RSET
RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY
(AUTONOMOUS)

Department of Mechanical Engineering

RSET VISION

To evolve into a premier technological and research institution, moulding eminent professionals with creative minds, innovative ideas and sound practical skill, and to shape a future where technology works for the enrichment of mankind.

RSET MISSION

To impart state-of-the-art knowledge to individuals in various technological disciplines and to inculcate in them a high degree of social consciousness and human values, thereby enabling them to face the challenges of life with courage and conviction.

DEPARTMENT VISION

To evolve into a centre of excellence by imparting professional education in mechanical engineering with a unique academic and research ambience that fosters innovation, creativity and excellence.

DEPARTMENT MISSION

- *To have state-of-the-art infrastructure facilities.*
- *To have highly qualified and experienced faculty from academics, research organizations and industry.*
- *To develop students as socially committed professionals with sound engineering knowledge, creative minds, leadership qualities and practical skills.*

PROGRAMME EDUCATIONAL OBJECTIVES

PEO 1: Demonstrate the ability to analyse, formulate and solve/design engineering/real life problems based on his/her solid foundation in mathematics, science and engineering..

PEO 2: Showcase the ability to apply their knowledge and skills for a successful career in diverse domains viz., industry/technical, research and higher education/academia with creativity, commitment and social consciousness.

PEO 3: Exhibit professionalism, ethical attitude, communication skill, team work, multidisciplinary approach, professional development through continued education and an ability to relate engineering issues to broader social context.

PROGRAMME OUTCOMES

1) **Engineering Knowledge:** Apply the knowledge of Mathematics, Science, Engineering fundamentals, and Mechanical Engineering to the solution of complex engineering problems.
2) **Problem analysis:** Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and Engineering sciences.
3) **Design/development of solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4) **Conduct investigations of complex problems:** Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5) **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.
6) **The Engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional Engineering practice.
7) **Environment and sustainability:** Understand the impact of the professional Engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable developments.
8) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice.
9) **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10) **Communication:** Communicate effectively on complex Engineering activities with the Engineering Community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11) **Project management and finance:** Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi-disciplinary environments.
12) **Life -long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES

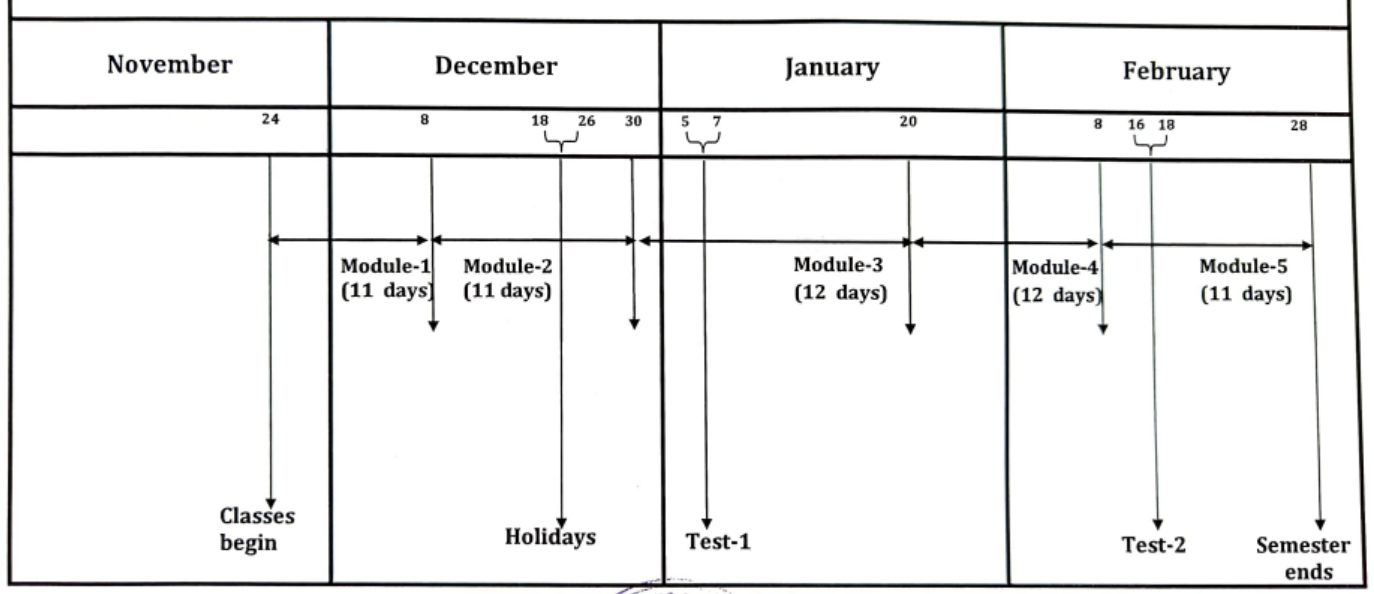
Mechanical Engineering Programme Students will be able to:

1) Apply their knowledge in the domain of engineering mechanics, thermal and fluid sciences to solve engineering problems utilizing advanced technology.
2) Successfully apply the principles of design, analysis and implementation of mechanical systems/processes which have been learned as a part of the curriculum.
3) Develop and implement new ideas on product design and development with the help of modern CAD/CAM tools, while ensuring best manufacturing practices.

SEMESTER PLAN

RSET
RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)

SEMESTER PLAN – S5
November 2021 – February 2022



November: 5 **December: 18** **January: 20** **February: 20**

Total no of working days: 69

Total no of instructional days: 57

PRINCIPAL
Rajagiri School of Engineering & Technology
Rajagiri Valley P.O., Kochi - 682 039

ASSIGNMENT SCHEDULE	
Week 4	**MET301 MECHANICS OF MACHINERY**
Week 5	**MET303 THERMAL ENGINEERING**
Week 5	**MET305 INDUSTRIAL & SYSTEMS ENGINEERING**
Week 6	**MET307 MACHINE TOOLS AND METROLOGY**
Week 7	**HUT300 INDUSTRIAL ECONOMICS AND FOREIGN TRADE**
Week 8	**MCN301 DISASTER MANAGEMENT**
Week 8	**MET301 MECHANICS OF MACHINERY**
Week 9	**MET303 THERMAL ENGINEERING**
Week 9	**MET305 INDUSTRIAL & SYSTEMS ENGINEERING**
Week 12	**MET307 MACHINE TOOLS AND METROLOGY**
Week 12	**HUT300 INDUSTRIAL ECONOMICS AND FOREIGN TRADE**
Week 13	**MCN301 DISASTER MANAGEMENT**

SCHEME

Code	Subject	Hours/week			Credits	Exam Slot
		L	T	P/D		
MET301	MECHANICS OF MACHINERY	3	1	0	4	A
MET303	THERMAL ENGINEERING	3	1	0	4	B
MET305	INDUSTRIAL & SYSTEMS ENGINEERING	3	1	0	4	C
MET307	MACHINE TOOLS AND METROLOGY	3	1	0	4	D
HUT300	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	3	0	0	2	E
MCN301	DISASTER MANAGEMENT	2	0	0	0	F
MET331	MACHINE TOOLS LAB-II	0	0	3	3	S
MET333	THERMAL ENGINEERING LAB-I	0	0	3	3	T
	Total	**19**	**4**	**4**	**27**	

4. MET301 MECHANICS OF MACHINERY

4.1 COURSE INFORMATION SHEET

1. COURSE INFORMATION SHEET

PROGRAMME: MECHANICAL ENGINEERING		**DEGREE:** BTECH **UNIVERSITY:**APJ Abdul Kalam Technological University
COURSE: MECHANICS OF MACHINERY		**SEMESTER:** V **CREDITS:** 4
COURSE CODE: MET301 **REGULATION:** 2019		**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: APPLIED MECHANICS		**CONTACT HOURS:** 3+1 (Tutorial) Hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY): NIL		**LAB COURSE NAME:** NA

SYLLABUS:

UNIT	DETAILS	HOURS
I	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.	10
II	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.	10
III	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.	9

IV	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	8
V	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	8
TOTAL HOURS		**45**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T1	Ballaney P. L., Theory of Machines and Mechanisms, Khanna Publishers,2005
T2	S. S. Rattan, Theory of Machines, Tata McGraw Hill,2009
R1	C. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education,2005
R2	D. H. Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education,2013
R3	G. Erdman, G. N. Sandor, Mechanism Design: Analysis and synthesis Vol I & II, Prentice Hall of India, 1984
R4	Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press,1988
R5	J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, McGraw Hill,2010

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
BE100	Engineering Mechanics	To have basic knowledge in statics, dynamics, force analysis.	1
MA201	Linear Algebra and Complex Analysis	To have basic knowledge in solution of linear equations, matrix methods, Eigen value problems.	3

COURSE OBJECTIVES:

1	To understand the kinematics of different mechanism and to conduct velocity analysis
2	To perform acceleration analysis of planar mechanisms and to design cam mechanisms for specified output motions.
3	To understand the basic concepts of toothed gearing and to conduct motion analysis of gear trains.
4	To understand the motion resulting from a specified set of linkages and to synthesise the mechanism
5.	To perform static force analysis of planar mechanisms
6.	To understand and analyse Gyroscopic effect on automobiles, ships, aircrafts.
7.	To perform dynamic balancing of rotating and reciprocating components.

COURSE OUTCOMES:

SL NO	DESCRIPTION	Bloom's Taxonomy Level
CMET301.1	To **understand** the kinematics of different mechanism and to conduct velocity **analysis**	Understand, Analyse (Level 2, 4)
CMET301.2	To perform acceleration **analysis** of planar mechanisms and to design cam mechanisms for specified output motions.	Analyze (Level 4)
CMET301.3	To **understand** the basic concepts of toothed gearing and to conduct motion **analysis** of gear trains.	Understand, analyze (Level 2, 4)
CMET301.4	To understand the motion resulting from a specified set of linkages and to **apply** the concept to synthesize the mechanism	Apply (Level 3)
CMET301.5	To perform static force **analysis** of planar mechanisms	Analyze (Level 4)
CMET301.6	To **understand** the concept and **analyse** gyroscopic effect on automobiles, ships, aircrafts.	Understand, analyze (Level 2, 4)
CMET301.7	To **compute** dynamic balancing of rotating and reciprocating components.	Apply (Level 3)

CO-PO AND CO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CME301.1	3	3	3	-	-	-	-	-	-	2	-	2	3	3	-
CMET301.1	3	3	3	-	-	-	-	-	-	2	-	2	3	3	-
CMET301.2	3	3	3	-	-	-	-	-	-	2	-	2	3	3	-
CMET301.3	3	3	3	-	-	-	-	-	-	2	-	2	3	3	-
CMET301.4	3	3	3	-	-	-	-	-	-	2	-	2	3	3	-
CMET301.5	3	3	3		-					2		2	3	3	-
CMET301.6	3	3	3	-	-	-	-	-	-	2	-	2	3	3	-
CMET301.7	3	3	3	-	-	-	-	-	-	2	-	2	3	3	-
Average value	3	3	3	-	-	-	-	-	-	2	-	2	3	3	-

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
CMET301.1 -PO1	H	Students understand different mechanisms and apply their knowledge in mathematics and Engineering fundamentals to find their degrees of freedom and to conduct velocity analysis.
CMET301.1 -PO2	H	Students can understand and analyze complex Engineering problems related to planar mechanisms and can reach substantiated conclusions using first principles of mathematics and Engineering.
CMET301.1 -PO3	H	Students are capable of designing planar mechanisms that meet the specified needs with appropriate consideration for public safety and environmental considerations.
CMET301.1 -PO10	M	Students are capable of communicating effectively and write effective reports and design documentation, make effective presentations, and give and receive clear instructions regarding kinematics of planar mechanisms
CMET301.1 -PO12	M	Students recognize the need for life- long learning in the area of planar and spatial mechanisms
CMET301.2 -PO1	H	Students could apply their Engineering knowledge to conduct acceleration analysis of complex mechanism and to design cams.

CMET301.2 -PO2	H	Students can understand and analyze complex Engineering problems related to planar mechanisms and can reach substantiated conclusions using first principles of mathematics and Engineering for designing cams.
CMET301.2 -PO3	H	Students are capable of designing and analysing planar mechanisms and cams that meet the specified needs with appropriate consideration for public safety and environmental considerations.
CMET301.2 -PO10	M	Students are capable of communicating effectively and write effective reports, make effective presentations, and give and receive clear instructions regarding analysis of planar mechanisms
CMET301.2 -PO12	M	Students recognize the need for life- long learning in the area of planar and spatial mechanisms
CMET301.3 -PO1	H	Students have knowledge in gear terminologies and apply their knowledge Engineering fundamentals for calculating velocity of gears in a gear train.
CMET301.3 -PO2	H	Students can understand and analyze complex Engineering problems related to gear mechanisms and can reach substantiated conclusions using first principles of mathematics and Engineering.
CMET301.3 -PO3	H	Students are capable of designing and analysing gear mechanisms that meet the specified needs with appropriate consideration for public safety.
CMET301.3 -PO10	M	Students are capable of communicating effectively and write effective reports, make effective presentations, and give and receive clear instructions regarding kinematic analysis of gear and gear trains
CMET301.3 -PO12	M	Students recognize the need for life- long learning in the area of gear and gear train analysis
CMET301.4 -PO1	H	Students will be able to apply their knowledge in mathematics and Engineering fundamentals to synthesize a mechanism
CMET301.4 -PO2	H	Students can understand, analyse and synthesize complex Engineering problems related to planar mechanisms and can reach substantiated conclusions using first principles of mathematics and Engineering.
CMET301.4	H	Students are capable of designing and analysing planar

-PO3		mechanisms that meet the specified needs with appropriate consideration for public safety and environmental considerations.
CMET301.4 -PO10	M	Students are capable of communicating effectively and write effective reports, make effective presentations, and give and receive clear instructions regarding synthesis of planar mechanisms
CMET301.4 -PO12	M	Students recognize the need for life- long learning in the area of planar and spatial mechanisms
CMET301.5 -PO1	H	Knowledge related to static force analysis of planar mechanisms aids to the solution of some complex engineering problems
CMET301.5 -PO2	H	Knowledge in force analysis helps students to formulate problems and comment on the possible solutions.
CMET301.5 -PO3	H	Knowledge in force analysis in mechanisms helps to assess societal, safety issues and the consequent responsibilities relevant to the professional Engineering practice.
CMET301.5 -PO10	M	Force analysis of planar mechanisms helps in communicate effectively and write effective reports, make effective presentations on complex engineering activities with the engineering community
CMET301.5 -PO12	M	Students recognize the need for life- long learning in the area of force analysis in mechanisms
CMET301.6 -PO1	H	Students are capable of explaining the theory of gyroscopic couple and can predict the effect of this couple in aircrafts, ships and automobiles.
CMET301.6 -PO2	H	Knowledge related to gyroscopic effect aids to the solution of some complex engineering problems
CMET301.6 -PO3	H	Apply reasoning informed by the contextual knowledge on gyroscopic effect helps to assess societal, safety issues and the consequent responsibilities relevant to the professional Engineering practice.
CMET301.6 -PO10	M	Students are capable of communicating effectively and write effective reports, make effective presentations, and give and receive clear instructions regarding gyroscopic effect in different applications
CMET301.6 -PO12	M	Students recognize the need for life- long learning in the area of gyroscopic effect in different applications

CMET301.7 -PO1	H	Knowledge related to balancing of rotating and reciprocating masses aids to the solution of some complex engineering problems
CMET301.7 -PO2	H	Students could apply their acquired knowledge to calculate unbalanced forces and couples in IC Engines.
CMET301.7 -PO3	H	Apply reasoning informed by the knowledge on balancing helps to assess societal, health, safety issues and the consequent responsibilities relevant to the professional Engineering practice.
CMET301.7 -PO10	M	Knowledge on balancing of rotating and reciprocating masses helps in communicate effectively on complex engineering activities with the engineering community
CMET301.7 -PO12	M	Students recognize the need for life- long learning in the area of balancing.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
CMET301.1-PSO1	H	Apply their knowledge in the domain of engineering mechanics to find degrees of freedom and to conduct velocity analysis of different planar mechanism
CMET301.1-PSO2	H	Students can successfully apply the kinematic principles of design and analysis for generating mechanisms of desired output motion.
CMET301.2-PSO1	H	Apply their knowledge in the domain of engineering mechanics to conduct kinematic analysis of different planar mechanism.
CMET301.2-PSO2	H	Students can successfully apply the kinematic principles of design and analysis for generating mechanisms of desired output motion.
CMET301.3-PSO1	H	Apply their knowledge in the domain of engineering mechanics to conduct analysis of motion of gear and gear train mechanism
CMET301.3-PSO2	H	Apply their knowledge in the domain of engineering mechanics to conduct analysis of motion of gear and gear train mechanism
CMET301.4-	H	Apply their knowledge in the domain of engineering

PSO1		mechanics to conduct synthesis of different planar mechanism
CMET301.4-PSO2	H	Students can successfully apply the kinematic principles of design and analysis for generating mechanisms of desired output motion.
CMET301.5-PSO1	H	Students will be able to analyse, formulate and solve real life engineering problem by learning the force analysis of different mechanisms
CMET301.5-PSO1	H	Students could apply their knowledge in the in the domain of applied mechanics to analyse mechanisms.
CMET301.6-PSO1	H	Students will be able to analyse, formulate and solve real life engineering problem related gyroscopic effects in ships, aeroplanes and two wheelers
CMET301.6-PSO1	H	Students are capable of applying principle of gyroscopic couple while designing such mechanism.
CMET301.7-PSO1	H	Students will be able to analyse, formulate and solve real life engineering problem by learning the basics of balancing
CME301.7-PSO2	H	Knowledge in force analysis helps students to balance a rotating and reciprocating unbalanced system.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS:

SL NO	DESCRIPTION	RELEVENCE TO PO\PSO	PROPOSED ACTIONS
1	Not identified		

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SL NO	TOPIC	RELEVENCE TO PO\PSO
1	Steering mechanism, differential mechanism, helical, worm, and bevel gear terminologies.	PO1, PO2, PO3, PO10, PO12, PSO1, PSO2

WEB SOURCE REFERENCES:

1	www.youtube.com for mechanism animations
2	https://www.youtube.com/watch?v=K4JhruinbWc for differential mechanism explanation
3	http://nptel.ac.in/courses/112104121/16 for synthesis of mechanism
4	https://youtu.be/p075LPq3Eas for balancing and static force analysis
5	https://youtu.be/MJeRFzs4oRU velocity and acceleration analysis

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

✓ CHALK & TALK	☐ STUD.ASSIGNMENT	✓ WEBRESOURCES	☐LCD/SMART BOARDS
☐ STUD. SEMINARS	☐ ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

✓ASSIGNMENTS	☐ STUD. SEMINARS	✓ TESTS/MODEL EXAMS	✓ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

✓ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	✓ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

