RSET

RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY

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.

DEPARTMENTMISSION

- *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: Demonstrat the ability to analyze, 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: Exhibite 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.

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15	**EC482 Biomedical Engineering**		
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17	**MP469 Industrial Psychology & Organizational Behaviour**		
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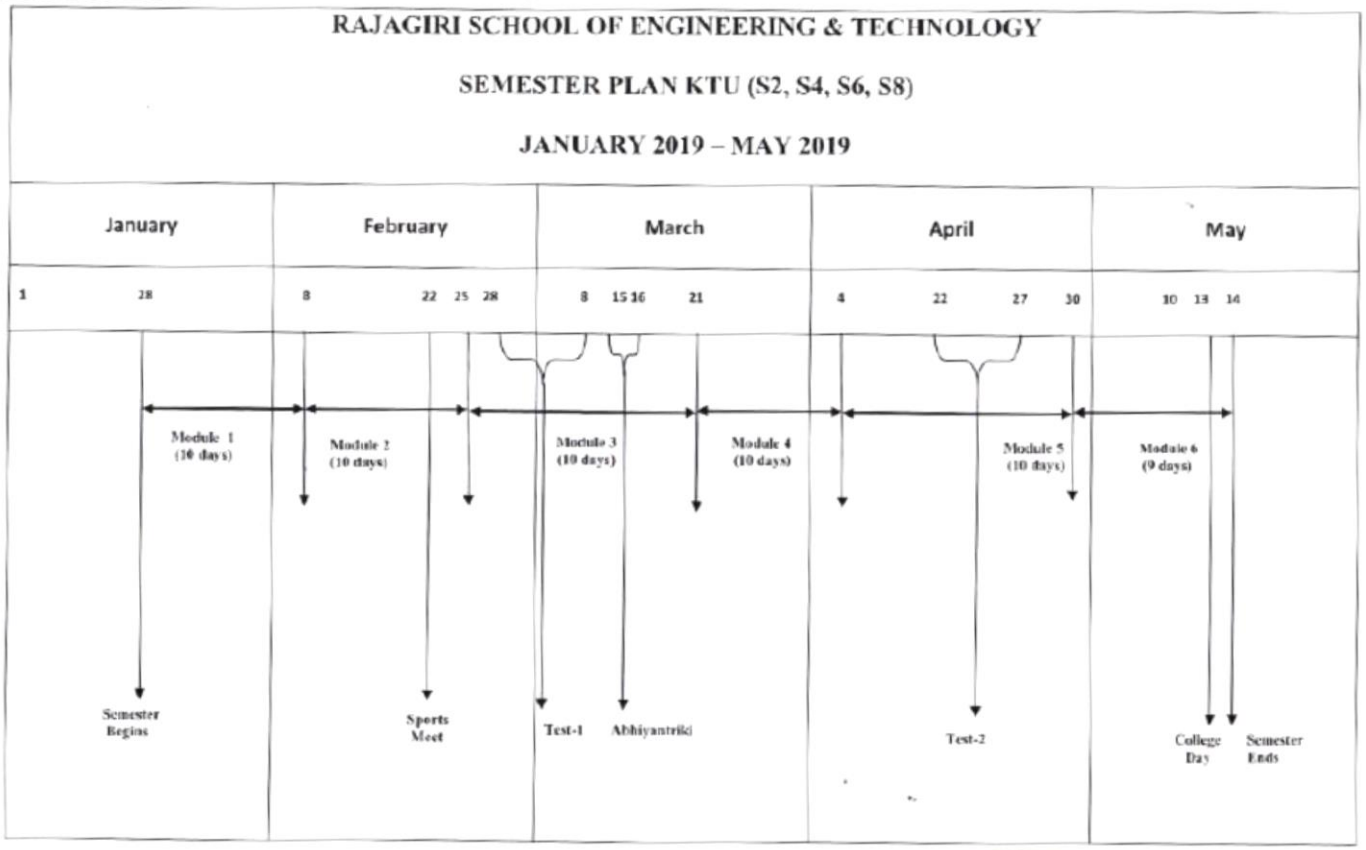
SEMESTER PLAN

RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY

SEMESTER PLAN KTU (S2, S4, S6, S8)

JANUARY 2019 – MAY 2019



January: 4 February: 20 March: 21 April: 20 May: 9

Total no of working days: 74

24/1/19

PRINCIPAL
Rajagiri School of Engineering & Technology
Rajagiri Valley P.O., Kochi - 68

ASSIGNMENT SCHEDULE	
Week 4	**ME402 Design Of Machine Elements II**
Week 5	**ME404 Industrial Engineering**
Week 5	**Elective 3**
Week 6	**Elective 4**
Week 7	**ME402 Design Of Machine Elements II**
Week 8	**ME404 Industrial Engineering**
Week 8	**Elective 3**
Week 9	**Elective 4**

SCHEME

Code	Subject	Hours/week			Credits	Exam Slot
		L	T	P/D		
ME402	Design of Machine Elements II	3	0	0	3	A
ME404	Industrial Engineering	3	0	0	3	B
ME466	Elective 4- Computational Fluid Dynamics	3	0	0	3	C
ME476	Elective 4- Material Handling & Facilities Planning	3	0	0	3	C
ME468	Elective 4- Nanotechnology	3	0	0	3	C
ME462	Elective 4- Propulsion Engineering	3	0	0	3	C
BM484	Elective 5-(Non Departmental) Medical Imaging & Image Processing Techniques	3	0	0	3	D
CE482	Environmental Impact Assessment	3	0	0	3	D
CE488	Disaster Management	3	0	0	3	D
CS484	Computer Graphics	3	0	0	3	D
EE486	Soft Computing	3	0	0	3	D
EC482	Biomedical Engineering	3	0	0	3	D
MA484	Operations Research	3	0	0	3	D
MP469	Industrial Psychology & Organizational Behaviour	3	0	0	3	D
MA482	Applied Linear Algebra	3	0	0	3	D
IT482	Information System Management	3	0	0	3	D
ME492	Project	18	0	0	6	
	Total	**30**	**0**	**0**	**18**	

4. ME 402 DESIGN OF MACHINE ELEMENTS 2

4.1 COURSE INFORMATION SHEET

PROGRAMME:MECHANICAL ENGINEERING	***DEGREE: BTECH***
PROGRAMME: **MECHANICAL ENGINEERING**	DEGREE: **B.TECH** University**: KTU**
COURSE: **DESIGN OF MACHINE ELEMENTS 2**	SEMESTER**: VIII** CREDITS: **4**
COURSE CODE: **ME** REGULATION:**KTU, 2016**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: **MACHINE DESIGN**	CONTACT HOURS: 3 **hours lecture and 1 hour tutorial per week**

SYLLABUS:

MODULE	CONTENTS	HOURS
I	Clutches – friction clutches, design considerations, multiple disc clutches, cone clutch, centrifugal clutch. Brakes- Block brake, band brake, band and block brake, internal expanding shoe brake	5
II	Rolling contact bearing- Design of bearings, Types, Selection of a bearing type, bearing life, static and dynamic load capacity, axial and radial loads, selection of bearings, dynamic equivalent load Sliding contact bearing- lubrication, lubricants, viscosity, Journal bearings, hydrodynamic theory, Sommerfield number, design considerations, heat balance, bearing housing and mountings	8
III	Gears- classification, Gear nomenclature, Tooth profiles, Materials of gears, Law of gearing (review only), virtual or formative number of teeth, gear tooth failures, Beam strength, Lewis equation, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, surface durability, heat dissipation – lubrication of gears – Merits and demerits of each type of gears. Design of spur gear	6
IV	Design of helical gear Design of bevel gear Design of worm & worm wheel	15

V	Design of flat belt- materials for belts, slip of the belts, creep, centrifugal tension Design of V-belt drives, Advantages and limitations of V-belt drive Selection of roller chains, power rating of roller chains, galling of roller chains, polygonal action, silent chain.	9
VI	Connecting rod – material, connecting rod shank, small end, big end, connecting rod bolts, inertia bending stress, piston Pressure vessels, thin cylinders, Thick cylinder equation, open and closed cylinders.	7

TOTAL HOURS = 50

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHOR/PUBLICATION*
T1	Narayana Iyengar B.R & Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill, 1984
T2	Jalaludeen , Machine Dsign, Anuradha Publications, 2016
T3	V.B.Bhandari, Design of Machine elements, McGraw Hill, 2016
R1	A text book of Machine Design, R S Khurmi
R2	Juvinall R.C & Marshek K.M., Fundamentals of Machine Component Design, John Wiley, 2011
R3	M. F. Spotts, T. E. Shoup, Design of Machine Elements, Pearson Education, 2006
R4	K. Mahadevan, K.Balaveera Reddy, Design Data Hand Book, CBS Publishers & Distributors, 2013
R5	Narayana Iyengar B.R & Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill, 1984
R6	PSG Design Data, DPV Printers, Coimbatore, 2012

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
ME401	Design of Machine Elements 1	To understand the methodology of various machine elements.	7

COURSE OBJECTIVES:

1	To provide basic design methods for clutches, brakes, belt drives, bearings, gears and connecting rod.
2	To introduce the design modifications to be considered for ease of manufacturing.

COURSE OUTCOMES:

Sl. NO	DESCRIPTION	Blooms' Taxonomy Level
CME401.1	To acquire knowledge and **design** of different types of clutches and brakes	Level 2,6
CME401.2	To **understand** the basics of bearings, types of bearing, lubrication system and **design** of bearings.	Level 2,6
CME401.3	To **understand** the concept of gears and the basic procedure in **design** of spur gear helical, bevel, worm gear.	Level 2,6
CME401.4	To acquire knowledge and **design** of flat belt, v belt and chains.	Level 2,6
CME401.5	To acquire basic **knowledge** in Connecting rod and Pressure vessels.	Level 1

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
CME401.1	2	2	3	-	-	-	-	-	-	-	-	-	2	-	-
CME401.2	2	2	3	-	-	-	-	-	-	-	-	-	2	-	-
CME401.3	2	2	3	-	-	-	-	-	-	-	-	-	2	-	-
CME401.4	2	2	3	-	-	-	-	-	-	-	-	-	2	-	-
CME401.5	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-

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

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM /HIGH	JUSTIFICATION
CME402.1-PO1	M	Students will get Engineering fundamentals regarding the design of clutches and brakes
CME402.1-PO2	M	Applying design considerations for proper designing of clutches and brakes
CME402.1-PO3	H	Students will be able to design clutches and brakes
CME402.2-PO1	M	Students should come to know the parameters for bearing design
CME402.2-PO2	M	Students will be able to understand the mathematical formulations in bearing
CME402.2-PO3	H	Designing suitable bearings to meet the need
CME402.3-PO1	M	Students will get Engineering fundamentals regarding the different types of gears
CME402.3-PO2	M	Students should be able to find out different forces acting on gears
CME402.3-PO3	H	Students can design gears with the help of design data book according to the specifications
CME402.4-PO1	M	Students will gain the basic knowledge in belt drives
CME402.4-PO2	M	Student will be able to calculate the forces with the help of data book
CME402.4-PO3	H	Student will be able to design belts
CME402.5-PO2	H	Students will be able acquire basic knowledge in connecting rods and pressure vessels

JUSTIFATIONS FOR CO-PSO MAPPING

MAPPING	LOW/MEDIUM /HIGH	JUSTIFICATION
CME402.1-PSO1	M	Recommending design considerations for clutches and brakes

CME402.2- PSO1	M	By studying various types of loads and by studying various types of bearings, one can illustrate suitable bearings to be used under a particular loading system.
CME402.3- PSO1	M	By following the procedure for designing of gears with the help of design data book and available information, types of gears to meet the need can be designed.
CME402.4-PSO1	M	By studying the various types of belts and its design, student will be able to select suitable belt drives for transmission and design the belt according to the requirements.

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

SI NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
-	NIL	-	-	-

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SI NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
-	NIL	-	-	-

WEB SOURCE REFERENCES:

1	http://nptel.ac.in/downloads/112105125/
2	http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/New_index1.html
3	elearning.vtu.ac.in/12/enotes/Des_Mac-Ele2/Unit6-RK.pdf
4	nptel.ac.in/courses/IIT-MADRAS/Machine_Design_II/pdf/3_5.pdf
5	nptel.ac.in/courses/107103012/module4/lec7.pdf

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

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

ASSESSMENT METHODOLOGIES-DIRECT

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

ASSESSMENT METHODOLOGIES-INDIRECT

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

4.2 COURSE PLAN

DAY	*MODULE*	*TOPIC PLANNED*
1	**1**	Clutches
2	**1**	Friction clutches
3	**1**	Design considerations
4	**1**	Multiple disc clutches
5	**1**	Cone clutch
6	**1**	Centrifugal clutch
7	**1**	Brakes
8	**2**	Design of bearings - Types - Selection of a bearing type
9	**2**	Bearing life - Rolling contact bearings
10	**2**	Static and dynamic load capacity
11	**2**	Axial and radial loads
12	**2**	Selection of bearings
13	**2**	Dynamic equivalent load
14	**2**	Lubrication and lubricants
15	**2**	Viscosity - Journal bearings
16	**2**	Hydrodynamic theory
17	**2**	Design considerations - heat balance
18	**2**	Bearing characteristic number - hydrostatic bearings.

