K. At the same time 14 kg/s of cooling water at 303K enters the heat exchanger. The flow conditions are such that overall heat transfer coefficient remains constant at 2270

W/m2 K. Determine the effectiveness and the heat transfer area required, assuming two streams are in parallel flow. Assume the specific heat for the both the streams = 4.2 kJ/kg K.

Course Outcome 5 (CO5):

1. Explains Stephan Boltzmann law of heat radiation?
2. Explain Wien's displacement law?

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SIXTH SEMESTER MECHANICAL ENGINEERING

Heat Transfer-MET384

Maximum: 100 Marks **Duration: 3 hours**

PART A

Answer all questions. Each question carries 3 marks

1. Explain Fourier's law of heat conduction?
2. What are the factors affecting thermal conductivity of solids, liquids and gases?
3. Write the equation for one dimensional heat conduction through a plane wall and represent it in a form of electrical analogy?
4. What is critical thickness of insulation and what is its importance?
5. Define Reynolds Number, Prandtl Number and Nusselt Number?
6. What is the difference between free and forced convection?
7. What is meant by NTU in heat exchangers? When it is used?
8. What is effectiveness of a heat exchanger?
9. Explains Stephan Boltzmann law of heat radiation?
10. Explain Wien's displacement law?

(10 X 3 = 30 Marks)

PART B

Answer one full question from each module

MODULE 1

11. a) Derive general conduction equation in Cartesian coordinate? (10 marks)

b)reduce the equation for steady one dimensional conduction heat transfer for homogeneous isotropic material without heat generation. (4marks)

12. a) Explain three different modes of heat transfer? (10 marks)

b) Write down the general conduction equation in cylindrical coordinate and explain the terms?

(4 marks)

MODULE II

13. a) The interior temperature of a refrigerator is maintained at 7°C. The walls are constructed with two mild steel sheets 3 mm thick with 5 cm of glass wool insulation between them. The heat transfer coefficients on inner and outer surface of refrigerator are 10 W/m2°C and 12.5 W/m2 °C respectively. Find the rate of heat leaked the refrigerator in watts when it is kept in a kitchen room. Also find inter wall temperatures. The temperature in kitchen room is 28°C.Take K (mild steel) =40 W/m-°C K (glass wool) = 0.04 W/m-°C. (10 marks)

b) Write an expression for one dimensional heat transfer along radial direction, through a hollow cylindrical surface of radius R1 and R2 , thermal conductivity K and length L. express it as an analogy of electric flow (4 marks)

14 a) Derive an expression for heat flow through "rectangular fin" of infinite length ? (12 marks)

b) What is the propose of a fins? (2 marks)

MODULE III

15 a) Air at 20°C at atmospheric pressure flows over a flat plate at a velocity of 3 m/s. If the plate is 1 m wide and at 80°C, calculate the following at x = 300 mm. Determine Hydrodynamic boundary layer thickness, Thermal boundary layer thickness, Local friction coefficient , Average heat transfer coefficient , Heat transfer rate (10 marks)

b) What is the difference between laminar and turbulent flow? (4 marks)

16 a) Air at pressure of 1 atm and temperature 60°C flows over a flat plate which maintains a surface temperature of 100°C. The plate has a length of 0.2m (in the flow direction) and width of 0.1m. The Reynolds number based on the plate length is 40000. What is the rate of heat transfer from plate to air? If the free stream velocity of air is doubled and the pressure is increased to 2.5 atm, what is the rate of heat transfer? (12 marks)

b) What is the importance of Reynolds number? (2 marks)

MODULE IV

17. a) Derive an expression for LMTD of "parallel flow" heat exchanger (10 marks)

b) What is fouling and scaling of heat exchangers? How to accommodate this factor in calculation

(4 marks)

18. a) A chemical having specific heat of 3.3 KJ/kg K, flowing at the rate of 20000 kg/h enters a parallel flow heat exchanger at 120° C. The flow rate of cooling water is 50000 kg/h with an inlet temperature of 20°C. The heat transfer area is 10 m2 and the overall heat transfer coefficient is 1050 W/m^2 K. Take specific heat of water as 4.186 KJ/kg K Find: (i) The effectiveness of the heat exchanger. (ii) The outlet temperature of water and chemical.