4.2 COURSE PLAN

DAY	MODULE	TOPIC PLANNED
1	1	Introduction to Kinematics of Machinery. Basic terms
2	1	Mechanism- basic terms,degrres of frreedom. problems based on dof
3	1	four bar mechanism - inversions
4	1	slider crank mechanism inversions
5	1	double slider crank mechanism- inversions
6	1	coupler curves,approximate and exact straight line mechanism ,mechanical advantage and transmission angle
7	1	velocity analysis of slider crank mechanism
8	1	velocity analysis of four bar mechanism
9	2	acceleration analysis of four bar mechanism
10	2	acceleration analysis of slider crank mechanism
11	2	velocity analysis of crank and slotted lever mechanism ,coriolis component
12	1	velocity analysis using instantaneous center method
13	2	introduction to cams and followers. Basic terminology
14	2	follower movement study
15	2	design of cam 1
16	2	design of cam 2
17	2	design of cam 3
18	2	introduction to gears
19	3	law of Gearing - involute spur gears involutometry - contact ratio
20	3	interference - backlash - gear standardization - interchangability
21	3	Gear trains - simple and compound gear trains - planetary gear trains
22	3	epicyclic gear train- problems
23	3	epicyclic gear train- problems
24	3	kinematic synthesis - introduction
25	3	motion generation problems
26	3	path generation problems
27	3	function generation problem- graphical
28	3	function generation problem- analylatical(freudensteins equation)
29	3	Static force analysis introduction
30	4	Problem- four bar mechanism static force analysis- graphical method

31	4	Super position principle- problem discussion- 4 bar mechanism
32	4	Principle of virtual work- problem discussion
33	4	Friction in mechanism- sliding pair
34	4	Friction in mechanism- revolute pair- problem discussion- friction in slidercrank mechanism
35	4	Problem discussion- static force analysis of slider crank mechanism with friction involved
36	4	Gyroscopic couple theory- Introduction
37	4	Gyroscopic effect in aeroplanes, ships
38	4	Gyroscopic effect in four wheelers
39	4	Gyroscopic effect in two wheelers
40	4	Balancing of rotating masses- introduction
41	5	Balancing of rotating masses- problem
42	5	Balancing of reciprocating masses- introduction, tractive force, swaying couple
43	5	Inline engine- balancing of primary and secondary force-imaginary crank method.
44	5	Balancing of V- engine
45	5	Balancing of V- engine - direct and reverse crank method

4.3 MODULE WISE SAMPLE QUESTIONS

MODULE 1

1. Briefly explain any two approximate straight line mechanisms.
2. With sketches, explain three inversions of a double slider crank chain.
3. With sketch, explain the Davis steering gear mechanism.
4. With sketches, explain two quick return motion mechanisms. State the application of this mechanism.
5. Give a neat sketch of the straight line motion ‘Hart mechanism’. Explain
6. Explain Complete and Incomplete Constraints.
7. Derive an expression for ratio of shaft velocities for Hooke’s joint.
8. Explain with neat sketch a roller follower.\

9. 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
10. What do you mean by instantaneous centre in a mechanism?
11. Explain the velocity analysis of four bar mechanism by instantaneous centre method
12. The crank of a slider crank mechanism is 15 cm and the connecting rod is 60 cm long. The crank makes 400 rpm in the clockwise direction. When it has turned $45^0$from the inner dead centre position, determine;
    (i) Velocity of slider.

    (ii) Angular velocity of connecting rod.

    (iii) Velocity of the midpoint of the connecting rod.

13. The link AD of a four bar linkage ABCD is fixed and AB rotates uniformly at 120 rpm in clockwise direction. Find the angular acceleration of links BC and CD and acceleration of point E in link BC. The dimensions of the linkage are AB = 7.5 cm, BC = 17.5 cm, EC = 5 cm, CD = 15 cm, DA = 10 cm, and angle BAD = 90°
14. The crank OP of a crank and slotted lever mechanism rotates at 100 rpm in the CCW direction as shown in Fig 1. Various lengths of links are OP=90mm, OA=300 mm, AR=480mm and RS=330 mm. the slider moves along an axis perpendicular to AO and is 120 mm from O. determine velocity of the slider when AOP is 135º.

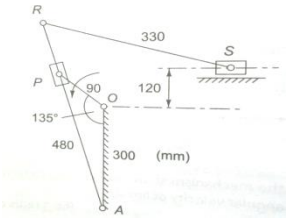


Figure 1

15. What is space centrode and body centrode.
16. What do you meant by coupler curves?
17. Define the term ‘friction circle’
18. What are binary, ternary and quaternary links?
19. 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 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.

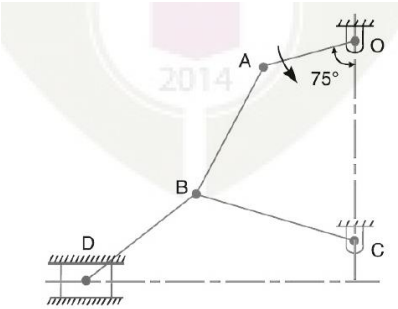


Figure 2

20. Draw the inversions of the mechanism shown in Figure 3 which leads to double crank, double rocker and crank rocker mechanisms. Describe the nature of motion of each link in each case also.

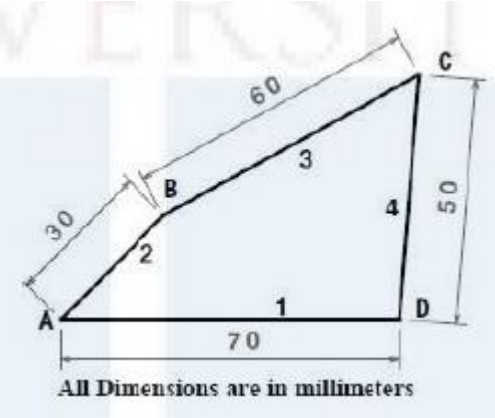


Figure 3.

MODULE 2

1. Define coriolis component of acceleration. In which case does it occur? How is its direction determined?
2. For the configuration of a slider crank mechanism shown in Fig.4, determine the
   a) Acceleration of the slider at B
   b) Acceleration of the point E
   c) Angular acceleration of link AB

   OA rotates at 20 rad/sec CCW.

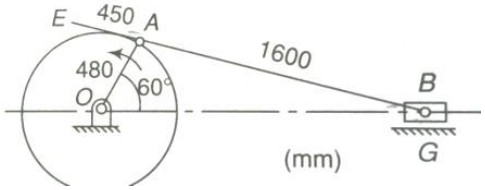


Figure 4

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. 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 5 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.

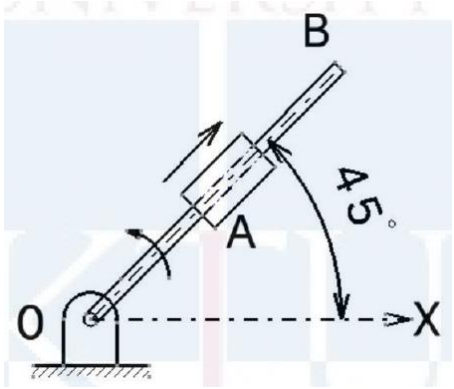


Figure 5

5. Obtain the expression for velocity when the cam follower motion is cycloidal in nature.
6. Sketch any three types of followers.
7. Explain the terms- circular pitch, pressure angle and contact ratio.
8. Explain how the displacement diagram for the simple harmonic motion of a cam follower can be constructed.
9. What is a tangent cam? Find the expression for the maximum velocity and acceleration of a roller follower on the flank for such a cam.

10. A tangent cam drives a roller follower whose line of stroke passes through the axis of the cam. The base circle diameter of the earn is 9 cm, roller diameter is 4 cm, the total angle of action is 90° and the nose circle radius is 0.5 cm. If the cam rotates at 120 rpm. Determine the acceleration of the roller centre: (1) when the roller just leaves the contact on the flank on its ascent (2) when the roller is at its outer end of its lift.
11. Discuss how the (i) velocity and (ii) acceleration curves vary with the follower motion and type of the cam. What is the procedure for drawing cam profile? Give any two typical examples.
12. A roller follower executing SHM has a diameter of 8 mm. The details are:
    (a) Outstroke of 25 mm during 120° rotation.
    (b) Dwell for 60°.
    (c) Return during 90°.
    (d) Dwell during remaining 90° of cam rotation.
    The follower is offset by 10 mm. Cam radius is 20 mm. If the cam rotates at 300 rpm with uniform velocity, find the maximum velocity and acceleration of the follower during the outstroke and return stroke. Draw the profile of the cam.
13. It is required to set out the profile of a cam to give the following motion to the reciprocating follower with a flat mushroom contact face: (i) follower to have a stroke of 20 mm during 120° of cam rotation; (ii) follower to dwell for 30° of cam rotation; (iii) follower to return to its initial position during 120° of cam rotation; (iv) follower to dwell for remaining 90° of cam rotation. The minimum radius of the cam = 25 mm. Outstroke and return stroke of the follower are performed with simple harmonic motion.
14. Derive an expression for maximum velocity and acceleration of the follower when the flat faced follower touches the circular flank of a circular arc convex cam
15. Explain with neat sketches different types of cams.
16. Draw the profile with oscillating follower for the following motion:
    (a) Follower moves through 20° during 120° cam rotation with SHM.

    (b) Dwell for 50° cam rotation.

    (c) Follower to return to its initial position in 90° of cam rotation with uniform acceleration and retardation.

(d) Dwell for the remaining period.

Distance between pivot centre and roller centre is 130 mm and distance between pivot centre and cam centre is 150 mm. Cam radius is 80 mm and roller diameter is 50 mm.

17. Discuss how velocity and acceleration curves vary with follower motion and type of the cam. What is the procedure for drawing a cam profile? Give an example.
18. 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.

MODULE 3

1. Explain undercutting. What are its causes?
2. How do we bring interchangeability of gears?
3. Draw the sketch of a simple epicyclic gear train. Mention its advantages over other type of gear trains.
4. What are the different forms of gear tooth?
5. The number of teeth in the gear shown in the Figure 6 are as follows:

T_S= 18; T_P= 24; T_C= 12 and T_A=72

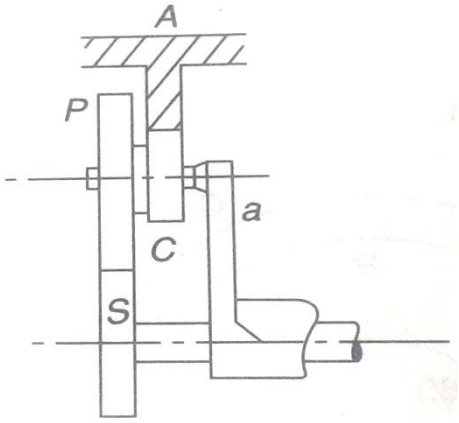


Figure 6

P and C forms a compound gear carried by the arm **a** and the annular gear A is held stationary. Determine the speed of the output at **a**. Also find the holding torque required on A if 5 kW is delivered to S at 800 rpm with an efficiency of 94%. In case the annulus A rotates at 100 rpm in the same direction as S, what will be the new speed of **a**?

6. What is interference in gears? Discuss its effects. What are the conditions necessary to avoid interference? Explain.

7. A pair of spur gear having 20 and 40 teeth is in mesh. The pinion being driving element rotates at 2000 rpm. Find the sliding velocity between teeth faces (i) At the point of engagement; (ii) At the pitch point; and (iii) At the point of disengagement. Assume the gear teeth are of 20° involute form. Addendum is 5 mm and module is 5 mm. Find also the angle through which pinion turns while one pair of teeth is in contact.
8. A pinion A has 20 teeth and is rigidly fixed to a motor shaft. The wheel B has 25 teeth gears with A and also with a fixed annular wheel D. The pinion C has 20 teeth and it is fixed to the wheel B and gears with annular wheel E which is keyed to the machine shaft. Band C can rotate together on a pin carried by an arm which rotates about the shaft on which A is fixed. Gears A. D and E are co-axial while B and C are compound wheels. If the motor runs at 1000 rpm, find the speed of rotation of the machine shaft.
9. Explain with neat sketches different types of gear train.
10. With neat sketch explain the working of an automotive differential.
11. Two mating spur gears with module of 6.5 mm have 19 and 47 teeth of 20° pressure angle, and 6.5 mm addendum. Determine the number of pairs of teeth in contact and the angle turned through by the larger wheel for one pair of teeth in contact.
12. A 20^0 involute pinion with 20 teeth drives a gear having 60 teeth. Module is 8mm, addendum of each gear is 10mm. State whether interference occurs or not.
13. In an epicyclic gear train as shown in Figure 7 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:
$T_C = 28$, $T_D = 26$, $T_E = T_F = 18$. Sketch the arrangement. Find the number of teeth on A and B. If the arm G makes 100 r.p.m clockwise and A is fixed, find the speed

B. 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.

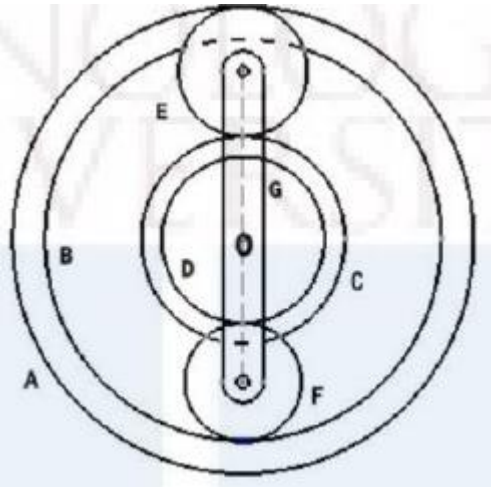
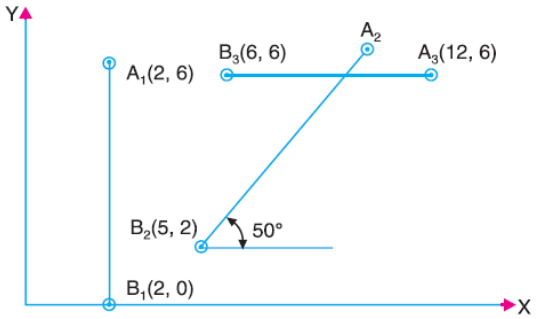


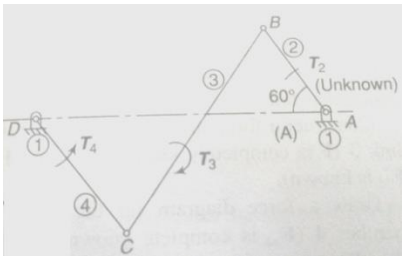
Figure 7

14. Differentiate between approximate and exact synthesis
15. How will you choose precision points in synthesis?
16. What is dimensional synthesis of a mechanism? Explain.
17. Determine the lengths of all the four links in a four bar chain for which the length of the smallest being 10cm, to generate $Y = \log_{10} X$ in the interval $1 \leq x \leq 10$ for three accuracy points. The range of angle of input link and output link are $45° \leq \theta \leq 105^0$ and $135° \leq \phi \leq 225°$.
18. Explain overlay method for kinematic synthesis. What are its applications?
19. Explain the role of function generator in synthesis.
20. Determine the proportions of four bar mechanism, by using three precision points, to generate $y = x^{1.5}$, where 'x' varies between 1 and 4. Take $\theta_s = 30^0$, $\Delta\theta = 90^0$, $\phi_s = 90^0$, $\Delta\phi = 90^0$. Take length of the fixed link as 25 mm
21. Explain two position and three position synthesis of a four bar mechanism
22. Synthesize a four bar mechanism to guide a rod AB through three consecutive positions A_1B_1, A_2B_2 and A_3B_3 as shown in the figure below.

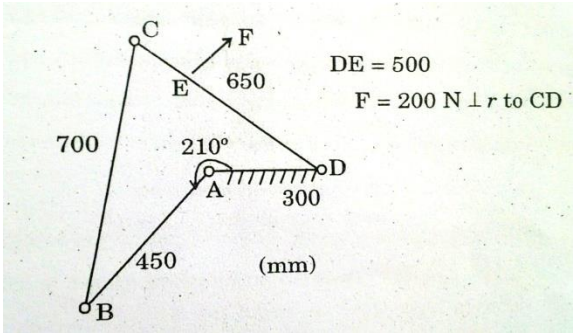


MODULE 4

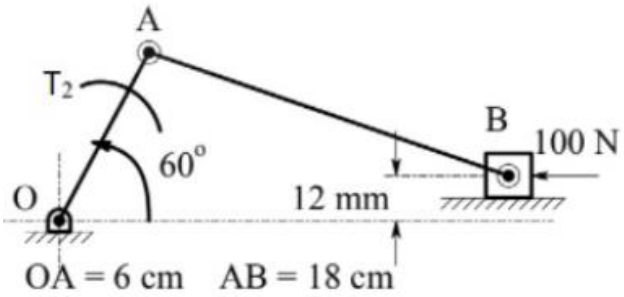
1. Explain the principle of virtual work applied in a slider crank mechanism.
2. In a four-bar mechanism ABCD the crank AB 5 cm long makes 60° with fixed link AD. Link Be = 7 cm, CD = 9 cm and AD = 10 cm. A force of 8 N at 73.5° acts on BC at a distance of 4 cm from B. Determine the reactive torque on link AB
3. Explain the static equilibrium conditions of two forces, three forces, two forces and a torque member.
4. In a four-bar mechanism ABCD the crank AB = 5 cm long makes 60° with fixed link AD. Link BC = 7 cm, CD = 9 cm and AD = 10 cm. A force of 8 N at 73.5° acts on BC at a distance of 4 cm from B. Determine the reactive torque to be applied on link AB so that the system is in static equilibrium.
5. Explain with an example the static force analysis of a slider crank mechanism in which friction is considered for sliding and revolute pairs.
6. In a four- link mechanism shown in the figure below, torque T_3 and T_4 have magnitudes of 30 Nm and 20 Nm respectively. The link lengths are AD= 800mm, AB= 300mm, BC= 700mm and CD= 400mm. For the static equilibrium of the mechanism, determine the required input torque T_2.



7. Find the torque required to be applied to link AB of the linkage shown in figure below to maintain static equilibrium. The force F is perpendicular to link CD acting at E. The dimensions of the links are in mm.



8. The applied load on the piston of an offset slider-crank linkage shown in figure below 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.



MODULE 5

1. Explain static and dynamic balancing.
2. Derive an expression for maximum swaying couple.
3. With a neat sketch briefly describe the working of cradle type balancing machine.
4. Four masses A, B, C, D are completely balanced. Masses C & D make angles of 90^0 and 195^0 respectively with that of mass B in CCW direction. The rotating mass have following properties:-

   m_B =25 kg, m_C = 40kg, m_D = 35 kg

   r_A= 150 mm, r_B = 200 mm, r_C = 100 mm, r_D = 180 mm.

   Planes B and C are 250mm apart.

   Find: (1) mass A and its angular position with that of mass B.

   (2) Positions of all the planes relative to the plane of mass A

6. 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.

7. 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.

