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.

INDEX			PAGE NO:
1	SEMESTER PLAN		8
2	ASSIGNMENT SCHEDULE		9
3	SCHEME		10
4	MET302 HEAT AND MASS TRANSFER		12
	4.1	COURSE INFORMATION SHEET	12
	4.2	COURSE PLAN	19
	4.3	SAMPLE QUESTIONS	20
5	MET304 DYNAMICS AND DESIGN OF MACHINERY		24
	5.1	COURSE INFORMATION SHEET	24
	5.2	COURSE PLAN	29
	5.3	SAMPLE QUESTIONS	30
6	MET306 ADVANCED MANUFACTURING ENGINEERING		38
	6.1	COURSE INFORMATION SHEET	38
	6.2	COURSE PLAN	44
	6.3	SAMPLE QUESTIONS	46
7	MET308 COMPREHENSIVE COURSE WORK		48
	7.1	COURSE INFORMATION SHEET	48
	7.2	COURSE PLAN	54
	7.3	SAMPLE QUESTIONS	60
8	MET312 NON - DESTRUCTIVE TESTING		62
	8.1	COURSE INFORMATION SHEET	62
	8.2	COURSE PLAN	68
	8.3	SAMPLE QUESTIONS	72
9	MET352 AUTOMOBILE ENGINEERING		75
	9.1	COURSE INFORMATION SHEET	75
	9.2	COURSE PLAN	80
	9.3	SAMPLE QUESTIONS	82
10	MET362 PRODUCT DEVELOPMENT AND DESIGN		88
	10.1	COURSE INFORMATION SHEET	88
	10.2	COURSE PLAN	94
	10.3	SAMPLE QUESTIONS	95
11	HUT310 MANAGEMENT FOR ENGINEERS		97
	11.1	COURSE INFORMATION SHEET	97
	11.2	COURSE PLAN	102
	11.3	SAMPLE QUESTIONS	104
12	MEL332 COMPUTER AIDED DESIGN AND ANALYSIS LAB		109
	12.1	COURSE INFORMATION SHEET	109
	12.2	COURSE PLAN	114

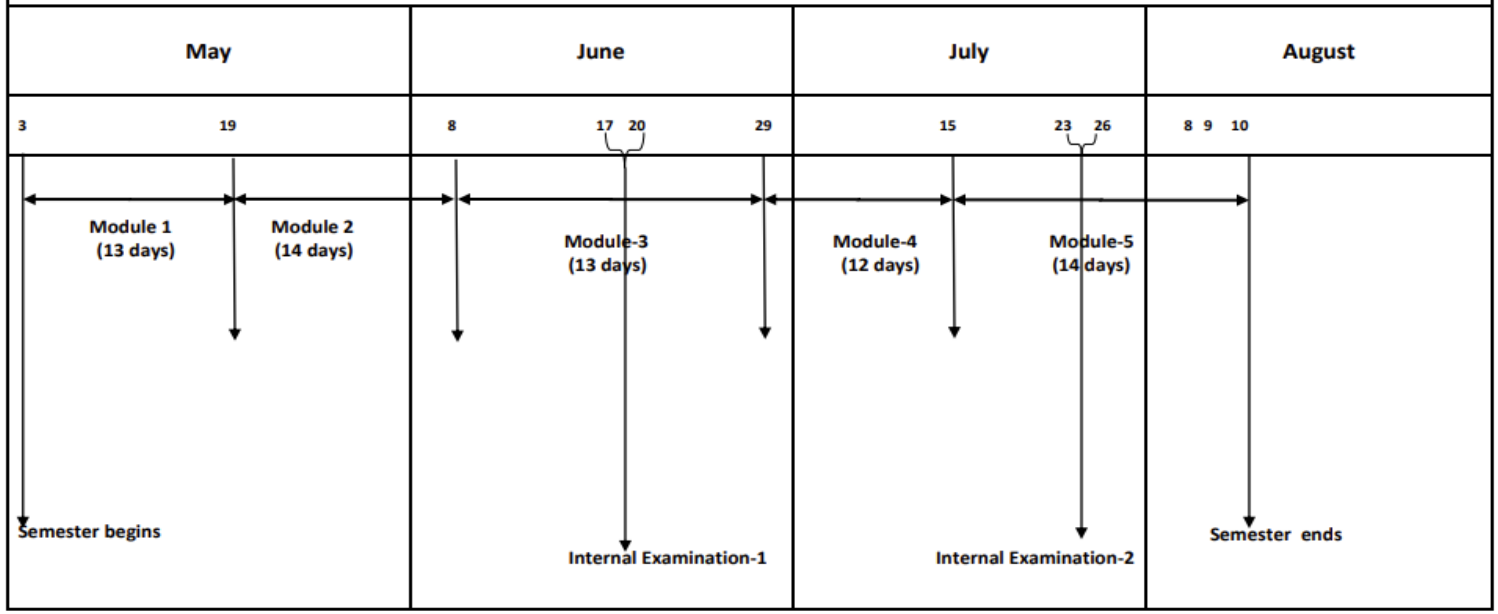
	12.3	SAMPLE QUESTIONS	**117**
13	**MEL334 THERMAL ENGINEERING LAB-II**		**118**
	13.1	COURSE INFORMATION SHEET	**118**
	13.2	COURSE PLAN	**123**
	13.3	SAMPLE QUESTIONS	**124**

SEMESTER PLAN

RSET
RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)

SEMESTER PLAN (S2/S4)

MAY 2022 – AUGUST 2022



May: 21 June: 23 July: 21 August: 7

Total no of working days: 72

Total no of instructional days: 66

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

SEMESTER VI

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET302	HEAT & MASS TRANSFER	3-1-0	4	4
B	MET304	DYNAMICS AND DESIGN OF MACHINERY	3-1-0	4	4
C	MET306	ADVANCED MANUFACTURING ENGINEERING	3-1-0	4	4
D	METXXX	PROGRAM ELECTIVE I	2-1-0	3	3
E ½	HUT300	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	3-0-0	3	3
	HUT310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	MET308	COMPREHENSIVE COURSE WORK	1-0-0	1	1
S	MEL332	COMPUTER AIDED DESIGN & ANALYSIS LAB	0-0-3	3	2
T	MEL334	THERMAL ENGINEERING LAB-II	0-0-3	3	2
R/M/H	VAC	REMEDIAL/MINOR/HONOURS COURSE	3-1-0	4*	4
TOTAL				**25/29**	**23/27**

4. MET302 HEAT AND MASS TRANSFER

4.1 COURSE INFORMATION SHEET

PROGRAMME: ME	***DEGREE:*** BTECH
COURSE: HEAT AND MASS TRANSFER	**SEMESTER: 6** **CREDITS:** 4
COURSE CODE: MET302 **REGULATION:** 2019	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: THERMAL & FLUID SCIENCE	**CONTACT HOURS:** 3+1 (Tutorial) Hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY): ME431	**LAB COURSE NAME: MECHANICAL ENGINEERING LAB**

SYLLABUS:

UNIT	*DETAILS*	*HOURS*
I	CONDUCTION HEAT TRANSFER Introduction to heat transfer - thermodynamics and heat transfer - typical heat transfer situations- modes of heat transfer - mechanism of heat transfer - basic laws of heat transfer - thermal conductivity - effect of temperature on thermal conductivity - combined heat transfer mechanism - real-life situations of combined heat transfer. Differential equations of heat conduction - boundary conditions and initial conditions, one-dimensional steady-state situations - plane wall, cylinder, sphere - the concept of thermal resistance, critical radius, conduction with heat generation - two-dimensional steady-state situations, transient conduction, lumped capacitance model, the concept of Heisler chart and Schmidt plot - conduction shape factor - numerical methods of analysis- thermal analysis of rectangular fins.	12
II	CONVECTION HEAT TRANSFER Fundamentals, order of magnitude analysis of momentum and energy equations; hydrodynamic and thermal boundary layers - relation between fluid friction and heat transfer - concepts of fluid mechanics, differential equation of heat convection, laminar flow heat transfer in a circular pipe - constant heat flux and constant wall temperature, thermal entrance region, turbulent flow heat transfer in a circular pipe, pipes of other cross-sections, heat transfer in laminar flow and turbulent flow over a flat plate, Reynolds analogy, flow across a cylinder and sphere - natural convection- basics, free convection heat transfer on a vertical flat plate - empirical relations for free convection heat transfer.	10
III	HEAT EXCHANGERS Condensation heat transfer phenomena - the condensation number - boiling heat transfer phenomena - simplified relations for boiling heat transfer - introduction to heat exchangers - types of heat exchangers - the overall heat	7

	transfer coefficient - fouling factor - LMTD analysis of heat exchangers, effectiveness-NTU method - analysis of variable properties - compact heat exchangers - heat exchanger design considerations.	
IV	RADIATION HEAT TRANSFER The physical mechanism of radiation heat transfer - radiation properties; black body radiation, Planck's law, Wien's displacement law, Stefan Boltzmann law, Kirchhoff's law; gray body radiation shape factors - heat exchange between non-black bodies - infinite parallel plates - radiation combined with conduction and convection.	7
V	MASS TRANSFER Introduction to mass transfer - molecular diffusion in fluids - steady-state molecular diffusion in fluids under stagnant and laminar flow conditions - Fick's law of diffusion -types of solid diffusion - mass transfer coefficients in laminar and turbulent flows - introduction to mass transfer coefficient - equimolar counter-diffusion - correlation for convective mass transfer coefficient - correlation of mass transfer coefficients for single cylinder - theories of mass transfer - overall mass transfer coefficients.	9
	TOTAL HOURS	**45**

TEXT/REFERENCE BOOKS:

T/R	***BOOK TITLE/AUTHORS/PUBLICATION***
T	**Sachdeva R C**, Fundamentals of Engineering Heat and Mass Transfer, New Age Science Limited, 2009
T	**R.K.Rajput**, Heat and mass transfer, S.Chand& Co.,2015
T	**Kothandaraman C.P.**, Fundamentals of Heat and Mass Transfer, New Age International, New Delhi, 2006
T	**P. K. Nag,** Heat and Transfer, McGraw-Hill, 2011
R	**Frank P. Incropera and David P. Dewitt,** Fundamentals of Heat and Mass Transfer, John Wiley & Sons, 2011
R	**J. P. Holman, Heat Transfer,** McGraw Hill, 2011
R	**M. NecatiOzisick,** Heat Transfer A Basic Approach, McGraw Hill Book Company
R	**Yunus A. Cengel,** Heat Transfer - A Practical Approach, McGraw-Hill Education.
R	**S. P. Sukhatme,** A Text Book on Heat Transfer, Universities Press, Hyderabad.
Data Book: ***Heat and Mass Transfer data book: C.P. Kothandaraman, S. Subramanya, New age International publishers, 2014***	

COURSE PRE-REQUISITES:

C.CODE	*COURSE NAME*	*DESCRIPTION*	*SEM*
C.CODE	**COURSE NAME**	**DESCRIPTION**	**SEM**
MET203	Mechanics of Fluids	Knowledge about the basics of boundary layer theory and Dimensional Analysis.	3
MET202	Engineering Thermodynamics	Knowledge about basic concepts of Thermodynamics.	3

COURSE OBJECTIVES:

1	To introduce the various modes of heat transfer and to develop methodologies for solving a wide variety of practical heat transfer problems.
2	To provide useful information concerning the performance and design of simple heat transfer systems.
3	Conceive the energy balance in any thermal practical situation involving heat transfer mechanisms.
4	To introduce mass transfer.

COURSE OUTCOMES:

SL. NO.	*DESCRIPTION*	*Bloom's Taxonomy Level*
CMET302.1	Solve problems involving steady state heat conduction with and without heat generation in simple geometries.	Apply (level 3)
CMET302.2	Evaluate heat transfer coefficients for Natural convection and Forced convection situations using empirical relations.	Analyze (level 4)
CMET302.3	Design Heat Exchangers and Fins and evaluate its performance.	Evaluate (level 5)
CMET302.4	Solve problems involving transient heat conduction and Understand the basics of Boiling and Condensation	Apply (level 3)
CMET302.5	Estimate radiation heat transfer between black body and gray body surfaces.	Analyze (level 4)
CMET302.6	Solve problems involving mass transfer due to diffusion, chemical reaction and convection.	Apply (level 3)

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
CMET 302.1	2	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CMET 302.2	-	2	2	3	-	2	2	-	-	-	-	-	2	-	-
CMET 302.3	2	1	1	-	-	2	2	-	-	-	-	-	2	-	-
CMET 302.4	2	2	-	2	-	-	-	-	-	-	-	-	2	-	-
CMET 302.5	2	2	2	-	-	-	2	-	-	-	-	-	2	-	-
CMET 302.6	-	-	-	3	-	3	3	-	-	-	-	-	2	-	-

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM / HIGH	JUSTIFICATION
CMET302.1-PO1	M	Students will be able to appreciate and to a considerable extent *solve complex engineering problems* related to steady state heat conduction with and without heat generation in simple geometries, based on acquired **knowledge**.
CMET302.1-PO2	M	**Problem analysis** based on *first principles of mathematics and engineering sciences* is essential to analyze complex engineering problems related to steady state heat conduction with and without heat generation.
CMET302.2-PO2	M	**Problem analysis** based on *first principles of mathematics and research based relevant data* is essential to evaluate heat transfer coefficients for Natural convection and Forced convection situations.
CMET302.2-PO3	M	In the **design/development of solutions** *for complex heat convection problems and to design heat transfer equipment* that consider the *public health andsafety*, the knowledge about various dimensionless numbers is a definite prerequisite.
CMET302.2-PO4	H	In the evaluation of heat transfer coefficients for Natural convection and Forced convection situations, students use HMT data book (eg. Kothandaraman) which has various established **empirical relations** based on experiments.

CMET302.2-PO6	M	Gained knowledge of various convection problems will help the students to develop heat transfer equipment which is beneficial for the society.
CMET302.2-PO7	M	Students can develop products in a sustainable manner by understanding the impact of the convection heat transfer solutions in societal and environmental contexts.
CMET302.3-PO1	M	Students will be able to *solve complex engineering problems* related to heat exchangers and fins, based on acquired **knowledge**.
CMET302.3-PO2	L	**Problem analysis** based on *first principles of mathematics and research based relevant data* is essential to design various heat exchangers and fins.
CMET302.3-PO3	L	In the **design/development of solutions** *for complex heat exchanger problems and to design proper fins* that consider the *public safety*, the knowledge about various types of heat exchangers and fins is essential.
CMET302.3-PO6	M	Gained knowledge of various heat exchangers and fins will help the students to develop heat transfer equipment which is **beneficial for the society**.
CMET302.3-PO7	M	Students can develop heat exchangers in a sustainable manner by considering environmental/**societal impact.**
CMET302.4-PO1	M	**Analytical knowledge** on the transient heat conduction, condensation and boiling helps the students to solve various real life heat transfer problems.
CMET302.4-PO2	M	**Problem analysis** based on *first principles of mathematics and research based relevant data* is essential to analyze complex engineering problems related to transient heat conduction, condensation and boiling.
CMET302.4-PO4	M	To solve problems involving transient heat conduction and to understand the basics of Boiling and Condensation, various non-dimensional numbers (eg. Biot number, Fourier number) based on **experimental data has to be used.**
CMET302.5-PO1	M	Students will be able to *solve complex engineering problems* related to radiation heat transfer, based on acquired **knowledge**.
CMET302.5-PO2	M	**Problem analysis** based on *first principles of mathematics and research based relevant data* is essential to estimate radiation heat exchange between black and gray body surfaces.
CMET302.5-PO3	M	Knowledge in various laws of radiation heat transfer is essential for the **design/development of equipment** which uses radiation heat exchange.
CMET302.5-PO7	M	Gained knowledge in various laws of radiation heat transfer will help the students to develop products which uses solar energy in a **sustainable** manner.

CMET302.6-PO4	H	Diffusion coefficients concentration factors, dimensionless numbers like Sc, Sh, etc. are required to solve problems involving mass transfer due to diffusion, chemical reaction and convection. These are available in data book **based on experiments.**
CMET302.6-PO6	H	Knowledge about various modes of mass transfer will help the students to develop products which is **beneficial for the society.**
CMET302.6-PO7	H	Knowledge in various modes of mass transfer will help to develop mass transfer equipment by considering **environmental impact.**

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
CMET302.1 -PSO1	M	Students will acquire basic knowledge on various modes of heat transfer and will be able to apply this knowledge to solve conduction heat transfer problems.
CMET302.2 -PSO1	M	Deeper knowledge gained into the significance of dimensional analysis will help to solve complex engineering problems related to convection heat transfer.
CMET302.3 -PSO1	M	The acquired knowledge on various modes of heat transfer will helps the students to design heat exchangers and fins.
CMET302.4 -PSO1	M	Students can apply their knowledge in transient heat conduction to solve engineering problems.
CMET302.5 -PSO1	M	The acquired knowledge on various laws of radiation heat transfer will helps the students to design equipment which uses solar energy.
CMET302.6 -PSO1	M	Students can apply their knowledge in various modes of mass transfer to solve engineering problems.

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

SNO	*DESCRIPTION*	*RELEVENCE TO PO\PSO*	*PROPOSED ACTIONS*
1	No Gaps		

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NIL

WEB SOURCE REFERENCES:

1	http://nptel.ac.in/courses/112101097/7,
2	http://nptel.ac.in/courses/112101097/
3	http://www.nptelvideos.in/2012/12/heat-and-mass-transfer.html
4	https://www.youtube.com/watch?v=tDs4cFOqTdM
5	https://www.youtube.com/watch?v=SNnd0f3xXlg
6	https://www.youtube.com/watch?v=QMg3vr7KgDA
7	https://www.youtube.com/watch?v=2AQ6iQc3_R8

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

4.2 COURSE PLAN

DAY	*MODULE*	*TOPIC PLANNED*
1	I	Introduction to heat transfer - thermodynamics and heat transfer - typical heat transfer situations- modes of heat transfer - mechanism of heat transfer - basic laws of heat transfer
2	I	Thermal conductivity - effect of temperature on thermal conductivity - combined heat transfer mechanism - real-life situations of combined heat transfer
3	I	Differential equations of heat conduction - boundary conditions and initial conditions - one-dimensional steady-state situations - plane wall
4	I	Plane wall (Numericals)
5	I	The concept of thermal resistance (Numericals)
6	I	Conduction with heat generation (Numericals)
7	I	Cylindrical, Sphere (Numericals), critical radius
8	I	Conduction shape factor (Numericals) - numerical methods of analysis
9	I	Transient conduction - lumped capacitance model (Numericals)
10	I	The concept of Heisler chart (Numericals)
11	I	Two-dimensional steady-state situations - Schmidt plot (Numericals)
12	I	Thermal analysis of rectangular fins (Numericals)
13	II	Concepts of fluid mechanics, order of magnitude analysis of momentum and energy equations
14	II	Differential equation of heat convection - Non dimensional numbers
15	II	Hydrodynamic and thermal boundary layers - heat transfer in laminar flow and turbulent flow over a flat plate (Numericals)
16	II	Relation between fluid friction and heat transfer - Reynolds analogy
17	II	Laminar flow heat transfer in a circular pipe - constant heat flux (Numericals), thermal entrance region
18	II	Constant wall temperature (Numericals)
19	II	Turbulent flow heat transfer in a circular pipe, Pipes of other cross-sections (rectangular) (Numericals)
20	II	Flow across a cylinder and sphere (Numericals)
21	II	Natural convection- basics, free convection heat transfer on a vertical flat plate (Numericals)
22	II	Empirical relations for free convection heat transfer (Numericals)
23	III	Condensation heat transfer phenomena - the condensation number
24	III	Boiling heat transfer phenomena - simplified relations for boiling heat transfer

25	III	Introduction to heat exchangers - types of heat exchangers
26	III	The overall heat transfer coefficient - fouling factor (Numericals)
27	III	LMTD analysis of heat exchangers (Numericals)
28	III	Effectiveness-NTU method - analysis of variable types (Numericals)
29	III	Compact heat exchangers - heat exchanger design considerations
30	IV	The physical mechanism of radiation heat transfer, radiation properties, black body radiation
31	IV	Planck's law, Wien's displacement law, Stefan Boltzmann law, Kirchhoff's law
32	IV	Planck's law, Wien's displacement law, Stefan Boltzmann law, Kirchhoff's law (Numericals)
33	IV	Gray body radiation shape factors
34	IV	Gray body radiation shape factors (Numericals)
35	IV	Heat exchange between non-black bodies - infinite parallel plates
36	IV	Heat exchange between non-black bodies - infinite parallel plates (Numericals)
37	V	Introduction to mass transfer - molecular diffusion in fluids - Fick's law of diffusion
38	V	Steady-state molecular diffusion in fluids under stagnant and laminar flow conditions
39	V	Types of solid diffusion. Mass transfer coefficients in laminar and turbulent flows (Numericals)
40	V	Mass transfer coefficients in laminar and turbulent flows (Numericals)
41	V	Introduction to mass transfer coefficient - equimolar counter-diffusion (Numericals)
42	V	Correlation for convective mass transfer coefficient (Numericals)
43	V	Correlation of mass transfer coefficients for single cylinder (Numericals)
44	V	Theories of mass transfer - overall mass transfer coefficients (Numericals)
45	V	Overall mass transfer coefficients (Numericals)

4.3 MODULE WISE SAMPLE QUESTIONS

MODULE 1

1. How does the science of Heat Transfer differ from the science of Thermodynamics?
2. What is heat flux? How is it related to the heat transfer rate?
3. Explain conduction shape factor and what is its significance
4. Starting with an energy balance on a cylindrical shell volume element, derive the steady three-dimensional heat conduction equation for a long cylinder with constant thermal conductivity in which heat is generated at a rate of q_g.