19	**3**	Gears- classification- Gear nomenclature
20	**3**	Tooth profiles - Materials of gears
21	**3**	Design of spur, helical, bevel gears and worm & worm wheel
22	**3**	Law of gearing
23	**3**	Virtual or formative number of teeth
24	**3**	Gear tooth failures- Beam strength
25	**3**	Lewis equation
26	**3**	Buckingham's equation for dynamic load
27	**3**	Wear load-endurance strength of tooth
28	**3**	Surface durability
29	**3**	Heat dissipation - lubrication of gears
30	**3**	Merits and demerits of each type of gears.
31	**3**	Design of spur gear
32	**4**	Design of helical gear
33	**4**	Design of bevel gear
34	**4**	Design of worm & worm wheel
35	**5**	Materials for belts,
36	**5**	Slip of the belts
37	**5**	Creep, centrifugal tension
38	**5**	Design of V-belt drives
39	**5**	Advantages and limitations of V-belt drive
40	**5**	Selection of roller chains,

41	**5**	Power rating of roller chains
42	**5**	Galling of roller chains, polygonal action, silent chain.
43	**6**	Connecting rod – material
44	**6**	Connecting rod shank ,
45	**6**	Small end, big end
46	**6**	Connecting rod bolts,
47	**6**	inertia bending stress, piston
48	**6**	Pressure vessels, thin cylinders
49	**6**	Thick cylinder equation
50	**6**	Open and closed cylinders

4.3. MODULE WISE SAMPLE QUESTIONS

MODULE 1

1. Explain uniform pressure theory and uniform wear theory
2. A plate clutch consists of one pair of contacting surfaces. The inner and outer diameters of the friction disk are 100 and 200 mm respectively. The coefficient of friction is 0.2 and the permissible intensity of pressure is 1 N/mm^2. Assuming uniform-wear theory, calculate the power-transmitting capacity of the clutch at 750 rpm.
3. An automotive plate clutch consists of two pairs of contacting surfaces with an asbestos friction lining. The torque transmitting capacity of the clutch is 550 N-m. The coefficient of friction is 0.25 and the permissible intensity of pressure is 0.5 N/mm^2. Due to space limitations, the outer diameter of the friction disk is fixed as 250 mm. Using uniform wear theory, calculate (i) the inner diameter of the friction disk; and (ii) the spring force required to keep the clutch in an engaged position.
4. A single plate clutch consists of one pair of contacting surfaces. Because of space limitations, the outer diameter of the friction disk is fixed as D. The permissible intensity of pressure is pa and the coefficient of friction, μ. Assuming uniform wear theory, plot the variation of the torque transmitting capacity against the ratio of diameters (d/D).

Show that the torque transmitting capacity of the clutch is maximum, when (d/D) is equal to 0.577

5. A single plate clutch is designed to transmit 10 kW power at 2000 rpm. The equivalent mass and radius of gyration of the input shaft are 20 kg and 75 mm respectively. The equivalent mass and radius of gyration of the output shaft are 35 kg and 125 mm respectively. Calculate: (i) the time required to bring the output shaft to the rated speed from rest; and (ii) the heat generated during the clutching operation.

MODULE 2

1. Give notes on bearing life and bearing characteristic number
2. In a particular application, the radial load acting on a ball bearing is 5 kN and the expected life for 90% of the bearings is 8000 h. Calculate the dynamic load carrying capacity of the bearing, when the shaft rotates at 1450 rpm.
3. A single-row deep groove ball bearing is subjected to a pure radial force of 3 kN from a shaft that rotates at 600 rpm. The expected life L10h of the bearing is 30 000 h. The minimum acceptable diameter of the shaft is 40 mm. Select a suitable ball bearing for this application.
4. A ball bearing is operating on a work cycle consisting of three parts—a radial load of 3000 N at 1440 rpm for one quarter cycle, a radial load of 5000 N at 720 rpm for one half cycle, and radial load of 2500 N at 1440 rpm for the remaining cycle. The expected life of the bearing is 10 000 h. Calculate the dynamic load carrying capacity of the bearing.
5. The following data is given for the hydrostatic step bearing of a vertical turbo generator: thrust load = 450 kN shaft diameter = 400 mm recess diameter = 250 mm shaft speed = 750 rpm viscosity of lubricant = 30 cP Draw a neat sketch showing the effect of film thickness on energy losses. Calculate the optimum film thickness for minimum power loss.

MODULE 3

1. It is required to design a pair of spur gears with 20° full-depth involute teeth based on the Lewis equation. The velocity factor is to be used to account for dynamic load. The pinion shaft is connected to a 10 kW, 1440 rpm motor. The starting torque of the motor is 150% of the rated torque. The speed reduction is 4 : 1. The pinion as well as the gear is made of plain carbon steel 40C8 (Sut = 600 N/mm2). The factor of safety can be taken as 1.5. Design the gears, specify their dimensions and suggest suitable surface hardness for the gears.
2. It is required to design a pair of spur gears with 20° full-depth involute teeth consisting of a 20-teeth pinion meshing with a 50 teeth gear. The pinion shaft is connected to a 22.5 kW, 1450 rpm electric motor. The starting torque of the motor can be taken as 150% of the rated torque. The material for the pinion is plain carbon steel Fe 410 (Sut = 410

N/mm2), while the gear is made of grey cast iron FG 200 (Sut =200 N/mm2). The factor of safety is 1.5. Design the gears based on the Lewis equation and using velocity factor to account for the dynamic load.

3. A pair of parallel helical gears consists of a 20 teeth pinion meshing with a 100 teeth gear. The pinion rotates at 720 rpm. The normal pressure angle is 20°, while the helix angle is 25°. The face width is 40 mm and the normal module is 4 mm. The pinion as well as the gear is made of steel 4OC8 (Sut = 600 N/mm2) and heat treated to a surface hardness of 300 BHN. The service factor and the factor of safety are 1.5 and 2 respectively. Assume that the velocity factor accounts for the dynamic load and calculate the power transmitting capacity of gears.
4. State two advantages and disadvantages of herringbone and double helical gears.
5. A pair of straight bevel gears has a velocity ratio of 2:1. The pitch circle diameter of the pinion is 80 mm at the large end of the tooth. 5 kW power is supplied to the pinion, which rotates at 800 rpm. The face width is 40 mm and the pressure angle is 20°. Calculate the tangential, radial and axial components of the resultant tooth force acting on the pinion

MODULE 4

1. A pair of helical gears consists of a 25 teeth pinion meshing with a 50 teeth gear. The normal module is 4 mm. Find the required value of the helix angle, if the centre distance is exactly 165 mm.
2. A pair of parallel helical gears consists of a 20 teeth pinion and the velocity ratio is 3 : 1. The helix angle is 15° and the normal module is 5 mm. Calculate (i) the pitch circle diameters of the pinion and the gear; and (ii) the centre distance.
3. Where do you use bevel gear?
4. What are the advantages of straight bevel gears over spiral bevel gears?
5. A pair of straight bevel gears has a velocity ratio of 2:1. The pitch circle diameter of the pinion is 80 mm at the large end of the tooth 5 kW power is supplied to the pinion, which rotates at 800 rpm. The face width is 40 mm and the pressure angle is 20°. Calculate the tangential, radial and axial components of the resultant tooth force acting on the pinion.
6. A pair of straight bevel gears is mounted on shafts, which are intersecting at right angles. The gears are made of steel and the surface hardness is 300 BHN. The number of teeth on the pinion and gear are 40 and 65 respectively. The module at the outside diameter is 3 mm, while the face width of the tooth is 35 mm. Calculate the wear strength of the tooth.
7. A pair of worm and worm wheel is designated as 2/52/10/4 10 kW power at 720 rpm is supplied to the worm shaft. The coeffi cient of friction is 0.04 and the pressure angle is 20°. Calculate the tangential, axial and radial components of the resultant gear tooth force acting on the worm wheel.

MODULE 5

1. It is required to select a fl at belt drive for a compressor running at 720 rpm, which is driven by a 25 kW, 1440 rpm motor. Space is available for a centre distance of 3 m. The belt is open-type.
2. It is required to select a Vbelt drive to connect a 15 kW, 2880 rpm normal torque A.C. motor to a centrifugal pump, running at approximately 2400 rpm, for a service of 18 hours per day. The centre distance should be approximately 400 mm. Assume that the pitch diameter of the driving pulley is 125 mm.
3. It is required to select a fl at-belt drive for a fan running at 360 rpm which is driven by a 10 kW, 1440 rpm motor. The belt drive is open-type and space is available for a centre distance of 2 m approximately. The belt velocity should be between 17.8 to 22.9 m/s. The power transmitting capacity of the belt per mm width per ply at 180° arc of contact and at a belt velocity of 5.08 m/s is 0.0118 kW. The load correction factor can be taken as 1.2. Suggest preferred diameters for motor and fan pulleys and give complete specifications of belting.
4. A V-belt drive is required for a 15-kW, 1440 rpm electric motor, which drives a centrifugal pump running at 360 rpm for a service of 24 hours per day. From space
5. considerations, the centre distance should be approximately 1 m. Determine (i) belt specifi cations; (ii) number of belts; (iii) correct centre distance; and (iv) pulley diameters.

MODULE 6

1. A pressure vessel consists of a cylindrical shell with an inner diameter of 1500 mm, and thickness of 20 mm. It is provided with a nozzle with an inner diameter of 250 mm and thickness of 15 mm. The yield strength of the material for the shell and nozzle is 200 N/mm2 and the design pressure is 2.5 MPa. The extension of the nozzle inside the vessel is 15 mm. The corrosion allowance is 2 mm, while the weld joint effi ciency is 0.85. Neglecting the area of welds, determine whether or not a reinforcing pad is required for the opening. If so, determine the dimensions of pad made from a plate of 15 mm thickness.
2. A pressure vessel consists of a cylindrical shell with torispherical ends. The crown and knuckle radii of torispherical end closure are 3/4 D and 1/8D respectively, where D is the diameter of the cylindrical shell. Derive an expression for the volume of end closure in terms of diameter of the shell. Assume that the thickness is negligibly small compared with the overall dimensions of the shell and the end closures. The capacity of this vessel is 10 m3 and the length is limited to 5 m. The vessel is subjected to an operating pressure of 0.5 MPa. The yield strength of the plate material is 200 N/mm2 and the corrosion allowance is 2 mm. The weld joint effi ciency can be taken as 0.6. Determine (i) the diameter of the cylindrical shell; (ii)

the length of the cylindrical shell; (iii) the crown radius; (iv) the knuckle radius; (v) the thickness of the cylindrical shell; (vi) the thickness of the torispherical ends.

3. A horizontal pressure vessel consists of a cylindrical shell enclosed by hemispherical ends. The volumetric capacity of the vessel should be approximately 2 m3 and the length should not exceed 3 m. Assuming the thickness negligibly small compared with overall dimensions of the vessel, determine the internal diameter and the length of the cylindrical shell. The pressure vessel is fabricated from steel plates with a yield strength of 255 N/mm2. The weld joint efficiency factor is 0.85 and corrosion allowance 2 mm. The pressure vessel is subjected to an operating pressure of 2 MPa. Calculate the thickness of the cylindrical shell and the hemispherical end closures.

Prepared by

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(FACULTY, DME)

Approved by

Dr. Thankachan T Pullan
(HOD DME)

5. ME 404 INDUSTRIAL ENGINEERING

5.1 COURSE INFORMATION SHEET

PROGRAMME: ***MECHANICAL ENGINEERING***	*DEGREE:* ***BTECH***
COURSE: INDUSTRIAL ENGINEERING	**SEMESTER:** 8 **CREDITS:** 3
COURSE CODE: ME404 **REGULATION:** 2015	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: MECHANICAL ENGG SCIENCE	**CONTACT HOURS:** 3 (Tutorial) hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY): NIL	**LAB COURSE NAME: NIL**

SYLLABUS:

MODULE	CONTENTS	HOURS
I	Introduction to Industrial Engineering - Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering - Field of application of Industrial Engineering Product Development and research- Design function - Objectives of design, - Manufacturing vs purchase- Economic aspects- C-V-P analysis – simple problems- Development of designs- prototype, production and testing - Human factors in design- Value Engineering .	**7**
II	Plant layout and Material handling- principles of material handling, Types of material handling equipments, Selection and application. Preventive and break- down maintenance - Replacement policy-- Methods of replacement analysis-Method of providing for depreciation- Determination of economic life - Simple problems.	**7**
III	Methods engineering: Analysis of work methods using different types of process chart and flow diagrams- Critical examination- Micro motion study and therbligs- Principles of motion economy – Work measurement- Performance rating.-Determination of allowances and standard time. - Job evaluation and merit rating - Objectives and principles of job evaluation--	**7**

	Wages and Incentives- Primary wage systems- Wage incentive plans	
IV	Industrial relations- Psychological attitudes to work and working conditions - fatigue- Methods of eliminating fatigue- Effect of Communication in Industry-Industrial safety-personal protective devices-, causes and effects of industrial disputes- Collective bargaining- Trade union - Workers participation in management.	**7**
V	Production planning and control- Importance of planning - job, batch and mass production-Introduction and need for a new productproduct life cycle. - Functions of production control - Routing , Scheduling, dispatching and follow up- Gantt charts. Inventory Control, Inventory models -Determination of EOQ and reorder levelsimple problems- Selective inventory control techniques	**7**
VI	Quality control and Inspection- Destructive and non-destructive testing methods- process capability- Statistical quality control – causes of variation in quality- control charts for X and R. Reliabilitycauses of failures- Bath tub curve.-System reliability- life testingIntroduction to concepts of, TQM, ISO, Six Sigma and Quality circles (Brief description only).	**7**
	TOTAL HOURS	**42**

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHOR/PUBLICATION*
T1	B. Kumar, Industrial Engineering Khanna Publishers,2013
T2	M Mahajan, Industrial Engineering & Production Management, Dhanpat Rai, 2005
T3	Martand Telsang, Industrial Engineering & Production Management, S. Chand, 2006
T4	O. P. Khanna, Industrial Engineering and Management, Dhanpat Rai, 2010
R1	E. S. Buffa, Modern Production management, John Wiley, 1983
R2	Grant and Ieven Worth, Statistical Quality Control, McGraw Hill, 2000

R3	Introduction to work study – ILO, Oxford And IBH Publishing,2008
R4	Ralph M Barnes, Motion and Time Study, Wiley, 198

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
MA 202,MA201	Statistics	Basic Concept of Statistics and Data	1
MA101	Mathematics	Fundamental Knowledge of Mathematics	I
HS300	Principles of Management	Understanding of different functional areas of management	1

COURSE OBJECTIVES:

1	To understand the fundamental tools and techniques in Industrial Engineering, application of Industrial Enginering, Production Methods, Product Development process and design process.
2	To understand the Facility Planning, Material Handling methods, maintenance planning.
3	Impart knowledge of the principles of Methods engineering, Job Evaluation and Merit Rating .
4	To have knowledge on Industrial relations, communication and management.
5	To understand the principles of Production planning and control, Inventory Control.
6	Impart knowledge on Quality Control, Statistical quality control, Total quality management.

