III - VIII Semester Scheme & Syllabus (2022) Department of MECHANICAL ENGINEERING

SCHEME AND SYLLABUS

Department of
MECHANICAL ENGINEERING

GLOBAL ACADEMY OF TECHNOLOGY
(Autonomous institution affiliated to VTU, Belagavi.
Accredited by NAAC with 'A' grade,
NBA Accredited CS, E&C, E&E, MECH and IS branches)
IDEAL HOMES TOWNSHIP,
RAJA RAJESHWARI NAGAR,
BENGALURU - 560098

Department of Mechanical Engineering
Global Academy of Technology
Rajarajeshwarinagar, Bengaluru-560098

H.P. Rajashekar Swamy
Dean Academic
Global Academy of Technology,
Rajarajeshwarinagar, Bengaluru-98

Global Academy of Technology – An Overview

(Autonomous Institution under Visvesvaraya Technological University, Belagavi)

Vision of the Institute:

Become a premier institution imparting quality education in engineering and management to meet the changing needs of society.

Mission of the Institute:

- **Create environment conducive for continuous learning through quality teaching and learning processes supported by modern infrastructure.**
- **Promote Research and Innovation through collaboration with industries.**
- **Inculcate ethical values and environmental consciousness through holistic education programs.**

Objectives:

With a very firm resolve, Global Academy of Technology is continuously investing untiring efforts to enable students to:

- Develop careers in Government and Private engineering organizations and other professionally related domains.
- Pursue higher studies and research to develop innovative solutions and technologies in engineering and other multi-disciplinary areas.
- Improve professional and personal traits oriented towards professional ethics and environmental compulsions.
- Inculcate professional leadership and successful entrepreneurship qualities.
- Help society in raising the quality of life.

Quality Policies:

a. Providing Excellent Education Through High Quality, Experienced and Committed Faculty.
b. Evolving creative processes for optimal Knowledge and Skill Transfer.
c. Building up state-of-the-art infrastructure at par with international standards.
d. Creating an environment for holistic personality development and develop research temperament.

HALLMARKS OF GLOBAL ACADEMY OF TECHNOLOGY:

- Proactive management determined to build the institute as a Centre of Excellence in engineering education.
- Qualified and dedicated faculty in all the departments.
- State of the art Infrastructure and up to date laboratory and Library facilities.
- Lush green campus with an environment of tranquillity and harmony.
- Student centric teaching-learning processes banking on Outcome Based Education; students friendly learning atmosphere.
- Emphasis on Project based learning throughout the course.

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- Strong Industry-Institute interface with more than twenty Memorandum of Understanding (MOUs) signed with leading industries and institutions of repute.
- Indian Institute of Information Technology (IIIT), Allahabad, has signed a MOU for providing internships to students of GAT, research assistance to faculty, and conducting Faculty Development Programs in key areas of IT - Big Data, Cloud Computing, Artificial Intelligence, and Machine Learning.
- Mahatma Gandhi University, Kottayam, has signed a MOU to facilitate research in Nano Technology and provide research assistance to faculty of GAT.
- Industrial consultancy undertaken in many departments.
- Excellent Placement with more than 80% of the eligible students placed in leading IT companies, core industries and Start-up companies.
- Holistic and integrated training modules covering communication skills, leadership skills, soft skills and technical skills through professional trainers.
- On campus and off campus internship facilities.
- Robust parent connects and Student counselling system.
- In-house technical skill training programs/add on courses to enhance the employability of the students.
- Strong and growing alumni connect in place.
- Exclusive Research and Development, Industry–Institute Interaction Cell and Teaching and Learning Centre in place.
- Rainwater harvesting facility in the campus.

The following academic processes are implemented on a regular basis to sustain a meaningful and proactive teaching-learning environment:

- Emphasis on **continuous revision of the curriculum,** based on feedback from the students and input from industry, alumni, and other stakeholders.
- Conduction of regular **training programme** for faculty, technical & supporting staff.
- Conduction of Academic Audit of each department on an annual basis.
- Under **open electives** students have the options to study subjects offered by other departments to augment their interdisciplinary knowledge.
- Students have to do **value added courses**, mandatory courses, certificate courses, and become members of professional bodies, etc.
- Advanced and enrichment courses are offered as Electives during the final year UG and PG Degree Programmes.
- **Self-Learning** is encouraged in students through MOOCs, NPTEL/SWAYAM, Coursera, Edex etc. Credit shall be awarded to students for completion of such courses.

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Department of Mechanical Engineering

(Accredited by National Board of Accreditation, New Delhi)

Vision of the Department:

Become one of the leading providers of education in mechanical engineering with emphasis on research, development, and innovation for the benefit of society.

Mission of the Department:

- Impart quality technical education in the field of mechanical engineering through excellent teaching-learning process, modern infrastructure and computing tools
- Prepare students for successful careers by providing placements and encouraging research, development and innovation through industry-institute interaction
- Instil professional ethics and environmental consciousness amongst students through inclusive development programs

About the Department:

Mechanical Engineering is one of the broadest and the most versatile engineering profession finding its application in all fields of technology. The boost in the manufacturing sector has raised the demand for Mechanical Engineers exponentially. The uniqueness of the discipline incorporates skills and expertise in the areas of Design, Manufacturing, Mechanics and Thermal sciences besides inter-disciplinary subjects that are essential to most sectors of industry.

The department is achieving its milestones at various stages of its growth by upgrading the course-curriculum for catering the needs of industry and research, by developing and maintaining state-of-art laboratories CNC Technology, 3D Printing and Automation.

The department conducts various training programs in collaboration with renowned industrial organizations such as Toyota, AMS-India, TATA Electronics Pvt. Ltd, EMI Product, Askar Microns, etc.

Our student teams have developed Formula Car, Go Kart and Solar Powered Vehicle and participated in racing competitions, won prizes, and have brought laurels to our department and to the college.

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III - IV SEMESTER
SCHEME AND SYLLABUS
Department of
MECHANICAL ENGINEERING

Global Academy of Technology
(Autonomous Institution Affiliated to VTU)
Scheme of UG Autonomous Program – 2022 Batch

III SEMESTER

Sl. No.	Course Code	Course Title	Course Type	Teaching Dept.	Teaching Hours/Week			Examination			CREDITS
					L	T	P	CIE	SEE	Total	
1	22MAT31C	Complex Variables and Probability	BS	MAT	2	2	0	50	50	100	3
2	22MED32	Strength of Materials (Integrated)	IPC	Respective Department	3	0	2	50	50	100	4
3	22MED33	Manufacturing Process (Integrated)	IPC		3	0	2	50	50	100	4
4	22MED34	Computer Aided Modelling	PC		2	0	2	50	50	100	3
5	22MED35	Material Science and Engineering	ESC		3	0	0	50	50	100	3
6	22MED36	Ability Enhancement Course – I: **Fundamentals of 3D Printing**	AEC		2	0	2	50	50	100	3
							Total	**300**	**300**	**600**	**20**

IV SEMESTER

Sl. No.	Course Code	Course Title	Course Type	Teaching Dept.	Teaching Hours/Week			Examination			CREDITS
					L	T	P	CIE	SEE	Total	
1	22MAT41C	Transforms Calculus and Numerical Techniques	BS	MAT	2	2	0	50	50	100	3
2	22MED42	Mechanical Measurements & Metrology (Integrated)	IPC	Respective Department	3	0	2	50	50	100	4
3	22MED43	Mechatronics	PC		3	0	0	50	50	100	3
4	22MED44	Theory of Machines	PC		2	2	0	50	50	100	3
5	22MED45	Thermodynamics	ESC		2	2	0	50	50	100	3
6	22MED46	Ability Enhancement Course – II: **Automation through Hydraulics & Pneumatics**	AEC		2	0	2	50	50	100	3
7	22MEDL47	Machine Shop	PC		0	0	1	50	50	100	1
							Total	**350**	**350**	**700**	**20**

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III SEMESTER

SYLLABUS

SEMESTER – III

Course: Complex Variables and Probability

Course Code	**22MAT31C**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**2:2:0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Course Objectives: To enable students to apply the knowledge of mathematics in the field of engineering by making them to learn:

CLO1	Analytic functions and complex line integrals
CLO2	Probability distributions
CLO3	Joint probability distributions
CLO4	Sampling distributions and testing of hypothesis

	No. of Hours/ RBT levels
Module 1 Function of a complex variable, Analytic functions, Cauchy-Riemann equations, construction of analytic functions using Milne Thomson method, Properties of analytic functions.	**08 Hours L2, L3**
Module 2 Conformal mapping, Bilinear transformations. Complex line integrals, Cauchy's theorem, Cauchy's integral formula, Singularities, poles, residues, Cauchy's residue theorem.	**08 Hours L2, L3**
Module 3 Probability, Axioms of probability, Conditional probability, Bayes theorem, Discrete and continuous random variables, Moments, Moment generating functions, Binomial, Uniform, Poisson, Exponential, Normal distributions.	**08 Hours L2, L3**
Module 4 Joint distributions (both discrete and continuous), Marginal and conditional distributions, Expectation and Covariance. Transformation of random variables, Central limit theorem and law of large numbers.	**08 Hours L2, L3**
Module 5 Sampling, Sampling distributions, standard error, test of hypothesis for means and proportions, student's t-distribution, chi-square distribution as a test of goodness of fit.	**08 Hours L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO31.1	Apply Cauchy Riemann equations to study different properties of analytic functions
CO31.2	Evaluate complex line integrals
CO31.3	Solve problems associated with random variables using probability distributions
CO31.4	Solve problems related to testing of hypothesis

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Textbooks:

1. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers 44th Edition, 2017
2. T Veerarajan, Probability, Statistics and Random Processes for Engineers, Tata McGraw Hill, 3rd Edition, 2008

Reference books:

1. B.V. Ramana, Higher Engineering Mathematics, Tata McGraw-Hill, 2006
2. N.P.Bali and Manish Goyal, A Textbook of Engineering Mathematics, Laxmi Publications 6 th Edition, 2014
3. Richard H Williams, Probability, Statistics and Random Processes for Engineers, Cengage Learning, 1st Edition, 2003.

Scheme of Examination:

Semester End Examination (SEE):
SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of three sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):
Three Tests are to be conducted for 40 marks each. Average of Marks scored in all three tests is added to test component. CIE is executed by way of quizzes / Alternate Assessment Tools (AATs), and three tests. **Some possible AATs:** seminar/assignments/ mini-projects/ concept videos/ partial reproduction of research work/ group activity/ any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

Component		Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignments	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping																
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO31.1	3	2	1									3				
CO31.2	3	2	1									3				
CO31.3	3	2	1									3				
CO31.4	3	2	1									3				
Average	3	2	1									3				

Low-1: Medium-2: High-3

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SEMESTER – III

Course: STRENGTH OF MATERIALS (Integrated)

Course Code	22MED32	CIE Marks (Theory + Lab)	30 + 20 = 50
Hours/Week (L: T: P)	3 : 0 : 2	SEE Marks	50
No. of Credits	4	Examination Hours	03

Prerequisites: Engineering Mechanics

Course Objectives: This course will enable the students to:

CLO1	Identify different types of stresses and strains developed in the member subjected to axial, bending, shear, torsion & thermal loads.
CLO2	To Solve problems on Elastic constants and determine Principal stresses for Uniaxial and Biaxial loads.
CLO3	Concept of Shear Force and Bending Moment Diagrams for beams subjected to different types of loads.
CLO4	Determine the maximum bending and shear stress in a given beam.
CLO5	Apply torsion equation to calculate angle of twist, size of shafts & shear stresses

Content	No. of Hours/ RBT levels
Module 1 **Simple stresses and strains:** Introduction, Properties of materials, Stress, Strain, tensile & compressive stresses, shear stress, Elastic limit, Hooke's law, Stress strain diagram for brittle and ductile materials, True stress and strain, Bars of varying sections, bars with cross sections varying in steps, bars with continuously varying cross sections (Circular & rectangular only) **Laboratory:** *Laboratory Exercise – 1, 2*	**08 Hours / L3**
Module 2 Thermal stresses, Shear stress and shear strain, Longitudinal strain, Lateral strain, Poisson's ratio, Volumetric strain, Elastic constants, and their relations. **Principal stresses and Mohr's Circle:** Introduction to uniaxial, bi-axial, bi-axial combined with shear stress, Stresses on inclined planes, Principal stresses and maximum shear stresses, Principal angles, Shear stresses on principal planes, Maximum shear tress, Mohr circle for plane stress conditions. **Thick and thin Cylinders**: Theoretical concepts only. (No Numerical) **Laboratory:** *Laboratory Exercise – 3*	**08 Hours / L3**
Module 3 **Shear Force & Bending moment diagram:** Introduction, types of beams, loads & reactions, shear force & bending moment. Sign convention for shear force and bending moment, Shear force and bending moment diagram for simply supported, cantilever & overhanging beams subjected to concentrated loads, uniformly distributed load, uniformly varying load & external moment. Maximum bending moment & point of contra flexure. **Laboratory:** *Laboratory Exercise – 4*	**08 Hours / L3**

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Module 4 **Bending stress in beams:** Introduction, theory of Pure or Simple bending, assumptions in pure bending, bending equation, Bending stress, Section modulus for various cross sections and simple numerical. **Shear stresses in beams:** Introduction to shear stress, shear stress in beam, Shear stress distribution for rectangular and circular cross section, simple numerical on shear stress on I and T sections. **Laboratory:** *Laboratory Exercise – 4, 6*	**08 Hours / L3**
Module 5 **Torsion of circular shafts:** Introduction, pure torsion, assumptions, Derivation of shear stress produced in solid and hollow circular shafts subjected to torsion, polar moment of Inertia, polar section modulus, torsional rigidity, power transmitted by a shaft. Simple numericals. **Deflection of Beams:** Introduction, differential equation for deflection, equations for deflections, slope and moments. **Laboratory:** *Laboratory Exercise – 5, 7*	**08 Hours / L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO32.1	**Analyze** the fundamental concepts of stress, strain, deformation, and material behavior under various loading conditions.
CO32.2	**Evaluate** thermal stresses, elastic constants, and biaxial stresses combined with shear stress
CO32.3	**Solve** complex problems involving statically determinate beams, and **construct** Shear Force Diagrams and Bending Moment Diagrams for different loading scenarios.
CO32.4	**Assess** bending and shear stresses for statically determinate beams with varying cross-sectional geometries.
CO32.5	**Integrate** the principles of torsion and deflection to find the performance of shafts and beams under different loading conditions.

Laboratory:

Exercise Number	Experiment	No. of Hours/ RBT Levels
1	Brinell, Rockwell and Vickers's hardness tests	**01 Hours/ L3**
2	Tensile and Compression tests of metallic members on UTM	**04 Hours/ L3**
3	Shear tests of metallic members on UTM	**02 Hours/ L3**
4	Bending test on metallic and non-metallic specimens on UTM	**01 Hours / L3**
5	Torsion test	**01 Hours / L3**
6	Izod and Charpy impact tests on MS Specimen. (Demo only)	**01 Hours / L3**
7	Wear characteristics. (Demo only)	

Textbooks:

1. **James M Gere, Barry J Goodno**, Mechanics of Materials, 9th Edition, Cengage, 2019.
2. **Ferdinand Beer & Russell Johnston**, Mechanics of materials, S.I units, TATA McGrawHill – 1st edition 2003
3. **Timoshenko**, Strength of Materials, 3rd Edition, CBS Publishers, 2002.

Reference books:

1. **William A Nash and Merle C Potter**, Strength of Materials, Schaum's Outline Series, 5th Edition, TMH.
2. **R C Hibbeler**, Mechanics of Materials, 9th Edition, Pearson, 2019.

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3. **Ferdinand P. Beer, E. Russell Johnston Jr., John T. DeWolf, David F. Mazurek, Sanjeev Sanghi**, Mechanics of Materials by 8th Edition, Special Indian Edition, 2020.
4. **S Ramamrutham & R Narayanana**, Strength of Materials, Dhanat Rai Publishing Company, 18th Edition, 2016.

E-Books / Web References

1. **E - Books:** "Strength of Materials", (http://freeengineeringbooks.com/Civil/Strength-of-Material-Books.php)
2. https://ocw.tudelft.nl/courses/aerospace-mechanics-of-materials/mechanics-subjects/
3. https://www.youtube.com/watch?v=_DH3546mSCM

MOOCs

1. NPTEL Course: "Strength of Materials" http:// https://nptel.ac.in/courses/112/107/112107146/#
2. NPTEL Course: "Strength of Materials" (https://onlinecourses.nptel.ac.in/)
3. MOOC Course: "Mechanics of Materials Courses", (https://www.coursera.org/courses?query=mechanics%20of%20materials)

Scheme of Examination: (Integrated courses)

Semester End Examination (SEE): SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Note: The laboratory assessment would be restricted to only the CIE evaluation.

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 30, the CIE would also include laboratory evaluation for 20 marks. The laboratory marks of 20 would comprise of 10 marks for regular laboratory assessment to include lab record and observation. 10 marks would be exclusive for laboratory internal assessment test to be conducted at the end of the semester.

Typical Evaluation pattern for integrated courses is shown in the Table below

Table: Distribution of weightage for CIE & SEE of Integrated courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**30**	**50**
	CIE Test-2	**30**	
	CIE Test-3	**30**	
	Laboratory	**20**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO32.1	3	2	2			1	1		1	1		1	2		
CO32.2	3	2	2			1	1		1	1		1	2		
CO32.3	3	2	2			1	1		1	1		1	2		
CO32.4	3	2	2			1	1		1	1		1	2		
CO32.5	3	2	2			1	1		1	1		1	2		
Average	3	2	2			1	1		1	1		1	2		

Low - 1: Medium - 2: High - 3

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SEMESTER – III

Course: MANUFACTURING PROCESS (Integrated)

Course Code	**22MED33**	**CIE Marks (Theory + Lab)**	**30 + 20 = 50**
Hours/Week (L: T: P)	**3 : 0 : 2**	**SEE Marks**	**50**
No. of Credits	**4**	**Examination Hours**	**03**

Prerequisites: Elements of Mechanical Engineering

Course Objectives: This course will enable the students to,

CLO1	Understand the various manufacturing processes and their methods involved in metal casting and process of moulding sands.
CLO2	Understand metal joining process, identify defects in weld, and cast components.
CLO3	Acquire knowledge of the working principles and operations performed on lathe, drilling, shaping, milling and grinding machines.
CLO4	Acquire knowledge of the working principles and operations performed on milling and metal finishing process.
CLO5	Acquire knowledge on principles and types of metal forming with specific regard to industrial applications.

Content	**No. of Hours/ RBT levels**
Module 1 **Pattern & Pattern Making:** Introduction to manufacturing, classification of manufacturing processes, introduction to foundry - Steps involved in casting, advantages, limitations, and applications of casting process. Pattern types, pattern materials, color coding and storing of patterns, allowances for pattern. **Moulding:** Moulding sand composition, preparation, properties, Binders, Additives. Moulding methods: No bake mould, sweep mould, CO_2 mould, shell mould, investment mould. Introduction to Melting furnaces, Direct and Indirect Furnace, Electric Arc Furnace, Cupola furnace. **Demonstration:** *Properties of Moulding Sand - Sand Testing* **Laboratory:** *Laboratory Exercise – I, II*	**08 Hours / L3**
Module 2 **Welding Process:** Arc welding: Principle, Metal arc welding (MAW), Flux Shielded Metal Arc Welding (FSMAW), Inert Gas Welding (TIG & MIG) Submerged Arc Welding (SAW), Resistance welding principles, Seam welding, Butt welding, Spot welding and Projection welding. **Defects & Inspection:** Sand Casting defects, welding defects- detection causes & remedy, Methods used for inspection of casting and welding. Visual, magnetic particle, fluorescent particle, ultrasonic. Radiography, eddy current, holography methods of inspection. **Laboratory:** *Laboratory Exercise – III and IV*	**08 Hours / L3**

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Module 3 **Lathe:** Types of lathes, parts of engine lathe, Operations and accessories of lathe machine: Centres, Chuck, Faceplate, Mandrel, Steady rest, follower rest, lathe dog, cutting speed, feed, and depth of cut. Machining time and power consumption. **Drilling:** Working principle, the nomenclature of twist drill, Classification, radial drilling machine. Machining time and power consumption.	**08 Hours / L3**
Module 4 **Milling:** Principle of milling, types of milling machines, Horizontal and Vertical milling machine with a sketch, milling machine speeds, and feeds, Milling cutters, Indexing: Simple, compound, differential indexing with simple numerical. Machining time and power consumption. **Metal Finishing Processes:** Introduction to grinding, Plain Cylindrical, Surface, Centreless grinding machines. Surface finish and surface roughness, Introduction to lapping, Honing, Polishing, Buffing.	**08 Hours / L3**
Module 5 **Metal Forming Process** Introduction to metal forming processes & classification of metal forming processes, Hot working and cold working of metals, Forging: Smith forging, drop forging & press forging, rolling of metals, Flat strip rolling, shape rolling operations. Principle of rod and wire drawing, Tube drawing, Principles of Extrusion, Hot and Cold extrusion. **Laboratory:** *Laboratory Exercise – V and VI*	**08 Hours / L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO33.1	Develop mold cavities using patterns made of wood, metal, and plastics, incorporating appropriate pattern allowances.
CO33.2	Select the most suitable arc welding process for specific applications, and diagnose defects encountered after casting and welding processes.
CO33.3	Analyze the operating principles and functions of Lathe machines, drilling machines, and shaping machines.
CO33.4	Assess the operation of milling machines and metal finishing processes and optimize their usage for specific applications.
CO33.5	Implement metal forming processes in real-time applications, demonstrating proficiency in integrating theoretical knowledge with practical operations.

