SEMESTER V

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET301	MECHANICS OF MACHINERY	PCC	3	1	0	4

Preamble:

This course aims to introduce the students to the fundamentals of the kinematics of various mechanisms and also its analysis for its displacement, velocity, and acceleration. The course will also cover the design of cams, theory and analysis of gears, gear trains and synthesis of mechanisms. The static force analysis of planar mechanisms and concept of gyroscopic couple along with its effect has also been included. This course also aids students in estimating unbalance in rotating and reciprocating masses and suggesting methods to overcome it.

Prerequisite: Engineering Mechanics (EST 100)

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

CO 1	Explain the fundamentals of kinematics, various planar mechanisms and interpret the basic principles of mechanisms and machines
CO 2	Perform analysis and synthesis of mechanisms
CO 3	Solve the problem on cams and gear drives, including selection depending on requirement.
CO 4	Calculate the gyroscopic effect in various situations
CO 5	Analyse rotating and reciprocating masses for its unbalance

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 12
CO 1	2										
CO 2	3	3	3	2	2						
CO 3	3	3	2	2	2						
CO 4	3	2	1	1	1						
CO 5	3	2	2	1	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): Explain the fundamentals of kinematics, various planar mechanisms and their components

1. Define the terms Link, Kinematic chain, Mechanism & Machine.

2. Explain Grashof's law.

3 Apply Kutzbach criterion to find the mobility of mechanisms.

4.Sketch and explain the various inversions of slider crank chain/fourbar chain

Course Outcome 2 (CO2) : Perform analysis and synthesis of mechanisms

1. Find out the velocity and acceleration of links of various planar mechanisms

2. State and prove the Arnold Kennedy's three centre theorem

2. Derive an expression for the magnitude and direction of Coriolis component of acceleration

3. Design a four bar mechanism to generate a given function accurate upto 3 positions

4. Do the static force analysis of four bar/slider crank mechanisms with different loading conditions

Course Outcome 3 (CO3): Solve the problem on cams and gear drives, including selection depending on requirement

1. Why is a roller follower preferred over knife edge follower

2. Design a cam profile to suit the situations for the follower such as SHM, dwell, constant velocity, uniform acceleration cycloidal motion etc

3. What do you understand by the term "interference" as applied to gears

4. Find out the gear train values of simple ,compound and epicyclic gear trains

Course Outcome 4 (CO4): Calculate the gyroscopic effect in various situations

1. What do you understand by Gyroscopic couple? Derive its formula for its magnitude.

2. Explain the effect of the gyroscopic couple on the reaction of the four wheels of a vehicle negotiating a curve.

3. Describe the working of a gyroscope.

4. How does gyroscopes help in guidance?

Course Outcome 5 (CO5): Analyse rotating and reciprocating masses for its unbalance

1. Distinguish between static balancing and dynamic balancing

2. Find out the magnitude and position of balancing masses required to balance unbalanced masses rotating in different planes.

3. What do you mean by primary and secondary unbalanced forces?

4. Find out the value of unbalanced primary force, primary couple, secondary force and secondary couple.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B. TECH DEGREE EXAMINATION

Course Code: MET301

Course Name: MECHANICS OF MACHINERY

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

PART – A

(ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS)

1. Find out the degree of freedom in the following cases.

a) A planar link b) Two planar links joined by a revolute joint c) Three Planar links joined by three revolute joints

2. Describe the motion of the following items as pure rotation, pure translation or complex planar motion.

a) The hand of a clock **b)** The pen in an XY plotter **c)** connecting rod of an IC engine

3. A rod of length 1m with its one end fixed at origin is oriented in the positive X direction. It rotates in the XY plane with an angular velocity of 10rad/s clockwise direction and angular acceleration of 10rad/s^2 in the counter clock wise direction at a particular instant. Find out the total acceleration experienced at the free end.

4. Obtain the expression for velocity when the cam follower motion is cycloidal in nature.

5. How do we bring interchangeability of gears?

6. What do you mean by type synthesis?

7. Define the term 'friction circle'

8. How does a gyroscope help in guidance of aircrafts?

9. Does a rotor which is statically balanced require dynamic balancing?

10. Why do we go for partial balancing in the case of balancing of reciprocating masses?

Part B

(ANSWER ONE FULL QUESTION FROM EACH MODULE)

MODULE – I

11. a) Draw the inversions of the mechanism shown in Figure 1 which leads to double crank, double rocker and crank rocker mechanisms. Describe the nature of motion of each link in each case also **(9 marks)**

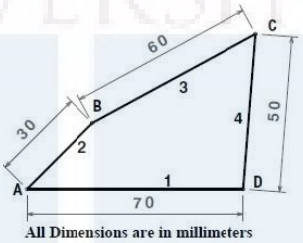


Figure-1

b) What are binary, ternary and quaternary links? **(5 marks)**

12. In the figure 2 given below the angular velocity of the crank OA is 600 r.p.m. Determine the linear velocity of the slider and angular velocity of all other links. The dimensions of various links are: OA=28 mm; AB = 44 mm; BC = 49 mm and BD = 46 mm. The centre distance between centres of rotation O and C is 65mm.The path of travel of slider is 11 mm below the fixed-point C **(14 marks)**

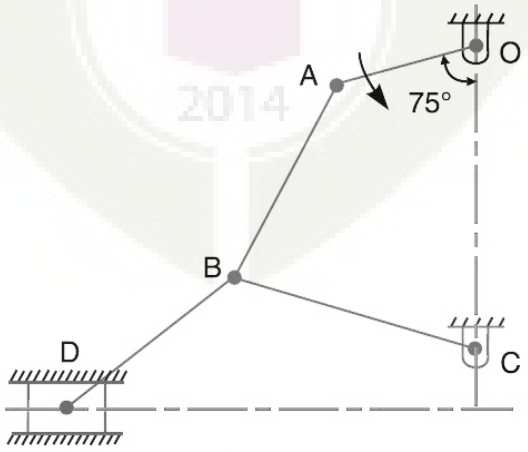


Figure-2

MODULE – II

13. a) What is meant by Coriolis component of acceleration. In which case does it occur? How is its direction determined? **(9 marks)**

b) A link OB rotating with a constant angular velocity of 2 rad/s in the counter clockwise direction and a block is sliding radially outwards on it with a uniform velocity of 0.75 m/s with respect to the rod as shown in the figure 3 below. Given OA =1 m and link OB is inclined to the positive X axis by 45°.Find out the absolute acceleration of block at A in magnitude and direction. **(5 marks)**

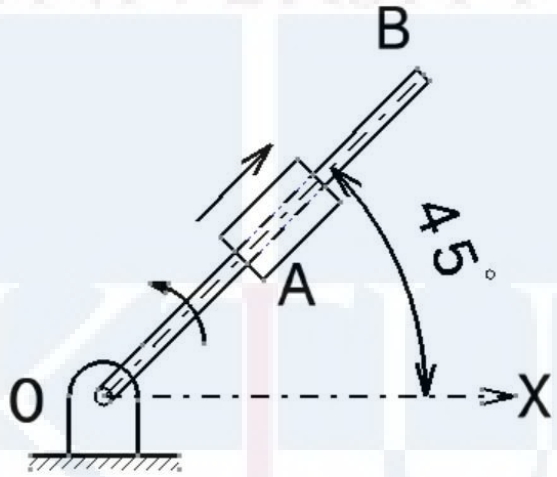


Figure-3

14. A cam rotating at 150 rpm operates a reciprocating follower of radius 2.5 cm. The follower axis is offset by 2.5 cm to the right. The least radius of the cam is 5 cm and the stroke of the follower is 5 cm. ascent and descent with take place by uniform acceleration and retardation. Ascent take place during 75° and descent during 90° of cam rotation. Dwell between ascent and descent is 60°. Draw the cam profile. Also sketch velocity and acceleration diagrams and mark salient values. **(14 marks)**

MODULE – III

15. In an epicyclic gear train as shown in Figure 4 the internal wheels A and B and the compound wheels C & D rotate independently about axis O. The wheels E and F rotate on pins fixed to the arm G.E gears with A and C and F gears with B and D. All wheels have the same module and the number of teeth are:

$Tc = 28$, $T_D = 26$, $T_E = T_F = 18$

i) Sketch the arrangement

ii) Find the number of teeth on A and B

iii) If the arm G makes 100 r.p.m clockwise and A is fixed, find the speed B

iv) If the arm G makes 100 r.p.m clockwise and wheel A makes 10 r.p.m counter clockwise, find the speed of wheel B **(14 marks)**

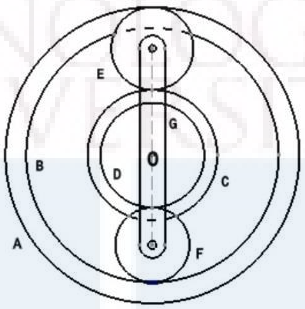


Figure-4

16. **a)** Design a four bar crank rocker to give 45° of rocker motion with a time ratio of 1:1.25 with 45° output rocker motion. **(9 marks)**

b) Design a slider crank mechanism to coordinate two positions of the input link and the slider for the following angular and linear displacement of the input link and slider respectively.