COURSE OUTCOMES:

Sl. NO	DESCRIPTION	Blooms' Taxomomy Level
1	Acquire a sound knowledge principals /application of Industrial Enginering.	Rememberin g (level1)
2	Use Industrial Enginering application area such as Facility Planning, Material Handling methods, maintenance planning, Methods engineering, Job Evaluation ,Merit Rating, Industrial relations, Production planning and control, Inventory Control, and Statistical quality control.	Application (level 3)

3	Select and use an appropriate principles/methods/ techniques/ modern concepts with reference to given application/situation in Facility Planning, Material Handling methods, maintenance planning, Methods engineering, Job Evaluation ,Merit Rating, Industrial relations, Production planning and control, Inventory Control, and Statistical quality control.	Evaluating (level 5)
4	Develop and implement new ideas/ modern concepts with reference to given application/situation in Industrial Enginering for best manufacturing practices.	Creating (level 6
5	Preparation and ability to engage in independent and *life-long learning* in the context of technological change in Industrial Enginering.	Analyse (level 4)

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**
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSO 1**	**PSO 2**	**PSO 3**
C705.1	1	1	2	3	-	2	2	1	2	2	-	2	-	-	-
C705.2	3	3	2	2	-	1	-	2	-	2	2	1	-	3	1
C705.3	1	2	3	2	3	-	1	-	-	-	3	-	-	3	2
C705.4	-	2	2	2	3	-	-	2	-	-	2	1	-	2	3
C705.5	-	-	-	-	-	-	1	-	-	2	2	3	-	1	-

JUSTIFATIONS FOR CO-PO MAPPING

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
C705.1-PO1	L	As they could use their acquired knowledge to solve engineering problems
C705.1-PO2	L	Knowledge in principles of Industrial Enginering helps the students to identify many problems related to production plants .
C705.1-PO3	M	Knowledge in principles of Industrial Enginering helps the students design system components or process that meet the specified needs.
C705.1-PO4	H	As they could use their acquired knowledge design of experiments, analysis and interpretation of data.
C705.1-PO6	M	The students will be able to take consequent responsibilities relevant to the professional engineering practice.
C705-PO7	M	The students will be able to make professional engineering solutions in societal and environmental contexts.

C705.1-PO8	L	The students will be able to make decision with professional ethics .
C705.1-PO9	M	The students will be able to work as an individual, and as a member or leader in diverse teams.
C705.1-P10	M	The students will be able to make effective reports and presentations.
C705.1-P12	M	Become aware of the requirement for advanced knowledge by prolonged learning.
C705.2-PO1	H	Apply the knowledge of mechanical Engineering to the solution of complex engineering problems.
C705.2-PO2	H	Identify and analyse complex engineering problems reaching substantiated conclusions
C705.2-PO3	M	Design solutions for design of systems and process are made with social and environmental considerations.
C705.2-PO4	M	Will be able to use knowledge and methods to provide valid conclusions.
C705.2-PO6	L	Will be able to apply reasoning informed by the contextual knowledge .
C705.2-PO7	L	Understand the impact of the professional engineering solutions in societal and environmental contexts.
C705.2-PO8	M	Apply ethical principles and to commit to professional ethics.
C705.2-P10	M	Communicate effectively on engineering activities and with society.
C705.2-P11	M	Demonstrate knowledge and understanding of engineering and Industrial Enginering principles and apply these to manage projects.
C705.2-P12	L	Recognize the need for engage in independent and life-long learning.
C705.3-PO1	L	As they could use their acquired knowledge to solve engineering problems
C705.3-PO2	M	Identify and analyse complex engineering problems reaching substantiated conclusions.
C705.3-PO3	H	Design solutions for design of systems and process are made with consideration for the public health and safety, and the cultural, social.
C705.3-PO4	M	As they could use their acquired knowledge design of experiments, analysis and interpretation of data.
C705.3-PO5	H	Create, Select, and apply appropriate techniques and modern engineering and IT tools including prediction and modelling to complex engineering activities.
C705.3-PO7	L	Understand the impact of the professional engineering solutions in societal and environmental contexts.
C705.3-P11	H	Demonstrate knowledge and understanding of engineering and Industrial Enginering principles to manage projects and in multidisciplinary environments
C705.4-PO2	M	Develop and implement new ideas/ modern concepts with reference to given application/situation for problem analysis and reaching substantiated conclusions.
C705.4-PO3	M	Develop and implement new ideas/ modern concepts with reference to given application/situation for problem analysis and reaching substantiated conclusions.
C705.4-PO4	M	As they could use new ideas/ modern concepts for analysis and interpretation of data.
C705.4-PO5	H	Create, Select, and apply appropriate techniques and modern engineering and IT tools including prediction and modelling to complex engineering activities, with reference to given application/situation in Industrial Enginering for best manufacturing practices.
C705.4-PO8	M	Develop new ideas/ modern concepts with reference to given application with commitment to professional ethics .
C705.4-P11	M	Demonstrate knowledge of new ideas/ modern concepts of engineering and

		Industrial Enginering principles to manage projects and in multidisciplinary environments
C705.4-P12	L	Recognize the need for engage in independent and life-long learning for develop and implement new ideas/ modern concepts.
C705.5-PO7	L	Preparation and ability to engage in independent and life-long learning in the context of sustainable developments.
C705.5-P10	M	Communicate effectively on complex engineering activities and to have ability to engage in independent and life-long learning in the context of technological change in Industrial Enginering.
C705.5-P11	M	Demonstrate knowledge and understanding of Industrial Enginering principles to manage projects and to have ability to engage in independent and life-long learning in the context of technological change.
C705.5-P12	H	Recognize the need for and ability to engage in independent and life-long learning in the context of technological change in Industrial Enginering.

MAPPING	LOW/ MEDIUM/ HIGH	JUSTIFICATION
C705.2-PSO 2	H	Apply the Industrial Enginering principles of mechanical systems/processes which have been learned as a part of the curriculum.
C705.2-PSO 3	L	Develop and implement new ideas with respect to Industrial Enginering while ensuring best manufacturing practices.
C705.3-PSO 2	H	Successfully apply the principles of Industrial Enginering for design and implementation of mechanical systems/processes .
C705.3-PSO 3	M	Develop and implement new ideas with the help of modern tools in Industrial Enginering while ensuring best manufacturing practices.
C705.4-PSO 2	M	Successfully apply new ideas/ modern concepts in Industrial Enginering for implementation of mechanical systems/processes .
C705.4-PSO 3	H	Develop and implement new ideas/ modern concepts in Industrial Enginering with reference to given application/situationwhile ensuring best manufacturing practices.
C705.5-PSO 2	L	Preparation and ability to engage in independent and life-long learning in the context of technological change and successfully apply for the implementation of mechanical systems/processes

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	Understanding on the Engineering Resource Planning Software Packages like Oracle,SAP etc., used in Industry.	Web source reference 1,2,3	1, 2,3, 4, 5	2,3
2	Understanding on the Material Requirement Planning Software Packages used in Industry.	Web source reference 4,5,6	1,2,3,4,5	2,3

WEB SOURCE REFERENCES:

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

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

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

Module 1

DAY.	*MODULE*	*Topic*
1	I	Introduction to Industrial Engineering, Evolution of modern Concepts in Industrial Engineering
2	I	Functions of Industrial Engineering - Field of application of Industrial

		Engineering
3	I	Product Development and research; Design function - Objectives of design,
4	I	Manufacturing vs purchase- Economic aspects
5	I	C-V-P analysis – simple problems
6	I	Development of designs- prototype, production and testing
7	I	Human factors in design- Value Engineering .
8	II	Plant layout and Material handling-
9	II	principles of material handling,
10	II	Types of material handling equipments, Selection and application.
11	II	Preventive and break- down maintenance -
12	II	Replacement policy--
13	II	Methods of replacement analysis- Method of providing for depreciation
14	II	Determination of economic life - Simple problems.
16	III	Methods engineering: Analysis of work methods using different types of process chart and flow diagrams
18	III	Critical examination- Micro motion study and therbligs
19	III	Principles of motion economy – Work measurement-Performance rating.
20	III	Determination of allowances and standard time. - Job evaluation and merit rating
21	III	Objectives and principles of job evaluation--Wages and Incentives; Primary wage systems- Wage incentive plans
22	IV	Industrial relations- Psychological attitudes to work and working conditions - fatigue
23	IV	Methods of eliminating fatigue- Effect of Communication in Industry
24	IV	Industrial safety-
25	IV	personal protective devices
26	IV	causes and effects of industrial disputes
27	IV	Collective bargaining- Trade union

28	IV	Workers participation in management.
29	V	Production planning and control- Importance of planning
30	V	job, batch and mass production-Introduction and need for a new productproduct life cycle.
31	V	Functions of production control
32	V	Routing , Scheduling, dispatching and follow up.
33	V	Gantt charts. Inventory Control, Inventory models
34	V	Determination of EOQ and reorder levelsimple problems
35	V	Selective inventory control techniques
36	VI	Quality control and Inspection
37	VI	Destructive and non-destructive testing methods
38	VI	process capability- Statistical quality control
39	VI	causes of variation in quality- control charts for X and R.
40	VI	Reliabilitycauses of failures- Bath tub curve.; System reliability- life testing
41	VI	Introduction to concepts of, TQM, ISO (Brief description only).
42	VI	Introduction to concepts of Six Sigma and Quality circles (Brief description only).

5.3 MODULE WISE SAMPLE QUESTIONS

Module – I – Short answer questions

1. Field of application of Industrial Engineering?
2. Significance of Product Development and research?
3. Explain Design function
4. What are Step in Value Engineering .

Module – II –Short answer questions

1. Define reliability.
2. Define MTTF, MTBM and MTTR.
3. What do you mean by depreciation?
4. What are two categories of condition based monitoring?
5. Mention the computer based maintenance systems which can be implemented in an industry.
6. What are the basic reasons for replacement ?
7. Define reliability.
8. Define MTTF, MTBM and MTTR.
9. What do you mean by depreciation?

10. What are two categories of condition based monitoring?
11. Mention the computer based maintenance systems which can be implemented in an industry.
12. What are the basic reasons for replacement ?

Module – III –Short answer questions

1. What is the objective of job evaluation?

2. What is a flow diagram? What do you understand by therbligs?

3. Explain process chart symbols.

4. Describe work sampling technique.

5. Enumerate the importance of industrial safety.

6. Explain the importance of communication in industry.

Module – IV–Short answer questions

1. What is the importance of Industrial relations.
2. Explain the term fatigue.
3. Give details of personal protective devices-
4. Explain the term Collective bargaining.
5. Define Industrial fatigue. What are the reasons ?
6. Mention the operative functions of HR management.
7. What are the causes of industrial fatigue?
8. What are the functions of personnel management?
9. Explain the individual and group behavior.
10. Explain the method of selection and training of workers in industries.
11. What are the causes of industrial disputes? Explain the various methods of settling disputes.
12. What are the various stresses developed in human body and suggest suitable steps to reduce them.
13. 7. Explain the effect of industrial fatigue. Explain any two causes and elimination of fatigue.
14. Define training. What are the needs of training? Explain the different types of training.

Module – V–Short answer questions

1. Give Importance of planning.
2. What is mean by product product life cycle.
3. What is Gantt charts.
4. Expalin term EOQ.
5. What is meant by reorder level.