Laboratory:

Exercise Number	Experiment	No. of Hours/RBT Levels
I & II	Preparation of Green Sand Mould - Single Piece Pattern and Split Piece Pattern and Development of a Cast product.	04 Hours/ L3
III & IV	Preparation of Welding Joints (At least two)	02 Hours/ L3
V & VI	Preparation of Forged Models (At least two)	04 Hours/ L3

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Textbooks:

1. **P. N. Rao,** Manufacturing Technology Foundry, Forming & Welding, Volume-I, McGraw Hill Education India, 4th Edition, 2019.
2. **O.P. Khanna,** Volume I and II, Dhanpat Rai Publications, 2017.

Reference books:

1. **Lindberg,** Processes and Materials of Manufacture, Prentice Hall India (p) Ltd
2. **Dr. P.C. Sharma,** A Textbook of Production Technology, S.Chand & Company PVT.LTD, 4th Edition, 2014.
3. **Amitabha Ghosh, Ashok Kumar Malik,** Manufacturing Science, Affiliated East-West Press Ltd, 1st Edition, 2015.
4. **Hajra Choudhary,** Workshop Technology, Media Promoters & Publishers, 13th Edition.
5. **Kalpakjian S., Schmid S.R,** Manufacturing Engineering & Technology, Pearson Edu Asia, 4th Edition.

E-Books / Web References

1. Metal casting- https://nptel.ac.in/courses/112107083/
2. Manufacturing process I - https://nptel.ac.in/courses/112107145/17
3. Manufacturing Process (video) - http://nptel.ac.in/courses/112107145/
4. Manufacturing Process- http://freevideolectures.com
5. Introduction to Casting- https://nptel.ac.in/courses/112107083/
6. Types of Furnaces- https://nptel.ac.in/courses/112107239/16
7. Introduction to Metal Forming - https://nptel.ac.in/courses/112107145/4
8. Plastic properties and Processing- https://nptel.ac.in/courses/112107086/13

MOOCs

1. https://nptel.ac.in/courses/112/104/112104301/
2. https://nptel.ac.in/courses/112/104/112104195/
3. https://www.youtube.com/watch?v=jdFrBtHeJbs&list=PLtAjRFb9nXmzRwSuuYmUoIxIQOu5ccdM
4. https://nptel.ac.in/courses/112/104/112104204/
5. https://nptel.ac.in/courses/112/104/112104195/
6. E-learning: www.vtu.ac.in

Scheme of Examination: (Integrated courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Note: The laboratory assessment would be restricted to only the CIE evaluation.

Continuous Internal Evaluation (CIE):

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Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 30, the CIE would also include laboratory evaluation for 20 marks. The laboratory marks of 20 would comprise of 10 marks for regular laboratory assessment to include lab record and observation. 10 marks would be exclusive for laboratory internal assessment test to be conducted at the end of the semester.

Typical Evaluation pattern for integrated courses is shown in the Table below

Table: Distribution of weightage for CIE & SEE of Integrated courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**30**	**50**
	CIE Test-2	**30**	
	CIE Test-3	**30**	
	Laboratory	**20**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO33.1	3	2	1						1	1		1			3
CO33.2	3	2	1						1	1		1			3
CO33.3	3	2	1						1	1		1			3
CO33.4	3	2	1						1	1		1			3
CO33.5	3	2	1						1	1		1			3
Average	3	2	1						1	1		1			3

Low - 1: Medium - 2: High - 3

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SEMESTER – III

Course: COMPUTER AIDED MODELLING

Course Code	**22MED34**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**2 : 0 : 2**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Computer Aided Engineering Drawing.

Course Objectives: This course will enable the students to

CLO1	Understand orthographic projection principles, create detailed drawings with dimensions and annotations.
CLO2	Draw the 3D part Model from the 2D sketches using Fusion 360.
CLO3	Develop Part Models and create assembly using Fusion 360.
CLO4	Convert Assembly drawing into 2D drafting and generate Bill of materials for Part/ subassembly/ assembled drawing.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Fusion 360 Software:** 3D Sketching Overview. **3D Models/Assembled Models:** Introduction to orthographic projection, Principle of visualization of objects, creating detailed drawings of simple machine elements in first angle projection for the provided 3D models/Assembled models, dimensions, Annotations, sectional views, full and half-sectional views, Bill of Materials. Introduction, Fundamental tolerances, Deviations, Methods of placing limit dimensions, Geometrical tolerances on drawings, Standards followed in the industry.	**10 Hours / L1, L2, L3**
Module 2 **Introduction to part drawing:** Conversion of 2D drawings into 3D parts and sectional views of simple machine components (Detailed 2D part drawings will be given).	**10 Hours / L1, L2, L3**
Module 3 **Introduction to assembly drawing:** Assembly of simple machine elements like Screw Jack, Machine Vice, Plummer block, Tool post, Socket and spigot Joint, Protected type flanged Coupling, (Detailed 2D part drawings will be given).	**15 Hours / L1, L2, L3**
Module 4 **Assembly Dataset:** Assembly of simple machine elements using dataset provided. **The Explode-Render application:** Exploding an assembly. **Rendering -** define textures, lighting, shadows, backgrounds and other properties to create presentation style images. Assign material properties to parts and subassemblies.	**5 Hours / L1, L2, L3**

Additional Assembly drawing for Practice purpose only: Tail stock, Rams bottom safety valve, windmill, Pelton Wheel, Kaplan Turbine, Francis Turbine, Bicycle, Car Body, PUMA 6-Axis Robot.

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COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO34.1	Demonstrate skills in utilizing Fusion 360 for developing a detailed orthographic view from 3D models with precise dimensioning, and annotations.
CO34.2	Create 3D representations from detailed 2D part drawings
CO34.3	Create assembly drawings based on provided engineering drawings, showcasing proficiency in assembling and illustrating complex components within the given design context.
CO34.4	Develop a 3D geometric model of machine assemblies using datasets, followed by the conversion of these models into 2D drafting.

Textbooks:

1. **K R Gopalakrishna,** Machine Drawing, New Age International Publishers, 6th Edition, 2019.
2. **N. D. Bhatt,** Machine Drawing, Charotar Publication, 50th Edition 2016.

Reference books:

1. **KL Narayana, P Kannaiah, K V Reddy,** Machine Drawing, New Age International Publishers, 6th Edition, 2019.
2. **Sidheshwar,** Machine Drawing, Tata McGraw-Hill Education, 33 reprint 2006.
3. **R. K. Dhawan,** Machine Drawing, S Chand Publishing reprint, 2006.

E-Books / Web References

1. https://www.autodesk.com/certification/learn/course/learn-fusion-360-in-90-minutes
2. Introduction to Modelling and Design for Manufacturing
3. https://www.autodesk.com/certification/learn/course/fusion360-intro-modeling-design professional

Scheme of Examination: Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be Four full questions. First, Second & fourth module carrying 20 marks each and third module carrying 40 marks. Students are required to answer **any Four full questions choosing at least one full question from each module.**

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 40 marks each. Average of three test is considered and added to assignment component of 10 marks.

Some possible AATs: Assignments/ oral presentation/ group activity / projects /any other. Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignment	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO34.1	3	2	2	-	3	1	1	-	2	2	-	3	3	-	-
CO34.2	2	2	2	-	3	1	1	-	2	2	-	3	3	-	-
CO34.3	2	2	2	-	3	1	1	-	2	2	-	3	3	-	-
CO34.4	2	2	2	-	3	1	1	-	2	2	-	3	3	-	-
Average	**2**	**2**	**2**	**-**	**3**	**2**	**2**	**-**	**2**	**2**	**-**	**2**	**3**	**-**	**-**

Low - 1: Medium - 2: High - 3

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SEMESTER – III

Course: MATERIAL SCIENCE AND ENGINEERING

Course Code	22MED35	CIE Marks	50
Hours/Week (L: T: P)	3 : 0 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Elements of Mechanical Engineering

Course Objectives: To enable students to apply the knowledge of materials and alloys by making them learn the:

CLO1	Basics of crystal structure and mechanism of nucleation in solids.
CLO2	Cooling curves and transformation diagrams of metals and alloys.
CLO3	Principles and varied methods of het treatment and its emphasis on structure property correlation of metals and alloys.
CLO4	Deformation and fracture mechanisms in metals and alloys.
CLO5	Trends in material technology with focus on nanomaterials, composites.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Crystal Structure:** Introduction, crystal structures, packing factor of cubic and HCP, structure, coordination number, Simple numerical on FCC, BCC crystal structure, crystal imperfections point, & line defects, Diffusion, Diffusion Mechanisms, Fick's laws of diffusion. **Homogeneous and heterogeneous nucleation**: Mechanism of solidification – nucleation and crystal growth, dendritic growth. Phases-single phase and multiphase solids, Gibb's phase rule, solid solutions and types, Intermediate phases, Types of phase diagrams.	**08 Hours / L1, L2, L3**
Module 2 **Cooling Curves and TTT Diagrams** Cooling curve for pure iron, Fe-C equilibrium diagrams, study of iron-carbon system in detail with emphasis on the invariant reactions **TTT Diagrams**: Introduction to TTT, Drawing of TTT diagram for Steels.	**08 Hours / L1, L2, L3**
Module 3 **Heat treatment Processes** Annealing, Normalizing, Hardening, Tempering, Mar tempering, Austempering, Concept of hardenability, Jominyend quench test, Factors affecting hardenability. **Surface hardening methods:** carburizing, cyaniding, nitriding, flame hardening and induction hardening.	**08 Hours / L1, L2, L3**
Module 4 **Mechanical Metallurgy**: Plastic deformation, slip and twinning. Fracture: types, stages	**08 Hours / L1, L2, L3**

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in cup & cone fracture, Griffith's criterion. **Fatigue and creep:** fatigue tests, mechanism, S-N curves, Factors affecting fatigue life. Various stages of creep, Mechanisms of creep, effect of temperature, creep fracture.	
Module 5 **Engineering Alloys**: Steel: Method of designation as per AISI–SAE. Properties, composition, and uses of low, medium, and high carbon steels. **Cast irons**: Microstructures & properties of White CI, Grey CI. Aluminum alloys, Copper alloys and introduction to metallography. **Introduction to plastic, ceramics, and Composite materials:** Classification of composites- Engineering applications of different plastics, ceramics & Composite Materials.	**08 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO35.1	Analyze the fundamental concepts of bonds & crystal structures during deformation of materials
CO35.2	Infer cooling curves and its correlation to structure and property in ferrous materials
CO35.3	Interpret the varied heat treatment process and its suitability to achieve desired mechanical properties.
CO35.4	Explore the creep, fatigue, and fracture behaviour of materials.
CO35.5	Categorize the material properties with developments of latest materials

Textbooks:

1. **Smith, Mc Graw Hill,4thEdition, 2009.**Foundations of Materials Science and Engineering
2. **William D. Callister, Wiley,** 2006 Material science and Engineering and Introduction
3. **Shackle ford., & M. K. Muralidhara,** Materials Science, Pearson Publication, 2007

Reference books:

1. **V.Raghavan**, Materials Science and Engineering, PHI, 2002
2. **Donald R. Askland and Pradeep .P. Phule**, The Science and Engineering of Materials, Cengage Learning 4lhEd., 2003

E-Books / Web References

1. **V Raghavan,** Materials science and Engineering by PHI,6th Edition,2016
   http://jp.b-ok.as/ireader/3384942

MOOCs

1. http:// onlinecourses.nptel.ac.in/noc19_me70/preview
2. http://nptel.ac.in/courses/112/106/112106138/

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Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three test is taken, CIE is executed by way of quizzes / Alternate Assessment Tools (AATs) for 10 marks.

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz/AAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO35.1	3	2	1	1		1	1					1			1
CO35.2	3	2	1	1		1	1					1			1
CO35.3	3	2	1	1		1	1					1			1
CO35.4	3	2	1	1		1	2					1			1
CO35.5	3	2	1	1		1	2					1			1
Average	**3**	**2**	**1**	**1**		**1**	**2**					**1**			1

Low - 1: Medium - 2: High – 3

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SEMESTER – III
Course: Ability Enhancement Course – I

Fundamentals of 3D printing

Course Code	**22MED36**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**2: 0 : 2**	**SEE Marks**	**50**
No. of Credits	**03**	**Examination Hours**	**03**

Course Objectives: This course will enable the students to:

CLO1	Grasp the fundamental concepts behind additive manufacturing, including the various technologies, materials, and processes
CLO2	Acquire knowledge and skills in Computer-Aided Design (CAD) software, enabling the creation and optimization of 3D models through slicing
CLO3	Learn post-printing procedures such as removing supports, surface finishing, and quality inspection to refine and enhance the final printed objects
CLO4	Learn how to set up, calibrate, and troubleshoot these machines for efficient and accurate printing

Content	**No. of Hours/ RBT levels**
Module 1 Introduction: Process, Classification, Advantages, Additive V/s Conventional Manufacturing processes, Applications	**05 Hours / L3**
Module 2 Additive Manufacturing Techniques: Fusion Deposition Modelling, Stereolithography, Selective Laser Sintering, Selective Laser Melting	**05 Hours / L3**
Module 3 Polymer Materials for FDM process: Acrylonitrile Butadiene Styrene (ABS), Polylactic Acid (PLA), Polyethylene Terephthalate Glycol (PETG), Thermoplastic polyurethane (TPU).	**05 Hours / L3**
Module 4 Post Processing: Significance of post-processing in additive manufacturing, Challenges and methods of post processing	**05 Hours / L3**

Practical Sessions	**No. of Hours/ RBT levels**
Computer Aided Design: Development of 3D Models, STL file generation *Tools used:* Tinker CAD and Autodesk Fusion 360	**05 Hours / L4**
Slicing: STL file manipulation, Object positioning and placement, Slicing parameters: Layer height, print speed, support settings, temperature settings, Generation of G- and M-codes. *Tools used*: Repetier host	**05 Hours / L5**
Printing: Machine setup, Build	**05 Hours / L5**
Post processing: Removal and clean-up, Finishing process	**05 Hours / L5**

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COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO36.1	Comprehend additive manufacturing principles, while demonstrating proficiency in Fusion Deposition Modeling's techniques with varied materials and explore diverse additive manufacturing techniques for practical industrial application.
CO36.2	Develop 3D models using TinkerCAD and Autodesk Fusion 360 and generate STL files, enabling efficient product design and prototyping in modern industries.
CO36.3	Generate codes through slicing methodologies using Repetier Host, fostering innovation and problem-solving skills necessary to design complex 3D models for diverse industrial applications.
CO36.4	Produce products by skillfully operating a 3D printer, adeptly fine-tuning settings to match various material types and specific applications.
CO36.5	Implement post-processing techniques, ensuring product quality through precise inspection, defect identification.

TEXTBOOKS:

1. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer.
2. Samuel N Bernier, Design for 3D Printing - Scanning, Creating, Editing, Remixing, and Making in Three Dimensions, Shroff Publishers & Distributors Pvt Ltd, 2016

Reference books:

1. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers.
2. 2. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: Principles and applications, 3rd Edition, World Scientific.
3. 3. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGrawHill, 2021. E-Books /

Web References

- https://www.nist.gov/additive-manufacturing
- https://www.metal-am.com/
- http://additivemanufacturing.com/basics/
- https://www.3dprintingindustry.com/

MOOCs

NPTEL Course: ''Fundamentals of Additive Manufacturing Technologies''
https://nptel.ac.in/courses/112103306

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be 40 marks for theory 60 marks for practical sessions.

SL	Details	**Max. marks**
	SECTION – I	
1	Theory Questions (Answer any TWO out of FOUR) from Module 1 & Module 2	20 M
2	Theory Questions (Answer any TWO out of FOUR) from Module 3 & Module 4	20 M
	SECTION – II	
3	Development of 3D Model using relevant modelling software	20 M
4	Slicing of 3D model using relevant slicing software	10 M
5	Setting up the 3D printing equipment and printing the model using 3D printer (Group Experiment)	10 M
6	Post Processing (Group Experiment)	20 M
	Total	**100 Marks**

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Continuous Internal Evaluation (CIE): Two Tests are to be conducted for 40 marks each. The average of the two tests are taken for computation of CIE on a scale of 40. CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and tests.

Some possible AATs:
Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses.

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	Quiz /OAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO36.1	1	2	-	-	-	-	1	-	-	-	-	1	2	-	-
CO36.2	1	3	1	1	2	-	-	1	-	1	-	-	2	-	-
CO36.3	1	3	2	-	-	-	-	-	-	1	-	-	2	-	-
CO36.4	1	3	1	1	2	-	1	-	1	-	1	1	2	-	-
CO36.5	1	2	-	1	-	-	1	-	1	-	-	-	2	-	-
Average	**1**	**3**	**2**	**1**	**2**	**-**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**-**	**-**

Low - 1: Medium - 2: High – 3

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IV SEMESTER

SYLLABUS

SEMESTER – IV

Course: Transforms Calculus and Numerical Techniques

Course Code	**22MAT41C**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**2:2:0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Course Objectives: To enable students to apply the knowledge of Mathematics in various fields of engineering by making them to learn:

CLO1	Laplace Transforms
CLO2	Fourier series and Fourier Transforms
CLO3	Numerical Methods

Content	No. of Hours/ RBT levels
Module 1 Laplace transforms of elementary functions, Unit-step and Dirac delta functions. Inverse Laplace Transforms, Solution of second order linear differential equations using Laplace transforms.	**08 Hours L2, L3**
Module 2 Fourier series of periodic functions, half range Fourier sine and cosine series. Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms.	**08 Hours L2, L3**
Module 3 Solution of algebraic and transcendental equations: Regula-Falsi and Newton-Raphson method. Finite differences: Newton's forward and backward difference formulae. Newton's divided difference formula and Lagrange's interpolation formula. Numerical integration: Simpson's 1/3rd, 3/8th, Weddle's rule.	**08 Hours L2, L3**
Module 4 Numerical solution of ordinary differential equations of first order and first degree using Modified Euler method, Runge-Kutta method of fourth order, Milne's and Adam-Bashforth predictor and corrector methods. Numerical solution of second order ordinary differential equations: Runge-Kutta method and Milne's method.	**08 Hours L2, L3**
Module 5 One dimensional wave and heat equation. Solution of heat and wave equation by method of separation of variables. Two-dimensional heat flow, Solution of Laplace's equation, Laplace's equation in polar coordinates. Two dimensional wave equation. Numerical solution of heat and wave equations.	**08 Hours L2, L3**

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COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO41.1	Determine Laplace and inverse Laplace transforms of given functions and solve linear differential equations
CO41.2	Determine Fourier series and Fourier Transform of given function.
CO41.3	Apply numerical techniques to solve algebraic and transcendental equations.
CO41.4	Apply numerical techniques for interpolation and to evaluate definite integrals.
CO41.5	Solve ordinary differential equations of first and second order using single step and multistep numerical methods
CO41.6	Solve problems related to heat and wave equations

Textbooks:

1. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers 44th Edition, 2017
2. B.V. Ramana, Higher Engineering Mathematics, Tata McGraw-Hill, 2006

Reference books:

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons 10th Edition, 2016
2. N.P.Bali and Manish Goyal, A Textbook of Engineering Mathematics, Laxmi Publications 6th Edition, 2014

Scheme of Examination: Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of three sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of Marks scored in all three tests is added to test component. CIE is executed by way of quizzes / Alternate Assessment Tools (AATs), and three tests.

Some possible AATs: seminar/assignments/ mini-projects/ concept videos/ partial reproduction of research work/ group activity/ any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

Component		Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignments	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO41.1	3	2	1									3				
CO41.2	3	2	1									3				
CO41.3	3	2	1									3				
CO41.4	3	2	1									3				
CO41.5	3	2	1									3				
CO41.6	3	2	1									3				
Average	**3**	**2**	**1**									**3**				

Low-1: Medium-2: High-3

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SEMESTER – IV

Course: MECHANICAL MEASUREMENTS AND METROLOGY (Integrated)

Course Code	**22MED42**	**CIE Marks (Theory + Lab)**	**30 + 20 = 50**
Hours/Week (L: T: P)	**3 : 0 : 2**	**SEE Marks**	**50**
No. of Credits	**4**	**Examination Hours**	**03**

Prerequisites: Engineering Physics

Course Objectives: This course will enable the students to

CLO1	Understand the standards of measurement, errors in measurement, limits and fits as applied to industrial specific standards.
CLO2	Know gauges, Basics of Geometrical Dimensioning and Tolerances.
CLO3	Know the types of comparators, principles and devices used for angular measurement.
CLO4	Understand static characteristics of measurement, types and principle of working of transducers.
CLO5	Understand the principles of strain, temperature and pressure measurement.