Prepared by **Approved by**

Mr. Jithin P. N and Mr. Senjo Manuel **Dr. Manoj G. Tharian**

(Faculty) **(HOD)**

5. MET303 THERMAL ENGINEERING

5.1 COURSE INFORMATION SHEET

PROGRAMME:**MECHANICAL ENGINEERING**	DEGREE: **BTECH**
COURSE: THERMAL ENGINEERING	**SEMESTER:** 4, **CREDITS:** 4
COURSE CODE: MET303 **REGULATION:** 2019	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN:THERMAL SCIENCE	**CONTACT HOURS:**3(LECTURE) + 1(TUTORIAL) HOUR/WEEK
CORRESPONDING LAB COURSE CODE (IF ANY): MEL 333	**LAB COURSE NAME:** THERMAL ENGINEERING LAB I

SYLLABUS:

MODULE	CONTENTS	HOURS
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.	9
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	9

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.	7
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	9
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	9

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHOR/PUBLICATION
T1	Rudramoorthy , Thermal Engineering, McGraw Hill Education India, 2003
T2	R.K Rajput, Thermal Engineering, Laxmi publications, 2010
T3	Arora C. P, Refrigeration and Air-Conditioning, McGraw-Hill, 2008
T4	Arora S. C. and Domkundwar, Refrigeration and Air-Conditioning, Dhanpat Rai, 2010
R1	V. Ganesan, Fundamentals of IC engines, Tata McGraw-Hill, 2002.
R2	J. B. Heywood, I.C engine fundamentals. McGraw-Hill, 2011.
R3	Rathore, Thermal Engineering, McGraw Hill Education India, 2010.
R4	Dossat. R. J, Principles of Refrigeration, Pearson Education India, 2002.
R5	Stoecker W.F, Refrigeration and Air-Conditioning, McGraw-Hill Publishing Company, 2009.

COURSE PRE-REQUISITES: MET202 Engineering Thermodynamics

COURSE OBJECTIVES:

1	application of principles studied in thermodynamics to different energy conversion systems like steam turbine, steam nozzle, steam power plant, IC engines and refrigeration systems
2	understand the combustion phenomenon in IC engines

COURSE OUTCOMES:

Sl. NO	DESCRIPTION	Blooms' Taxomomy Level
CMET303.1	Explain the working of steam power cycle and related components	Level 1 & 2 Knowledge, understand
CMET303.2	Discuss the working of steam turbines and methods for evaluating the performance	Level 3 Apply

CMET303.3	Illustrate the performance testing and evaluation of IC engines	Level 3 Apply
CMET303.4	Explain the combustion phenomenon and pollution in IC engines	Level 2 understand
CMET303.5	Discuss the principles of refrigeration and air-conditioning and basic design considerations	Level 3 Apply

CO-PO AND CO-PSO MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	**PSO 1**	**PSO 2**	**PSO 3**
CMET202.1	3	3	2										3		
CMET202.2	3	3	2										3		
CMET202.3	3	3	2										2		
CMET202.4	3	3	2										2		
CMET202.5	3	3	2										3		

1- Low correlation (Low), 2- Medium correlation(Medium), 3-High correlation(High)

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
CMET303.1 - PO1	H	Students will be able to use the acquired knowledge of fundamental concepts to solve complex problems related to steam power cycle and related components
CMET303.1 - PO2	H	Problem analysis based steam power cycle and related components
CMET303.1 – PO3	M	Students will gain confidence in design and development of components used in steam power plants
CMET303.2 - PO1	H	Students will be able to use the acquired knowledge of fundamental concepts to solve complex problems related to steam turbines and methods for evaluating the performance.
CMET303.2 - PO2	H	Problem analysis based on velocity triangles to determine the performance of steam turbines.
CMET303.2 – PO3	M	Development of solution for complex engineering problems and processes requires analysis for steam turbines
CMET303.3 - PO1	H	Students will be able to use the acquired knowledge of fundamental concepts to solve complex problems related to performance testing and evaluation of IC engines
CMET303.3 - PO2	H	Problem analysis based on performance testing and evaluation of IC engines

CMET303.3 – PO3	M	Development of solution for complex engineering problems and processes requires analysis related to performance testing and evaluation of IC engines
CMET303.4 - PO1	H	Students will be able to use the acquired knowledge of fundamental concepts to solve complex problems related to combustion phenomenon and pollution in IC engines
CMET303.4 - PO2	H	Problem analysis based combustion phenomenon and pollution in IC engines
CMET303.4 – PO3	M	Development of solution for complex engineering problems and processes requires analysis related to combustion phenomenon and pollution in IC engines
CMET303.5 - PO1	H	Students will be able to use the acquired knowledge of fundamental concepts to solve complex problems related to refrigeration and air-conditioning
CMET303.5 - PO2	H	Problem analysis based on refrigeration and air-conditioning
CMET303.5 – PO3	M	Development of solution for complex engineering problems and processes requires analysis related to refrigeration and air-conditioning.

JUSTIFATIONS FOR CO-PSO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
CMET303.1-PSO1	H	Students will be able to apply the acquired knowledge of fundamental concepts to solve engineering problems related to steam engineering
CMET303.2-PSO1	H	Students will be able to apply the knowledge on velocity triangles and compounding to solve steam turbines – single and multi-stages
CMET303.3-PSO1	M	Students will be able to use the acquired knowledge of fundamental concepts to solve complex problems related to performance testing & evaluation of IC engines
CMET303.4-PSO1	M	Students will be able to use the acquired knowledge of fundamental concepts to solve complex problems related to combustion phenomenon and pollution in IC engines
CMET303.5-PSO1	H	Students will be able to use the acquired knowledge of fundamental concepts to solve complex problems related to refrigeration and air-conditioning

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS: NIL

WEB SOURCE REFERENCES:

1	https://nptel.ac.in/courses/112/103/112103275/

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ **CHALK & TALK**	☑ **STUD. ASSIGNMENT**	☑WEB RESOURCES
☑ LCD/SMART BOARDS	☐ STUD. SEMINARS	☐ ADD-ON COURSES

ASSESSMENT METHODOLOGIES-DIRECT

☑ **ASSIGNMENTS**	☐ STUD. SEMINARS	☑ **TESTS/MODEL EXAMS**	☑ **UNIV. EXAMINATION**
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ **STUDENT FEEDBACK ON FACULTY (TWICE)**
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by **Approved by**

P.P.Krishnaraj Dr. Manoj G. Tharian

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5.2 COURSE PLAN

DAY	MODULE	TOPIC PLANNED
1	I	Steam engineering- Rankine cycle, Modified Rankine cycle
2	I	Relative efficiency, Improvement in steam cycles – T-s diagram, p-v diagram, h-s diagram
3	I	Reheat, Regenerative and Binary vapour cycle – T-s diagram, p-v diagram
4	I	Numerical on Rankine Cycle, Reheat Cycle, Regenerative Cycle
5	I	Steam Boilers: Types of boilers, Cochran boiler, Babcock and Wilcox boiler-Construction, Principle of Operations, Working, Advantages, Disadvantages
6	I	Benson boiler, La Mont boiler, Loeffler boiler, Velox boiler - Construction, Principle of Operations, Working, Advantages, Disadvantages
7	I	Boiler Mountings and Accessories, Steam nozzles: -Types of nozzle-Velocity of steam, mass flow rate
8	I	Critical pressure ratio and its significance, effect of friction, super saturated flow

9	I	Numerical on steam Nozzle
10	II	Steam turbines: classification, compounding of turbines – Pressure compounding, Velocity compounding, Pressure Velocity compounding
11	II	Pressure velocity variation, Velocity diagram
12	II	Work done, efficiency
13	II	Condition for maximum efficiency
14	II	Numerical using velocity diagrams
15	II	Multistage turbines-condition line, stage efficiency
16	II	Steam turbine performance-reheat factor, degree of reaction
17	II	Cycles with reheating and regenerative heating
18	II	Governing of turbines – Throttle governing, Nozzle control governing, Bypass governing
19	III	Actual cycle analysis of IC engines- Deviation of actual engine cycle from ideal cycle
20	III	Variable specific heats
21	III	Rotary engines, Stratified charge engine
22	III	Super charging and turbo charging
23	III	Performance Testing of I C Engines- Indicator diagram, mean effective pressure
24	III	Torque, Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, Thermal efficiency and relative efficiency, Specific fuel consumption
25	III	Numerical on performance parameters
26	III	Morse test
27	III	Heat balance test and Retardation test
28	IV	Combustion in I.C. Engines- Analysis of fuel combustion-A/F ratio, equivalence ratio, excess air
29	IV	Combustion phenomena in S.I. engines; Ignition limits, stages of combustion in S.I. Engines, Ignition lag, velocity of flame propagation
30	IV	Auto ignition, detonation; effects of engine variables on detonation; theories of detonation, octane rating of fuels
31	IV	Preignition; S.I. engine combustion chambers
32	IV	Combustion in C.I. Engines; delay period;
33	IV	Variables affecting delay period; knock in C.I. engines, Cetane rating
34	IV	C.I. engine combustion chambers

35	IV	Air pollution from I.C. Engine and its control
36	IV	Pollutants from S.I. and C.I. Engines, Methods of emission control
37	V	Refrigeration– Reversed Carnot cycle, Numerical on Reversed Carnot Cycle
38	V	Air refrigeration system - Reversed Joule cycle, Numerical on Reversed Joule Cycle
39	V	Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams. Effect of operating parameters on COP
40	V	Methods of improving COP of simple cycle, Super heating and under cooling
41	V	Psychometric properties – specific humidity, relative humidity and degree of saturation- thermodynamic equations- enthalpy of moisture- DBT, WBT and DPT–psychrometers, psychometric chart
42	V	Psychometric processes- adiabatic mixing, sensible heating and cooling, humidifying and dehumidifying
43	V	Air washer, bypass factor, sensible heat factor
44	V	Comfort and industrial air conditioning, Comfort air conditioning, factors affecting human comfort, Effective temperature
45	V	Comfort chart, Summer air conditioning, factors affecting, cooling load estimation

5.3 MODULE WISE SAMPLE QUESTIONS

Module 1

1. List one advantage and one disadvantage of the reheat cycle and of the regenerative cycle.
2. An ideal Rankine cycle employs steam as working fluid. Saturated vapor enters the turbine at 80 bar and saturated liquid exits the condenser at a pressure of 0.08 bar. The net power output of the cycle is 100 MW. Both turbine and the pump have an isentropic efficiency of 85%. Determine for the cycle (a) the thermal efficiency, (b) the mass flow rate of the steam, and (c) the rate of heat transfer into the working fluid as it passes through the boiler.
3. In a single heater regenerative cycle the steam enters the turbine at 30 bar, 400oC and the exhaust pressure is 0.1 bar. The feed water heater is a direct contact type which operates at 5 bar. Find 1) the efficiency and specific steam consumption of the cycle, 2) Increase in efficiency and specific steam consumption as compared to cycle without regeneration. Pump work may be neglected
4. Explain the working of Babcock-Wilcox boiler with neat sketch and differentiate between fire tube and water tube boiler.
5. Draw the T-s diagram of Rankine cycle with superheated steam at the inlet of the steam turbine and develop the equation of cycle efficiency.
6. Explain the working of a Velox boiler with the aid of a neat sketch
7. 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 250 ^{o}C and finally expanded to 0.1 bar. Find out the efficiency of this cycle. What will be the efficiency without reheating? Pump work can be neglected
8. Derive the expression for critical pressure for maximum discharge through a nozzle.
9. Discuss the merits and demerits of water tube boiler over fire tube boiler.
10. With a schematic, explain working of any one safety valve employed as a boiler mounting.
11. What do you mean by the term ‘Choking’ in connection with flow through a steam nozzle? Illustrate the phenomena with the help of mass flow rate vs pressure ratio diagram.
12. Draw representative schematic of subsonic and supersonic nozzle. Under what conditions, a convergent-divergent duct behaves as a nozzle?

Module 2

1. Draw blading diagram for a two-row Curtis stage (ie, velocity compounded stage) followed by two reaction stages and plot pressure and velocity variation in axial direction.
2. Draw Combined Velocity diagram of a Parsons Reaction Turbine operating under maximum blading efficiency condition. Show blade angles, absolute and relative velocity components on the diagram. How can you evaluate axial thrust developed by this reaction stage
3. A four stage steam turbine receives steam at 35 bar and 435oC and exhausts at 0.04 bar. Each stage has same efficiency ratio of 0.76. If the pressure at the end of stages are 5, 1.2 and 0.25 bar respectively, determine (i) Rankine enthalpy drop, (ii) Work done and (iii) Reheat factor.

4. A steam turbine plant operates on Rankine cycle with steam entering turbine at 40 bar, 350ºC and leaving at 0.05 bar. Steam leaving turbine condenses to saturated liquid inside condenser. Feed pump, pumps the liquid into boiler. Determine (i) pump work per kg of steam, (ii) net work per kg of steam and (iii) the cycle efficiency assuming all processes to be ideal.
5. What do you meant by governing of steam turbine? Explain different methods of governing.
6. Differentiate between impulse and reaction turbines.
7. Define i) stage efficiency ii) degree of reaction iii) reheat factor.
8. Illustrate any two methods of compounding steam turbines
9. Obtain the condition for maximum blade efficiency in single stage impulse turbine
10. The data pertaining to single stage impulse turbine is as follows: Steam velocity = 500 m/s; Blade speed = 200 m/s; Exit angle of moving blade = 25°; Nozzle angle = 20°. Neglecting the effect of friction when passing through the blade passages, calculate (a) inlet angle of moving blade, (b) exit velocity , (c) work done per kg of steam, (d) axial thrust and (e) diagram efficiency
11. a) Explain 'Reheat Factor'. Why is its magnitude always greater than unity? (4) b) Define the term degree of reaction as applied to a steam turbine. Show that for Parson's reaction turbine the degree of reaction is 50%.

Module 3

1. Compare two stroke and four stroke engines.
2. Prove that efficiency of Ericsson cycle is same as that of Carnot cycle
3. Explain the concept of stratified charge engines and mention its advantages over conventional engines.
4. What do you meant by turbo charging and supercharging?
5. A single cylinder 4 stroke engine was tested and following observations were noted. Area of indicator diagram = 3 cm2 . Length of indicator diagram = 4 cm. Indicator spring constant is 10 bar/cm. Speed of the engine is 400 rpm. Brake drum diameter = 120 cm. Dead weight on brake = 380 N. Spring balance reading is 50 N. Fuel consumption rate is 2.8 kg/hr and calorific value of the fuel is 42000 kJ/kg. Bore is 16 cm and stroke is 20 cm. Find frictional power, mechanical efficiency, specific fuel consumption and brake thermal efficiency.
6. List the advantages of four stroke cycle engine over two stroke cycle engines?
7. An engine is working on an Otto cycle, and has air at a pressure of 1 bar and temperature 300K at the entry. Air is compressed adiabatically to a compression ratio of 7. The heat is added at constant volume till the temperature rises to 2000 K. Find (i) the air standard efficiency. (ii) the heat supplied. Take Cv =0.717 kJ/kg K and γ = 1.4.
8. Derive an expression for the Air Standard Efficiency of the Diesel cycle in terms of the compression ratio and cut-off ratio.
9. During the test on single cylinder oil engine, working on the four stroke cycle and fitted with a rope brake, the following readings are taken: Effective diameter of brake wheel = 630 mm ; Dead load on brake = 200 N; Spring balance reading = 30N ; Speed = 450 r.p.m. ; Area of indicator diagram = 420 mm2 ; Length of Indicator diagram = 60 mm ; Spring scale = 1.1 bar per mm ; Diameter of cylinder =100mm ; Stroke = 150 mm ; Quantity of oil used = 0.815 kg/h ; calorific value of oil = 42000 kJ/kg Calculate brake

power, indicated power, mechanical efficiency, brake thermal efficiency and brake specific fuel consumption.

10. Compare Otto and Diesel cycle for i) same compression ratio and heat input, ii) same maximum pressure and heat input.
11. Explain the supercharging of engine.
12. In an engine working on Diesel cycle, inlet pressure and temperature are 1 bar and 17oC respectively. Pressure at the end of adiabatic compression is 35 bar. After constant pressure heat addition, the ratio of expansion is 5. Calculate i) heat addition, ii) heat rejection and iii) efficiency of the cycle. Assume Υ = 1.4, Cp = 1.004 kJ/kg K and Cv = 0.717 kJ/kg
13. Describe Morse test. What are the assumptions made in this test?
14. Explain the working of a rotary engine with a neat sketch.
15. Define dissociation. Discuss the effect of dissociation on power developed by an Otto cycle with neat sketches.
16. Discuss the purpose of supercharging with a neat schematic of a supercharged engine
17. Discuss the purpose of supercharging with a neat schematic of a supercharged engine
18. Discuss the effect of dopes and additives on performance of IC engines.
19. The compression ratio of an engine working on Otto cycle is 6 and A:F ratio of the mixture is 15. The Calorific value of the fuel used is 44 MJ/kg. The pressure and temperature of the mixture at the beginning of compression are 1 bar and 60oC. Determine the maximum pressure in the cylinder if the compression follows the law . Specific heat value is given by, kJ/kg K, where T is in K.
20. Explain the working of a Stirling engine with the support of thermodynamic cycle on p-v diagram.
21. At the design speed the following data apply to a gas turbine set employing a heat exchanger: Isentropic efficiency of compressor = 75%, Isentropic efficiency of turbine = 85%, Combustion efficiency = 98%, Mechanical Transmission efficiency = 99%, Mass rate of air = 22.7 kg/sec, Pressure ratio = 6:1, Heat exchanger effectiveness = 75%, Maximum cycle temperature = 1000 K. The ambient air pressure and temperature are 15oC and 1.013 bar respectively. Assuming no pressure loss in heat exchanger and combustion chamber, calculate the net power output, specific fuel consumption and thermal efficiency of the cycle. Take calorific value of fuel as 43125 kJ/kg, cp = 1.005 kJ/kg K and Υ = 1.4 during compression and cp = 1.147kJ/kg K and Υ = 1.33 during heating and expansion.

Module 4

1. With a neat sketch, explain the method of flue gas analysis using an Orsat apparatus.
2. Differentiate between knock and pre-ignition.
3. Write a short note on how Catalytic convertor reduces emission of hydrocarbons and carbon monoxide
4. What are the stages of combustion in a SI engine? Explain with the support of pressure vs crank angle diagram.
5. Define highest useful compression ratio (HUCR) and Octane Number for an SI engine fuel. How it is evaluated?
6. Explain with a neat sketch, Annular combustion chamber of a gas turbine plant.
7. Explain the effect of regeneration on gas turbine plant output and efficiency.