Module – VI –Short answer questions

1. Define process capability.

2. What is variability?

3. Distinguish defects and defectives. Which is the chart is used when observing defects per unit?

4. What do you mean by acceptance sampling?

Module – I –Analytical/Problem solving questions

1. What are the Functions of Industrial Engineering
2. What are the Objectives of design,
3. What is Human factors in design? Explain?
4. The financial details of a company are as below. Variable cost per unit is Rs.30, Selling price per unit is Rs.40, Fixed expenses are Rs.1,00,000. Calculate 1). The break-even units 2). Margin of safety considering the actual sales as 15000 units 3). The selling price per unit, if BEP is brought down to 8000 units
5. Demand for a component is at the rate of 6000 per year and this demand is going to continue for next years. The company has two options. It can get the component manufactured from outside or it can manufacture in house. It costs the company Rs.2.8 per unit to buy the component. The in-house manufacture will incur a fixed cost to the extent of Rs.10000 and variable cost of Rs.1.5 per unit. Give the decision rule for make or buy.

Module – II –Analytical/Problem solving questions

1. Explain the various types of system configurations.

2. Sketch and explain bath tub curve.

3. What is TPM ? Also, list its objectives and benefits.

4. Explain the eight pillars of TPM.

5. What are the various causes of failures of an equipment?

6. The following mortality rates have been observed for a certain type of light bulbs in an installation with 1000 bulbs. When any resistor fails, it is replaced. The cost of replacing a resistor individually is Rs.3.0. If all the resistors are replaced at the same time, the cost per resistor is Rs.0.70.

i	*1*	*2*	*3*	*4*	*5*	*6*
Probability of failure to date	0.09	0.25	0.49	0.85	0.97	1.00

Module – III –Analytical/Problem solving questions

1. How job evaluation affects human relation in industry?

2. What do you mean by ergonomics? Explain the objectives and applications of ergonomics.

3. State the duties of the following in connection with industrial safety. 1) Plant safety inspector 2) Plant supervisor.

4. State and explain in brief the steps involved in methods study procedure.

5. What is meant by Mircromotion study? Discuss the role of Therbligs in Micromotion study.

6. How merit rating differs from job evaluation? Explain the non-qualitative methods of merit rating.

Module – IV –Analytical/Problem solving questions

1. Importance of Psychological attitudes to work and working conditions.
2. Detail on Methods of eliminating fatigue.
3. Give with example Effect of Communication in Industry
4. Imprtance of Industrial safety.
5. Give details on causes and effects of industrial disputes .
6. Trade union in industry. What is the relevance ?
7. Explain with example Workers participation in management.

Module – V–Analytical/Problem solving questions

1. Explain the different factors of production.
2. What is the importance of Production planning and control
3. Compare job, batch and mass production?
4. What are the Functions of production control
5. Differentiate Routing , Scheduling, dispatching and follow up.
6. Expalin different Inventory models.
7. Explain the method for determination of EOQ and reorder level.
8. The rate of use of a particular raw material stores is 20 units/year. The cost of receiving and placing an order is Rs.40. The cost of each units Rs.100. The cost of carrying inventory in percent/year is 16 and it depends on the average stock. Determine EOQ.
9. Usha corporation currently practices the following system for the procurement of an item. No. of orders in a year = 8, ordering cost =Rs.750/order, each time order quantity =250 units, carrying cost = 40% and cost of each unit = Rs.40/-. Comment on the ordering policy of the company and estimate the loss to the company in not practicing scientific inventory policy.
10. What are the inventory control techniques.

Module – VI – Methods of manufacturing – Analytical/Problem solving questions

1. Differentiate ranging from 100% inspection and sampling inspection?
2. Explain the significance of statistical quality control.
3. What are the types of control chart? Discuss the steps involved in the construction of it.
4. Distinguish between chance causes and assignable causes
5. What do you mean by cost control? Explain the various steps involved in the process of cost control

Prepared by **Approved by**

Mr. Mathew Baby **Dr.Thankachan T. Pullan**

Faculty **HoD (ME)**

6. ME466 ELECTIVE4 Computational Fluid Dynamics

6.1 COURSE INFORMATION SHEET

PROGRAMME: ME (KTU)	*DEGREE: BTECH*
***COURSE:* Computational Fluid Dynamics**	**SEMESTER: 8 CREDITS:** 3
***COURSE CODE:* ME466** ***REGULATION:* 2016**	**COURSE TYPE:** ELECTIVE
COURSE AREA/DOMAIN: **FLUID MECHANICS**	**CONTACT HOURS:** 3Hours/Week. (LTP: 3-0-0)
***CORRESPONDING LAB COURSE CODE (IF ANY):* NIL**	**LAB COURSE NAME:** NA

SYLLABUS:

UNIT	*DETAILS*	*HOURS*
UNIT	**DETAILS**	**HOURS**
I	*Introduction to CFD*: Historical background, applications, advantages. Basic steps of CFD. Meshes, Structured and unstructured mesh, Classification of structured grids. Governing equations: continuity and momentum equations. Equation of transport of a scalar. Potential, Euler and Navier-Stokes equations	07
II	*Steady and unsteady flows.* Typical boundary conditions such as Dirichlets and Neumann conditions. TDMA method., Numerical problem up to four unknowns using TDMA. Cell centred finite volume discretisation of terms of governing equations such as time derivative, convective and diffusion.	07
III	*Analytical solution of a one dimensional convection diffusion equation*. Upwind, central and blended difference approximations for convection term, QUICK scheme. Implicit, explicit and Crank Nicolson schemes.	07
IV	*Statistical representation of turbulent flows*: Homogeneous turbulence and isotropic turbulence, General Properties of turbulent quantities, Reynolds average Navier stokes (RANS) equation, Closure problem in turbulence	07
V	*Turbulence modeling*, Different types of turbulence models: advantages and disadvantages. Structured Grid generation –Unstructured Grid generation– Mesh refinement – Adaptive mesh	07
VI	*Pressure-velocity decoupling for incompressible flows* - SIMPLE and PISO algorithms. Density based solutions for compressible flow, TVD and Van-leerschemes for compressible flow. Typical results of CFD analysis. Stream lines, method for generating stream line, velocity contours and pressure contours, Method of drawing a velocity vector. Solution of Lagrangian coordinates of a fluid particle. Commercial CFD packages.	07
TOTAL HOURS		**42**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T1	Patankar Suhas V., Numerical Heat Transfer and Fluid Flow, Taylor &Francis,1980
T2	Versteeg H.K. &Malalasekera W., An introduction to Computational Fluid Dynamics, Longman,2008
R1	Anderson Dale A., Tannehill John C. &Pletcher Richard H., Computational Fluid Mechanics and Heat Transfer, Taylor & Francis, 2016
R2	Fletcher C.A.J., Computational Techniques for Fluid Dynamics I, Springer Verlag,1984

Course pre-requisites:

C.CODE	COURSE NAME	DESCRIPTION	SEM
ME203	MECHANICS OF FLUIDS	To have basic knowledge in FLUID MECHANICS: statics and dynamics	3

Course objectives:

1	To introduce numerical modelling and its role in the field of viscous fluid flows and heat transfer.
2	To enable the students to understand the various discretization methods, solution procedures and turbulence modelling.
3	To create confidence to solve complex problems in the field of fluid flow and heat transfer using high speed computers.

COURSE OUTCOMES:

SNO	DESCRIPTION	Bloom's Taxonomy Level
CME466.1	**Recognize** the particular flow regime present in typical engineering system (laminar, turbulent, steady, unsteady, rotational, irrotational??)	*Knowledge* (Level 1)
CME466.2	**Demonstrate** the ability for numerical modelling in the field of fluid flow and heat transfer	*Demonstrate* (Level 2)
CME466.3	**Apply** the various discretization methods, solution procedures and turbulence modeling to solve fow and heat transfer problems	*Apply* (Level 3)
CME466.4	Choose the appropriate fluid mechanics principles needed to **analyze** the fluid-flow situations (eg., whether to use potential flow equations or NS equations?, which turbulence model suits where??)	*Analyze* (Level 4)
CME466.5	**Know** established engineering methods to solve complex engineering problem (principles behind CFD softwares like Ansys Fluent, CFX, openFOAM etc.??)	*Knowledge* (Level 1)

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
CME466.1	1	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CME466.2	3	3	3	3	-	-	-	-	-	-	-	1	2	1	-
CME466.3	2	-	3	-	-	-	-	-	-	-	-	-	2	1	1
CME466.4	3	2	-	1	-	-	-	-	-	-	-	1	2	-	-
CME466.5	1	2	1	1	1	-	-	-	-	-	-	1	1	1	2
ME466	**1.6**	**2.4**	**3**	**1.7**	**1**	-						**1**	**1.6**	**2**	**1.5**

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
CME466.1-PO1	L	Students will be able to appreciate and to a considerable extent *solve complex engineering problems* related to fluid mechanics, based on acquired **knowledge**.
CME466.1-PO2	M	**Problem analysis** based on *first principles of mathematics (solution to pdes) and research based relevant data* (Re, *Cd, Cl*) is essential to *recognize* various flow regimes.
CME466.2-PO1	H	Students will be able to **demostrate** their ability to *solve complex engineering problems* involving fluid flow and heat transfer, based on acquired ability for numerical modelling *applying knowledge of fundamentals in maths and science*.
CME466.2-PO2	H	**Problem analysis** based on *first principles of mathematics (solution to pdes) and research based relevant data* (*non dimensional numbers and range of them based on experiments*) is essential to *grasp (demonstrate)* the theory behind various numerical models.
CME466.2-PO3	H	In the **design/development of solutions** *for complex fluid flow problems, to design fluid transmission systems, in the design of flight elements (aircraft wings)* that ensures civilian *safety* on ground, the knowledge of flow characteristics (non dimensional flow characteristic numbers, pressure variations, flow separation effects, vortex shedding etc.) is a definite prerequisite. These solutions can only be effectively devloped only through numerical modeling.
CME466.2-PO4	H	While **conducting investigations of complex problems** to *validate/conclude* on *analysis* whether a turbeulent flow is effectively simulated, the student has to *use research based knowledge* (numerical schemes, turbulence emperical coefficients, etc: exhaustive data is available) and *interpret relevant data* at his/her disposal.

CME466.2-PO12	L	The student is considered to have *recognized the need* for **life-long learning** in computational fluid mechanics and be *prepared and developed the ability to engage in independent and life-long learning in the broadest context of technological change* in various applications of fluid mechanics.
CME466.3-PO1	M	Deeper **knowledge** gained into the concepts of turbulence moeling will help to *solve complex engineering problems* related to correct prediction of hydrodynamic/aerodynamic effects for bodies in relative motion with any fluid. For. eg. geophysical motion of clouds, naval hydrodynamics, aircraft aerodynamics, flutter analysis, fluid str interactions etc.
CME466.3-PO3	H	Through the **application** of various discretization methods, solution procedures and turbulence modeling it is possible to **design solutions** for complex engineering problems involving flow and heat transfer. Engineering system components or processes are designed based on these.
CME466.4-PO1	H	Having had considerable background in fluid physics, additional **knowledge** on fluid flow types with a computational perspective will take a student to *very high level of connect with physics* when trying to *solve a complex engineering problem involving flow and heat transfer..*
CME466.4-PO2	M	**Problem analysis** based on *first principles of mathematics* (formulation of pdes, analytical equations etc) *and research based relevant data* (coefficients for equations in various turbulence models) is essential to *analyze, evaluate, debate and recommend* appropriate turbulence model (*reaching conclusions*) for various flows encountered in engg. applications. For. eg. suitability of *kw*, *ke* or *sst* model ??
CME466.4-PO12	L	The student is considered to have *recognized the need* for **life-long learning** in the computational techniques behind using potential flow theory, boundary layer theory and turbulence modeling and be *prepared and develop the inclination to engage in independent and life-long learning* in these areas of computational fluid dynamics. Familiarization of changing computational methods, newwer softwares and their application for engineering problems is a life long learning process, and **one has to be always keep himself/herself updated with latest CFD techniques**.
CME466.5-PO1	L	Student will gain a broad overview of *basic/fundamental knowledge in (engineering)* flow simulation softwares like Ansys Fluent, openFoam etc but his/her **knowledge** will be limited to *recognizing* various theories behind turbulence modeling, theory behind application of the boundary conditions, problem setting etc. However this itself is fundamental in the *solution to a complex problem at an undergraduate engineering level.*