(12 marks)

b) Explain matrix type of heat exchangers? (2 marks)

MODULE V

19 a) Calculate the heat exchange by radiation between the surfaces of two long cylinders having radii 120 mm and 60 mm respectively. The axes of the cylinders are parallel to each other. The inner cylinder is maintained at a temperature of 130°C and emissivity of 0.6. Outer cylinder is maintained at a temperature of 30°C and emissivity of 0.5. (10 marks)

b) Explains Stephan Boltzmann law of heat radiation? (4 marks)

20. a) Calculate the radiation exchange per unit area between two parallel plates of temperature 4000C and 250C. Emissivity of hot and cold plates are 0.9 and 0.7 respectively. Find the percentage reduction in heat transfer, if a radiation shield of emissivity 0.25 is placed in between the plates

(7 marks)

b) Explain Wien's displacement law? (7 marks)

Syllabus

Module 1- INTRODUCTION TO HEAT TRANSFER

Modes of Heat Transfer: Introduction to Conduction, Convection, radiation. Conduction: Fourier law of heat conduction-Thermal conductivity of solids, liquids and gases-Factors affecting thermal conductivity- Most general heat conduction equation in Cartesian and cylindrical coordinates.

Module 2 CONDUCTION HEAT TRANSFER

One dimensional steady state conduction with and without heat generation conduction through plane walls, cylinders. Critical thickness of insulation – Heat transfer through composite wall- extended surface heat transfer – fin performance – effect of variable thermal conductivity.

Module 3 CONVECTION HEAT TRANSFER

Convection heat transfer: Newton's law of cooling- Free and forced convection. Laminar and Turbulent flow, Reynolds Number, Critical Reynolds Number, Prandtl Number, Nusselt Number, Grashoff Number and Rayleigh's Number. Elementary ideas of hydrodynamics and thermal boundary layers-Thickness of Boundary layer-Displacement, Momentum and Energy thickness (description only).

Module 4 HEAT EXCHANGERS

Heat exchangers: Classification – log mean temperature difference – overall heat transfer coefficient – fouling and scaling of heat exchangers – LMTD and NTU method of performance evaluation of heat exchangers.

Module 5 RADIATION HEAT TRANSFER

Radiation: Fundamentals of radiation – radiation spectrum – thermal radiation – concept of black body and grey body – monochromatic and total emissive power – absorptivity, reflectivity and transmissivity - laws of radiation – radiation between two surfaces – geometrical factors for simple configuration – radiation shields – electrical network method of solving problems.

Text Books

1. Sachdeva R. C., Fundamentals of Engineering Heat and Mass Transfer, New Age Science Limited

2. R. K. Rajput, Heat and mass transfer, S. Chand & Co.

3. Nag P. K., Heat and Mass Transfer, McGraw Hill.

4. Kothandaraman, C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi.

Data Book

Heat and Mass Transfer data book: C.P. Kothandaraman, S. Subramanyan, New age International publishers.

Reference Books

1. Holman J.P, "Heat transfer", Mc Graw-Hill, 10th. Ed.

2. Yunus A Cengel, "Heat and Mass Transfer: Fundamentals and Applications" McGraw-Hill Higher Education.

3. Frank P. Incropera and David P. Dewitt, Heat and Mass Transfer, John Wiley and sons.

COURSE PLAN

MODULE	TOPICS	HOURS ALLOTED
1	Modes of Heat Transfer: Introduction to Conduction, Convection, radiation. Conduction: Fourier law of heat conduction-Thermal conductivity of solids, liquids and gases-Factors affecting thermal conductivity	**4-0-0**
	General heat conduction equation in Cartesian coordinates. General heat conduction equation in Cylindrical coordinates	**3-1-0**
2	One dimensional steady state conduction with and without heat generation conduction through plane walls, cylinders. Critical thickness of insulation – Heat transfer through composite wall- extended surface heat transfer – fin performance – effect of variable thermal conductivity.	**8-2-0**
	Convection heat transfer: Newton's law of cooling- Free and forced convection. Laminar and Turbulent flow, Reynolds Number, Critical	

3	Reynolds Number, Prandtl Number, Nusselt Number, Grashoff Number and Rayleigh's Number. Elementary ideas of hydrodynamics and thermal boundary layers-Thickness of Boundary layer-Displacement, Momentum and Energy thickness	**7-2-0**
4	Heat exchangers: Classification – log mean temperature difference – overall heat transfer coefficient – fouling and scaling of heat exchangers – LMTD and NTU method of performance evaluation of heat exchangers	**8-2-0**
5	Radiation: Fundamentals of radiation – radiation spectrum – thermal radiation – concept of black body and grey body – monochromatic and total emissive power – absorptivity, reflectivity and transmissivity - laws of radiation – radiation between two surfaces – geometrical factors for simple configuration – radiation shields – electrical network method of solving problems.	**7-2-0**

CODE	MACHINE TOOLS ENGINEERING	CATEGORY	L	T	P	Credits
MET385		VAC	3	1	0	4

Preamble:

This course facilitate students to learn about various machine tools and operations performed on them. Theoretical foundation offered by this course must help the learners to make appropriate decisions vis-a-vis preliminary planning and selection of machine tools, acquiring adequate supervisory skills and to help the learners to efficiently interact with their peers to arrive at solutions for day-to-day shop floor problems.