Content	**No. of Hours/ RBT levels**
Module 1 **Standards of measurement**: Definition and Objectives of metrology, line and end standard, Transformation from line standard to end standard, calibration of end standards, Characteristics/Numericals. Definitions and concept of accuracy, precision. Errors in measurement, classification of errors. **System of Limits, Fits, Tolerance and Gauges:** Definition of tolerance, principle of interchange ability and selective assembly. Concept of limits, size and tolerances, compound tolerances, Hole base system & shaft base system, Limit gauging, classification of gauges, Taylor's principle. **Laboratory:** *Laboratory Exercise – I, II*	**08 Hours / L2**
Module 2 **Geometrical Dimensioning and Tolerances:** History and Background of GD&T, Commonly Used GD&T Terms & Symbols, Material Condition Modifiers, Datum and features, Datum Reference Frame, Types of GD&T tolerances, Straightness, and flatness, Circularity and Cylindricity, Profile of a Line and Surface, Angularity, Perpendicularity, and Parallelism, Position, Concentricity and Symmetry, Circular and Total Runout, Virtual Condition. General Rules of GD & T. Machine tool metrology, machine tool tests to check for Straightness, Flatness, Parallelism, Squareness, Roundness, Cylindricity, Runout. **Laboratory:** *Laboratory Exercise – III*	**08 Hours / L3**
Module 3 **Comparators:** Introduction to Comparators, characteristics, and classification of comparators. Measurements using Autocollimator, NPL flatness interferometer, Laser interferometer. **Angular measurements**: Bevel Protractor, Sine Principle and use of Sine bars, Sine	**08 Hours / L3**

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centre, use of angle gauges, (numerical on building of angles) **Laboratory:** *Laboratory Exercise – IV, V and VI*	
Module 4 **Measurement systems and methods:** Definition, Significance of measurement, Generalized measurement system, Static characteristics- Accuracy, Precision, Calibration, Threshold, Sensitivity, Hysteresis, Repeatability, Linearity, Loading effect, Dynamic characteristics- System response, Time delay. **Transducers:** Transfer efficiency, primary and secondary transducers, and classification of transducers with examples. Quality attributes of transducers, intermediate modifying devices. **Measurement of Force and Torque:** Basic principles, proving ring, torque measurement, hydraulic dynamometer.	**08 Hours / L3**
Module 5 **Strain measurement**: Theory of strain gauges, Types, Electrical resistance strain gauge, Preparation and mounting of Strain gauges, Gauge factor, Methods of strain measurement. **Pressure and Temperature measurement**: Basic principles, use of elastic members, Bridgeman gauge, McLeod gauge, Thermocouple, Laws of Thermocouple, and Optical Pyrometer. **Laboratory:** *Laboratory Exercise – VII and VIII*	**08 Hours / L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to

CO42.1	Interpret the concept of standards in measurement, tolerances, limits, fits and interchangeability in measurements.
CO42.2	Apply the concepts of geometrical tolerances in assemblies and industry components.
CO42.3	Inspect the process of linear and angular measurements as applied to a few machine made components.
CO42.4	Infer on the concept of principles of transducers and their measurement of force and torque.
CO42.5	Demonstrate the measurement of pressure, temperature and strain measurement.

Laboratory:

Exercise Number	Experiment	No. of Hours/RBT Levels
I & II	1. Calibration of Micrometer using slip gauges. 2. Calibration of Vernier caliper	**02 Hours/L3**
III & IV	3. Measurements of surface roughness using Tally Surf/Mechanical Comparator.	**02 Hours/L3**
V & VI	4. Measurement of angle using Bevel protractor 5. Measurement of angle using Sine Centre / Sine bar. 6. Measurements using Optical Projector	**04 Hours/L3**
VII VIII	7. Calibration of Load cell using standard weights 8. Calibration of Pressure Gauge using Bourdon tube measurement.	**02 Hours/L3**

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Textbooks:

1. **Beckwith Marangoni and Lienhard** Mechanical Measurements by, Pearson Education, 6th Ed.,2006.
2. **B C Nakra, K K Chaudhry** Instrumentation, Measurement and Analysis, McGraw–Hill, 4th Edition.
3. **R.K. Jain Engineering** Metrology, Khanna Publishers, 2009.

Reference books:

1. **N.V. Raghavendra and L. Krishnamurthy**, Engineering Metrology and Measurements, Oxford University Press.
2. **Ernest Deoblin**, Deoblin's Measurement system, Dhanesh manick, McGraw–Hill
3. **Bentley**, Engineering Metrology and Measurements, Pearson Education.

MOOCs

1. https://onlinecourses.nptel.ac.in/noc19_me70/preview
2. https://nptel.ac.in/courses/112/106/112106138/

Scheme of Examination: (Integrated courses)

Semester End Examination (SEE): SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Note: The laboratory assessment would be restricted to only the CIE evaluation.

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 30, the CIE would also include laboratory evaluation for 20 marks. The laboratory marks of 20 would comprise of 10 marks for regular laboratory assessment to include lab record and observation. 10 marks would be exclusive for laboratory internal assessment test to be conducted at the end of the semester.

Typical Evaluation pattern for integrated courses is shown in the Table below

Table: Distribution of weightage for CIE & SEE of Integrated courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**30**	**50**
	CIE Test-2	**30**	
	CIE Test-3	**30**	
	Laboratory	**20**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO42.1	3	1	1	1		1	1	1	1			1			3
CO42.2	3	1	1	1		1	1	1	1			1			3
CO42.3	3	1	1	1		1	1	1	1			1			3
CO42.4	3	1	1	1		1	1	1	1			1			3
CO42.5	3	1	1	1		1	1	1	1			1			3
Average	**3**	**1**	**1**	**1**		**1**	**1**	**1**	**1**			**1**			**3**

Low - 1: Medium - 2: High – 3

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SEMESTER – IV

Course: MECHATRONICS

Course Code	**22MED43**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**2: 0 :2**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Course Objectives: This course will enable the students to

CLO1	Familiarize with the fundamentals of IoT and Embedded systems.
CLO2	Get acquainted with the sensors and the actuators, which are commonly used in mechatronics systems.
CLO3	Impart knowledge about the Arduino Programming

Content	No. of Hours/ RBT levels
Module 1 **Introduction**: Definition of Mechatronics, evolution, elements of mechatronic system, Objective of mechatronics Advantages and Disadvantages of Mechatronics system, Applications of Mechatronics, Mechatronics design process, Control system – elements of measurement system, functions of control system, Open and closed loop control systems, Elements of a closed-loop system.	**8 Hours / L1, L2, L3**
Module 2 **Microprocessor & Microcontrollers**: Introduction, Microprocessor systems, Microcontrollers, Difference between microprocessor and Microcontrollers. Microprocessor Architecture: Microprocessor architecture and terminology, Assembler, Registers: General purpose registers, temporary registers, Special purpose registers, Program Counter, Fetch and write cycle, state, bus interrupts, stack and stack pointer.	**8 Hours / L1, L2, L3**
Module 3 **Transducers and sensors**: Difference between transducer and sensor, Performance parameters of a Sensor / Transducers, Classification of transducers, Primary and secondary transducers. **Applications of sensors**: Photodiode, Photoresistor (LDR), Phototransistor, Ultrasonic Sensors, temperature sensors, LVDT, Capacitance sensors, force and torque sensors, Strain gauges, and Hall Effect sensors.	**8 Hours / L1, L2, L3**
Module 4 **DRIVES AND ACTUATORS:** Relays, Solenoids, DC motor: Brushed and Brushless type DC motors, AC Motor: Induction and Synchronous motors, stepper motors, Servo motor, PWM's – Pulse Width Modulation **Case Studies**: Automatic Washing Machine, Engine Management System, Automatic control of water level, Anti-lock braking system, Automatic car parking system.	**8 Hours / L1, L2, L3**

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Module 5	
Introduction to IoT: IoT basics, Arduino as microcontroller, prototyping with breadboard, Arduino programming, Interfacing LEDs, Buzzers, Switches, Sensors, DC motors, Servo motors with Arduino, PWM on Arduino	**8 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to

CO43.1	Analyze the basic components and principles of Mechatronics in practical settings.
CO43.2	Demonstrate a comprehensive understanding of their architecture, functionalities, and applications of Microprocessors & Microcontrollers
CO43.3	Demonstrate an understanding of transducers and sensors, encompassing their functionalities, classifications, and principles of operation
CO43.4	Select and apply drives and actuators like relays, solenoids, and AC & DC motors effectively in various industrial settings
CO43.5	Demonstrate practical embedded programming skills through coding, debugging Arduino-based programs for sensors, actuators, and control systems.

Textbooks:

1. W Bolton. (2019). Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education, Sixth Edition, pp. 1-682.
2. D. Shetty and R. Kolk. (2011). Mechatronics System Design, 2nd edition, SI Global Engineering

Reference books:

1. Mechatronics – HMT. (2000). Tata McGraw Hill Publishing Company Ltd.
2. David G. Alciatore and Michael B Histand. (2007). Introduction to Mechatronics and Measurement systems, Tata McGraw Hill, Third Edition.
3. Robert H. Bishop. (2002). The Mechatronics Handbook, CRC Press.

E-Books / Web References

1. https://docs.arduino.cc/learn/starting-guide/getting-started-arduino/
2. https://howtomechatronics.com/

MOOCs

1. NPTEL Course: "Mechatronics" https://onlinecourses.nptel.ac.in/noc21_me27/preview
2. NPTEL Course: "Design of Mechatronic Systems" https://onlinecourses.nptel.ac.in/noc21_me129/preview

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 40. CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

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Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz /OAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO43.1	3	3	1	-	-	-	-	-	-	-	-	-	2	-	-
CO43.2	2	2	-	-	-	-	-	-	-	-	-	2	2	-	-
CO43.3	2	3	1	-	-	1	-	-	-	-	-	2	2	-	-
CO43.4	2	3	1	-	-	1	-	-	-	-	-	2	2	-	-
CO43.5	2	3	3	2	2	1	1	-	1	-	1	2	2	-	-
Average	**2**	**3**	**2**	**2**	**2**	**1**	**1**	**-**	**1**	**-**	**1**	**2**	**2**	**-**	**-**

Low - 1: Medium - 2: High – 3

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SEMESTER – IV

Course: THEORY OF MACHINES

Course Code	**22MED44**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**2 : 2 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Engineering Mechanics

Course Objectives: This course will enable the students to:

CLO1	Impart knowledge on various types of mechanisms and their inversions.
CLO2	Familiarize with motion transmission elements of spur gear, gear trains and cams.
CLO3	Understand the static force analysis of four bar and Slider-crank mechanisms graphically.
CLO4	Understand the gyroscopic effect on aeroplane, ship, two & four wheel vehicle.
CLO5	Understand the need for balancing of rotating to achieve static & dynamic equilibrium conditions.

Content	**No. of Hours/ RBT levels**
Module 1 **Fundamentals of Mechanisms**: Kinematic Link & pairs, Classification of kinematic pairs, Constrained motion & its types, Kinematic chain, Mechanism, Degrees of freedom, Mobility of mechanism & Grubbler's criteria. List the Inversions of Four bar chain, Slider crank chain and Double slider crank chain. **Inversion Mechanisms:** Quick return motion mechanisms - Crank and slotted lever Mechanism. Straight-line motion mechanisms: Peaucellier's mechanism. Intermittent Motion mechanisms: Geneva wheel mechanism, Ratchet and Pawl mechanism. Toggle mechanism, Pantograph, Ackerman steering gear mechanism.	**08 Hours / L3**
Module 2 **Gears:** Gear terminology, Law of gearing, path of contact, arc of contact, contact ratio of spur gear. Interference in involute gears, methods of avoiding interference, Expressions for minimum number of teeth to avoid interference (No derivations), Numerical on spur gear. **Gear Trains:** Simple gear trains, Compound gear trains, Reverted gear train, Epicyclic gear trains: Method to find Velocity ratio Or train value - Tabular method. Torque calculation in epicyclic gear trains.	**08 Hours / L3**
Module 3 **Cams:** Classification of cams & followers, Cam nomenclature, Follower motions: Uniform velocity (UV), Uniform acceleration and deceleration (UARM), Simple harmonic motion (SHM), & cycloidal motion. Cam profiles: cam profiles with knife-edge follower & roller follower (Inline & offset).	**08 Hours / L3**

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Module 4 **Static force Analysis:** Static equilibrium. Equilibrium of two and three force members. Members with two forces and torque, Free body diagrams, Static force analysis of four bar mechanism and Slider-crank mechanism (**Graphical method**). **Gyroscope:** Principle of gyroscope, gyroscopic couple. Effect of gyroscopic couple on aeroplane, ship, stability of two wheelers and four wheelers (**No derivations for 2 & 4 wheelers**), numerical problems.	**08 Hours / L3**
Module 5 **Balancing of Rotating Masses:** Static and dynamic balancing, balancing of single rotating mass by balancing masses in same plane and in different planes. Balancing of several rotating masses by balancing masses in the same plane and in different planes.	**08 Hours / L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to

CO44.1	Analyze the kinematic mechanisms & their inversions for various applications.
CO44.2	Analyze speed and torque in gear trains with knowledge of spur gear terminologies.
CO44.3	Illustrate CAM profiles with an acquaintance of follower motions.
CO44.4	Examine static equilibrium conditions for four-bar & slider-crank mechanisms.
CO44.5	Analyze the gyroscopic effect in the context of stabilization of aeroplane, ship, two & four-wheeler vehicles.
CO44.6	Assess static & dynamic equilibrium conditions for rotating masses.

Textbooks:

1. **Rattan S.S,** Theory of Machines, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 4th Edition, 2014.
2. **Uickers, J J, Pennock G R & Shigley J E,** Theory of Machines & Mechanisms, SI Edition, OXFORD University Press, 3rd Edition 2009.

Reference books:

1. **Sadhu Singh**, Theory of Machines, Pearson Education (Singapore) Pvt Ltd, Indian Branch New Delhi, 2nd Edition 2006.
2. **P. L. Ballaney**, Theory of Machines and Mechanisms, Khanna Publications – 2003.
3. **Thomas Bevan**, Theory of Machines, Pearson Education Ltd., 3rd Edition, 2010.
4. **A. G. Ambekar**, Mechanism and Machine Theory, PHI, 2007.
5. **Dr. R K Bansal, Dr. J S Brar**, Theory of Machines, Laxmi Publications (New Delhi), 5th Edition 2016.

E-Books / Web References

1. Text Book: Robt. F. McKay, The Theory of Machines (https://archive.org/details/theoryofmachines00mckarich)
2. Text Book: Theory of Machines, Sadhu Singh, 3rdEdition. 2011, Pearson, Kindle Edition (http://www.cs.cmu.edu/~rapidproto/mechanisms/tablecontents.html)
3. https://ekeeda.com/degree-courses/mechanical-engineering/theory-of-machines

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MOOCs

1. NPTEL Course: "Kinematics of Machines" (http://nptel.ac.in/courses/112104121/1)
2. NPTEL Course: "Kinematics of Machines" https://nptel.ac.in/courses/112/105/112105268/
3. NPTEL Course : "Dynamics of Machines" https://nptel.ac.in/courses/112/101/112101096/
4. NPTEL Course : "Dynamics of Machines" https://nptel.ac.in/courses/112/104/112104114/

Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 40. The assignment/Quiz would be for a total of 10 marks.
CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

Some possible AATs: Assignments / Oral presentations / Group activity/Projects

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	QUIZ/OAT	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO44.1	3	2	2	1		1	1						2		
CO44.2	3	2	2	1		1	1						2		
CO44.3	3	2	2	1		1	1						2		
CO44.4	3	2	2	1		1	1						2		
CO44.5	3	2	2	1		1	1		1	1			2		
CO44.6	3	2	2	1		1	1		1	1			2		
Average	**3**	**2**	**2**	**1**		**1**	**1**		**1**	**1**			**2**		

Low - 1: Medium - 2: High – 3

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SEMESTER – IV

Course: THERMODYNAMICS

Course Code	**22MED45**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**2 : 2 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Course Objectives: The students will be taught:

CLO1	The fundamental concepts, terms and terminologies involved in thermodynamics
CLO2	To Identify and describe energy exchange processes (in terms of various forms of energy, heat, and work) in thermodynamic systems using basic laws
CLO3	The fundamental concepts of basic vapor power and refrigeration cycles
CLO4	The application of basic principles in a systematic way to analyze basic thermodynamic cycles.
CLO5	The testing of IC engines and calculation of performance parameters.

Content	No. of Hours/ RBT levels
Module 1 **Introduction, Basic Concepts**: Thermodynamic system and control volume, Microscopic and macroscopic point of view, thermodynamic properties, state of a substance, process and cycle, Thermodynamic equilibrium, Concept of Continuum, Quasi-static process, The Zeroth Law of Thermodynamics, Temperature scales, simple numerical. **First law of Thermodynamics**: First law for a closed system undergoing a cycle and change of state, energy, PMM1, first law of thermodynamics for steady flow process, steady flow energy equation applied to nozzle, diffuser, boiler, turbine, compressor, pump, heat exchanger and throttling process, simple numerical.	**08 Hours / L1, L2, L3**
Module 2 **Second law of thermodynamics**: Limitations of first law of thermodynamics, Kelvin-Planck and Clausius statements and their equivalence, PMM2, causes of irreversibility, Carnot theorem, and simple numerical. **Entropy**: Clausius theorem, property of entropy, inequality of Clausius, entropy change in an irreversible process, principle of increase of entropy, entropy change for non-flow and flow Processes, simple numerical.	**08 Hours / L1, L2, L3**
Module 3 **Pure Substances:** Properties of pure substances, Water and steam – Constant temperature and constant pressure heating. **Vapor Power cycles**: Carnot vapor cycle, Rankine cycle, comparison of Carnot and Rankine cycle, calculation of cycle efficiencies, simple numerical **Refrigeration Cycles:** Simple Vapor Compression Refrigeration (VCR) cycle on P-h and T-s diagrams, analysis of the simple cycle, factors affecting the performance of the cycle, Reversed Carnot cycle and its limitation, Bell-Coleman cycle, simple numerical.	**08 Hours / L1, L2, L3**

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Module 4 **Air Standard Cycles:** Carnot, Otto, Diesel, Dual and Stirling cycles, P-V and T -s diagrams, description, efficiencies (no derivations) and mean effective pressures (no derivations). Comparison of Otto, Diesel, dual cycles, simple numerical on Otto and Diesel cycle. **Gas Turbine cycles**: Simple Brayton cycle, open and closed cycle, gas turbine fuels, actual Brayton cycle, optimum pressure ratio for maximum thermal efficiency (no derivation), work ratio, simple numerical.	**08 Hours / L1, L2, L3**
Module 5 **Internal Combustion Engines**: Performance parameters-calculations and its measurements - Motoring method, Willian's line method, dynamometers-mechanical, electrical, and hydraulic, Air box method, Morse test, Valve timing diagram, heat balance sheet, engine performance curves, simple numerical.	**08 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO45.1	Synthesize the fundamental principles of thermodynamics and apply the laws of thermodynamics to quantitatively evaluate the performance parameters of thermal systems..
CO45.2	Solve complex engineering problems involving closed and open systems by applying the laws of thermodynamics and the concept of entropy, making appropriate assumptions.
CO45.3	Analyze the performance of basic vapor power cycles and refrigeration systems using thermodynamic property tables and charts.
CO45.4	Evaluate the thermodynamic cycles of various thermal systems to identify potential enhancements and innovations.
CO45.5	Integrate advanced knowledge of energy conversion and performance characteristics of internal combustion engines to develop and optimize real-time applications.

Textbooks:

1. **P K Nag,** Basic and Applied Thermodynamics, Tata McGraw-Hill, 2nd Edition, 2017
2. **R K Rajput,** Thermal Engineering, Lakshmi Publication, 10th Edition, 2018.

Reference books:

1. **Yunus A Cengel, Michael A Boles,** Thermodynamics-An Engineering Approach, McGrawHill Education, 9th Edition,2019.
2. **V Ganesan,** Internal Combustion Engines, McGraw-Hill, 4th Edition, 2017.

E-Books / Web References

1. Working of IC engine, https://www.youtube.com/watch?v=DZt5xU44IfQ
2. Working of Refrigerator, https://www.youtube.com/watch?v=7NwxMyqUyJw
3. Working of Thermal Power Plant, https://www.youtube.com/watch?v=IdPTuwKEfmA

MOOCs

1. https://nptel.ac.in/courses/127106135
2. NPTEL Course on APPLIED THERMODYNAMICS FOR ENGINEERS by Dr. Dipankar N. Basu, Associate Professor, Department of Mechanical Engineering, Indian Institute of Technology Guwahati https://nptel.ac.in/courses/112/103/112103275/

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3. NPTEL Course on ENGINE EMISSIONS by Prof B P Pundir, Department of Mechanical Engineering, Indian Institute of Technology Kanpur https://nptel.ac.in/courses/112/104/112104033/

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of Marks scored in each test is added to test component. CIE is executed by way of quizzes / Alternate Assessment Tools (AATs), and three tests.

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz /AAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO45.1	3	2	2	1		1						1		1	
CO45.2	3	2	2	1		1						1		1	
CO45.3	3	2	2	1		1	1			1		1		1	
CO45.4	3	2	2	1		1	1			1		1		1	
CO45.5	3	2	2	1		1	1			1		1		1	
Average	**3**	**2**	**2**	**1**		**1**	**1**			**1**		**1**		**1**	

Low - 1: Medium - 2: High - 3

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SEMESTER – IV

Course: Ability Enhancement Course II

Automation through Hydraulics & Pneumatics

Course Code	**22MED46**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**2: 0: 2**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Physics.