8. Define Swirl, Tumble and Squish. Explain how various types of CI engine combustion chamber is designed to produce swirl, with suitable diagrams.
9. Sketch the heat balance curves for C I Engine at constant speed and discuss the nature of curve.
10. Explain flash point, fire point and calorific value of fuels.
11. Write a short note about the pollutants from SI and CI engines.
12. Explain the stages of combustion in C I Engine.
13. Write a short note on alternate fuels for IC engines.
14. What is EGR? Explain how EGR reduces NOx emission.
15. What are the basic requirements of a good combustion chamber.
16. "Factors tending to increase detonation in S I Engine tend to reduce knock in C I Engine". Explain the validity of the above statement.
17. What is the influence of octane number and cetane number on petroleum fuels?
18. Determine the air-fuel ratio and the theoretical amount of air required by mass for complete combustion of a fuel containing 85% of carbon, 8% of hydrogen, 3% of oxygen, 1% of sulphur and the remaining as ash.
19. Explain the difference between „Pre-ignition" and "Auto-ignition"
20. What is meant by "delay period". What are the various factors that affect the delay period?
21. List and discuss on any four alternative fuels for internal combustion engines.
22. Sketch and explain T-head and L-head combustion chamber of SI engine.
23. Bring out the differences in the combustion process in S.I. and C.I. engines with the aid of pressure – crank angle diagrams.
24. How catalytic converter helps to reduce emission of an engine?
25. Explain about Octane and Cetane rating of fuels.
26. With the help of a pressure – crank angle diagram explain different stages of CI engine combustion.
27. Explain detonation in SI engine with the help of auto ignition theory. What are the factors effecting detonation? Also mention various effects caused by detonation.

Module 5

1. Derive an expression for COP of Reversed Carnot cycle with help of P-V and T-S diagram.
2. Define DBT,WBT,DPT.
3. Explain sensible heating, sensible cooling, cooling and dehumidification, heating and humidification.
4. Explain adiabatic saturation process.

5. A mixture of dry air and water vapour is at a temperature of 22°C under a total pressure of 730 mm of Hg. The dew point temperature is 15°C. Find (a) partial pressure of water vapour; (b) relative humidity; (c) specific humidity; (d) enthalpy of air per kg of dry air; (e) specific volume of air per kg of dry air. Use only equation to solve the problem.
6. 120 m^3 of air per minute at 35°C DBT and 50 % RH is cooled to 20°C DBT by passing through a cooling coil. Determine the following: (a) RH of out coming air and its WBT; (b) capacity of cooling coil; (c) Amount of water vapour removed per hour. Use only equations to solve the problem.

7. 250 m^3 of air is supplied per minute from outdoor conditions of 38° C DBT and 25° C WBT to an air conditioned room. The air is dehumidified by a cooling coil having a by-pass factor 0.35 and dew point temperature 13° C and then by a chemical dehumidifier. Air leaves the chemical dehumidifier at 32° C DBT. Air then passed over a cooling coil, where surface temperature is 13°C and by-pass factor is 0.25. Calculate the capacities of the two cooling coils and the humidifier.
8. The humidity ratio of atmospheric air at 28° C DBT and 760 mm of Hg is 0.016 kg/kg of dry air. Determine: (i) Partial pressure of water vapour; (ii) Relative humidity; (iii) Dew point temperature; (iv) Specific Enthalpy; and (v) Vapour Density.
9. Define thermodynamic wet bulb temperature.
10. What is the significance of sensible heat factor in air conditioning?
11. Write a short note on: (a) By pass factor for cooling coils and (b) Dehumidification.
12. Discuss, briefly the factors affecting the optimum effective temperature for comfort.
13. Explain the concept of "Effective Temperature" with reference to comfort air-conditioning.
14. Discuss dry and wet compression with the help of T-S diagram.
15. Discuss the effect of pressure drop in condenser and evaporator of a vapour compression system.
16. Sketch the T-S and P-h diagrams for vapour compression refrigeration cycles when vapour after compression is (a) Superheated and (b) Dry saturated.
17. What is sub cooling and superheating? Explain with help of diagrams.
18. The capacity of a refrigerator is 70 kW when working between -6°C and 25°C. Determine the mass of ice produced per day from water at 25°C. Also find the power required to drive the unit. Assume that the cycle operates on reversed Carnot cycle and the latent heat of ice is 335 kJ/kg.
19. A dense air refrigeration cycle operates between pressures of 4 bar and 16 bar. The air temperature after heat rejection to the surroundings as 37°C and air temperature at exit of refrigerator is 7°C. The Isentropic Efficiencies of compressor and turbine are 80%. Calculate the COP and power per TR.
20. An air refrigeration system works between the pressure limits of 1 bar and 5 bar. The temperatures of the air entering the compressor and expander cylinder are 10°C and 25°C respectively. The Expander and compressor follow the law $pV^{1.3} = C$ for expansion and compression. Find the following: (a) Theoretical COP of Refrigeration Cycle. (b) If the load on the refrigeration machine is 10 TR, find the amount of air circulated per minute through the system assuming that actual COP is 50% of the theoretical COP. (c) The stroke length and piston diameter of single acting compressor if the compressor runs at 300 r.p.m. and the Volumetric Efficiency is 85%. Assume L/d = 1.5, Cp = 1005 J/kg K and C_V = 0.71 kJ/kg K.

Prepared by	**Approved by**
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6. MET305: INDUSTRIAL AND SYSTEMS ENGINEERING

6.1 COURSE INFORMATION SHEET

PROGRAMME: ME	***DEGREE:*** BTECH
PROGRAMME: MECHANICAL ENGINEERING	DEGREE: **B.TECH** UNIVERSITY**: A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
COURSE: INDUSTRIAL AND SYSTEMS ENGINEERING	SEMESTER**: VI** CREDITS: **4**
COURSE CODE: MET305 ***REGULATION: UG***	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: Production & Industrial Engineering	CONTACT HOURS: **4 hours/Week.**

SYLLABUS:

UNIT	***DETAILS***	***HOURS***
I	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.	6 L+2T
II	Introduction to materials management – objectives – Types of material handling equipment's -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	6 L + 2T
III	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.	5 L + 2T
IV	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.	8L + 3T

V	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	8L + 3T
TOTAL HOURS		**45**

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHORS/PUBLICATION*
T1	Martand Telsang, Industrial Engineering & Production Management, S. Chand, 2006
T2	M Mahajan, Industrial Engineering & Production Management, Dhanpat Rai, 2005
T3	O. P. Khanna, Industrial Engineering and Management, Dhanpat Rai, 2010
T4	James P. Womack, Daniel T. Jones and Daniel Roos, "The Machine That Changed the World", Free Press, New York, 2007.
T5	Alexis Leon, "ERP Demystified", Tata McGraw Hill Education Private Limited, New Delhi, 2008.
R1	Kjell Zandin and Harold Maynard, "Maynard's Industrial Engineering Handbook", McGraw-Hill Education, 2001.
R2	Philips E. Hicks, "Industrial Engineering and Management – A new perspective", McGraw Hill International Editions, New York, 1994.
R3	B. Kumar, Industrial Engineering Khanna Publishers,2013
R4	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.
R5	Ravi Shankar, "Industrial Engineering and Management", Golgotia Publications Pvt Ltd, NewDelhi, 2009.

COURSE PRE-REQUISITES: NIL

COURSE OBJECTIVES:

1	To facilitate the students to acquire knowledge about management principles and practices of an industry
2	To empowers the students to amalgamate their knowledge of materials management, inventory management, lean manufacturing, agile manufacturing, industrial relations and enterprise resource planning
3	To inculcate the skills needed to apply industrial & systems engineering principles in an industry.

COURSE OUTCOMES:

SNO	DESCRIPTION	Bloom's Taxonomy Level
CMET 305.11	Implement various tools and techniques in industrial engineering.	Remember (Level1)
CMET 305.2	Calculate the inventory system for a given requirement.	Apply (Level 3)
CMET 305.3	Explain the importance of industrial relations	Understand (Level 2)
CMET 305.4	Select the lean manufacturing tools to find and eliminate wastes	Apply (Level 3)
CMET 305.5	Identify the framework of agile manufacturing	Understand (Level 2)
CMET 305.6	Identify core and extended modules of enterprise resource planning	Apply (Level 3)

CO-PO AND CO-PSO MAPPING

	PO 1	PO 2	PO 3	P 0 4	P 0 5	P 0 6	P 0 7	P 0 8	P 0 9	P 0 10	P 0 11	P 0 12	PS 0 1	PS 0 2	PS 0 3
CMET 305.1	2	-	-	-	2	-	-	-	2	-	2	2	-	2	-
CMET 305.2	3	-	-	2	-	-	-	-	-	2	2	2	-	3	1
CMET 305.3	-	-	-	-	-	1	-	-	2	2	1	2	-	-	2
CMET 305.4	2	1	-	2	1	-	-	-	-	-	2	2	-	2	3
CMET 305.5	-	-	-	2	1	-	-	-	2	-	2	2	-	1	-
CMET 305.6	2	-	-	-	3	-	-	-	-	-	2	2	-	-	2

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
CMET 305.1-PO1	M	As they could use their acquired knowledge to solve engineering problems
CMET 305.1-PO5	M	Create, Select, and apply appropriate techniques and modern engineering and IT tools including prediction and modelling to complex

		engineering activities.
CMET 305.1-PO9	M	Knowledge in principles of Industrial Engineering helps the students function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
CMET 305.1-P11	M	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi-disciplinary environments.
CMET 305.1-P12	M	Become aware of the requirement for advanced knowledge by prolonged learning.
CMET 305.2-P1	H	Apply the knowledge of mechanical Engineering and systems to the solution of complex engineering problems.
CMET 305.2-P4	M	Will be able to use knowledge and methods to provide valid conclusions.
CMET 305.2-P10	M	Communicate effectively on engineering activities and with society.
CMET 305.2-P11	M	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi-disciplinary environments.
CMET 305.2-P12	M	Become aware of the requirement for advanced knowledge by prolonged learning.
CMET 305.3-P6	L	Apply reasoning informed to assess societal, health, safety, and the consequent responsibilities relevant to the professional Engineering practice.
CMET 305.3-PO9	M	Knowledge in principles of Industrial Engineering helps the students function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
CMET 305.3-P10	M	Communicate effectively on engineering activities and with society.
CMET 305.3-P11	L	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi-disciplinary environments.
CMET 305.3-P12	M	Become aware of the requirement for advanced knowledge by prolonged learning.
CMET 305.4-PO1	M	As they could use their acquired knowledge to solve engineering problems
CMET 305.4-PO1	L	Identify and analyze Engineering problems reaching substantiated conclusions using principles of Engineering sciences.
CMET 305.4-P4	M	Will be able to use knowledge and methods to provide valid conclusions.
CMET 305.4-PO5	L	Create, Select, and apply appropriate techniques and modern engineering and IT tools including prediction and modelling to complex engineering activities.

CMET 305.4-P11	M	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi-disciplinary environments.
CMET 305.4-P12	M	Become aware of the requirement for advanced knowledge by prolonged learning.
CMET 305.4-P12	M	Become aware of the requirement for advanced knowledge by prolonged learning.
CMET 305.5-P4	M	Will be able to use knowledge and methods to provide valid conclusions.
CMET 305.5-PO5	L	Create, Select, and apply appropriate techniques and modern engineering and IT tools including prediction and modelling to complex engineering activities.
CMET 305.5-PO9	M	Knowledge in principles of Industrial Engineering helps the students function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
CMET 305.5-P11	M	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi-disciplinary environments.
CMET 305.5-P12	M	Become aware of the requirement for advanced knowledge by prolonged learning.
CMET 305.6-PO1	M	As they could use their acquired knowledge to solve engineering problems
CMET 305.6-PO5	H	Create, Select, and apply appropriate techniques and modern engineering and IT tools including prediction and modelling to complex engineering activities.
CMET 305.6-P11	M	Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi-disciplinary environments.
CMET 305.6-P12	M	Become aware of the requirement for advanced knowledge by prolonged learning.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
CMET 305.1-PSO 2	M	Successfully apply the principles of Industrial Engineering for design and implementation of mechanical systems/processes.
CMET 305.2-PSO 2	H	Successfully apply the principles of Industrial Engineering for design and implementation of mechanical systems/processes.
CMET 305.2-PSO3	L	Develop and implement new ideas with the help of modern tools in Industrial Engineering while ensuring best manufacturing practices.

CMET 305.3-PSO3	L	Develop and implement new ideas with the help of modern tools in Industrial Engineering/Relations while ensuring best manufacturing practices.
CMET 305.4-PSO 2	M	Successfully apply the principles of Lean manufacturing for design and implementation of mechanical systems/processes.
CMET 305.4-PSO3	H	Develop and implement new ideas with the help of modern tools in Lean manufacturing while ensuring best manufacturing practices.
CMET 305.5-PSO 2	L	Successfully apply the principles of Agile manufacturing for design and implementation of mechanical systems/processes.
CMET 305.4-PSO3	H	Develop and implement new ideas with the help of modern tools in Agile manufacturing while ensuring best manufacturing practices.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS:

SNO	*DESCRIPTION*	*RELEVENCE TO PO\PSO*	*PROPOSED ACTIONS*
1	Nil		

WEB SOURCE REFERENCES:

1	http://en.wikipedia.org/wiki/Enterprise_resource_planning
2	http://www.capterra.com/enterprise-resource-planning-software/
3	http://www.netsuite.com/portal/resource/articles/erp/what-is-erp.shtml
4	http://www.softwareadvice.com/manufacturing/mrp-software-comparison/
5	http://en.wikipedia.org/wiki/Material_requirements_planning
6	https://www.youtube.com/watch?v=EK-9XwV4PRE
7	https://www.youtube.com/watch?v=TI-dSckvw0Q
8	https://www.youtube.com/watch?v=TB_a-nvJL2o
9	https://www.youtube.com/watch?v=oBH5bhw3ctQ
10	http://nptel.ac.in/courses/110101010
11	http://nptel.ac.in/courses/110106045/
12	http://nptel.ac.in/courses/110106044/
13	http://nptel.ac.in/courses/110108047/

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☑ STUD. ASSIGNMENT	☑ WEB RESOURCES	☑ LCD/SMART BOARDS
☐ STUD. SEMINARS	☐ ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

☑ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (ONCE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

6.2 COURSE PLAN

DAY	*MODULE*	*TOPIC PLANNED*
1	1	Introduction to Industrial Engineering- Evolution of modern Concepts in Industrial Engineering -
2	1	Functions of Industrial Engineering - Field of application of Industrial Engineering
3	1	Design function - Objectives of design- Development of designs- prototype, production and testing
4	1	Human factors in design – Principles of good product design- tolerance design
5	1	Quality and cost considerations- product life cycle-
6	1	standardization, simplification, diversification- concurrent engineering
7	1	Comparison of production alternatives - Economic aspects
8	1	C-V-P analysis – simple problems
9	2	Introduction to materials management - Objectives – Types of material handling equipments
10	2	Principles of material handling –Material selection
11	2	value analysis – make or buy decisions
12	2	Make or buy decisions-Purchasing procedure
13	2	Inventory -Functions, Costs, Classifications

14	2	EOQ Models- Assumptions-
15	2	Quantity discount model- Q system- P system
16	2	Reorder level - Simple problems, JIT
17	3	Industrial relations - Psychological attitudes to work and working conditions
18	3	Fatigue- Methods of eliminating fatigue
19	3	Effect of Communication in Industry
20	3	Industrial safety-personal protective devices
21	3	Causes and effects of industrial disputes
22	3	Collective bargaining.
23	3	Trade union - Workers participation in management
24	4	Lean Manufacturing and Agile manufacturing- Principles of Lean Manufacturing(LM)
25	4	Basic elements of LM– Introduction to LM Tools.
26	4	Concept of wastes in LM and their narration
27	4	Stages of 5S and waste elimination
28	4	Stages of 5S and waste elimination
29	4	Conventional Manufacturing versus Lean Manufacturing - Need for LM.
30	4	Agile manufacturing – Definition , business need
31	4	Agile manufacturing - conceptual frame work,
32	4	Agile manufacturing - characteristics, and generic features
33	4	Approaches to enhance ability in manufacturing
34	4	Managing people in agile organization
35	5	Introduction of Enterprise Resource Planning- Introduction of enterprise resource planning (ERP)- Concept of Enterprise,
36	5	ERP Overview - Integrated information system - Myths about ERP – Evolution of ERP
37	5	Myths about ERP - Basic ERP concepts
38	5	Small, medium and large enterprise vendor solutions
39	5	Benefits of ERP implementation, Success and failure factors of ERP implementation
40	5	Business intelligence (BI), E-Commerce and E-Business
41	5	Business Process Reengineering (BPR)
42	5	Data warehousing, Data mining, Online Analytical Processing(OLAP)
43	5	Product lifecycle management(PLC)
44	5	Supply chain management(SCM), Customer relationship management (CRM)
45	5	ERP implementation challenges, Emerging trends on ERP

6.3 MODULE WISE SAMPLE QUESTIONS

Module – I

1. What are the functions of Industrial Engineering?
2. What are the objectives of Industrial Engineering?
3. Explain the Evolution of modern Concepts in Industrial Engineering?
4. What are the Field of application of Industrial Engineering?
5. What are the Design function?
6. What the steps in Development of designs?
7. What is Human factors in design?
8. What are the Principles of good product design?
9. Explain the importance tolerance design?
10. Explain the relation of quality and cost ?
11. Describe the concept of product life cycle?
12. What is standardization, simplification, diversification?
13. What is concurrent engineering?
14. Explain the concept of C-V-P analysis with figure?
15. A firm incurs fixed cost of Rs.8000 and variable cost of Rs.20000 and its total sales receipt is Rs.30000. Determine the break-even point.

Module – 2

1. What are the objectives materials management?
2. What are the Types of material handling equipments –
3. What are the principles of material handling?
4. How the Material selection being done or steps in material selection?
5. What is value analysis ?
6. How make or buy decisions are done?
7. Demand for a component is at the rate of 6000 per year and this demand is going to continue for next years. The company has two options. It can get the component manufactured from outside or it can manufacture in house. It costs the company Rs.2.8 per unit to buy the component. The in-house manufacture will incur a fixed cost to the extent of Rs.10000 and variable cost of Rs.1.5 per unit. Give the decision rule for make or buy.
8. Explain Purchasing and procedures.?
9. What are inventory management models?
10. Explain with figureEOQ Models?

11. A manufacturing company purchase 9000 parts of a machine for its annual requirements ordering for month usage at a time, each part costs Rs. 20. The ordering cost per order is Rs. 15 and carrying charges is 15% of the average inventory per year. You have been assigned to suggest a more economical purchase policy for the company. What advice you offer and how much would it save the company per year?
12. What is Q system and P system?
13. Explain the Concept of JIT manufacturing system?

Module – 3

1. Explain the importance of Industrial relations?
2. Explain about Psychological attitudes to work and working conditions ?
3. What the different causes of fatigue?
4. Explain about Methods of eliminating fatigue?
5. Explain with figure the communication method?
6. What is importance Industrial safety?
7. What are personal protective devices used?
8. What are the causes and effects of industrial disputes?
9. What are the methods of Collective bargaining?
10. What are popular Trade union in India? What is the importance of Trade union?
11. How Workers participation in management is ensured or what the methods of Workers participation in management?