Prerequisite:
MET285 Material Science and Technology (Minor), MET286 Manufacturing Technology (Minor)

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Describe basic concepts involved in metal cutting.
CO 2	Differentiate between machine tools, their components, operations carried out and their unique metal removing mechanisms.
CO 3	Describe how to specify machine tools and cutting tools.
CO 4	Calculate the time required for machining.
CO 5	Clarify advantages of CNC over manual machine tools.
CO 6	Clarify how non-conventional machining techniques are advantageous to finish jobs with intricate profiles and closer tolerances.

Mapping of course outcomes with program outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	-	-	-	-	-	-	-	2	-	-	-
CO 2	1	-	1	-	3	-	-	-	2	1	-	-
CO 3	-	-	-	2	-	-	-	-	2	-	1	-
CO 4	3	2	-	-	-	-	-	-	2	-	-	-
CO 5	-	-	-	-	2	-	-	-	2	-	-	2
CO 6	-	-	-	-	-	-	1	-	2	-	-	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination (marks)
	1 (marks)	2 (marks)	
Remember	15	15	35
Understand	15	15	35
Apply	10	10	15
Analyse	10	10	15
Evaluate	-	-	-
Create	-	-	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe the geometry of a single point cutting tool with a neat diagram.
2. Define machinability.
3. List various cutting tool materials and their applications.

Course Outcome 2 (CO2):

1. Examine two reasons for centre drilling on lathe.
2. Differentiate between up milling and down milling.
3. Differentiate a wire-cut EDM from a general purpose EDM.

Course Outcome 3 (CO3):

1. List all specification parameters of a lathe.
2. Specify a plain milling cutter.
3. Specify a twist drill.

Course Outcome 4 (CO4):

1. Calculate the time required for drilling a 20 mm hole in metal blank having thickness of 36 mm. The cutting speed is 15 metres/minute and feed is 0.2 mm/revolution.
2. Calculate the r.p.m. of lathe to obtain a cutting speed of 25 metres/minute, when turning a rod of diameter 32 mm diameter.
3. Calculate machining time for cylindrical grinding, if length of longitudinal travel =500 mm, feed =1.0 mm/revolution and work piece r.p.m = 500 in a single pass.

Course Outcome 5 (CO5):

1. Clarify whether a conventional machine tool can be retrofitted with a CNC system.
2. Describe advantages of CNC system in manufacturing.
3. Distinguish between open loop system and closed loop system by giving an example for each.

Course Outcome 6 (CO6):

1. Describe advantages of WJM over traditional punching/manual cutting
2. Compare process capabilities of conventional drilling and laser beam drilling.
3. Clarify why an EDM is not used as a replacement to CNC milling machine.

MODEL QUESTION PAPER

FIFTH SEMESTER MECHANICAL ENGINEERING

MET385 MACHINE TOOLS ENGINEERING

Max. Marks: 100 Duration: 3 hours

Part−A

Answer all questions. Each question carries 3 marks.

1. State the effect of cutting speed, feed and depth of cut on surface finish obtainable.
2. Explain why built up edge on a tool is undesirable.
3. A brass pin of 500 mm length and 40 mm diameter is turned on a lathe to 38.8 mm diameter in one pass. The cutting speed is 60 metres/minute and feed is 0.8 mm/min. Calculate the machining time.
4. How do you specify (a) portable drilling machine (b) radial drilling machine (c) multiple spindle drilling machine.
5. List various operations that can be performed on a milling machine.
6. Differentiate between grain and grade in a grinding wheel.
7. Bring out the differences between continuous path control and point-to-point positioning.
8. List the generic advantages of CNC system over their manual counterparts.
9. Discuss the characteristics of dielectric fluids used in EDM.
10. List the advantage of WJM over traditional cutting.

Part−B

Answer one full question from each module.

Module I

11. (a) Sketch the three views of a 25 mm single point square tool bit having tool signature as indicated below: 15,15,10,10,15,10 (3 mm) (7 marks)

(b) Define machinability. Discuss all variables affecting machinability.

(7 marks)

12. (a) Discuss various cutting tool materials and their applications.