$\theta_{12} = 30°$ & $S_{12} = 100$ mm **(5 marks)**

MODULE – IV

17. The applied load on the piston of an offset slider-crank linkage shown in Fig. is 100 N, and the coefficient of friction between the slider and the guide is 0.27, using any method ,determine the magnitude and sense of torque T_2 applied on OA for the static equilibrium of the linkage. **(14 marks)**

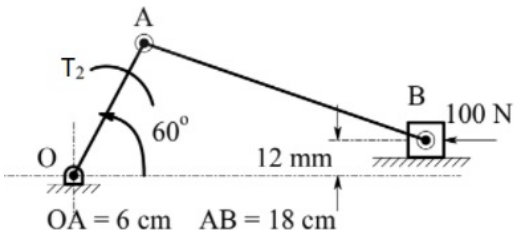


Figure-5

18 a) The wheels of a motor cycle have a moment of inertia of 5 kg m^2 and the engine parts, a moment of inertia of 0.35 kgm^2. The wheel axles and the crank shaft of the engine are all parallel to each other. If the ratio of reduction gears is 4:1, the wheel diameter is 700 mm, determine the magnitude and direction of the gyroscopic couple when the motor cycle negotiates a curve of 50 m radius at a speed of 50 km/hr. If the mass of the motor cycle with rider is 250 kg with centre of gravity at 65 cm above the ground in vertical position, determine the speed of the motor cycle rounding a curve of 60 m if the road condition permits an angle of heel of 45°. **(10 marks)**

b) Explain spin vector, precession vector, gyroscopic applied torque vector and gyroscopic reactive torque vector. **(4 marks)**

MODULE – V

19. A shaft carries four masses A, B, C and D which are placed in parallel planes perpendicular to the longitudinal axis. Th unbalanced masses at planes B and C are 3.6 kg and 2.6kg respectively and both are assumed to be concentrated at a radius of 25mm while the masses in planed A and D are both at a radius of 40mm.The angle between the planes B and C is 100° and that between B and A is 190°, both angles being measured in counter clock wise direction from the plane B .The planes containing A and B are 250mm apart and those containing B and C are 500mm.If the shaft is to be completely balanced ,determine

i) Masses at the planes A and D

ii) the distance between the planes C and D

iii) the angular position of the mass D **(14 marks)**

20. A five cylinder in-line engine running at 750 r.p.m. has successive cranks 144° apart, the distance between the cylinder centre lines being 375 mm. The piston stroke is 225mm and the ratio of the connecting rod to the crank is 4. Examine the engine for balance of primary and secondary forces and couples. Find the maximum values of these and the position of the

central crank at which these maximum values occur. The reciprocating mass for each cylinder is 15 kg. **(14 marks)**

Syllabus

Module 1

Introduction to kinematics and mechanisms - various mechanisms, kinematic diagrams, degree of freedom- Grashof's criterion, inversions, coupler curves mechanical advantage, transmission angle. straight line mechanisms exact, approximate. Displacement, velocity analysis– relative motion - relative velocity. Instantaneous centre -Kennedy's theorem.

Module 2

Acceleration analysis- Relative acceleration - Coriolis acceleration - graphical and analytical methods.
Cams - classification of cam and followers - displacement diagrams, velocity and acceleration analysis of SHM, uniform velocity, uniform acceleration, cycloidal motion
Graphical cam profile synthesis, pressure angle.

Module 3

Gears – Classification- terminology of spur gears – law of gearing -tooth profiles- involute spur gears- contact ratio - interference - backlash - gear standardization – interchangeability. Gear trains - simple and compound gear trains - planetary gear trains.

Kinematic synthesis (planar mechanisms) - type, number and dimensional synthesis – precision points. Graphical synthesis for motion - path and prescribed timing - function generator. 2 position and 3 position synthesis – overlay Method. Freudenstein's equation.

Module 4

Static force analysis- Analysis of four bar linkages and slider crank mechanism, graphical method, Matrix method, principle of virtual work. Analysis of four bar and slider crank mechanisms with sliding and pin friction.

Gyroscopic couples-spin, precession and applied gyroscopic couple vectors-effects on the stability of two wheelers, four wheelers, sea vessels and air crafts, application of gyroscopes

Module 5

Static balancing-dynamic balancing-balancing of several masses in the same plane-several masses in different planes-graphical and analytical method-force and couple polygons.

Balancing of reciprocating masses -Single cylinder engine-multi cylinder engine -V-engine

Text Books

1. Ballaney P. L., Theory of Machines and Mechanisms, Khanna Publishers,2005
2 . S. S. Rattan, Theory of Machines, Tata Mc Graw Hill,2009

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. Norton, Kinematics and Dynamics of Machinery, Tata McGraw Hill,2009

Course Contents and Lecture Schedule

No 1	Topic **Module-1-**	No. of lectures **10 Hours**
1.1	Introduction to kinematics and mechanisms	1 Hr
1.2	Various mechanisms	2 Hr
1.3	Kinematic diagrams, degree of freedom, Grashof's criterion	2 Hr
1.4	Inversions	1 Hr
1.5	Coupler curves mechanical advantage, transmission angle.	1 Hr
1.6	Straight line mechanisms exact, approximate	1 Hr
1.7	Displacement, velocity analysis, Kennedy's theorem.	2 Hr
2	**Module 2-**	**10 Hours**

2.1	Acceleration analysis- Relative acceleration - Coriolis acceleration -	1 Hr
2.2	Graphical and analytical methods. .	2Hr
2.3	Cams - classification of cam and followers	1 Hr
2.4	Displacement diagrams, velocity and acceleration analysis of SHM,	2 Hr
2.5	Uniform velocity,uniform acceleration and cycloidal motion	1 Hr
2.5	Graphical cam profile synthesis, pressure angle.	2 Hr
2.6	Analysis of tangent cam with roller follower and circular cam with flat follower	1 Hr
3	**Module-3**	**9 Hours**
3.1	Gears – terminology of spur gears – law of Gearing	1 Hr
3.2	involute spur gears - contact ratio- interference - backlash - gear standardization-interchangeability	1 Hr
3.3	Gear trains - simple and compound gear trains - planetary gear trains	2 Hr
3.4	Kinematic synthesis (planar mechanisms) - type, number and dimensional synthesis – precision points.	2 Hr
3.5	Graphical synthesis for motion - path and prescribed timing - function generator. 2 position and 3 position synthesis	2 Hr
3.6	Overlay Method. Freudenstein's equation	1 Hr
4	**Module-4-**	**8 Hours**
4.1	Static force analysis- Analysis of four bar linkages and slider crank mechanism	2 Hr
4.2	Graphical method, Matrix method	1 Hr
4.3	principle of virtual work	1 Hr
4.4	Analysis of four bar and slider crank mechanisms with sliding and pin friction.	1 Hr

4.4	Gyroscopic couples-spin, precession and applied gyroscopic couple vectors	2 Hr
4.5	Effects on the stability of two wheelers **,** Four wheelers, sea vessals and air crafts	1 Hr
5	**Module-5- Kinematics-synthesis**	**8 Hours**
5.1	Static balancing-dynamic balancing-	2 Hr
5.2	balancing of several masses in the same plane	1 Hr
5.3	several masses in different planes-graphical and analytical method	1 Hr
5.4	force and couple polygons	1 Hr
5.5	Balancing of reciprocating masses -Single cylinder engine	1 Hr
5.6	multi cylinder engine-v engine-inline engine	2 Hr

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET303	THERMAL ENGINEERING	PCC	3	1	0	4

Preamble: This course involve the application of principles studied in thermodynamics to different energy conversion systems like steam turbine, steam nozzle, 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: MET202 Engineering Thermodynamics

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. Dry saturated steam enters a frictionless adiabatic nozzle with negligible velocity at a temperature of 300 °C. It is then expanded to a pressure of 40 bar. For a mass flow rate of 2 kg/s, calculate the exit velocity of the steam.

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. In a reaction turbine, the mean blade speed is 150 m/s and the ratio of blade speed to steam speed is 0.625. The outlet angles of fixed and moving blades are 20^o and 30^o respectively. Calculate (i) the degree of reaction (ii) the adiabatic enthalpy drop in a pair of blade rings and (iii) the gross stage efficiency. The specific volume of steam at fixed blade outlet is 0.567 m^3 and at moving blade outlet 0.6 m^3. Assume the efficiency of blades when considered as nozzles 0.90 and $k^2 = 0.86$, where k is the blade velocity coefficient.

3. Derive the conditions for maximum efficiency of a Parsons reaction turbine.

4. 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. How Morse test and retardation test helps to find the friction power of an engine?
4. Explain the procedure for heat balance test and its significance.

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.
4. Explain different pollution control methods employed for reducing the emissions in IC engines.

Course Outcome 5 (CO5):

1. Derive the expression for COP of an ideal air refrigeration cycle.
2. A food storage locker with R12 refrigerant requires a refrigeration of 2400 kJ/min. capacity has an evaporator temperature of 263 K and a condenser temperature of 303 K.The refrigerant is sub cooled by 6 ^{o}C before entering the expansion valve and vapour is superheated by 7 ^{o}C before leaving the evaporator coil. The refrigeration compressor is a two cylinder single acting with stroke equal to 1.25 times the bore and operates at 1000 rpm. Calculate i) Mass of refrigerant circulated/min. ii) Heat removed by condenser/min iii) Theoretical bore and stroke.
3. Sensible and latent loads on a space are 50 kW and 10 kW respectively. Cold and dehumidified air at 10 ^{o}C DBT and 90 % RH is used to maintain the space condition at 24 ^{o}C DBT. Find i) RSHF ii) space relative humidity and iii) mass flow rate of supply air?

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

V SEMESTER BTECH DEGREE EXAMINATION

MET303: THERMAL 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. With the help of a diagram explain turbocharging.
6. Explain the procedure of Morse test.
7. Discuss about pollutants coming from a CI engine.
8. What do you meant by Octane number?
9. Why reversed Carnot cycle is practically impossible to execute?
10. Define bypass factor and mention its significance. (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. What will be the efficiency if reheating is not employed? Pump work can be neglected. (8 marks)

    b) Derive the expression for mass flow rate of steam through a nozzle and obtain the critical pressure ratio. (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) With the help of a neat figure explain the working of Wankel engine. Mention its merits and demerits over conventional IC engines. (9 marks)

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

16. a) 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. (10 marks)

b) Explain the concept of charge stratification in IC engines. (4 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. a) With the help of figures compare different types of SI engine combustion chambers. (8 marks)

    b) Discuss any two emission control methods employed in reducing the emission of CI engine. (6 marks)

MODULE 5

19. a) A freezer of 20 TR capacity has evaporator and condenser temperature of -30 ^{o}C and 25 ^{o}C respectively. The refrigerant R-12 is sub-cooled by 4 ^{o}C before entering the expansion valve and is superheated by 5 ^{o}C 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) 2.5 kg of air is cooled and dehumidified from 30 ^{o}C DBT, 40% RH to 15 ^{o}C DBT & 80% RH in a cooling and dehumidifying coil. Find (i) ADP, (ii) Bypass Factor and (iii) Heat Transfer. If bypass factor is halved keeping the ADP same find (iv) exit air condition and (v) Heat Transfer. (10 marks)

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

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, Loeffler boiler, Velox boiler, Boiler Mountings and Accessories. Steam nozzles: -Types of nozzle,Velocity of steam, mass flow rate, critical pressure ratio and its significance, effect of friction, super saturated flow.

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, variable specific heats. Rotary engines, Stratified charge engine, Super charging and turbo charging. 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. Morse test, Heat balance test and Retardation test.