Module – 4

1. Explain the Principles of Lean Manufacturing(LM)?
2. What are the Basic elements of LM?
3. Explain any 2 LM Tools?
4. Explain the Concept of wastes in LM?
5. What are the stages of 5S and waste elimination?
6. Compare Conventional Manufacturing versus Lean Manufacturing?
7. What is the Need for LM. Agile manufacturing?
8. What is the conceptual frame work of LM.
9. What are the characteristics of Agile manufacturing?
10. What are Approaches to enhance agility in manufacturing?
11. What is the concept of Managing people in agile organization?

Module – 5

1. Explain the components of enterprise resource planning (ERP)?
2. Importance of Integrated information system?
3. What are the Myths about ERP?
4. How Evolution of ERP happended over time?
5. What are the Benefits of ERP implementation?
6. What are the Success and failure factors of ERP implementation?
7. Explain about Small, medium and large enterprise vendor solutions with example?
8. What is the concept of Business intelligence (BI)?
9. Explain E-Commerce and E-Business?
10. What is Business Process Reengineering (BPR)?
11. What is the difference between Data warehousing, Data mining?
12. What is Online\ Analytical Processing(OLAP)? What is its advantage?
13. What is meant by Product lifecycle management(PLC)?
14. Explain Supply chain management(SCM)?
15. What is Customer relationship management (CRM)?
16. What are the challenge in ERP implementation?
17. What are the Emerging trends on ERP?

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7. MET307 MACHINE TOOLS AND METROLOGY

7.1 COURSE INFORMATION SHEET

PROGRAMME: MECHANICAL ENGINEERING	**DEGREE:** BTECH **UNIVERSITY:**APJ Abdul Kalam Technological University
COURSE: MACHINE TOOLS AND METROLOGY	**SEMESTER:** V **CREDITS:** 4
COURSE CODE: MET 307 **REGULATION:** 2019	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: : PRODUCTION & INDUSTRIAL ENGINEERING	**CONTACT HOURS:** 3 (Lecture) + 1 (Tutorial) hours/week.
CORRESPONDING LAB COURSE CODE (IF ANY): MEL 204 & MEL 331	**LAB COURSE NAME:** MACHINE TOOLS LAB I & II

SYLLABUS:

UNIT	DETAILS	HOURS
I	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.	10
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.	9
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.	9
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.	10
V	Instruments for checking straightness, flatness and squareness–pneumatic gauging –precision gauging –automatic gauging for inspection-Optical	9

	measuring instruments –Comparators –Measurements of surface roughness –- gauging and measurements of screw and gears- Advanced measuring devices – Laser interferometers- Coordinate Measuring Machine (CMM).	
TOTAL HOURS		**47**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T1	Chapman W. A. J., Workshop Technology, Viva books (P) Ltd
T2	HMT, Production Technology, Tata McGraw-Hill
T3	Engineering Metrology and Measurements, N.V. Raghavendra, l. Krishnamurthy, oxford university press
T4	Galyer J.F.W., Schotbolt C.R., Metrology for Engineers, ELBS
R1	Acharkan. N., Machine Tool Design Vol. 1 to 4, MIR Publication
R2	Chernov, Machine Tools, MIR Publication.
R3	HajraChoudary, Elements of workshop technology, Vol I & II, Media Publishers.
R4	ASME, Hand book of Industrial Metrology.
R5	Hume K. J., Engineering Metrology, Macdonald &Co. Ltd.
R6	Sharp K.W.B., Practical Engineering Metrology, Sir Isaac Pitman & Sons Ltd.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
MET 205	Metallurgy and Material Science	Basic knowledge in materials, material properties, heat treatments is essential in selection of appropriate machine tools and measuring devices	III
PHT 110	Engineering Physics	Fundamentals is required to understand the working principles of measuring devices	I

COURSE OBJECTIVES:

1	To develop knowledge of appropriate process parameters to be used for various machining operations.
2	Understand the fundamentals of modern quality concepts. Be able to apply statistical techniques.
3	Understand the principles and operation of precision measurement tools and equipment used in modern manufacturing.

COURSE OUTCOMES:

SL NO	DESCRIPTION	Bloom's Taxonomy Level
CMET307.1	Analyze various machining process and calculate relevant quantities such us velocities, forces and powers.	Analyze (Level 4)
CMET307.2	Analyze the tool nomenclature with surface roughness obtainable in each machining processes.	Analyze (Level 4)

CMET307.3	Understand the limitations of various machining process with regard to shape formation and surface texture.	Understand (Level 2)
CMET307.4	Demonstrate knowledge of the underlying principles of measurement, as they relate to mechanical measurement, electronic instrumentation, and thermal effects.	Understand (level 2) Apply (level 3)
CMET307.5	Get an exposure to advanced measuring devices and machine tool metrology.	Understand (level 2)

CO-PO AND CO-PSO MAPPING

SL NO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CMET307.1	2	3	-	-	-	-	-	-	-	-	2	1	-	2	-
CMET307.2	2	3	-	-	-	-	-	-	-	-	2	1	-	2	-
CMET307.3	2	1	-	2	2	-	-	-	-	-	-	2	-	-	-
CMET307.4	3	-	2	-	-	-	-	-	-	-	2	2	-	-	-
CMET307.5	2	-	-	2	3	-	-	-	-	-	-	3	-	-	2
CMET307	**2.2**	**2**	**2**	**2**	**2.5**	**-**	**-**	**-**	**-**	**-**	**2**	**1.8**	**-**	**2**	**2**

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
CMET307.1-PO1	M	Knowledge will be attained by studying mathematical equations and solutions to find out the machining forces, power and velocity required for various processes
CMET307.1-PO2	H	Ability to analyze the machining parameters such as cutting force, velocity and power required will ensure the right selection of factors for the processes
CMET307.1-PO11	M	Knowledge attained in the machining parameters will help the students to carry out the practice workshop sessions as a team and also on an individual basis
CMET307.1-PO12	L	Advancements happening in the machining sector will enhance students to have a lifelong learning.
CMET307.2-PO1	M	Ability to apply the knowledge on tools' nomenclature and the surface roughness obtainable in each machining process
CMET307.2-	H	Ability to analyze the nomenclature of the tools required for

PO2		the various machining processes and its influence on the machining characteristics
CMET307.2-PO11	M	Knowledge attained on the tool characteristics will support the students in the practice sessions individually and as a team as well while accomplishing a product feature and texture
CMET307.2-PO12	L	Advanced tools and peculiarities for the machining process will enhance students to have a lifelong learning in the tool development.
CMET307.3-PO1	M	Knowledge gained on the principles of working of different machine tools will help the students on the selection of proper machining method
CMET307.3-PO2	L	Ability to analyze the limitations of each machining process and understanding with regard to shape formation and surface texture
CMET307.3-PO4	M	Ability to analyze different machining processes and to understand about its capabilities to produce components with superior quality and product texture
CMET307.3-PO5	M	After knowing the limitations and benefits of various processes, students will be able to find better tools and methods to overcome the issues related to the current technologies
CMET307.3-PO12	M	Continuous technological changes in the machining sector will help the students to choose right most method to produce mechanical components with better product quality
CMET307.4-PO1	H	Ability to select, calibrate and use appropriate measuring equipment requires identification of measure and, selection of equipment by referring standard available equipment, and analysing the results obtained using reference values.
CMET307.4-PO3	M	A good knowledge in measuring equipment equip them to design solutions to complex engineering problems by measuring various parameters affecting them.
CMET307.4-PO11	M	Knowledge gained will equip the students to manage projects in multi-disciplinary fields.
CMET307.4-PO12	M	They have a life-long learning in the broadest context of technological change.
CMET307.5-PO1	M	Students will identify best measuring equipment suited for various problems.
CMET307.5-PO4	M	Will help to analyse and interpret data to derive conclusions.
CMET307.5-PO5	H	Will help to select the best technology/machine for a particular application.
CMET307.5-PO12	H	They have a life-long learning in the broadest context of technological change.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
CMET307. 1-PSO2	**M**	Ability to analyze different machining process and calculate relevant quantities such as velocities, forces and powers after knowing the principles of machining processes
CMET307. 2-PSO2	**M**	Knowledge attained to analyze the tool nomenclature with surface roughness obtainable in each machining processes will enable students to select appropriate cutting tool for the process.
CMET307. 5-PSO3	M	Familiarized with various advanced measuring devices and machine tool metrology help them to perform manufacturing practice.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS:

SL NO	DESCRIPTION	RELEVENCE TO PO\PSO	PROPOSED ACTIONS
1	Mechanism of metal removal, wear mechanisms, Factors affecting tool life	PO3, PO5	Notes/Lecture/Seminar
2	Introduction to machine vision, Stress, Strain, Force and Torque Measurement.	PO4, PO5, PO6	Notes/Lecture/Seminar

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SL NO	TOPIC	RELEVENCE TO PO\PSO
1	Advanced machining and finishing processes	PO1, PO5

WEB SOURCE REFERENCES:

1	https://nptel.ac.in/courses/112/105/112105127/
2	https://nptel.ac.in/courses/112/105/112105126/
3	https://nptel.ac.in/courses/112/103/112103245/
4	https://nptel.ac.in/courses/112/105/112105233/
5	https://nptel.ac.in/courses/112/106/112106138/
6	https://www.youtube.com/watch?v=JZQP6stcFTU
7	https://nptel.ac.in/content/storage2/courses/112105125/pdf/mod1les3.pdf
8	https://nptel.ac.in/courses/112/106/112106179/
9	http://www.digimat.in/nptel/courses/video/112106179/L10.html

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑CHALK & TALK	☑STUD. ASSIGNMENT	☑ WEB RESOURCES	☑LCD/SMART BOARDS
☑ STUD. SEMINARS	☐ ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

☑ ASSIGNMENTS	☑ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

Prepared by

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Approved by

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7.2 COURSE PLAN

DAY	MODULE	TOPIC PLANNED
1	I	General purpose machine tools – types and classification of machine tools –Lathe – types and classification of lathe –specification for a lathe
2	I	Feed, depth of cut, speed-methods of holding work and tool
3	I	lathe accessories and attachments
4	I	lathe operations and tools used for each operations
5	I	Brief study of the machine and the nature and type of jobs handled by the following: - tool room lathe – duplicate lathe
6	I	capstan and turret lathe
7	I	horizontal and vertical-single spindle and multi spindle screw machines.
8	I	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)
9	I	Drilling and boring Machines – Types and specifications –Brief descriptions about the machines and nature, types of job handled by each of them.
10	I	Drill bit nomenclature- cutting forces in drilling – tool and work holding devices-boring tools and reamers.
11	II	Milling machines – types and specifications- Milling operations and types of milling cutters used for each.
12	II	Milling tool nomenclature - Cutting forces in milling –Calculation of machining time- Indexing head and its use
13	II	Different indexing methods - Differential indexing (Self learning portion discretion of faculty, fundamentals to be explained in the class)
14	II	Grinding, honing and lapping – types of grinding machines
15	II	operations: cylindrical, surface and center less grinding –internal grinding, tool and cutter grinding
16	II	cutting forces in grinding
17	II	Grinding mechanisms – Grinding wheels: Specification – types of abrasives, grain size
18	II	Types of bond, grade, and structure –Marking system of grinding wheels – Selection of grinding wheels –need of better surface finish;

19	II	surface roughness obtainable in grinding, honing, lapping and burnishing; Surface roughness comparisons between different conventional metal cutting processes
20	III	Broaching machines and different machines
21	III	Broaching cutter and its features
22	III	Different broaching processes – internal external broaching
23	III	Gear cutting –methods used in gear production
24	III	Form cutters, gear generating machines
25	III	Gear hobbing machines, gear broaching
26	III	Bevel gear cutting operation
27	III	Straight and spiral gears-worm gear cutting
28	III	Gear finishing operations
29	IV	Metrology –principles of achieving accuracy –economicmachining accuracy – precision Vs accuracy
30	IV	errors- standards of measurements
31	IV	Theory of tolerances and allowances
32	IV	system of limits and fits
33	IV	types of fits
34	IV	interchangeability and selective assembly –Taylor's Principle-
35	IV	Gauges – classification of gauges- plug, ring, taper angle,
36	IV	slipand snap gauges –feeler gauges-dial indicator
37	IV	principle of gauge tolerance –wear allowance
38	IV	gauge materials.
39	V	Instruments for checking straightness, angle, flatness andsquareness of guiding surface(Self learning portion, discretionof faculty, fundamentals to be explained in the class).
40	V	pneumatic gauging –precision gauging –automatic gauging for inspection.
41	V	Optical measuring instruments, basic principle –interferometer-optical flat
42	V	optical tool makers' microscopeautocollimator.
43	V	Comparators – mechanical, optical, pneumatic, electric and electronic comparators. (Self-learning portion, discretion offaculty, fundamentals to be explained in the class).
44	V	Measurements of surface roughness – elements of roughness –symbols

		specifying –instruments and for measuring surface roughness
45	V	Measurements of screw: terminology, measurement of screw thread elements
46	V	measurement of gears: terminology, errors inspur gears, measurement of gear elements.
47	V	Advanced measuring devices – Laser interferometers-Coordinate Measuring Machine (CMM)

7.3 MODULE WISE SAMPLE QUESTIONS

Module 1

1. What are the various thread cutting methods?
2. What is Swiss type automat?
3. Explain the following parts of lathe?

(a) Lathe bed

(b) Carriage

4. What is an apron?
5. List any four methods by which taper turning is done in a center lathe.
6. Distinguish between Capstan lathe and Turret lathe.
7. Mention four different types of chucks used in a machine shop.
8. What is the purpose of a mandrel? How many types of mandrels is there in common use?
9. What are the advantages of using a collect chuck?
10. Why is it essential that the cutting point of the tool should be level with the spindle center while machining taper on a work piece?
11. Calculate the power required for cutting a steel rod of 50mm in diameter at 200rpm. Assume cutting force of 160 kgf.
12. What are the advantages of automatic lathes?
13. What are the functions of feed rod and lead screw?
14. Why was power chucks developed?
15. Give the specification of a lathe
16. What is meant by “swing of the lathe”?
17. List out the various types of lathe.
18. What are the various mechanisms are used for a automatic feeding in lathes?
19. Write the advantages of automat over conventional lathes
20. What is called carrier plate and lathe dog?
21. Differentiate semi-automatic and automatic lathe.
22. Mention the differences between shaper and planer.
23. Define the cutting speed, feed and machining time for drilling.
24. What do you know about straight fluted drill and fluted drill?
25. Write the differences between drilling and tapping.
26. State the differences between a vertical shaper and slotters.
27. Mention the operations performed by a planner.
28. Name any four work holding devices in shaper.

29. Define lapping
30. Why reaming operation is performed?
31. Define cutting ratio of the shaper

Module 2

1. What are the differences between drilling and reaming?
2. Briefly describe the importance of quill mechanism.
3. What is the difference between up milling and down milling?
4. How do you classify milling cutters?
5. Differentiate conventional and climb milling?
6. What is a shell mill?
7. What is straddle milling?
8. What do you mean by differential indexing?
9. Why is milling a versatile machining process?
10. What do you understand by Gang milling?
11. List out the various milling operations.
12. Name different types of Knee and Column type milling machines.
13. Name different types of production milling machines.
14. Name principal parts of knee and column type milling machine.
15. What are the limitations of a milling machine?
16. Define conventional milling
17. Define Climb milling
18. Define milling cutter.
19. Name the materials used for milling cutters.
20. What is plain milling cutter?
21. What is a side milling cutter?

Module 3

1. List four applications of broaching machines.
2. What is broaching?
3. What is gear finishing? Why it is done?
4. Define gear shaving.
5. What is the main advantage of broaching over shaping process?
6. For which of the following operations, broaching can be used?
7. Why push type broaches are made shorter in length?
8. Why chip breakers are provided on the broach?
9. Why neck section provided in the pull type broaches are made shorter in diameter?
10. What are the principal types of broaching machines?
11. Why broaching process is long and laborious?
12. State the principle involved in gear shaping?
13. What are the various methods of shaping the gear blank?
14. Write the advantages of gear shaping (Generating)?
15. Explain axial hobbing process?
16. What are the advantages of gear hobbing?
17. Give any three differences between gear bobbing and gear milling?

Module 4

1. What are the factors affecting the accuracy of the measuring system?
2. Define error.
3. Distinguish between static and random error?
4. Write short note on “Systematic errors”.
5. Write short notes on the classification of error.
6. Differentiate between precision and accuracy with suitable example.
7. What are the various possible sources of errors in measurements? What do you understand by systematic error and random errors?
8. List different types of fits?
9. Explain the concept of interchangeability?
10. Explain the concept of selective assembly?
11. Why is an allowance different from a tolerance?
12. What are fits?
13. Explain Taylor principle in gauge design.
14. Name any two materials commonly used for gauges.
15. What are limit gauges?
16. Explain the need of angle gauges.
17. Explain the construction and working principle of Limit Gauge with sketch.
18. How flatness is tested?

Module 5

1. Name the different types of interferometer?
2. List some of the applications of laser interferometer.
3. What are the advantages of laser interferometer?
4. What is CMM?
5. What are the types of CMM?
6. List any four possible causes of error in CMM.
7. Name the types of accuracy specification used for CMM.
8. Discuss the application of computer aided inspection
9. State the application of CMM in machine tool metrology
10. Name the type of accuracy specifications used for CMM
11. State the applications of CMM
12. Mention the disadvantages of CMM.
13. Explain the construction and working principle of AC laser interferometer
14. with neat diagram?
15. Explain the construction and principle of CMM.
16. How are CMMs classified with respect to constructional features? Sketch andstate their main applications, merits and demerits.
17. What are the types of gear?
18. What are the various methods used for measuring the gear tooth thickness?
19. Name the various types of pitch errors found in screw.
20. Name the various method of measuring the minor diameter of the thread.

21. Define the effective diameter of thread.
22. Name the two corrections to be applied for the measurement of effectivediameter.
23. What is meant by “Best size wire” in screw thread measurement?
24. Explain drunken error in screw threads.
25. How straightness, flatness and roundness are measured.
26. Explain Tomlinson surface meter.
27. Describe a method to find out flatness of a surface plate.
28. With a neat sketch explain Johansson Mikrokator.
29. Explain the construction and working principle of Tomlinson surface meter with neat diagram
30. Describe the method of evaluating roughness using
    (i) Peak to valley high method. (ii) C.L.A. method.
31. With a neat sketch explain the working of an autocollimator.