CME466.5-PO2	M	**Problem analysis** based on *first principles of flow physics* for eg., defining the proper boundary conditions, recognizing the various flow physics that may be coupled, etc is essential to *analyze*, *evaluate, debate and recommend* a suitable computational solution methodology, step size and convergence criteria.
CME466.5-PO3	L	In the **design/development of solutions** *for complex external flow problems and to design fluid dynamic systems* that ensures civilian *safety (as with passengers in aircraft, human safety with nuclear reactors, boilers etc)* the knowledge of devising a numerical test model is now a acceptable practise before prototype development or experiments. Computer modeling of such flow and heat transfer problem is done using modern tools like Ansys Fluent, CFX, etc. for which student will get the *basic ideas*.
CME466.5-PO4	L	CFD softwares like Ansys Fluent, CFX, openFOAM etc are the tools to **conduct investigations of complex problems:** These tools 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. However, usage of these tools are limited to *kowledge* level only for this course.
CME466.5-PO5	L	*Basic knowledge* of CFD softwares like Ansys Fluent, CFX, openFOAM will promote **usage of these modern tools**: Student will gain basic knowlede to *create, select, and apply appropriate numerical techniques in such modern engineering and IT tools* to predict and model complex engineering activities with an understanding of the limitations of such tools.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
CME466.1-PSO1	M	Students will acquire *deep knowledge on continuity, potential flow and NS equations, and basic knowledge on meshes and grid generations* which together will help him/her **apply their knowledge in the domain of engineering mechanics, thermal and fluid sciences to solve engineering problems** utilizing advanced technology, which is the backbone of CFD.
CME466.2-PSO1	M	Numerical modelling in the field of fluid flow and heat transfer involves programming with proper *discretization schemes (upwind, QUICK, implicit, explicit, etc.) and matrix algorithms (eg., TDMA)* which will help the student to **apply their knowledge in the domain of engineering mechanics, thermal and fluid sciences to solve engineering problems** using high-level programming

		languages/commercial softwares.
CME466.2-PSO2	L	Numerical modelling in the field of fluid flow and heat transfer**, will help to successfully apply the principles of design**, analysis and implementation of mechanical systems/processes **learned as a part of the curriculum.** For eg., designing a heat exchanger with his/her knowledge in Heat and Masss transfer, will be additionally be helped by numerical simulations learned through CFD. However this present course will provide him the **basic capability only**.
CME466.3-PSO1	M	Students **will be able to apply knowledge in the domain of thermal and fluid sciences** to solve engineering problems (for eg. to solve fow and heat transfer problems) utilizing advanced technology (softwares), which **essentially involves computational techniques with various discretization methods, solution procedures and turbulence modeling.**
CME466.3-PSO2	L	In the **design and analysis** *of free and forced vortex flows* (for predicting aerosol, cloud, geophysical fluid transport, etc) the *processes* (computational methods, wind & water tunnels) will be **based on the successful application of the principles learned** on fluid dynamics (vorticity, stream function, continuity). However this level of knowledge **will be basic** and has to be developed through experience.
CME466.3-PSO3	L	**Application of proper discretization methods** and iterative techniques have helped solution procedures involving shock and (or) turbulence. For. eg., modeling flow and heat transfer for ICBMs once considered unsolvable in engineering world. This is purely due to advent of **CFD+CAD**+CAM tools. Similarly the **student will be able to develop and implement new ideas on innovative product development.**
CME466.4-PSO1	M	With the **knowledge in** the domain of framing governing equations for flow (continuity eqn along with potential flow or NS equations), **thermal and fluid sciences** (fluid mechanics), the students **will be successful in solving fundamental engineering problems utilizing advanced technology in an industry** for various flow problems numerically or analytically.
CME466.5-PSO1	L	Students **gain only a peripheral knowledge in** the domain of turbulence modeling (*law of wall, mixing length, k-e, k-w, sst k-w*) which is behind the established engineering methods (**principles behind CFD softwares** like Ansys Fluent, CFX, openFOAM etc.??), that predict mixing and flow separation (*thermal and fluid sciences*). Though elaborate for an undergraduate course, to be successful in **solving high level aircraft/ ship manufacturing engineering problems,** further specific in depth studies are required.

CME466.5-PSO2	L	Student will be able to **successfully apply principles of design, analysis and implementation of experimental mechanical systems** based on turbulence, flow controls, wind tunnel design, airfoil design (vortex shedding, shape factor, turbulence models, relevant non-dimensional numbers, etc) using the **basics of CFD software philosophy** which have been **learned as a part of the curriculum.**
CME466.5-PSO3	M	**CFD softwares like Ansys Fluent, CFX, openFOAM** are best for parmetric studies to cut down experimental and prototype costs **for product design and development**. These are **modern CAE/CAD/CAM tools which ensure best manufacturing practises** without costly trial and error practices. The student will **gain knowledge** in these softwares **atleast at a level to implement for devising undergraduate projects** and has to improve through experience.

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

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

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

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SINO:	TOPIC	RELEVENCE TO PO\PSO

WEB SOURCE REFERENCES:

1	https://www.youtube.com/watch?reload=9&v=hzTCCcsOTg8
2	http://freevideolectures.com/Course/89/Fluid-Mechanics
3	https://www.youtube.com/watch?v=kwqoyuZTglQ
4	https://www.youtube.com/watch?v=G4YHzSmT3qU
5	https://www.youtube.com/watch?v=qcZSWABWbfc

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

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

ASSESSMENT METHODOLOGIES-DIRECT

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

ASSESSMENT METHODOLOGIES-INDIRECT

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

6.2 COURSE PLAN

DAY	*MODULE*	*TOPIC PLANNED*
1	I	*Introduction to CFD*, Historical background, applications, advantages.
2	I	Basic steps of CFD. Meshes, Structured and unstructured mesh
3	I	Basic steps of CFD. Meshes, Structured and unstructured mesh
4	I	Classification of structured grids
5	I	Governing equations: continuity and momentum equations
6	I	Equation of transport of a scalar. Potential, Euler and Navier-Stokes equations
7	I	Equation of transport of a scalar. Potential, Euler and Navier-Stokes equations
8	II	*Steady and unsteady flows*. Typical boundary conditions such as Dirichlets and Neumann conditions.
9	II	Steady and unsteady flows. Typical boundary conditions such as Dirichlets and Neumann conditions.
10	II	TDMA method
11	II	TDMA method. Numerical problem up to four unknowns using TDMA.
12	II	TDMA method. Numerical problem up to four unknowns using TDMA.
13	II	Cell centred finite volume discretisation of terms of governing equations such as time derivative, convective and diffusion.
14	II	Cell centred finite volume discretisation of terms of governing equations such as time derivative, convective and diffusion.
15	III	*Analytical solution of a one dimensional convection diffusion*
16	III	Upwind, central and blended difference approximations for convection term
17	III	Upwind, central and blended difference approximations for convection term
18	III	QUICK scheme
19	III	Implicit schemes

20	III	Explicit schemes
21	III	CrankNicolson scheme
22	IV	Statistical representation of turbulent flows
23	IV	Homogeneous turbulence and isotropic turbulence
24	IV	General Properties of turbulent quantities
25	IV	General Properties of turbulent quantities
26	IV	Reynolds average Navier stokes (RANS) equation
27	IV	Reynolds average Navier stokes (RANS) equation
28	IV	Closure problem in turbulence .
29	V	*Turbulence modeling*, Different types of turbulence models: advantages and disadvantages.
30	V	Different types of turbulence models: advantages and disadvantages.
31	V	Structured Grid generation
32	V	Unstructured Grid generation
33	V	Mesh refinement – Adaptive mesh
34	VI	*Pressure-velocity decoupling for incompressible flows* - SIMPLE algorithm
35	VI	SIMPLE and PISO algorithms.
36	VI	Density based solutions for compressible flow- TVD and Van-leerschemes for compressible flow.
37	VI	Typical results of CFD analysis.
38	VI	Stream lines, method for generating stream line, velocity contours and pressure contours,
39	VI	Method of drawing a velocity vector.
40	VI	Solution of Lagrangian coordinates of a fluid particle.
41	VI	Commercial CFD packages.
42	VI	Commercial CFD packages.

6.3 MODULE WISE SAMPLE QUESTIONS

MODULE: 1 Introduction to CFD techniques

1.

A two-dimensional small-disturbance velocity potential equation for compressible flows is given as

$\left(1-M_{\infty}^{2}\right)\frac{\partial^{2}\phi}{\partial x^{2}}+\frac{\partial^{2}\phi}{\partial y^{2}}=0$, where M is the Mach number of flow.

(i) Examine whether this equation is parabolic, elliptic, or hyperbolic?
(ii) Justify your inference from pure physical arguments.

2.

Identify the natural and essential boundary conditions of the following differential equation:

$\frac{d^2}{dx^2}\left[a(x)\frac{d^2y}{dx^2}\right]+b(x)=0$, for $0<x<L$; subject to the following boundary conditions:

$y=0$ and $dy/dx=0$ at $x=0$; $\left[a(x)\frac{d^2y}{dx^2}\right]_{x=L}=A$, $\left[\frac{d}{dx}\left(a(x)\frac{d^2y}{dx^2}\right)\right]_{x=L}=0$.

MODULE: 2 Steady and unsteady flows, TDMA

1.

Finite volume discretization equation for scalar variable ϕ is obtained as:

$-5\phi_P=-3\phi_E-2\phi_W+5$

Is the above discretization expected to yield a physically unrealistic solution. Justify with reasoning.

2.

For a 1-D convection – diffusion problem, fluid density = 1000kg/m^3, flow velocity = 1m/s, diffusion coefficient = 10^{-9} m^2/s, and domain length = 1m. Will a central difference scheme work, for a numerical solution of this problem (Given that dimension of the solution vector for the TDMA should not exceed 1000)? Give reasons for your answer?

MODULE: 3 One dimensional convection diffusion equation

1. Write short notes on the various advection schemes in CFD.

2.

Consider the solution of the following template 1 –D wave equation: $\frac{\partial u}{\partial t}+c\frac{\partial u}{\partial x}=0$

Using a modified FTCS scheme, in which the term u_i^n for time discretization is expressed as $u_i^n=\frac{1}{2}\left(u_{i+1}^n+u_{i-1}^n\right)$, where the index 'i' represents spatial discretization where as the superscript 'n' represents temporal discretization. Examine the numerical stability of this scheme using von- Neumann stability analysis.

MODULE: 4 Statistical representation of turbulent flows

1. Write short notes on turbulent viscosity and RANS equations.
2. What are the rues for mean time averaging

MODULE: 5 Turbulence modeling

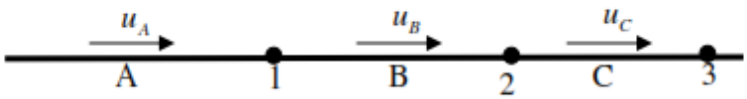
1. Explain the concept of Prandtl's mixing length theory for turbulent boundary layer flows.
2. What is '*law of the wall*' ? Short notes on mesh refinement and mesh independence.
3. Write short notes on Delaunay triangulation

MODULE: 6 Pressure-velocity decoupling algorithms

1.

In the one-dimensional constant-density situation shown below, the momentum equations for u_B and u_c can be written as follows:

$$u_B = 5 + 2.5(p_1 - p_2)$$
$$u_c = 5 + 7.5(p_2 - p_3)$$



The boundary conditions are as: $u_A = 15$ (all values are given in consistent units). Obtain the values for p_1 and p_2, following the SIMPLE calculation procedure. Comment on the uniqueness of your solution.

2. Draw the Flow/chart for describing Solution of Navier-Stokes Equations for Incompressible Flows Using SIMPLE algorithm

Prepared by **Approved by**

Dr.Ajith Kumar A **Dr.Thankachan T Pullan**
(Faculty) **(HOD)**

ME 476 MATERIAL HANDLING & FACILITIES PLANNING

7.1 COURSE INFORMATION SHEET

PROGRAMME: MECHANICAL ENGINEERING	**DEGREE: B.TECH**
COURSE: MATERIAL HANDLING & FACILITIES PLANNING	SEMESTER**: VIII** CREDITS: **3**
COURSE CODE: ME 476 REGULATION: 2016	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: PRODCUTION AND INDUSTRIAL ENGINEERING	CONTACT HOURS: **3** HOURS/WEEK.
CORRESPONDING LAB COURSE CODE (IF ANY):	LAB COURSE NAME:

SYLLABUS:

UNIT	*DETAILS*	*HOURS*
I	Design of layout of factories, Office, Storage area etc. on consideration of facilities of working people, Storage facilities and general equipment for amenities of working people – Product, Process and combination layout – Systematic layout planning, Design of Assembly lines, Line balancing methods.	8
II	Computer applications in layout designs, Environmental aspects like lighting, Ventilation, dust control, humidity. Different type of Plant services like steam compressed air etc.	6
III	Plant safety, Elements off Industrial safety- Causes and prevention of accidents – Pollution and environmental consideration.	6
IV	Introduction, Material Handling systems, Material Handling principles, Classification of Material Handling Equipment, Relationship of material handling to plant layout.	8

V	Basic Material Handling systems: Selection, Material Handling method- path, Equipment, function oriented systems.	7
VI	Methods to minimize cost of material handling- Maintenance of Material Handling Equipment's, Safety in handling, Ergonomics of Material Handling equipment. Design, Miscellaneous equipment	7
Total Hours		**42**

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHORS/PUBLICATION*
T/R	A W Peymberton, Plant layout and Material Handling, John Wiley
T/R	James A Apple, Plant layout and Material Handlin, Krieger Pub Co,1998
T/R	John A Sehbin, Plant layout and Material Handling-
T/R	K C Arora & Shinde, Aspects of Material handling, Lakshmi Publications
T/R	P B Mahapatra, Operations Management, PHI, 2010

COURSE PRE-REQUISITES:

C.CODE	*COURSE NAME*	*DESCRIPTION*	*SEM*
	Nil		

COURSE OBJECTIVES:

1	To understand the overall facilities planning process
2	To educate product, process and schedule design and their effects on the facility layout
3	To introduce concepts of material handling and safety in industries