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. Air pollution from I.C. Engine and its control: Pollutants from S.I. and C.I. Engines, Methods of emission control.

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. Effect of operating parameters on COP, Methods of improving COP of simple cycle, Super heating and under cooling. Psychometric properties – specific humidity, relative humidity and degree of saturation, thermodynamic equations, enthalpy of moisture, DBT, WBT and DPT, psychrometers, psychometric chart. Psychometric processes- adiabatic mixing, sensible heating and cooling, humidifying and dehumidifying, air washer, bypass factor, sensible heat factor, Comfort and industrial air conditioning, Comfort air conditioning- factors affecting

human comfort, Effective temperature, comfort chart, Summer air conditioning, factors affecting, cooling load estimation.

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, , La Mont boiler, Loeffler boiler, Velox boiler, Boiler Mountings and Accessories.	3
1.3	Steam nozzles:-Types of nozzle- Velocity of steam, mass flow rate, critical pressure ratio and its significance, effect of friction, super saturated flow.	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, variable specific heats.	2
3.2	Rotary engines, Stratified charge engine, Super charging and turbo charging.	2
3.3	Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque, Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency and relative efficiency, Specific fuel consumption.	3
3.4	Morse test, Heat balance test and Retardation test.	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 propagation, auto ignition, detonation; effects of engine variables on detonation; theories of detonation, octane rating of fuels; pre-ignition; S.I. engine combustion chambers.	3
4.3	Combustion in C.I. Engines; delay period; variables affecting delay period; knock in C.I. engines, Cetane rating; C.I. engine combustion chambers.	3
4.4	Air pollution from I.C. Engine and its control: Pollutants from S.I. and C.I. Engines, Methods of emission control.	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. Effect of operating parameters on COP, Methods of improving COP of simple cycle, Super heating and under cooling.	2
5.3	Psychometric properties – specific humidity, relative humidity and degree of saturation- thermodynamic equations- enthalpy of moisture- DBT, WBT and DPT–psychrometers, psychometric chart.	1
5.4	Psychometric processes- adiabatic mixing, sensible heating and cooling, humidifying and dehumidifying, air washer, bypass factor, sensible heat factor.	2
5.5	Comfort and industrial air conditioning, Comfort air conditioning-factors affecting human comfort, Effective temperature, comfort chart, Summer air conditioning, factors affecting, cooling load estimation.	2

MET305	INDUSTRIAL & SYSTEMS ENGINEERING	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble:

This course is designed to facilitate the students to acquire knowledge about management principles and practices of an industry. It empowers the students to amalgamate their knowledge of materials management, inventory management, lean manufacturing, agile manufacturing, industrial relations and enterprise resource planning and thus inculcate the skills needed to apply these principles in an industry.

Prerequisite: NIL

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

CO 1	**Implement various tools and techniques in industrial engineering**
CO 2	**Calculate the inventory system for a given requirement**
CO 3	**Explain the importance of industrial relations**
CO 4	**Select the lean manufacturing tools to find and eliminate wastes**
CO 5	**Identify the framework of agile manufacturing**
CO 6	**Identify core and extended modules of enterprise resource planning**

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**				2				2		2	2
CO 2	**3**			2						2	2	2
CO 3						1			2	2	1	2
CO 4	**2**	1		2	1						2	2
CO 5				2	1				2		2	2
CO 6	**2**				3						2	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	40	60
Apply	20		20
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. Calculate the breakeven point for the product.

2. What are the functions of Industrial Engineering?

3. What are the human factors to be considered while designing a new product?

Course Outcome 2 (CO2)

1. List various types of material handling equipments

2. Determine the optimum quantity to be ordered

3. Describe the role played by the materials management function in enabling an organisation to achieve profitability.

Course Outcome 3(CO3):

1. Define 'Job Satisfaction'.

2. Describe the causes of poor industrial relations.

3. What is meant by 'collective bargaining'?

Course Outcome 4 (CO4):

1.Compare the inventory levels in conventional and lean manufacturing systems.

2.Expand the Japanese terms of 5S

3.Describe the basic elements of lean manufacturing

Course Outcome 5 (CO5):

1. Describe the components of agile manufacturing system

2. List the measures that are used to measure innovation in agile production system.

3. How do strategic linkages aid the organisation to acquire agility?

Course Outcome 6 (CO6):

1. Enumerate ERP implementation stages.

2. With the aid of a block diagram, explain the construction and working of ERP framework.

3. Describe ERP related technology

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION

MET305 INDUSTRIAL & SYSTEMS ENGINEERING

Max. Marks: 100 Duration: 3 Hours

PART A

Answer ALL questions, each carries 3 marks.

1. What are the human factors to be considered while designing a new product?
2. Describe the procedure followed while designing a product.
3. List various types of material handling equipments
4. Describe the concept of JIT manufacturing system
5. Describe the causes and effects of industrial disputes and how it can be eliminated
6. What are the methods of elimination of fatigue?
7. Expand the Japanese terms of 5S.
8. Describe the characteristics of agile manufacturing.
9. State the evolution of ERP.
10. What is Online Analytical Processing?

PART B

Module 1

11. a) How inventories are classified and costs associated by inventories? (5)

b) A manufacturer has to supply 10,000 units of product annually. The unit cost is Rs. 2 and it costs Rs.36 to place an order. The inventory carrying cost is estimated at 9% of average inventory investment. Determine 1. EOQ 2.Optimum number of orders to be placed per annum. 3. Minimum total cost of inventory (9)

12 a) What are the principles of good product design (10)

b) The fixed cost of producing a product in a company is Rs. 8,00,000. Variable cost per unit of the product is Rs. 30. Each unit of the product is going to be sold at a price of Rs. 180. Determine the breakeven point of this product. (4)

Module 2

13. Describe the role played by the materials management function in enabling an organisation to achieve profitability. (14)

14. a) What is meant by quantity discount? (4)

b) A retailer procures batteries for quartz watches and sells them to watch repair shops. The price paid by the retailer varies on the basis of the quantities of batteries procured by him. The quantity and the price/unit pattern offered to him are given below:

Quantity (Q)	Price per one unit of battery
$0 \leq Q < 100$	Rs.20
$100 \leq Q < 200$	Rs.18
$200 \leq Q$	Rs.15

The monthly demand for the batteries is 600 units. The storage cost is 15% of unit cost of the battery and the cost of ordering is Rs.30 per order. Determine the optimum quantity to be ordered by the retailer so that the total cost of procurement is minimum. (10)

Module 3

15. (a) List any five objectives of Trade union. (5)

(b) Trace the history of Trade unionism. (9)

16 (a) Explain conditions to be met for maintaining good industrial relations. (7)

(b) Describe the causes of poor industrial relations. (7)

Module 4

17. (a) Enumerate the objectives and key principles of lean manufacturing paradigm. (7)

(b) Compare traditional and lean manufacturing paradigms. (7)

18. List and describe any ten components of agile manufacturing system. (14)

Module 5

19. Describe the key processes of "Customer Relationship Management". (14)

20 a) With the aid of a block diagram, explain the construction and working of ERP framework. (7)

(b) Explain the differences between 'Business Engineering' and 'Business Process Reengineering'. (7)

Syllabus

Module 1

Introduction to Industrial Engineering - Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering - Field of application of Industrial Engineering - Design function - Objectives of design- Development of designs- prototype, production and testing - Human factors in design - Principles of good product design- tolerance design- quality and cost considerations- product life cycle- standardization, simplification, diversification- concurrent engineering- comparison of production alternatives - Economic aspects- C-V-P analysis – simple problems.

Module 2

Introduction to materials management – objectives – Types of material handling equipments - principles of material handling –Material selection – value analysis – make or buy decisions- Purchasing and procedures. Basic inventory management - Inventory -Functions, Costs, Classifications - EOQ Models- Assumptions- Quantity discount model- Q system- P system- Reorder level - Simple problems- Concept of JIT manufacturing system.

Module 3

Industrial relations- Psychological attitudes to work and working conditions - fatigue- Methods of eliminating fatigue- Effect of Communication in Industry-Industrial safety-personal protective devices-, causes and effects of industrial disputes- Collective bargaining- Trade union - Workers participation in management.

Module 4

Principles of Lean Manufacturing(LM) – Basic elements of LM– Introduction to LM Tools- Concept of wastes in LM and their narration - stages of 5S and waste elimination - Conventional Manufacturing versus Lean Manufacturing - Need for LM. Agile manufacturing - Definition, business need, conceptual frame work, characteristics, and generic features - Approaches to enhance ability in manufacturing - Managing people in agile organization

Module 5

Introduction of enterprise resource planning (ERP)- Concept of Enterprise, ERP Overview - Integrated information system - Myths about ERP – Evolution of ERP- Benefits of ERP implementation - Success and failure factors of ERP implementation - Small, medium and large enterprise vendor solutions- ERP and related technology: Business intelligence (BI), E-Commerce and E-Business, Business Process Reengineering (BPR), Data warehousing, Data mining, Online Analytical Processing(OLAP), Product lifecycle management(PLC), Supply chain

management(SCM), Customer relationship management (CRM)- ERP implementation challenges - Emerging trends on ERP

Text Books

1. Martand T. Telsang, "Industrial Engineering & Production Management", S. Chand and Company Limited, 2018.

2. M. Mahajan, "Industrial Engineering & Production Management", Dhanpat Rai & Co. (P) Limited, 2015.

3. O. P. Khanna, "Industrial Engineering and Management", Dhanpat Rai Publications, 2018.

4. James P. Womack, Daniel T. Jones and Daniel Roos, "The Machine That Changed the World", Free Press, New York, 2007.

5. Alexis Leon, "ERP Demystified", Tata McGraw Hill Education Private Limited, New Delhi, 2008.

Reference Books

1. Kjell Zandin and Harold Maynard, "Maynard's Industrial Engineering Handbook", McGraw-Hill Education, 2001.

2. Philips E. Hicks, "Industrial Engineering and Management – A new perspective", McGraw Hill International Editions, New York, 1994.

3. B. Kumar "Industrial Engineering and Management ", Khanna Publishers,2013.

4. S.R. Devadasan, V. Mohan Sivakumar, R. Murugesh and PR Shalij, "Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities" PHI Learning private Limited, New Delhi, 2012.