(b) Define tool failure. List and explain 2 reasons for normal tool wear. (7 marks)

(7 marks)

Module II

13. Describe construction details of an engine lathe with a neat illustration. (14 marks)

14. Draw and explain any four operations carried out in a lathe. (14 marks)

Module III

15. Draw and explain up milling and down milling. Decide which type is suitable to prevent backlash. (14 marks)

16. List all factors to be considered for selection of grinding wheels. Discuss each in detail. (14 marks)

Module IV

17. Discuss all elements of a CNC system with a suitable block diagram. (14 marks)

18. Discuss construction details of a CNC lathe and compare process capability of CNC lathe with that of a manual lathe. (14 marks)

Module V

19. Describe ultrasonic drilling process giving areas of application. (14 marks)

20. Discuss construction and operation of a wire-cut EDM system with the help of a suitable diagram. (14 marks)

Syllabus

Module 1

Definition of machining−brief history of machining−role of machining in society. Introduction to metal cutting: Elements of cutting process− orthogonal cutting− mechanism of chip formation−machining variables -types of chips−chip breaker− geometry of single point cutting tool− tool nomenclature- speed, feed, depth of cut – cutting fluids- effect of machining variables on surface roughness- Cutting tool materials−types−application. Machinability−tool life and wear.

Module 2

General purpose machine tools – Lathe: principle of operation of lathe−construction details of lathe−work holding and tool holding parts of lathe− types of lathe and specification−machining time calculation on lathe−main operations. Drilling Machines: principle of operation- construction details- work holding and tool holding devices− types of drilling machine and specification. Twist drill geometry–specification−calculation of machining time in drilling.

Module 3

Milling machines: Principle of operation of milling machine-types and specifications−principal parts-work holding devices−types of milling cutters-elemental milling motions-up milling, down milling calculation of machining time. Grinding machines: classification −operations− surface, cylindrical and centerless grinding−grinding wheels−specification−types of abrasives, grain size. Dressing and truing of grinding wheels−selection of grinding wheels.

Module 4

Machine tools with Computer Numeric Control: Principle of operation of CNC system−basic components of CNC system− classification of CNC systems− open loop control and closed loop control− point to point and continuous path control− absolute positioning and incremental positioning−CNC lathe−construction and operation – CNC milling machine−construction and operation (elementary treatment only)

Module 5

Non-conventional techniques in machining: Electric Discharge Machining (EDM): mechanisms of metal removal- elements of an EDM− spark generation− application of EDM – Wire-cut EDM-features. UltraSonic Machining (USM): mechanism of metal removal- elements of USM-applications. Water Jet Machining (WJM): mechanism of metal removal-elements of WJM-applications.

Text Books

1. R.K.Jain, Production Technology, Khanna publishers, 17th ed., 2013.
2. Hajra Choudhary, Elements of Workshop Technology Vol. II, Media Promoters & Publishers Pvt. Ltd., 2010.

Reference Books

1. Serope Kalpakjian, Steven R. Schmid – Manufacturing Engineering and Technology, 8th ed. Pearson.
2. Chapman W.A.J., Workshop Technology, Viva books (P) Ltd, 1998.
3. Peter J. Hoffman, Eric S. Hopewell et al., Precision Machining Technology, Cengage Learning, 2014.
4. Malkin Stephen, Grinding Technology: Theory and application of Machining with Abrasives, Industrial press, 2008.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures	COs
1.1	Definition of Machining−brief history of machining−role of machining in society – automotive- aerospace− medical−consumable goods.	1	CO1
1.2	Introduction to metal cutting−elements of cutting process−work piece-tool interaction in orthogonal cutting- rake angle, shear angle, cutting angle, clearance angle−mechanism of chip formation−chip breaker.	1	CO1
1.3	Machining variables- geometry of chips (types of chips)- cutting speed, feed, depth of cut- tool geometry (single point)-nomenclature-cutting fluids.	3	CO1
1.4	Effect of machining variables on surface roughness.	2	CO1
1.5	Cutting tool materials and application.	1	CO1
1.6	Machinability-factors affecting it –machinability index.	1	CO1
1.7	Tool life and tool wear.	1	CO1
2.1	General purpose machine tools− lathe- principle and operation of lathe-how to specify a lathe-types of lathe.	1	CO2 CO3
2.2	Construction details of engine lathe-work holding and tool holding parts of lathe.	2	CO2
2.3	Main operations in lathe- machining time calculation of plain turning.	2	CO4