5. Starting with an energy balance on a rectangular volume element, derive the one-dimensional heat conduction equation for a plane wall with constant thermal conductivity and no heat generation.
6. Starting with an energy balance on a spherical shell volume element, derive the one-dimensional heat conduction equation for a sphere with constant thermal conductivity and no heat generation.
7. In a nuclear reactor, heat is generated uniformly in the 5 cm diameter cylindrical uranium rods at a rate of 7×10^7 W/m^3. If the length of the rods is 1 m, determine the rate of heat generation in each rod.
8. Consider a large 3 cm-thick stainless steel plate in which heat is generated uniformly at a rate of 5×10^6 W/m^3. Assuming the plate is losing heat from both sides, determine the heat flux on the surface of the plate during steady operation.
9. Consider a large 5 cm thick brass plate (k =111 W/m.°C) in which heat is generated uniformly at a rate of 2×10^5 W/m^3. One side of the plate is insulated while the other side is exposed to an environment at 25°C with a heat transfer coefficient of 44 W/m^2 °C. Explain where in the plate the highest and the lowest temperatures will occur, and determine their values.
10. A chemical reaction takes place in a cylinder (k= 0.6 W/m K) of inner radius 15mm and outer radius 45mm. The inner surface is at 580OCand it is insulated. Assuming the reaction rate of 0.55 MW/m3 in the reactor volume, find the temperature at the outer surface of the reactor.
11. What is meant by logarithmic mean area and derive an expression for logarithmic mean area for spheres.
12. Obtain an expression for the critical radius of insulation of a cylinder.
13. Define the terms Efficiency and Effectiveness of a fin. Develop a relation between them.
14. Derive an expression for the temperature distribution along an infinitely long fin (rectangular) in dimensionless form under 1D steady state condition.

MODULE 2

1. Define Grashof number. Explain its significance in natural convection heat transfer.
2. Explain Reynold's Analogy. What is its significance?
3. By dimensional analysis, establish the functional relationship between the relevant non-dimensional numbers in the case of forced convection heat transfer.
4. Calculate the heat transfer from a 60W incandescent bulb at 115 0C to ambient air at 25 0C. Assume the bulb as a sphere of 50mm dia. Also find the percentage of power lost by convection.
5. Define Prandtl number. Explain its significance.
6. Discuss the interrelationship between heat and momentum transfer. Write the equation relating fluid friction and heat transfer.
7. Air at 30^0C is flowing across a tube with a velocity of 25 m/s. The tube should be either a cylinder of dia. 5cm or a square with a side of 5cm. Compare the rate of heat transfer in each case if the tube surface temperature is 130^0C.

MODULE 3

1. Explain various regimes of saturated pool boiling.
2. Discuss the condensation process. Explain the different kinds of condensation process.
3. Derive the expressions for velocity distribution and mass flow rate of laminar film condensation on a vertical plate.
4. How does transient heat transfer differ from steady heat transfer?
5. Consider a round potato being baked in an oven. Would you model the heat transfer to the potato as one, two, or three-dimensional? Would the heat transfer be steady or transient?
6. Consider an egg being cooked in boiling water in a pan. Would you model the heat transfer to the egg as one, two, or three-dimensional? Would the heat transfer be steady or transient?
7. Draw the temperature profiles for counter flow and parallel flow heat exchangers when used as a condenser.
8. Derive an expression for the effectiveness of a parallel flow heat exchanger as a function of Number of Transfer Unit and Capacity Ratio.
9. Hot fluid enters on the shell side of a 2 - 4 heat exchanger (2 shell pass & 4 tube pass) at 75^0C and leaves at 39^0C while the cold fluid enters at 15^0C and leaves at 33^0C on the tube side. Calculate the correction factor for this heat exchanger.
10. An oil cooler for a lubricating system must cool 1000 kg/hr. of lubricating oil (C_p = 2.09kJ/K) from 80^0C to 40^0C by using a cooling water flow of 1000 kg/hr. at 30^0C. Give your choice for a parallel flow or counter flow heat exchanger is suitable for this duty with reasons. Calculate the surface area of the heat exchanger.
11. Water enters a Cross flow heat exchanger (both fluids unmixed) at 5^0C and flows at the rate of 4600 kg/hr. to cool 4000 kg/hr. of air that is initially at 40^0C. Calculate the exit temperatures of air and water if the surface area of the heat exchanger is 25 m^2.

MODULE 4

1. Define Irradiation and Radiosity.
2. Explain the principle of working of a Radiation Shield. Give an expression for the total resistance of heat exchange between two infinitely long parallel plates when two shields are placed in between them.
3. Emissivity of two large parallel plates maintained at 800^0C and 300^0C are 0.3 and 0.5 respectively. Find the net radiant heat exchange per unit area for these plates. Find the percentage reduction in heat transfer when a polished aluminum radiation shield of emissivity 0.05 is placed between them.
4. A long steel rod 2cm dia. is to be heated from 425^0C to 550^0C. It is placed concentrically in a long cylindrical furnace which has an inside dia. of 15cm. The inner surface of the furnace is at a temperature of 1000^0C and has an emissivity of

0.85. If the emissivity of the rod is 0.6 find the time required for the heating operation. Take density of steel, $\rho = 7845$ kg/m^3 and specific heat, $c_p = 0.67$ kJ/ kg K

5. State and prove the Kirchhoff's law of thermal radiation.
6. Define the terms (i)Absorptivity, (ii) Reflectivity and (iii) Transmissivity
7. What is black body? Explain the reasons for considering a large cavity with a small hole as a black body.
8. Discuss the procedure of setting up the electrical network analogy for thermal radiation systems and find an expression for gray body factor.
9. Determine heat lost by radiation per meter length of 80mm dia. pipe ($\varepsilon = 0.74$) at 300^{0}C, if:
    a. Located in a large room with concrete walls at a temperature of 27^{0}C
    b. Enclosed in a 160mm dia. concrete conduit at a temperature of 27^{0}C

MODULE 5

1. Explain the significance of Schmidt and Lewis Number.
2. What are the different modes of mass transfer? Give one examples for each.
3. State Fick's law of diffusion. What do you understand by diffusion coefficient? Give its unit.
4. An open pan 15cm in diameter and 30cm deep is filled with water at a level of 15cm and is exposed to atmospheric air at 30% relative humidity. The entire system is at 60^{0}C. Calculate the evaporation rate of water and the time required for all water to evaporate.
5. Derive the general mass transfer equation in Cartesian coordinates.
6. Define Mass flux and Molar flux.
7. Discuss the analogy between heat and mass transfer.
8. Derive an expression for isothermal evaporation of water into air.

Prepared by

Mr. Akash James
(Faculty)

Approved by

Dr. Manoj G. Tharian
(HOD)

5. MET 304 DYNAMICS AND DESIGN OF MACHINERY

5.1 COURSE INFORMATION SHEET

PROGRAMME: MECHANICAL ENGINEERING	***DEGREE: BTECH UNIVERSITY:KTU***
COURSE: DYNAMICS AND DESIGN OF MACHINERY	**SEMESTER:** 6 **CREDITS:** 4
COURSE CODE: MET304 REGULATION: 2020	**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	Dynamic force analysis- D' Alembert's principle –four bar mechanism- engine force analysis (reciprocating engines)- piston side thrust-connecting rod force-piston effort- dynamic force analysis considering mass of the connecting rod-analytical method. Flywheels-turning moment diagrams for four stroke internal combustion engine and multi cylinder engines-coefficient of fluctuation of speed-coefficient of fluctuation of energy design of flywheels.	12
II	Introduction- free vibration of single degree undamped systems- natural frequency-energy method- Newton's second law (free body diagram)-damped systems- logarithmic decrement. Forced vibration-single degree of freedom systems-harmonic excitation-vibration isolation transmissibility-whirling of shafts.	6
III	Introduction to two degree of freedom systems- natural frequencies and mode shapes. Introduction to design-definition, steps in the design process, materials and their properties elastic and plastic behaviour of metals, ductile and brittle behaviour, shear, bending and torsional stresses, combined stresses, stress concentration factor.	10
IV	Shock and impact loads- fatigue loading- Gerber, Goodman and Soderberg criteria, endurance limit stress, factors affecting endurance limit, factor of safety. Deign of riveted joints- material for rivets, modes of failure, efficiency of joint, design of boiler and tank joints, structural joints.	5
V	Design of welded joints-welding symbols, stresses in fillet and butt welds, Butt	11

	joint in tension, fillet weld in tension, fillet joint under torsion, fillet weld under bending, eccentrically loaded welds. Springs- classification, spring materials, stresses and deflection of helical springs, axial loading, curvature effect, resilience, static and fatigue loading, surge in spring, critical frequency, concentric springs, end construction.	
TOTAL HOURS		**44**

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHORS/PUBLICATION*
T1	P.L. Ballaney, Theory of Machines and Mechanisms, 25th Edition, Khanna Publishers, 2018
T2	Rattan S. S., Theory of Machines, 5th Edition, Tata McGraw-Hill Education, 2019
T3	V. P. Singh, Theory of Machines, Dhanpat Rai,2013
T4	Data Book: K. Mahadevan, K. Balaveera Reddy, Design Data Handbook for Mechanical Engineers in SI and Metric Units, 4th Edition, CBS Publishers & Distributors, 2013
T5	Data Book: NarayanaIyengar B.R., Lingaiah K., Machine Design Data Handbook, 2nd Edition, McGraw-Hill Inc, 2003
T6	Data Book: PSG College, Design Data: Data Book of Engineers, 4th Edition. Kalakathir Achchagam, 2019
R1	Charles E. Wilson, J. Peter Sadler, Kinematics and Dynamics of Machinery, 3rd Edition, Tata McGraw-Hill Education, 2002
R2	Amithabha Ghosh, Asok Kumar Malik, Theory of Mechanisms and Machines, 3rd Edition, East West Press, 1988
R3	Thomas Bevan, Theory of Machines, 3rd Edition, Pearson, 2009
R4	C. E. Wilson, P. Sadler, *Kinematics and Dynamics of Machinery*, 3rd edition, Pearson Education.. G. Erdman, G. N. Sandor, *Mechanism Design: Analysis and synthesis Vol I &II*,Prentice Hall of India
R5	Holowenko, Dynamics of Machinery, John Wiley
R6	W.T.Thompson, Theory of vibration, Prentice Hall,1997

COURSE PRE-REQUISITES:

C.CODE	*COURSE NAME*	*DESCRIPTION*	*SEM*
EST 100	ENGINEERING MECHANICS	To have basic knowledge in statics, dynamics, force analysis.	1/2

COURSE OBJECTIVES:

1	*Do engine force analysis and to draw turning moment diagrams*
2	*Analyse free and forced vibrations of single degree of freedom systems*
3	*Determine the natural frequencies of a two degree of freedom vibrating system and to calculate the stresses in a structural member due to combined loading*
4	*Design machine elements subjected to fatigue loading and riveted joints*
5	*Design welded joint and close coiled helical compression spring*

COURSE OUTCOMES:

Students are capable of:

SNO	*DESCRIPTION*	*Bloom's Taxonomy Level*
CMET304.1	Student will be able to do engine force **analysis** and to **draw** turning moment diagrams	III- Apply IV- Analyze
CMET304.2	Student will be able to **analyse** free and forced vibrations of single degree of freedom systems	IV-Analyze
CMET304.3	Students can **determine** the natural frequencies of a two degree of freedom vibrating system and to **calculate** the stresses in a structural member due to combined loading	III- Apply
CMET304.4	Students will be able to **analyze** and design machine elements subjected to fatigue loading and riveted joints	III- Apply
CMET304.5	Students will be able to **analyze** and design design welded joint and close coiled helical compression spring	III- 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*
CMET304.1	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CMET304.2	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CMET304.3	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CMET304.4	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CMET304.5	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
AVG. VALUE	3	3	2												

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
CMET304.1-PO1	H	Knowledge related to dynamic force analysis of planar mechanisms aids to the solution of some complex engineering problems
CMET304.1-PO2	H	Knowledge in force analysis helps students to formulate problems and comment on the possible solutions.
CMET304.1-PO3	M	Knowledge in force analysis in mechanisms help to analyse and formulate design solutions to engineering problem.
CMET304.2-PO1	H	Students could apply their knowledge in solving problems to find frequency of vibration for both damped and un damped free vibration and forced vibration system.
CMET304.2-PO2	H	Knowledge related to different vibration systems aids to the solution of some complex engineering problems
CMET304.2-PO3	M	Apply reasoning informed by the contextual knowledge of free vibration and forced vibration system helps to formulate solutions and design of Engineering problems.
CMET304.3-PO1	H	Students capable of writing equation of motion of two degree, multi degree of freedom systems and choosing methods to solve frequency of such systems at different modes of vibration.
CMET304.3-PO2	H	Students can gain the basic knowledge of steps involved in design process
CMET304.3-PO3	M	Students understands basic design procedure and material properties Students understand fundamental design factors and learn different failure theories.
CMET304.4-PO1	H	Student understands the basic concepts of riveted joints. The load variations during the application of fluctuating load are studied.
CMET304.4-PO2	H	The forces acting of the system are identified. Formulations are solved to select suitable parameter for design.
CMET304.4-PO3	M	With the optimum constrains riveted joints are designed.
CMET304.5-PO1	H	Student understands the basic concepts of welded joints and about the load acting on springs.
CMET304.5-PO2	H	The forces acting of the system are identified. Formulations are solved to select suitable parameter for design.
CMET304.5-PO3	M	With the optimum constrains welded joints and springs are designed.

WEB SOURCE REFERENCES:

1	Dynamic force analysis of mechanism- https://www.youtube.com/watch?v=fEdz91oWrts
2	Gyroscope- https://www.youtube.com/watch?v=cquvA_IpEsA
3	Balancing of rotating masses https://www.youtube.com/watch?v=5tVHxX2QgIA
4	Balancing video of a rotating turbine impeller https://www.youtube.com/watch?v=VKr5RZt6MQo
5	http://nptel.ac.in/downloads/112105125/
6	http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/New_index1.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 (ONCE)✓
☐ ***ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS***	☐ OTHERS

5.2 COURSE PLAN

DAY	MODULE	TOPIC PLANNED
1	1	Dynamic force analysis
2	1	D' Alembert's principle –Four bar mechanism
3	1	D' Alembert's principle –Four bar mechanism
4	1	Engine force analysis (reciprocating engines)
5	1	Piston side thrust connecting rod force
6	1	Piston effort
7	1	Dynamic force analysis considering mass of the connecting rod-analytical method
8	1	Flywheels, turning moment diagrams
9	1	Four stroke internal combustion engines
10	1	Multi cylinder engines
11	1	Coefficient of fluctuation of speed
12	1	Coefficient of fluctuation of energy-design of flywheels
13	2	Introduction- free vibration of single degree undamped systems
14	2	Systems natural frequency-energy method
15	2	Newton's second law (free body diagram)-damped systems- logarithmic decrement
16	2	Forced vibration-single degree of freedom systems
17	2	Harmonic excitation-vibration isolation
18	2	Transmissibility-whirling of shafts
19	3	Introduction to two degree of freedom systems
20	3	Natural frequencies
21	3	Mode shapes
22	3	Introduction to design-definition, steps in design process
23	3	Materials and their properties
24	3	Elastic and plastic behaviour of metals ductile and brittle behaviour
25	3	Shear
26	3	Bending and torsional stresses
27	3	Combined stresses
28	3	Stress concentration factor.

29	4	Shock and Impact loads, fatigue loading- Gerber, Goodman and Soderberg criteria,
30	4	Endurance limit stress, factors affecting endurance limit, factor of safety.
31	4	Deign of riveted joints- material for rivets
32	4	Modes of failure, efficiency of joint
33	4	Design of boiler and tank joints, structural joints
34	5	Design of welded joints
35	5	Welding symbols, stresses in fillet and butt welds
36	5	Butt joint in tension, fillet weld in tension
37	5	Fillet joint under torsion, fillet weld under bending
38	5	Eccentrically loaded welds
39	5	Springs- classification, spring materials
40	5	Stresses and deflection of helical springs, axial loading
41	5	Effect, resilience, static and fatigue loading
42	5	Surge in spring
43	5	Critical frequency
44	5	Concentric springs, end construction

5.3 MODULE WISE SAMPLE QUESTIONS

MODULE 1

1. Explain the principle of virtual work applied in a slider crank mechanism.
2. Explain equivalent offset inertia force in plane motions.
3. Explain a dynamically equivalent system. What are the conditions it should satisfy?
4. Find the magnitude and direction of inertia force acting on links AB, BC, CD, in the four bar mechanism shown in Fig: 1
   AB= 500 mm, BC= 660 mm, CD= 560 mm, AD= 1000 mm (horizontal),
   ω_{AB} = 10.5 rad/sec (CCW), angular retardation α_{AB}= 26 rad/sec2 , < DAB= 600
5. Mass of link AB, MAB = 3.54 kg, MBC = MCD = 3.54 kg /m length. Centre of gravity link AB lies at 200 mm from A and has a moment of inertia of 88500 kg mm2. For link 3 & 4 Centre of gravity is at its mid-point.

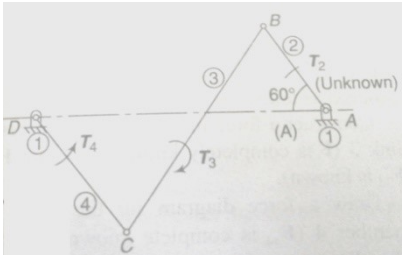
6. Find the equivalent offset inertia distance at which the inertia force are acting on the links AB, BC, and CD of the mechanism shown in Fig 1. With a neat sketch represent equivalent offset inertia forces acting on each link
7. Explain static and dynamic balancing.
8. Derive an expression for maximum swaying couple.
9. With a neat sketch briefly describe the working of cradle type balancing machine.
10. Explain hammer blow and variation of tractive force.
11. The following data refers to a two cylinder uncoupled locomotive engine:
    Rotating mass per cylinder = 280 kgm, Reciprocating mass per cylinder= 300 kg, Distance between wheels= 1400mm, Distance between cylinder centers= 600 mm, Angular velocity of balancing mass= 15.43 rad/sec, Crank radius= 300 mm, Radius of centre of balancing mass= 620 mm, Angle between cylinder cranks= 90 deg, Dead load on each wheel= 3.5 tonne

    Find: a) Balancing mass required in the planes of driving wheels if whole of the revolving and 2/3 rd of the reciprocating mass are to be balanced

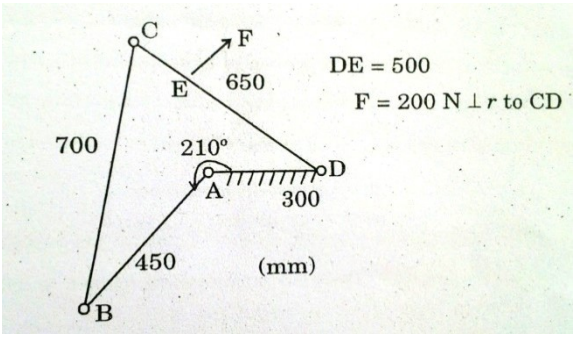
    b) Swaying couple , c) Tractive force , d) Maximum and minimum pressure on the rails

12. Derive the expression for coefficient of fluctuation of energy.
13. Explain the turning moment diagram of a single cylinder four stroke engine with a neat sketch.
14. Determine the energy released by the flywheel having a mass of 2 kN and radius of gyration of 1.2 m when the speed decreases from 460 rpm to 435 rpm.
15. Explain and derive an expression for a) Piston effort b) Force along the connecting rod c) Thrust on the sides of the cylinder d) Crank effort e) Thrust on the bearings.
16. A flywheel fitted to a steam engine has a mass of 800 kg. Its radius of gyration is 360 mm. The starting torque of the engine is 580 Nm and may be assumed constant. Find the kinetic energy of the flywheel after 12 seconds.
17. 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
18. Explain the static equilibrium conditions of two forces, three forces, two forces and a torque member.
19. 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.
20. Explain with an example the static force analysis of a slider crank mechanism in which friction is considered for sliding and revolute pairs.
21. 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.