Course Objectives: To enable students to apply the knowledge of hydraulics and pneumatics in broad domain of mechanical engineering by making them to learn:

CLO1	Components used in Hydraulics and Pneumatics
CLO2	Identify different control valves used in Hydraulics and Pneumatics
CLO3	Construction of Hydraulic Circuits
CLO4	Construction of Pneumatic Circuits

Content	**No. of Hours/ RBT levels**
Module 1 **Introduction to fluid power systems:** Components and structure of Hydraulics & Pneumatic systems. Advantages, disadvantages and applications. Hydraulic and Pneumatic components – compressor, valves and actuators. Working principle of actuators and valves with symbols and basic circuit preparation. Fault detection and identification in hydraulic and pneumatic circuits **Experiments on Hydraulic Kit** 1. Direct & Indirect control of double acting hydraulic cylinder. 2. Speed Control of Double acting cylinder using Meter in circuit. **Open Ended Experiment**: Speed Control of Double acting cylinder using Meter out circuit.	**10 Hours / L2**
Module 2 **Multi- Cylinder Application:** Coordinated and sequential motion control, motion and control diagrams. Signal elimination methods, Cascading method- principle, practical application examples (up to two cylinders) using cascading method (using reversing valves). Introduction to Siemens Diagnostic Kit **Open ended experiments of Industrial Fault detection and control**.	**10 Hours / L2**

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Module 3 **Signal Processing Elements:** Use of Logic gates. **Experiments on Pneumatics** 1. Raising and lowering of the ladle using double piloted 5/2 directional control valve 2. Pin Feeding Device with speed control using Flow control valve 3. Direct & Indirect control of single and double acting pneumatic cylinders **Open Ended Experiment**: Billiards balls distribution from a gravity magazine using Logic gates.	**10 Hours / L3**
Module 4 **Electro- Pneumatic Control:** Principles - signal input and output, pilot assisted solenoid control of directional control valves, use of relay and contactors. Control circuitry for simple signal cylinder application **Open ended experiments of Industrial Fault detection and control**	**10 Hours / L3**

	Component	Marks	Total Marks
CIE	**Construction and Execution of Hydraulics & Pneumatic Circuits and Fault Detection of Circuits**	**30**	**50**
	Internal Assessment Test	**20**	

Scheme of Examination:

Semester End Examination (SEE): SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions from module 1 & 2 carrying 20 marks each. Students are required to answer both the questions**.**

Module 1,2,3 & 4 is based on conduction of experiments on hydraulic and pneumatic kit. There will be One experiment from each module carrying 30 marks each. Students are required to conduct two experiments).

COURSE OUTCOMES: Upon completion of this course, student will be able to

22MED46.1	Analyze the working principles of hydraulic and pneumatic systems.
22MED46.2	Evaluate the operation and functionalities of pneumatic and hydraulic control valves.
22MED46.3	Implement hydraulic control circuits by applying fundamental principles of hydraulic controls.
22MED46.4	Demonstrate the operation of pneumatic control circuits using signal processing elements.

Textbooks:

1. **Anthony Esposito** Fluid Power with Applications, Sixth edition, Pearson Education, Inc, 2000.
2. **Andrew Parr** 'Pneumatics and Hydraulics', Jaico Publishing Co

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Reference books:

1. **S. R. Majumdar** Oil Hydraulic systems', Principles and Maintenance, Tata McGraw Hill Publishing Company Ltd. - 2001
2. **Pippenger,** Hicks Industrial Hydraulics, " McGraw Hill, New York

E-Books / Web References

1. https://www.just.edu.jo/~haalshraideh/Courses/IE431/Lecture_slides/Hydrolics%20and%20Pneumatics.pdf

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO46.1	3	2	1		1	1	1					1			3
CO46.2	3	2	1		1	1	1					1			3
CO46.3	3	2	1		1	1	1					1			3
CO46.4	3	2	1		1	1	1					1			3
Average	**3**	**2**	**1**		**1**	**1**	**1**					**1**			**3**

Low - 1: Medium - 2: High - 3

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SEMESTER – IV

Course: MACHINE SHOP

Subject Code	**22MEDL47**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**0 : 0 : 1**	**SEE Marks**	**50**
Credits	**01**	**Examination Hours**	**03**

Course Objectives: This course will enable the students to

CLO1	Guide students to use fitting tools to perform fitting operations.
CLO2	Provide an insight to different machine tools, accessories, and attachments.
CLO3	Train students into machining operations to enrich their practical skills.
CLO4	Inculcate team qualities and expose students to shop floor activities.

Sl. No.	**Experiments**	**No. of Hours/ RBT levels**
	Part- A	
1	Introduction to lab and safety measures, study the constructional features of Lathe, Milling, Drilling and Shaping machines with the help of sketches and diagrams, role of machining in industries. Preparation of at least two fitting models by proficient handling and application of hand tools.	**06 Hours / L3**
	Part - B	
1	**Lathe work** – Production of composite job, which includes facing, turning, step turning, taper turning, threading, knurling, drilling and boring. Selection of cutting parameters and machining time calculation	**06 Hours / L3**
2	**Milling machine** – Usage of milling cutters to understand face milling, plain milling and end milling on vertical milling machine and Produce T-slots, Perform cutting of gear teeth on horizontal milling machine	**04 Hours / L3**
3	**Drilling machine** – Produce holes and carry out operations such as boring, reaming and threading and perform simple calculations based on selection	**04 Hours / L3**
	Part – C	
1	Demonstration of surface grinding on flat surfaces	**01 Hours / L3**
2	Demonstration of power hacksaw	**01 Hours / L3**
3	Demonstration of CNC lathe and milling machine	**02 Hours / L3**
4	Shaping machine – Cutting of V-groove/ Rectangular/ Dovetail groove	**02 Hours / L3**

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Course Outcomes: Upon successful completion of this course, student will be able to

CO1	Analyze the working mechanisms of conventional machine tools and interpret their functionalities in various manufacturing processes.
CO2	Select and justify the appropriate hand tools and cutting tools required for specific material removal processes.
CO3	Fabricate fitting models according to given drawings using hand tools, demonstrating precision and accuracy.
CO4	Manufacture components to specified tolerances and dimensions using various operations on a lathe machine.
CO5	Engineer components with precise gear teeth, slots, grooves, and holes to specified requirements using milling, shaping, and drilling machines, optimizing the processes for efficiency and quality.

Textbooks:

1. **P N Rao**, Manufacturing Technology Vol I & II, 5th Edition
2. **Sharma P C**, A textbook of Production Technology Vol I and II, S Chand and Company Ltd., New Delhi.

References:

1. **Chapman W A,** Workshop technology Vol I & Vol II
2. **Hajra Choudhary S K and Hajra Choudhary A K,** Elements of Manufacturing technology Vol II

Website references:

1. https://nptel.ac.in/courses/112/105/112105233/
2. http://vlabs.iitb.ac.in/vlabs-dev/labs/mit_bootcamp/machine_tools/labs/index.php

Scheme of Examination:

Semester End Examination (SEE):

One model using Lathe machine	**40 Marks**
One model using Milling / Shaping / Drilling	**40 Marks**
Viva Voce	**20 Marks**

Note: SEE will be conducted for 100 Marks and reduced to 50

Continuous Internal Evaluation (CIE):

Weekly performance - Lab participation + Report	**30 Marks**
One Internal Assessment at the end of semester	**20 Marks**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO47.1	3	3	2			1	1	1	3	1		2			3
CO47.2	3	3	2			1	1	1	3	1		2			3
CO47.3	3	3	2			1	1	1	3	1		2			3
CO47.4	3	3	2			1	1	1	3	1		2			3
CO47.5	3	3	2			1	1	1	3	1		2			3
Average	**3**	**3**	**2**			**1**	**1**	**1**	**3**	**1**		**2**			**3**

Low - 1: Medium - 2: High – 3

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V - VI SEMESTER
SCHEME AND SYLLABUS
Department of
MECHANICAL ENGINEERING

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(Autonomous Institution Affiliated to VTU)
Scheme of UG Autonomous Program – 2022 Batch

V SEMESTER

Sl. No.	Course Code	Course Title	Course Type	Teaching Dept.	Teaching Hours/Week			Examination			CREDITS
					L	T	P	CIE	SEE	Total	
1	22MED51	Management & Economics	PC	Respective Department	2	2	0	50	50	100	3
2	22MED52	Fluid Mechanics & Machinery (Integrated)	IPC		3	0	2	50	50	100	4
3	22MED53	Design of Machine Elements	PC		3	2	0	50	50	100	4
4	22MED54	Mechanical Vibrations	PC		3	0	0	50	50	100	3
5	22MED55X	Program Elective 1	PEC		3	0	0	50	50	100	3
6	22MED56	Ability Enhancement Course – III: **CNC Technology**	AEC		1	0	2	50	50	100	2
7	22CIV57	Environmental Science	CV	Civil	1	0	0	50	50	100	1
	OR										
	22UHV57	Universal Human Values	BS	Respective Department							
TOTAL								**350**	**350**	**700**	**20**

Program Elective 1*			
22MED551	Design for Manufacturing & Assembly	22MED553	Automotive Engineering & Hybrid Vehicle Technology
22MED552	Energy, Environment and Sustainable Development	22MED554	Product Life Cycle Management

***NPTEL for Credit transfer**: Students can take 12 weeks NPTEL course as an equivalent to Program elective. The NPTEL courses of duration less than 12 weeks will not be considered for credit transfer. The courses (only technical) taken are as per the recommendation of BOS of respective department. The similarity of the contents as offered by NPTEL should not exceed a maximum of 40% of the courses being registered by the student. The NPTEL course need to be completed before the registration of the elective. Any certificate obtained after the registration of elective would not be considered. The validity of NPTEL certificate is for two years and it cannot be used more than once to avail the benefit. The student is eligible to transfer a maximum of nine credits in the entire duration of the program. The grades will be awarded as equivalent to the grades obtained in the NPTEL course.

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Scheme of UG Autonomous Program – 2022 Batch

VI SEMESTER

Sl. No.	Course Code	Course Title	Course Type	Teaching Dept.	Teaching Hours/Week			Examination			CREDITS
					L	T	P	CIE	SEE	Total	
1	22MED61	Industrial Robotics	PC	Respective Department	3	0	0	50	50	100	3
2	22MED62	Heat Transfer (Integrated)	IPC		3	0	2	50	50	100	4
3	22MED63	Finite Element Methods (Integrated)	IPC		3	0	2	50	50	100	4
4	22MED64X	Program Elective 2	PEC		2	2	0	50	50	100	3
5	22MED65X	Open Elective 1	OEC	Offering Department	3	0	0	50	50	100	3
6	22CIV66	Environmental Science	HSM	Civil	1	0	0	50	50	100	1
	OR										
	22UHV66	Universal Human Values	BS	Respective Department							
7	22MEDMP67	Mini Project	MP	Respective Department	Two Contact hours per week			50	50	100	2
TOTAL								**350**	**350**	**700**	**20**

Program Elective 2*			
22MED641	Renewable Energy Technologies	22MED643	Design of Transmission Elements
22MED642	Research Methodology	22MED644	Data Analytics
Open Elective 1 (Offered to other branch students)			
22MED651	Project & Operations Management	22MED652	Total Quality Management

***NPTEL for Credit transfer**: Students can take 12 weeks NPTEL course as an equivalent to Program elective. The NPTEL courses of duration less than 12 weeks will not be considered for credit transfer. The courses (only technical) taken are as per the recommendation of BOS of respective department. The similarity of the contents as offered by NPTEL should not exceed a maximum of 40% of the courses being registered by the student. The NPTEL course need to be completed before the registration of the elective. Any certificate obtained after the registration of elective would not be considered. The validity of NPTEL certificate is for two years and it cannot be used more than once to avail the benefit. The student is eligible to transfer a maximum of nine credits in the entire duration of the program. The grades will be awarded as equivalent to the grades obtained in the NPTEL course.

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V SEMESTER

SYLLABUS

SEMESTER –V

Course: Management & Economics

Course Code	22MED51	CIE Marks	50
Hours/Week (L: T: P)	2: 2: 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: NiL

Course Objectives: To provide an insight to**,**

CLO1	Understand needs, functions, roles, scope and evolution of Management.
CLO2	Discuss Decision making, Organizing, Staffing, Directing and Controlling.
CLO3	Describe the understanding of motivation and different control system in Management.
CLO4	Understand various interest rate methods and implement the suitable one.
CLO5	Select the best economic model from various available alternatives.
CLO6	Estimate various depreciation values of commodities.

Content	No. of Hours/ RBT levels
Module 1 **Management: Introduction** - Meaning - nature and characteristics of Management, Scope and Functional areas of management - Management as a science, art of profession - Management & Administration - Roles of Management, Levels of Management. **Planning:** Nature, importance and purpose of planning process, Objectives - Types of plans (Meaning Only) - Decision making Importance of planning - steps in planning & planning premises - Hierarchy of plans.	**08 hrs.** **L1, L2, L3**
Module 2 **Organizing and Staffing:** Nature and purpose of organization Principles of organization - Types of organization - Centralization Vs Decentralization of authority and responsibility. Nature and importance of staffing--Process of Selection & Recruitment (in brief). **Directing & Controlling**: Meaning and nature of directing Leadership styles, Motivation Theories, Communication - Meaning and importance - coordination, meaning and importance. Meaning and steps in controlling - Essentials of a sound control system.	**08 hrs.** **L1, L2, L3**
Module 3 **Introduction:** Engineering and economics, Laws of demand and supply, Difference between Microeconomics & Macroeconomics, equilibrium between demand & supply, elasticity of demand, price elasticity, income elasticity. Law of Returns. Interest and interest factors, simple and compound interest, Cash flow diagrams, personal loans and EMI payment calculation with flexible interest rates, Discussion and problems.	**08 hrs.** **L1, L2, L3**

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Module 4 **Present, future and annual worth and rate of returns:** Basic present worth comparisons, Present worth equivalence, Assets with unequal lives and infinites lives, future worth comparisons, payback comparisons. Equivalent annual worth comparisons, situations for annual worth comparisons. Asset life, Rate of return, minimum acceptable rate of return, IRR anomalies and misconceptions, Cost of capital, comparisons of all present future and annual worth with IRR, product costing, Discussions and problems.	**08 hrs.** **L1, L2, L3**
Module 5 **Costing and depreciation:** Components of costs, estimation of selling price, marginal cost, first cost, all kinds of overheads, indirect cost estimation with depreciation, mensuration and estimation of material cost, cost estimation of mechanical process, idling time. Causes of depreciation, methods of computing depreciation charges, straight line method, declining balance method, sum of years method, sinking fund method, and service output methods.	**08 hrs.** **L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO51.1	**Explain** the development of management and the role it plays at different levels in an organization.
CO51.2	**Select** the process and role of effective planning, organizing and staffing for the development of an organization.
CO51.3	**Implement** good leadership, communication and coordination for establishing effective control in an organization.
CO51.4	**Understand** engineering economics demand supply and its importance in economic decision making and problem solving.
CO51.5	**Calculate** present worth, annual worth and IRR for different alternatives in economic decision making.
CO51.6	**Understand** the procedure involved in estimation of Cost for a simple component, Product costing and depreciation, its methods.

Textbooks:

1. Principles of Management – P.C. Tripathi, P.N. Reddy; Tata McGraw Hill, 5th Edition 2012.
2. Engineering Economy Riggs J.L McGraw Hill 4th edition.

Reference books:

3. Mechanical estimation T.R. Banga& S.C. Sharma Khanna Publishers 17th edition 2015
4. Engineering Economy Thuesen H.G PHI 2002
5. Management and Entrepreneurship – N.V.R. Naidu & T. Krishna Rao, I.K. International, New Delhi – 2008
6. Engineering Economy Thuesen H.G PHI 2002

E-Books / Web References

1. **https://www.youtube.com/watch?v=vOykcERGw9Y- Principles of management**
2. https://drive.google.com/file/d/1O871eMrnRA84N2d2dmRKA5Rtel4QdJ6y/view - Engineering Economics -R. Panneerselvam

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MOOCs

1. https://nptel.ac.in/courses/110105075 - **Foundation Course in Managerial Economics**
2. https://nptel.ac.in/courses/122106031- **Management Concepts**

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full questionfrom each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. An average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and an average of three tests. One quiz is to be conducted and evaluated for 10 marks.

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	AAT/Quiz	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO51.1	2	-	-	-	-	-	-	-	-	-	3	1	-	-	3
CO51.2	3	-	-	-	-	-	-	2	-	-	3	1	-	-	3
CO51.3	2	-	-	-	-	-	-	1	1	1	3	1	-	-	3
CO51.4	3	-	-	-	-	-	-	-	-	-	3	1	-	-	3
CO51.5	3	2	-	-	-	-	-	-	-	-	3	1	-	-	3
CO51.6	2	1	-	-	-	-	-	-	-	-	3	1	-	-	3
Average	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**2**	**1**	**1**	**3**	**1**	**-**	**-**	**3**

Low - 1: Medium - 2: High – 3

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SEMESTER – V

Course: FLUID MECHANICS AND MACHINERY (Integrated)

Course Code	**22MED52**	**CIE Marks (Theory + Lab)**	**40+10**
Hours/Week (L: T: P)	**3: 0: 2**	**SEE Marks**	**50**
No. of Credits	**4**	**Examination Hours**	**03**

Prerequisites: Fluid Mechanics, Physics, Basics of Mathematical concepts learnt in the 1st year of Mathematics.

Course Objectives: To enable students to apply the knowledge of fluid machinery in broad domain of mechanical engineering and henceforth they will be taught:

CLO1	The basics of fluid properties and measurement of pressure
CLO2	Working of a turbomachine and its correlation to Thermodynamics
CLO3	Working Principle, Model studies of Hydraulic Turbines
CLO4	Working Principle, Model studies of Steam Turbines
CLO5	Principle or working, slip and cavitation in Centrifugal and reciprocating Pumps

Content	**No. of Hours/ RBT levels**
Module 1 **Basics:** Introduction, types of fluid, - viscosity, surface tension, capillarity, vapour pressure & cavitation, Numerical problems. (No derivations). **Fluid Kinematics:** Introduction, methods of describing fluid motion – Rate of flow, continuity equation in Cartesian 2D and 3D coordinates, velocity and acceleration in fluid motion, Velocity potential function and stream function, Equipotential line, line of constant stream function, Relation between stream function and velocity potential function, Numerical problems (No derivations).	**8 Hours / L3**
Module 2 **Fluid Dynamics:** Introduction, equations of motion, Euler's equation of motion, Bernoulli's equation from Euler's equation, Assumptions, Navier Stokes Equation, Bernoulli's equation for real fluid, Applications of Bernoulli's equation (Venturi meter, Orifice meter, pitot tube) Numerical problems. No Derivations. **Introduction and Basics:** Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification of turbomachines. Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles – Principle and Types Numerical Problems. (No derivations). ***Laboratory Exercise:*** *Experiment I, II, III, IV*	**8 Hours L3**
Module 3 **Hydraulic Turbines**: Classification, various efficiencies. Pelton Wheel – Principle of working, velocity triangles, design parameters, maximum efficiency, and numerical problems. Franci's turbine – Principle of working, velocity triangles, design parameters, and numerical problems.	**8 Hours / L3**

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Kaplan and Propeller turbines - Principle of working, velocity triangles, design parameters and Numerical Problems. Theory and types of Draft tubes. (No Derivations) Concepts of Specific Speed and Model Studies, (No Derivations) ***Laboratory Exercise:*** *Experiment V, VI and VII*	
Module 4 **Steam Turbines**: Classification, Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, multi-stage impulse turbine, expression for maximum utilization factor, Numerical Problems. Reaction turbine – Parsons's turbine, condition for maximum utilization factor, reaction staging. Numerical Problems Concepts of Specific Speed and Model Studies, (No Derivations)	**8 Hours / L3**
Module 5 **Centrifugal Pumps**: Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Theoretical head – capacity relationship, Minimum speed for starting the flow, Problems, (No Derivations). **Reciprocating Pumps**: Classification and parts of centrifugal pump, Working, Discharge, Work done by a single stage pump, double stage pump, Slip of a reciprocating pump, Numerical Problems, (No Derivations) ***Laboratory Exercise:*** *Experiment VIII, IX and X*	**8 Hours / L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO52.1	Evaluate the properties of fluids and analyze the mechanics of fluids at rest to solve complex engineering problems.
CO52.2	Synthesize and integrate the basic principles and equations of fluid mechanics and turbomachines to design and optimize fluid systems.
CO52.3	Formulate and implement advanced applications of Euler's equation to enhance the performance and efficiency of hydraulic turbines.
CO52.4	Critically assess and correlate the principles of steam turbines with specific speed and model studies to innovate and improve turbine designs.
CO52.5	Design and evaluate centrifugal and reciprocating pump systems based on an in-depth understanding of their working principles to address complex fluid transport challenges.

Laboratory:

Exercise Number	Experiment	No. of Hours/ RBT Levels
I, II, III, IV	Calibration of flow measuring devices – Orifice Meter, Nozzles, Venturi meter and V- Notch	04 Hours/ L3
V, VI, VII	Performance on hydraulic Turbines-Pelton wheel, Francis Turbine and Kaplan Turbines	02 Hours/ L3
VIII, IX and X	Performance hydraulic Pumps a. Single stage and multistage centrifugal pumps b. Reciprocating pump	04 Hours/ L3

Textbooks:

1. **Dr R K Bansal**, Fluid Mechanics: Lakshmi Publication 10th Edition/ 2018.
2. **V Kadambi, Manohar Prasad,** An Introduction to Energy Conversion, Volume III, Turbo machinery

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Reference books:

1. **S M Yahya**, Turbines, Fans and Compressors, Tata McGraw Hill, 2nd Edition
2. **D.G. Shepherd**, Principles of Turbomachines MacMillan, 1964.