5. Ravi Shankar, "Industrial Engineering and Management", Golgotia Publications Pvt Ltd, NewDelhi, 2009.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Introduction to Industrial Engineering	
1.1	Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering - Field of application of Industrial Engineering	2
1.2	Design function - Objectives of design- Development of designs- prototype, production and testing - Human factors in design - Principles of good product design- tolerance design	2
1.3	Quality and cost considerations- product life cycle- standardization, simplification, diversification- concurrent engineering	2
1.4	Comparison of production alternatives - Economic aspects- C-V-P analysis – simple problems	2
2	Introduction to materials management	

2.1	Objectives – Types of material handling equipments	1
2.2	Principles of material handling –Material selection – value analysis	2
2.3	Make or buy decisions-Purchasing procedure	1
2.4	Inventory -Functions, Costs, Classifications	1
2.5	EOQ Models- Assumptions- Quantity discount model- Q system- P system- Reorder level - Simple problems, JIT	3
3	Industrial relations	
3.1	Psychological attitudes to work and working conditions	1
3.2	Fatigue- Methods of eliminating fatigue	1
3.3	Effect of Communication in Industry-Industrial safety-personal protective devices	2
3.3	Causes and effects of industrial disputes- Collective bargaining	2
3.4	Trade union - Workers participation in management	1
4	Lean Manufacturing and Agile manufacturing	
4.1	Principles of Lean Manufacturing(LM) – Basic elements of LM– Introduction to LM Tools	2
4.2	Concept of wastes in LM and their narration	1
4.3	Stages of 5S and waste elimination	2
4.4	Conventional Manufacturing versus Lean Manufacturing - Need for LM.	1
4.5	Agile manufacturing – Definition , business need	1
4.6	Agile manufacturing - conceptual frame work, characteristics, and generic features	2
4.7	Approaches to enhance ability in manufacturing -	1
4.8	Managing people in agile organization	1
5	Introduction of Enterprise Resource Planning	
5.1	Introduction of enterprise resource planning (ERP)- Concept of Enterprise, ERP Overview - Integrated information system - Myths about ERP – Evolution of ERP	2
5.2	Myths about ERP - Basic ERP concepts - Small, medium and large enterprise vendor solutions	2
5.3	Benefits of ERP implementation, Success and failure factors of ERP implementation	1
5.4	Business intelligence (BI), E-Commerce and E-Business, Business Process Reengineering (BPR)	2
5.5	Data warehousing, Data mining, Online Analytical Processing(OLAP), Product lifecycle management(PLC)	2
5.6	Supply chain management(SCM), Customer relationship management (CRM)	1
5.7	ERP implementation challenges, Emerging trends on ERP	1

MET 307	MACHINE TOOLS AND METROLOGY	CATEGORY	L	T	P	Credits
		PCC	3	1	0	4

Preamble:

To develop knowledge of appropriate process parameters to be used for various machining operations.

Understand the fundamentals of modem quality concepts. Be able to apply statistical techniques.

Understand the principles and operation of precision measurement tools and equipment used in modern manufacturing.

Prerequisite: MET 205Metallurgy and Material Science and PHT 110 Engineering Physics

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

CO 1	Analyze various machining process and calculate relevant quantities such us velocities, forces and powers.
CO 2	Analyze of the tool nomenclature with surface roughness obtainable in each machining processes.
CO 3	Understand the limitations of various machining process with regard to shape formation and surface texture.
CO 4	Demonstrate knowledge of the underlying principles of measurement, as they relate to mechanical measurement, electronic instrumentation, and thermal effects.
CO 5	Get an exposure to advanced measuring devices and machine tool metrology.

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	2	3	-	-	-	-	-	-	-		2	1
CO 2	2	3	-	-	-	-	-	-	-	-	2	1
CO 3	2	1	-	2	2	-	-	-	-	-	-	2
CO 4	3	-	2	-	-	-	-	-	-	-	2	2
CO 5	2	-	-	2	3	-	-	-	-	-	-	3

ASSESSMENT PATTERN

Bloom's taxonomy	Continuous Assessment Tests		End Semester Examination (Marks)
	Test 1 (Marks)	Test 11 (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/self learning (Minimum 3 numbers)	15 marks
Continuous Assessment Test(Minimum 2numbers)	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 anyone. Each question can have maximum 2 sub-divisions and carry 14 marks.

COURSE LEVEL ASSESSMENT QUESTIONS

Course Outcome 1 (CO1) Analyze various machining process and calculate relevant quantities such us velocities, forces and powers.

1. List out various types of Lathe attachment explain
2. Explain the working principle of slotter
3. In a verniercalliper, the main scale reads in millimetres with a least count of 0.1 mm.Ten divisions on the vernier correspond to nine divisions of the main scale. Determine the

leastcount of the calliper.

4. A shaft is manufactured within the specified limits of 30.02 and 29.98 mm. Find the high and low limits of the bush to give a maximum clearance of 0.10 mm and minimum clearance of 0.02 mm.
5. What is the difference between rough grinding and precision grinding?

Course Outcome 2 (CO2): Analysis of the tool nomenclature with surface roughness obtainable in each machining processes.

1. Define the terms 'Cutting speed', 'feed' and 'depth of cut'?
2. How are abrasives selected for grinding operation?
3. Why a coolant used in grinding work?
4. How the grinding wheel is selected for a particular job?
5. Describe the nomenclature of hob.
6. Discuss the significant machining parameters for shaping machine.

Course Outcome 3 (CO3): Understand the limitations of various machining process with regard to shape formation and surface texture.

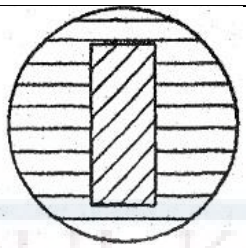
1. What is the difference between drilling, boring and reaming?
2. Explain any three thread production processes.
3. Explain counter sinking and trepanning.
4. Explain different types of gear hobbing machines.
5. Explain planning of guide gibs and slotting of keyways.

Course Outcome 4 (CO4): Students will demonstrate knowledge of the underlying principles of measurement, as they relate to mechanical measurement, electronic instrumentation, and thermal effects.

1. Describe the GO and NOGO gauge design procedure with neat sketch.
2. **Design general type GO and NO GO gauges for a 40H7/d8 fit. 40 mm lies in the diameter range 30 to 50. Show graphically the disposition of gauge tolerance zones relative to the work tolerance zones. Standard tolerance for IT7 is 16i and IT8 is 25i, where 'I' is the standard tolerance unit. The upper deviation for 'd' shaft is $-16D^{0.44}$.**
3. **A 50 mm long pin having diameter 20 ± 0.02 mm, will be electroplated for a thickness of 50 ± 5 μm. Estimate the size of a GO limit gauge, neglecting the gauge to tolerances.**

Course Outcome 5 (CO5): Get an exposure to advanced measuring devices and machine tool metrology.

1. Is assessment length greater/lesser than transverse length in surface roughness measurements? Why?
2. A surface tested under an optical flat using interferometer shows the following interference fringe pattern. Intercept the nature of the surface.



3. What are difference between Rt and Rz with neat sketches
4. How are CMM classified based on their construction? With neat sketches explain the merits and applications any one of them.

MODEL QUESTION PAPER

FIFTH SEMESTER MECHANICAL ENGINEERING

MACHINE TOOLS AND METROLOGY-MET 307

Max. Marks: 100 Duration: 3 Hours
Part – A

Answer all questions.
Answer all questions, each question carries 3 marks

1. What is trepanning? Explain with sketch.
2. What are the use of face plate and angle plate in a lathe?
3. With a sketch, show rake angle of milling cutter and chip breaker.
4. What s the difference between grinding wheel dressing and truing
5. What is the principle of Gear shaping? Explain.
6. Write note on gear errors.
7. Differentiate between precision and accuracy.
8. Explain the process of wringing of slip gauges.
9. Write the importance of cut off length in surface roughness measurement
10. Explain the principle of measurement by light wave interference method.

PART –B

Answer one full question from each module.

MODULE – 1

11. a. What are the attachments used on a center lathe and what purpose do they serve? (7 marks).

b.Draw a drillsignature, name the important angles and explain their each functionand explain plaining of guide gibs(7 marks).

12. Draw sketch of a crank shaper, mark the important parts and explain their functions. Explain how quick return mechanism works. (14 marks).

MODULE – 2

13. a. Explain the principle of working of centreless grinding machine. (7 marks).

b. What are 'Through Feed', 'In Feed', and 'End Feed' in centreless grinding operations? (7 marks).

14. a**.** Explain in detail with neat sketches of a) Slot and groove milling, b) profile milling c) thread milling(7 marks).

b**.** What is the need of better surface finish and how honing, lapping and burnishing process are different in its features and roughness obtainable, explain with sketches. (7 marks).

MODULE – 3

15. Why gear finishing processes are required? Write down the advantages and limitations of gear shaving and gear lapping process with neat sketches. (14 marks).

16 Describe the different methods of manufacturing various types of gears i. Preforming ii. Producing gear teeth by machining iii. Finishing gear teeth (14 marks).

MODULE – 4

17 Discuss all the principles of achieving accuracy. Explain all types of errors. (14 marks).

18. Determine limit dimensions for a clearance fit between mating parts of diameter 40 mm, providing a minimum clearance of 0.10 mm with a tolerance on the hole equal to 0.025mm and on shaft 0.05mm using both systems(14 marks).

MODULE – 5

19 a) Define the following terms in surface texture measurements: -
(i) Primary Texture.(ii) Secondary Texture.(iii) Lay(iv) Sampling Length.(7 marks).

b) Describe the method of evaluating roughness using(i) Peak to valley high method.
(ii) C.L.A. method. (7 marks).

20 a) Discuss the different types of probes used in CMM (7 marks).

b.) Explain the various steps in machine vision system (7 marks).

SYLLABUS

MODULE – 1

General purpose machine tools – types and classification of machine tools –types and classification of lathe – methods of holding work and tool –lathe accessories and attachments –lathe operations -tool room lathe – duplicate lathe –capstan and turret lathe –horizontal and vertical-single spindle and multi spindle screw machines - Shaping, Plaining and Slotting machines – Work holding devices-types of operations - surface roughness obtainable indexing - Drilling and boring Machines – -Drill bit nomenclature- cutting forces in drilling – tool and work holding devices-boring tools and reamers.

MODULE – II

Milling tool nomenclature - Cutting forces in milling – Calculation of machining time- Indexing head Different indexing methods -Grinding, honing and lapping – types of grinding machines-operations: cutting forces in grinding -Grinding mechanisms – Grinding wheels - surface roughness obtainable in grinding, honing and lapping.