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



MODULE 2

1. Difference between vibration absorbers and vibration isolators.
2. Explain co-ordinate coupling.
3. Explain the working of unturned dry friction damper with a neat diagram.
4. Derive an expression for displacement transmissibility of a spring mass damper system subjected to a force.
5. Explain two types of frequency measuring instruments
6. A machine weighing 1600 kg is mounted on a spring having stiffness of 10800 N/cm. A piston within the machine weighing 25 N has a reciprocating motion with a stroke of 7.5 cm and a speed of 6000 rpm. Assume the motion to be simple harmonic. Determine: a) Amplitude of vibration of machine. b) Transmissibility and force transmitted to the ground. Take ξ= 0.2

a) A single cylinder vertical petrol engine of total mass 320 kg is mounted upon a steel chassis and causes a vertical static deflection of 2 mm. The reciprocating parts of the engine have a mass of 24kg and move through a vertical stroke of 150mm. with simple harmonic motion. A dashpot attached to the system offers a resistance of 490 N at a velocity of 0.3 m/sec. Determine: The speed of the driving shaft at resonance, The amplitude of steady state vibration when the driving shaft of the engine rotates at 480 rpm.

7. A centrifugal pump rotating at 600 r.p,m. is driven by an electric motor running at 1500 r.p.m through a single stage reduction gearing. The moment of inertia of the pump impeller and the motor are 150 Kg-m^2 and 450 Kg-m^2 respectively. The lengths of the pump shaft and the motor shafts are 500 mm and 300 mm, and their diameters are 100 mm and 60 mm respectively. Neglecting the inertia of the gears, find the frequency of torsional oscillations of the system, and draw the mode shape. Take G = 82 GPa.
8. The rotor of a turbo charger weighing 90 N is keyed to the centre of 25 mm diameter steel shaft 40 cm between bearings. Determine: Critical speed of shaft, The amplitude of vibration of rotor at a speed of 3200 rpm, if the eccentricity is 0.015 mm, Dynamic force transmitted to the bearing at this speed. Take density of shaft material as 8 gm/cm^3, E= 200 GPa,
9. Derive an expression for energy dissipated per cycle in single degree of freedom system with viscous damping.
10. Find the expression of frequency of free vibration of the system shown in figure 1. Assume the chord passing over the frictionless pulley is inextensible.

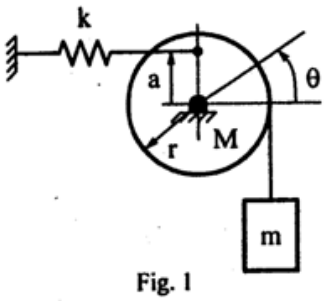


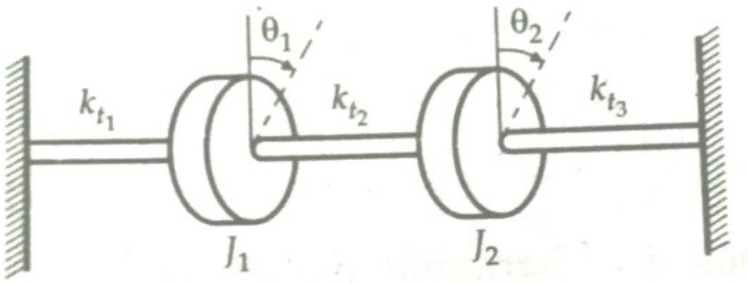
Fig. 1

11. A vibrating system is defined by the following parameters: m= 3 kg, k= 100 N/m, C=3 N-sec/m Determine: a) damping factor, b) the natural frequency of damped vibration, c) Logarithmic decrement, d) the ratio of two consecutive amplitudes and e) The number of cycles after which the original amplitude is reduced to 20 percent.

MODULE 3

1. Explain in detail the design consideration in design of machine elements
2. Briefly describe a) theories of failure b) Creep
3. Discuss the various factors affecting which govern the selection of material for machine component.
4. Explain the weighted point method for material selection and state its limitations.
5. What are the ergonomic conditions in machine design?
6. Explain Fits and tolerances
7. Briefly describe standards and code in design.
8. Explain the term a) modulus of elasticity b) Explain ductile and brittle material using a stress-strain diagram.
9. Explain a) combine stress b) stress concentration factor
10. Briefly explain the steps in design process

11. Describe critical speed of shaft.
12. Find the natural frequencies for the torsional system shown in figure below:
    Given $J_1 = J_0$, $J_2 = 2J_0$ and $k_{t1} = k_{t2} = k_{t3} = k_t$



13 A mild steel shaft of 50 mm diameter is subjected to a bending moment of 2000Nm and a torque T. If the yield point of the steel in tension is 200 MPa., find the maximum principle stress; the maximum shear stress of yielding.

14 A cylinder shaft made of steel of yield strength 700Mpa is subjected to static loads consisting of bending moment 10kNm and a torsional moment 30 kNm. Determine the diameter of the shaft using maximum shear stress theory and maximum strain energy theory, assuming a factor of safety of 2. Take E=210 GPa and Poisson's ratio = 0.25.

15 Explain the following theories of failure a) Maximum normal stress theory, b) Maximum shear stress theory and c) Distortion theory

16 A rod of 50mm diameter is subjected to compressive load of 20 kN together with a twisting moment of 1.5kNm. It is made of C40 steel (σyt = 328.6 MPa). Determine the factor of safety according to a) maximum normal stress theory and b) Maximum shear stress theory.

17 A bolt is subjected to tensile load of 18kN and a shear load of 12 kN. The material has a yield stress of 328.6 MPa. Taking factor of safety as 2.5, determine the core diameter of bolt according to the following theories of failure a) Rankine's theory, b)Shear stress theory, c)Shear energy theory and c) Saint Venant's theory (Possion ratio = 0.298).

18 A machine member is subjected to the following stress σx = 150 MPa, τ=24 MPa. Find the equivalent stress as per the following theories of failure, a) Shear stress theory, b) Normal stress theory and c) Von-Mises theory.

19 Find the diameter of a rod subjected to a bending moment of 3 kNm and a twisting moment of 1.8 kNm according to the following theories of failure, taking normal yield stress as 420 MPa and factor of safety as 3. a) Normal stress theory and b) Shear stress theory.

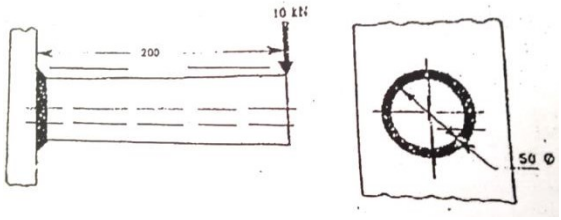
20 A M.S shaft having yield stress as 232 MPa is subjected to the following stresses σx =120 MPa and σy =-60 MPa and τ = 36 MPa. Find the factor of safety using: a) Rankine's theory, b) Guest's theory of failure and c) Von-Mises theory of failure.

Module 4

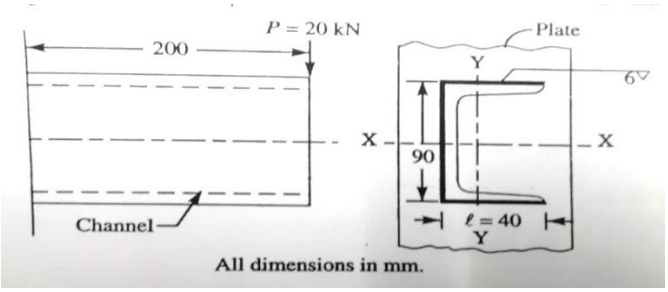
1. 1. Write a note on (i) fatigue failure and its prediction (ii) Factors affecting endurance limit.
2. A cantilever beam shown in figure below is subjected to load varying from P to 3P. Determine the value of P if the material of beam has ultimate strength of 620.8 MPa., yield strength of 400 MPa and endurance strength of 345.2 MPa. The stress concentration factor may be taken as 1.4. Analyze the member at the change of cross section A-A. Use factor of safety =3.
3. What are riveted joins? What are its advantages and disadvantages of riveted joints over welded joins? Explain. Also explain the type of rivet heads.
4. Design a triple riveted zigzag lap joint to connect two plates each 12mm thick. Draw a neat sketch of the joint.
5. Design a triple riveted double covered butt joint with unequal cover plates to connect two plates of 20mm thickness. Use permissible values of tensile, compressive and shear stress are 90 N/mm^2, 150 N/mm^2 and 60 N/mm^2 respectively.
6. A double riveted double cover butt joint in plates 20mm thick is made with 25mm diameter rivets at 100 mm pitch. The permissible stresses are: Tensile =120 MPa, Shear stress 100 MPa, crushing stress =150 Mpa. Find the efficiency of joint, taking the strength of the rivet in double shear as twice than that of single shear.
7. Design a double riveted butt joint with two cover plates for the longitudinal seam of a boiler shell 1.5m in diameter is subjected to a steam pressure of 0.95 N/mm^2. Assume joint efficiency as 75%, allowable tensile stress in the plate 90MPa, compressive stress 140Mpa and shear stress in the river 56 MPa.

Module 5

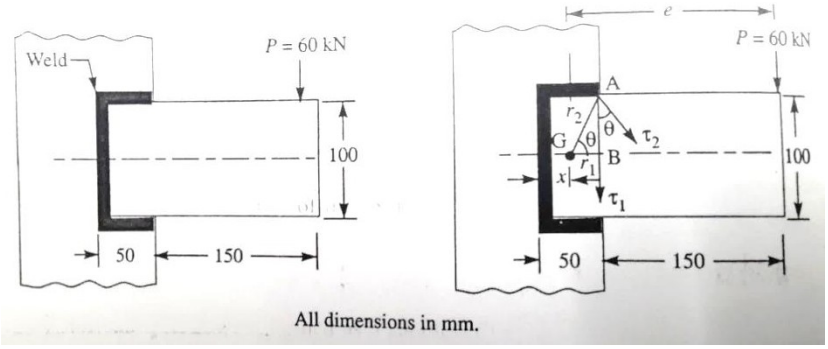
1. What are the different types of welded joints?
2. A circular shaft, 50mm in diameter is welded to a support by means of a fillet weld as shown in the figure. Determine the size of the weld if the permissible shear stress in the weld is limited to 100 N/m^2.



3. Find the maximum shear stress induced in the weld of 6 mm size when a channel, as shown in figure below, is welded to a plate and loaded with 20kN force at a distance of 200mm.



4. A rectangular steel plate is welded as a cantilever to a vertical column and supported a single concentrated load P, as shown in figure below. Determine the weld size if shear stress is not exceed 140 MPa.



5. A helical compression spring of a cam-mechanism is subjected to an initial pre load of 50 N. The maximum operating force during the load cycle is 150N. The wire diameter is 3 mm while the mean coil diameter is 18mm. The spring is made of oil hardened and tempered valve spring wire of grade–SW (Sut =1430N/mm^2). Determine the factor of safety used in the design on the basis of fluctuating stress.
6. Design a helical spring for a safety valve. The valve must blow off at a pressure of 1.2 MPa and should lift by 3mm for 5% increase in pressure. The valve diameter is 60mm. The maximum allowable shear stress is 400 MN/m^2 and the modulus of rigidity is 82.7 Gpa. Assume the spring index as 8.
7. The load on a steel helical compression spring varies from 500 N to 1200 N. The spring index is 6 and the desired factor of safety is 1.3. Determine the required wire size by taking yield shear stress as 600 MN/m^2 and the endurance shear stress as 300 MN/m^2.
8. A semi elliptical laminated spring is to carry a load of 600N and consists of 8 leaves 46mm wide, two of the leaves being of full length. The spring is to be made 1000mm between the eyes and is held at the centre by a 60 mm wide band. Assume that the spring is initially stressed so as to induce an equal stress of 500 N/mm^2 when fully loaded. Design the spring giving a) thickness of leaves b) eye diameter c) length of leaves d) maximum deflection and radius to which the leaves should be initially bent.
9. A helical compressed spring made of oil tempered carbon steel, is subjected to a load which varies from 400 N to 1000 N. The spring index is 6 and the design factor of safety is 1.25.

The yield stress in shear is 770 MPa and endurance stress in shear is 350 Mpa, find: (a) size of the spring wire, (b) Diameter, (c) Number of turns of the spring and (d) Free length of the spring. The compression of the spring at the maximum load is 30mm. The modulus of rigidity of the material may be taken as 80 kN/mm^2.

10. 10 . Design a helical compression spring for a maximum load of 1000 N for a deflection of 25 mm using the value of spring index as 5. The maximum permissible shear stress for spring wire is 420 MPa and modulus of rigidity is 84 kN/mm^2.
11. The load on a steel helical compression spring varies from 500 N to 1200 N. The spring index is 6 and the desired factor of safety is 1.3. Determine the required wire size by taking yield shear stress as 600 MN/m^2 and the endurance shear stress as 300 MN/m^2.
12. An automotive single plate clutch, with two pairs of friction surfaces, transmits 300 Nm torque at 1500rpm. The inner and outer diameters of the friction disk are 170 and 270mm respectively. The coefficient of friction is 0.35. The normal force on the friction surfaces is exerted by nine helical compression springs, so that the clutch is disengaged when the external force further compressed the springs. The spring index is 5 and the number of active coils is 6. The springs are made of patented and cold-drawn steel wires of grade 2. (G=81370 N/mm^2). The permissible shear stress for the spring is 30% off the ultimate tensile strength. Design the spring and specify their dimensions.
13. A concentric spring consists of two helical compression springs having the same free length. The composite spring subjected to a maximum force of 2000 N. The wire diameter and mean coil diameter of inner spring are 8mm and 64mm respectively. Also, the wire diameter and mean coil diameter of the outer spring are 10 and 90 mm respectively. The number of active coils in inner and outer springs is 12 and 8 respectively. Assume same material for two springs and the modulus of rigidity of spring material is 81370 N/mm^2. Calculate a) The force transmitted by each spring, b) The maximum deflection of the spring and c) The maximum torsional shear stress induced in each spring.
14. A helical compression spring of the exhaust valve mechanism is initially compressed with a preload of 375 N. When the spring is further compressed and the valve is fully opened, the torsional shear stress in the spring wire should not exceed 750 N/mm^2. Due to space limitations, the outer diameter of the spring should not exceed 42 mm. The spring is to be designed for minimum weight. Calculate the wire diameter and the mean coil diameter of the spring.

Prepared by **Approved by**

Dr. Joseph Babu K.
(Faculty)

Dr. Manoj G. Tharian
(HOD)

6. MET306 ADVANCED MANUFACTURING ENGINEERING

6.1. COURSE INFORMATION SHEET

PROGRAMME: ME	***DEGREE:*** BTECH
COURSE: ADVANCED MANUFACTURING ENGINEERING	**SEMESTER: 6 CREDITS: 4**
COURSE CODE: MET306 **REGULATION:** 2019	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: MANUFACTURING ENGINEERING	**CONTACT HOURS:** 3+1 (Tutorial) Hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY): MEL204	**LAB COURSE NAME:** MACHINE TOOLS LAB-I

SYLLABUS:

UNIT	*DETAILS*	*HOURS*
I	Powder Metallurgy- Powder Production- Powder characteristics- Mixing – Compaction: - techniques- sintering- Theory metal cutting - Orthogonal and oblique cutting- chip formation- Merchant's theory-Friction force - cutting tool materials -Thermal aspects of machining –Tool wear and wear mechanisms - Economics of machining- Machinability- Cutting fluids.	10
II	Programmable Logic Controllers (PLC) – CNC: systems - contouring systems: principle of operation -DDA integrator: -Principle of operation, exponential deceleration –liner, circular and complete interpolator - NC part programming - Computer aided part programming – machining centers, feedback devices.	9
III	Non Traditional machining processes: - EDM, USM, ECM, LBM, EBM, PAM, IBM, AJM, AWJM.	9
IV	High velocity forming of metals - Sheet metal forming - explosive forming - Electro hydraulic forming - Electro Magnetic Forming.	8
V	Micromachining: Diamond turn mechanism, Advanced finishing processes: - Abrasive Flow Machining, Magnetic Abrasive Finishing. - Magnetorheological Finishing, Magnetorheological Abrasive Flow Finishing, Magnetic Float Polishing, Elastic Emission Machining. - Material addition processes: - stereo-lithography, selective laser sintering, fused deposition modeling, laminated object manufacturing, laser engineered net-shaping, laser welding, LIGA process.	9
	TOTAL HOURS	**45**

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHORS/PUBLICATION*
T	**YoramKoren,** Computer control of manufacturing systems, TMH
T	**Jain V.K.,** Introduction to Micromachining, Narosa publishers.
T	**Davies K and Austin E.R,** Developments in high speed metal forming, the machinery publishing Co, 1970, SBN -853332053
R	**ASTME,** High velocity forming of metals, PHI, 1968.
R	**Ibrahim Zeid, R Sivasubrahmanian** CAD/CAM: Theory & Practice Tata McGraw Hill Education Private Limited, Delhi.
R	**P.Groover, E.M. Zimmers, Jr.** "CAD/CAM"; Computer Aided Design and Manufacturing, Prentice Hall of India, 1987
R	**Petruzella Frank D.** - Programmable logic controllers
R	**Jain V.K.,** Advanced Machining Processes, Allied Publishers Pvt. Ltd.
R	**Armarego and Brown,** The Machining of Metals, Prentice – Hall.
R	**Paul. H. Black,** Theory of Metal Cutting, McGraw Hill.
R	**ASM hand book Volume 16,** Machining, ASM international, 1989
R	**Lal G.K.,** Introduction to Machining Science, New Age Publishers.

COURSE PRE-REQUISITES:

C.CODE	*COURSE NAME*	*DESCRIPTION*	*SEM*
C.CODE	**COURSE NAME**	**DESCRIPTION**	**SEM**
MET205	Metallurgy and material science	Knowledge about the basics of materials and its properties.	3
MET204	Manufacturing Processes	Knowledge about basic concept of various conventional and non-conventional material removal processes.	3

COURSE OBJECTIVES:

1	To understand the capabilities, limitations of conventional manufacturing & machining process and what the need of advanced manufacturing processes is.
2	To understand, how to formulate tool path and program CNC machines.
3	To understand, how PLC operate and control automated equipment and systems.
4	To understand the need of atomic level surface roughness and machining process.
5	To understand the need of high velocity forming of metals.

COURSE OUTCOMES:

SL. NO.	*DESCRIPTION*	*Bloom's Taxonomy Level*
CMET306.1	To be conversant with the advanced machining process and to appreciate the effect of process parameters on the surface integrity aspects during the advanced machining process.	Understand (level 2)
CMET306.2	CNC programming, select appropriate tooling and fixtures.	Apply (level 3)
CMET306.3	To categorize the various non-traditional material removal process based on energy sources and mechanism employed.	Understand (level 2)
CMET306.4	Analyze the processes and evaluate the role of each process parameter during micro machining of various advanced material removal processes.	Evaluate (level 5)
CMET306.5	Explain the processes used in additive manufacturing for a range of materials and applications.	Understand (level 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*
CMET 306.1	3	-	-	-	2	-	-	-	-	-	-	2	3	2	3
CMET 306.2	2	-	2	-	3	-	-	-	-	-	-	-	3	3	3
CMET 306.3	2	-	-	-	2	-	-	-	-	-	-	2	2	3	2
CMET 306.4	2	3	-	-	2	-	-	-	-	-	-	-	3	3	3
CMET 306.5	2	-	-	3	2	-	-	-	-	-	2	-	3	3	3

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	*LOW/MEDIUM / HIGH*	*JUSTIFICATION*
CMET306.1-PO1	H	Students will be able to appreciate and *solve complex engineering problems* related to advanced machining

		processes, based on acquired **knowledge**.
CMET306.1-PO5	M	Students will be able to select and apply advanced manufacturing techniques including modelling using CAD/CAM facilities.
CMET306.1-PO12	M	Students will be able to engage in life-long learning in the context of ever-evolving manufacturing technology.
CMET306.2-PO1	M	Students will be able to appreciate and *solve complex engineering problems* related to CNC Programming, based on acquired **knowledge.**
CMET306.2-PO3	M	Students will possess ability to **Design/develop solutions** *for complex machining problems and design CNC programmes* that consider the *machining time and public safety*.
CMET306.2-PO5	H	Students will be able to select and apply advanced manufacturing techniques using CNC Programming and CAD/CAM facilities.
CMET306.3-PO1	M	Students will be able to appreciate and *solve complex manufacturing engineering problems* related to non-conventional machining processes, based on acquired **knowledge**.
CMET306.3-PO5	M	Students will be able to select and apply advanced non-conventional machining techniques including modelling using CAD facilities.
CMET306.3-PO12	M	Students will be able to engage in life-long learning in the context of ever-evolving manufacturing technology that include advanced non-traditional machining processes.
CMET306.4-PO1	M	Students will be able to *solve complex manufacturing engineering problems* based on acquired **knowledge** on micromachining processes.
CMET306.4-PO2	H	**Problem analysis** based on *first principles of mathematics and engineering sciences* is essential to analyze complex engineering problems related to micromachining processes.
CMET306.4-PO5	M	Students will be able to select and apply advanced micromachining techniques including modelling using CAD facilities.
CMET306.5-PO1	M	Students will be able to *solve current complex manufacturing engineering problems* based on acquired **knowledge** on additive manufacturing.
CMET306.5-PO4	H	Students will be able to **conduct experiments** in the area of additive manufacturing techniques and **analyze** data to provide valid conclusions.
CMET306.5-PO5	M	Students will be able to *select and apply advanced additive manufacturing techniques* including modelling using CAD/CAM facilities.
CMET306.5-	M	Students will be able to manage projects and associated

PO11		finance based on selection of materials and additive manufacturing techniques.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
CMET306.1 -PSO1	H	Students will be able to apply knowledge in the domain of advanced machining processes and solve engineering problems using CAD/CAM technology.
CMET306.1 -PSO2	M	Students will be able to successfully apply the design principles and implementation of *advanced machining processes* learned as a part of curriculum.
CMET306.1 -PSO3	H	Students will be able to *implement new ideas on product design and development* using advanced machining processes and CAD/CAM technology.
CMET306.2 -PSO1	H	Students will be able to apply knowledge in the domain of CNC machining and solve engineering problems using CNC programming and CAD/CAM technology.
CMET306.2 -PSO2	H	Students will be able to successfully apply the CNC programming methodology in the domain of *advanced machining processes* learned as a part of curriculum.
CMET306.2 -PSO3	H	Students will be able to *implement new ideas on product design and development* using CNC programming techniques and CAD/CAM technology.
CMET306.3 -PSO1	M	Students will be able to apply knowledge in the domain of unconventional machining processes and solve engineering problems using non-traditional manufacturing techniques.
CMET306.3 -PSO2	H	Students will be able to successfully apply the design principles and implementation of *non-traditional material removal processes* learned as a part of curriculum.
CMET306.3 -PSO3	M	Students will be able to *implement new ideas on product design and development* using unconventional machining processes with the help of modern machinery.
CMET306.4 -PSO1	H	Students will be able to apply knowledge in the domain of micromachining processes and solve engineering problems using advanced manufacturing technology.
CMET306.4 -PSO2	H	Students will be able to successfully apply the design principles and implementation of *micromachining processes* learned as a part of curriculum.
CMET306.4 -PSO3	H	Students will be able to *implement new ideas on product design and development* using advanced micromachining

		techniques and CAD/CAM technology.
CMET306.5 -PSO1	H	Students will be able to apply knowledge in the domain of *additive manufacturing* and solve engineering problems using recent production techniques based on rapid prototyping.
CMET306.5 -PSO2	H	Students will be able to successfully apply the design principles and implementation of *additive manufacturing processes* learned as a part of curriculum.
CMET306.5 -PSO3	H	Students will be able to *implement new ideas on product design and development* using CAD/CAM technology in the domain of additive manufacturing.