E-Books / Web References

1. Principles of Turbomachinery https://engineeringvideolectures.com/course/805
2. Fundamentals of Turbomachinery https://books.google.co.in/books?id=3NXzbV_YW_oC&printsec=copyright&redir_esc=y#v=onepage&q&f=false

MOOCs

1. https://onlinecourses.nptel.ac.in/noc21_me75/preview
2. https://nptel.ac.in/courses/112106200

Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

The laboratory assessment would be restricted to only the CIE evaluation.

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 30. The assignment would be for a total of 10 marks, the CIE would also include laboratory evaluation for 10 marks.
CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

Some possible methods of assessment for assignments: Assignments / Oral presentations / Group activity/Projects. Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Integrated courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**30**	**50**
	CIE Test-2	**30**	
	CIE Test-2	**30**	
	Assignment/Quiz	**10**	
	Laboratory	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO52.1	3	3	2	2			2		1	1				2	
CO52.2	3	3	2	2			2		1	1				2	
CO52.3	3	3	2	2			2		1	1				2	
CO52.4	3	3	2	2			2		1	1				2	
CO52.5	3	2	2	2			2		1	1				2	
Average	**3**	**3**	**2**	**3**			**2**		**1**	**1**				**2**	

Low - 1: Medium - 2: High - 3

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SEMESTER – V

Course: DESIGN OF MACHINE ELEMENTS

Course Code	22MED53	CIE Marks	50
Hours/Week (L: T: P)	3 : 2 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Strength of Materials

Course Objectives: The students will be taught:

CO1	The steps in mechanical design procedure, materials, codes and use of standards and design for static strength, stress concentration
CO2	Analyze and design machine components for impact and fatigue strength.
CO3	Concepts and design of shafts, couplings and keys
CO4	to analyze and design riveted joints and welded joints
CO5	The design of pin joints and power screws.

Content	No. of Hours/ RBT levels
Module 1 **Fundamentals of Mechanical Engineering Design**, Design steps, Design considerations, Engineering Materials and their Mechanical properties, Standards and Codes, Factor of safety, Classification of stresses. **Static Stresses:** Numerical on Machine elements subjected to Normal, Bending, Shear and Combined stresses. Theories of failure (No Numerical)	**10 Hours / L1, L2, L3**
Module 2 **Stress concentration:** Determination of stress concentration factor, problems. **Impact Loads:** Problems with Impact stress due to Axial, Bending and Torsional loads. **Fatigue Loads:** Simple numerical on machine elements subjected to fatigue loads.	**10 Hours / L1, L2, L3**
Module 3 **Design of Shafts:** Torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under combined loads. Simple problems. **Design of keys:** Simple Numerical **Design of Couplings:** Introduction, Rigid Flange coupling & Bush type flexible coupling.	**10 Hours / L1, L2, L3**
Module 4 **Riveted Joints:** Failures of riveted joints, Joint Efficiency, Boiler Joints, Riveted Brackets, eccentrically loaded joints. **Types of Welded joints:** Strength of butt and fillet welds, welded brackets with transverse and parallel fillet welds, eccentrically loaded welded joints.	**10 Hours / L1, L2, L3**

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Module 5	
Design of Cotter and Knuckle joints. **Threaded fasteners:** Design of fasteners, load is acting parallel to the axis of the bolts (rectangular and circular base), load is acting perpendicular to the axis of the bolts, load acting in a plane of bolts.	**10 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO53.1	Apply codes and standards, design processes, and failure theories to design and optimize machine members under static loads.
CO53.2	Analyze and mitigate stress concentration effects in machine members to enhance their resilience against impact loads.
CO53.3	Synthesize solutions for shafts, keys, and couplings by solving complex loading problems and optimizing their performance.
CO53.4	Evaluate the performance and reliability of structures utilizing various types of riveted and welded joints.
CO53.5	Optimize the design of knuckle and cotter joints, and determine the appropriate size of threaded fasteners for effective motion transmission between machine elements.

TEXTBOOKS:

1. **Mechanical Engineering Design,** Joseph E Shigley and Charles Mischke. McGraw Hill International edition, 6th Edition 2009.
2. **Design of Machine Elements,** V.B. Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

DESIGN DATA HAND BOOK:

1. **Design Data Handbook, Volume 1,** K. Lingaiah, McGraw Hill, 2nd Ed.

REFERENCE BOOKS:

1. **Machine Design,** Robert L. Norton, Pearson Education Asia, 2001.
2. **Design of Machine Elements,** M. F. Spotts, T. E. Shoup, L. E Hornberger, S. R. Jayram and C. V. Venkatesh, Pearson Education, 2006.
3. **Machine Design,** Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition, 2008.
4. **Fundamentals of Machine Component Design,** Robert C. Juvinall and Kurt M Marshek, Wiley India Pvt. Ltd., New Delhi, 3rd Edition, 2007.

WEB/ONLINE REFERENCES

www.nptel.ac.in

MOOCs

1. NPTEL Course: "Design of Machine Elements" http:// https://nptel.ac.in/courses/112/107/112107146/#
2. NPTEL Course: "Strength of Materials" (https://onlinecourses.nptel.ac.in/)
3. MOOC Course: "Machine Design", (https://www.coursera.org/courses?query=mechanics%20of%20materials)
4. Free Video Lectures: "Design of Machine Elements", (https://freevideolectures.com/course/96/)

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Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 50 marks each. The average of the three tests are taken for computation of CIE on a scale of 40. The assignment would be for a total of 10 marks,
CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

Some possible methods of assessment for assignments:

Assignments / Oral presentations / Group activity/Projects

Typical Evaluation pattern for regular courses is shown in Table 1.

Table 1: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignment	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO53.1	3	2	2	1		1	1			1		2	2		
CO53.2	3	2	2	1		1	1			1		2	2		
CO53.3	3	2	2	1		1	1			1		2	2		
CO53.4	3	2	2	1		1	1			1		2	2		
CO53.5	3	2	2	1		1	1			1		2	2		
Average	**3**	**2**	**2**	**1**		**1**	**1**			**1**		**2**	**2**		

Low - 1: Medium - 2: High – 3

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SEMESTER – VI
Course: Mechanical Vibrations

Course Code	**22MED54**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3: 0 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Engineering Mechanics

Course Objectives: This course will enable the students to:

CLO1	Understand the fundamentals of Vibration Theory.
CLO2	Mathematically model real-world mechanical vibration problems.
CLO3	Determine natural frequencies of undamped, damped and forced vibrating systems of one, degree freedom systems.
CLO4	Learn the process of vibration measurements and control.
CLO5	Understand the fundamental principles of maintenance and condition monitoring techniques.

Content	No. of Hours/ RBT levels
Module 1 **Undamped (Single Degree of Freedom) Free Vibrations** **Introduction to Vibrations, Types of vibrations,** Derivations for spring mass systems, Methods of Analysis, Natural frequencies of simple systems, Springs in series and parallel, Torsional and Transverse vibrations, Effect of mass of spring and Problems.	**8** **L1,L2,L3**
Module 2 **Damped free vibrations** Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and Problems.	**8** **L1,L2,L3**
Module 3 **Forced Vibrations** Introduction, Analysis of forced vibration with constant harmonic excitation - magnification factor, rotating and reciprocating unbalances, excitation of support (relative and absolute amplitudes), force and motion transmissibility.	**8** **L1,L2,L3**
Module 4 **Vibration Measuring Instruments and Whirling of shafts: Seismic Instruments** Vibrometers, Accelerometer, Frequency measuring instruments and Problems. Whirling of shafts with and without damping, discussion of speeds above and below critical speeds and Problems.	**8** **L1,L2,L3**

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Module 5	
Modal analysis and Condition Monitoring Signal analysis, dynamic testing of machines and structures, Experimental modal analysis, Machine condition monitoring and diagnosis.	**8** **L1, L2,L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO54.1	Develop advanced mathematical models for analyzing and optimizing simple vibration systems.
CO54.2	Formulate the equation of motion, natural frequency, damping factor, and logarithmic decrement for complex damped free vibration (SDOF) systems.
CO54.3	Evaluate complex forced vibration issues using frequency response curves, phase angle plots, vibration isolation techniques, and transmissibility analysis.
CO54.4	Optimize the use of seismic and frequency measuring instruments, and critically analyze and solve problems related to the critical speed of shafts with and without damping.
CO54.5	Design and implement advanced vibration-based condition monitoring systems to enhance the reliability and performance of engineering applications.

Textbooks:

1. Mechanical Vibrations, S. S. Rao, Pearson Education Inc, 4th edition, 2003.
2. Mechanical Vibrations, V. P. Singh, Dhanpat Rai & Company, 3rdedition, 2006.

Reference books:

3. Theory of Vibration with Applications, W. T. Thomson, M. D. Dahleh and C. Padmanabhan, Pearson Education Inc, 5th edition, 2008.
4. Mechanical Vibrations: S. Graham Kelly, Schaum's outline Series,Tata McGraw Hill, Special Indian Edition, 2007.
5. Theory and Practice of Mechanical Vibrations: J. S. Rao &K.Gupta, New Age International Publications, New Delhi, 2001.
6. Mechanical Vibrations, G. K.Grover, Nem Chand and Bros, 6th edition, 1996

E-Books / Web References

3. https://www.youtube.com/watch?v=-WCBkuGTtz8&list=PLMgYkY7H7uuScB-VW9d81PW-kyWp0tY05 (complete videos on vibrations – all syllabus)
4. https://www.math.nyu.edu/faculty/childres/vibes.pdf
5. http://vdol.mae.ufl.edu/CourseNotes/EML4220/vibrations.pdf

MOOCs

1. **https://nptel.ac.in/courses/112107212**
2. **https://nptel.ac.in/courses/112107087**

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any five full questions choosing at least **one full question from each module**.

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Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is to be conducted and evaluated for 10 marks

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-2	**40**	
	Quiz /AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO54.1	2	2	1	1		1	1					1	1		
CO54.2	2	2	1	1		1	1					1	1		
CO54.3	2	2	1	1		1	1					1	1		
CO54.4	2	2	1	1		1	1					1	1		
CO54.5	2	2	1	1		1	1					1	1		
Average	**2**	**2**	**1**	**1**		**1**	**1**					**1**	**1**		

Low - 1: Medium - 2: High - 3

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SEMESTER – V

Course: Design for Manufacturing & Assembly

Course Code	22MED551	CIE Marks	50
Hours/Week (L: T: P)	3:0:0	SEE Marks	50
No. of Credits	03	Examination Hours	03

Prerequisites: Manufacturing Process

Course Objectives: The students will be taught

CLO1	The basic design rules for manufacturing and material selection.
CLO2	The concept of production process for ease of manufacturing.
CLO3	The various factors to be considered for selection of metals and alloys and relationship to manufacturing processes
CLO4	The concepts of design for manufacturing and assembly for product manufacturing.
CLO5	The Comparison of various manufacturing processes and assembly techniques required for product development.

Content	No. of Hours/ RBT levels
Module 1 **Introduction:** Design Philosophy, steps in design process, General design rules for manufacturabilty; Basic principles of designing for economical production-creativity in design. Materials: Selection of materials for design, Developments in materials technology, Criteria for materials selection.	**8 Hours / L1, L2, L3**
Module 2 **Machining process**: Over view of various machining processes. General design rules for machining, Dimensional tolerance and surface roughness, Design for machining ease, Redesign of components for Machining ease with suitable examples.	**8 Hours / L1, L2, L3**
Module 3 **Metal casting**: selection of casting process, general design considerations for casting, casting tolerances, product design rules for sand casting. Metal joining: Appraisal of various welding processes, factors in design of weldments, general design guidelines, pre and post treatment of welds.	**8 Hours / L1, L2, L3**
Module 4 **Forging:** Design factors for forging, closed die forging, design parting lines of dies, drop forging die design, General design recommendations. EXTRUSION: Design guide lines for extruded sections, Design principles for punching, blanking, bending, deep drawing, Keeler -Goodman formability diagram.	**8 Hours / L1, L2, L3**
Module 5 **Design for assembly:** General design guidelines for manual assembly, Assembly efficiency, Classification system for manual handling, Classification system for manual insertion and fastening, Effect of part symmetry on handling time.	**8 Hours / L1, L2, L3**

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COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO551.1	Evaluate design rules for manufacturability to optimize production efficiency and product quality.
CO551.2	Assess general design recommendations to enhance the manufacturability and performance of machined parts.
CO551.3	Implement advanced design considerations and tolerance strategies to improve the quality and precision of cast components.
CO551.4	Develop innovative design solutions for extruded sections, adhering to advanced guidelines for manufacturability and functionality
CO551.5	Analyze the classification system for manual insertion and fastening, applying advanced design guidelines to improve assembly efficiency and reliability

Textbooks:

1. Product design for manufacture and assembly, Geoffry Booth royd, Peter Dewhurst and W. A. Knight, CRC Press, T1.

Reference books:

1. A. K. Chitale and R.C. Gupt ‘‘Product design and Manufacturing” –prentice-Hall of India, New Delhi, 2003,
2. Kevin Otto and Kristin Wood,” Production Design”, Person Education,
3. Surender Kumar, Goutham Sutradhar, ‘‘Design and Manufacturing”, oxford & IBH Publishing co, Pvt Ltd, 1998,

E-Books / Web References

1. https://link.springer.com/article/10.1007/s00170-022-08837-6#:~:text=Introduction-,The%20design%20for%20manufacturing%20and%20assembly%20(DFMA)%20is%20a%20family,of%20the%20product%20under%20development.
2. https://www.machinedesign.com/automation-iiot/article/21213546/a-history-of-design-for-manufacturing-and-assembly

MOOCs

NPTEL Course: “Design for Manufacture and Assembly
https://nptel.ac.in/courses/107103012

Scheme of Examination:
Semester End Examination (SEE):
SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):
Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE. The assignment component would be for 10 marks. CIE is executed by way of quizzes / Alternate Assessment Tools (AATs), and three tests.

Some possible methods of assessment for assignments: Assignments/ Oral presentations / Group activity/Projects.

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Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignment/Quiz /AAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO551.1	3	2	1	1		1		1		1		1			2
CO551.2	3	2	1	1		1		1		1		1			2
CO551.3	3	2	1	1		1		1		1		1			2
CO551.4	3	2	1	1		1		1		1		1			2
CO551.5	3	2	1	1		1		1		1		1			2
Average	**3**	**2**	**1**	**1**		**1**		**1**		**1**		**1**			**2**

Low - 1: Medium - 2: High – 3

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SEMESTER – V

Course: Energy, Environment and Sustainable Development

Course Code	22MED552	CIE Marks	50
Hours/Week (L: T: P)	3 : 0 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites:

Course Objectives: The students will be taught:

CLO1	The evaluation of economic frameworks for managing natural resources in development process
CLO2	The Energy Consumption Rates of conventional energy sources.
CLO3	The air and water quality standards.
CLO4	The need for solid waste management.
CLO5	The need and key concepts of sustainability.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Energy, Environment and Sustainability, Fundamental Dimensions and Systems of Units** Basic human needs, Energy, Environment, Sustainability, Simple Numerical Problems Fundamental Dimensions and Systems of Units, Dimensional Homogeneity and Unit Conversion, Components and Systems, Simple Numerical Problems **Renewable Energy for Sustainable Development- Challenges and Opportunities in India** Introduction, Renewable Energy in India, Policies and Regulations on Renewable Energy, Renewable Energy- SWOT Analysis, Renewable Energy Options for India	**08 Hours / L3**
Module 2 **Energy Consumption Rates and Non-Renewable Energy Sources** World Energy Consumption Rates, Fossil Fuels, Nuclear Energy **Energy and Agriculture in India, Population Growth and Environmental Degradation** Introduction, Energy to Agriculture, Energy from Agriculture, Trends in Population Growth, Effects of Population Growth on Environmental Sources, Population and Resource Depletion Problem, Caring Environment for Sustainable Development	**08 Hours / L3**

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Module 3 **Air and Air Quality Standards** Atmosphere, Weather and Climate, Green House Gases, Measurement of pollutants, Air quality and Health Issues, HVAC Systems, Methods to manage Contaminants, Global air Quality Issues climate change, **Water Resources, Consumption Rate, Quality Standards** Basic Concepts of Water, Water Cycle, Properties of Water, Global Water Distribution, Global Water Quality Issues	**08 Hours / L3**
Module 4 **Sources of Drinking Water in India, Overview of Water Crisis** Water for Life, Sources of Drinking Water and in India, Water Crisis, and Priorities of action **Municipal and Industrial Waste Solid Waste management** Introduction, Conceptualization, Groups of Waste, Objectives of Study, Solid Waste: Indian Scenario, Solid Waste- Different Views, Case study on Solid waste management	**08 Hours / L3**
Module 5 **Sustainability, Policy Interventions for Sustainable Environmental Management in India,** The Earth Charter, Key Sustainability Concepts, Assessments and Tools, Economics, **Environment and Development**- Theory and Practice, Sustainable Development and Environmental Management- International Initiatives, Legal Framework for Environmental Management Legislation, Policies for Sustainable Environmental Management- Ecological Economics Approach	**08 Hours / L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO552.1	Evaluate the interconnections between energy, environment, and sustainable development within the Indian context to propose informed strategies for improvement.
CO552.2	Formulate innovative solutions to energy market issues and environmental challenges using advanced economic analysis and tools
CO552.3	Evaluate comprehensive insights into energy management systems, policies, and Acts to drive policy development and system improvements
CO552.4	Investigate and provide advanced solutions for water resource management and industrial solid waste management in India
CO552.5	Design for progressive sustainable energy management policies and legal frameworks to enhance sustainability and regulatory compliance in India

Textbooks:

1. "Exergy: Energy, Environment, and Sustainable Development", İbrahim Dinçer, Marc A. Rosen, Elsevier, Second Edition, 2007.
2. Energy, the Environment, and Sustainability By Efstathios E. Michaelides
3. Amlan Chakrabarti, Energy Engineering and Management, PHI, Eastern Economy Edition.

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Reference books:

1. Energy Economics and the Environment: Conservation, Preservation and sustainability, Edition First Edition, Edited by: Mohammad Younus Bhat, Hiranmoy Roy, &M. S. Bhatt

E-Books / Web References

https://www.kobo.com/us/en/ebook/energy-the-environment-and-sustainability

https://www.taylorfrancis.com/books/mono/10.1201/b22169/energy-environment-sustainability-efstathios-michaelides

MOOCs

https://www.coursera.org/learn/exploring-renewable-energy

https://www.mooc-list.com/course/renewable-power-and-electricity-systems-coursera

https://www.edx.org/professional-certificate/usmx-environmental-management-for-sustainability

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE. The assignment component would be for 10 marks. CIE is executed by way of quizzes / Alternate Assessment Tools (AATs), and three tests.

Some possible methods of assessment for assignments: Assignments / Oral presentations / Group activity/Projects.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz /AAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO552.1	3	2	2	3		1	1			1	2	1			1
CO552.2	3	2	2	3		1	1			1	2	1			1
CO552.3	3	2	2	3		1	1			1	2	1			1
CO552.4	3	2	2	3		1	1			1	2	1			1
CO552.5	3	2	2	3		1	1			1	2	1			1
	3	**2**	**2**	**3**		**1**	**1**			**1**	**2**	**1**			**1**

Low - 1: Medium - 2: High – 3

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SEMESTER – V

Course: Automotive Engineering and Hybrid Vehicle technology

Course Code	**22MED553**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3 : 0 : 0**	**SEE Marks**	**50**
No. of Credits	**03**	**Examination Hours**	**03**

Prerequisites: Elements of Mechanical engineering

Course Objectives: the students are taught to:

CLO1	Relate the functions and importance of automotive parts and their performance
CLO2	Know the working of transmission and brake systems.
CLO3	Gain the knowledge of operation and working of steering and suspension systems.
CLO4	The concepts of various Injection system and its advancements.
CLO5	Understand the Hybrid Vehicle technology, Automobile emissions control techniques & the Norms

Content	No. of Hours/ RBT levels
Module 1 **ENGINE COMPONENTS AND IT'S PARTS**: Spark Ignition (SI) & Compression Ignition (CI) engines, cylinder – arrangements and their relative merits, Liners, Piston, connecting rod, crankshaft, valves, valve actuating mechanisms, valve and port timing diagrams, Types of combustion chambers for S.I. Engine and C.I. Engines. **COOLING AND LUBRICATION**: Cooling requirements, Types of cooling- Thermo siphon system, forced circulation water cooling system, water pump, Radiator, Significance of lubrication, Splash and Forced feed system.	**08 Hours / L1, L2, L3**
Module 2 **FUELS, FUEL SUPPLY SYSTEMS FOR SI AND CI ENGINES**: Conventional fuels, Alternative fuels, Normal and Abnormal combustion, Cetane and Octane numbers, Fuel mixture requirements for SI engines, Types of carburettors, Multi point and Single point fuel injection systems, fuel transfer pumps, Fuel filters, fuel injection pumps and injectors. Electronic Injection system, Common Rail Direct Injection System. **SUPERCHARGERS AND TURBOCHARGERS**: Naturally aspirated engines, Forced Induction, Types of superchargers, Turbocharger construction and operation, Intercooler, Turbocharger lag.	**08 Hours / L1, L2, L3**

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Module 3 **TRANSMISSION SYSTEMS**: Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints. Differential and rear axle, Hotchkiss Drive and Torque Tube Drive. **BRAKES**: Types of brakes, mechanical compressed air, vacuum, and hydraulic braking system construction and working of master and wheel cylinder, brake shoe arrangements, Disk brakes, drum brakes, Antilock –Braking systems,	**08 Hours / L1, L2, L3**
Module 4 **STEERING AND SUSPENSION SYSTEMS**: Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Suspension, Torsion bar suspension systems, leaf spring, coil spring, independent suspension for front wheel and rear wheel, Air suspension system. **IGNITION SYSTEM**: Battery Ignition system, Magneto Ignition system, electronic Ignition system.	**08 Hours / L1, L2, L3**
Module 5 **HYBRID AND ELECTRIC VEHICLES** Main components and working principles of a hybrid and electric vehicles, Different configurations of hybrid and electric vehicles. Power Split devices for Hybrid Vehicles - Operation modes - Control Strategies for Hybrid Vehicle - Economy of hybrid Vehicles - Case study on specification of electric and hybrid vehicles. **AUTOMOTIVE EMISSION CONTROL SYSTEMS**: Different air pollutants, formation of photochemical smog and causes. Automotive emission controls, Euro I, II, III and IV norms, FAME Policy	**08 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO553.1	Analyze the functions and interactions of different automobile parts and lubrication systems to enhance vehicle performance and maintenance.
CO553.2	Evaluate the selection and application of diverse fuels and injection systems to improve efficiency and environmental sustainability in automotive engineering.
CO553.3	Assess transmission and braking systems to enhance vehicle safety and operational efficiency.
CO553.4	Design advanced steering and suspension systems, evaluating their applications to improve vehicle handling and comfort.
CO553.5	Develop advanced hybrid vehicle systems, analyzing and mitigating automobile emissions to reduce environmental impact.