2.4	Drilling machines – principle of operation-construction details.	1	CO2
2.5	Work holding and tool holding devices.	2	CO2
2.6	Types of drilling machine- specification of radial drilling machine.	1	CO3
2.7	Twist drill geometry and specification- calculation of drilling time.	1	CO4
3.1	Milling machine- purpose and principle of operation-types an specification.	1	CO2
3.2	Differentiate Horizontal milling machine and vertical milling machine – principal parts and work holding devices of vertical milling machine.	1	CO2
3.3	Types of milling cutters- elemental milling movements- up milling, down milling – calculation of plain milling time.	2	CO4
3.4	Grinding machines- classification- surface, cylindrical and centre less grinding.	1	CO2
3.5	Grinding wheels−specification−types of abrasives, grain size−dressing and truing of grinding wheels−selection of grinding wheels.	3	CO3
4.1	Machine tools with CNC- principle of operation of CNC – basic components (block diagrams)	2	CO2
4.2	Classification of CNC systems− open loop control and closed loop control− point-to-point and continuous path control− absolute positioning and incremental positioning.	2	CO5
4.3	CNC lathe- construction and operation (elementary treatment)	2	CO5
4.4	CNC milling machine- construction and operation (elementary treatment)	2	CO5
5.1	Non-conventional techniques in machining: Electric Discharge machining (EDM): mechanism of metal removal- elements of an EDM− physics of spark generation.	2	CO6
5.2	Applications of EDM process.	1	CO6
5.3	Wire-cut EDM-features and applications.	1	CO6
5.4	Ultrasonic Machining (USM): mechanism of metal removal- elements of USM-applications.	2	CO6
5.5	Water Jet Machining (WJM): mechanism of metal removal-elements of WJM- applications.	2	CO6

MET386	INDUSTRIAL ENGINEERING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This course helps an engineering student to understand the functions and techniques of Industrial Engineering. It addresses economic aspects of the business decision and the concepts of human factors in design. The course involves productivity improvement methods, Work study, Method study and Time study. Industrial Engineering Tools and Techniques for Plant management including Plant layout and Material handling are also covered in this course. The students also will able understand Production Planning and Control process, and procedures. The other focus areas of Industrial Engineering, Quality practices, Project Management and Replacement technique are also part of this course.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the functions of Industrial Engineering, Economic aspects of business and Human factors in design
CO 2	Apply Principles of Work study, Method study and Work measurement techniques.
CO 3	Develop layout for a manufacturing/service system and apply plant management and Material handling techniques.
CO 4	Evaluate Production Planning and Control techniques and Inventory control
CO 5	Analyse Quality practices, and Apply Project Management and Replacement techniques.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1			2			3	3				3	
CO 2		3	3			3						
CO 3		3	3		3							
CO 4		3	3	3	3						3	
CO 5		3	3	3		3	3				3	

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	**2**	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State functions of an Industrial Engineer which will lead to improvement in productivity?.

2. How the productivity of s system can be improved? List factors affecting productivity that can be controlled.

3. Asian industries specialize in the manufacture of small capacity motors. The cost structure of the motor is as under

Material	Rs 50/-
Labour	Rs 80/-
Variable overhead	75% of labour cost

Fixed cost of the company amount 2,40,000 Rs/annum

The sales price of the motor is Rs 230/- each

Determine the number of motors to be manufactured to break even

How many motors are to be sold to make a profit of Rs 1 Lakh

If the sale price is reduced by Rs. 15/- how many motors are to sold to break even

Course Outcome 2 (CO2)

1. What is the concept of work content? What are reasons for excess of work content?

2. Differentiate between Two hand process chart and Multiple Activity chart.

3. The following data refers to the study conducted for an operation. The table shows the actual time for elements in minutes.

Cycle elements	1	2	3	4	5
1	2.5	2.6	2.4	2.5	2.5
2	6.0	6.2	6.1	5.9	6.0
3	2.3	2.1	2.4	2.2	2.3
4	2.4	2.5	2.6	2.8	2.5

i) Element 3 is machine elements

ii)Take performance rating as 110

Take following personal allowance of 30 minutes in shift of 8 hours, fatigue allowance 15%, contingency allowance 2%. Estimate the standard time for the operation and production per 8 hour shift.

Course Outcome 3(CO3):

1. List the different types of layout. Differentiate between Product and process layout based any five parameters.

2. Consider the following assembly network relationships of a product. The number of shifts per day is two and the number of working hours per shift is 8. The company aims to produce 80 units of the product per day. Group the activities into work stations using Ranking Positional Weight method and compute balancing efficiency.

Operation Number	Immediate predecessor	Duration (Min)
1	-	7
2	1	2
3	1	2
4	1	5
5	2,3	8
6	3,4	3
7	5	4
8	5,6	7
9	4,6	9
10	7,8,9	8

3. The initial cost of an equipment is Rs 21000/- expected salvage value Rs 1000 and expected useful life of 10 years. Calculate the depreciation and book value after 1 year and 9 years using sinking fund method and straight line method. Take interest rate as 6%

Course Outcome 4 (CO4):

1. Explain the steps of Production planning Process,

2. Describe the importance Product Life cycle in Product development and Management

3. A manufacturer has to supply his customer a 2400 units of his products per year. Shortages are not permitted. Inventory carrying cost amounts to Rs. 0.8/- per unit per annum. The setup cost per run is Rs 60/- . Find

i. EOQ

ii. Optimum number of order per annum

iii. Average annual inventory cost(min)

iv. Optimum period of supply per order

Course Outcome 5 (CO5):

1. Explain the Procedure of X and R chart .

2. The mortality rate are given in the table below for certain type of electric bulb. There are 2000 bulb in use and it costs Rs 12/- to replace an individual bulb that has burnt. If all the bulbs are replaced simultaneously, it would cost Rs. 4/- per bulb. It is proposed to replace all the bulbs in fixed intervals, whether or not they have burnt out and to continue replacing burnt bulbs out bulbs if they fail. At what intervals should all the bulbs be replaced?