COURSE OUTCOMES:

SNO	*DESCRIPTION*	*Bloom's Taxonomy Level*
CME476.1	Identify the value of facility planning on the strategy of a firm	Understand (level 2)
CME476.2	Develop a systematic plant layout	Apply (level 3)

CME476.3	Analyse the safety and environmental aspects in facilities planning	Analyse (level 4)
CME476.4	Understand various material handling systems and classification of material handling equipment	Understand (level 2)
CME476.5	Selection and Maintenance of material handling equipment with safety and ergonomics aspects	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***
C 4 7 6 . 1	1	1				2	2	2	2		2			2	
C 4 7 6 . 2			2				2								2
C 4 7 6 . 3						2	2							2	
C 4 7 6 . 4	1	2									2			2	
C 4 7 6 . 5	1		2	2							2	2		2	2

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	***LOW/MEDIUM/HIGH***	***JUSTIFICATION***
CME 476.1-PO 1	L	Uses basic knowledge in mechanical engineering to identify the line balancing methods
CME 476.1-PO 2	L	Identify the different layout types reach sustained conclusion on planning facility layout
CME 476.1-PO 6	M	Considering the amenities and facilities of workers can apply to the reasoning capability in assessing the societal health and safety.
CME 476.1-PO 7	M	Assessing the value of facility planning on the strategy of a firm develop the need of sustainable developments
CME 476.1-PO 8	M	Getting an insight on systematic layout planning on consideration of facilities of working people apply ethical principles to commit professional ethics
CME 476.1-PO 9	M	Facilitating the general amenities for co-workers through plant layout make the individual as a good team player.
CME 476.1-PO 11	M	Understanding the value of facility planning strategy of a firm leads to apply in one's own work to manage projects in multi-disciplinary environment

CME 476.2-PO 3	M	Computer applications in layout design leads to complex engineering layout solutions
CME 476.2-PO 7	M	Applying environmental aspects in layout design understand the impact of professional engineering solutions in societal and environmental contexts
CME 476.3-PO 6	M	Pollution and environmental consideration makes the engineer to analyse commitment of engineer to society.
CME 476.3-PO 7	M	Safety and environmental aspects understands the need of sustainable developments in new and existing designs of layout facility.
CME 476.4-PO 1	L	Knowledge on various material handling systems guides to make better layout
CME 476.4-PO 2	M	Relationship of material handling knowledge make the student to solve real time problems in the system.
CME 476.4-PO 11	M	Knowledge and understanding on Material handling principles can demonstrate engineering and management capability to work with multidisciplinary environment
CME 476.5-PO 1	L	Selection and design knowledge on material handling helps to create equipment's with safety and ergonomics.
CME 476.5-PO 3	M	Design of material handling system and equipment's in terms of maintainability, ergonomics and safety along with environmental aspect gives solutions for new and old layouts which require modernisation
CME 476.5-PO 4	M	Path function and equipment could be used to conduct complex investigations pertain to material handling systems
CME 476.5-PO 11	M	Methods to minimise material handling cost can make one to work as a member as well as project lead in terms of management and finance
CME 476.5-PO 12	M	Applying maintenance principles to material handling system requires lifelong learning and investigations

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM /HIGH*	*JUSTIFICATION*
CME 476.1-PSO 2	M	Applying the design principles in layout of factories students will identify the facility planning strategies of a firm.

CME 476.2-PSO 3	M	The computer applications in layout design leads to development of plant layout ensuring the best manufacturing practices.
CME 476.3-PSO 2	M	Analysing the safety and environmental aspects of facilities planning helps to successfully design a layout ensuring plant safety
CME 476.4-PSO2	M	Classifying the material handling system and relationship between material handling and plant layout leads to asses facility in order to design or redesign an existing facility
CME 476.5- PSO2	M	Right selection of material handling system design and Maintenance with safety and ergonomics aspects helps to make mechanical systems work and processes better
CME 476.5- PSO3	M	To develop and design material handing method for a new product developed the path, equipment and function gives an insight.

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

SlNO	*DESCRIPTION*	*RELEVENCE TO PO\PSO*	*PROPOSED ACTIONS*

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SNO	DESCRIPTION	RELEVENCE TO PO\PSO	PROPOSED ACTIONS

WEB SOURCE REFERENCES:

1	http://www.godrejmhe.in
2	http://www.mhi.org/agvs
3	http://www.voltas-mh.com/
4	http://toyotamaterialhandlingindia.com/
5	www.konecranes.in/equipment/lift-trucks/forklifts

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

7.2 COURSE PLAN

DAY	*MODULE*	*TOPIC PLANNED*
1	1	Design of layout of factories, Office, Storage area etc.,
2	1	Design of layout of factories
3	1	Design of layout of factories, Office, Storage area etc. on consideration of facilities of working people
4	1	Design of layout of factories, Office, Storage area etc. on consideration of facilities of working people
5	1	Product, Process and combination layout –Systematic layout planning
6	1	Product, Process and combination layout –Systematic layout planning
7	1	Design of Assembly lines, Line balancing methods.
8	1	Design of Assembly lines, Line balancing methods.
9	2	Computer applications in layout designs,
10	2	Computer applications in layout designs,
11	2	Environmental aspects like lighting, Ventilation, dust control, humidity.
12	2	Environmental aspects like lighting, Ventilation, dust control, humidity.
13	2	Different type of Plant services like steam compressed air etc
14	2	Different type of Plant services like steam compressed air etc
15	3	Plant safety, Elements off Industrial safety
16	3	Plant safety, Elements off Industrial safety

17	3	Causes and prevention of accidents while using material handling equipment's
18	3	Causes and prevention of accidents while using material handling equipment's
19	3	Pollution and environmental consideration of material handling
20	3	Pollution and environmental consideration of material handling
21	4	Introduction to Material Handling systems
22	4	Introduction to Material Handling systems
23	4	Introduction to Material Handling systems
24	4	Material Handling systems, Material Handling principles,
25	4	Classification of Material Handling Equipment,
26	4	Relationship of material handling to plant layout
27	4	Relationship of material handling to plant layout
28	5	Basic Material Handling systems:
29	5	Basic Material Handling systems:
30	5	Selection, of Material Handling system method- path, Equipment, function oriented systems.
31	5	Selection, of Material Handling method- path, Equipment, function oriented systems.
32	5	method- path, Equipment, function oriented systems
33	5	method- path, Equipment, function oriented systems
34	5	Equipment function oriented systems.
35	5	Equipment function oriented systems.
36	6	Methods to minimize cost of material handling-
37	6	Methods to minimize cost of material handling
38	6	Maintenance of Material Handling Equipment
39	6	Maintenance of Material Handling Equipment
40	6	Safety in handling,
41	6	Ergonomics of Material Handling equipment.
42	6	Design, Miscellaneous equipment

7.3 MODULE WISE SAMPLE QUESTIONS

UNIT-I

1. Illustrate Design of layout of factories, Office, Storage area etc. on consideration of facilities of working people.
2. Make a sense of Storage facilities and general equipment for amenities of working people –
3. Classify Product, Process and combination layout.
4. Describe Systematic layout planning.
5. Summarise Design of Assembly lines and Line balancing methods

UNIT-II

1. Explain computer applications in layout designs
2. Interpret Environmental aspects like lighting, Ventilation, dust control, humidity while designing layouts
3. Asses the importance of different type of Plant services like steam compressed air etc.

UNIT-III

1. Correlate plant safety and its implementation on a plant layout,
2. Prioritise the Elements off Industrial safety- Causes and prevention of accidents
3. Recognise the Pollution and environmental consideration on plant layout.

UNIT-IV

1. Trace what are the Material Handling systems,
2. Identify the Material Handling principles,
3. Classify Material Handling Equipment
4. Relate the relevance of material handling to plant layout.

UNIT-V

1. What characteristics make you choose a Basic Material Handling systems:
2. How do you recommend Material Handling method- based on path, Equipment, function oriented systems.

UNIT VI

1. Recommend Methods to minimize cost of material handling
2. Conclude the Maintenance policy of Material Handling Equipment's.
3. While designing Material Handling and Miscellaneous equipment how will you justify the Design in Safety and Ergonomics aspects,

Prepared by **Approved by**

Mr.Jithin K Francis **Dr.Thankachan T Pullan**
(Faculty) **(HOD)**

8. ME468 NANOTECHNOLOGY

8.1 COURSE INFORMATION SHEET

PROGRAMME: MECHANICAL ENGINEERING	*DEGREE: B.TECH*
COURSE: NANOTECHNOLOGY	SEMESTER: VIII CREDITS: 3
COURSE CODE: ME 468 REGULATION: UG	COURSE TYPE: ELECTIVE
COURSE AREA/DOMAIN: MATERIALS SCIENCE AND TECHNOLOGY	CONTACT HOURS: 3 Lectures
CORRESPONDING LAB COURSE CODE (IF ANY): NA	LAB COURSE NAME: NA

SYLLABUS:

MODULE	CONTENTS	HOURS
I	Introduction and scope-Classification of nanostructures: Quantum dots, quantum wires, quantum wells, nanoclusters, nanotubes, super lattices, nanocrystalline materials-Effects of nanometer length scale – Changes to the system total energy, changes to the system structures.	5
II	Effect of Nanoscale dimensions on various properties – structural, thermal, chemical, mechanical, magnetic, optical and electronic properties.	8
III	Fabrication methods: Top down and bottom up approaches-Top down processes: Milling, Lithographics, machining process, pulsed laser methods- Bottom up processes: Vapour phase deposition methods, PVD, CVD, electro deposition, plasma assisted deposition process, MBE, chemical methods, colloidal and solgel methods	6
IV	Characterisation methods: General classification of characterization methods, Microscopy techniques: Scanning Electron Microscopy, Transmission Electron Microscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy, Diffraction Techniques-Spectroscopy Techniques – Raman Spectroscopy, Surface analysis and depth profiling-Mechanical Properties-Magnetic and Thermal properties.	15
V	Applications of Nanotechnology (nano materials and devices)-Applications of nanocomposites, nanocrystalline materials, nano layered structures, nanomagnetic materials-magneto resistance- Carbon nanotubes: SW, MW, nanostructured coatings- nano sensors: order from chaos, characterization, perception, nano sensor based on quantum size effect, Electrochemical sensors, Sensors based on physical properties, Nanobiosensors, smart dust.	9
VI	Nanomachines: covalent and noncovalent approaches, Molecular motors and machines, molecular devices, single molecular devices, practical problems with molecular device-Nanofluids: nanoparticles, preparation of nanofluids, thermophysical properties of nanofluids in comparison with base fluid. Nanoswitches - nano computers- nanofilters	7

Total Hours 42

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHOR/PUBLICATION*
T1	Bharat Bhushan – Springer Handbook of Nano technology
T2	A.K. Bandyopdhyay, Nanomaterials, , New age international publishers,2008
T3	Pradeep T., IIT Madras - NANO: The Essentials, Tata McGraw Hill
T4	Charles P Poole, Frank J Owens, Introduction to Nanotechnology, John Wiley and Sons, 2003
T5	Jeremy Ramsden,Nanotechnology, William Andrew, Elsevier, 2011
T6	V.S.Muralidharan, A Subramnya,Nano science and Technology, Ane books Pvt Ltd
R1	Gregory Timp, Nanotechnology, Springer-Verlag, 2009
R2	John Mongillo, Nano Technology, Greenwood Press, 2007
R3	Kelsall Robert. W, Ian Hamley, MarkGeoghegan, Nanoscale Science and Technology, Wiley Eastern,2005

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
ME210	MME	Materials Science and Engineering	Third
ME220	MT	Manufacturing Technology	Fourth
ME306	AMT	Advanced Manufacturing technology	Fifth

COURSE OBJECTIVES:

1	To introduce nanotechnology and nanostructures
2	To introduce fabrication and characterization techniques used in nanotechnology

COURSE OUTCOMES:

SI NO:	DESCRIPTION	Blooms' Taxonomy Level
ME 468.1	Students will be able to *identify* different nanocrystalline materials, nanostructures, processing and charecterisation techniques etc	Knowledge (level 1)
ME 468.2	Students will be able to *distinguish* different nano materials and nano structures	Understand (level 2)
ME 468.3	Students will be able to *correlate* the structure with different properties and processing of nano structured materials.	Apply (level 3)
ME 468.4	Students will be able to *understand* the application of nanotechnology in nano materials and devices	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
ME 468.1	3	1	-	-	-	-	-	-	-		-	-	-	-	-
ME 468.2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
ME 468.3	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
ME 468.4	3	2	-	-	-	-	-	-	-	-	-	2	-	-	1

JUSTIFATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM /HIGH	JUSTIFICATION
ME 468.1-PO1	H	Helps in acquiring fundamental knowledge of nanomaterials and materials engineering
ME 468.2-PO1	H	Helps in distinguishing between nano materials and nano structures as part of acquiring fundamental knowledge of nanotechnology
ME 468.3-PO1	H	Improves the fundamental knowledge on the microstructure-mechanical property correlation of engineering materials including nano materials
ME 468.4-PO1	H	Updates the knowledge on different manufacturing and advanced manufacturing technology by understanding of the application of nanotechnology in materials and devices.
ME 468.1-PO2	L	Helps in the first stages of problem analysis like identification and research literature related to nanotechnology
ME 468.2-PO2	M	Helps in the first stages of problem analysis like identification, understanding and research literature related to nanomaterials and structures.
ME 468.3-PO2	H	Helps in problem analysis like identification, literature review and analysis of relationship between structure and properties of nano materials and structures.
ME 468.4-PO2	H	Helps in the first stages of problem analysis like identification, understanding and research literature related to application of nanomaterials and structures.
ME 468.4-PO12	H	Students understand the importance of continuous learning by acquiring fundamental knowledge on uptodate science and technology in order to stay alive in the current technological world.