Textbooks:

1. Automobile engineering, **Kirpal Singh**, Vol I and II (12th Edition) Standard Publishers 2011
2. Automotive Mechanics, **S. Srinivasan**, (2nd Edition) Tata McGraw Hill 2003.

Reference books:

1. Automobile Engineering, **R. B. Gupta, Satya Prakashan**,(4th Edition)
2. Fundamentals of Automobile Engineering, **K.K.Ramalingam**, Scitech Publications (India) Pvt. Ltd.

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3. Automotive mechanics, **William H Crouse & Donald L Anglin** (10th Edition) Tata McGraw Hill Publishing
4. Automotive mechanics: Principles and Practices, **Joseph Heitner,** D Van Nostrand Company, Inc

E-Books / Web References

1. **E - Books:** https://www.pdfdrive.com/automotive-engineering-
2. E-Books: https://engineeringbookspdf.com/category/automobile-engineering-books/
3. Web reference: https://pib.gov.in/newsite/PrintRelease.aspx?relid=191377

MOOCs

1. NPTEL Course: "Fundamental of Automotive " https://nptel.ac.in/courses/107106088
2. NPTEL Course: "Injection systems" (https://nptel.ac.in/courses/112103262)
3. MOOC Course: "Braking system", (https://hypersonictech.in/automotive-brake-system/
4. MOOC Course: "Emission control", (https://www.mooc-list.com/tags/carbon-emissions)

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is conducted and evaluated for 10 marks.

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz 1/AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO553.1	3	1	1			1	1					1	2		
CO553.2	3	1	1			1	1					1	2		
CO553.3	3	1	1			1	1					1	2		
CO553.4	3	1	1			1	1					1	2		
CO553.5	3	1	1			1	1					1	2		
Average	**3**	**1**	**1**			**1**	**1**					**1**	**2**		

Low - 1: Medium - 2: High - 3

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SEMESTER – V

Course: PRODUCT LIFE CYCLE MANAGEMENT

Course Code	**22MED554**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3 : 0 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Management & Entrepreneurship

Course Objectives:

CLO1	To familiarize with various strategies of PLM
CLO2	Understand the concept of product design and simulation.
CLO3	Develop New product development, product structure and supporting systems
CLO4	Interpret the technology forecasting and product innovation and development in business processes.
CLO5	Understand product building and Product Configuration.

Content	No. of Hours/ RBT levels
Module 1 **INTRODUCTION TO PLM AND PDM** Introduction to PLM, Need for PLM, opportunities and benefits of PLM, different views of PLM, components of PLM, phases of PLM, PLM feasibility study. PLM Strategies, strategy elements, its identification, selection and implementation. Product Data Management, implementation of PDM systems.	**08 Hours / L2**
Module 2 **PRODUCT DESIGN** Engineering design, organization and decomposition in product design, product design process, methodical evolution in product design, concurrent engineering, design for 'X' and design central development model. Strategies for recovery at end of life, recycling, human factors in product design. Modelling and simulation in product	**08 Hours / L2**
Module 3 **PRODUCT DEVELOPMENT** New Product Development, Structuring new product development, building decision support system, Estimating market opportunities for new product, new product financial control, implementing new product development, market entry decision, launching and tracking new product program. Concept of redesign of product.	**08 Hours / L2**

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Module 4 **TECHNOLOGY FORECASTING** Technological change, methods of technology forecasting, relevance trees, morphological methods, flow diagram and combining forecast of technologies Integration of technological product innovation and product development in business processes within enterprises, methods and tools in the innovation process according to the situation, methods and tools in the innovation process according to the situation.	**08 Hours / L2**
Module 5 **PRODUCT BUILDING AND STRUCTURES** Virtual product development tools for components, machines, and manufacturing plants: 3D CAD systems, digital mock-up, model building, model analysis, production (process) planning, and product data technology, Product structures: Variant management, product configuration, material master data, product description data, Data models, Life cycles of individual items, status of items.	**08 Hours / L2**

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Evaluate the implementation of Product Lifecycle Management (PLM) to enhance product development and lifecycle processes.
CO2	Optimize product design methodologies, including organization, decomposition, design for 'X', and the central development model, to improve product innovation and efficiency.
CO3	Develop advanced strategies for new product development, including market opportunity estimation, product launch, and tracking, to maximize market success and profitability
CO4	Implement cutting-edge technology forecasting and product innovation strategies to drive competitive advantage and business growth
CO5	Design advanced virtual product development tools to enhance product building and configuration, ensuring high-quality and efficient production processes

Textbooks:

1. Stark, John. Product Lifecycle Management: Paradigm for 21st Century Product Realization, Springer-Verlag, 2004. ISBN 1852338105
2. Fabio Giudice, Guido La Rosa, Product Design for the environment-A life cycle approach, Taylor & Francis 2006

Reference books:

1. Saaksvuori Antti / ImmonenAnselmie, product Life Cycle Management Springer,Dreamtech,3-540-25731-
2. Product Lifecycle Management, Michael Grieves, Tata McGraw Hill

E-Books / Web References

1. https://onlinecourses.swayam2.ac.in/imb19_mg01/preview
2. https://www.mygreatlearning.com/academy/learn-for-free/courses/product-lifecycle-management

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MOOCs

1. https://nptel.ac.in/courses/110104084
2. https://nptel.ac.in/courses/112107217

Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is conducted and evaluated for 10 marks.

Some possible methods of assessment for assignments: Assignments/ Oral presentations / Group activity/Projects

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz/AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO554.1	3	1	1	1		1	1					1			1
CO554.2	3	1	1	1		1	1					1			1
CO554.3	3	1	1	1		1	1					1			1
CO554.4	3	1	1	1		1	1					1			1
CO554.5	3	1	1	1		1	1					1			1
Average	**3**	**1**	**1**	**1**		**1**	**1**					**1**			**1**

Low - 1: Medium - 2: High – 3

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SEMESTER – V

Course: Ability Enhancement Course – III

CNC Technology

Course Code	**22MED56**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**1 : 0 : 2**	**SEE Marks**	**50**
No. of Credits	**02**	**Examination Hours**	**03**

Course Objectives: To enable students to apply the knowledge CNC Technology in broad domain of mechanical engineering by making them to learn:

CLO1	Fundamentals of CNC Machines and its construction
CLO2	Programming CNC machine operated on FANUC Controller
CLO3	Operation of CNC Turning center

Content	No. of Hours/ RBT levels
Module 1 **Fundamentals of CNC Technology:** Fundamentals of CNC Machines, Construction, Machining Operations and sequence, Cutting Tools, Cutting Parameters, Work and Tool holding devices, Reading Part Drawing. **CNC Turning Programming:** Programming Concepts, G & M Codes, Canned Cycles, Programming Syntax, Tool Path.	**12 Hours / L3**
CNC Turning Machine Setting & Operating CNC System console operation, MDI & Jog Modes, Work Offsets and Tool offsets,mounting cutting tools, manual entry of CNC part programs, single block check for errors and tool collisions and auto mode operation	**12 Hours / L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO56.1	Develop part programming using G- and M- codes
CO56.2	Set up the CNC machining center for manufacturing
CO56.3	Produce the parts on CNC Turning Machine

Textbooks:

1. Automation, Production Systems and Computer-Integrated Manufacturing, by Mikell P Groover, 4th Edition, 2015, Pearson Learning.

2. CAD / CAM Principles and Applications by P N Rao, 3rd Edition, 2015, Tata McGraw-Hill.

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO56.1	3	2	2	-	-	-	-	-	1	1	-	3	3	-	-
CO56.2	3	-	-	-	3	2	2	-	1	-	-	3	3	-	-
CO56.3	3	-	-	-	3	-	-	-	3	3	-	3	3	-	-
Average	3	2	2		3	2	2		3	3		3	3	-	-

Low - 1: Medium - 2: High - 3

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SEMESTER – V

Course: Environmental Science

Course Code	22CIV57	CIE Marks	50
Hours/Week (L: T: P)	1 : 0 : 0	SEE Marks	50
No. of Credits	1	Examination Hours	1 hour

Course Objectives: Students will be taught:

CLO1	The fundamentals of environmental science.
CLO2	The types of natural resources
CLO3	The various global environmental concerns.
CLO4	The types of wastes generated and their handling at a basic level
CLO5	The area of environmental law and policies with a few important acts in the field

Content	No. of Hours/ RBT Levels
Module 1 **Environment:** • Definition, scope & importance • Components of Environment Ecosystem: Structure and function of various types of ecosystems • Human Activities – Food, Shelter, and Economic & Social Security. • Population - Growth, variation among nations – population explosion and impact on environment **Biodiversity:** Types, Value, Hot spots, Threats and Conservation of biodiversity, Forest Wealth, and Deforestation.	**04 Hours / L2**
Module 2 **Natural Resources**: Forest, Water, Mineral, Food, Energy, Land Environmental Pollution - Definition – causes, effects and control measures of: (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards.	**04 Hours / L2**
Module 3 **Global Environmental Concerns** (Concept, policies and case-studies): Ground water depletion/recharging, Climate Change; Acid Rain; Ozone Depletion; Radon and Fluoride problem in drinking water; Resettlement and rehabilitation of people, Environmental Toxicology.	**04 Hours / L2**
Module 4 **Sources:** Sources of Solid waste, Types of solid waste, Physical and Chemical composition of municipal solid waste. Solid Waste Management Rules in India, Sources and management of E – Waste, Biomedical Waste, Hazardous waste, and construction waste at individual and community level. Socio-economic aspect of waste management Environmental Toxicology.	**04 Hours / L2**

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Module 5	04 Hours / L2
Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): Environment Impact Assessment, Environmental Management Systems, ISO14001; Environmental Stewardship, NGOs.	

Textbooks:

1. Environmental studies, Benny Joseph, Tata Mcgraw-Hill 2nd edition 2012
2. Environmental studies, S M Prakash, pristine publishing house, Mangalore 3rd edition-2018
3. Gilbert M.Masters, Introduction to Environmental Engineering and Science, 2nd edition, Pearson Education, 2004

Reference books:

1. Benny Joseph, Environmental studies, Tata Mcgraw-Hill 2nd edition 2009
2. M.Ayi Reddy Textbook of Environmental Science and Technology, BS publications 2007
3. Dr. B.S Chauhan, Environmental Studies, University of science press 1st edition

Web References:

https://www.hzu.edu.in/bed/E%20V%20S.pdf

https://onlinecourses.nptel.ac.in/noc23_hs155/preview

https://onlinecourses.swayam2.ac.in/cec19_bt03/preview

Scheme of Examination:

Semester End Examination (SEE): SEE Question paper is to be set for 50 marks with multiple choice questions of 1 mark each covering all aspects of the syllabus.

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 50 marks each. The average of the three tests are taken for computation of CIE. Question paper for each of the CIE is to be of the multiple-choice type with 50 question each.

Typical Evaluation pattern for regular courses is shown in Table.

Table 1: Distribution of weightage for CIE & SEE for 1 credit course

	Component	Marks	Total Marks
CIE	CIE Test-1	**50**	**50**
	CIE Test-2	**50**	
	CIE Test-2	**50**	
SEE	Semester End Examination	**50**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
22CIV57.1	2	-	-	-	-	-	3	-	-	-	-	-	1	-	-
22CIV57.2	2	1	-	-	-	-	3	-	-	-	-	1	1	-	1
22CIV57.3	2	-	2	-	-	2	3	1	-	-	-	1	1	-	1
22CIV57.4	2	2	-	-	-	2	3	-	-	-	-	-	-	-	1
22CIV57.5	2	-	-	-	-	2	3	-	-	-	-	-	-	1	1
Average	**2**	**2**	**2**	**-**	**-**	**2**	**3**	**1**	**-**	**-**	**-**	**1**	**1**	**1**	**1**

Low-1: Medium-2: High-3

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SEMESTER – V

Course: Universal Human Values

Course Code	22UHV57	CIE Marks	50
Hours/Week (L: T: P)	1 : 0 : 0	SEE Marks	50
No. of Credits	1	Examination Hours	1 hour

Course Objectives: Students will be taught:

CLO1	To create an awareness on Engineering Ethics and Human Values.
CLO2	To understand social responsibility of an engineer.
CLO3	To appreciate ethical dilemma while discharging duties in professional life.

Content	No. of Hours
Module 1 **Introduction to Value Education** • Value Education, Definition, Concept and Need for Value Education. • The Content and Process of Value Education. • Basic Guidelines for Value Education, Self-exploration as a means of Value Education. • Happiness and Prosperity as parts of Value Education.	**05 Hours**
Module 2 **Harmony in the Human Being** • Human Being is more than just the Body, Harmony of the Self ('I') with the Body. • Understanding Myself as Co-existence of the Self and the Body. • Understanding Needs of the Self and the needs of the Body. • Understanding the activities in the Self and the activities in the Body.	**05 Hours**
Module 3 **Harmony in the Family and Society and Harmony in the Nature** • Family as a basic unit of Human Interaction and Values in Relationships. • The Basics for Respect and today's Crisis: Affection, Guidance, Reverence, Glory, Gratitude and Love, • Comprehensive Human Goal: The Five Dimensions of Human Endeavour. • Harmony in Nature: The Four Orders in Nature. • The Holistic Perception of Harmony in Existence.	**05 Hours**
Module 4 **Social Ethics** • The Basics for Ethical Human Conduct, Defects in Ethical Human Conduct. • Holistic Alternative and Universal Order, • Universal Human Order and Ethical Conduct, • Human Rights violation and Social Disparities.	**05 Hours**
Module 5 **Professional Ethics** • Value based Life and Profession., Professional Ethics and Right Understanding. • Competence in Professional Ethics. • Issues in Professional Ethics – The Current Scenario. • Vision for Holistic Technologies, Production System and Management Models.	**05 Hours**

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COURSE OUTCOMES: Upon completion of this course, student will be able to:

22UHV57.1	Understand the significance of value inputs in a classroom and start applying them intheir life and profession
22UHV57.2	Distinguish between values and skills, happiness and accumulation of physical facilities,the Self and the Body, Intention and Competence of an individual, etc.
22UHV57.3	Understand the role of a human being in ensuring harmony in society and nature.
22UHV57.4	Distinguish between ethical and unethical practices and start working out the strategy toactualize a harmonious environment wherever they work.

Textbooks:

1. A.N Tripathy, New Age International Publishers, 2003.
2. Bajpai. B. L, New Royal Book Co, Lucknow, Reprinted, 2004
3. Bertrand Russell Human Society in Ethics & Politics

Reference books:

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. Corliss Lamont, Philosophy of Humanism.
4. Gaur. R.R., Sangal. R, Bagari G.P, A Foundation Course in Value Education,Excel Books, 2009.
5. Gaur. R.R., Sangal R, Bagaria G.P, Teachers Manual, Excel Books, 2009.
6. I.C. Sharma, Ethical Philosophy of India, Nagin & co, Julundhar
7. William Lilly- Introduction to Ethics -Allied Publisher

Scheme of Examination:

Semester End Examination (SEE): SEE Question paper is to be set for 50 marks with multiple choice questions of 1 mark each covering all aspects of the syllabus.

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 50 marks each. The average of the three tests are taken for computation of CIE. Question paper for each of the CIE is to be of the multiple-choice type with 50 question each.

Typical Evaluation pattern for regular courses is shown in Table.

Table 1: Distribution of weightage for CIE & SEE for 1 credit course

	Component	Marks	Total Marks
CIE	CIE Test-1	**50**	**50**
	CIE Test-2	**50**	
	CIE Test-2	**50**	
SEE	Semester End Examination	**50**	**50**
		Grand Total	**100**

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
22UHV57.1	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
22UHV57.2	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
22UHV57.3	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
22UHV57.4	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
Average	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**

Low-1: Medium-2: High-3

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VI SEMESTER

SYLLABUS

SEMESTER – VI
Course: Industrial Robotics

Course Code	**22MED61**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3: 0 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Course Objectives: This course will enable the students to:

CLO1	Understand the fundamental concepts and technical specifications of industrial robotics, including robot anatomy, configurations, and control systems.
CLO2	Understand and apply the principles of 2D transformations and robot kinematics, including matrix representation and homogeneous transformations.
CLO3	Understand and derive the dynamic equations of motion for robotic systems using Lagrangian and Newton-Euler formulations.
CLO4	Understand and implement various trajectory planning methods for robotic motion in both joint space and Cartesian space.
CLO5	Understand key concepts and techniques in robot programming, including different programming levels and offline programming systems.

Content	No. of Hours/ RBT levels
Module 1 **Industrial Robotics:** Definition of Robotics, robot anatomy, joints and end effectors, Robotic configuration, Work volume, Robot motions, Robot drive system, Precision of movement: Spatial resolution, Accuracy and Repeatability. Degrees of freedom, Asimov's laws of robotics, Robot specifications Introduction to PID control systems, notations and symbols, position and orientation of rigid body, properties of rotation matrices about X-, Y- and Z-axis (simple numerical)	**08 Hours / L1, L2, L3**
Module 2 **Transformations:** 2D transformations, translation, rotation (Rotation about x, y, z axis) and scaling. Introduction to Direct and inverse kinematics. (only definition) **Robot kinematics:** Introduction- Matrix representation- rigid motion & homogeneous transformation- D-H representations.	**08 Hours / L1, L2, L3**
Module 3 **Robot Dynamics:** Kinetic energy, potential energy, Spring-mass-damper system using Lagrangian formulation. Equations of motion using Lagrangian – Euler formulations, equations of motion of 1- and 2- DoF.	**08 Hours / L1, L2, L3**
Module 4 **Trajectory planning:** Joint space schemes, cubic trajectory, third order polynomial trajectory planning, Linear segments with Parabolic Blends (LSPB) trajectory. Cartesian space schemes – cartesian straight line and circular motion planning.	**08 Hours / L1, L2, L3**
Module 5 **Robot programming:** Introduction, levels of robot programming, requirements of robot programming language, problems pertaining to robot programming languages, offline programming systems, central issues in OLP systems, automating subtasks in OLP systems, simple programs on robot applications.	**08 Hours / L1, L2, L3**

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COURSE OUTCOMES: Upon completion of this course, student will be able to

CO61.1	Apply the principles of robot anatomy, configurations, and PID control systems to optimize the precision and efficiency of robotic movements in industrial applications.
CO61.2	Analyze 2D transformations, direct and inverse kinematics, and D-H representations to effectively model and control robotic movements.
CO61.3	Formulate and solve the equations of motion for robotic systems, including 1- and 2-degree-of-freedom (DoF) systems, using Lagrangian and Newton-Euler methods.
CO61.4	Develop trajectory planning techniques, including cubic and third-order polynomial trajectories, Linear Segments with Parabolic Blends (LSPB), as well as Cartesian straight line and circular motion planning for robotic systems.
CO61.5	Develop robot programs, addressing issues related to robot programming languages, offline programming systems, and automating subtasks, while implementing simple programs for practical robot applications.

Textbooks:

1. Computer Integrated Manufacturing - Mikell P. Groover, Pearson, 3rd edition, 2009
2. Introduction to robotics mechanics and control - John J. Craig, Pearson, 3rd edition, 2009

Reference books:

1. Robotics for Engineers - Yoram Koren, McGraw Hill International, 1st edition, 1985.
2. Industrial Robotics - Weiss, Nagel, McGraw Hill International, 2nd edition, 2012.
3. Robotic Engineering - An Integrated approach, Klafter, Chmielewski and Negin, PHI, 1st edition, 2009.
4. Computer Based Industrial Control - Krishna Kant, EEE-PHI, 2nd edition, 2010.
5. An Introduction to Automated Process Planning Systems- Tiess Chiu Chang & Richard A. Wysk.