Prepared by **Approved by**

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8. HUT300: INDUSTRIAL ECONOMICS AND FOREIGN TRADE

8.1 COURSE INFORMATION SHEET

PROGRAMME: ME	***DEGREE:*** BTECH
PROGRAMME: MECHANICAL ENGINEERING	DEGREE: **B. TECH** UNIVERSITY**: A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
COURSE: INDUSTRIAL ECONOMICS & FOREIGN TRADE	SEMESTER**: IV** CREDITS: **3**
COURSE CODE: HUT300 ***REGULATION: UG 2019***	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: APPLIED ECONOMICS	CONTACT HOURS: **3 hours/Week.**

SYLLABUS:

UNIT	*DETAILS*	*HOURS*
I	• ***Basic Concepts and Demand and Supply Analysis:*** o *Scarcity and Choice - Basic Economic Problems- PPC* o *Firms and its Objectives – Types of Firms* o *Utility – Law of Diminishing Marginal Utility* o *Demand and its Determinants – Law of Demand – Elasticity of Demand - measurement of Elasticity and its applications* o *Supply, Law of Supply and Determinants of Supply* o *Equilibrium – Changes in Demand and Supply and its effects* o *Consumer Surplus and Producer Surplus (Concepts)* o *Taxation and Deadweight Loss.*	*7*
II	• *Production and Cost:* o *Production Function – Law of Variable Proportion – Economies of Scale – Internal and External Economies* o *Isoquants, Isocost Line and Producer's Equilibrium – Expansion path* o *Technical Progress and its Implications – Cobb-Douglas Production Function* o *Cost concepts – Social Cost: Private Cost and External Cost – Explicit and Implicit Cost – Sunk Cost* o *Short Run Cost Curves - Long Run Cost Curves* o *Revenue (concepts)* o *Shutdown Point – Break-even Point*	*7*
III	• ***Market Structure****:* o *Perfect and Imperfect Competition* o *Monopoly, Regulation of Monopoly* o *Monopolistic Competition (features and equilibrium of a firm)* o *Oligopoly – Kinked Demand Curve – Collusive Oligopoly (meaning)*	*6*

	○ *Non-price Competition* ○ *Product Pricing – Cost Plus Pricing – Target Return Pricing - Penetration Pricing – Predatory Pricing – Going Rate Pricing – Price Skimming*	
IV	• ***Macro-Economic Concepts:*** ○ *Circular Flow of Economic Activities* ○ *Stock and Flow – Final Goods and Intermediate Goods - Gross Domestic Product* ○ *National Income* ○ *Three Sectors of an Economy- Methods of Measuring National Income* ○ *Inflation- Causes and Effects – Measures to Control Inflation- Monetary and Fiscal Policies* ○ *Business Financing- Bonds And Shares -Money Market And Capital Market – Stock Market – Demat Account And Trading Account - SENSEX And NIFTY*	*7*
V	• *International Trade:* ○ *Advantages and Disadvantages of International Trade* ○ *Absolute and Comparative Advantage Theory* ○ *Heckscher - Ohlin Theory* ○ *Balance of Payments – Components – Balance of Payments – Deficit and Devaluation -Trade Policy – Free Trade Versus Protection – Tariff and Non-Tariff Barriers.*	*8*
TOTAL HOURS		

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHORS/PUBLICATION*
T	Gregory N Mankiw, 'Principles of Micro Economics', Cengage Publications
T	Gregory N Mankiw, 'Principles of Macro Economics', Cengage Publications
T	Dwivedi D N, 'Macro Economics', Tata McGraw Hill, New Delhi.
T	Mithani D M, 'Managerial Economics', Himalaya Publishing House, Mumbai.
T	Francis Cherunilam, 'International Economics', McGraw Hill, New Delhi.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
MAT 101	Linear Algebra & Calculus	Basic Calculus	I

COURSE OBJECTIVES:

1	To familiarise the underlying concepts like scarcity, choice, demand and supply, and utility in economics
2	To understand the concepts related to cost and apply while analysing production function of a firm
3	To differentiate between different market structures and evaluate the competitive conditions of each market feasible for firms
4	To effectively analyse reasons behind economic fluctuations occurring in the country by learning important macroeconomic indicators and policies
5	To logically identify the link between domestic and international market and its implications on the host country

COURSE OUTCOMES:

SLNO	DESCRIPTION	Bloom's Taxonomy Level
HUT300.1	Explain the problem of scarcity of resources and consumer behaviour, and to evaluate the impact of government policies on the general economic welfare.	Cognitive knowledge level: Understand
HUT300.2	Take appropriate decisions regarding volume of output and to evaluate the social cost of production.	Cognitive knowledge level: Apply
HS300.3	Determine the functional requirement of a firm under various competitive conditions.	Cognitive knowledge level: Analyse
HUT300.4	Examine the overall performance of the economy, and the regulation of economic fluctuations and its impact on various sections in the society.	Cognitive knowledge level: Analyse
HUT300.5	Determine the impact of changes in global economic policies on the business opportunities of a firm.	Cognitive knowledge level: Analyse
HUT300.6	Explain the problem of scarcity of resources and consumer behaviour, and to evaluate the impact of government policies on the general economic welfare.	Cognitive knowledge level: Understand

CO-PO AND CO-PSO MAPPING

	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
HUT300.1	2										3	
HUT300.2	2	2			2	2	3				3	
HUT300.3	2	2	1								3	
HUT300.4	2	2	1			1					3	
HUT300.5	2	2	1								3	

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
HUT300.1-PO 1	M	Knowledge of economic concepts elaborated in Module I are required to understand, analyse and find solutions to societal problems.
HUT300.1-PO 11	M	Module I helps to apply the concept of scarcity considering the major economic problems and finding the feasible output production at a point of time. Eg: PPF
HUT300.2-PO 1	M	Knowledge of economic concepts elaborated in Module II are required to analyse and evaluate the cost of production and find optimum output at firm level.
HUT300.2-PO	M	The concepts related to Production cost in Module II like TC, AC, MC etc, in identifying the variations in production function and its impact on an industrial undertaking
HUT300.2-PO5	M	As an economy progresses technological advancement and inclusive development are indispensable. The resource utilization and its optimal utilization is of greater importance during this advancement. Module II provides theoretical understanding about Law of Variable Proportions, Optimal output production etc for firms/industry who engage in experimenting with new methods of production/technology
HUT300.2-PO 6	M	Every firm level/industrial level activity has its repercussion on the society. This impact can be identified using the cost concepts in Module III. For example, calculating social cost.
HUT300.2-PO 7	H	A firm in order to sustain should have an idea about profitability, that is about cost and revenue. The idea of social cost for example provides the impact of a firm's activity on the society/environment. Shut down point helps a firm to minimise its loss. Module II gives this idea of Production costs.
HUT300.2-PO 11	H	Module II helps to apply the concepts of production like AC,VC & MC to determine the prices of factors of production, to calculate the cost of production, to identify optimal pricing and ways to minimise loss.
HUT300.3-PO1	M	Knowledge of economic concepts elaborated in Module III are required to understand and evaluate various forms of market structures and identify feasible markets for different types of firms.
HUT300.3-PO2	M	Knowledge of types of markets and their features in Module III are

		required to identify the types of market, the comparison between firms in different types of markets.
HUT300.3-PO 3	L	Module III details about different kinds of markets feasible for different kinds of firms. Identifying the exact market for a product will increase the scope for more innovations and solutions.
HUT300.3-PO 11	L	Module III provides knowledge on markets where every market has different features and hence it gives an idea about which product will sustain in which market. Identifying market types give an idea about various market strategies that help firms to survive competitions in such markets.
HUT300.4-PO 1	M	Knowledge of economic concepts elaborated in Module IV are important macroeconomic indicators like GDP, Inflation, etc to analyse and evaluate how variations in these indicators affect the economic conditions within an economy
HUT300.4-PO2	M	Module IV provides insight in to the endogenous factors affecting firm/industry. This helps in solving/finding solutions to industrial problems within a country.
HUT300.4-PO5	L	Not all layers of the economy are equal. Every segment of the society deals with different kinds of problem. A policy impact may sometimes become boon to some segments but it can be a curse to some other segments of the economy. Module IV gives a general understanding of the macroeconomic indicators and policy framework of our country.
HUT300.4-PO 4	M	The economic activities in a country are interdependent. An investment, the launch of a new product, expansion of an industry, inclusion of new technology creates more employment opportunities, more revenue, increased demand, market failure etc. Module IV provides an understanding of how these economic activities are linked to each other and the changes resulting from this interdependence
HUT300.4-PO 11	H	Launching a product or service in a society has its own implications, since every economic activity is interdependent. Module IV gives an idea on macroeconomic indicators required to understand the practicality of an industrial activity. The understanding of share market gives an idea about share capital, competition among firms and the money market as a whole.
HUT300.5-PO 1	M	Domestic and international markets are linked in a complex way in this era of globalization. Module V lays down the basic concepts to understand that link between the two markets.
HUT300.5-PO2	M	Module V gives an insight in to how a firm is linked to a global network and the repercussions. It provides an idea about the exogenous forces affecting a firm's/industry's survival.
HUT300.5-PO3	M	When firms/industries go global it is important to understand how export and import prices affect pricing of a product. This decides the profitability of a product and thereby the firm. Module V deals with foreign trade and its impact on the growth of a firm globally.
HUT300.5-PO 11	H	Entering a global market invites new technological spill over, export receipts, more investment, cost and more competition. Module V provides the complexities of international trade and the challenges the firm might face. This gives ground knowledge about how versatile a leader should be while managing a global firm/industry

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
HUT300.3-PSO 2	M	To understand the requirements of the firm under competitive atmosphere and implement the equipped knowledge to solve various decision problems.
HUT300.5-PSO 3	H	To track the technological advancement and progress accordingly and to identify potential opportunities and implement new marketable ideas.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS:

SNO	*DESCRIPTION*	*RELEVENCE TO PO\PSO*	*PROPOSED ACTIONS*
1	Cost Engineering	PO2,PO3 TO PSO2	Audio PPT
2	Location Theories	PO7 TO PSO3	Assignment
3	Industrial Policy and Growth in India	PO6 TO PSO3	Classroom Discussion
4	Methods of evaluating Investment Decisions	PO3 TO PSO3	Audio PPT
5	Patents	PO3, PO5 TO PSO2	Assignment
6	Risk Analysis and Decision Making	PO2, PO3 TO PSO2	Audio PPT
7	Innovation and Rivalry	PO2 TO PSO2	Classroom Discussion

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SINO:	**TOPIC**	**RELEVENCE TO PO\PSO**
1	Theories of Industrial Location and Regional Development	PO7 TO PSO3
2	Industrial Investment –Trends – Kerala Model	PO6 TO PSO3
3	Trends and Pattern of Regional Development in Kerala	PO6 TO PSO3
4	Theories of Growth of Firms	PO7 TO PSO3
5	Industrial Finance – Sources of Finance	PO3 TO PSO3
6	Social Cost Benefit Analysis	PO2 TO PSO2

WEB SOURCE REFERENCES:

1	https://www.india.gov.in/topics/industries National Portal of India
2	https://www.cii.in/ The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes
3	https://commerce.gov.in/ The Department formulates, implements and monitors the Foreign Trade Policy (FTP) which provides the basic framework of policy and strategy to be followed for promoting exports and trade
4	http://mospi.nic.in/annual-survey-industries The ASI frame is based on the lists of registered factories / units maintained by the Chief Inspector of Factories in each State and those maintained by registration authorities in respect of bidi and cigar establishments and electricity undertakings.
5	https://msme.gov.in/ MSMEs are complementary to large industries as ancillary units and this sector contributes enormously to the socio-economic development of the country.

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☑ STUD. ASSIGNMENT	☑ WEB RESOURCES	☐LCD/SMART BOARDS
☐ STUD. SEMINARS	☐ ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

☑ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (ONCE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

8.2 COURSE PLAN

DAY	MODULE	TOPIC PLANNED
1	MODULE 1	Scarcity and Choice,Basic Economic Problems
2	MODULE 1	Production Possibility Curve
3	MODULE 1	Firms and its Objectives
4	MODULE 1	Demand,determinants,law of demand,elasticity
5	MODULE 1	Supply,determinants,law of supply,elasticity
6	MODULE 1	Equilibrium,Changes in demand and supply
7	MODULE 1	Consumer surplus and Producer surplus
8	MODULE 1	Taxation and deadweight loss.
9	MODULE 2	Law of Variable Proportion
10	MODULE 2	Internal and External economies of scale
11	MODULE 2	Isoquants,isocost line and Producer's equlibrium
12	MODULE 2	Expansion path-Technical progress and its implications
13	MODULE 2	Cobb-Douglas production function
14	MODULE 2	Cost concepts-social,private and external cost.
15	MODULE 2	Explicit and Implicit cost.
16	MODULE 2	Short run cost curves and Long run cost curves.
17	MODULE 2	Shut down point and Break even point.
18	MODULE 3	Perfect competition and Imperfect coompetition
19	MODULE 3	Monopoly and Monopolistic competition
20	MODULE 3	Oligopoly and Collusive Oligopoly
21	MODULE 3	Product pricing, Cost plus pricing,Target return pricing
22	MODULE 3	Penentration pricing,Predatory pricing
23	MODULE 3	Going rate pricing,Price skimming
24	MODULE 4	Circular flow of economic activities
25	MODULE 4	Circular flow of economic activities
26	MODULE 4	Stock and flow,Final goods and intermediate goods.
27	MODULE 4	National Income-Three sectors of an economy
28	MODULE 4	Methods of measuring national income.
29	MODULE 4	Inflation and causes and effects,measures to control inflation.
30	MODULE 4	Monetary and fiscal policies
31	MODULE 4	Bonds and shares,money market and capital market
32	MODULE 4	Stock market,demat account and trading account.
33	MODULE 5	Advantages and disadvantages on international trade,absolute and comparative advantage
34	MODULE 5	Heckscher-Ohlin theroy and BOP
35	MODULE 5	Trade policy,free trade versus protection,tariff and non-tariff barriers

8.3 MODULE WISE SAMPLE QUESTIONS

MODULE I

1. Explain in detail the fundamental problems of an economy. (Problem of scarcity+ 3 problems).
2. Elaborate the role of Business economics in managerial decision making (definition + any 5 points).
3. Define the following concepts with an example:
   I. Problem of scarcity
   II. Tradeoff
   III. Opportunity cost
   IV. Diminishing Marginal Utility (diagram - marking)
   V. Resource allocation
3. With the help of a diagram and table depict a production possibility frontier (diagram + mark 3 areas clearly). What does a PPF represent? State the assumptions of a PPF. Depict choice, tradeoff and opportunity cost in the diagram
4. Sate the law of diminishing marginal utility (LDMU) with the help of a table and diagram (draw the two diagram + 3 different levels of utility. Mark the core points where TU is maximum MU is zero). List out the assumptions of LDMU.
5. Define an equilibrium price. How is an equilibrium price determined in the market? Explain the same with the help of a diagram and table. Explain the stages of excess demand and excess supply.
6. Solve the following:
   I. Consider the demand for a good. At price Rs 4, the demand for the good is 25 units. Suppose price of the good increases to Rs 5, and as a result, the demand for the good falls to 20 units. Calculate the price elasticity
   II. Consider the demand curve D(p)=10 – 3p. What is the elasticity at price 5/3?

III. Suppose the price elasticity of demand for a good is – 0.2. If there is a 5 % increase in the price of the good, by what percentage will the demand for the good go down?

IV. Suppose the price elasticity of demand for a good is – 0.2. How will the expenditure on the good be affected if there is a 10 % increase in the price of the good?

7. Define (a) normal good (b) inferior good (c) substitute good (d) complement good and, (e) Giffen goods
8. Explain the concept dead weight loss.
9. Differentiate between consumer surplus and producer plus.
10. Explain the reason behind shift in demand and supply curves.
11. Suppose the price of Covishield vaccine is ₹750 per dose, and the market demand curve for Covishield vaccine is a usual downward slopping curve and the supply curve for the same is upward slopping. With the help of a diagram depict the equilibrium price and quantity as P* and Q* respectively. Suppose that in Kerala the government intervenes at this point, finding that there is less inclusion of vaccinated people due to the high price and the government sets a price floor of ₹250 per dose. What change would this bring to the demand curve, given there would be supply of the vaccine accordingly and why? Indicate the new equilibrium. Now suppose that the IMA (Indian Medical Association) announces that Covaxin is more effective than Covishield and the Central government intervene at this point and sets a price floor of Covaxin ₹150 per dose. Explain how would this impact the market for Covishield? Indicate the new equilibrium. Now, if the price of Covishield falls further to ₹100, will it have an impact on the demand for Covishield? Explain your answer fully with the aid of diagrams.
12. Discuss any five determinants of demand and supply.
13. Explain with the help of a diagram how a lump sum tax can minimise both consumer and producer surplus and create deadweight loss.
14. Discuss various situation that leads to deadweight loss.
15. Discuss different types of firms with examples.

MODULE II

1. State the law of variable proportion and explain it with the help of a diagram and table. (Clearly mark the III stages and also mention the rational stage. Briefly explain what happens in each stage)

2. Write a note on Cobb – Douglas production function (define equation and write the properties)

   i. Let the production function of a firm $AK^{1/2}L^{1/2}$ Find out the maximum possible output that the firm can produce with 100 units of L and 100 units of K.

   ii. Let the production function of a firm be $AK^{1/2}L^{1/2}$. Find out the maximum possible output that the firm can produce with 5 units of L and 2 units of K. What is the maximum possible output that the firm can produce with zero unit of L and 10 units of K?

3. Does the term shut down mean closing down the entire production unit? If no, then explain the term "shut down point" with the help of diagram (draw the correct diagram). Give a clear explanation for the diagram and substantiate why a firm should continue its production until shutdown point?

4. With the help of a diagram explain the term break-even. From the given data below, calculate:

   I. P/V ratio

   II. Fixed cost

   III. Sales volume

   To earn a profit of Rs. 80,000.

   Given, Sales = 200000

   Profit gained = 20000

   Variable cost = 70 %

   (1, 40,000)

5. Find Margin of Safety from the following:

   i. Total sales: 300000

   ii. VC = 150000

   iii. 10000

6. How the internal economies differ from external economies?
7. List any three reason for the expansion path.
8. Explain the concepts TFC, TVC, TC, AFC, AVC and AC with equations.
9. Explain the following concepts with the help of an example:

   a. Social Cost: Private Cost and External Cost
   b. Explicit and Implicit Cost

c. Sunk Cost

10. Explain with the help of a diagram Producer's equilibrium.
11. Explain how long – run AC curve is derived and how optimal output is determined.
12. Explain the properties of Isoquant and Iso cost curves with the help of a diagram.
13. Discuss the concepts Total Revenue, Average Revenue and Marginal Revenue with the help of a diagram.
14. Derive Marginal Product of Labour and Capital from the Cobb Douglas Production Function $A\ L^{\alpha}\ K^{\beta}$. Suppose we know that output in the economy is given by the production function: $Y_T = A_t K t^{1/3} L t^{2/3}$. If technology is growing at a rate of 1% per year, the capital stock by 3%, and the labor supply by 2%, what will total growth in the economy be?
15. Discuss the assumptions of short run production function.