MODULE – III

Broaching machines –different machines – cutter for broaching – broaching processes – internal external broaching - Gear cutting –methods in gear production – form cutters –gear generating machines – gear hobbing machines – gear broaching -Bevel gear cutting –worm gear cutting –gear finishing.

MODULE – IV

Metrology –principles of achieving accuracy -Theory of tolerances and allowances –system of limits and fits – types of fits – interchangeability and selective assembly –standards of measurements- Gauges – classification of gauges –principle of gauge tolerance –wear allowance.

MODULE – V

Instruments for checking straightness, flatness and squareness–pneumatic gauging –precision gauging – automatic gauging for inspection-Optical measuring instruments –Comparators –Measurements of surface roughness –- gauging and measurements of screw and gears- Advanced measuring devices – Laser interferometers- Coordinate Measuring Machine (CMM).

Text Books

1. Chapman W. A. J., Workshop Technology, Viva books (P) Ltd
2. HMT, Production Technology, Tata McGraw-Hill
3. Engineering Metrology and Measurements, N.V. Raghavendra, l. Krishnamurthy, oxford university press
4. Galyer J.F.W., Schotbolt C.R., Metrology for Engineers, ELBS.

Reference

1. Acharkan. N., Machine Tool Design Vol. 1 to 4, MIR Publication
2. Chernov, Machine Tools, MIR Publication.
3. HajraChoudary, Elements of workshop technology, Vol I & II, Media Publishers.
4. ASME, Hand book of Industrial Metrology.
5. Hume K. J., Engineering Metrology, Macdonald &Co. Ltd.
6. Sharp K.W.B., Practical Engineering Metrology, Sir Isaac Pitman & Sons Ltd.

COURSE CONTENT AND LECTURE SCHEDULES.

Module	TOPIC	No.of hours	Course outcomes
1.1	General purpose machine tools – types and classification of machine tools –Lathe – types and classification of lathe – specification for a lathe –	1	CO3
	Feed,depth of cut, speed-methods of holding work and tool – lathe accessories and attachments –lathe operations and tools used for each operations -	3	CO1
1.2	Brief study of the machine and the nature and type of jobs handled by the following: - tool room lathe – duplicate lathe – capstan and turret lathe –horizontal and vertical-single spindle and multi spindle screw machines.	3	CO2
1.3	Shaping, Plaining and Slotting machines – Types and specifications – quick return motion –hydraulic feed and its advantages - automatic feed – speed,feed and depth of cut– Work holding devices-types of operations and examples of work done- surface roughness obtainable indexing (Self learning portion, discretion of faculty, fundamentals to be explained in the class)	1	CO3
1.4	Drilling and boring Machines – Types and specifications – Brief descriptions about the machines and nature, types of job	1	CO3

	handled by each of them.		
1.5	-Drill bit nomenclature- cutting forces in drilling – tool and work holding devices-boring tools and reamers.	1	CO2
2.1	Milling machines – types and specifications- Milling operations and types of milling cutters used for each.	1	CO3
2.2	- Milling tool nomenclature - Cutting forces in milling – Calculation of machining time- Indexing head and its use -	1	CO1 CO3
2.3	Different indexing methods - Differential indexing (Self learning portion discretion of faculty, fundamentals to be explained in the class)	1	
2.4	Grinding, honing and lapping – types of grinding machines-operations: cylindrical, surface and center less grinding – internal grinding, tool and cutter grinding - cutting forces in grinding	3	CO1 CO3
2.5	Grinding mechanisms – Grinding wheels: Specification – types of abrasives, grain size -Types of bond, grade, and structure – Marking system of grinding wheels – Selection of grinding wheels –need of better surface finish; surface roughness obtainable in grinding, honing, lapping and burnishing; Surface roughness comparisons between different conventional metal cutting processes.	3	CO3
3.1	Broaching machines –different machines – cutter for broaching – different broaching processes – internal external broaching.	3	CO3
3.2	Gear cutting –methods used in gear production – form cutters – gear generating machines – gear hobbing machines – gear broaching.	3	CO3
3.3	Bevel gear cutting – straight and spiral gears-worm gear cutting –gear finishing operations.	3	CO3
4.1	Metrology –principles of achieving accuracy –economic machining accuracy – precision Vs accuracy - errors- standards of measurements-	2	CO 4
4.2	Theory of tolerances and allowances –system of limits and fits – types of fits – interchangeability and selective assembly – Taylor's Principle-	4	CO 4
4.3	Gauges – classification of gauges- plug, ring, taper angle, slip and snap gauges –feeler gauges-dial indicator –principle of gauge tolerance –wear allowance-gauge materials.	4	CO 4 CO 5
5.1	Instruments for checking straightness, angle, flatness and squareness of guiding surface(Self learning portion, discretion of faculty, fundamentals to be explained in the class). – pneumatic gauging –precision gauging –automatic gauging for inspection.	2	CO 4 CO 5

5.2	Optical measuring instruments, baisc principle – interferometer-optical flat –optical tool makers' microscope-autocollimator.	2	CO 5
5.3	Comparators – mechanical, optical, pneumatic, electric and electronic comparators. (Self learning portion, discretion of faculty, fundamentals to be explained in the class).	1	CO 4
5.4	Measurements of surface roughness – elements of roughness – symbols specifying –instruments and for measuring surface roughness-	1	CO 4
	Measurements of screw: terminology, measurement of screw thread elements-measurement of gears: terminology, errors in spur gears, measurement of gear elements.	2	
5.5	Advanced measuring devices – Laser interferometers-Coordinate Measuring Machine (CMM)	1	CO 5

CODE	COURSE NAME:	CATEGORY	L	T	P	CREDIT
MEL331	MACHINE TOOLS LAB II	PCC	0	0	3	2

Preamble:

1. To learn the measurement of bores by internal micrometers, bore indicators, indirect methods etc.
2. To learn the measurement of the Angle and taper by Bevel protractor, Sine bars, indirect methods etc.
3. Allow to study the various limits, fits and tolerances adopted in the production drawings.
4. To learn to measure straightness, flatness, roundness, profile, screw threads and gear teeth.
5. To learn, to prepare programs for CNC machines and measurements in CMM.

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

CO 1

Apply the procedures to measure length, angles, width, depth, bore diameters, internal and external tapers, tool angles, and surface roughness by using different instruments and by different indirect methods.

CO 2

Determine limits and fits and allocate tolerances for machine components

CO 3

CNC programming and to use coordinate measuring machine to record measurements of complex profiles with high sensitivity.

CO 4

Use effective methods of measuring straightness, Squareness, flatness, roundness, profile, screw threads and gear teeth.

CO 5

Securing knowledge of manufacturing components within the tolerance limit and surface roughness according to given drawings using various machine tools.

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	-	-		3	-	-	-	-	-	-	-	-
CO 4	-	3	-	-	-	-	-	-	-	-	-	-
CO 5	-	-	-	-	3	-	-	-	-	-	-	-

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions:

Practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

SYLLABUS

Experiments on Grinding machine – Programming and experiments on CNC machines- Uncertainty in metrology and measurement standards - Errors and their impact on the calculation of uncertainties - Measurement types and instrument selection - Geometric features of parts - Measuring straightness, squareness, flatness, roundness, and profile -Screw threads and gear teeth, optical contour projectors - Gage measurement - Surface texture and roughness measurement – flaw detection - Coordinate measuring machine - Modern measuring instruments and machines.

Reference books

1. Yoram Koren, Numerical Control of Machine Tools, McGraw-Hill.
2. Shotbolt C.R. and Gayler J.F.W, Metrology for Engineers, 5th edition, ELBS, London.
3. Sharp K.W.B. and Hume, Practical Engineering Metrology, Sir Isaac Pitman and sons Ltd,

London.

4. Collett, C.V. and Hope, A.D, Engineering Measurements, Second edition, ELBS/Longman

Experiments	List of Experiments	Course outcomes	No. of hours
1	**Programming and experiment on CNC machines** Study and preparation of programme, simulation and exercise on CNC lathe:-turning, step turning, taper turning, thread cutting, ball and cup turning etc.	CO 3	3
2	Study and preparation of programme, simulation and exercise on CNC milling machine: - surface milling, pocket milling, contour milling etc.		3
3	**Experiment on Grinding machine** Exercise on surface grinding, cylindrical grinding and tool grinding etc.	CO 1 CO 5	3
	Measurement of cutting forces and roughness in grinding process and correlate with varying input parameters.		
4	**Basics for mechanical measurements** Calibration of vernier caliper, micrometer and dial gauge. Determination of dimensions of given specimen using vernier caliper, micrometer, height gauge, bore dial gauge etc. Determination of dimensions of a rectangular, square, cylindrical specimens using slip gauges and comparing with height gauge/vernier caliper etc	CO 1 CO 2	3
	Experiments on Limits, Fits and Tolerance Determine the class of fits between given shaft and hole. etc		
5	**Experiments on Repeatability and Reproducibility** Study and analysis of repeatability and reproducibility of given batch of steel balls. etc.	CO 1 CO 2	3
6	**Linear measurements** Study of different linear measuring instruments etc. Calibration of LVDT using slip gauges	CO 1 CO 5	3

7	**Straightness error measurement** Study of different straightness error measuring instruments – basic principle of auto collimator, spirit level and laser interferometer. Measurement of straightness error of a CI surface plate using auto collimator and comparing with sprit level. Laser interferometer used to determine straightness error To check straightness error of a straight edge by the wedge method using slip gauges.	CO 4	3
8	**Angle measurements** Angular measurements using bevel protractor, combination sets, clinometers, angle dekkor etc. Measurement of angle and width of a V-block and comparing with combination sets. Measurement of angle using sine bar of different samples. Determination of angle and taper of a taper plug gauge	CO 1	3
9	**Out of roundness measurement** Study of different methods used for measuring out of roundness Measurement of out of roundness using form measuring instrument Measurement of out of roundness using V-block and dial gauge Measurement of out of roundness using bench centre and dial gauge etc.	CO 4	3
10	**Screw thread measurement** Measurement of screw thread parameters using two wire and three wire method. Measurement of screw thread parameters using tool maker's microscope etc. Measurement of screw thread parameters using thread ring gage, thread plug gage, thread snap gage, screw thread micrometer, optical comparator etc.	CO 4	3
11	**Bore measurement** Measurement of a bore by two ball method. Measurement of a bore by four ball method. Bore measurement using slip gauges and rollers.	CO 1	3