JUSTIFATIONS FOR CO-PSO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
ME 468.4-PSO3	L	Students will be able to apply their knowledge in the domain of engineering mechanics to understand the nanotechnology.

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

SI NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	Finds difficulty in correlating with the actual situations	Nanotechnology Laboratory visit & Reading	2,3,5,6,7	

PROPOSED ACTIONS: Topics beyond syllabus/assignment/industry visit/guest lecturer/video lectures etc.

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SI NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH Pos	RELEVANCE WITH PSOs
1	MEMS and NEMS	Notes	1,2	

WEB SOURCE REFERENCES:

1	**nptel.ac.in/courses/103103033/module9/lecture1.pdf**
2	V. Pokropivny, R. Lohmus, I. Hussainova, A. Pokropivny, S. Vlassov. Introduction in nanomaterials and nanotechnology. – University of Tartu. –2007, 225p (pdf available)
3	What is Nano Technology? Adapted from Online Materials Available from NNIN: http://www.nnin.org/nnin_edu.html.
4	Nanotubes-nptel.ac.in/courses/103103033/module9/lecture3.pd
5	https://www.sciencedaily.com/terms/carbon_nanotube.htm
6	A brief introduction about MEMS and NEMS: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.111.3275&rep=rep1&type=pdf
7	https://www.mri.psu.edu/materials-characterization-lab/ ...techniques/ nanoindentation
8	https://www.sciencedirect.com/topics/materials-science/boundary-lubrication

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

Day	Module	Topic
1	1	Introduction and scope-Classification of nanostructures
2	1	Quantum dots, quantum wires
3	1	Quantum wells, nanoclusters, nanotubes
4	1	Super lattices, nanocrystalline materials
5	1	Effects of nanometer length scale
6	1	Changes to the system total energy
7	1	Changes to the system structures.
8	2	Effect of Nanoscale dimensions on various properties
9	2	Structural properties
10	2	Thermal properties
11	2	Chemical properties
12	2	Magnetic properties
13	2	Optical properties
14	2	Electronic properties
15	3	Fabrication methods: Top down and bottom up approaches
16	3	Top down processes: Milling
17	3	Lithographics, machining process, pulsed laser methods
18	3	Bottom up processes: Vapour phase deposition methods, PVD, CVD
19	3	Electro deposition, plasma assisted deposition process
20	3	MBE, chemical methods
21	3	Colloidal and solgel methods
22	4	Characterisation methods: General classification of characterization methods, Microscopy techniques
23	4	Scanning Electron Microscopy,
24	4	Transmission Electron Microscopy
25	4	Scanning Tunneling Microscopy, Atomic Force Microscopy

26	4	Diffraction Techniques-Spectroscopy Techniques – Raman Spectroscopy
27	4	Surface analysis and depth profiling
28	4	Mechanical Properties-Magnetic and Thermal properties.
29	5	Applications of Nanotechnology (nano materials and devices)- Applications of nanocomposites,
30	5	Nanocrystalline materials, nano layered structures
31	5	Nanomagnetic materials-magneto resistance-
31	5	Nanomagnetic materials-magneto resistance-
32	5	Carbon nanotubes: SW, MW,
33	5	Nanostructured coatings
34	5	Nano sensors: order from chaos
35	5	Characterization, perception, nano sensor based on quantum size effect
36	5	Electrochemical sensors, Sensors based on physical properties,
37	5	Nanobiosensors, smart dust
38	6	Nanomachines: covalent and non covalent approaches,
39	6	Molecular motors and machines, molecular devices, single molecular devices,
40	6	Practical problems with molecular device-
41	6	Nanofluids: nanoparticles, preparation of nanofluids,
42	6	Thermophysical properties of nanofluids in comparison with base fluid.
43	6	Nanoswitches - nano computers- nanofilters
44	6	Revision

8.3 Questions

Module1

1. Elaborate various classification of nanostructures.
2. Differentiate Quantum dots, quantum wires, quantum wells.
3. Explain the effects of nanometer length scale in the systems energy and structures.
4. What are nano tubes give examples.

Module 2

1. How the effect of Nanoscale dimensions influence on various properties?
2. Structural properties.
3. Thermal properties
4. Chemical properties
5. Mechanical properties
6. Magnetic properties
7. Optical properties

8. Electronic properties

Module 3

1. Describe Top down and bottom up approaches
2. Describe lithography
3. Describe PVD and CVD
4. Describe various chemical methods

Module 4

1. Explain the principle behind scanning tunnelling microscope and atom force microscope
2. Give short note on Transmission electron microscope on nano materials charecterization
3. What is surface analysis and depth profiling
4. How is diffraction technique useful in nano material analysis

Module 5

1. Describe various types of carbon nanotubes and applications.
2. What are the applications of nanocomposites?
3. Difference between nanocrystalline materials and nano layered structures.
4. What is smart dust?

Module 6

1. What is molecular machines and molecular motors
2. Explain nano fluids and their applications
3. Give short notes on Nanoswitches - nano computers- nanofilters

Prepared by **Approved by**

Dr.Sreekumar V.M. **Dr. Thankachan T Pulla**
(Faculty) **(HOD DME)**

9. ME 462 PROPULSION ENGINEERING

9.1 COURSE INFORMATION SHEET

*PROGRAMME:**MECHANICAL ENGINEERING***	*DEGREE: **BTECH***
COURSE:PROPULSION ENGINEERING	**SEMESTER: VIII CREDITS:** 3
COURSE CODE:ME 462 **REGULATION:** 2016	**COURSE TYPE:** ELECTIVE IV
COURSE AREA/DOMAIN:FLUID &THERMAL SCIENCE	**CONTACT HOURS:**2(LECTURE) + 1(TUTORIAL) HOUR/WEEK
CORRESPONDING LAB COURSE CODE (IF ANY):NIL	**LAB COURSE NAME:NIL**

SYLLABUS:

MODULE	CONTENTS	HOURS
I	Fundamentals of Propulsion- Classification types of propulsive devices-Airscrew, Turbojet, Turboprop, turbofan, Turboshaft, Ramjet, Scramjet, Pulsejet and Rocket engines. Comparative study of performance characteristics applications.	**7**
II	Theory of propulsion – Thrust, thrust power and efficiencies of turbojet engine. Thermodynamics analysis of turbojet engine cycle, Propellers: Types of propellers	**7**
III	Turbojet engine components- air intakes, Compressors, Combustion chambers, turbines, nozzles turbine and compression matching – Thrust augmentation.	**7**
IV	Rocket propulsion- general operating principles of chemical, electrical nuclear and solar rockets. Chemical Rockets- Classification. Performance parameters for chemical rockets and their relationship, Energy and efficiencies, simple problems, Solid propellants- Types- burning rate- grain Configurations, - Classification- Typical fuels and oxidizers, properties and specifications, Selection.	**7**
V	Liquid propellant feed systems, injectors, Starting and ignition, Igniters liquid propellant, Precautions in propellant handling. Hybrid Rockets combustion processes in SPR and LPR combustion instability- Control of instabilities –Cooling of Rocket motors.	**7**
VI	Flight Performance- Velocity and attitude in simplified vertical Refractory staging of rockets. Rocket Testing- Test facilities and safeguards. Measurement System Terminology, Flight Testing.	**7**

TEXT/REFERENCE BOOKS:

T/R/D	*BOOK TITLE/AUTHOR/PUBLICATION*
T1	K Ramamurthi, Rocket Propulsion, Laxmi Publications, 2016.
T2	Saeed Farokhi, Aircraft Propulsion, Wiley, 2e, 2014.
R1	G. P. Sutton and Oscar Biblarz, Rocket Propulsion elements- John Wiley & Sons, 2013.
R2	J Mattingly, H von Ohain, Elements of Propulsion: Gas Turbines and Rockets, AIAA, 2006.
R3	Philip Hill, Carl Peterson: Mechanics and Thermodynamics of Propulsion, Pearson, 2014.
R4	Ronald D Flack, Fundamentals of Jet Propulsion with Applications, Cambridge University Press, 2005.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
ME 205	Thermodynamics	Steady flow energy equation. Different thermodynamic processes	Third

COURSE OBJECTIVES:

1	To give an overview of various air craft engines, rocket engines and their applications.
2	To provide knowhow on tools to analyze various rocket propulsion.
3	To know the testing of rocket engines.

COURSE OUTCOMES:

Sl. NO	DESCRIPTION	Blooms' Taxomomy Level
CME462.1	To ***recognize*** different propulsive devices and ***compare*** them based on performance characteristics.	***Knowledge Level - 1*** ***Understand Level-2***
CME462.2	To ***apply*** the knowledge of thermodynamics and ***evaluate*** performance parameters of turbojet engine.	***Apply Level-3*** ***Analyse Level -4***
CME462.3	To ***list*** and ***explain*** different components in a turbojet engine.	***Knowledge Level - 1*** ***Understand Level-2***

CME462.4	To ***understand*** different efficiencies associated with rocket engines and ***evaluate*** its performance parameters.	***Understand Level-2*** ***Analyze Level-4***
CME462.5	To ***understand*** the fuels, feed systems & combustion process in chemical rockets	***Understand Level-2***
ME462.6	To ***calculate*** flight performance of rockets and ***understand*** measurements systems and tests involved in it.	***Understand Level-2*** ***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**
CME409.1	**2**												**1**		
CME409.2	**3**	**2**	**1**										**2**	**1**	
CME409.3	**3**												**1**	**1**	
CME409.4	**3**	**2**	**1**										**1**	**1**	
CME409.5	**2**		**2**											**2**	
CME409.6	**2**	**2**	**1**											**1**	

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

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
CME462.1-PO1	M	Students will be able to differentiate different types of aircraft engines. The will be able to compare the performance of different engines and choose the right one to solve the problem at hand.
CME462.2-PO1	M	Students will apply their knowledge of thermodynamics to solve simple engineering problems related to turbojet engines
CME462.2-PO2	H	Students are in a position to evaluate the performance parameters of turbojet engine by conducting thermodynamics analysis.
CME462.2-PO3	L	Students will be able to evaluate and fix the performance parameters for preliminary design of turbojet engines.
CME462.3-PO1	H	Students will gain knowledge about different parts in turbojet engine and understand their operation. This will help them in solving problems related to turbojet engine
CME462.4-PO1	H	Students will be aware of how energy stored in rockets is being expended dissipated during the propulsion of rockets. They will understand various losses associated with rocket propulsion. This will help them to understand various parameters involved in performance analysis of rocket engines & solve problems.
CME462.4-PO2	M	Knowing the energy associated with rocket propulsion students can

		identify the performance parameters and evaluate them through thermodynamic analysis.
CME462.4-PO3	H	Students will be able to evaluate and fix the performance parameters for preliminary design of rocket engines.
CME462.5-PO1	M	Students will gain knowledge of different aspects of chemical rockets like the type of fuel used, characteristics of fuel, fuel feed systems, burning rate, combustion process etc…
CME462.5-PO3	M	Students can decide the type of fuel, type of feed systems to be used while designing rocket engines.
CME462.6-PO1	M	Students will be aware various measurement methods and tests involved in study of rocket flights. They will be able to solve simple problems related to rocket flight such as calculating rocket velocity, altitude etc...
CME462.6-PO2	M	Using the principles of physics (kinematics, Laws of motion) students can analyse engineering problems related to flight performance of rockets and draw conclusions regarding maximum altitude gained and escape velocity required at a particular altitude.
CME462.6-PO3	L	Students will be able to evaluate and fix the flight performance parameters for preliminary design of rocket.

JUSTIFATIONS FOR CO-PSO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
CME462.1-PSO1	L	Students will have knowledge of different types of aircraft engines and the ability to compare them based on their performance.
CME462.2-PSO1	M	Students will use their knowledge of thermodynamics to conduct analysis of turbojet engines and evaluate its performance parameters.
CME462.2-PSO2	L	Evaluating various performance parameters can be helpful during design of turbojet engines.
CME462.3-PSO1	L	Students have good knowledge on types of components used in turbojet engine and the science behind the operation of each component.
CME462.3-PSO2	L	The understanding of different components and its operation forms the base for design of turbojet engine
CME462.4-PSO1	M	Students will use the knowledge of thermal science to understand how energy is utilised and what are the different losses associated with rocket engines. They will be able to evaluate various performance parameters based on this knowledge
CME462.4-PSO2	L	Evaluating various performance parameters can be helpful during design of rocket engines
CME462.5-PSO2	M	Knowledge of various fuels, feed systems, combustion process can be used for design of rocket engines
CME462.6-PSO2	L	Evaluation of flight performance can be used for design of rockets.