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

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

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NIL

WEB SOURCE REFERENCES:

1	https://nptel.ac.in/courses/112103202
2	https://nptel.ac.in/courses/112105127
3	https://nptel.ac.in/courses/112103306
4	https://onlinecourses.nptel.ac.in/noc20_me14/preview

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

6.2 COURSE PLAN

DAY	*MODULE*	*TOPIC PLANNED*
1	I	Introduction: Need and comparison between traditional, non-traditional and micro & nano machining process.
2	I	Powder Metallurgy: Need of P/M - Powder Production methods:- Atomization, electrolysıs, Reduction of oxides, Carbonyls (Process parameters, characteristics of powder produced in each method).
3	I	Powder characteristics: properties of fine powder, size, size distribution, shape, compressibility, purity etc.
4	I	Mixing – Compaction:- techniques, pressure distribution, HIP & CIP.
5	I	Mechanism of sintering, driving force for pore shirking, solid and liquid phase sintering - Impregnation and Infiltration Advantages, disadvantages and specific applications of P/M.
6-8	I	Theory metal cutting in turning: Tool nomenclature, attributes, surface roughness obtainable - Orthogonal and oblique cutting - Mechanism of metal removal - Mechanism of chip formation –chip breakers – Merchant's theory.
9	I	Friction force laws in metal cutting - development of cutting tool materials.
10	I	Thermal aspects of machining -Tool wear and wear mechanisms - Economics of machining, Machinability, Cutting fluids.
11	II	Programmable Logic Controllers (PLC):need – relays - logic ladder program –timers, simple problems only.
12-14	II	Point to point, straight cut and contouring positioning - incremental and absolute systems – open loop and closed loop systems - control loops in contouring systems: principle of operation -DDA integrator:- Principle of operation, exponential deceleration –liner, circular and complete interpolator.
15-16	II	NC part programming: part programming fundamentals - manual programming –NC coordinate systems and axes – tape format – sequence number, preparatory functions, dimension words, speed

		word, feed world, tool world, miscellaneous functions
17-19	II	Computer aided part programming:– CNC languages – APT language structure. Programming exercises: simple problems on turning and drilling etc**. -** machining centers, feedback devices.
20-21	III	Non Traditional machining processes:- Electric Discharge Machining (EDM):- Mechanism of metal removal, dielectric fluid, spark generation, recast layer and attributes of process characteristics on MRR, accuracy, HAZ etc, Wire EDM, applications and accessories.
22-23	III	Ultrasonic Machining (USM):-mechanics of cutting, effects of parameters on amplitude, frequency of vibration, grain diameter, slurry, tool material attributes and hardness of work material, applications.
24	III	Electro chemical machining (ECM):- Mechanism of metal removal attributes of process characteristics on MRR, accuracy, surface roughness etc, application and limitations.
25-27	III	Laser Beam Machining (LBM), Electron Beam Machining (EBM), Plasma arc Machining (PAM), Ion beam Machining(IBM) – Mechanism of metal removal, attributes of process characteristics on MRR, accuracy etc and structure of HAZ compared with conventional process; application, comparative study of advantages and limitations of each process.
28	III	Abrasive Jet Machining (AJM), Abrasive Water Jet Machining (AWJM) - Working principle, Mechanism of metal removal, Influence of process parameters, Applications, Advantages & disadvantages.
29-30	IV	High velocity forming of metals:-effects of high speeds on the stress strain relationship steel, aluminum, Copper – comparison of conventional and high velocity forming methods- deformation velocity, material behavior, stain distribution.
31-32	IV	Stress waves and deformation in solids – types of elastic body waves-relation at free boundaries- relative particle velocity.
33-34	IV	Sheet metal forming: - explosive forming:-process variable, properties of explosively formed parts, etc.
35-36	IV	Electro hydraulic forming: - theory, process variables, etc, comparison with explosive forming -Electro Magnetic Forming.
37-39	V	Micromachining: Diamond turn mechanism, material removal mechanism, applications.- Advanced finishing processes: - Abrasive Flow Machining, Magnetic Abrasive Finishing.
40-42	V	Magnetorheological Finishing, Magnetorheological Abrasive Flow Finishing, Magnetic Float Polishing, Elastic Emission Machining.
43-45	V	Material addition process**:-** stereo-lithography, selective laser sintering, fused deposition modeling, laminated object manufacturing, laser engineered net-shaping, laser welding, LIGA process.

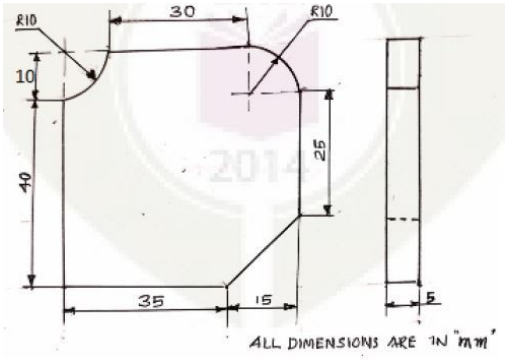
6.3 MODULE WISE SAMPLE QUESTIONS

MODULE 1

15. Explain the need and comparison between traditional and non-traditional manufacturing processes.
16. Explain Merchant's theory with neat sketches.
17. Explain the different stages of sintering process in Powder metallurgy
18. Differentiate the impregnation and infiltration process in Powder metallurgy.

MODULE 2

8. What are the different word address formats used in part programming?
9. Mention the purpose of miscellaneous functions in part programming. Write any 2 M –codes with their applications.
10. What is meant by interpolation in NC systems? Explain different types of interpolations.
11. Write a Manual Part Program for the given figure.



MODULE 3

12. What are the parameters influencing the MRR in USM process.
13. How LBM differs from and EBM.
14. Explain IBM with neat sketch; applications and vividly the process parameters influencing on it.
15. Describe the mechanism of material removal in Ion beam machining
16. What are the functions and desirable properties of dielectric fluid in EDM?

MODULE 4

c. Compare high velocity forming with conventional forming process.
d. What are stress waves? Write the equation for finding the velocity of shear wave.
e. Explain Electro Magnetic Forming and show that it can be applied to internal, external and surface forming operations.
f. Explain the two Techniques in Explosive forming process

g. Differentiate P wave and S wave in High Velocity Forming

MODULE 5

9. Explain the material removal mechanism in Diamond turn machining process.
10. With a neat sketch explain Diamond turn machining process.
11. With a neat sketch explain Selective Laser Sintering.
12. Describe the Laminated Object Manufacturing Process
13. Write a note on Elastic Emission Machining
14. Explain the LIGA and its application, what is the aspect ratio in LIGA.

Prepared by

Mr. Athul Sathyanath
(Faculty)

Approved by

Dr. Manoj G. Tharian
(HOD)

7. MET308 COMPREHENSIVE COURSE WORK

7.1 COURSE INFORMATION SHEET

*PROGRAMME:**MECHANICAL ENGINEERING***	*DEGREE:* ***BTECH***
COURSE: COMPREHENSIVE COURSE WORK	**SEMESTER:** 6 **CREDITS:** 1
COURSE CODE: MET308 **REGULATION:** 2019	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: MECHANICAL ENGINEERING	**CONTACT HOURS:** 2 HOUR/WEEK
CORRESPONDING LAB COURSE CODE (IF ANY):NIL	**LAB COURSE NAME:**NIL

SYLLABUS:

MODULE	CONTENTS	
MODULE 1 Fluids and continuum, Physical properties of fluids, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics- Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies. Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, stream lines,path lines, streak lines, stream tubes, , stream function and potential function, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Bernoulli's equation, Pipe Flow: Viscous flow: shear stress and velocity distribution in a pipe Hagen Poiseuille equation. Darcy-Weisbach equation MODULE 2 Development of atomic structure - Primary bonds: - characteristics of covalent, ionic and metallic bond - properties based on atomic bonding Crystallography: - SC, BCC, FCC, HCP structures, APF, Miller Indices: - crystal plane and direction - Modes of plastic deformation: - Slip and twinning. Classification of crystal imperfections - forest of dislocation, role of surface defects on crack initiation- Burgers vector –Frank Read source - Correlation of dislocation density with strength and nano concept - high and low angle grain boundaries– driving force for grain growth and applications.		

Phase diagrams: - need of alloying - classification of alloys - Hume Rothery`s rule – equilibrium diagram of common types of binary systems: five types - Coring - lever rule and Gibb`s phase rule - Reactions- Detailed discussion on Iron-Carbon equilibrium diagram with micro structure and properties -Heat treatment: - TTT, CCT diagram, applications - Tempering- Hardenability, Jominy end quench test, applications- Surface hardening methods.

MODULE 3

Basic Thermodynamic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.
First law of Thermodynamics - First law applied to Non flow and flow Process- SFEE, Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements, Equivalence of two statements Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Available Energy, Availability and Irreversibility- Second law efficiency.

MODULE 4

Casting:-Characteristics of sand - patterns- cores- -chaplets- simple problems- solidification of metals and Chvorinov's rule - Elements of gating system- risering -chills
Welding:-welding metallurgy-heat affected zone- grain size and hardness- stress reliving- joint quality -heat treatment of welded joints - weldability - destructive and non-destructive tests of welded joints Thermit welding, friction welding - Resistance welding, Arc Welding, Oxyacetyline welding.
Rolling:- principles - types of rolls and rolling mills - mechanics of flat rolling-Defects- vibration and chatter - flat rolling -miscellaneous rolling process
Forging: methods analysis, applications, die forging, defects in forging

MODULE 5

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.
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.

TEXT/REFERENCE BOOKS

T/R	*BOOK TITLE/AUTHOR/PUBLICATION*
T1	Given in the curriculum

COURSE PRE-REQUISITES: NIL

C.CODE	COURSE NAME	DESCRIPTION	SEM
-	-	-	-

COURSE OBJECTIVES:

The course is designed to ensure that the students have firmly grasped the foundational knowledge in Mechanical Engineering familiar enough with the technological concepts. It provides an opportunity for the students to demonstrate their knowledge in various Mechanical Engineering subjects.

COURSE OUTCOMES:

Sl. NO	DESCRIPTION	Blooms' Taxomomy Level
CMET308.1	Learn to prepare for a competitive examination	Knowledge Level 1
CMET308.2	Comprehend the questions in Mechanical Engineering field and answer them with confidence	Knowledge Level 1,2,3
CMET308.3	Communicate effectively with faculty in scholarly environments	Knowledge Level 2
CMET308.4	Analyze the comprehensive knowledge gained in basic courses in the field of Mechanical Engineering	Knowledge Level 1,2,3

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**
CMET308.1	**3**	**2**										**2**		**2**	
CMET308.2	**3**	**2**										**2**		**2**	
CMET308.3	**3**	**2**										**2**		**2**	
CMET308.4	**2**	**3**										**2**		**2**	

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

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/ MEDIUM / HIGH	JUSTIFICATION
CMET308.1 -PO1	3	Developing comprehensive knowledge in the core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery and contribute to solving engineering problems in competitive examinations.
CMET308.2 -PO1	3	Developing comprehensive knowledge in the core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery and contribute to solving engineering problems.
CMET308.3 -PO1	3	Communicate effectively the basic knowledge in the core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery and contribute to solving engineering problems.
CMET308.4 -PO1	2	Analyse the practical implications of core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery and contribute to solving engineering problems.
CMET308.1	3	Analysis of various theories and principles of core mechanical

-PO2		engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery and contribute to solving engineering problems in competitive examinations.
CMET3082.2-PO2	3	Analysis of various theories and principles of core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery and contribute to solving engineering problems.
CMET308.3-PO2	3	Analysis of various theories and principles of core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery and contribute to solving engineering problems in competitive examinations.
CMET308.4-PO2	2	Analysis of various theories and principles of core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery and contribute to solving engineering problems in competitive examinations.
CMET308.1-PO12	2	Comprehensive knowledge gained from core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery will be clearly communicated when called upon.
CMET3082.2-PO12	2	Comprehensive knowledge gained from core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery will be clearly communicated when called upon.
CMET308.3-PO12	2	Comprehensive knowledge gained from core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery will be clearly communicated when called upon.
CMET308.4-PO12	2	Comprehensive knowledge gained from core mechanical engineering subjects like Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery will be clearly communicated when called upon.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
CME352.1-PSO2	2	The student will be successfully able to apply the principles of Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery which are studied as part of their curriculum.
CME352.2-PSO2	2	The student will be successfully able to apply the principles of Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery which are studied as part of their curriculum.
CME352.3-PSO2	2	The student will be successfully able to apply the principles of Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery which are studied as part of their curriculum.
CME352.4-PSO2	2	The student will be successfully able to apply the principles of Fluid mechanics, Materials Science, Thermodynamics, Manufacturing Sciences and Design of Machinery which are studied as part of their curriculum.

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

SL NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	NIL	NIL	-	-

WEB SOURCE REFERENCES:

1	www.nptel.ac.in
2	https://www.nodia.co.in/gate-previous-year-solved-papers

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

7.2COURSE PLAN

Module 1

Sl. No.	*Topic*	*No. of lecture hours*
1	Fluids and continuum, Physical properties of fluids, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids.	1
2	Fluid Statics- Pressure-density-height relationship,	1

	manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies.	
3	Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, stream lines, path lines, streak lines, stream tubes, stream function and potential function,	1
4	Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation),	1
5	Bernoulli's equation, Pipe Flow: Viscous flow: shear stress and velocity distribution in a pipe Hagen Poiseuille equation. Darcy-Weisbach equation	1
Total hours : 5		

MODULE 2

Sl. No.	***Topic***	***No. of lecture hours***
1	Development of atomic structure - Primary bonds: - characteristics of covalent, ionic and metallic bond - properties based on atomic bonding Crystallography: - SC, BCC, FCC, HCP structures, APF,	1
2	Miller Indices: - crystal plane and direction - Modes of plastic deformation: - Slip and twinning.	1

3	Classification of crystal imperfections - forest of dislocation, role of surface defects on crack initiation- Burgers vector – Frank Read source -	1
4	Correlation of dislocation density with strength and nano concept - high and low angle grain boundaries– driving force for grain growth and applications.	1
5	Phase diagrams: - need of alloying - classification of alloys - Hume Rothery`s rule – equilibrium diagram of common types of binary systems: five types -	1
6	Coring - lever rule and Gibb`s phase rule - Reactions- Detailed discussion on Iron-Carbon equilibrium diagram with micro structure and properties -	1
7	Heat treatment: - TTT, CCT diagram, applications - Tempering- Hardenability, Jominy end quench test, applications- Surface hardening methods.	1
Total hours : 7		

MODULE 3

Sl. No.	*Topic*	*No. of lecture hours*
1	Basic Thermodynamic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.	1
2	First law of Thermodynamics - First law applied to Non flow and flow Process- SFEE,	1
3	Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements, Equivalence of two statements Entropy- Entropy changes in various thermodynamic processes	1
4	Principle of increase of entropy and its applications, Available Energy, Availability and Irreversibility- Second law efficiency.	1
Total hours : 4		

MODULE 4

Sl. No.	*Topic*	*No. of lecture hours*
1	Casting: - Characteristics of sand - patterns- cores- -chaplets- simple problems- solidification of metals and Chvorinov's rule - Elements of gating system- risering -chills	1
2	Welding:-welding metallurgy-heat affected zone- grain size and hardness- stress reliving- joint quality -	1
3	Heat treatment of welded joints - weldability - destructive and non-destructive tests of welded joints	1
4	Thermit welding, friction welding - Resistance welding, Arc Welding, Oxyacetyline welding.	1
5	Rolling: - principles - types of rolls and rolling mills - mechanics of flat Rolling-Defects-vibration and chatter - flat rolling -miscellaneous rolling process	1
6	Forging: methods analysis, applications, die forging, defects in forging	1
Total hours : 6		

MODULE 5

Sl. No.	*Topic*	*No. of lecture hours*
1	Introduction to kinematics and mechanisms - various mechanisms, kinematic diagrams, degree of freedom- Grashof's criterion, inversions, coupler curves mechanical advantage, transmission angle.	1
2	Straight line mechanisms exact, approximate. Displacement, velocity analysis– relative motion - relative velocity. Instantaneous centre -Kennedy's theorem.	1
3	Acceleration analysis- Relative acceleration - Coriolis acceleration - graphical and analytical methods.	1
4	Cams - classification of cam and followers - displacement diagrams,	1
5	Velocity and acceleration analysis of SHM, uniform velocity, uniform acceleration, cycloidal motion	1
6	Graphical cam profile synthesis, pressure angle.	1
Total hours : 6		

7.3 MODULE WISE SAMPLE QUESTIONS

Module 1

1. The shear stress developed in lubricating oil, of viscosity 9.81 poise, filled between two parallel plates 1cm apart and moving with relative velocity of 2 m/s is
(a) 20 N/m2
(b) 19.62 N/m2
(c) 29.62 N/m2
(d) 40 N/m2

2. For a Newtonian fluid
(a) Shear stress is proportional to shear strain
(b) Rate of shear stress is proportional to shear strain
(c) Shear stress is proportional to rate of shear strain
(d) Rate of shear stress is proportional to rate of shear strain

Module 2

3. Atomic packing factor (APF) in the case of copper crystal is
(a) 0.52
(b) 0.68
(c) 0.74
(d) 1.633

4. What is the approximate strain energy expression for a dislocation of unit length, irrespective of its edge or screw character?
(a) G2b/2
(b) Gb2/2
(c) G2b/4
(d) Gb2/4

Module 3

5. Consider the following statements
1. Zeroth law of thermodynamics is related to temperature
2. Entropy is related to first law of thermodynamics
3. Internal energy of an ideal gas is a function of temperature and pressure
4. Van der Waals' equation is related to an ideal gas
Which of the above statements is/are correct?
(a) 1 only
(b) 2, 3 and 4
(c) 1 and 3

(d) 2 and 4

6. A gas is compressed in a cylinder by a movable piston to a volume one-half of its original volume. During the process, 300 kJ heat left the gas and the internal energy remained same. What is the work done on the gas?
(a) 100 kNm
(b) 150 kNm
(c) 200 kNm
(d) 300 kNm

Module 4

7. Which one of the following casting processes is best suited to make bigger size hollow symmetrical pipes?
(a) Die casting
(b) Investment casting
(c) Shell moulding
(d) Centrifugal casting

8. In gas welding of mild steel using an oxy-acetylene flame, the total amount of acetylene consumed was 10 litre. The oxygen consumption from the cylinder is
(a) 5 litre
(b) 10 litre
(c) 15litre
(d) 20 litre

Module 5

9. The number of inversions for a slider crank mechanism is
(a) 6 (b) 5 (c) 4 (d) 3

10. Total number of instantaneous centers for a mechanism with n links are
(a) n/2 (b) n (c) (n- 1) / 2 (d) (n(n-1)) /2

Prepared by

Dr. Mathew Joseph

Mr. James Mathew

(Faculty)