	Bore measurement using bore dial gauge etc.		
12	**Gear metrology** Study of types of gears – gear terminology – gear errors - Profile Projector. Measurement of profile error and gear parameters using profile projector etc. **Use of Comparators** Exercise on comparators: mechanical, optical, pneumatic and electronic comparators.	CO 4	3
13	**Use of Tool maker's microscope** Study of tool maker's microscope – use at shop floor applications. Measurement of gear tooth parameters using tool maker's microscope. Measurement of different angles of single point cutting tool using tool maker's microscope.	CO 1	3
14	**Surface roughness measurement** Measurement of surface roughness using surface profilometer /roughness measuring machine of turned, milled, grounded, lapped and glass etc specimens.	CO 1	3
15	**Squareness measurement** Determination of squareness of a trisquare using angle plate and slip gauges etc.	CO 1	3
16	**Flatness measurement** Study of optical flat and variation of fringe patterns for different surfaces. Determination of parallelism error between micrometer faces etc. Compare given surface using optical flat with interpretation chart**.**	CO 4	3
17	**Vibration measurement** Measurement of displacement, velocity and acceleration of vibration.	CO 5	3

18	**Use of Pneumatic comparator** Checking the limits of dimensional tolerances using pneumatic comparator Calibration using air plug gauge etc	CO 5	3
19	**Rotation measurement** Determination of rpm using tachometer, optical tachometer and stroboscope, etc. **Flaw detection** Study and use of ultrasonic flaw detector.	CO 5	3
20	**Other measurements** Study and making measurements with precision vernier calipers, dial calipers, point micrometer spline micrometer, wire groove micrometer, depth micrometer, V- anvil micrometers, depth gear tooth micrometer, thread micrometer, disc micrometer, thread pitch gauge, vernier height gauge, feeler gauge, three pin micrometer, depth gauge, pitch gauge, thickness gauge, radius gauge, hole test etc. Analysis of automobile exhaust gas and flue gas. Use of feeler gauge to determine the gap of spark plug. Any other modern measuring instruments CMM, EDM, Wire cut EDM,USM etc	CO 5	3

A minimum of 12 sets of experiments are mandatory out of total 20 experiments but both experiments mentioned for programming and experiments on CNC machines are mandatory.

Besides to the skill development in performing the work, oral examination should be conducted during end semester examination.

The student's assessment, continuous evaluation, record bonafides, awarding of sessional marks, oral examination etc. should be carried out by the assistant professor or above.

CODE	COURSE NAME:	CATEGORY	L	T	P	CREDIT
MEL333	THERMAL ENGINEERING LAB 1	PCC	0	0	3	2

Preamble: The course is intended to impart basic understanding on the working of internal combustion engines. This includes various performance tests on internal combustion engines as well as makes the students familiar with the evaluation of fuel properties such as viscosity, flash and fire points, calorific value etc. which are key to any performance test.

Prerequisite: Should have undergone a course on Thermal Engineering with emphasis on IC engines

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

CO 1	**Measure thermo-physical properties of solid, liquid and gaseous fuels**
CO 2	**Identify various systems and subsystems of Diesel and petrol engines**
CO 3	**Analyse the performance characteristics of internal combustion engines**
CO 4	**Investigate the emission characteristics of exhaust gases from IC Engines**
CO 5	**Interpret the performance characteristics of air compressors / blowers**

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	3			2		3	2		2
CO 2	**3**		2	3			2		3	2		2
CO 3	**3**		2	3			2		3	2		2
CO 4	**3**		2	3			2		3	2		2
CO 5	**3**		2	3			2		3	2		2

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

General instructions:

Practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

List of Exercises/Experiments: (Lab experiments may be given considering 12 sessions of 3 hours each. Minimum 12 experiments to be performed.)

1. Determination of flash and fire points of petroleum fuels and oils
2. Determination of viscosity of lubricating oils and fuels and its variation with temperature
3. Determination of calorific value of solid and liquid fuels- Bomb Calorimeter
4. Determination of calorific value of gaseous fuels –Gas Calorimeter
5. Familiarisation of various systems and subsystems of petrol engine / MPFI engine
6. Familiarisation of various systems and parts of Diesel engine / Turbocharged engine
7. Performance test on petrol engines / MPFI engine
8. Performance test on Diesel engines / Turbocharged engine
9. Heat Balance test on petrol/Diesel engines
10. Determination volumetric efficiency and Air-fuel ratio of IC engines
11. Cooling curve of IC engines
12. Valve timing diagram of IC engines
13. Economic speed test on IC engines
14. Retardation test on IC engines
15. Morse test on petrol engine
16. Experiment to find flame temperature of premixed flames at different equivalence ratios and temperature of diffusion flames at different fuel flow rates.
17. Analysis of automobile exhaust gas and flue gas using exhaust gas analyser.
18. .Performance test on reciprocating compressor
19. Performance test on rotary compressor/blower

Reference Books

1. J.B.Heywood, I.C engine fundamentals, McGraw-Hill, 2017
2. V. Ganesan, Fundamentals of IC engines, Tata McGraw-Hill, 2017
3. Stephen R Turns, An Introduction to Combustion: Concepts and Applications, McGraw-Hill, 2017

SEMESTER V

MINOR

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)

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 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 ^{o}C and 25 ^{o}C respectively. The refrigerant R-12 is sub-cooled by 4 ^{o}C before entering the expansion valve and is superheated by 5 ^{o}C 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	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. (7 marks)

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

SEMESTER V

HONOURS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET 393	EXPERIMENTAL STRESS ANALYSIS	VAC	3	1	0	4

Preamble:

The course imparts to the students, the basic aspects of theory of elasticity and stress-strain relationship as well as experimental stress analysis that includes the most versatile techniques like photo elasticity, strain gauges and non-destructive test (NDT) methods.

Course Outcomes:

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

CO 1 Analyse the stresses, strains and deformations of structures under 2- and 3-dimensional loading by tensorial and graphical (Mohr's circle) approaches

CO 2 Describe the different instrument used for strain measurement materials using stress-strain relationships.

CO 3 Explain the concept behind the measurement and instrumentation.

CO 4 Describe the concept behind Photo elasticity and brittle coating.

CO 5 Describe the different NDT methods to evaluate the strength.

Mapping of course outcomes with program outcomes assessment Pattern

	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								1
CO 2	3	3	1	1								1
CO 3	3	2	1	1								1
CO 4	3	2	1	1								1
CO 5	3	1	1	1								1

Assessment Pattern

Blooms Category	Continuous Assessment Tests		ESE
	1	2	
Remember			
Understand	40	40	80
Apply		10	10
Analyse	10		10
Evaluate			
Create			

Mark Distribution

Total Marks	CIE	ESE	ESE Duration	
150	**50**	**100**	**3 Hrs**	

Continuous Internal Evaluation Pattern

Attendance	10
Continuous Assessment Tests (2 nos)	25
Assignments/ Quiz/ Course Project	15

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): Analyse the stresses, strains and deformations of structures under 2- and 3-dimensional loading by tensorial and graphical (Mohr's circle) approaches.

1. Determine the resultant traction at a point in a plane using the stress tensor.
2. Evaluate the principal stresses, principal strains and their directions from a given state of stress or strain.
3. Write the stress tensor and strain tensor.

Course Outcome 2 (CO2): Describe the different instrument used for strain measurement materials using stress-strain relationships.

1. With help of fig, explain the construction and working of any one type of strain gauge.
2. Explain how strain can be measured over a long time at high and low temperature.
3. Explain how the delta rosette can be used for analysing the strain.

Course Outcome 3 (CO3): Describe the concept behind the measurement and instrumentation.

1. Describe Range and Sensitivity of a circuit
2. Define error, accuracy and precision with respect to measuring instrument.
3. With help of fig, Describe any one type of displacement measuring transducer.

Course Outcome 4 (CO4): Describe the concept behind Photo elasticity and brittle Coating.

1. Enumerate different steps involved in brittle coating.
2. Describe the effect of stressed model in plane polariscope.
3. Describe compensation techniques in photo elasticity.

Course Outcome 5 (CO5): Describe the different NDT methods to evaluate the strength.

1. Describe dye penetrant test with help of figure.
2. Explain penetrameter with help of figure.
3. With help of figure, explain Magnetic particle test.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION

MET 393 EXPERIMENTAL STRESS ANALYSIS

Max. Marks:100 Duration: 3Hours

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

1. Define stress at a point.
2. Explain principal stresses and strain.
3. How static and dynamic strain can be measured over a strain circuits.
4. What are residual stresses? What are its beneficial and harmful effects?
5. What are transducers? What are its properties?
6. Explain the different principles of measurements
7. Define stress optic law
8. What are the main uses of photo elastic coatings?
9. Distinguish between Destructive testing and Non-destructive testing.
10. What are the properties of X rays and Gamma rays.

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

MODULE – 1

11. The state of stress at a point is given by the Cartesian stress tensor $\begin{matrix} 3 & -1 & 1 \\ -1 & 5 & -1 \\ 1 & -1 & 3 \end{matrix}$ Kpa. Find (a) the stress invariant (b) characteristic equation (c) Principal stresses (d) Unit normal of the principal planes. (14marks)

12. a) Derive the expression for Cauchy's equation for stress on a given plane, normal stress & shear stress. (7marks)

b) Derive stress compatibility equation of plane strain problems. (7marks)

MODULE – 2

13. a) With help of neat sketch, explain a mechanical strain gauge (7 marks)

b) Explain how rectangular rosette can be analyzed for strain measurement. (7 marks)

14. a) With help of fig, explain a optical strain gauge. (7 Marks)

b) Describe how strain can be measured over a long period at low and high temperature. (7 marks)

MODULE – 3

15. a) with help of figure, explain the working of cathode ray oscilloscope. (7 marks)

b) With help of fig, explain the working of displacement transducer. (7 marks)

16. a) Prove that constant current potentiometer circuit has more sensitivity than that of a constant voltage circuit (7 marks)

b) With help of fig, explain the working of force transducer. (7 marks)

MODULE – 4

17 a) Describe the different types of available brittle coatings. (7marks)

b) Obtain the expression for intensity of light emerging from a plane polariscope with dark field set up. (7marks)

18 a) With help of fig, explain Tardy's method of compensation. (10 marks)

b) Explain isochromatic and isoclinics fringe pattern (4 marks)

MODULE – 5

19. a) Explain laser testing methods in NDT. (7 marks)

b) With help of fig, explain the steps involved in LPI. (7 marks)

20. a) With help of fig, explain Radiography test. (7 marks)

b) Explain the working of X – ray fluoroscopy (7 marks)

SYLLABUS

Module 1: Analysis of deformable bodies: stress, stress at a point using Cartesian stress tensor, Cauchy's equation for stress on a given plane, normal stress & shear stress; Strain, deformation and displacement (in Cartesian coordinates), strain components, 2D plane stress and plane strain problems, principal stresses (2D & 3D), stress invariants, Mohr's circle representation for stress in 2D and problems, representation 3D stress in Mohr's circle using principal stresses as input.