Week	1	2	3	4	5	6
Probability of failure	0.05	0.2	0.25	0.3	0.15	0.05

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION

Course Code : MET386

Course Name : **INDUSTRIAL ENGINEERING**

Max. Marks : 100 Duration : 3 Hours

Part A

(**ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS**)

1. What are the factors influencing productivity?
2. Explain the role ergonomics plays in environmental man-machine interface
3. What is micro motion study? What are the steps involved?
4. Explain flow diagram with example
5. Explain REL Chart
6. Explain the criteria for selecting Material handling equipment
7. How order promising is done during Production planning
8. Briefly explain any three selective inventory control techniques

9. Explain the significance of Bathtub curve
10. Briefly explain the stages of TQM implementation

Part B

(ANSWER ONE FULL QUESTION FROM EACH MODULE)

Module 1

11. a) Explain the factors affecting make or buy decisions. (7marks)

b) ABC company plans to sell an article at local market. The articles are purchased at Rs 5 on the condition that all unsold items shall be returned. The rent for the space Rs 2000. The article will be sold at Rs 9 . Determine the number of articles which must be sold to i) to break even ii) to earn Rs 400 profit iii)if the company sells 750 articles . Calculate the margin of Safety (7 marks)

12. a) Explain the principles in the application of Anthropometric data. How it can be used in work place design? (8 marks)

b) Explain the functions of Industrial Engineering (6 Marks)

Module 2

13. a) Explain the use recording techniques in method study. Differentiate between Operations Process chart and Flow process chart. (7 Marks)

b) The observed time and the performance rating for five elements are given. Compute the standard time assuming rest and personal allowance as 15% and contingency as 2% of basic time.

Element	**1**	**2**	**3**	**4**	**5**
Observed time	0.2	0.08	0.50	0.12	0.10
Performance rating	85	80	90	85	80

(7 Marks)

14 a) Explain the different techniques used for work measurement. (7 Marks)

b) The following data refers to the study conducted for an operation. The table shows the actual time for elements in minutes.

Cycle elements	1	2	3	4	5
1	2.5	2.6	2.4	2.5	2.5
2	6.0	6.2	6.1	5.9	6.0
3	2.3	2.1	2.4	2.2	2.3
4	2.4	2.5	2.6	2.8	2.5

i) Element 3 is machine elements

ii)Take performance rating as 110

Take following personal allowance of 30 minutes in shift of 8 hours, fatigue allowance 15%, contingency allowance 2%. Estimate the standard time for the operation and production per 8 hour shift. (7 Marks)

Module 3

15. a) Explain Systematic Layout planning with the help of block diagram. (6 Marks)

b) Consider the following assembly network relationship of a product. The number of shifts per day is two and the number of working hours per shift is 12. The company aims to produce 100 units of the product per day. Group the activities into work stations using Rank Positional Weight Method and compute balancing efficiency.

Operation number	Immediate preceding Tasks	Duration (Min)
1	-	7
2	1	2
3	1	2
4	1	5
5	2,3	8
6	3,4	3

7	5	4
8	5,6	7
9	4,6	9
10	7,8,9	8

(8 Marks)

16 a) The initial cost of an equipment is Rs 21000/- expected salvage value Rs 1000 and expected useful life of 10 years. Calculate the depreciation and book value after 1 year and 9 years using sinking fund method and straight line method. Take interest rate as 6%. (6 Marks)

b)The price of an office equipment is Rs 2.5 lakhs the salvage value at the end of 10 years is Rs 25,000/ Calculate the amortised value after 5 years by using i) sinking fund method ii) declining balance method. (8 Marks)

Module 4

17 a) What are the different types of Production system, explain (7 Marks)

b)Consider the following 3 machine and 5 jobs flow shop problem. Check whether Johnson's can be extended to this problem. What is the optimal schedule for this problem and corresponding makespan? Draw the Gantt chart.

Job	Machine 1	Machine 2	Machine 3
1	11	10	12
2	13	8	20
3	15	6	15
4	12	7	19
5	20	9	7

(7 Marks)

18 a) Explain the Product Life cycle and its importance in Product management. (7 Marks)

b) ABC industry needs 15,000 units/year of a bought out component which will be used in its main product. The ordering cost is Rs. 125 per order and holding cost per unit per year is 20% of the purchase price per unit which is Rs. 75.

i. Find economic order quantity

ii. Number of order per year

iii. Time between successive orders

The activities involved in ABC manufacturing company are listed below with their time estimates. Draw the network for the given activities and carry out critical path calculations.