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NIL

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

SI NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	Fuels used in LPR	Student Assignment	4	2

WEB SOURCE REFERENCES:

1	https://www.youtube.com/watch?v=tf6slGC9Va4 - Working of turbojet engine
2	https://www.youtube.com/watch?v=x8DK4rM6Y90 – Working of Turbofan engine
3	https://www.youtube.com/watch?v=xpOa3B03gYg – Working of Ramjet & SCRamjet engine
4	https://www.youtube.com/watch?v=QQB1Iw3zJbc – Working of rocket engine
5	https://www.youtube.com/watch?v=RiPzzA281E0 – Rocket engine testing

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

9.2 COURSE PLAN

Day	*Module*	*Topic*
1	I	Fundamentals of Propulsion- Classification types of propulsive devices
2	I	Airscrew, Turbojet
3	I	Turboprop, turbofan, Turboshaft.
4	I	Ramjet, Scramjet, Pulsejet and Rocket engines.
5	I	Comparative study of performance characteristics applications.
6	I	Comparative study of performance characteristics applications.
7	I	Comparative study of performance characteristics applications.
8	II	Theory of propulsion – Thrust, thrust power and efficiencies of turbojet engine.
9	II	Thermodynamics analysis of turbojet engine cycle

10	II	Numerical
11	II	Numerical
12	II	Numerical
13	II	Numerical
14	II	Propellers: Types of propellers
15	II	Propellers: Types of propellers
16	III	Turbojet engine components- air intakes
17	III	Compressors
18	III	compressors
19	III	Combustion chambers
20	III	turbines
21	III	nozzles turbine and compression matching
22	III	Thrust augmentation
23	IV	Rocket propulsion- general operating principles of chemical, electrical nuclear and solar rockets
24	IV	Chemical Rockets- Classification. Performance parameters for chemical rockets and their relationship,
25	IV	Energy and efficiencies, Numerical
26	IV	Solid propellants- Types- burning rate- grain Configurations
27	IV	Classification- Typical fuels and oxidizers
28	IV	properties and specifications, Selection
29	V	Liquid propellant feed systems, injectors
30	V	, Starting and ignition, Igniters
31	V	liquid propellant, Precautions in propellant handling.
32	V	Hybrid Rockets combustion processes in SPR and LPR
33	V	combustion instability- Control of instabilities
34	V	Cooling of Rocket motors
35	VI	Flight Performance- Velocity and attitude in simplified vertical Refractory staging of rockets.

36	VI	Flight Performance- Velocity and attitude in simplified vertical Refractory staging of rockets.
37	VI	Rocket Testing- Test facilities and safeguards
38	VI	Measurement System Terminology
39	VI	Flight Testing
40	VI	Numerical
41	VI	Numerical
42	VI	Numerical

9.3 MODULE-WISE QUESTIONS

Module 1

1 What is meant by a jet propulsion system?
2 How will you classify propulsive engines?
3 What is the difference between shaft propulsion and jet propulsion?
4 List the different types of jet engines.
5 Define the principle of Ram jet engine.
6 Give the components of a turbo jet.
7 Give the difference between pulsejet and ram jet engine.
8 Give the difference between turbojet and ram jet engine.
9 Give the difference between Jet propulsion and Rocket propulsion.
10 What is the difference between turbo prop engine and turbo jet engine.
11 What is ram effect?
12 Differentiate between pressure thrust and momentum thrust.
13 Why a ram jet engine does not require a compressor and a turbine?
14 Define Rocket propulsion.

Module 2

1. What is specific impulse?
2. Write the formula for propulsive efficiency and define the same.
3. Explain specific thrust as applied to jet engines.
4. Air enters a turbojet engine at 80 kPa, 240 K and at inlet velocity of 280 m/s. The pressure ratio across the compressor is 8. The turbine inlet temperature is1200 K and the pressure at nozzle exit is 80 kPa. The work developed by the turbine equals

the compressor work input. The diffuser, compressor, turbine and nozzle processes are isentropic and there is no pressure drop for flow through the combustor. For operation at steady state, determine the velocity at the nozzle exit and the pressure at each principal state. Neglect kinetic energy at the exit of all the components except the nozzle and neglect potential energy throughout.

5. The diameter of the propeller of an air craft is 2.5 m. It flies at a speed of 500 kmph .at an altitude of 8000 m. For a flight to jet speed ratio of 0.75, determine:
   - *i.* Flow rate of air through the propeller.
   - *ii.* Thrust produced, and power.
   - *iii.* Specific thrust and impulse
6. An air craft flies at 960 km/hr. One of its turbojet engines takes in 40 kg/s of air and expands the gases to the ambient pressure. The air fuel ratio is 50 and the lower Calorific value of the fuel is 43 MJ/ kg. For maximum thrust power determine:
   - *a.* Jet velocity. b. Thrust.
   - *a.* Thrust power. d. Specific thrust.
   - *b.* Propulsive, thermal and overall efficiencies.
   - *c.* TSFC.

Module 3

1 What is “thrust augmentation”?
2. Why after burners are used in turbojet engine?
3. With neat sketch explain different parts of a turbojet engine.
4. Explain various methods used for thrust augumentation.
5. Explain the working of various components in a turbojet engine with neat sketch.

Module 4

1 Define thrust for a rocket engine and how it is produced.
2 Explain specific thrust & specific impulse for rocket engine.
3 The following data refer to a rocket engine. Propellant flow rate is 200 kg/s. The thrust chamber pressure is 37 bar and its temperature is 3000 K. The nozzle exit diameter is 0.6 m, nozzle exit pressure is 1.1 bar, ambient pressure is 0.60 bar and thrust produced is 380 kN. Calculate Effective jet velocity, actual jet velocity, specific impulse and specific propellant consumption.
4 The data for a rocket engine is given below:

Combustion chamber pressure = 38 bar, combustion chamber temperature = 3500K, oxidizer flow rate = 41.67 kg/s, mixture ratio = 5, properties of exhaust gas $\gamma = 1.3$, $R = 287$ J/kg K. If the expansion in the rocket nozzle takes place to ambient pressure 583.59 N/m^2, find:

a. Nozzle throat area.

b. Thrust.

c. Thrust coefficient.

d. Characteristic velocity.

e. Exit velocity of gas.

f. Maximum possible exhaust velocity.

Module 5

1 What are the types of rocket engines?

2 Compare solid and liquid propellant rockets.

3 What are the types of liquid propellants used in rocket engines?

4 Give two liquid propellants.

5 What is mono-propellants? Give example.

6 What is bi-propellant? Give Example.

7 Name some oxidizers used in rockets.

8 Name few advantages of liquid propellant rockets over solid propellant rockets.

9 Give the important requirements of rocket engine fuels.

10 Explain restricted and unrestricted burning in rockets?

11 A rocket flies at 10,080 kmph with an effective exhaust velocity of 1400 m/s and propellant flow rate of 5.0 kg/s. If the heat of reaction of the propellant is 6500 kJ/kg of the propellant mixture, determine:

I. Propulsion efficiency and Propulsion power.

II. Engine output and thermal efficiency.

III. Overall efficiency.

Module 6

1. Explain power flight coasting in rocket flight.
2. Explain booster rocket and retro rockets.
3. Define Mass ratio, propellant mass fraction, velocity loss & altitude loss due to gravity.
4. Derive expression for velocity of rocket at the end of powered flight.

5. What is effect of mass ratio, specific impulse and burnout time on maximum velocity attained by rocket?
6. Derive expression for maximum altitude gain during powered flight.

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20. ME 492 Project

20.1 COURSE INFORMATION SHEET

PROGRAMME: MECHANICAL	*DEGREE: BTECH*
COURSE: PROJECT	**SEMESTER: 8 CREDITS:** 6
COURSE CODE: ME 492 *COURSE TYPE: CORE*	**UNIVERSITY:** KTU UNIVERSITY **REGULATION:**2016
COURSEAREA/DOMAIN: MECHANICAL ENGINEERING	**CONTACT HOURS:** 18 (PRACTICAL) Hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY):NIL	**LAB COURSE NAME:**NA

SYLLABUS:

UNIT	*DETAILS*	*HOURS*
	In depth, study of the topic assigned in the light of the preliminary report prepared in the seventh semester. Review and finalization of the approach to the problem relating to the assigned topic Preparing a detailed action plan for conducting the investigation, including team work Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed Final development of product/process, testing, results, conclusions and future directions Preparing a paper for Conference presentation/Publication in Journals, if possible Preparing a report in the standard format for being evaluated by the dept. assessment board Final project presentation and viva voce by the assessment board	

COURSE OBJECTIVES:

1	To give a platform for the students to apply the theoretical knowledge they gained during the course and conduct analysis and create working models.
2	To enable the students to use different design platforms for design and analysis of project.
3	To give a chance to improve communication skills and enable the students to express the theoretical knowledge to defend
4	To impart theoretical knowledge about wind tunnels and experimental fluid mechanics.
5	To give the students a feel of working in a team environment and contribute to the success of the project.

COURSE OUTCOMES:

SNO	DESCRIPTION	Bloom's Taxonomy Level
C492.1	Ability to effectively gather and interpret information from literature survey. And use this knowledge to identify, formulate, **analyze** and solve complex problems and to **evaluate** and interpret various solutions.	**Analyze** Level 4 **Evaluate** Level 5
C492.2	Gain the ability to **communicate** effectively with written, oral, and visual means in a technical setting.	**Apply** Level 3
C492.3	Ability to use modern design and analysis tools to analyse and evaluate complex problems.	**Analyze** Level 4 **Evaluate** Level 5
C492.4	Students will be able to carry out calculations involved in **design**, consider and **evaluate** alternate assumptions, approaches, and procedures. Ability to fabricate system components related to engineering problems giving consideration to environment and society.	**Evaluate** Level 5 **Create** Level 6
C492.5	Ability to serve as effective team member to plan and complete the project/task within a specified budget and time.	**Analyse** Level 4

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
C492.1	3	3	3	3	1	-	-	-	-	-	-	3	3	3	1
C492.2	2	-	-	-	-	-	-	2	2	3	-	-	-	-	-
C492.3	-	2	2	2	3	-	-	-	-	2	-	-	2	2	3
C492.4	-	2	3	3	-	3	3	-	-	-	-	-	3	3	3
C492.5	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM / HIGH	JUSTIFICATION
C492.1-PO1	H	Students will be able to use the fundamental knowledge in the field of engineering to solve the problems related to project work.

C492.1-PO2	H	Students will be able to identify eco-friendly and consumer friendly projects and conduct a detailed study on the evolution of it and suggest alternatives or fresh designs.
C492.1-PO3	H	Students will be able to design projects aiming social responsibilities, minimized health impacts and meeting customer requirements.
C492.1-PO4	H	Students will be able to conduct a thorough research, design and fabrication of experimental setups and analysis of the obtained result.
C492.1-PO5	L	Students can also interpret the results from literature through the use of modern analysis and design tools
C492.1-PO12	H	Students can earn self-confidence in handling complex projects and that will help in handling independent projects.
C492.2-PO1	M	Students will be able to effectively communicate their engineering knowledge to a community through presentations.
C492.2-PO8	M	Each member of the group should divide the quantum work equally and should contribute to the project ethically
C492.2-PO9	M	Individual reports must be made and should be properly communicated to other group members to comprehend the same
C492.2-PO10	3	Technical presentations and reports to be made based on the work carried out and should give clear explanations
C492.3-PO2	M	Students will be able to use modern design and analysis tool prior to the fabrication for synthesis.
C492.3-PO3	M	Students will be able to use modern tools to design products which is customer friendly and environmentally sustainable.
C492.3-PO4	M	Students will be able to use advanced analysis software to conduct a check on the functionality of the product.
C492.3-PO5	H	Students will be able to analyse complex engineering problems with software packages such as ANSYS, CATIS, etc
C492.3-PO10	M	Students will be able to communicate effectively based on the simulation results obtained through usage of modern tool
C492.4-PO2	M	Student will be able to make necessary design calculations and proper selection of suitable materials.
C492.4-PO3	H	Student will be able to design and develop products which give utmost importance to social, economic and environment sustainability.
C492.4-PO4	H	Students will be able to design, fabricate and conduct performance testing on the developed products and analyse the experiment observations for further improvement.

C492.4-PO6	H	Students select the project and orient their projects to the benefit of the society
C492.4-PO7	H	Student focuses on environment friendly projects with less wastage
C492.5-PO11	H	Students will be evolved as a good team players with better managerial skills.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
C492.1-PSO1	H	Students will be able to apply their knowledge in fundamentals to find suitable solution to the problems.
C492.1-PSO2	H	Students will be able to make use of their understanding in the core areas of mechanical engineering during the design and analysis.
C492.1-PSO3	L	Students will get benefitted from different CAM/CAD packages during the design and implementation
C492.2-PSO1	M	They will be able to use advanced technology to apply their engineering knowledge
C492.2-PSO2	M	They will be able to use modern tools to design and analyse mechanical systems.
C492.3-PSO3	H	Students will be able to choose the appropriate manufacturing techniques during fabrication.
C492.4-PSO1	H	Students will be able to make use of the advanced technologies to develop new products which can sustain for a long time.
C492.4-PSO2	H	Students will be able to come up with the products that has customer acceptance.
C492.4-PSO3	H	Student will be able to suggest alternative designs/products to the existing ones.

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

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