Module 2: Strain measurements: strain gauges and stress gauges. Mechanical, optical and electrical gauges – Construction and applications. Variable resistance strain gauges, gauge characteristics, gauge sensitivity, static and dynamic strain – strain measurement over a long period at low and high temperature. Strain rosettes – Rectangular rosettes, Delta rosettes. Residual stresses : Beneficial and harmful effects.

Module 3: Instrumentation: Strain circuits, potentiometer circuits, Range and sensitivity, The wheatstones bridge, sensitivity, Galvanometer, Transient response, Principles of measurements: Error, Accuracy and precision , Uncertainty analysis, Curve fitting. Oscillograph, cathode ray oscilloscope, Transducers – Displacement, Force, Pressure, velocity and acceleration.

Module 4: Photo elasticity: The polariscope, Stress optic law, Polariscope arrangements – Plane polariscope and Circular Polariscope. Dark field and light field, isochromatic and isoclinics, Use of photo elastic coatings, compensation techniques.
Brittle coatings: Coating stresses, Failure theories, steps in brittle coating tests.

Module 5: Non Destructive testing Methods – Types – dye penetrant methods, Radiography – X – ray and Gamma ray – X – ray fluoroscopy. Penetrameter – Magnetic particle methods. Introduction to lasers in NDT – Ultrasonic flaw detection**.**

Text Books

1. J. W. Dally and W. F. Riley, Experimental Stress Analysis ـ McGraw Hill, 1991
2. L.S. Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, Experimental Stress Analysis, Tata Mc Graw Hill, 1984.
3. A. Mubin, Experimental Stress Analysis, Khanna Publishers, 2003.
4. Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, 1996.

Reference Books

1. M. Hetenyi, Handbook of Experimental Stress Analysis, John Wiley & Sons Inc, New York, 1950
2. C.C. Perry and H.R. Lissener, Strain Gauge Primer, McGraw Hill, 2nd Ed., 1962.

3. W.J. McGonnagle_Non_destructive Testing_Mc Graw Hill, 1961.

COURSE PLAN

No	Topic	No. of Lectures
1	**Module 1: Stress and Strain Analysis**	**9 hrs**
1.1	Describe the deformation behaviour of elastic solids in equilibrium under the action of a system of forces. Describe method of sections to illustrate stress as resisting force per unit area. Stress vectors on Cartesian coordinate planes passing through a point .	1 hr
1.2	Direction cosines of a plane. Equality of cross shear (Derivation not required). Write Cauchy's equation (Derivation not required) for stress on a plane as the product of stress tensor and direction cosine vector. Normal and tangential (shear) components of stress on a plane.	1 hr
1.3	Deformation, displacement, gradient of deformation and strains in elastic solids. Cartesian components of strain and Cauchy's strain-displacement relationships (small-strain only). Strain tensor in 2D and 3D. Write the stress tensor and strain tensor for Plane stress and Plane Strain analysis.	1 hr
1.4	Stress on an oblique plane under axial loading, Discuss principal planes, characteristic equation to find principal stresses for 2D and 3D state of stress, stress invariants. Evaluate principal stresses in 2D and 3D using characteristic equations.	2 hrs
1.5	Discuss the order of principal stress and maximum shear stress. Compare the principal stresses in 2D and 3D state of stress. Represent the state of stress using principal stress tensor. Determine the direction of principal stresses as eigenvectors of the principal stress tensor.	2 hrs
1.6	Represent the 2D and 3D state of stress using principal stress graphically (Mohr's circle). Determine the maximum shear stress by Mohr's circle method and compare with the theoretical relations.	2 hrs
2	**Module 2: Strain measurements**	**8 hrs**
2.1	Strain gauges and stress gauges, Different types of strain gauges – construction and working, Different application of strain gauges. Variable resistance strain gauge	2 hr
2.2	Gauge characteristics, gauge sensitivity, measurement of static and dynamic strain, and measurement of strain over a long period at high and low temperature.	2 hrs
2.3	Strain rosette - Rectangular rosettes and Delta rosettes (simple problems).	2 hrs
2.4	Residual stresses, harmful effects of residual stresses, beneficial effects of residual stresses.	2 hrs
3	**Module 3 :Instrumentation**	**9 hrs**
3.1	Strain circuits, potentiometer circuits, Range and sensitivity, The wheatstones bridge.	2 hrs
3.2	Principles of measurements: Error, Accuracy and precision,	1 hr

	Uncertainty analysis, Curve fitting.	
3.3	Oscillograph ,cathode ray oscilloscope,	1 hr
3.4	Transducer – Characteristics and properties.	1 hr
3.5	Displacement transducer – Construction and working, Pressure transducer - Construction and working.	2 hrs
3.6	Velocity transducer - Construction and working	1 hr
3.7	Acceleration transducer - Construction and working.	1 hr
4	**Module 4 : Photoelasticity.**	**8 hrs**
4.1	The polariscope, Stress optic law, Polariscope arrangements – Plane polariscope and Circular Polariscope.	2 hrs
4.2	Dark field and light field , isochromatics and isoclinics , Use of photoelastic coatings.	2 hrs
4.3	Different types of compensation techniques.	2 hrs
4.4	Coating stresses, Failure theories, steps in brittle coating tests.	2 hr
5	**Module 5 :Non Destructive Methods.**	**8 hrs**
5.1	Non Destructive testing Methods – Types – dye penetrant methods, Radiography – X – ray and Gamma ray.	2 hrs
5.2	X – ray fluoroscopy , Penetrameter (Detailed description)	2 hr
5.3	Magnetic particle methods, advantages and disadvantages, applications.	2 hrs
5.4	Introduction to lasers in NDT – Ultrasonic flaw detection.	2 hrs

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET395	ADVANCED THERMODYNAMICS	VAC	3	1	0	4

Preamble: This course involves the application of principles studied in thermodynamics for analysis of thermal energy systems. This course also covers the properties of pure substances, Energy balance of reacting systems and advances in chemical thermodynamics.

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

CO 1	Apply the concepts of basic thermodynamics, entropy and energy for analyses of thermal energy systems.
CO 2	Understand properties of pure substance and thermodynamic properties of real gases
CO 3	Apply energy balances to reacting systems for both closed and open system.
CO 4	Define the chemical equilibrium constant and apply the general criteria for chemical equilibrium analysis to reacting ideal-gas mixtures.

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									

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	10	10	20
Apply	20	20	50
Analyse	10	10	20
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. One kg of water at 273 K is brought into contact with a heat reservoir at 373 K. When the water has reached 373 K , find the entropy change of water, of the heat reservoir and of the universe.
2. State and prove Clausius Theorem
3. Water at 363 K flowing at the rate of 2 kg/s mixes adiabatically with another stream of water at 303 K flowing at the rate of 1 kg/s. Estimate the entropy generation rate and rate of exergy loss due to mixing. Take $T_0 = 300$ K

Course Outcome 2 (CO2)

1. A large insulated vessel is divided into two chambers one containing 5 kg of dry saturated steam at 0.2 MPa and the other 10 Kg of steam 0.8 quality at 0.5 MPa. If the partition between the chambers is removed and the steam is mixed thoroughly and allowed to settle, find the final pressure , steam quality and entropy change in the process
2. Draw the phase equilibrium diagram for a pure substance on h-s plot with relevant constant property lines.
3. Show that for an ideal gas the slope of the constant volume line on the T-S diagram is more than that of the constant pressure line.

Course Outcome 3(CO3):

1. Determine the adiabatic flame temperature when liquid octane at 298 K is burned with 300% theoretical air at 298 K in a steady flow process
2. What is heat of reaction? When is it positive and when negative?

3. Calculate the degree of ionization of cesium vapour at 10^{-6} atm at the two temperatures of 2260 and 2520 K

Course Outcome 4 (CO4):

1. Explain law of mass action
2. Explain reaction equilibrium constant.
3. Discuss second law analysis of reactive systems

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

V SEMESTER BTECH DEGREE EXAMINATION

MET395: ADVANCED THERMODYNAMICS

Maximum: 100Marks Duration:3 hours

PART A

Answer all questions, each question carries 3 marks

1. Show that entropy is a property of the system
2. What is the meaning of quality of energy
3. Draw the phase equilibrium diagram for a pure substance on T-s plot with relevant constant property lines.
4. Write Clausius – Clapeyron equations
5. Explain law of corresponding states
6. Explain Wander-Walls equation of state
7. Explain Second-Law Analysis of Reacting systems
8. What do you meant by adiabatic flame temperature?
9. Explain law of mass action
10. What is van't Hoff equation

(10×3=30Marks)

PART B

Answer one full question from each module

MODULE 1

11. Three identical finite bodies of constant heat capacity are at temperatures 300, 300 and 100 K. If no work or heat is supplied from outside, what is the highest temperature to which any one of the bodies can be raised by the operation of heat engines or refrigerators (14 marks)

12. A pressure vessel has a volume of 1m3 and contains air at 1.4 MPa, 448K. The air is cooled to 298K by heat transfer to surroundings at 298 K. Calculate the availability in the initial and final states and irreversibility of the process. Take P0 = 100kPa (14 marks)

MODULE 2

13. Steam initially at 0.3 MPa, 523K is cooled at constant volume. Find

a) Temperature at which steam become saturated vapour,

b) What is the quality at 353 K,

c) What is the heat transferred per kg of steam in cooling from 523 K to 353 K

(14 marks)

14. Derive Maxwell relations and TdS equations (14 marks)

MODULE 3

15. a) What are virial coefficients ? When do they become zero? (7 Marks)

b) Express Wander – Walls constants in terms of critical properties (7 marks)

16. Calculate the volume of 2.5 Kg moles of steam at 236.4 atm. And 776.76 K with the help of compressibility factor vs reduced pressure graph. At this given volume and pressure what would be the temperature in K, if steam behaves like a Vander-Walls gas. The critical pressure, volume and temperature of steam are 218.2 atm, 57 cm3/g mole and 647.3 K respectively.