(7 Marks)

Module 5

19 a) Differentiate between PERT and CPM, Specify the difference in application (6 Marks)

b) Consider the following data of the project

Activity	Predecessor	Duration (Weeks)		
		a	m	b
A	_	3	5	8
B	_	6	7	9
C	A	4	5	9
D	B	3	5	8
E	A	4	6	9
F	C,D	5	8	11
G	C,D,E	3	6	9
H	F	1	2	9

i. Construct the project network

ii. Find expected duration and variance of each activity

iii. What is the probability of completing the project in 30 weeks?

(8 Marks)

20 a) What is Process Capability? Explain the significance Process capability Index

(7 Marks)

b)The cost of a machine is Rs. 60,000/-. The salvage value and the running costs of a machine are shown in the table. Depreciation is cumulative. Find the most economical replacement age of the machine. (7 marks)

Year	1	2	3	4	5	6
Running cost in Rs.	12050	14100	16375	18875	20500	24550
Resale value in Rs	40000	30000	25000	15000	10500	7000

Syllabus

Module 1

Introduction to Industrial Engineering - Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering.
Productivity- productivity measures- dynamics of productivity change- Techniques for improving productivity.
Production costs concepts – Manufacturing Vs Purchase- problems- Economic aspects- C-V-P analysis – simple problems..
Ergonomics Man-Machine systems-Anthropometry Work place design and ergonomics - Value Engineering.

Module 2
Work study-procedure-concept of work content- techniques to reduce work content.
Method Study-steps-recording techniques-operation process chart-flow process chart-two hand process chart-multiple activity chart. Diagrams- Flow diagrams-String diagrams. Micro-motion study-SIMO chart- critical examination. Principle of motion economy.
Work measurement- techniques of work measurement - Time Study- - Steps in time study-calculation of standard time (problems)- allowances.

Module 3
Plant location, plant layout and material handling- Type of layouts and characteristics –Tools and techniques for plant layout- travel chart – REL chart- Computer algorithms for layout design CRAFT-ALDEP (methods only)- Systematic layout planning -Line balancing–RPW (problem).
Principles of material handling-selection and type of material handling equipment- Unit load concept- Automated Material Handling Systems- AGVs.
Depreciation -Method of providing for depreciation- straight line method- Declining balance method- Sinking fund methods (Problems)

Module 4
Production Planning and control -Types of Production systems.
Demand forecasting- Forecasting methods, Aggregate planning- methods- Master Production Schedule-techniques-order promising- Material Requirement Planning-bill of material-

product structure diagram- MRP record processing- Shop floor control - Scheduling flow shop and job shop scheduling methods, Johnson's algorithm-dispatching rules - Gantt charts. Introduction and need for a new product-product life cycle.
Inventory Control, Inventory models – Basic model -price discounts -problems – determination of safety stock - Selective inventory control techniques

Module 5

Quality control - Statistical quality control –causes of variation in quality- control charts for X and R (problems). Process Capability- process capability index- Reliability-causes of failures- Bath tub curve.-System reliability. Introduction to concepts of, TQM, ISO, Six Sigma and Quality circles.
Project management- Critical Path Method, PERT, crashing of networks
Determination of economic life -Replacement policy-- Methods of replacement analysis.

Text Books

1. Martand Telsang, Industrial Engineering & Production Management, S. Chand, Third revised edition 2018.
2. B. Kumar, Industrial Engineering Khanna Publishers, Tenth Edition 2015
3. Thomas E Vollmann , William L Berry , D Clay Whybark, F Robert Jacobs, Manufacturing Planning and Control for Supply Chain Management, McGraw Hill Education (India) Private Limited, Fifth Edition 2017
4. M Mahajan, Industrial Engineering & Production Management, Dhanpat Rai, 2015
5. O. P. Khanna, Industrial Engineering and Management, Dhanpat Rai, 2018

Reference Books

1. E. S. Buffa, Modern Production management, John Wiley, 1983
2. Grant and Ieven Worth, Statistical Quality Control, McGraw Hill, 2000
3. Ralph M Barnes, Motion and Time Study, Wiley, 1980
4. Richard L. Francis, F. McGinnis Jr., John A. White, Facility Layout and Location: An Analytical Approach, 2nd Edition,1991