Approved by

Dr. Manoj G. Tharian

(HOD)

8. MET312 NON - DESTRUCTIVE TESTING

8.1 COURSE INFORMATION SHEET

*PROGRAMME:**MECHANICAL ENGINEERING***	*DEGREE: **BTECH***
COURSE: Non-Destructive Testing	**SEMESTER:** 6 **CREDITS:** 3
COURSE CODE: MET 312 **REGULATION:** 2019	**COURSE TYPE:** ELECTIVE
COURSE AREA/DOMAIN: Material Science & Technology	**CONTACT HOURS:** 2 (LECTURE) + 1 (TUTORIAL) HOUR/WEEK
CORRESPONDING LAB COURSE CODE (IF ANY):NIL	**LAB COURSE NAME:**NIL

SYLLABUS:

MODULE	CONTENTS	HOURS
I	NDT Versus Mechanical Testing-Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation-Relative merits and limitations-various physical characteristics of materials and their applications in NDT. Visual Inspection: Fundamentals of Visual Testing – vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods – mirrors, magnifiers, Boroscopes and fibro scopes– light sources and special lighting–calibration- computer enhanced system	7
II	Liquid Penetrant Inspection: Principles – types and properties of liquid penetrants – developers – advantages and limitations of various methods - Preparation of test materials – Application of penetrants to parts, removal of excess penetrants, post cleaning – Control and measurement of penetrant process variables –selection of penetrant method – solvent removable, water washable, post emulsifiable – Units and lighting for penetrant testing – calibration- Interpretation and evaluation of test results - dye penetrant process applicable codes and standards.	7
III	Magnetic Particle Inspection (MPI): Important terminologies related to magnetic properties of material, principle-magnetizing technique, procedure, and equipment, fluorescent magnetic particle testing method, sensitivity-application and limitation-Methods of magnetization, magnetization techniques such as head shot technique, cold shot technique- central conductor testing, and magnetization using products using yokes-direct and indirect method of magnetization -	6

	continuous testing of MPI, residual technique of MPI- checking devices in MPI, Interpretation of MPI, indications, advantage and limitation of MPI.	
IV	Ultrasonic Testing: Basic principles of sound propagation, types of sound waves, Principle of UT-methods of UT, their advantages and limitations-Piezoelectric Material, Various types of transducers/probe-Calibration methods, contact testing and immersion testing, normal beam and straight beam testing, angle beam testing, dual crystal probe, ultrasonic testing techniques resonance testing, through transmission technique, pulse echo testing technique, instruments used UT, accessories such as transducers, types, frequencies, and sizes commonly used. Reference of standard blocks-technique for normal beam inspection-flaw characterization technique, defects in welded products by UT-Thickness determination by ultrasonic method;- Study of A, B and C scan presentations-Time of Flight Diffraction (TOFD).	7
V	Radiography: X-rays and Gamma rays, Properties of X-rays relevant to NDE - Absorption of rays - scattering. Characteristics of films-graininess, Density, Speed, Contrast. Characteristic curves. Inspection techniques like SWSI, DWSI, DWDI, panoramic exposure, real time radiography, films used in industrial radiography Eddy Current Testing: Generation of eddy currents – effect of change of impedance on instrumentation – properties of eddy currents – eddy current sensing elements, probes, type of coil arrangement – absolute, differential, lift off, operation, applications, advantages, limitations Field factor and lift of effect, edge effect, end effect, impedance plane diagram in brief, depth of penetration of ECT, relation between frequency and depth of penetration in ECT.	7

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHOR/PUBLICATION*
T1	Baldev Raj, Practical Non – Destructive Testing, Narosa Publishing House ,1997.
T2	J.Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2011).
T3	B.Raj, T. Jayakumar and M. Thavasimuthu, Practical Non Destructive Testing, Alpha Science International Limited, 3 rd edition (2007).

T4	T. Rangachari, J. Prasad and B.N.S. Murthy, Treatise on Non-destructive Testing and Evaluation, Navbharath Enterprises, Vol.3, (1983).
T5	Ed. Peter.J. Shull, Non-destructive Evaluation: Theory, Techniques, and Applications, Marcel Dekker (2002).
R1	C. Hellier, Handbook of Non-Destructive Evaluation, McGraw-Hill Professional, 1st edition (2001).
R2	J. Thomas Schmidt, K. Skeie and P. Maclntire, ASNT Non Destructive Testing Handbook: Magnetic Particle Testing, American Society for Non-destructive Testing, American Society for Metals, 2nd edition (1989).
R3	Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, Springer-Verlag, 1990.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
Nil			

COURSE OBJECTIVES:

1	To introduce the basic principles, techniques, equipment, applications and limitations of NDT methods such as Visual, Penetrant Testing, Magnetic Particle Testing, Ultrasonic Testing, Radiography, Eddy Current.
2	To enable selection of appropriate NDT methods.
3	To identify advantages and limitations of Non-destructive testing methods
4	To make aware the developments and future trends in NDT.

COURSE OUTCOMES:

Sl. NO	DESCRIPTION	Blooms Taxonomy Level
CMET312.1	Have a basic ***knowledge*** of surface NDT which enables to carry out various inspections in accordance with the established procedures.	Knowledge Application Level 1 & 3

CMET312 .2	The students will be able to ***differentiate*** various defect types and ***select*** the appropriate NDT methods for the specimen.	Understand Application Level 2 & 3
CMET312 .3	Calibrate the instrument and ***evaluate*** the component for imperfections.	Understand Application Level 2 & 3
CMET312 .4	Have a basic ***knowledge*** of ultrasonic testing which enables them to perform inspection of samples.	Knowledge Application Level 1 & 3
CMET312 .5	Have a complete theoretical and practical ***understanding*** of the radiographic testing, interpretation and evaluation.	Knowledge Application Level 1 & 3

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
CMET312.1	3	3	2	-	-	-	-	-	-	-	-	1	3	-	-
CMET312.2	3	3	2	-	-	-	-	-	-	-	-	1	3	-	-
CMET312.3	3	3	1	-	-	-	-	-	-	-	-	2	3	-	-
CMET312.4	3	3	2	-	-	-	-	-	-	-	-	2	3	-	-
CMET312.5	3	3	1	-	-	-	-	-	-	-	-	1	3	-	-
CMET312	3	3	1.6	-	-	-	-	-	-	-	-	1.4	3	-	-

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

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
CMET312.1-PO1	3	Students use the knowledge to build upon the existing fundamental concepts
CMET312.1-PO2	3	Students can analyse and identify the appropriate testing method to follow and helps in developing a thorough understanding.
CMET312.1-PO3	2	Helps students to effectively design the appropriate testing methods to follow.
CMET312.1-PO12	1	Students recognise the need for self-study and importance of earning skills in Non-Destructive Testing through lifelong learning
CMET312.2-	3	Students use the knowledge to build upon the existing

PO1		fundamental concepts
CMET312.2-PO2	3	Students can analyse and identify the appropriate testing method to follow and helps in developing a thorough understanding.
CMET312.2-PO6	2	Helps students to effectively design the appropriate testing methods to follow.
CMET312.2-PO12	1	Students recognise the need for self-study and importance of earning skills in Non-Destructive Testing through lifelong learning
CMET312.3-PO1	3	Students use the knowledge to build upon the existing fundamental concepts
CMET312.3-PO2	3	Students can analyse and identify the appropriate testing method to follow and helps in developing a thorough understanding.
CMET312.3-PO3	1	Helps students to effectively design the appropriate testing methods to follow.
CMET312.3-PO12	2	Students recognise the need for self-study and importance of earning skills in Non-Destructive Testing through lifelong learning
CMET312.4-PO1	3	Students use the knowledge to build upon the existing fundamental concepts
CMET312.4-PO2	3	Students can analyse and identify the appropriate testing method to follow and helps in developing a thorough understanding.
CMET312.4-PO3	2	Helps students to effectively design the appropriate testing methods to follow.
CMET312.4-PO12	2	Students recognise the need for self-study and importance of earning skills in Non-Destructive Testing through lifelong learning
CMET312.5-PO1	3	Students use the knowledge to build upon the existing fundamental concepts
CMET312.5-PO2	3	Students can analyse and identify the appropriate testing method to follow and helps in developing a thorough understanding.
CMET312.5-PO3	1	Helps students to effectively design the appropriate testing methods to follow.

CMET312.5-PO12	1	Students recognise the need for self-study and importance of earning skills in Non-Destructive Testing through lifelong learning

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
CMET312.1-PSO1	3	Apply the knowledge of advanced technology in engineering
CMET312.2-PSO1	3	Apply the knowledge of advanced technology in engineering
CMET312.3-PSO1	3	Apply the knowledge of advanced technology in engineering
CMET312.4-PSO1	3	Apply the knowledge of advanced technology in engineering
CMET312.5-PSO1	3	Apply the knowledge of advanced technology in engineering
CMET312.6-PSO1	3	Apply the knowledge of advanced technology in engineering

JUSTIFATIONS FOR CO-PSO MAPPING

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

SI NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	No hands on training	One day training in NDT equipments	PO1, PO2, PO3	PSO1

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SL NO	TOPIC	RELEVENCE TO PO\PSO
1	NDT ASNT Level 2 international certification course	PO1,PO2,PO3,PSO1

WEB SOURCE REFERENCES:

1	www.nptel.ac.in
2	https://www.nde-ed.org/

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

8.2 COURSE PLAN

Module 1

Sl. No.	*Topic*	*No. of lecture hours*
1	NDT Versus Mechanical testing-Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterization	2

2	Relative merits and limitations-various physical characteristics of materials and their applications in NDT	1
3	Fundamentals of Visual Testing – vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods	1
4	Mirrors, magnifiers, Boroscopes and fibro scopes	1
5	light sources and special lighting, calibration- computer enhanced system	2
Total hours : 7		

Module 2

Sl. No.	*Topic*	*No. of lecture hours*
1	Liquid Penetrant Inspection: Principles – types and properties of liquid penetrants – developers	1
2	Advantages and limitations of various methods - Preparation of test materials	1
3	Application of penetrants to parts, removal of excess penetrants, post cleaning	1
4	Control and measurement of penetrant process variables – selection of penetrant method	1
5	solvent removable, water washable, post emulsifiable – Units and lighting for penetrant testing	1
6	calibration- Interpretation and evaluation of test results – dye penetrant process applicable codes and standards	2
Total hours: 7		

Module 3

Sl. No.	Topic	No. of lecture hours
1	Magnetic Particle Inspection (MPI): Important terminologies related to magnetic properties of material	1
2	Principle-magnetizing technique, procedure, and equipment, fluorescent magnetic particle testing method, Sensitivity.	1
3	Methods of magnetization, magnetization techniques such as head shot technique, cold shot technique- central conductor testing	1
4	magnetization using products using yokes-direct and indirect method of magnetization - continuous testing of MPI	1
5	residual technique of MPI- checking devices in MPI	1
6	Indications, advantage and limitation of MPI	1
Total hours : 6		

Module 4

Sl. No.	Topic	No. of lecture hours
1	Ultrasonic Testing: Basic principles of sound propagation, types of sound waves, Principle of UT-methods of UT	1
2	Piezoelectric Material, Various types of transducers/probe Calibration methods, contact testing and immersion testing, normal beam and straight beam testing	1
3	Angle beam testing, dual crystal probe, ultrasonic testing techniques resonance testing, through transmission technique, pulse echo testing technique	1

4	Accessories such as transducers, types, frequencies, and sizes commonly used. Reference of standard blocks	1
5	Technique for normal beam inspection Thickness determination by ultrasonic method	1
6	Study of A, B and C scan presentations, Instruments used	1
7	Time of Flight Diffraction (TOFD).	1
Total hours : 7		

Module 5

Sl. No.	*Topic*	*No. of lecture hours*
1	Radiography: X-rays and Gamma rays, Properties of X-rays relevant to NDE - Absorption of rays - scattering	1
2	Characteristics of films- graininess, Density, Speed, Contrast. Characteristic curves. Inspection techniques like SWSI, DWSI, DWDI	1
3	Panoramic exposure, real time radiography, films used in industrial radiography	1
4	Eddy Current Testing: Generation of eddy currents – effect of change of impedance on instrumentation – properties of eddy currents	1
5	Eddy current sensing elements, probes, type of coil arrangement – absolute, differential, lift off, operation, applications, advantages, limitations	1
6	Field factor and lift of effect, edge effect, end effect, impedance plane diagram in brief, depth of penetration of ECT	1

7	Relation between frequency and depth of penetration in ECT.	1
Total hours : 7		

8.3 MODULE WISE SAMPLE QUESTIONS

MODULE: 1

1. Define Non-destructive testing?

2. Explain the basic principle of Visual testing?

3. Explain the different uses of non-destructive testing?

4. Write a note on the importance of Eye in Visual testing.

5. Compare destructive and non-destructive testing.

6. Explain the various optical aids used for Visual Inspection.

7. Write a short note on Future progresses and economic aspects of NDT.

8. Explain the characteristics of a good penetrant and the different types of penetrants?

MODULE: 2

1. Explain the sequence of operation of Liquid penetrant testing?

2. Explain the basic principle of Liquid penetrant testing?

3. Explain the properties required for a good penetrants and developers?

4. Explain the different types of penetrants and developers?

MODULE: 3

1. How are the materials classified based on their interaction with a magnetic field?

2. Explain the Hysteresis Loop and Magnetic Properties of a material?

3. What is Magnetic Particle Inspection. What are it's advantages and disadvantages?

4. How are the materials classified based on their interaction with a magnetic field?

5. Describe the important safety precautions that are to be followed in Magnetic Particle Inspection (M.P.I)?

MODULE: 4

1. Compare X-rays and Gamma rays?

2. What is Snell's Law and its significance in Ultrasonic Testing?

3. Explain various methods of inspection using ultrasonic testing?

4. Explain the different modes of wave propagation? Also explain the main properties of Acoustic plane wave?

5. Explain shear waves in Ultrasonic Testing? What are it's limitations?

6. Explain the various data presentation formats in Ultrasonic Testing? Also explain it's various measurement and calibration techniques?

MODULE: 5

1. Define the terms (a) Radiation Energy, (b) Intensity, (c) Exposure and (d) Ionization in Radiographic Testing?

2. Describe the inspection techniques (i) DWSI and (ii) DWDI used in Radiographic Testing (RT) with simple sketches?

3. Explain the basic principle of Radiographic Testing. Also state it's applications, advantages and disadvantages?

4. Define Permeability?

5. State the basic principle of Radiographic Testing (RT) with simple sketches and explain about various types of electromagnetic radiation sources used in RT method.

6. Define 'lift off effect', 'edge effect' and 'end effect' in ECT?

7. Define the term Isotope Decay Rate (Half-Life)?

8. Explain the working of Piezoelectric transducer with schematic diagram? Also explain the various types of transducers?

9. What are the physical aspects of E.C.T?

10. What is the principle of thermography?

11. Explain how Eddy current testing (E.C.T) is used to measure the following : (i) hardness, (ii) coating thickness and (iii) conductivity ?

12. Describe the principle and operation of non-contact thermographic inspection with a neat sketch. Also state it's advantages and limitations?

Prepared by **Approved by**

Mr. Tony Chacko **Dr. Manoj G Tharian**

(Faculty) **(HOD)**

9. MET352 AUTOMOBILE ENGINEERING

9.1. COURSE INFORMATION SHEET

PROGRAMME: MECHANICAL ENGINEERING	**DEGREE:** BTECH **UNIVERSITY:** APJ Abdul Kalam Technological University
COURSE: AUTOMOBILE ENGINEERING	**SEMESTER:** VI **CREDITS:** 3
COURSE CODE: MET352 **REGULATION:** 2019	**COURSE TYPE:** ELECTIVE
COURSE AREA/DOMAIN: Material Science and Production Engineering	**CONTACT HOURS:** 2 (Lecture) + 1 (Tutorial) hours/week.
CORRESPONDING LAB COURSE CODE (IF ANY): NA	**LAB COURSE NAME:** NA

SYLLABUS:

UNIT	DETAILS	HOURS
I	Components of an automobile. General classification. Conventional Chassis construction- Types of frames- Frameless constructions. Vehicle dimensions. Friction clutch: Principle, dry friction clutches- Pull type diaphragm clutch, multiple diaphragm clutch, multi-plate hydraulically operated automatic transmission clutch, semi centrifugal clutch, fully automatic centrifugal clutch, and integral single plate diaphragm clutch. Electromagnetic clutch operation. Clutch friction materials, wet clutch. Manual transmission- Need of gear box, power to weight ratio, speed operating range-five speed and reverse sliding mesh, constant mesh, and synchromesh gear boxes. Automatic transmission- Epicyclic gear box - torque convertor – Over drives. Automated manual transmission.	7
II	Suspension: - suspension geometry, terminology- Macpherson strut friction and spring offset - suspension roll centers: - roll centers, roll axis, roll center height, short swing and long arm suspension, transverse double wishbone, parallel trailing double arm and vertical pill strut suspension, Macpherson strut suspension, semi-trailing arm rear suspension, telescopic suspension. High load beam axle leaf spring, sprung body roll stability. Rear axle beam suspension- body roll stability analysis: - body roll couple, body roll stiffness, body over turning couple. Rear suspension: - live rigid axle suspension, non-drive rear suspension-swing arm rear wheel drive independent suspension. Low pivot split axle coil spring wheel drive independent suspension, trailing and semi trailing arm rear wheel drive independent suspension. Transverse double link arm rear wheel drive independent suspension, De Dion axle rear wheel suspension - Hydrogen	7

	suspension, hydro-pneumatic automatic height correction suspension.	
III	Brakes: mechanical and hydraulic brakes (review only) – properties of friction lining and pad materials, theory of internal shoe brake, equations – effect of expanding mechanism of shoes on total braking torque, equations. Braking of vehicles: - brakes applied on rear, front and all four wheels, equations –calculation of mean lining pressure and heat generation during braking operation, equations. – braking of vehicle moving on curved path, simple problems. Anti-Lock Braking system (ABS): - hydro-mechanical ABS - hydro-electric ABS – air electric ABS. Brake servos: - direct acting suspended vacuum assisted brake servo unit operation - hydraulic servo assisted brake systems. Pneumatic operated disc brakes – electronic-pneumatic brakes. Regenerative braking system.	7
IV	Steering: -basic principle of a steering system– Ackermann –over steer and under steer – slip angle, camber, king pin inclination, caster, toe-in and toe-out. Steering gear box:-worm and roller type steering gear box – Re-circulating ball nut and rocker lever– need of power assisted steering. Piston for IC engine, piston rings, piston pin, connecting rod, crank shaft, crank pin, cam shaft, valves, fly wheel, fluctuation of energy and size of fly wheel, hub and arms, stress in a fly wheel rim, simple problems. Fuel injection systems: multiport fuel injection (MPFI) and common rail direct injection (CRDI) systems. Super charging in engines, turbo charger, turbo lag. Electric Vehicle Technology (EVT): EV Architecture, types of batteries, battery parameters, super capacitors. Fuel cells and its efficiency. EV Chassis – requirements, suspension for EVs. Recent Electric vehicles-Electric mobility aids. Future of electric vehicles –Tesla S, Maglev trains, Electric rail road systems.	7
V	Aerodynamic drag: pressure drag, air resistance, opposing motion of a vehicle, equations, after flow wake, drag coefficients, various body shapes, base drag, vortices, trailing vortex drag, attached transverse vortices. Aerodynamic lift: -lift coefficients, vehicle lift, underbody floor height versus aerodynamic lift and drag, aerofoil lift and drag, front end nose shape. Car body drag reduction: -profile edge chamfering, bonnet slope and wind screen rake, roof and side panel chamfering, rear side panel taper, under body rear end upward taper, rear end tail extension, under body roughness. Aerodynamic lift control: - under body dams, exposed wheel air flow pattern, partial enclosed wheel air flow pattern, rear end spoiler, negative lift aerofoil wings. After body drag: - square back drag, fast back drag, hatch back drag, notch back drag.	7
TOTAL HOURS		**35**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T1	Heinz Heisler, Vehicle and engine technology, 2nd edition, Butterworth-Heinemann, 1998.
T2	R.B. Gupta., Auto design, Satya Prakashan Publishers, New Delhi, 2016.
T3	James Larminie and John Lowry, Electric vehicle technology explained, 2nd edition, Wiley publications, 2015.
T4	Kirpal Singh, Automobile Engineering Vol.1 & Vol.2, 13th edition, Standard Publishers, 2020.
R1	V.A.W. Hillier, Fundamentals of modern vehicle technology, 2nd edition, Butterworth-Heinemann, 1998.
R2	Tom Denton, Electric and Hybrid Vehicles, 2nd edition, Routledge Publishers, 2020.
R3	Hillier and Peter Coobes, Fundamentals of motor vehicle technology, Nelson Thornes, 2004

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
EST 120	Basics of Civil and Mechanical Engineering	Should have a basic knowledge on types and components of IC engines, their working cycle, CRDI, MPFI and hybrid vehicles	I

COURSE OBJECTIVES:

1	To know the anatomy of automobile in general
2	To understand the working of different automotive systems and subsystems
3	To update the latest developments in automobiles

COURSE OUTCOMES:

SL NO	DESCRIPTION	Bloom's Taxonomy Level
CMET352.1	Students will be able to ***explain*** different automotive systems and subsystems.	Remember (level 1) Understand (level 2)
CMET352.2	Students will be able to ***illustrate*** the principles of transmission, suspension, steering and braking systems of an automobile	Understand (level 2)
CMET352.3	Students will be able to ***build*** a basic knowledge about the technology in electric vehicles	Understand (level 2)
CMET352.4	Students will be able to ***summarize*** the concept of aerodynamics in automobiles	Apply (level 3)

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
CMET352.1	3	-	-	-	-	-	-	-	-	-	-	3	-	-	-
CMET352.2	3	-	-	-	-	-	-	-	-	-	-	3	-	-	-
CMET352.3	3	-	-	-	-	-	-	-	-	-	-	3	-	-	-
CMET352.4	3	-	-	-	-	-	-	-	-	-	-	3	-	2	-
CMET352	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**-**	**2**	**-**

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
CMET352.1-PO1	H	Identifying and explaining automobile system requires the application level knowledge in engineering fundamentals
CMET352.1-PO12	H	With the knowledge gained they can decide their area of interest for higher studies.
CMET352.2-PO1	H	Application level knowledge in mechanical engineering is essential in understanding the principles of transmission, suspension, steering and braking systems of an automobile
CMET352.2-PO12	H	With the knowledge gained they can decide their area of interest for higher studies.
CMET352.3-PO1	H	Fundamental knowledge in electric vehicle technology helps them to understand the current technological changes occurring in electrical vehicles
CME463.3-PO12	H	They have a life-long learning in the broadest context of technological change..
CMET352.4-PO1	H	While learning aerodynamic drag, lift etc. they could apply their knowledge to solve engineering problems.
CMET352.4-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
CMET352. 4-PSO2	M	Students will be able to apply the principles of design and analysis in the aerodynamic design of automobiles.