(14 marks)

MODULE 4

17. a) Explain second law efficiency of a reactive system ? (4 marks)

b) Explain first law analysis of reactive systems. (10 Marks)

18. The products of combustion of an unknown hydrocarbon CxHy have the following composition a measured by an Orsat apparatus

CO_2 8%, CO 0.9%, O_2 8.8% and N_2 82.3 % Find a) Composition fuel b) air-fuel ratio and c) percentage of excess air used. (14 marks)

MODULE 5

19. a) What is Gibbs function of formation (5 marks)

b) Explain the phase equilibrium for a single component system (9 marks)

20. a) What is degree of reaction (5 marks)

b) Explain the phase equilibrium for a multi component system (9 marks)

Syllabus

Module 1

RECAPITULATION OF FUNDAMENTALS. Basic definition and concepts; The basic laws of Thermodynamics, Entropy flow and entropy production, 3rd law of Thermodynamics, Availability in steady flow open system and in a closed system, Irreversibility and effectiveness.

Module 2

PROPERTIES OF PURE SUBSTANCES. P-V-T surfaces, phase diagram, phase changes, various properties diagram, 1st order phase transition and 2nd order phase transition, Clapeyron's equation, Ehrenfest's equations, Maxwell's equations, equation for internal energy, enthalpy, entropy, specific heat and joule Thompson coefficient.

Module 3

EQUATION OF STATE FOR REAL GASES. Compressibility factor and generalised compressibility chart, Law of corresponding state, law of pseudo critical pressure and temperature, reduced coordinate, Wander-Walls equation of state and other equation of state.

Module 4

CHEMICAL REACTION. Fuels and Combustion, First-Law Analysis of Reacting Systems: Steady-Flow Systems and Closed Systems, Entropy Change of Reacting Systems, Second-Law Analysis of Reacting systems.

Module 5

CHEMICAL THERMODYNAMICS. Gibb's theorem, Gibbs function of mixture of inert ideal gases, Chemical equilibrium, Thermodynamic equation for phase, Degree of reaction, equation of reaction, law of mass action, heat of reaction and Vant Hoff Isober, Phase Equilibrium for a Single-Component System and Multi-Component System

Text books:

1. Richard Edwin Sonntag , G.J. Van Wylen, Introduction to Thermodynamics- Classical and Statistical Wiley , 1991

2. Cengel and Boles.,Thermodynamics : An engineering Approach McGraw-Hill, 2007 Sixth Edition

3. P.K. Nag. Engineering Thermodynamics Tata McGraw -Hill , 2013

Reference books:

1. M. Zemansky, R H Dittman. Heat and Thermodymics –7th Edition 1998

2. E. F . Obert, Concepts of thermodynamics – McGraw-Hill, 1963

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Basic definition and concepts; The basic laws of Thermodynamics,	3
1.2	Entropy flow and entropy production, 3rd law of Thermodynamics,	2
1.3	Availability in steady flow open system and in a closed system	2
1.4	Irreversibility and effectiveness.	2
2		
2.1	PROPERTIES OF PURE SUBSTANCES. P-V-T surfaces, phase diagram, phase changes, various properties diagram,	3
2.2	1st order phase transition and 2nd order phase transition, Clapeyron's equation, Ehrenfest's equations,	3
2.3	Maxwell's equations, equation for internal energy, enthalpy, entropy, specific heat and joule Thompson coefficient.	3
3		
3.1	EQUATION OF STATE FOR REAL GASES. Compressibility factor and generalised compressibility chart,	2
3.2	Law of corresponding state	2
3.3	law of pseudo critical pressure and temperature	3
3.4	Reduced coordinate, Wander-Walls equation of state and other equation of state.	2
4		
4.1	CHEMICAL REACTION. Fuels and Combustion,	1
4.2	First-Law Analysis of Reacting Systems: Steady-Flow Systems and Closed Systems	3
4.3	Entropy Change of Reacting Systems	2
4.4	Second-Law Analysis of Reacting systems	3
5		
5.1	CHEMICAL THERMODYNAMICS. Gibb's theorem, Gibbs function of mixture of inert ideal gases,	2
5.2	Chemical equilibrium, Thermodynamic equation for phase,	2
5.3	Degree of reaction, equation of reaction, law of mass action,	2
5.4	Heat of reaction and Vant Hoff Isober, Phase Equilibrium for a Single-Component System and Multi-Component System	3

CODE	COURSENAME	CATEGORY	L-T-P	CREDITS
MET 397	FLUID POWER AUTOMATION	VAC	3-1-0	4

Preamble :

This course provides basic ideas of fluid power automation. It enables the students to design and optimize pneumatic and hydraulic automation systems.

Prerequisite : Nil

Course Outcomes :

After completion of the course the student will be able to

CO1	Explain the concept of power generating elements
CO2	Describe fundamentals of actuator and accumulator
CO3	Explain in detail control and regulation elements
CO4	Illustrate different circuit design methods
CO5	Illustrate electrical control of pneumatic and hydraulics circuits

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom 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 and duration of ESE

Total Marks	CA	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 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 the need and benefits of automation.
2. Discuss the various components of a fluid power system.
3. Discuss about the hydraulic and pneumatic element selection criteria based with respect to a typical example.

Course Outcome 2 (CO2):

1. Write a detailed note on Linear Actuators.
2. Give a short notes on (a) Spring Return Single acting Cylinder and (b) Double acting cylinder with a piston rod on both sides
3. Make a circuit sketch showing the use of accumulators as a shock absorber.

Course Outcome 3 (CO3):

1. Explain different types of direction and flow control valves.
2. Explain the components of closed loop hydraulic systems with a block diagram.
3. With a neat sketch, describe the construction and working of pressure compensated flow control valve.

Course Outcome 4 (CO4):

1. Construct a ladder diagram for a hydraulic circuit with six cylinders used to control industrial robot.
2. Describe combinational and sequential logical circuits.
3. Design and develop a hydraulic circuit for the following sequence using cascade method. A+ B+ C+

Course Outcome 5 (CO5):

1. Explain basic electrical devices used in electro pneumatic circuits.
2. Explain the functions of relays, timers andcounters in hydraulic and pneumatic circuits.
3. Explain the basic structure of a PLC.

MODEL QUESTION PAPER
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
V SEMESTER B.TECH DEGREE EXAMINATION
MET397: FLUID POWER AUTOMATION

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

PART A

Answer all questions, each question carries 3 marks

1. What are the limitations of fluid power automation?
2. What are the factors to be considered in the selection of pump?
3. Define spool valve?
4. How is counter represented in ladder diagram?
5. What is a linear actuator?
6. What is the function Karnaugh map?
7. Define underlap and overlap in the context of servo valve spools?
8. What are the uses of relays in hydraulic and pneumatic circuits?
9. What is the function of intensifier?
10. List the components of PLC. (10 X 3 = 30 marks)

PART B

Answer one full question from each module

Module 1

11. Describe in brief with neat sketches any 16 ISO symbols used for fluid power elements. (14 marks)
12. Briefly explain the working and construction details of Vane pump with a diagram (14 marks)

Module 2

13. Describe the working principle of hydraulic accumulators (14 marks)
14. With a neat sketch, explain the end cushion provided in hydraulic cylinder (14 marks)

Module 3

15. Draw a neat sketch and explain the working of pressure and temperature compensated flow control valve (14 marks)
16. Write short notes on direction control valves and its types with neat sketches (14 marks)

Module 4

17. Draw and explain the working principle of fail-safe circuit with overload protection (14 marks)
18. Design and draw a hydraulic circuit for A+B+B+A+ sequencing operation and explain. (14marks)

Module 5

19. Design and draw electro hydraulic circuit for hydraulic motor braking system

(14 marks)

20. a) Draw the fluid power symbols of any 4 accessories (4 marks)
    b) Describe the advantages and disadvantages of fluid power systems

(10 marks)

Syllabus

Module 1
Need for automation, classification of drives- hydraulic and pneumatic –comparison ISO symbols for fluid power elements, selection criteria Fluid power generating elements-hydraulic pumps and motorgears, vane, piston pumps-motors-selection and specification

Module 2
Drive characteristics- linear actuator–types, mounting details, cushioning–power packs–accumulators

Module 3
Control and regulation elements—direction, flow and pressure control valves-methods of actuation, types, sizing of ports. Spool valves- operating characteristics, electro hydraulic servo valves-different types-characteristics and performance

Module 4
Typical design methods –ladder diagram- sequencing circuits design - combinational logic circuit design-cascade method - Karnaugh map method.

Module 5
Electrical control of pneumatic and hydraulic circuits- use of relays, timers, counters, interfacing with PLCs, proportional control of hydraulic systems

Text Books:

1. Alavudeen A, Fluid Power Transmission and Control, Charotar Publishing House, 2007
2. Jagadeesha T, Hydraulics and Pneumatics, I K International Publishing House, 2015
3. AntonyEsposito,FluidPowerSystemsandcontrol,Prentice-Hall,1988

Reference Books:

1. PeterRohner,FluidPowerlogiccircuitdesign, MacmillanPress, 1994.
2. E.C.FitchandJ.B.Surjaatmadja.Introductiontofluidlogic,McGrawHill, 1978
3. HerbertE.Merritt,Hydrauliccontrolsystems,JohnWiley&Sons,1967
4. Dudley.A.Pease,BasicFluidPower,PrenticeHall,1967

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
I	Need for automation, classification of drives- hydraulic and pneumatic – comparison, ISO symbols for fluid power elements, selection criteria	4
	Fluid power generating elements – **h**ydraulic pumps and motorgears, vane, piston pumps-motors- selection and specification	5
II	Drive characteristics- linear actuator–types, mounting details, cushioning–power packs–accumulators	9
III	Control and regulation elements—direction, flow and pressure control valves- methods of actuation, types, sizing of ports, spool valves-operating characteristics, Electro hydraulic servo valves-different types-characteristics and performance	10
IV	Typical design methods –Ladder diagram- sequencing circuits design - combinational logic circuit design-cascade method – Karnaugh map method.	9
V	Electrical control of pneumatic and hydraulic circuits- use of relays, timers, counters ,interfacing with PLCs, proportional control of hydraulic systems	8