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Introduction to Industrial Engineering - Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering. Productivity- productivity measures- dynamics of productivity change- Techniques for improving productivity. Production costs concepts – Manufacturing Vs Purchase- problems- Economic aspects- C-V-P analysis – simple problems.. Ergonomics Man-Machine systems-Anthropometry Work place design and ergonomics - Value Engineering	7-2-0
2	Work study-procedure-concept of work content- techniques to reduce work content. Method Study-steps-recording techniques-operation process chart-flow process chart-two hand process chart-multiple activity chart. Diagrams- Flow diagrams-String diagrams. Micro-motion study-SIMO chart- critical examination. Principle of motion economy. Work measurement- techniques of work measurement - Time Study- - Steps in time study- calculation of standard time (problems)- allowances	7-2-0
3	Plant location, plant layout and material handling- Type of layouts and characteristics – Tools and techniques for plant layout- travel chart – REL chart- Computer algorithms for layout design CRAFT-ALDEP (methods only)- Systematic layout planning -Line balancing–RPW (problem). Principles of material handling-selection and type of material handling equipment- Unit load concept- Automated Material Handling Systems- AGVs. Depreciation -Method of providing for depreciation- straight line method- Declining balance method- Sinking fund methods (Problems)	7-2-0
4	Production Planning and control **-**Types of Production systems. Demand forecasting- Forecasting methods, Aggregate planning- methods- Master Production Schedule-techniques-order promising- Material Requirement Planning-bill of material-product structure diagram- MRP record processing- Shop floor control - Scheduling flow shop and job shop scheduling methods, Johnson's algorithm-dispatching rules -- Gantt charts. Introduction and need for a new product-product life cycle. Inventory Control, Inventory models – Basic model -price discounts -problems – determination of safety stock - Selective inventory control techniques	7-2-0
5	Quality control - Statistical quality control –causes of variation in quality- control charts for X and R (problems). Process Capability- process capability index- Reliability-causes of failures- Bath tub curve.-System reliability. Introduction to concepts of, TQM, ISO, Six Sigma and Quality circles. Project management- Critical Path Method, PERT, crashing of networks Determination of economic life -Replacement policy-- Methods of replacement analysis.	7-2-0

MED481	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

Preamble: Mini Project Phase I: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Chemical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:

- Survey and study of published literature on the assigned topic;
- Preparing an Action Plan for conducting the investigation, including team work;
- Working out a preliminary Approach to the Problem relating to the assigned topic;
- Block level design documentation
- Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility;
- Preparing a Written Report on the Study conducted for presentation to the Department;

CO1	Identify and synthesize problems and propose solutions to them.
CO2	Prepare work plan and liaison with the team in completing as per schedule.
CO3	Validate the above solutions by theoretical calculations and through experimental
CO4	Write technical reports and develop proper communication skills.
CO5	Present the data and defend ideas.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3					3	3		2
CO2	3			3				3	3	3	3	
CO3	3	3	3	3	3					3		
CO4					3			3	3	3		1
CO5	3	3	3	3				3		3	3	1

*1-slight/low mapping, 2- moderate/medium mapping, 3-substantial/high mapping

Continuous Internal Evaluation Pattern:

Sl. No.	Level of Evaluation	Marks
1	Interim evaluation by the committee	**20**
2	Project Guide	**30**
3	Final Seminar evaluation by the committee	**30**
4	The report evaluated by the evaluation committee	**20**
	Total	**100**
	Minimum required to pass	**50**

The evaluation committee comprises a panel of HoD or a senior faculty member, Project coordinator and project supervisor.

MED482	MINI PROJECT	CATEGORY	L	T	P	CREDIT
		PWS	0	0	3	4

Preamble: Mini Project Phase I: A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The object of Project Work I is to enable the student to take up investigative study in the broad field of Chemical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on a group of three/four students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:

- Survey and study of published literature on the assigned topic;
- Preparing an Action Plan for conducting the investigation, including team work;
- Working out a preliminary Approach to the Problem relating to the assigned topic;
- Block level design documentation
- Conducting preliminary Analysis/ Modelling/ Simulation/ Experiment/ Design/ Feasibility;
- Preparing a Written Report on the Study conducted for presentation to the Department;

CO1	Identify and synthesize problems and propose solutions to them.
CO2	Prepare work plan and liaison with the team in completing as per schedule.
CO3	Validate the above solutions by theoretical calculations and through experimental
CO4	Write technical reports and develop proper communication skills.
CO5	Present the data and defend ideas.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3					3	3		2
CO2	3			3				3	3	3	3	
CO3	3	3	3	3	3					3		
CO4					3			3	3	3		1
CO5	3	3	3	3				3		3	3	1

*1-slight/low mapping, 2- moderate/medium mapping, 3-substantial/high mapping

Continuous Internal Evaluation Pattern:

Sl. No.	Level of Evaluation	Marks
1	Interim evaluation by the committee	**20**
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3	Final Seminar evaluation by the committee	**30**
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