E-Books / Web References

1. **Fundamentals of Robot Technology**: An Introduction to Industrial Robots, Tele operators and Robot Vehicles: https://www.pdfdrive.com/fundamentals-of-robot-technology-an-introduction-to-industrial-robots-teleoperators-and-robot-vehicles-d157678284.html
2. **Robot Operating System for Absolute Beginners**: Robotics Programming Made Easy: https://www.pdfdrive.com/robot-operating-system-for-absolute-beginners-robotics-programming-made-easy-e176394485.html
3. **Introduction to Robotics:**
   - http://www.mech.sharif.ir/c/document_library/get_file?uuid=5a4bb247-1430-4e46-942c-d692dead831f&groupId=14040
   - https://www.researchgate.net/publication/273697873_Introduction_to_Robotics

MOOCs

1. NPTEL Course: "ROBOTICS" : https://nptel.ac.in/courses/112105249
2. NPTEL Course: "Introduction to Robotics": https://onlinecourses.nptel.ac.in/noc20_de11/preview

Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module

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carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 40.

CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

Some possible AATs: Assignments / Oral presentations / Group activity/Projects

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	QUIZ/OAT	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO61.1	3	2	2	1	-	1	-	-	-	-	-	2	2	-	-
CO61.2	3	2	2	1	-	1	-	-	-	-	-	2	2	-	-
CO61.3	3	2	2	1	-	1	-	-	-	-	-	2	2	-	-
CO61.4	3	2	2	1	-	1	-	-	-	-	-	2	2	-	-
CO61.5	3	2	2	1	-	1	-	-	-	-	-	2	2	-	-
Average	3	2	2	1	-	1	-	-	-	-	-	2	2	-	-

Low - 1: Medium - 2: High - 3

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SEMESTER – VI

Course: HEAT TRANSFER (Integrated)

Course Code	22MED62	CIE Marks (Theory + Lab)	30 + 20 = 50
Hours/Week (L: T: P)	3 : 0 : 2	SEE Marks	50
No. of Credits	4	Examination Hours	03

Prerequisites:

Course Objectives: The students will be taught:

CLO1	The types of heat transfer applied to engineering systems
CLO2	Various engineering correlations used in heat transfer analysis and their application in thermal design of engineering components and systems.
CLO3	The heat transfer process parameters used in solving engineering problems related to conduction, convection, and radiation
CLO4	The boundary layer concept in forced and free convection problems
CLO5	Boiling and condensation concepts to use in the design of heat exchangers

Content	No. of Hours/ RBT levels
Module 1 **Basic Concepts:** Modes of heat transfer: Basic laws governing conduction, convection and radiation heat transfer, Thermal conductivity; Convective heat transfer co-efficient, General 3 – dimensional heat conduction equation in Cartesian co-ordinates. (No derivations) **Steady state heat conduction:** Steady state heat conduction in plane wall and multilayer walls, Thermal contact resistance, discussion on 3-D conduction in cylindrical and spherical coordinate systems, (No derivations) **Demonstration and Hands on:** *Demonstration - I* **Laboratory:** *Laboratory Exercise – I, II*	**8 Hours / L1, L2, L3**
Module 2 **Heat transfer in extended surfaces (Fins)** – infinitely long fin, fin with insulated tip and fin with convective heat transfer at the tip, Fin Efficiency or Effectiveness. Numerical problems on Fin Heat Transfer, (No derivations) **Demonstration and Hands on:** *Demonstration - II* **Laboratory:** *Laboratory Exercise – III*	**8 Hours / L1, L2, L3**

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Module 3 **Forced Convection**: Dimensional analysis, Physical significance of Reynolds, Prandtl, Nusselt and Stan**ton** numbers. Use of empirical correlations for flow over a flat plate, over a cylinder and spheres. Numerical problems. (No derivations) **Free Convection**: Dimensional analysis for free convection - physical significance of Grashof number; use of experimental correlations for Free convection from or to Vertical, Horizontal plates and cylinders, and spheres. (No derivations) **Laboratory:** *Laboratory Exercise – IV, V*	**8 Hours / L1, L2, L3**
Module 4 **Condensation Heat Transfer**: Dropwise and film wise Condensation on a Vertical Flat Surface; Film Thickness and Heat Transfer Coefficient; Correlations for Condensation on Horizontal Tube and Horizontal Tube Banks; Numerical problems. (No derivations). **Heat Exchangers:** Classification of Heat Exchangers; Overall Heat Transfer coefficient, Fouling and Fouling factor; LMTD, Effectiveness-NTU methods of analysis of Heat Exchangers, Numerical problems. **Laboratory:** *Laboratory Exercise – VI and VII*	**8 Hours / L1, L2, L3**
Module 5 **Radiation Heat Transfer:** Thermal Radiation; definitions of various terms; Stefan-Boltzmann's law, Kirchhoff's law, Planck's law and Wein's Displacement law. Radiation heat exchange between two parallel infinite black surfaces, between two parallel infinite gray surfaces; effect of Radiation Shield; Numerical Problems. **Laboratory:** *Laboratory Exercise – VIII and IX*	**8 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO62.1	Analyze and compute conduction heat transfer across various geometries.
CO62.2	Quantify thermal energy transfer in both steady-state and transient scenarios by employing advanced charts and correlation tables.
CO62.3	Apply the boundary layer concept to critically examine and interpret heat flow through bodies with different cross-sections concerning forced and free convection.
CO62.4	Evaluate and optimize heat transfer rates for complex phase transformation problems, including condensation, evaporation, and heat exchangers.
CO62.5	Synthesize and critically review fundamental concepts and laws of radiation and assess radiation exchange between two finite bodies.

Laboratory:

Exercise Number	Experiment	No. of Hours/ RBT Levels
I & II	Determination of Thermal Conductivity of a Metal Rod, Determination of Overall Heat Transfer Coefficient of a Composite wall.	01 Hours/ L3
III	Determination of Effectiveness on a Metallic fin.	01 Hours/ L3
IV & V	Determination of Heat Transfer Coefficient in a free Convection on a vertical cylinder, Determination of Heat Transfer Coefficient in a forced Convection through a pipe	02 Hours/ L3
VI & VII	Determination of LMDT and Effectiveness in a Parallel Flow and	02 Hours/ L3

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	Counter Flow Heat Exchanger.	
VIII & IX	Determination of Emissivity of a Surface, Determination of Stefan Boltzmann Constant.	02 Hours/ L3
Demonstration – I	Determination of temperature distribution along fin subjected to heat loss through convection using Numerical approach (ANSYS/CFD package)	02 Hours/ L3

Textbooks:

3. **Yunus A. Cengel, Afshin J Ghajar –** Heat and Mass Transfer, Fundamentals and Applications, Sixth edition, Tata Mc Graw Hill.
4. **Er.R.K. Rajput,** A textbook of Heat and Mass Transfer, Revised Edition, 2019, S Chand and Company Ltd.

Reference books:

5. **Incropera, F. P. and De Witt,** Fundamentals of Heat and Mass Transfer, D. P., 5th Edition, John Wiley and Sons, New York, 2006.
6. **M. Necati Ozisik,** Heat Transfer, A Basic Approach, McGraw Hill, New York, 2005.
7. **Holman, J. P,** Heat Transfer, 9th Edition, Tata McGraw Hill, New York, 2008.

E-Books / Web References

1. https://www.pdfdrive.com/heat-transfer-d19467627.html

MOOCs

5. NPTEL Course: "Heat and Mass Transfer" (https://nptel.ac.in/courses/112101097)
6. MOOC Course: "Heat and Mass Transfer" (https://www.coursera.org)
7. Free Video Lectures: "Heat and Mass transfer", (https://freevideolectures.com/course/3533/convective-heat-transfer)

Scheme of Examination: (Integrated courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Note: The laboratory assessment would be restricted to only the CIE evaluation.

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 30, the CIE would also include laboratory evaluation for 20 marks. The laboratory marks of 20 would comprise of 10 marks for regular laboratory assessment to include lab record and observation. 10 marks would be exclusive for laboratory internal assessment test to be conducted at the end of the semester.

Typical Evaluation pattern for integrated courses is shown in the Table below

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Table: Distribution of weightage for CIE & SEE of Integrated courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**30**	**50**
	CIE Test-2	**30**	
	CIE Test-3	**30**	
	Laboratory	**20**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO62.1	3	2	1	1		1	1	1	1	1		1		1	
CO62.2	3	2	1	1		1	1	1	1	1		1		1	
CO62.3	3	2	1	1		1	1	1	1	1		1		1	
CO62.4	3	2	1	1		1	1	1	1	1		1		1	
CO62.5	3	2	1	1		1	1	1	1	1		1		1	
Average	**3**	**2**	**1**	**1**		**1**	**1**	**1**	**1**	**1**		**1**		**1**	

Low - 1: Medium - 2: High – 3

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SEMESTER – VI

Course: FINITE ELEMENT METHODS (Integrated)

Course Code	**22MED63**	**CIE Marks**	**30 + 20 = 50**
Hours/Week (L: T: P)	**3 : 0 : 2**	**SEE Marks**	**50**
No. of Credits	**4**	**Examination Hours**	**03**

Prerequisites: Strength of Materials

Course Objectives: This course will enable the students to:

CLO1	Learn basic concepts of the Finite Element Method (FEM) and elasticity theory for engineering problems.
CLO2	Use polynomial interpolation and element formulations to solve engineering problems in finite element analysis
CLO3	Use stiffness matrices for bars, trusses, and beams, solve problems with different loads, and analyze 1-D heat transfer.
CLO4	Apply Lagrange's interpolation methods and numerical integration techniques in finite element analysis.
CLO5	Use key numerical methods to solve engineering problems.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Finite Element Method**: Definition of FEM, General steps of the finite element method. Engineering applications of finite element method. Advantages of the Finite Element Method. Types of elements based on geometry (1D, 2D, 3D Elements), Size of elements, Location of nodes, Banded matrix and effect of node numbering on banded matrix. **Basics of theory of elasticity:** Stress and strain tensor, Plane stress and Plane strain, Equilibrium conditions (No derivation), strain displacement relation, Stress-Strain relations. **Laboratory**: Introduction to FEM Software (Ansys APDL and Workbench)	**10 Hrs./ L1, L2, L3**
Module 2 **Polynomial form of interpolation**: PASCAL's triangle, Convergence criteria, Simplex, complex, and multiplex elements, Global and natural coordinate system, Stiffness matrix, iso-, sub- and super parametric elements. **Analysis of Bars**: Stiffness matrix (direct stiffness method), Shape functions in Global and Natural coordinate systems, Numerical on stepped bars subjected to axial loads. **Laboratory**: Analysis of Bars	**10 L1, L2, L3**
Module 3 **Analysis of trusses**: Stiffness matrix, Numerical on truss structures (Maximum 3 members only)	**10 L1, L2, L3**

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Lagrange's form of interpolation: Higher order elements, Shape functions of quadratic bar element, CST elements, quad element. Numerical integration: Gauss quadrature one point, two-point and three-point formulae. **Laboratory**: Analysis of Trusses	
Module 4 **Analysis of beams:** Formulation of stiffness matrix and load vectors, Hermite shape functions (no derivation), Numerical on FE solution for beam structures with point load, UDL and UVL. **Dynamic Analysis:** Mass matrices, Consistent element mass matrices for bar and truss elements, Evaluation of Eigenvalue and Eigen vectors of bars and beam elements. **Laboratory**: Static and Dynamic analysis of Beams	**10** **L1, L2, L3**
Module 5 **Heat Transfer Analysis:** 1-D steady state heat transfer, Heat transfer through slabs with different boundary conditions, one dimensional heat transfer in thin fins, problems **Numerical Methods:** Potential energy method, Rayleigh Ritz and Galerkin's method (simple numerical) **Laboratory**: Analysis of Plane stress and Plain Strain elements (2D) Analysis of Heat transfer through Composite Walls	**10** **L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO63.1	Evaluate different element types in FEM and their impacts and integrate advanced elasticity concepts to derive and solve practical engineering challenges.
CO63.2	Analyze simplex, complex, and multiplex elements, and iso-, sub-, and super-parametric elements.
CO63.3	Formulate and apply stiffness matrices for bars, trusses, and beams, solve numerical problems involving axial loads and various loading conditions, and analyze 1-D steady-state heat transfer in different scenarios.
CO63.4	Utilize Lagrange's interpolation for higher-order elements, including quadratic bar elements, CST elements, and quad elements, and apply Gauss quadrature methods for numerical integration with one, two, and three points.
CO63.5	Apply the Potential Energy Method, Rayleigh-Ritz Method, and Galerkin's Method to solve engineering problems through simple numerical examples.

Textbooks:

1. Finite Element Method in Engineering, S.S. Rao, 4th Edition, Elsevier, 2006.
2. Finite Element Methods, Daryl. L. Logon, Thomson Learning 3rd edition, 2001

Reference books:

1. J.N.Reddy, "Finite Element Method"- McGraw -Hill International Edition. Bathe K. J. Finite Elements Procedures, PHI. 2.
2. Cook R. D., et al. "Concept sand Application of Finite Elements Analysis"- 4th Edition, Wiley & Sons, 2003.

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E-Books / Web References

1. https://www.youtube.com/watch?v=C6X9Ry02mPU
2. https://www.youtube.com/watch?v=GHjopp47vvQ
3. https://www.youtube.com/watch?v=MC8pTORcKJM

MOOCs

1. https://www.youtube.com/watch?v=UOp6JEiJctA-(NPTEL)

Scheme of Examination: (Integrated courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Note: The laboratory assessment would be restricted to only the CIE evaluation.

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 30, the CIE would also include laboratory evaluation for 20 marks. The laboratory marks of 20 would comprise of 10 marks for regular laboratory assessment to include lab record and observation. 10 marks would be exclusive for laboratory internal assessment test to be conducted at the end of the semester.

Typical Evaluation pattern for integrated courses is shown in the Table below

Table: Distribution of weightage for CIE & SEE of Integrated courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**30**	**50**
	CIE Test-2	**30**	
	CIE Test-3	**30**	
	Laboratory	**20**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO63.1	3	2	2	-	3	1	-	-	1	2	-	2	2	-	-
CO63.2	3	2	2	-	3	1	-	-	1	2	-	2	2	-	-
CO63.3	3	2	2	-	3	1	-	-	1	2	-	2	2	-	-
CO63.4	3	2	2	-	3	1	-	-	1	2	-	2	2	-	-
CO63.5	3	2	2	-	3	1	-	-	1	2	-	2	2	-	-
Average	3	2	2	-	3	1	-	-	1	2	-	2	2	-	-

Low - 1: Medium - 2: High - 3

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SEMESTER –VIII
Course: RENEWABLE ENERGY TECHNOLOGIES

Course Code	**22MED641**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3 : 0 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: NiL

Course Objectives: To provide an insight to**,**

CLO1	To introduce students to various energy sources, with a focus on solar radiation and its measurement, and to understand the energy scenario in India and globally.
CLO2	To provide students with an in-depth understanding of solar radiation geometry and its application in solar thermal and photovoltaic systems, focusing on practical aspects and system components.
CLO3	To introduce students to the principles and applications of wind and biomass energy, covering the characteristics, design, and challenges associated with these renewable energy sources.
CLO4	To provide students with a comprehensive understanding of hydroelectric, tidal, and wave energy systems, including their mechanics, design, advantages, and limitations.
CLO5	To explore the principles and applications of ocean thermal energy conversion (OTEC) and geothermal energy.

Content	**No. of Hours/ RBT levels**
Module 1 **Introduction:** Energy sources (including fossil fuels and nuclear energy), India's production and reserves of commercial energy sources, need for nonconventional energy sources, energy alternatives, Indian and global energy scenario. **Solar Radiation & Measurement:** Extra-Terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data. Pyrometer, shading ring Pyrheliometer, sunshine recorder, schematic diagrams, and principle of working, actinometer and bolometer.	**08 Hrs. / L3**
Module 2 **Solar Radiation Geometry:** Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle, expressions for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent time, apparent motion of sun, day length, numerical problems. **Solar Thermal Systems:** Flat plate collector, Evacuated Tubular Collector, Solar air collector, Solar concentrator, Solar distillation, Solar cooker, Thermal energy storage systems, Solar Pond, Solar Chimney (Tower). **Solar Photovoltaic Systems:** Introduction, Solar cell Fundamentals, Characteristics and classification, Solar cell: Module, panel and array construction.	**08 Hrs. / L3**

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Module 3 **Wind Energy:** Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis windmills, elementary design principles; coefficient of performance of a windmill rotor, design aspects, numerical examples. **Energy from Biomass:** Energy plantation, biogas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of biogas, problems associated with bio-gas production, application of biogas, application of biogas in engines, cogeneration plant, advantages & disadvantages.	**08 Hrs. / L3**
Module 4 **Hydroelectric plants:** Advantages & disadvantages of waterpower, Hydrographs and flow duration curves - numerical, Storage and pondage, General layout of hydel power plants- components such as Penstock, surge tanks, spill way and draft tube and their applications, pumped storage plants, Detailed classification of hydroelectric plants. **Tidal Power:** Tides and waves as energy suppliers and their mechanics, fundamental characteristics of tidal power, harnessing tidal energy, limitations of tidal energy. **Energy from ocean waves:** Wave energy conversion, Wave energy technologies, advantages, and disadvantages.	**08 Hrs. / L3**
Module 5 **Ocean Thermal Energy Conversion:** Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC, case studies. **Geothermal energy:** Introduction, Principle of working, types of geothermal stations with schematic diagram Estimates of Geothermal Power, Nature of geothermal fields, Geothermal resources, Hydrothermal, Resources Geo pressured resources, Hot dry rock resources of petro-thermal systems, Magma Resources-Interconnection of geothermal fossil systems, Advantages, and disadvantages of geothermal energy over other energy forms, Geothermal stations in the world.	**08 Hrs. / L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO641.1	Evaluate the need for alternative energy sources and use advanced techniques for measuring and interpreting solar radiation data using specialized instruments.
CO641.2	Analyze the geometric aspects of solar radiation and evaluate the design and functionality of various solar thermal and photovoltaic systems.
CO641.3	Evaluate the potential and challenges of wind energy and biomass energy by analyzing the design and characteristics of wind machines and biogas plants.
CO641.4	Analyze the advantages and disadvantages of hydroelectric, tidal, and wave energy
CO641.5	Analyze the principles and operational mechanisms of ocean thermal energy conversion and geothermal energy systems

Textbooks:

1. Solar Energy Principles, Thermal Collection &Storage, S.P. Sukhatme: Tata McGraw Hill Pub., New Delhi.
2. Non-Conventional Energy Sources, G. D. Rai, New Delhi.
3. Renewable Energy, power for a sustainable future, Godfrey Boyle,2004
4. The Generation of electricity by wind, E. W. Golding.
5. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub.,2009

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Reference books:

1. Fundamentals of Renewable Energy Resources by G.N.Tiwari, M.K.Ghosal, Narosa Pub., 2007.
2. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub., 2009.
3. Non-Conventional Energy Resources by Shobh Nath Singh, Pearson India., 2016
4. Environmental Justice in India: The National Green Tribunal, By Gitanjali Nain Gill, Routledge (2016).
5. Ref: The Oxford Handbook of Comparative Environmental Law, edited by Emma Lees, Jorge E. ViÒuales, Oxford University Press (2019)

E-Books / Web References

3. https://www.youtube.com/watch?v=iZyzvDj6Y3c&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=2
4. https://www.youtube.com/watch?v=Og4LEc7SpdQ&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=3
5. https://www.youtube.com/watch?v=L3AEXdvtIkk&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=19
6. https://www.youtube.com/watch?v=TUu40kDqcEc&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk&index=24

Scheme of Examination:

Semester End Examination (SEE): SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 40 marks each. An average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and an average of three tests. One quiz is to be conducted and evaluated for 10 marks

Some possible AATs: Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	AAT/Quiz	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO641.1	3	2	2			2	2					2		3	
CO641.2	3	2	2			2	2					2		3	
CO641.3	3	2	2			2	2					2		3	
CO641.4	3	2	2			2	2					2		3	
CO641.5	3	2	2			2	2					2		3	
Average	**3**	**2**	**2**			**2**	**2**					**2**		**3**	

Low - 1: Medium - 2: High – 3

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SEMESTER – VI

Course: Research Methodology

Course Code	22MED642	CIE Marks	50
Hours/Week (L: T: P)	3 : 0 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Course Objectives: The students will be taught:

CLO1	The basic concept of research and its methodologies
CLO2	To analyse and process the data using various techniques
CLO3	The skills in qualitative and quantitative data analysis and presentation.
CLO4	The ability to choose methods appropriate to research objectives.