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

SL NO	DESCRIPTION	RELEVENCE TO PO\PSO	PROPOSED ACTIONS
1	Emissions from petrol and diesel vehicles – prevention and control methods	PO7, PO10, PO12	Seminar/ Assignment

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	Automotive Electronics	PO3, PO6, PO10, PO12
2	Latest technologies adopted in various systems in automobile	PO3, PO6, PO10, PO12

WEB SOURCE REFERENCES:

1	https://nptel.ac.in/courses/108106170
2	https://archive.nptel.ac.in/courses/108/103/108103009/
3	http://web.iitd.ac.in/~achawla/public_html/736/15-Suspension_systems_and_components_v2.pdf
4	https://nptel.ac.in/courses/107106080
5	https://www.youtube.com/watch?v=qhvi7f4c3bw
6	https://nptel.ac.in/courses/107106088
7	http://www.tezu.ernet.in/sae/Download/transmission.pdf
8	http://www.oecd.org/eco/outlook/48333701.pdf
9	https://www.youtube.com/watch?v=FeXZq_w9mZo

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**

Mr. Jibin Noble
(Faculty)

Dr.Manoj G. Tharian
(HoD)

9.2 COURSE PLAN

DAY	MODULE	TOPIC PLANNED
1	I	Introduction, Chassis construction- Types of frames.
2	I	Frameless construction, Vehicle dimensions
3	I	Principle of dry friction clutches- Single plate, Multi plate.
4	I	Semi centrifugal clutch, fully automatic centrifugal clutch, and
5	I	Integral single plate diaphragm clutch. Electromagnetic clutch operation., clutch friction materials, wet clutches
6	I	Sliding mesh, constant mesh , synchromesh gear boxes, epicyclic gear boxes
7	I	Torque convertor, Over drives, Automated manual transmission
8	II	Suspension: - suspension geometry, terminology. Macpherson strut friction and spring offset.

9	II	Suspension roll centers:-roll centers, roll axis, roll centre height, short swing and long arm suspension.
10	II	Transverse double wishbone, parallel trailing double arm and vertical pill strut suspension, Macpherson strut suspension, semi-trailing arm rear suspension, telescopic suspension.
11	II	High load beam axle leaf spring, sprung body roll stability. Rear axle beam suspension- body roll stability analysis:- body roll couple, body roll stiffness, body over turning couple.
12	II	Rear suspension: - live rigid axle suspension, non drive rear suspension-swing arm rear wheel drive independent suspension.
13	II	Low pivot split axle coil spring wheel drive independent suspension, trailing and semi trailing arm rear wheel drive independent suspension.
14	II	Transverse double link arm rear wheel drive independent suspension, De Dion axle rear wheel suspension. Hydrogen suspension, hydro-pneumatic automatic height correction suspension.
15	III	Types of Brakes, Properties of friction lining and pad materials. Theory of internal shoe brake, equations
16	III	Effect of expanding mechanism of shoes on total braking torque, equations.
17	III	Braking of vehicles:- brakes applied on rear, front and all four wheels, equations.
18	III	Calculation of mean lining pressure and heat generation during braking operation, equations.
19	III	Braking of vehicle moving on curved path, simple problems. Hydro-mechanical ABS - hydro-electric ABS
20	III	Air-electric ABS. Brake servos: -direct acting suspended vacuum assisted brake servo unit operation - Hydraulic servo assisted brake systems.
21	III	Pneumatic operated disc brakes - electronic-pneumatic brakes. Regenerative braking systems.
22	IV	Ackermann steering mechanism, over steer and under steer.
23	IV	Worm and roller type steering gear box, Re-circulating ball nut and rocker lever, power assisted steering.
24	IV	IC engines, piston, rings, pin, flywheel, connecting rod. Crank shaft, crank pin, cam shaft, valve mechanism
25	IV	Fuel injection systems ,Turbochargers, turbo lag.
26	IV	EV Architecture, types of batteries, battery parameters, super capacitors. Fuel cells and its efficiency.
27	IV	EV Chassis - requirements, suspension for EVs. Recent Electric

		vehicles- Electric mobility aids.
28	IV	Future of electric vehicles -Tesla S, Maglev trains, Electric rail road systems.
29	V	Aerodynamic drag: pressure drag, air resistance, opposing motion of a vehicle.
30	V	Flow wake, drag coefficients, various body shapes, base drag, vortices, trailing vortex drag, attached transverse vortices.
31	V	Aerodynamic lift-lift coefficients, vehicle lift. Under body floor height versus aerodynamic lift and drag. Aerofoil lift and drag, front end nose shape.
32	V	Car body drag reduction:-profile edge chamfering, bonnet slope and wind screen rake.
33	V	Roof and side panel chamfering, rear side panel taper, under body rear end upward taper, rear end tail extension, under body roughness.
34	V	Aerodynamic lift control:- under body dams, exposed wheel air flow pattern, partial enclosed wheel air flow pattern, rear end spoiler, negative lift aerofoil wings.
35	V	After body drag: - square back drag, fast back drag, hatch back drag, notch back drag.

9.3 MODULE WISE SAMPLE QUESTIONS

Module 1

1. List any four components of a chassis.
2. List the three types of chassis construction
3. Mention the different loads acting on vehicle frame.
4. Write about the requirements of frame and selection of cross section for the frame members.
5. Compare integral body construction and chassis body construction.
6. What is the function of an automobile clutch? Name the various types of clutches used in automobiles.
7. Explain different types of materials used for linings in clutches.
8. Explain the construction and working of Pull type diaphragm clutch.
9. Explain the construction and working of Multiplate diaphragm type clutch.

10. Explain the construction and working of Multiplate hydraulically operated automatic transmission clutches.
11. Explain the construction and working of Semi Centrifugal Clutch.
12. Explain the construction and working fully automatic centrifugal clutch.
13. Explain the construction and working Composite flywheel and integral single plate diaphragm clutch.
14. Explain the necessity of gear box in automobiles?
15. Explain the construction and working of Hydrokinetic fluid couplings.
16. What is a torque converter? Why it is used in some vehicles?
17. What is an overdrive unit? Mention its advantages.
18. Describe the principle of a torque converter. Discuss its advantages and disadvantages.
19. Discuss the advantages of a constant mesh gear box over the sliding mesh type.
20. Explain the working of Sliding mesh gear box.
21. Explain the working of Constant mesh gear box.
22. Explain the construction and working of five speed and reverse double stage s synchromesh gearbox.
23. Explain the construction and working of five speed and reverse single stage synchromesh gearbox.
24. Explain Hydrokinetic fluid coupling efficiency and torque capacity.
25. Explain Hydrokinetic three clement torque converter.

Module 2

1. Briefly explain the suspension geometry.
2. What is Roll center and Roll axis? With the help of a neat sketch determine the roll center height.
3. Derive the roll center height for short swing arm suspension.
4. With the help of a neat sketch explain Long swing arm suspension.
5. With the help of a neat sketch explain Transverse double wishbone suspension.
6. With the help of a neat sketch explain Parallel trailing double arm and vertical pillar strut suspension.
7. With the help of a neat sketch explain MacPherson strut suspension.
8. With the help of a neat sketch explain Semi-trailing arm rear suspension.
9. With the help of a neat sketch explain telescopic suspension.
10. With the help of a neat sketch explain Rigid axle beam suspension.
11. Explain Body roll stability analysis.
12. With the help of neat sketches explain:
    Body roll couple
    Body roll stiffness
    Body overturning couple
13. Explain anti-roll bars.
14. Explain live rigid axle rear suspension.

15. Explain Swing arm rear wheel drive independent suspension.
16. Explain Low pivot split axle coil spring rear wheel drive independent suspension.
17. Explain Trailing arm rear wheel drive independent suspension.
18. Explain Semi-trailing arm rear wheel drive independent suspension.
19. Explain Transverse double link arm rear wheel drive independent suspension.
20. Explain DeDion axle rear wheel drive suspension.
21. Explain Hydrogen interconnected suspension.
22. Explain Hydropneumatic automatic height correction suspension.

Module 3

1. What is the principle of automotive brakes?
2. What is the basics of defining braking efficiency?
3. What should be the minimum stopping distance for a car running at 80kmh?
4. What is the usual percentage of total braking effort provided at the front wheels and why?
5. Describe any type of a regenerative brake system.
6. Derive the equation for finding
   (a) brakes applied on rear,
   (b) brakes applied on front
   (c) brakes applied on all four wheels
7. What is a servo brake?
8. What do you understand from the term ‘Servo action’ in brakes? How is it achieved?
9. What is ABS?
10. Derive the equation for finding the mean lining pressure and heat generated during braking operation.
11. How is the vacuum from the engine intake manifold is utilized to actuate the vehicle brakes? Explain with neat and labeled line diagrams.
12. Briefly describe the main features of an air brake system.
13. What are the various types of power brakes? Discuss their merits and demerits.
14. Explain
    (a) hydro-mechanical ABS
    (b) hydro-electric ABS
    (c) air-electric ABS.
15. Explain the working of direct acting suspended vacuum assisted brake servo unit.
16. A car weighs 13kN and has a wheel base of 2.5 meters. The center of gravity of the car is 1.2m in front of the rear axle and 800 cm above the ground level. The car is having brakes on all four wheels. The coefficient of adhesion between the road and the wheels is 0.5. If the car is moving up an incline of angle whose sine is equal to 0.1, calculate: (a) load distribution between front and rear axles. (b) distance at which it can be stopped while going at a speed of 50 kmh when only rear wheel brakes are used.

Module 4

1. State the requirements of a good steering system.
2. What are the functions of steering system?
3. Define camber, SAI and castor.
4. What is center point steering?

5. What is slip angle?
6. Define understeer and oversteer.
7. Explain with the help of neat and labeled sketches the significance of the following?
   Camber
   Caster
   Kingpin inclination
   Toe in
   Toe out
8. Explain the principle of Ackerman Steering Mechanism.
9. What does steering axis inclination mean? What is its effect on steering system.
10. Describe with the help of a neat sketch Worm and roller type steering gearbox.
11. Describe with the help of a neat sketch Recirculating ball nut and rocker lever steering gearbox.
12. Explain Recirculating hall rack and seem steering gear box.
13. Describe with the help of a neat sketch
14. What is the necessity of a power steering? Describe in detail with the help of a sketch the working of power steering in common use.
15. Describe the various qualities of an automotive piston.
16. Discuss the various functions piston in an automobile cylinder.
17. What is piston clearance? Why it is necessary?
18. With the help of suitable sketches explain the constructional features of various types of piston rings.
19. Explain with simple line sketches the working of compression and oil control rings.
20. Describe the functions of I. C. Engine connecting rod.
21. Explain the function and construction of an I.C. Engine crank shaft.
22. Why do some connecting rods have hole drilled from the small end to the big end bearings?
23. Why poppet valve is so called? Why a poppet valve sometimes called a mushroom valve?
24. What is the function of camshaft?
25. How does the piston head shape affect engine performance?
26. What are skirt, land, and crown in a piston?
27. What is the function of piston skirt?
28. Name the best known aluminum alloys for automotive pistons.
29. Explain in detail about the various types of materials used for manufacturing piston.
30. What is the advantage of a cast steel piston?
31. What are the functions of piston rings?
32. Which type of ring end gap is most commonly used?
33. State any two materials used for piston rings.
34. What advantage is obtained by having phosphate coating over the piston rings?
35. State the advantages of chrome plating the piston rings.
36. What advantage is obtained by using stainless steel for piston rings?
37. How many rings are usually there on a piston of a automotive engine?
38. Why are a minimum of two compression rings required on a piston?
39. What functions are performed by a compression ring?
40. What advantage is obtained by having a tapered external face for a piston ring?
41. What is the function of a connecting rod?

42. Why should the connecting rod be lighter yet strong?
43. Name any two materials used for connecting rods.
44. Give a comparison between MPFI and CRDI system.
45. Explain fuel injection in SI engines.
46. With the help of a neat sketch explain CRDI.
47. Give a note on supercharged engines and naturally aspirated engines.
48. Explain the construction and operating principle of a turbocharger.
49. What is turbo lag?
50. What is supercharging and how is it achieved in automotive IC engines?
51. Which engine is more suited to supercharging, Si engine or CI engine?
52. What do you mean by CRDI? How does it improve the efficiency of the engine?
53. Make a sectioned sketch of a petrol engine piston and name its various parts.
54. A 2.2 kW, 960 rpm motor powers the cam driven ram of a press through a gearing of 6:1 ratio. The rated capacity of the press is 20 kN and has a stroke of 200 mm. Assuming that the cam driven ram is capable of delivering the rated load at a constant velocity during the last 15% of a constant velocity stroke. Design a suitable flywheel that can maintain a coefficient of Speed fluctuation of 0.02. Assume that the maximum diameterof the flywheel is not to exceed 0.6m.
55. A single-cylinder, four- stroke oil engine develops 25 kW at 300 rpm. The work done by the gases during expansion stroke is 2.3 times the work done on the gases during compression stroke and the work done during the suction and exhaust strokes is negligible. If the turning moment diagram during expansion is assumed to be triangular in shape and the speed is to be maintained within 1% of the meanspeed, find the moment of inertia of the flywheel.
56. The following data refers to a single-cylinder four cycle diesel engine speed = 2500 rpm, stroke = 25cm, diameter of cylinder = 21 cm, length of connecting rod = 44 cm, CG of connecting rod is 18 cm from crank pin center, time for 60 complete swings of the connecting rod about piston pin = 72 s, mass of connecting rod = 4.5 kg, mass of piston with rings = 2.5 kg, equivalent mass of crank at crank radius = 2 kg, counterbalance mass of the crank at crank radius = 2 kg, piston pin, crank pin and main bearing diameters 2, 8 and 8 cm respectively. The indicator card is assumed as an idealised diesel cycle, which can be described as follows: The compression starts with an initial pressure of 0.1 MPa and the law of compression curve is given by the exponent 1.4. The compression ratio is 16. The fuel is admitted for 30% of the stroke, at constant pressure and the expansion law is given by the exponent 1.4, which takes place at the end of the stroke. The exhaust and suction takes place at constant pressure of 0.1 MPa. Suggest a suitable flywheel for this engine if the coefficient of fluctuation of speed is 0.03.
57. Explain the basic principle of hydrogen fuel cell and its efficiency.
58. Explain the technology of high speed electric trains.
59. What is the difference between an electric vehicle and a hybrid vehicle?

60. List out the differences in the chassis design of an electric vehicle comparing with the conventional chassis.
61. Explain the basic operation of a fuel cell.

Module 5

1. What are the various forces that act on a moving vehicle?
2. Explain vehicle drag.
3. Define coefficient of rolling resistance.
4. Explain the term rolling resistance.
5. What are the factors that affect rolling resistance?
6. Explain the term grad ability and draw bar pull.
7. Explain pressure drag. How can it be reduced?
8. Derive the formula for calculating the opposing resistance of a body passing through air.
9. What is after flow wake?
10. What is drag coefficient? Explain it for different body shapes.
11. With the help of a neat sketch, explain vehicle lift.
12. With the help of neat sketches, explain aerofoil lift and drag.
13. With the help of neat sketches explain the air flow movement over various front end nose shapes.
14. Discuss the effects of following in car body drag reduction:
    (a) profile edge chamfering,
    (b) Bonnet slope and wind screen rake
    (c) roof and side panel chamfering
    (d) rear side panel taper
    (e) underbody rear end upward taper
    (f) rear end tail extension
    (g) Underbody roughness.
15. With the help of neat sketches explain the effects of following in aerodynamic lift control.
    (a) underbody dams
    (b) exposed wheel air flow pattern
    (c) partial enclosed wheel air flow pattern
    (d) rear end spoiler
    (e) negative lift aerofoil wings.
16. Explain:square back drag, fast back drag, hatch back drag and notch back drag.

Prepared by

Mr. Jibin Noble
(Faculty)

Approved by

Dr.Manoj G. Tharian
(HoD)

10. MET362 PRODUCT DEVELOPMENT AND DESIGN

10.1 COURSE INFORMATION SHEET

PROGRAMME: ME	***DEGREE:*** BTECH
PROGRAMME: MECHANICAL ENGINEERING	DEGREE: **B.TECH** UNIVERSITY**: A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
COURSE: PRODUCT DEVELOPMENT AND DESIGN	SEMESTER**: VI** CREDITS: **3**
COURSE CODE: MET362 ***REGULATION: UG***	COURSE TYPE: **ELECTIVE**
COURSE AREA/DOMAIN: MECHANICAL SYSTEMS ,DESIGN AND ANALYSIS	CONTACT HOURS: **3+1 (Tutorial) hours/Week.**

SYLLABUS:

UNIT	***DETAILS***	***HOURS***
I	Introduction: Classification/ Specifications of Products, Product life cycle, product mix. Introduction to product design, Modern product development process Design by evolution, Design by innovation, Morphology of design. Ethics in product design, legal factors and social issues.	6
II	Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design. Conceptual Design: Generation, selection & embodiment of concept, Product architecture. Industrial design: process, need. Robust Design: Taguchi Designs, Design of experiments.	6
III	Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly. Design for Maintenance. Design for Environment. Ergonomics in product design. Aesthetics in product design. Concepts of size and texture color.	7
IV	Value Engineering / Value Analysis: Definition. Methodology, Case studies. Product costing. Economic analysis: Qualitative & Quantitative. Psychological and Physiological considerations.	7
V	Concurrent Engineering -Elements of concurrent engineering, Benefits Rapid prototyping: concepts, processes and advantages. Reverse engineering: steps in reverse engineering- hardware and software in reverse engineering Tools for product design – Drafting / Modeling software. Patents & IP Acts-Overview, Disclosure preparation.	9
TOTAL HOURS		**35**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T1	Karl T Ulrich, Steven D Eppinger, *Product Design & Development* Tata McGraw Hill, 2003
R1	Baldwin E N, Neibel B W, *Designing for Production* Edwin Homewood Illinois.
R2	Bralla J G (Ed.), *Handbook of Product Design for Manufacture* McGraw Hill, NewYork, 1986
R3	D. T. Pham, S.S. Dimov, *Rapid Manufacturing-The Technologies and Applications of Rapid Prototyping and Rapid Tooling*, Springer – Verlag, London, 2001.
R4	David G Ullman, *The Mechanical Design Process* McGraw Hill Inc Singapore 1992
R5	Hollins B, Pugh S, *Successful Product Design* Butter worths London, 1990
R6	Jones J C, *Design Methods Seeds of Human Futures* John Willey, 1970
R7	Kevin Otto, Kristin Wood, *Product Design: Techniques in Reverse Engineering and new Product Development*, Pearson Education New Delhi, 2000
R8	N J M Roozenberg, J Ekels, N F M Roozenberg, *Product Design Fundamentals and Methods* John Willey & Sons 1995.
R9	Andreas Gebhardt, *Rapid Prototyping*, Carl Hanser – Verlag, Munich, 2003

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
	NIL		

COURSE OBJECTIVES:

1	To create confidence in developing new products.
2	To acquaint with methods and tools for product design and development.
3	To equip with practical knowledge in conceptualization, design and development of new product.