MODULE III

1. State any five differences between (a) Monopoly and Oligopoly (b) Monopoly and Monopolistic competition.
2. How price skimming is different from cost plus pricing?
3. How equilibrium price is determined under monopoly market. Why monopolist is known as the price maker?
4. In perfect competition industry is the price maker and firm is the price taker. Elaborate the statement with the help of suitable diagram and explanation.
5. What are the methods of non-price competition under oligopoly?
6. Explain about the kinked demand curve under the oligopoly market. Why in certain stages demand curve is elastic and inelastic?
7. How penetration pricing is different from predatory pricing?
8. Differentiate between perfect competition and monopolistic competition.
9. Explain collusive oligopoly and its features.
10. Discuss why under perfect competition the demand curve is perfectly elastic.
11. Explain with the help of a diagram, how price and output are determined under monopoly.
12. Explain with the help of a diagram, how price and output are determined under monopolistic competition.
13. Explain with the help of a diagram, how price and output are determined under oligopoly.

14. Explain with the help of a diagram, how price and output are determined under perfect competition.
15. Explain why the demand curve under monopolistic competition is a more elastic demand curve.

MODULE IV

1. Explain the four sector model of circular flow of income with the help of a neat diagram. Explain each transaction between the players.
2. Explain the following with correct formula from GDP @ MP:
    a. Gross Domestic Product at Factor cost
    b. Gross National Product at Market Price
    c. Net National Product at Factor Cost
    d. Suppose the GDP at market price of a country in a particular year was Rs 1,100 crores. Net Factor Income from Abroad was Rs 100 crores. The value of Indirect taxes – Subsidies was Rs 150 crores and National Income was Rs 850 crores. Calculate the aggregate value of depreciation.
3. Define Inflation. Explain with the help of a diagram (a) Cost push Inflation (b) Demand pull inflation
4. How does inflation affect fixed income group and wage earners?
5. State any five differences between demat account and trading account.
16. Differentiate between money market and capital market.
17. Is GDP a perfect measure of national income? Substantiate.
18. Explain the three different methods of National Income with suitable equations.
19. Differentiate between stock and flow with suitable example.
20. Explain how to open a Demat account.
21. Explain the four sector model of circular flow of income.
22. Explain GDP deflator with formula.
23. Write a note on SENSEX and NIFTY.

MODULE V

1. What is devaluation?
2. Distinguish between free trade and protection
3. List any six arguments in favour of protection?

4. What is free trade? What are its disadvantages?
5. What do you mean by absolute advantage theory? Explain with the help of a nation's trade relation example.
6. Explain the Heckscher Ohlin theory with a suitable diagram?
7. What are the different types of equilibrium in BOP? Explain the causes for and the methods of correcting disequilibrium in BOP.
8. Distinguish between the tariff and non-tariff barriers
9. Discuss any three tariff barriers and its impact on exporting and importing nations.
10. Discuss any three non-tariff barriers and explain its impact on exporting nd importing nations.
11. What are the advantages and disadvantages of international trade?
12. State the methods of correcting BoP disequilibrium.
13. Explain appreciation and depreciation of a currency and how does it affect the BoP of a country?
14. State the assumptions of comparative advantage theory.
15. Differentiate between absolute and comparative advantage.

Prepared by **Approved by**

Ms. Saritha V **Dr.Sonia Paul**
(Faculty) **(HOD)**

9. MCN301 DISASTER MANAGEMENT

9.1 COURSE INFORMATION SHEET

PROGRAMME: ME	***DEGREE:*** BTECH
PROGRAMME: MECHANICAL ENGINEERING	DEGREE: **B.TECH** UNIVERSITY**: A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
COURSE: DISASTER MANAGEMENT	SEMESTER**: V** CREDITS: **Nil**
COURSE CODE: MCN 301 ***REGULATION: UG 2019***	COURSE TYPE: **NON-CREDIT**
COURSE AREA/DOMAIN: GENERAL	CONTACT HOURS: **2 hours/Week.**

SYLLABUS:

UNIT	***DETAILS***	***HOURS***
I	Systems of earth Lithosphere- composition, rocks, soils; Atmosphere-layers, ozone layer, greenhouse effect, weather, cyclones, atmospheric circulations, Indian Monsoon; hydrosphere- Oceans, inland water bodies; biosphere Definition and meaning of key terms in Disaster Risk Reduction and Management- disaster, hazard, exposure, vulnerability, risk, risk assessment, risk mapping, capacity, resilience, disaster risk reduction, disaster risk management, early warning systems, disaster preparedness, disaster prevention, disaster mitigation, disaster response, damage assessment, crisis counselling, needs assessment.	5
II	Hazard types and hazard mapping; Vulnerability types and their assessment- physical, social, economic and environmental vulnerability. Disaster risk assessment –approaches, procedures	5
III	Disaster risk management -Core elements and phases of Disaster Risk Management Measures for Disaster Risk Reduction – prevention, mitigation, and preparedness. Disaster response- objectives, requirements; response planning; types of responses. Relief; international relief organizations.	5
IV	Participatory stakeholder engagement; Disaster communication- importance, methods, barriers; Crisis counselling Capacity Building: Concept – Structural and Non-structural Measures, Capacity Assessment; Strengthening Capacity for Reducing Risk	5
V	Common disaster types in India; Legislations in India on disaster management; National disaster management policy; Institutional arrangements for disaster management in India. The Sendai Framework for Disaster Risk Reduction- targets, priorities for action, guiding principles.	5
TOTAL HOURS		**25**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
R1	R. Subramanian, Disaster Management, Vikas Publishing House, 2018
R2	M. M. Sulphey, Disaster Management, PHI Learning, 2016
R3	UNDP, Disaster Risk Management Training Manual, 2016
R4	United Nations Office for Disaster Risk Reduction, Sendai Framework for Disaster Risk Reduction 2015-2030, 2015

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
NIL			

COURSE OBJECTIVES:

1	The objective of this course is to introduce the fundamental concepts of hazards and disaster management.

COURSE OUTCOMES:

SNO	DESCRIPTION	Bloom's Taxonomy Level
CMCN301.1	Students will be able to define and use various terminologies in use in disaster management parlance and organise each of these terms in relation to the disaster management cycle.	Understand (level 2)
CMCN301.2	Students will be able to distinguish between different hazard types and vulnerability types and do vulnerability assessment.	Understand (level 2)
CMCN301.3	Students will be able to identify the components and describe the process of risk assessment, and apply appropriate methodologies to assess risk.	Understand (level 2)
CMCN301.4	Student will be able to explain the core elements and phases of Disaster Risk Management and develop possible measures to reduce disaster risks across sector and community.	Apply (level 3)
CMCN301.5	Student will be able to identify factors that determine the nature of disaster response and discuss the various disaster response actions.	Understand (level 2)
CMCN301.6	Student will be able to explain the various legislations and best practices for disaster management and risk reduction at national and international level.	Understand (level 2)

CO-PO AND CO-PSO MAPPING

	PO 1	PO 2	PO 3	P 0 4	P 0 5	P 0 6	P 0 7	P 0 8	P 0 9	P 0 1 0	P 0 1 1	P 0 12	PS 0 1	PS 0 2	PS 0 3
CMCN301.1		2				2				2		2			
CMCN301.2	2	3	2		2	2	3			3		2		2	
CMCN301.3	2	3	2	2	2	2	3			3		2			2
CMCN301.4	3	3	3		2	2	3					2		2	2
CMCN301.5	3	3			2	2	3					2		2	
CMCN301.6	3					2	3	3				2			

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
CMCN301.1-PO2	M	Awareness of standard terms used in disaster management will help students address practical engineering problems in challenging environments.
CMCN301.1-PO6	M	Awareness of standard terms used in disaster management will help students assess the societal, health, and safety issues relevant to professional engineering practice.
CMCN301.1-PO10	M	Awareness of standard terms used in disaster management will help students communicate effectively with the engineering community and society during an emergency.
CMCN301.1-PO12	M	Awareness of standard terms used in disaster management will help students pursue independent and life-long learning in the broadest context of technological change post-pandemic.
CMCN301.2-PO1	M	Various mathematical and numerical tools are used in vulnerability assessment.
CMCN301.2-PO2	H	Extensive research and a basic understanding of mathematics are needed to conduct vulnerability assessments.
CMCN301.2-PO3	M	Assessing vulnerability helps the stakeholders to design a practical disaster management framework.
CMCN301.2-PO5	M	Complex analytical and numerical modeling tools are used in vulnerability assessment.
CMCN301.2-	M	Awareness of different hazard types and vulnerabilities will

PO6		help the students to assess the societal, health, and safety issues relevant to the professional engineering practice.
CMCN301.2-PO7	H	Assessing vulnerability is essential in improving the capacity to reduce the risks related to disasters.
CMCN301.2-PO10	H	The students will identify the vulnerable community/society/individuals and communicate with them effectively.
CMCN301.2-PO12	M	Awareness of disasters and vulnerability will help students pursue independent and life-long learning in the broadest context of technological change post-pandemic.
CMCN301.3-PO1	M	Various empirical and analytical methods are used in risk assessment.
CMCN301.3-PO2	H	Extensive research and a basic understanding of science, mathematics, and social sciences are needed to conduct a risk assessment.
CMCN301.3-PO3	M	Risk assessment helps the stakeholders to design a practical disaster management framework.
CMCN301.3-PO4	M	Research-based knowledge and a basic understanding of data analysis, data interpretation, and information synthesis are required to carry out a risk assessment.
CMCN301.3-PO5	M	Complex analytical and numerical modeling tools are used to assess natural hazards like floods, earthquakes, landslides, etc.
CMCN301.3-PO6	M	Awareness of risk assessment fundamentals will help the students assess the societal, health, and safety issues relevant to the professional engineering practice.
CMCN301.3-PO7	H	Understanding elements at risk and risk assessment are essential in strengthening the capacity, developing sustainable mitigation measures, and improving resilience.
CMCN301.3-PO10	H	The students will identify the community/society/individuals at risk and communicate with them effectively.
CMCN301.3-PO12	M	Awareness of future risks and risk assessment will help students pursue independent and life-long learning in the broadest context of technological change post-pandemic.
CMCN301.4-PO1	H	A basic understanding of engineering sciences and mathematics is needed to reduce disaster risks across sectors and communities.
CMCN301.4-	H	Extensive research and a basic understanding of science,

PO2		mathematics, and social sciences are needed to develop risk reduction measures.
CMCN301.4-PO3	H	A decent disaster management framework helps the stakeholders to develop risk reduction measures.
CMCN301.4-PO5	M	GIS and numerical modeling softwares can be used to analyze natural hazards like floods, earthquakes, landslides, etc.
CMCN301.4-PO6	M	Awareness of disaster risk management fundamentals will help the students assess the societal, health, and safety issues relevant to the professional engineering practice.
CMCN301.4-PO7	H	Understanding the core elements and phases of disaster risk management is essential in strengthening the capacity, developing sustainable mitigation measures, and improving resilience.
CMCN301.4-PO12	M	Awareness of disaster risk management strategies will help students pursue independent and life-long learning in the broadest context of technological change post-pandemic.
CMCN301.5-PO1	H	A basic understanding of engineering and social sciences is needed to formulate disaster response strategies.
CMCN301.5-PO2	H	Extensive research and a basic understanding of science, mathematics, and social sciences are needed to develop disaster response measures.
CMCN301.5-PO5	M	Modern tools like GIS, GPS, etc., are used to develop emergency plans for natural hazards.
CMCN301.5-PO6	M	Awareness of the fundamentals of disaster response will help the students to assess the societal, health, and safety issues relevant to the professional engineering practice
CMCN301.5-PO7	H	Understanding disaster response strategies is essential in strengthening the capacity, developing sustainable mitigation measures, and improving resilience.
CMCN301.5-PO12	M	Awareness of disaster response strategies will help students pursue independent and life-long learning in the broadest context of technological change post-pandemic.
CMCN301.6-PO1	H	Awareness of various legislations, policies, and frameworks in disaster management will help students address practical engineering problems in challenging environments.
CMCN301.6-PO6	M	Awareness of various legislations, policies, and frameworks in disaster management will help students assess the societal, health, and safety issues relevant to professional

		engineering practice.
CMCN301.6-PO7	H	Understanding various legislations, policies, and frameworks in disaster management is essential in strengthening the capacity, developing sustainable mitigation measures, and improving resilience.
CMCN301.6-PO8	H	A professional engineer should be aware of various legislations, policies, and frameworks in disaster management.
CMCN301.6-PO12	M	Awareness of various legislations, policies, and frameworks in disaster management will help students pursue independent and life-long learning in the broadest context of technological change post-pandemic.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
CMCN301. 2-PSO 2	M	Apply the principles of analysis and implementation of systems in the process of vulnerability assessment.
CMCN301. 3-PSO 3	M	Using modern design tools and product implementation in the process of risk assessment.
CMCN301. 4-PSO 2	M	Application of different mechanical systems aiding the steps of risk reduction.
CMCN301. 4-PSO 3	M	Novel designs for practically implementing structural solutions for risk reduction measures.
CMCN301. 5-PSO 2	M	Applicability of the principles of design and mechanical systems in the various disaster response actions.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS:

SNO	*DESCRIPTION*	*RELEVENCE TO PO\PSO*	*PROPOSED ACTIONS*
1	Nil		

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SlNO:	TOPIC	RELEVENCE TO PO\PSO
1	Nil	

WEB SOURCE REFERENCES:

1	https://nptel.ac.in/courses/105/104/105104183/
2	https://nptel.ac.in/courses/124/107/124107010/

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☑ STUD. ASSIGNMENT	☑ WEB RESOURCES	☑ LCD/SMART BOARDS
☑ STUD. SEMINARS	☐ ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

☑ ASSIGNMENTS	☑ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (ONCE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

10 COURSE PLAN

DAY	*MODULE*	*TOPIC PLANNED*
1	1	Introduction about various Systems of earth, Lithosphere-composition, rocks, Soils; Atmosphere-layers, ozone layer, greenhouse effect, weather
2	1	Cyclones, atmospheric circulations, Indian Monsoon; hydrosphere-Oceans, inland water bodies; biosphere
3	1	Definition and meaning of key terms in Disaster Risk Reduction and

		Management- disaster, hazard,
4	1	Exposure, vulnerability, risk, risk assessment, risk mapping, capacity, resilience, disaster risk reduction, Disaster risk management, early warning systems
5	1	Disaster preparedness, disaster prevention, disaster, Mitigation, disaster response, damage assessment, crisis counselling, needs assessment.
6	2	Various Hazard types, Hazard mapping; Different types of Vulnerability types and their assessment
7	2	Vulnerability assessment and types, Physical and social vulnerability
8	2	Economic and environmental vulnerability, Core elements of disaster risk assessment
9	2	Components of a comprehensive disaster preparedness strategy approaches, procedures
10	2	Different disaster response actions
11	3	Introduction to Disaster risk management, Core elements of Disaster Risk Management
12	3	Phases of Disaster Risk Management, Measures for Disaster Risk Reduction
13	3	Measures for Disaster prevention, mitigation, and preparedness.
14	3	Disaster response- objectives, requirements. Disaster response planning; types of responses.
15	3	Introduction- Disaster Relief, Relief; international relief organizations.
16	4	Participatory stakeholder engagement
17	4	Importance of disaster communication.
18	4	Disaster communication- methods, barriers. Crisis counselling
19	4	Introduction to Capacity Building. Concept – Structural Measures, Non-structural Measures.
20	4	Introduction to Capacity Assessment, Capacity Assessment; Strengthening, Capacity for Reducing Risk
21	5	Introduction-Common disaster types in India.
22	5	Common disaster legislations in India on disaster management
23	5	National disaster management policy, Institutional arrangements for disaster management in India.
24	5	The Sendai Framework for Disaster Risk Reduction and targets
25	5	The Sendai Framework for Disaster Risk Reduction-priorities for action, guiding principles

9.3 MODULE WISE SAMPLE QUESTIONS

MODULE I

1. Explain disaster risk management.
2. Explain and classify hazards with suitable examples.
3. Explain the subsystems of Earth.
4. Explain; (i) Risk (ii) Vulnerability (iii) Exposure (iii) Resilience
5. Illustrate the evidences of climate change with examples
6. Elucidate the impacts of climate change.
7. Write a short note on **Greenhouse effect.** List the greenhouse gases and mention their sources.
8. Discuss the causes of climate change.
9. Explain **Global Warming**. Enumerate the causes and suggest some methods to reduce it.
10. Discuss vulnerability in the context of Kerala floods. Also explain how we can reduce the vulnerability associated with flood hazards by disaster risk management.

MODULE II

1. What is hazard mapping? What are its objectives?
2. What is participatory hazard mapping? How is it conducted? What are its advantages?
3. Explain the applications of hazard maps.
4. Explain the types of vulnerabilities and the approaches to assess them.
5. Differentiate between hazards and disaster with examples.
6. Differentiate between preparedness and mitigation.

7. "While doing vulnerability assessment, it is essential to collect historical data on the magnitude of the hazard and the damage that it caused to specific elements." Substantiate this statement by providing a suitable example.

MODULE III

1. Explain briefly the concept of 'disaster risk'.

2. List the strategies for disaster risk management 'before', 'during' and 'after' a disaster.

3. What is disaster preparedness? Explain the components of a comprehensive disaster preparedness strategy.

4. What is disaster prevention? Distinguish it from disaster mitigation giving examples.

5. Explain the core elements of disaster risk management.

6. Explain the factors that decide the nature of disaster response.

7. Explain the different disaster response actions.

8. How important is vulnerability and risk assessment for pre-disaster management? As an administrator, what are key areas that you would focus on in a Disaster Management System?

9. Explain the standard operating procedures during normal times, alert/warning, during disaster and rehabilitation.

MODULE IV

1. What are the steps to effective disaster communication? What are the barriers to communication?
2. Explain capacity building in the context of disaster management.
3. Briefly explain the levels of stakeholder participation in the context of disaster risk reduction.
4. Explain the importance of communication in disaster management.
5. Explain the benefits and costs of stakeholder participation in disaster management.
6. How are stakeholders in disaster management identified?
7. Discuss the measures for disaster risk reduction. Elucidate the process of strengthening the capacity in terms of reducing risk.
8. Explain different levels of stakeholders.

MODULE V

1. Explain the salient features of the National Policy on Disaster Management in India.
2. Explain the guiding principles and priorities of action according to the Sendai Framework for Disaster Risk Reduction.
3. What are Tsunamis? How are they caused?
4. Explain the earthquake zonation of India.
5. Explain three objectives of national policy on disaster management.
6. Explain common disaster types in India.

Prepared by
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Approved by
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10. MEL331 MACHINE TOOLS LAB II

10.1 COURSE INFORMATION SHEET

PROGRAMME: ME	***DEGREE:*** BTECH
PROGRAMME: MECHANICAL ENGINEERING	DEGREE: **B.TECH** UNIVERSITY**: A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
COURSE: MACHINE TOOLS LAB II	SEMESTER**: V** CREDITS: **2**
COURSE CODE: MEL 331 ***REGULATION: 2019***	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: PRODUCTION & INDUSTRIAL ENGINEERING	CONTACT HOURS: **3 Lab Hours/Week**

SYLLABUS:

UNIT	DETAILS	HOURS
	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. Experiments :- 1. Programming and experiment on CNC machines 2. Study and preparation of programme, simulation and exercise on CNC milling machine 3. Experiment on Grinding machine 4. Basics for mechanical measurements 5. Experiments on Repeatability and Reproducibility 6. Angle measurements 7. Linear measurements 8. Straightness error measurement 9. Out of roundness measurement 10. Screw thread measurement 11. Bore measurement 12. Gear metrology 13. Use of Tool maker's microscope 14. Surface roughness measurement	3 Lab Hours/Week

	15. Squareness measurement 16. Flatness measurement 17. Vibration measurement 18. Use of Pneumatic comparator 19. Rotation measurement 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. 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.	