COURSE OUTCOMES:

SNO	DESCRIPTION	Bloom's Taxonomy Level
CMET 362.1	Determine the life cycle of a product and product development process.	Understand (level 3)
CMET 362.2	Develop knowledge of robust design and conceptual design	Understand (level 3)
CMET 362.3	Introduce the concept of Design for Manufacturing and Assembly	Understand

	in product design.	(level 3)
CMET 362.4	Use value engineering in the development of product.	Apply (level 3)
CMET 362.5	Incorporate ergonomics and rapid prototyping in product development.	Apply (level 3)

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*
CMET 362.1	3	3	2											2	
CMET 362.2	3	3	2											2	
CMET 362.3	3	3	2											2	3
CMET 362.4	3	3	2											2	
CMET 362.5	3	3	2											2	3

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
CMET 362.1-PO 1	H	The students will be able to apply the knowledge of Engineering fundamentals and Mechanical Engineering to determine the life cycle of a product and product development process.
CMET 362.1-PO 2	M	By the application of Problem analytical skills like Identification, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions to Determine the life cycle of a product and product development process.
CMET 362.1-PO 3	M	By determining the life cycle of a product and product development process the student will be able to design solutions for complex Engineering problems and design system components or processes that meet the specified needs.
CMET	M	The students will be able to apply: Apply the knowledge

362.2-PO1		of Engineering fundamentals and Mechanical engineering to Develop knowledge of robust design and conceptual design.
CMET 362.2-PO 2	H	By the application of Problem analytical skills like Identification, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions to Develop knowledge of robust design and conceptual design
CMET 362.2-PO 3	M	Developing the knowledge of robust design and conceptual design the student will be able to design solutions for complex Engineering problems and design system components or processes that meet the specified needs.
CMET 362.3-PO 1	H	The students will be able to apply the knowledge of Engineering fundamentals and Mechanical Engineering to Introduce the concept of Design for Manufacturing and Assembly in product design.
CMET 362.3-PO 2	M	By the application of Problem analytical skills like Identification, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions to Introduce the concept of Design for Manufacturing and Assembly in product design
CMET 362.3-PO 3	M	Understanding the concept of Design for Manufacturing and Assembly in product design student will be able to Design solutions for complex Engineering problems and design system components or processes that meet the specified needs.
CMET 362.4-PO 1	H	The students will be able to apply the knowledge of Engineering fundamentals and Mechanical Engineering to Use value engineering in the development of product.
CMET 362.4-PO 2	H	By the application of Problem analytical skills like Identification, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions to Use value engineering in the development of product.
CMET	M	Applying the value engineering in the development of

362.4-PO 3		product student will be able to design solutions for complex Engineering problems and design system components or processes that meet the specified needs.
CMET 362.5-PO 1	M	The students will be able to apply the knowledge of Engineering fundamentals and Mechanical Engineering to Incorporate ergonomics and rapid prototyping in product development.
CMET 362.5-PO 2	M	By the application of Problem analytical skills like Identification, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions to Incorporate ergonomics and rapid prototyping in product development.
CMET 362.5-PO 3	H	Applying the ergonomics and rapid prototyping in product development the student will be able to arrive at design solutions for complex Engineering problems and design system components or processes that meet the specified needs.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
CMET 362.1-PSO 2	M	Knowledge on the life cycle of a product and product development process help to Successfully implement the principles of design, analysis and implementation of mechanical systems.
CMET 362.2-PSO 2	M	knowledge of robust design and conceptual design can be applied to the design, analysis and implementation of mechanical systems.
CMET 362.3-PSO 2	M	The concept of Design for Manufacturing and Assembly in product design will enable to Successfully design, analysis and implementation of mechanical systems.
CMET 362.4-PSO 2	M	Use of value engineering in product development the principles of design, analysis and implementation of mechanical systems can be done successfully.
CMET 362.5-PSO 2	M	Involving ergonomics and rapid prototyping techniques in product development the student can successfully apply the principles of design, analysis and implementation of mechanical systems.

CMET 362.3-PSO 3	M	Introducing the concept of Design for Manufacturing and Assembly in product design with the help of modern CAD/CAM tools, ensures the best manufacturing practices.
CMET 362.5-PSO 3	M	Incorporate ergonomics and rapid prototyping in product development to develop and implement new ideas with the help of modern CAD/CAM tools.

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:

SINO:	TOPIC	RELEVENCE TO PO\PSO
	Nil	

WEB SOURCE REFERENCES:

1	https://www.youtube.com/watch?v=j_bQf0InYHM
2	https://2012books.lardbucket.org/pdfs/an-introduction-to-business-v2.0/s14-product-design-and-development.pdf
3	https://nptel.ac.in/courses/112107217
4	https://nptel.ac.in/courses/112104230
5	https://www.youtube.com/watch?v=-TDn25K-Jh4
6	https://www.youtube.com/watch?v=EdDgrkjiFbI
7	https://www.youtube.com/watch?v=oDdOqLblmVQ

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	*MODULE*	*TOPIC PLANNED*
1	1	Introduction: Classification/ Specifications of Products
2	1	Product life cycle, product mix.
3	1	Introduction to product design
4	1	Modern product development
5	1	Design by evolution, Design by innovation, Morphology of design
6	1	Ethics in product design, legal factors and social issues.
7	2	Creativity Techniques: Creative thinking, conceptualization, brain storming
8	2	primary design, drawing, simulation, detail design.
9	2	Conceptual Design: Generation, selection & embodiment of concept
10	2	Product architecture
11	2	Industrial design: process, need.
12	2	Robust Design: Taguchi Designs, Design of experiments.
13	3	Design for Manufacturing and Assembly:
14	3	Methods of designing for Manufacturing and Assembly.
15	3	Design for Maintenance
16	3	Design for Environment.
17	3	Ergonomics in product design
18	3	Aesthetics in product design.
19	3	Concepts of size and texture color.
20	4	Value Engineering / Value Analysis: Definition. Methodology, Case studies
21	4	Value Engineering / Value Analysis: Definition. Methodology, Case studies

22	4	Product costing.
23	4	Economic analysis: Qualitative & Quantitative.
24	4	Economic analysis: Qualitative & Quantitative.
25	4	Psychological and Physiological considerations.
26	4	Psychological and Physiological considerations.
27	5	Concurrent Engineering
28	5	Elements of concurrent engineering, Benefits
29	5	Rapid prototyping: concepts, processes and advantages.
30	5	Rapid prototyping: concepts, processes and advantages.
31	5	Reverse engineering: steps in reverse engineering- hardware and software in reverse engineering
32	5	Reverse engineering: steps in reverse engineering- hardware and software in reverse engineering
33	5	Tools for product design – Drafting / Modeling software
34	5	Tools for product design – Drafting / Modelling software
35	5	Patents & IP Acts- Overview, Disclosure preparation.

10.3 MODULE WISE SAMPLE QUESTIONS

MODULE 1

1. State the features of a good product design.
2. Explain the morphology of design.
3. Describe about the product life cycle.
4. Explain the various steps involved the morphology of design?
5. Analyze the steps and responsibilities involved in the development of a new product with the help of an example?

MODULE II

1. Discuss the brainstorming technique.
2. Discuss about the robust design.
3. Describe the industrial design process.
4. Discuss the various steps in robust design process?
5. Analyze the various activities involved in the industrial design process?

MODULE III

1. Explain DFM Method in design.
2. Explain the importance of ergonomics in product design.

3. Explain the environmental impacts derived from the manufacturing sector.
4. Elaborate the role of ergonomic factors in product design?
5. Analyze the ergonomic factors that need to be considered in the design of a chair?
6. Explain how the design for assembly affects the product design with the help of two examples?

MODULE IV

1. Discuss the advantages of value analysis.
2. Compare Value analysis and value engineering.
3. Discuss some of the quantitative economic analysis tool used in industry.
4. Define Value Engineering. Explain the application of the value engineering concept with the help of two case studies?
5. How the cost of a product is determined? Explain with suitable example.

MODULE V

1. Describe the steps in reverse engineering.
2. Explain the concept of Concurrent Engineering, Rapid prototyping
3. Explain about the patenting system.
4. Analyze the major factors that contribute to the improved product quality by incorporating the concurrent engineering concept?
5. Explain Stereo-lithography and Fused Deposition Modelling with sketch. Compare the advantages and disadvantages of these techniques?

Prepared by
Mr. Jithin K Francis
(Faculty)

Approved by
Dr.Manoj G Tharian
(HOD)

11. HUT310 MANAGEMENT FOR ENGINEERS

11.1 COURSE INFORMATION SHEET

PROGRAMME: ME	*DEGREE: BTECH*
COURSE: *MANAGEMENT FOR ENGINEERS*	**SEMESTER:** 6 **CREDITS:** 3
COURSE CODE: *HUT310* ***REGULATION:*** *2019*	**COURSE TYPE:** Common
COURSE AREA/DOMAIN: *Management*	**CONTACT HOURS:** 3 hours/week
CORRESPONDING LAB COURSE CODE (IF ANY): NIL	**LAB COURSE NAME: NA**

SYLLABUS:

UNIT	*DETAILS*	*HOURS*
1	**Module 1 (Introduction to management Theory** **Introduction to management theory, Management Defined, Characteristics of Management, Management as an art-profession, System approaches to Management, Task and Responsibilities of a professional Manager, Levels of Manager and Skill required.**	7
2	**Module 2 Management and organization** **Management Process, Planning types , Mission, Goals, Stra Programmes, Procedures, Organising, Principles of Organisation, Delega Span of Control, Organisation Structures, Directing, Leadership, Motiva Controlling..**	5
3	**Module 3 Productivity and decision making** Concept of productivity and its measurement; Competitiveness; Decision making process; decision making under certainty, risk and uncertainty; Decision trees; Models of decision making.	7
4	**Module 4 Project management** Project Management, Network construction, Arrow diagram, Redundancy. CPM and PERT Networks, Scheduling computations, PERT time estimates, Probability of completion of project, Introduction to crashing.	8
5		8

	Module 5 (functional areas of management **Introduction to functional areas of management, Operations management, Human resources management, Marketing management, Financial management, Entrepreneurship, Business plans, Corporate social responsibility, Patents and Intellectual property rights.**	
	TOTAL HOURS	35

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHORS/PUBLICATION*
R	**H. Koontz, and H. Weihrich, Essentials of Management: An International Perspective. 8th ed., McGraw-Hill, 2009.**
T	**P C Tripathi and P N Reddy, Principles of management, TMH, 4th edition, 2008**
T	**P. Kotler, K. L. Keller, A. Koshy, and M. Jha, Marketing Management: A South Asian Perspective. 14th ed., Pearson, 2012.**
T	**M. Y. Khan, and P. K. Jain, Financial Management, Tata-McGraw Hill, 2008**
R	**R. D. Hisrich, and M. P. Peters, Entrepreneurship: Strategy, Developing, and Managing a New Enterprise, 4th ed., McGraw-Hill Education, 1997**
R	**D. J. Sumanth, Productivity Engineering and Management, McGraw-Hill Education, 1985**
R	**K. Ashwathappa, 'Human Resources and Personnel Management', TMH, 3 rd edition, 2005**
T	**R. B. Chase, Ravi Shankar and F. R. Jacobs, Operations and Supply Chain Management, 14th ed. McGraw Hill Education (India), 2015**

COURSE PREREQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
NIL	NIL	NA	-

COURSE OBJECTIVES:

1	To learn the basic concepts and functions of management and its role in the performance of an organization
2	To understand various decision-making approaches available for managers to achieve excellence
3	Students will have a broad view of different functional areas of management like operations, human resource, finance and marketing.

COURSE OUTCOMES:

SL. NO.	DESCRIPTION	Bloom's Taxonomy Level
C310.1	Explain the characteristics of management in the contemporary context	Understand
C310.2	Describe the functions of management	Understand
C310.3	Demonstrate ability in decision making process and productivity analysis	Understand
C310.4	Illustrate project management technique and develop a project schedule	Apply
C310.5	Summarize the functional areas of management	Understand
C310.6	Comprehend the concept of entrepreneurship and create business plans	Understand

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
C310.1	2				1	2	2	2		2	1	1			
C310.2	2				1	1		2	1	2	1	1			
C310.3	2	2	2	2	1										
C310.4	2	2	2	2	1						2	1			
C310.5	2					1	1		1	2	1				
C310.6		2	2	2	1	1	1	1	1	1	1	1			

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

SNO	DESCRIPTION	RELEVANCE TO PO\PSO	PROPOSED ACTIONS
1	Functions of management	Lecture	6,8,9,11

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

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SL NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	**Case study**	**Provide reference materials**	**6,8,9,11**	**-**

WEB SOURCE REFERENCES:

1	**https://www.indeed.com/career-advice/career-development/types-of-management-theories#:~:text=Management%20theories%20are%20a%20collection,perform%20at%20their%20highest%20ability**

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

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

ASSESSMENT METHODOLOGIES-DIRECT

☐ASSIGNMENTS	☐STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑UNIV. EXAMINATION
☐ 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

11.2 COURSE PLAN

DAY	MODULE	TOPIC PLANNED
1	1	Introduction to management
2	1	Levels of managers and skill required
3	1	Classical management theories
4	1	neo-classical management theories
5	1	modern management theories
6	1	System approaches to Management,
7	1	Task and Responsibilities of a professional Manager
8	2	Management process – planning
9	2	Mission – objectives – goals – strategy – policies – programmes – procedures
10	2	Organizing, principles of organizing, organization structures
11	2	Directing, Leadership
12	2	Motivation, Controlling
13	3	Concept of productivity and its measurement Competitiveness
14	3	Decision making process;
15	3	Models in decision making

16	3	Decision making under certainty and risk
17	3	Decision making under uncertainty
18	3	Decision trees
19	3	Models of decision making.
20	4	Project Management
21	4	Network construction
22	4	Arrow diagram, Redundancy
23	4	CPM and PERT Networks
24	4	Scheduling computations
25	4	PERT time estimates
26	4	Probability of completion of project
27	4	Introduction to crashing
28	5	Introduction to functional areas of management,
29	5	Operations management
30	5	Human resources management ,
31	5	Marketing management
32	5	Financial management

33	5	Entrepreneurship,
34	5	Business plans
35	5	Corporate social responsibility, Patents and Intellectual property rights

11.3 MODULE WISE SAMPLE QUESTIONS

MODULE 1

1. "Management is getting things done through others." Elaborate.
2. Comment on the true nature of management. Is it a science or an art?
3. Explain the systems approach to management.
4. Describe the roles of a manager
5. Explain the 14 principles of administrative management?
6. Explain the different managerial skills
7. What are planning premises, explain the classification of planning premises.
8. Distinguish between strategy and policy. How can policies be made effective?

MODULE 2

1. Planning is looking ahead and controlling is looking back. Comment with suitable examples
2. Explain the process of communication?
3. What are planning premises, explain the classification of planning premises.
4. Distinguish between strategy and policy. How can policies be made effective?
5. Explain three motivational theories.
6. Describe the managerial grid.

MODULE 3

1. **Explain the hierarchy of objectives?**

2. **Explain the types of decisions?**

3. **Modern forest management uses controlled fires to reduce fire hazards and to stimulate new forest growth. Management has the option to postpone or plan a burning. In a specific forest tract, if burning is postponed, a general administrative cost of Rs. 300 is incurred. If a controlled burning is planned, there is a 50% chance that good weather will prevail and burning will cost Rs. 3200. The results of the burning may be either successful with probability 0.6 or marginal with probability 0.4. Successful execution will result in an estimated benefit of Rs. 6000, and marginal execution will provide only Rs. 3000 in benefits. If the weather is poor, burning will be cancelled incurring a cost of Rs. 1200 and no benefit.**

   i) Develop a decision tree for the problem.

   (ii) Analyse the decision tree and determine the optimal course of action.

4. **Student tuition at ABC University is $100 per semester credit hour. The Education department supplements the university revenue by matching student tuition, dollars per dollars. Average class size for a typical three credit course is 50 students. Labour costs are $4000 per class, material costs are $20 per student, and overhead costs are $25,000 per class. (a) Determine the total factor productivity. (b) If instructors deliver lectures 14 hours per week and the semester lasts for 16 weeks, what is the labour productivity?**

5. **An ice-cream retailer buys ice cream at a cost of Rs. 13 per cup and sells it for Rs. 20 per cup; any remaining unsold at the end of the day, can be disposed of at a salvage price of Rs. 2.5 per cup. Past sales have ranged between 13 and 17 cups per day; there is no reason to believe that sales volume will take on any other magnitude in future. Find the expected monetary value and EOL, if the sales history has the following probabilities**

Market Size	**13**	**14**	**15**	**16**	**17**
Probability	**0.10**	**0.15**	**0.15**	**0.25**	**0.35**

6. **At Modem Lumber Company, Kishore the president and a producer of apple crates sold to growers, has been able, with his current equipment, to produce 240 crates per 100 logs. He currently purchases 100 logs per day, and each log requires 3 labour hours to process. He believes that he can hire a professional buyer who can buy a better quality log at the same cost. If this is the case, he increases his production to 260 crates per 100 logs. His labour hours will increase by 8 hours per day. What will be the impact on productivity**

(measured in crates per labour-hour) if the buyer is hired? What is the growth in productivity in this case?

MODULE 4

1. **Describe the Economic man model?**
2. **Explain the concepts of crashing and dummy activity in project management.**
3. **A project has the following list of activities and time estimates:**

   Draw the network. (b) Show the early start and early finish times. (c) Show the critical path

Activity	Time (Days)	Immediate Predecessors
A	1	-
B	4	A
C	3	A
D	7	A
E	6	B
F	2	C, D
G	7	E, F
H	9	D
I	4	G, H

Draw the network. (b) Show the early start and early finish times. (c) Show the critical path

4. **An opinion survey involves designing and printing questionnaires, hiring and training personnel, selecting participants, mailing questionnaires and analysing data. Develop the precedence relationships and construct the project network.**

5. **The following table shows the precedence requirements, normal and crash times, and normal and crash costs for a construction project:**

Activity	Immediate Predecessors	Required Time (Weeks)		Cost (Rs.)	
	Crash	Normal	Crash	Normal	Crash
A	-	4	2	10,000	11,000
B	A	3	2	6,000	9,000
C	A	2	1	4,000	6,000
D	B	5	3	14,000	18,000
E	B, C	1	1	9,000	9,000
F	C	3	2	7,000	8,000
G	E, F	4	2	13,000	25,000
H	D, E	4	1	11,000	18,000
I	H, G	6	5	20,000	29,000

Draw the network. (b) Determine the critical path. (c) Determine the optimal duration and the associated cost.

6. **Differentiate between CPM and PERT**

MODULE 5

1. **Differentiate the quantitative and qualitative methods in forecasting.**

2. **What are the key metrics for sustainability measurement? What makes the measurement and reporting of sustainability challenging?**

3. **What is meant by market segmentation and explain the process of market segmentation ?**

4. **The Honda Co. in India has a division that manufactures two-wheel motorcycles. Its budgeted sales for Model G in 2019 are 80,00,000 units. Honda's target ending inventory is 10,00, 000 units and its beginning inventory is 12, 00, 000 units. The company's budgeted selling price to its distributors and dealers is Rs. 40, 000 per motorcycle. Honda procures all its wheels from an outside supplier. No defective wheels are accepted. Honda's needs for extra wheels for replacement parts are ordered by a separate division of the company. The company's target ending inventory is 3,00,000 wheels and its beginning inventory is 2,00,000 wheels. The budgeted purchase price is Rs. 1,600 per wheel. (a) Compute the budgeted revenue in rupees. (b) Compute the number of motorcycles to be produced. Compute the budgeted purchases of wheels in units and in rupees.?**

5. **"Human Resource Management policies and principles contribute to effectiveness, continuity and stability of the organization". Discuss. (b) What is a budget? Explain how sales budget and production budgets are prepared?**

6. **Distinguish between the following: (a) Assets and Liabilities (b) Production concept and Marketing concept (c) Needs and Wants (d) Design functions and Operational control functions in operations**

Prepared by:
Ms. Rinju Mariam Rolly
Ms. Mariya Vincent
Mr. Karunakara P. Menon
Mr. Vimal kumar V
Mr. Philip James
(Faculties in Charge)

Dr.Manoj G Tharian
(HOD)

12. MEL332 COMPUTER AIDED DESIGN AND ANALYSIS LAB

12.1 COURSE INFORMATION SHEET

PROGRAMME: ME	***DEGREE:*** BTECH (KTU)
COURSE: Computer Aided Design & Analysis Lab	**SEMESTER: 6** **CREDITS:** 2
COURSE CODE: MEL332 **REGULATION:** 2019	**COURSE TYPE:**CORE LAB
COURSE AREA/DOMAIN: Mechanical Systems, Design and Analysis	**CONTACT HOURS:** 6 Lab Hours/Week.

SYLLABUS:

Sl. No.	***DETAILS***	***HOURS***
	Part A (Minimum 6 models)	6 lab hours/ week
1	Creation of high end part models (minimum 2 models, questions for examinations must not be taken from this portions)	6
2	Creating assembly models of Socket and spigot joint, Knuckle Joint, Rigid flange couplings, Bushed pin flexible coupling, Plummer block, Single plate clutch and cone friction clutch. Pipe joints, Screw jack, Tail stock etc. (minimum 4 models)	12
	PART B (Minimum 6 problems)	
3	Structural analysis. (minimum 3 problems)	6
4	Structural analysis. (minimum 3 problems)	3
5	Fluid flow analysis. (minimum 1 problem)	3

TEXT/REFERENCE BOOKS:

T/R	***BOOK TITLE/AUTHORS/PUBLICATION***
R1	Daryl Logan, A First course in Finite Element Method, Thomson Learning, 2007
R2	David V Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill,2003
R3	Ibrahim Zeid, CAD/ CAM Theory and Practice, McGraw Hill, 2007
R4	Mikell P. Groover and Emory W. Zimmer, CAD/ CAM – Computer aided design and manufacturing, Pearson Education,1987
R5	T. R. Chandrupatla and A. D. Belagundu, Introduction to Finite Elements in Engineering, Pearson Education, 2012

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
EST 110	Engineering Graphics	To have basic knowledge about orthographic projections	1
MEL201	Computer Aided Machine Drawing	To have basic knowledge in machine parts, assembly design and to develop 2D sketch in CAD software.	3

COURSE OBJECTIVES:

1	To provide working knowledge on Computer Aided Design methods and procedures
2	To impart training on solid modelling software
3	To impart training on finite element analysis software

COURSE OUTCOMES:

SNO	DESCRIPTION	Bloom's Taxonomy Level
CMEL322.1	Students are capable of ***developing*** 3D models of machine components, complex geometries etc. using CATIA V6	Apply Level 3
CMEL322.2	Students are capable to assembly the parts created to ***develop*** the whole mechanism.	Apply Level 3
CMEL322.3	Students are capable to ***generate*** 2D sketches of the assembled parts and provide dimensions and symbols to generate 2D drawing.	Apply Level 3
CMEL322.4	Students can ***apply*** their knowledge in importing CAD geometries and to modify and mesh using different meshing methods and local meshing controls as a part of pre-processing of the FE problem in ANSYS workbench	Apply Level 3
CMEL322.5	Students have knowledge to ***conduct*** simple structural, fluid flow and thermal analysis problems in ANSYS.	Analyse Level 4

CO-PO AND CO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CMEL 322.1	3	2	3	-	3	-	-	-	-	3	-	3	-	3	3
CMEL 322.2	3	2	3	-	3	-	-	-	-	3	-	3	-	3	3
CMEL 322.3	3	2	3	-	3	-	-	-	-	3	-	3	-	3	3
CMEL 322.4	3	2	3	-	3	-	-	-	-	3	-	3	3	-	3
CMEL 322.5	3	2	3	-	3	-	-	-	-	3	-	3	3	-	3
CMEL 332 *(AVG. VALUE)*	3	2	3		3					3		3	3	3	3

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
CMEL322.1-PO1	3	Students have the capability to apply fundamental engineering knowledge in the design and modelling of machine components
CMEL322.1-PO2	2	Students are capable to using first principles of mathematics and Engineering sciences to create and analyse better design of machine components and systems.
CMEL322.1-PO3	3	Students are capable of preparing 3D models as per the design of system components that meet the specified needs with appropriate consideration for the public health and safety
CMEL322.1-PO5	3	Knowledge in using modern 3D modelling tool to develop machine components.
CMEL322.1-PO10	3	Students are capable to effectively communicate about the 3D models, mechanisms generated with effective reports and design documentation, make effective presentations, and give and receive clear instructions regarding the design.
CMEL322.1-PO12	3	Recognize the need for, life- long learning in the area of system design and analysis.
CMEL322.2-PO1	3	Students have the capability to apply fundamental engineering knowledge in the design, modelling and assembly of machine components
CMEL322.2-PO2	2	Students are capable to using first principles of mathematics

		and Engineering sciences to create, assemble and analyse better design of machine components and systems.
CMEL322.2-PO3	3	Students are capable of preparing 3D mechanism as per the design of system components that meet the specified needs with appropriate consideration for the public health and safety
CMEL322.2-PO5	3	Knowledge in using the latest version of CATIA 3D modelling software to assemble the parts developed to generate the whole assembly/ mechanism.
CMEL322.2-PO10	3	Students are capable to effectively communicate about the 3D models, mechanisms generated with effective reports and design documentation, make effective presentations, and give and receive clear instructions regarding the design.
CMEL322.2-PO12	3	Recognize the need for, life- long learning in the area of system design and analysis.
CMEL322.3-PO1	3	Students have the capability to apply fundamental engineering knowledge in the design, modelling and assembly of machine components and to generate and understand the 2D views of components.
CMEL322.3-PO2	2	Students are capable to using first principles of mathematics and Engineering sciences to generate 2D sketches and analyse for a better design of machine components and systems.
CMEL322.3-PO3	3	Students are capable of preparing 2D Drawing of 3D mechanism as per the design of system components that meet the specified needs with appropriate consideration for the public health and safety
CMEL322.3-PO5	3	Knowledge in using the latest version of CATIA 3D modelling software to generate 2D sketches of assembled parts and to provide dimensions and symbols to generate the 2D drawing.
CMEL322.3-PO10	3	Students are capable to effectively communicate about the 3D models, mechanisms generated with effective reports and design documentation, make effective presentations, and give and receive clear instructions regarding the design.
CMEL322.3-PO12	3	Recognize the need for, life- long learning in the area of system design and analysis.
CMEL322.4-PO1	3	Students have the capability to apply fundamental mathematics, science and engineering knowledge in the

		analysis of machine components and system
CMEL322.4-PO2	2	Students are capable to using first principles of mathematics and Engineering sciences to analyse machine components and systems.
CMEL322.4-PO3	3	Students are capable of conducting analysis of system components that meet the specified needs with appropriate consideration for the public health and safety
CMEL322.4-PO5	3	Students are capable of conducting analysis using modern tools like ANSYS
CMEL322.4-PO10	3	Students are capable to effectively communicate about the 3D models, mechanisms, systems generated and analysed using analysis packages with effective reports and design documentation, make effective presentations, and give and receive clear instructions regarding the design and analysis.
CMEL322.4-PO12	3	Recognize the need for, life- long learning in the area of system design and analysis.
CMEL322.5-PO1	3	Students have the capability to apply fundamental mathematics, science and engineering knowledge in the analysis of machine components and system
CMEL322.5-PO2	2	Students are capable to using first principles of mathematics and Engineering sciences to analyse better design of machine components and systems.
CMEL322.5-PO3	3	Students are capable of conducting analysis of system components that meet the specified needs with appropriate consideration for the public health and safety
CMEL322.5-PO5	3	Students are capable of conducting analysis using modern tools like ANSYS.
CMEL322.5-PO10	3	Students are capable to effectively communicate about the 3D models, mechanisms, systems generated and analysed using analysis packages with effective reports and design documentation, make effective presentations, and give and receive clear instructions regarding the design and analysis.
CMEL322.5-PO12	3	Recognize the need for, life- long learning in the area of system design and analysis.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
CMEL322.1-PSO2	3	Students are capable of applying the principles of design and implementation of mechanical systems/processes which have been learned as a part of the curriculum.
CMEL322.1-PSO3	3	Develop and implement new ideas on product design and development with the help of modern CAD tools
CMEL322.2-PSO2	3	Students are capable of applying the principles of design and implementation of mechanical systems/processes which have been learned as a part of the curriculum.
CMEL322.2-PSO3	3	Develop and implement new ideas on product design and development with the help of modern CAD tools
CMEL322.3-PSO2	3	Students are capable of applying the principles of design and implementation of mechanical systems/processes which have been learned as a part of the curriculum.
CMEL322.3-PSO3	3	Develop and implement new ideas on product design and development with the help of modern CAD tools
CMEL322.4-PSO1	3	Apply their knowledge in the domain of engineering mechanics, thermal and fluid sciences to solve engineering problems utilizing the capability of modern analysis software.
CMEL322.4-PSO3	3	Develop and implement new ideas on product analysis with the help of modern Analysis packages
CMEL322.5-PSO1	3	Apply their knowledge in the domain of engineering mechanics, thermal and fluid sciences to solve engineering problems utilizing the capability of modern analysis software.
CMEL322.5-PSO3	3	Develop and implement new ideas on product analysis with the help of modern Analysis packages

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

SNO	*DESCRIPTION*	*RELEVENCE TO PO\PSO*	*PROPOSED ACTIONS*
	nil	nil	nil

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

WEB SOURCE REFERENCES:

1	Knuckle joint assembly -https://www.youtube.com/watch?v=GBg1Rwjcd6s
2	Screw jack assembly- https://www.youtube.com/watch?v=gTvl6gvJX9o
3	Cantilever beam structural analysis https://www.youtube.com/watch?v=u9YnCJnSmCw
4	Introduction to static structural analysis-https://www.youtube.com/watch?v=vnpq5zzOS48

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
Mr. Jithin P. N. & Dr. Joseph Babu
(Faculty)

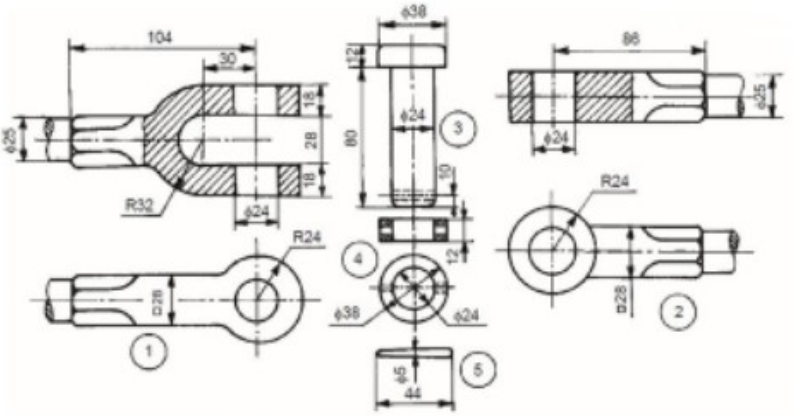
Approved by
Dr. Manoj G. Tharian
(HOD)

12.2 COURSE PLAN

Day	TOPICS PLANNED
1	Introduction to sketcher workbench to draw 2D geometries- Standard tool bar, profile tool bar, view tool bar, sketch tool bar, constraint tool bar, Introduction to Part design workbench- Sketch based features toolbar - Tutorial 1 (one 3D model)
2	Part design workbench- Dress up feature tool bar, Transformation feature tool bar - Tutorial 2 (IC engine piston)
3	Assembly design workbench tools- Engineering connections tool bar- Tutorial 3 (Socket and Spigot)
4	Assembly design workbench tools- Engineering connections tool bar- Tutorial 4 (Flexible coupling)
5	Assembly design workbench tools- Engineering connections tool bar- Tutorial 5 (Screw jack)
6	Assembly design workbench tools- Engineering connections tool bar- Tutorial 6 (Knuckle joint)
7	Introduction to ANSYS workbench- static structural solver- Tutorial 7 (Static structural analysis problem)
8	Meshing Methods – Local and global meshing methods and tools, Tutorial 8, 9 (Structural Analysis problems)
9	Introduction to steady state thermal solver- Tutorial 10 (Thermal analysis problem)
10	Tutorial 11(Thermal analysis problem)
11	Introduction to CFD solver- Fluent- Tutorial 12 (CFD analysis of flow over cylinder (2D problem))

12.3 SAMPLE QUESTIONS

1. Create an assembly model using the part details given below:



Parts list

Sl. No.	Name	Matl.	Qty.
1	Fork end	Forged steel	1
2	Eye end	Forged steel	1
3	Pin	Mild steel	1
4	Collar	Mild steel	1
5	Taper pin	Mild steel	1

Knuckle joint

2. Air flows over a long cylinder of 150mm diameter at a velocity of 3m/sec at a temperature of 105º F. Using this data and applying finite element technique find
   a. Max velocity
   b. Plot flow trajectories
   c. Cut plot of velocity

13. MEL 334 THERMAL ENGINEERING LAB-II

13.1 COURSE INFORMATION SHEET

PROGRAMME: ME	**DEGREE:** BTECH
COURSE: THERMAL ENGINEERING LAB-II	**SEMESTER: 6** **CREDITS:** 2
COURSE CODE: MEL 334 **REGULATION:** 2019 SCHEME	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: THERMAL SCIENCE	**CONTACT HOURS:** 3 (Practical) hours/Week

SYLLABUS:

UNIT	DETAILS	Lab cycle
EXPERIMENTS	1. Determination of LMTD and effectiveness of parallel flow, Counter flow and cross flow heat exchangers 2. Determination of heat transfer coefficients in free convection 3. Determination of heat transfer coefficients in forced convection 4. Determination of thermal conductivity of solids (composite wall/metal rod) 5. Determination of thermal conductivity of powder 6. Determination of Stefan Boltzman constant 7. Measurement of solar radiation 8. Study and performance test on refrigeration (Refrigeration Test rig) 9. Study and performance test on air conditioning equipment (Air Conditioning test rig) 10. Performance study on heat pipe 11. Calibration of Thermocouples 12. Calibration of Pressure gauge	

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
R1	Yunus A. Cengel, "Heat Transfer a Practical Approach", Tata McGraw-Hill Education, 4th Edition, 2012.
R2	R. C. Sachdeva, "Fundamentals of Engineering, Heat and Mass Transfer", New Age publication, 3 rd Edition, 2012.
R3	Holman J.P, "Heat transfer", Mc Graw-Hill, 10th. Ed., 2009
R4	Frank P. Incropera and David P. Dewitt, Heat and Mass Transfer, John Wiley and sons, 2011.
R5	Kothandaraman, C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi, 2006.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
MET 302	HEAT &MASS TRANSFER	This course gives an introduction to the various modes of heat transfer and to develop methodologies for solving a wide variety of practical heat transfer problems It also provides useful information concerning the performance and design of simple heat transfer systems	6

COURSE OUTCOMES:

SNO	DESCRIPTION	Bloom's Taxonomy Level
MEL334.1	Evaluate thermal properties of materials in conduction, convection and radiation.	Evaluate (level 5)
MEL334.2	Analyse the performance of heat exchangers.	Analyse (level 4)
MEL334.3	Illustrate the operational performances of refrigeration and air conditioning systems.	Apply (level 3)
MEL334.4	Perform calibration of thermocouples and pressure gauges.	Apply (level 3)

CO-PO AND CO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MEL334.1	3		2	3			2		3	2		2	2		
MEL334.2	3		2	3			2		3	2		2	2		
MEL334.3	3		2	3			2		3	2		2	2		
MEL334.4	3		2	3			2		3	2		2	2		

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
MEL334.1-PO 1	H	Students can apply the mathematical skills and engineering knowledge in calculation of thermal properties of materials
MEL334.1-PO 3	M	Students can analyse and infer the thermal properties and use them for design and development of thermal systems
MEL334.1-PO 4	H	Students can utilise the knowledge gained from

		conducting the experiments and use the results to solve complex problems.
MEL334.1-PO 7	M	Students can utilise the knowledge gained from conducting the experiments and use the results to develop environment friendly and sustainable thermal systems.
MEL334.1-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.
MEL334.1-PO 10	M	Students will learn to effectively furnish the observations, results and inferences in the form of lab record.
MEL334.1-PO 12	M	Since students acquire knowledge about determining different thermal properties of materials, he/she can explore different materials for thermal applications
MEL334.2-PO 1	H	Students can apply their mathematical knowledge and skills to analyse the performance of heat exchangers
MEL334.2-PO 3	M	Students can analyse and infer the performance and use them for design and development of heat exchangers
MEL334.2-PO 4	H	Students can utilise the knowledge gained from conducting the experiments and use the results to solve complex problems related to heat exchangers
MEL334.2-PO 7	M	Students can utilise the knowledge gained from conducting the experiments and use the results to develop environment friendly and sustainable heat exchangers
MEL334.2-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.
MEL334.2-PO 10	M	Students will learn to effectively furnish the observations, results and inferences in the form of lab record.
MEL334.2-PO 12	M	Since students acquire knowledge about determining performance of heat exchangers, he/she can use it in future studies.
MEL334.3 - PO 1	H	Students can apply the theoretical knowledge gained from the thermal engineering classes to calculate CoP of refrigeration and air conditioning systems.
MEL334.3 - PO 3	M	Students can infer the performance of refrigeration and air conditioning systems which can be used for its design and development.
MEL334.3-PO 4	H	Students can utilise the knowledge gained from conducting the experiments and use the results to solve complex problems related to refrigeration and air

		conditioning systems.
MEL334.3 - PO 7	M	Students can utilise the knowledge gained from conducting the experiments and use the results to develop environment friendly and sustainable refrigeration and air conditioning systems.
MEL334.3 - 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.
MEL334.3 -PO 10	M	Students will learn to effectively furnish the observations, results and inferences in the form of lab record.
MEL334.3-PO 12	M	Students gain knowledge and hands on experience with refrigeration and air conditioning systems. Which can be used for their future studies
MEL334.4 - PO 1	H	Students can apply their mathematical knowledge for the calibration of the pressure gauges and thermocouples.
MEL334.4 - PO 3	M	Students will be able to interpret the calibration curves and understand how to predict the quantity at different heads.
MEL334.3-PO 4	H	Students can utilise the knowledge gained from conducting the experiments and use the results to solve complex problems on thermal systems.
MEL334.4 - PO 7	M	Students can utilise the knowledge gained from conducting the experiments and use the results to develop environment friendly and sustainable thermal systems
MEL334.4 - 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.
MEL334.4 -PO 10	M	Students will learn to effectively furnish the observations, results and inferences in the form of lab record.
MEL334.4-PO 12	M	Ability to interpret calibration curves serves as a foundation for project works higher studies.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	LOW/ MEDIUM /HIGH	JUSTIFICATION
MEL202.1-PSO1	M	Students can apply their knowledge in fluid science to solve engineering problems in the domain of thermal systems
MEL202.2- PSO1	M	Students can apply their knowledge in mathematics & fluid science for the development of heat exchangers

MEL202.3-PSO1	M	Students can apply their knowledge in thermal science to develop refrigeration and air conditioning systems.
MEL202.4-PSO1	M	Students can apply their knowledge in mathematics & thermal science for the interpretation of calibration curves.

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

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: Nil

WEB SOURCE REFERENCES:

1	https://vlab.amrita.edu/index.php?sub=1&brch=194
2	http://htv-au.vlabs.ac.in/
3	https://mfts-iitg.vlabs.ac.in/

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

Prepared by
Mr. Rathish T R
(Faculty)

Approved by
Dr. Manoj G Tharian
(HoD, DME)

13.2 COURSE PLAN

DAY	CYCLE	NAME OF EXPERIMENT
1	I	Study and performance test on refrigeration (Refrigeration Test rig)
2		Study and performance test on air conditioning equipment (Air Conditioning test rig)
3		Calibration of Thermocouple
4		Calibration of Pressure gauge
5		Determination of thermal conductivity of powder
6		Determination of thermal conductivity of solids (composite wall/metal rod)
7	II	Performance study on heat pipe
8		Determination of Stefan Boltzman constant
9		Determination of heat transfer coefficients in forced convection
10		Determination of heat transfer coefficients in free convection
11		Measurement of solar radiation
12		Determination of LMTD and effectiveness of parallel flow, Counter flow and cross flow heat exchangers

13.3. SAMPLE QUESTIONS

1. What is COP in refrigeration?
2. Write the expression for Fourier law of heat conduction. Explain the terms.
3. Explain Stefan Boltzman law of radiation?
4. An aeroplane taking left turn and the rotor rotating clockwise when viewed from back. Explain the gyroscopic effect on the plane.
5. Name one spring controlled governor
6. Dittus–Boelter correlation for fully developed turbulent flow in pipes
7. Draw the p-h diagram of a vapour compression refrigeration system.
8. Name the two major types of refrigeration system.
9. Nusselt Number is the ratio of
10. Reynolds Number is the ratio of
11. Explain hunting in governors
12. What does specific humidity mean?
13. Name the equipment used for measuring WBT and DBT.
14. Torsional stiffness of shaft, K_s =
15. Prandl Number is the ratio of =
16. Name two practical methods used to achieve nearly isothermal compression
17. What do you mean by dew point temperature?
18. If relative humidity is 100% then what happens to DBT and WBT?
19. Which refrigerant is used in our test rig of refrigeration and a/c.?
20. Draw the psychrometric chart and show the following process on it
    a) sensible cooling b) sensible heating c) humidification d) dehumidification e) cooling and dehumidification f) heating and humidification g) cooling and humidification h) heating and dehumidification
21 Grashof Number is the ratio of
22 Write one dimensional radial heat flow conduction equation through a hollow cylinder, under steady state conditions:

23 Axis of precession means:

24 What are the limitations of Watt governor? Explain how it is solved in Porter governor?

25 The radial heat conduction equation for single hollow sphere transferring heat from inside to outside without heat generation is given by:

26 Draw a diagram representing summer air conditioning system.

27 Explain Newton's law of cooling.

28 Name the two major types of refrigeration system.

29 What does an isochronous governor mean? Draw the controlling force vs radius of rotation graph for an isochronous governor.

30 Nusselt Number is the ratio of……?