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHORS/PUBLICATION*
R1	Yoram Koren, Numerical Control of Machine Tools, McGraw-Hill.
R2	Shotbolt C.R. and Gayler J.F.W, Metrology for Engineers, 5th edition, ELBS, London.
R3	Sharp K.W.B. and Hume, Practical Engineering Metrology, Sir Isaac Pitman and sons Ltd, MECHANICAL ENGINEERING, London.
R4	Collett, C.V. and Hope, A.D, Engineering Measurements, Second edition, ELBS/Longman

COURSE OBJECTIVES:

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:

Sl. No.	*DESCRIPTION*	*Blooms' Taxomomy Level*
CMEL331.1	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.	Apply, Analyze 3 & 4
CMEL331.2	Determine limits and fits and allocate tolerances for machine components.	Apply, Analyze, Evaluate 3, 4 & 5
CMEL331.3	CNC programming and to use coordinate measuring machine to record measurements of complex profiles with high sensitivity.	Apply, Analyze 3 & 4
CMEL331.4	Use effective methods of measuring straightness, Squareness, flatness, roundness, profile, screw threads and gear teeth.	Apply 5
CMEL331.5	Securing knowledge of manufacturing components within the tolerance limit and surface roughness according to given drawings using various machine tools.	Understand 2

CO-PO AND CO-PSO MAPPING

	PO 1	***PO 2***	***PO 3***	***PO 4***	***PO 5***	***PO 6***	***PO 7***	***PO 8***	***PO 9***	***PO 10***	***PO 11***	***PO 12***	*PSO 1*	*PSO 2*	*PSO 3*
CMEL331.1	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**	**-**
CMEL331.2	**-**	**-**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**-**
CMEL331.3	**-**	**-**	**-**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**-**
CMEL331.4	**-**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**-**
CMEL331.5	**-**	**-**	**-**	**-**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

2- Low correlation (Low), 2- Medium correlation(Medium), 3- High correlation(High)

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	*LOW/ MEDIUM/ HIGH*	*JUSTIFICATION*
CMEL331.1-PO1	H	Knowledge about the importance of precision and accuracy of instruments will enable students to carry out calibration set up as a part of experiment.
CMEL331.2-PO3	H	Apply the principles of limits fits and tolerances to designing various system components.
CMEL331.3-PO4	H	Students will be able to analyse, interpret and synthesis the data that they obtained from the experiment and will make conclusions from the results.
CMEL331.4-PO2	H	Parameters of engineering components like gear, tools, thread, etc. can be found out by using the knowledge that the students gained from the lab equipment during lab sessions.
CMEL331.5-PO5	H	Students will gain practical knowledge in CNC machine after acquiring knowledge about NC part programming.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/ MEDIUM/ HIGH*	*JUSTIFICATION*
CMEL331.1-PSO1	M	Understanding of mechanism and principle of measuring devices will help the students to carry out measurements accurately.
CMEL331.2-PSO2	H	Understanding the principles of Limits, fits and tolerances and applying them in the process of design and manufacturing of mechanical components.
CMEL331.3-PSO2	H	After gaining knowledge in CNC part programming, students can work on CNC machines which is one of the modern technology used in most of the industries for machining operations.
CMEL331.4-PSO2	H	Ability to use modern equipments available for measuring surface roughness, tool angles, gear parameters using roughness tester, tool makers microscope, profile projector.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS:

SNO	DESCRIPTION	RELEVENCE TO PO\PSO	PROPOSED ACTIONS
1	Nil		

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

WEB SOURCE REFERENCES:

1	http://www.mfg.mtu.edu/cyberman/quality/sfinish/terminology.html
2	https://www.youtube.com/watch?v=D3J41HE_RMA
3	nptel.ac.in/courses/112106068/31
4	http://reotemp.com/thermocoupleinfo/thermocouple-vs-RTD.htm
5	www.ignou.ac.in/upload/Unit-7-62
6	https://www.isa.org/standards-and-publications/isa-publications/intech magazine/automation-basics/thermocouples-versus-rtds/
7	http://www.differencebetween.net/science/difference-between-rtd-and thermocouple/
8	http://nptel.ac.in/courses/105106114/pdfs/Unit4/4_1g%20a.pdf

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☐ STUD. ASSIGNMENT	☑WEB RESOURCES	☐LCD/SMART BOARDS
☐ STUD. SEMINARS	☐ ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

☐ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☑STUD. LAB PRACTICES	☑STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐CERTIFICATIONS

☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑STUDENT FEEDBACK ON FACULTY (ONCE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

10.2 COURSE PLAN

DAY	*EXPERIMENTS PLANNED*
1	Introduction to MT Lab
2	Cycle-1 six experiments: Groups 1-6 in the order 1-2-3-4-5-6.
3	Cycle-1 six experiments: Groups 1-6 in the order 6-1-2-3-4-5.
4	Cycle-1 six experiments: Groups 1-6 in the order 5-6-1-2-3-4.
5	Cycle-1 six experiments: Groups 1-6 in the order 4-5-6-1-2-3.
6	Cycle-1 six experiments: Groups 1-6 in the order 3-4-5-6-1-2.
7	Cycle-1 six experiments: Groups 1-6 in the order 2-3-4-5-6-1.
8	Cycle-2 six experiments: Groups 1-6 in the order 7-8-9-10-11-12.
9	Cycle-2 six experiments: Groups 1-6 in the order 8-9-10-11-12-7
10	Cycle-2 six experiments: Groups 1-6 in the order 9-10-11-12-7-8
11	Cycle-2 six experiments: Groups 1-6 in the order 10-11-12-7-8-9
12	Cycle-2 six experiments: Groups 1-6 in the order 11-12-7-8-9-10 Cycle-2 six experiments: Groups 1-6 in the order 12-7-8-9-10-11

Cycle 1

Experiment 1 - Angular Measurements Using Bevel Protractor

Experiment 2 - Measurement of Thread Parameters

Experiment 3 - Grinding Practice on Surface Grinding Machine

Experiment 4 - Measurement of Surface Roughness

Experiment 5 - Measurement of Linear Specimen Dimensions

Experiment 6 - Machining Using CNC Lathe

Cycle 2

Experiment 7 - Measurement of Bore Diameter Using Four Ball Method

Experiment 8 - Measurement of Gear Parameters

Experiment 9 - Measurement of Single Point Cutting Tool Angles

Experiment 10 - Angular Measurements Using Sine Bar

Experiment 11 - Measurement of Roundness of The Given Cylindrical Specimen

Experiment 12 - Machining Using CNC Milling Machine

10.3 SAMPLE QUESTIONS

1. Measure the acute and obtuse angles of the given specimen using Bevel Protractor.
2. Find the major diameter, minor diameter, pitch and thread angle of the given thread using Tool maker's microscope.
3. Machine the given work piece according to the dimension specified in the drawing using Surface Grinding Machine.
4. Determine the surface roughness parameters of the given specimen using surface roughness tester.
5. Measure the various linear dimensions of the given sample specimens using vernier caliper and micrometer.
6. Machine the given workpiece to the given shape and dimensions using a CNC Lathe.
7. Measure the bore diameter of the given specimen using four-ball method
8. Measure the chordal gear tooth thickness and face width of the given specimen gear.
9. Measure the various angles of the given single point cutting tool using Tool maker's microscope.
10. Measure the various angles of the given sample specimen using sine bar setup.
11. Measure the roundness and roundness errors of the given cylindrical specimen.
12. Machine the given workpiece to the given shape and dimensions using a CNC milling machine.

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11. MEL333 THERMAL ENGINEERING LAB I

11.1 COURSE INFORMATION SHEET

PROGRAMME: ME	**DEGREE:** BTECH
COURSE: THERMAL ENGINEERING LAB I	**SEMESTER: 5** **CREDITS:** 2
COURSE CODE: MEL 333 **REGULATION:** 2019	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: FLUID & THERMAL SCIENCE	**CONTACT HOURS:** 3 (Practical) hours/Week

SYLLABUS:

UNIT	DETAILS	Lab cycle
EXPERIMENTS	1. Performance test on petrol engines	Cycle 1
	2. Performance test on Diesel engines	
	3. Retardation test on IC engines	
	4. Heat Balance test on Diesel engines	
	5. Determination of flash and fire points of petroleum fuels and oils	
	6. Determination of calorific value of liquid fuels- Bomb Calorimeter	
	7. Cooling curve of IC engines	Cycle 2
	8. Valve timing diagram of IC engines	
	9. Morse test on petrol engine	
	10. Performance test on reciprocating compressor	
	11. Economic speed test on IC engines	
	12. Determination of viscosity of lubricating oils	

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
R1	J. B. Heywood, I.C engine fundamentals, McGraw-Hill, 2017
R2	V. Ganesan, Fundamentals of IC engines, Tata McGraw-Hill, 2017
R3	Stephen R Turns, An Introduction to Combustion: Concepts and Applications, McGraw-Hill, 2017

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
MET 303	Thermal Engineering	This course gives an introduction to the fundamentals of I C engine performance and testing.	5

COURSE OUTCOMES:

SNO	DESCRIPTION	Bloom's Taxonomy Level
MEL333.1	Measure thermo-physical properties of solid, liquid and gaseous fuels.	Analyse (level 4)
MEL333.2	Identify various systems and subsystems of Diesel and petrol engines	Understand (level 2)
MEL333.3	Analyse the performance characteristics of internal combustion engines	Apply (level 3)
MEL333.4	Interpret the performance characteristics of air compressors	Evaluate (level 5)

CO-PO AND CO-PSO MAPPING

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
MEL333.1	3		2	3			2		3	2		2	1		
MEL333.2	3		2	3			2		3	2		2	1		
MEL333.3	3		2	3			2		3	2		2	1		
MEL333.4	3		2	3			2		3	2		2	1		

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
MEL333.1-PO 1	H	Students can apply the mathematical skills and engineering knowledge in calculation of calorific value, viscosity, flash and fire point of fuels and oils used in IC engines
MEL333.1-PO 3	M	Students will be able to understand the design and fabrication of different test equipment used for conducting the experiments and develop their own with regards to public safety
MEL333.1-PO 4	H	Students can analyse and infer the results obtained for calorific value, viscosity, flash and fire point of fuels and oils used in IC engines by comparing with the theoretical values.
MEL333.1-PO 7	M	Students will understand the importance of the test methods used with regards to environment and sustainability.

MEL333.1-PO 9	H	Students will learn how to work in a team and as an individual to take out the readings and do the calculations.
MEL333.1-PO 10	M	Students will learn to effectively furnish the observations, results and inferences in the form of lab record.
MEL333.1-PO 12	M	Since students acquire knowledge about different basic measuring devices and techniques to determine thermos physical properties, he/she can explore different devices used in the industry.
MEL333.2-PO 1	H	Students can apply their knowledge for the identification various systems and sub systems used in IC engines.
MEL333.2-PO 3	M	Students will be able to understand various systems and sub systems used in IC engines and develop their own with regards to public safety
MEL333.2-PO 4	H	Students can analyses and infer the subsystems used in working of IC engines
MEL333.2-PO 7	M	Students will understand the importance of the systems used with regards to environment and sustainability.
MEL333.2-PO 9	H	Students will learn how to work in a team and as an individual in gaining knowledge on systems and subsystems.
MEL233.2-PO 10	M	Students will learn to effectively furnish the observations and understandings during viva session and while reporting the functioning of systems.
MEL333.2-PO 12	M	Ability to interpret systems and subsystems act as a foundation for higher studies.
MEL202.3 - PO 1	H	Students can apply the mathematical skills and engineering knowledge in performance characteristics of IC engines
MEL202.3 - PO 3	M	Students will be able to understand the design and fabrication of different test equipment used for conducting the experiments and develop their own with regards to public safety
MEL202.3 - PO 4	H	Students can analyses and infer the results obtained for performance characteristics of IC engines by comparing with the theoretical values.
MEL202.3 - PO 7	M	Students will understand the importance of the test methods used with regards to environment and sustainability.
MEL202.3 - PO 9	H	Students will learn how to work in a team and as an individual to take out the readings and do the calculations.
MEL202.3 -PO 10	M	Students will learn to effectively furnish the observations,

		results and inferences in the form of lab record.
MEL202.3-PO 12	M	Since students acquire knowledge about different basic measuring devices and techniques to determine performance characteristics of IC engines, he/she can explore different devices used in the industry.
MEL202.4 - PO 1	H	Students can apply the mathematical skills and engineering knowledge in performance characteristics of air compressors
MEL202.4 - PO 2	M	Students will be able to understand the design and fabrication of different test equipment used for conducting the experiments and develop their own with regards to public safety
MEL202.4 – PO 4	H	Students can analyse and infer the results obtained performance characteristics of air compressors by comparing with the theoretical values.
MEL202.4 - PO 7	M	Students will understand the importance of the test methods used with regards to environment and sustainability.
MEL202.4 - PO 9	H	Students will learn how to work in a team and as an individual to take out the readings and do the calculations.
MEL202.4 -PO 10	M	Students will learn to effectively furnish the observations, results and inferences in the form of lab record.
MEL202.4-PO 12	M	Since students acquire knowledge about different basic measuring devices and techniques to determine performance characteristics of air compressors, he/she can explore different devices used in the industry.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
MEL202.1-PSO1	M	Students can apply their knowledge in thermal science to solve engineering problems in the domain of thermos physical properties of fuel/oil.
MEL202.2- PSO1	M	Students can apply their knowledge in mathematics & thermal science for the interpreting the working of various systems and sub Systems.
MEL202.3-PSO1	M	Students can apply their knowledge in mathematics & thermal science for the interpretation of performance curves.
MEL202.4-PSO1	M	Students can apply their knowledge in fluid sciences to

		understand the performances of compressors.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS: Nil

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: Nil

WEB SOURCE REFERENCES:

1	https://nptel.ac.in/courses/112/103/112103262/

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☐ STUD. ASSIGNMENT	☑ WEB RESOURCES	☑ VIDEO RECORDINGS
☑LCD/SMART BOARDS	☐ STUD. SEMINARS	☐ ADD-ON COURSES	

ASSESSMENT METHODOLOGIES-DIRECT

☐ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑UNIV. EXAMINATION
☑ STUD. LAB PRACTICES	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (ONCE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

11.3 COURSE PLAN

DAY	*CYCLE*	*NAME OF EXPERIMENT*
1	I	Performance test on petrol engines
2		Performance test on Diesel engines

3		Retardation test on IC engines
4		Heat Balance test on Diesel engines
5		Determination of flash and fire points of petroleum fuels and oils
6		Determination of calorific value of liquid fuels- Bomb Calorimeter
7	II	Cooling curve of IC engines
8		Valve timing diagram of IC engines
9		Morse test on petrol engine
10		Performance test on reciprocating compressor
11		Economic speed test on IC engines
12		Determination of viscosity of lubricating oils

11.3 SAMPLE QUESTIONS

Lab Questions

1. Conduct a load test on the single cylinder 4 stroke petrol engine and plot the following graphs.
    a. Total fuel consumption Vs Brake Power
    b. Specific fuel consumption Vs Brake Power
    c. Brake mean effective pressure Vs Brake Power
    d. Brake thermal efficiency Vs Brake Power
2. Find out the frictional power and mechanical efficiency of the single cylinder four stroke diesel engine by retardation test.
3. Conduct a load test on the twin cylinder diesel engine and plot the following graphs.
    a. Total fuel consumption Vs Brake Power
    b. Specific fuel consumption Vs Brake Power
    c. Brake mean effective pressure Vs Brake Power
    d. Brake thermal efficiency Vs Brake Power
    e. Mechanical efficiency Vs Brake Power
4. Determine the kinematic viscosity of the given oil at any 3 different temperatures. Discuss the effect of temperature on kinematic viscosity of the oil.
5. Determine the calorific value of the given liquid fuel using the bomb calorimeter.
6. Determine the best cooling water temperature for the HM engine running at the rated speed and at half load.
7. Prepare the heat balance chart of the 4-cylinder 4 stroke diesel engine.

8. Conduct a performance test on the single cylinder diesel engine and plot the following graphs.
    a. Total fuel consumption Vs Brake Power
    b. Specific fuel consumption Vs Brake Power
    c. Brake mean effective pressure Vs Brake Power
    d. Indicated mean effective pressure Vs Brake Power
    e. Indicated thermal efficiency. Vs Brake Power
9. Find the Flash and Fire points of the given oil using Cleave Land Open Cup Apparatus.
10. Conduct a load test on the four-cylinder 4 stroke petrol engine and plot the following graphs.
    a. Total Fuel Consumption (TFC) Vs. Brake Power (BP)
    b. Specific Fuel Consumption (SFC) Vs. Brake Power (BP)
    c. Brake mean effective pressure (BMEP) Vs. Brake Power (BP)
    d. Brake Thermal Efficiency ($\eta_{B.thermal}$) Vs. Brake Power (BP)
11. Conduct Morse test on given multi cylinder petrol engine to determine the indicated power developed in each of the cylinder in the engine and to determine the mechanical efficiency.

Viva Questions

1. Why have eight cylinders in an engine instead of a big single cylinder of the same displacement?
2. Why different types of sound are produced in different bikes though they say run on SI engine?
3. What may be the reason behind badly damaged piston shown in the picture? Give the explanation if it is a CI engine piston.

4. What is Dissociation? Discuss its effects.
5. Explain stages of combustion in CI engines.
6. Derive the efficiency of fundamental cycle for the engines were ignition of the fuel which is injected into the combustion chamber is caused by the elevated temperature of the air in the cylinder due to mechanical compression (adiabatic compression).
7. Explain ignition limit, ignition delay and pre-ignition.
8. Explain the effect of compression ratio on Knocking.
9. What is an Internal Combustion Engine?
10. List some advantages of internal combustion engines?

11. What are limitations of internal combustion engines
12. What is Compression ratio of I.C. engine?
13. What is carburettor in I.C. engine?
14. What are Engine Pistons?
15. List types of internal combustion engine?
16. Please explain Combustion thermodynamics?
17. What is Combustion modelling?
18. What is valve timing diagram?
19. Explain Spark ignition engines?
20. What is Crankshaft?
21. Explain the function of Fly wheel?
22. What is scavenging?
23. What is indicator diagram?
24. What is flame front?
25. What is ignition lag in SI Engine?
26. What is 2-stroke IC Engine?
27. Name the fuel used by IC Engines?
28. What is the 6 stroke engine?

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