Content	No. of Hours/ RBT levels
Module 1 **Research Methodology: Introduction** Definition of research, role and objectives of research, types of research, Research Approaches, Significance, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India Defining the Research Problem, Technique involved in defining the problem. Definition of Research Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs.	**8 Hours / L1, L2, L3**
Module 2 **Sampling Design:** Definition, Steps in Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs, How to Select a Random Sample, Random Sample from an Infinite Universe, Complex Random Sampling Designs, simple numericals. **Measurement and Data collection:** Measurement Scales, sources of error in measurement, Collection of primary and secondary data, Case study method.	**8 Hours / L1, L2, L3**
Module 3 **Processing and Analysis of Data** Processing of data, Problems in processing, Types of analysis, Measures of central tendency, dispersion, skewness, Regression Analysis, simple numericals. **Sampling Fundamentals** Fundamental definitions, important fundamental distributions, sampling theory, Sandler's A-test, concept of standard error, estimation, estimation population proportion, simple numericals.	**8 Hours / L1, L2, L3**

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Module 4 **Testing of Hypotheses I** Hypotheses definition, basic concepts, Procedure for Hypothesis Testing, Flow Diagram for Hypothesis Testing, Important Parametric Tests, Hypothesis Testing of Means, Hypothesis Testing for Comparing Two Related Samples, Hypothesis Testing of Proportions, Simple numericals. **Chi-square Test** Chi-square as a Test for Comparing Variance, Chi-square as a Non-parametric Test, Conditions for the Application of χ2 Test, Steps Involved in Applying Chi-square Test, Simple numericals.	**8 Hours / L1, L2, L3**
Module 5 **Analysis of Variance and Covariance** Definition of Analysis of Variance (ANOVA), the Basic Principle of ANOVA, ANOVA Technique, Setting up Analysis of Variance Table, Short-cut Method for One-way ANOVA, Coding Method, Two-way ANOVA, Analysis of Co-variance (ANOCOVA), ANOCOVA Technique and its assumptions, Simple numericals.	**8 Hours / L1, L2, L3**

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO642.1	Demonstrate the ability to comprehend the aims and objectives of research methodology and choose the appropriate research design
CO642.2	Explicate the various data collection and sampling techniques in research
CO642.3	Develop skills in data processing, analysis and estimating the error quantitatively
CO642.4	Explain the various hypothesis testing techniques instrumental in research
CO642.5	Apply basic data analytics techniques: ANOVA

Textbooks:

1. Research Methodology, C R Kothari, Gaurav Garg, 4th Edition, 2019, New Age International Publishers, ISBN: 978007008390-5
2. Research Methodology a step by step guide for beginners, Ranjith Kumar, SAGE Publications Ltd., 3rd Edition, 2011

Reference books:

1. Research Methods: the concise knowledge base, 1st edition, William Michael Trochim, Atomic Dog Publishing, 2005.
2. Fundamental of Research Methodology and Statistics, Yogesh Kumar Singh, Publisher: New Age International Pvt Ltd,2006.

E-Books / Web References

1. https://onlinecourses.nptel.ac.in/noc23_ge36/preview
2. https://onlinecourses.swayam2.ac.in/cec20_hs17
3. https://onlinecourses.nptel.ac.in/noc20_ge01
4. https://in.coursera.org/learn/research-methods

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Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE. The assignment component would be for 10 marks. CIE is executed by way of quizzes / Alternate Assessment Tools (AATs), and three tests.

Some possible methods of assessment for assignments: Assignments / Oral presentations / Group activity/Projects.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignment/Quiz /AAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO642.1	2	2	2	2		1	1	1	2	2	2	1			2
CO642.2	2	2	2	2	2	1	1	1	2	2	2	1			2
CO642.3	2	2	2	2	2	1	1	1	2	2	2	1			2
CO642.4	2	2	2	2	2	1	1	1	2	2	2	1			2
CO642.5	2	2	2	2	2	1	1	1	2	2	2	1			2
	2	2	2	2	2	1	1	1	2	2	2	1			2

Low - 1: Medium - 2: High - 3

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SEMESTER – VI

Course: DESIGN OF TRANSMISSION ELEMENTS

Course Code	**22MED643**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**2 : 2 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Engineering Mechanics, Strength of Materials, Design of Machine Elements.

Course Objectives: The students will be taught:

CO1	To calculate stresses in helical springs and design leaf springs.
CO2	To design flat and V belts, wire ropes, and chains, and understand their performance.
CO3	To design clutches and brakes for automotive systems, focusing on materials and performance
CO4	To design spur and helical gears, focusing on strength and wear.
CO5	To design bevel and worm gears, selecting materials and ensuring efficiency.

Content	No. of Hours/ RBT levels
Module 1 **Helical Springs:** Types of springs, spring materials, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, concentric springs. **Leaf Springs**: Stresses in leaf springs, equalized stresses, nipping of leaf springs. Design of leaf springs.	**10 Hours / L1, L2, L3**
Module 2 **Belts:** Materials of construction of flat and V belts, power rating of belts, concept of slip and creep, initial tension, effect of centrifugal tension, maximum power condition. Selection of flat and V belts- length & cross section from manufacturers' catalogues. **Wire ropes and Chains**: Construction of wire ropes, stresses in wire ropes, and selection of wire ropes, Chains: Types of chains, Selection of roller chains.	**10 Hours / L1, L2, L3**
Module 3 **Design of Clutches:** Necessity of a clutch in an automobile, types of clutch, friction materials and its properties. Design of cone clutch, single plate and multi-plate clutches based on uniform pressure and uniform wear theories. **Design of Brakes:** Different types of brakes, Concept of self-locking of brakes. Practical examples, Design of block brakes, band brakes.	**10 Hours / L1, L2, L3**
Module 4 **Gear drives:** Classification of gears, materials, standard systems of gear tooth **Spur Gears:** Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear. **Helical Gears:** Definitions, transverse and normal module, design based on strength, dynamic load and wear.	**10 Hours / L1, L2, L3**

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Module 5	
Bevel Gears: Definitions, Types of bevel gears, design based on strength, dynamic load and wear. **Worm Gears**: Definitions, materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives.	**10 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO643.1	Calculate the stresses in helical springs with circular and non-circular cross-sections and apply principles to the design and stress analysis of leaf springs.
CO643.2	Determine the suitable materials, design specifications, and performance parameters for flat and V belts, wire ropes, and chains, including the calculation of power ratings, slip and creep effects, and stress analysis.
CO643.3	Design various types of clutches and brakes while considering friction materials, self-locking concepts for effective power transmission and braking performance in automotive applications.
CO643.4	Design spur and helical gears based on strength, dynamic load, and wear, using Lewis equation and form factors for spur gears and helical gears.
CO643.5	Design bevel gears and worm gears, selecting appropriate materials and applying design principles to ensure strength, minimize dynamic loads and wear, and optimize the efficiency of worm gear drives.

TEXT BOOKS:

1. **Mechanical Engineering Design,** Joseph E Shigley and Charles R.Mischke. McGraw Hill International edition, 6th Edition 2009.
2. **Design of Machine Elements,** V.B. Bhandari, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

DESIGN DATA HAND BOOK:

1. **Design Data Hand Books, Volume 1 and 2,** K. Lingaiah, McGraw Hill, 2nd Ed.

REFERENCE BOOKS:

1. **Machine Design,** Robert L. Norton, Pearson Education Asia, 2001.
2. **Design of Machine Elements,** M. F. Spotts, T. E. Shoup, L. E Hornberger, S. R. Jayram and C. V. Venkatesh, Pearson Education, 2006.
3. **Machine Design,** Hall, Holowenko, Laughlin (Schaum's Outlines series) Adapted by S.K. Somani, Tata McGraw Hill Publishing Company Ltd., New Delhi, Special Indian Edition, 2008.
4. **Fundamentals of Machine Component Design,** Robert C. Juvinall and Kurt M Marshek, Wiley India Pvt. Ltd., New Delhi, 3rd Edition, 2007.

WEB/ONLINE REFERENCES

www.nptel.ac.in

MOOCs

1. NPTEL Course: "Design of Machine Elements" http:// https://nptel.ac.in/courses/112/107/112107146/#
2. NPTEL Course: "Strength of Materials" (https://onlinecourses.nptel.ac.in/)
3. MOOC Course: "Machine Design", (https://www.coursera.org/courses?query=mechanics%20of%20materials)
4. Free Video Lectures: "Design of Machine Elements", (https://freevideolectures.com/course/96/)

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Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 50 marks each. The average of the three tests are taken for computation of CIE on a scale of 40. The assignment would be for a total of 10 marks,
CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

Some possible methods of assessment for assignments: Assignments / Oral presentations / Group activity / Projects

Typical Evaluation pattern for regular courses is shown in Table 1.

Table 1: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignment	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO643.1	3	2	2	1		1	1			1		2	2		
CO643.2	3	2	2	1		1	1			1		2	2		
CO643.3	3	2	2	1		1	1			1		2	2		
CO643.4	3	2	2	1		1	1			1		2	2		
CO643.5	3	2	2	1		1	1			1		2	2		
Average	**3**	**2**	**2**	**1**		**1**	**1**			**1**		**2**	**2**		

Low - 1: Medium - 2: High – 3

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SEMESTER – VI
Course: Data Analytics

Course Code	**22MED644**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3 : 0 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Basics of Probability and Statistics

Course Objectives: This course will enable the students to,

CLO1	Provide an overview of the good practice of data visualization.
CLO2	Learn how to navigate Tableau and connect to data sources, leverage drag-and-drop interface to create impactful visualizations.
CLO3	Facilitate project-based opportunities to identify, understand, analyze, prepare, and present effective visualizations on a variety of data.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Data Science and Analytics:** Basic Terminology in data Science and Analytics, Requirements of Data Science and Analytics, Data Science Venn Diagram, Modeling of Data. **Case study on Automating (Mechanical) Government Paper Pushing, Printing and Marketing Dollars, Firing all Mechanical Engineers – Right or Wrong?**	**08 Hours /L3**
Module 2 **Insight into Data**: Flavors of Data, Structured and Unstructured Data, Qualitative, Quantitative Data, Levels of Data, Discrete and Continuous Data. Data Preprocessing and Post Processing, Measures of Center and Variation. Five Steps in Data Analytics **Case study on Coffee Shop Data, World Soft Drinks Consumption Data, Covid Vaccination Data.**	**08 Hours /L3**
Module 3 **Data Communication:** Identifying effective and ineffective Visualizations. Scatter Plots, Line Graphs, Bar Charts, Histograms, Box Plots, Correlation and Causation of Data, Verbal Communication – Story Telling of Data. Strategy of Presenting. **Data Analytics using Tableau:** History of Tableau, Advantages and disadvantages of Tableau, Tableau architecture, Tableau Public and Tableau Desktop, Terminologies, Data types, Data roles, Data aggregation, File types.	**08 Hours /L3**
Module 4 **Tableau Training:** Installing Tableau, Create Bar Charts, maps and Pie charts. **Creating Interactive Dashboards,** Understand Types of Joins and how they work, Create Table Calculations, Create Dual Axis Charts, Work with Timeseries Data (two methods), Create Data Hierarchies, Assigning Geographical Roles to Data Elements.	**08 Hours /L3**

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Module 5	08 Hours /L3
Connecting Tableau to Real time Data: Connect Tableau to various Datasets: Excel and CSV files, Create Area Charts, scatter plots, Tree maps, story lines, Data Blending, Forecasting and Clustering, density Charts.	

COURSE OUTCOMES: Upon completion of this course, students will be able to

CO644.1	Recognize the significance of Data Analytics in analyzing data for physical significance to real time mechanical data.
CO644.2	Understand the insight into types and classifications of data
CO644.3	Recognize the significance of Data presentation for physical significance to real time mechanical data.
CO644.4	Apply the concepts of data visualization and analysis using tableau
CO644.5	Infer on the data analyzed and derive conclusive results.

Textbooks:

1. **Donatel Santos:** Tableau 10: Business Intelligence Cookbook, 10th edition, 2016.
2. **Dona M Wong:** The Wall Street Journal Guide to Information Graphics: The Do's and Don't's of Presenting Data, facts and Figures, 12th Edition 2021.

Reference books:

1. **Stephen Few**: Information Dashboard Design: Displaying Data for At- a-Glance Monitoring, O'Reilly Media, 2013.

Books / Web References

1. Data Visualization and Exploration with R A Practical Guide to Using R RStudio and Tidyverse for Data Visualization Exploration and Data Science Applications: https://www.pdfdrive.com/data-visualization-and-exploration-with-r-a-practicalguide-to-using-r-rstudio-and-tidyverse-for-data-visualization-exploration-and-datascience-applications-d176184240.html
2. 2. Beginning Data Science in R: Data Analysis, Visualization, and Modelling for the Data Scientist: https://www.pdfdrive.com/beginning-data-science-in-r-data-analysisvisualization-and-modelling-for-the-data-scientist-d181093942.htmlhttps://pm-guide.netguru.com/

MOOCs

1. https://www.coursera.org/learn/datavisualization
2. https://freevideolectures.com/course/4041/nptel-introduction-to-learning-analytics/11
3. https://www.edx.org/course/data-visualization-for-all

Scheme of Examination: (Theory courses)

Semester End Examination (SEE): SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 40. CIE is executed by way of two quizzes/Other Assessment Tools (OATs), and three tests. **Some possible AATs:** Assignments / Oral presentations /Group activity/Projects. Typical Evaluation pattern for regular courses shown in Table.

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Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	QUIZ/OAT	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO644.1	2	3	1									2			1
CO644.2	2	3	3	3	2							2			1
CO644.3	2	3	3	3	2							2			1
CO644.4	2	3	3	3	2							2			1
CO644.5	2	3	3	3	2							2			1
Average	2	3	3	3	2							2			1

Low - 1: Medium - 2: High - 3

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SEMESTER – VI

Open Elective

Course: Project & Operations Management

Course Code	**22MED651**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3 : 0 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Management and Entrepreneurship

Course Objectives: This course will enable the students to,

CLO1	To instill Project Management principles and practices to create/develop a unique product, a unique service or capability to perform a service, unique result, such as an outcome or document and/or a unique combination of one or more products, services or results.
CLO2	To inculcate the S.M.A.R.T deliverables of a project and evaluate the impact of these deliverables on the states of nature viz. economic, material, social, and environmental.
CLO3	To elucidate the benefits of Project Management and its applications on business value creation comprising tangible (Monetary assets, Stakeholder equity, Utilities and Market share etc.) and intangible elements (Strategic alignment, Goodwill and Brand recognition etc.).

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Project Management:** Understanding Project Management, Defining the Project Manager's Role, Defining the functional Manager's role, the project manager as the planning agent, Project Sponsor Interface, project Champions, Project Driven v/s Non-project Driven Organizations. Classifications of Projects, Differing views of Project Management, Concurrent Engineering: A project Management approach, informal Project Management Product v/s Project management, Project Life cycles, Many faces of failure.	**10 Hours /L3**
Module 2 **Planning:** Phases of Project Life Cycle: Initiating Process (Engineering Quote Process, The Project Award, Project with a Kick-off), Planning Process (Information Sharing, Development & Updating in Project Plan), Executing Process, Monitoring and Controlling Process and Closing Process. Scope Management: Development of Work Breakdown Structure (WBS) and Resources Management. Estimation of WBS effort.	**10 Hours /L3**
Module 3 **Network Scheduling Techniques:** Network Fundamentals, Slack time, Network planning, estimating total project time, Total PERT/CPM planning, Crashing of Networks, PERT/CPM Numericals.	**10 Hours /L3**

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Module 4 **Project Development Models:** Introduction and Comparison between Waterfall Methodology and Agile Methodology. Waterfall Model: Stages of Waterfall methodology (Requirements, Design, Implementation, verification or testing and Deployment & Maintenance), Prominent Uses of Waterfall Methodology, Advantages and Disadvantages of Waterfall Methodology. **Agile Methodology:** Overview, Agile Manifesto, 3C's of Agile (Card, Conversation and Confirmation), Benefits of Agile Model.	**10 Hours /L3**
Module 5 **Forecasting:** Nature and Use of Forecast, Forecasting Models and methods – Selection of Forecasting Techniques, measures of Forecasting accuracy, simple moving average, weighted moving average, double moving average, simple exponential smoothening, adjusted exponential smoothening, Linear regression method. **Inventory Control**: Inventory Decisions, Costs, Inventory Models.	**10 Hours /L3**

COURSE OUTCOMES: Upon completion of this course, students will be able to

CO651.1	Recognize the significance of Project Management in complex business setups and describe an organized flow structure for effective accomplishment of predetermined objectives of organization.
CO651.2	Understand the Project life cycle processes and construct appropriate action plan for optimizing resources of the underlying project deliverables.
CO651.3	Apply the knowledge of construction of networks and the estimation of time of completion of the project
CO651.4	Distinctively of elaborate the difference between the Waterfall Methodology and Agile Methodology and apply the appropriate Project development models
CO651.5	Understand the costs and models of forecasting and inventory techniques.

Textbooks:

3. **Harold Kerzner:** Project Management - A Systems Approach to Planning, Scheduling, and Controlling, 10th edition.
4. A Guide to the Project Management Body of Knowledge – Project Management Institute.
5. **Kalpesh Asher:** Project Management and Agile Essentials – A Practical Self-Study Guide, Vibrant Publishers.
6. Pannerselvam, Production and Operations Management – Third Edition, PHI

Reference books:

2. **Mark C. Layton, Steven J. Ostermiller**: Agile Project Management for Dummies.
3. **Prasanna Chandra:** Project Management – Planning & Control, TMH.

E-Books / Web References

3. https://opentextbc.ca/projectmanagement/
4. https://pm-guide.netguru.com/

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MOOCs

4. https://www.edx.org/course/introduction-to-project-management?index=product&search_index=product&webview=false&campaign=Introduction+to+Project+Management&source=edX&product_category=course&placement_url=https%3A%2F%2Fwww.edx.org%2Flearn%2Fproject-management

Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 40.

CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

Some possible AATs: Assignments / Oral presentations / Group activity/Projects

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	QUIZ/OAT	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO651.1	2	1	2	3	3				2	2	3	2			
CO651.2	3	3	3	3	1				2	2	3	2			
CO651.3	2	3	3	2	1				2	2	3	2			
CO651.4	2	2	3	2	1				2	2	3	2			
CO651.5	2	2	2	2	2				2	2	3	2			
Average	**2**	**3**	**3**	**3**	**2**				**2**	**2**	**3**	**2**			

Low - 1: Medium - 2: High - 3

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SEMESTER – VI
Open Elective
Course: TOTAL QUALITY MANAGEMENT

Course Code	22MED652	CIE Marks	50
Hours/Week (L: T: P)	3 : 0 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Management & Entrepreneurship

Course Objectives: The students are taught to:

CLO1	Understand the various approaches to TQM and Quality management system.
CLO2	Explain The characteristics of quality leader and his role.
CLO3	Know the Develop feedback and suggestion systems for quality management.
CLO4	The knowledge in Tools and Techniques of quality management

Content	No. of Hours/ RBT levels
Module 1 **Principles and Practice:** Definition, basic approach, gurus of TQM, TQM Framework, awareness, defining quality, historical review, obstacles, benefits of TQM. **Quality Management Systems**: Introduction, benefits of ISO registration, ISO 9000 series of standards, ISO 9001 requirements.	**08 Hours / L2**
Module 2 **Leadership:** Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making,	**08 Hours / L2**
Module 3 **Customer Satisfaction and Customer Involvement**: Customer Satisfaction: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, case studies. **Employee Involvement** – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward, gain sharing, performance appraisal, unions and employee involvement, case studies.	**08 Hours / L2**
Module 4 **Continuous Process Improvement:** process, the Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem-solving methods, Kaizen, reengineering, six sigma,	**08 Hours / L2**

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Statistical Process Control: Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, Control charts, state of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams, case studies.	
Module 5 **Tools and Techniques:** Benching marking, information technology, quality management systems, environmental management system, and quality function deployment, quality by design, failure mode and effect analysis, product liability, total productive maintenance	**08 Hours / L2**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO652.1	Evaluate various approaches to Total Quality Management (TQM) and analyze the standards and requirements of ISO 9000 and ISO 9001, including the benefits of implementing the ISO 9000 series.
CO652.2	Assess the characteristics of quality leaders, effective individuals, and ethical considerations.
CO652.3	Examine the importance of customer satisfaction and employee involvement through detailed case studies.
CO652.4	Apply statistical tools for the continuous improvement of quality systems and evaluate their effectiveness in real-world scenarios.
CO652.5	Implement tools and techniques for effective TQM and identify areas for quality improvement using Quality Function Deployment (QFD) and Failure Mode and Effects Analysis (FMEA).

Textbooks:

1. Dale H. Besterfield et al, Total Quality Management, Third edition, Pearson Education. (First Indian Reprints 2004).
2. Shridhara Bhat K, Total Quality Management – Text and Cases, Himalaya Publishing House, First Edition 2002.

Reference books:

1. M. Zairi, Total Quality Management for Engineers, Woodhead Publishing.
2. A New American TQM, four revolutions in management, ShojiShiba, Alan Graham, David Walden, Productivity press, Oregon.
3. 100 Methods for Total Quality Management: Gopal K. Kanji and Mike Asher, ISBN: 0803977476, Publisher: Sage Publications, Inc.;Edition – 1

E-Books / Web References

1. **Gurus of TQM**
   - https://www.focusstandards.org/quality-gurus-key-contributions/
2. **TQM Framework**
   - https://www.emeraldinsight.com/doi/abs/10.1108/eb060192
3. **Principles of TQM:**
   - https://study.com/academy/lesson/five-principles-of-total-quality-management-tqm.html
4. **Characteristics of quality leaders**
   - https://www.mechlectures.com/leadership-characteristics-quality-leaders/
   - https://www.briantracy.com/blog/leadership-success/the-seven-leadership-qualities-of-great-leaders-strategic-planning/
5. **Customer Satisfaction and Customer Involvement**

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- https://www.emeraldinsight.com/doi/abs/10.1108/17566691311316248
- https://study.com/academy/lesson/consumer-involvement-in-the-decision-making-process.html

6. **Statistical Process Control**
   - http://asq.org/learn-about-quality/seven-basic-quality-tools/overview/overview.html
   - https://www.whatissixsigma.net/7-qc-tools/
7. **Design for Six Sigma**
   - https://quality-one.com/six-sigma/

MOOCs

1. NPTEL Course: "Total Quality Management" https://archive.nptel.ac.in/courses/110/104/110104080/
2. NPTEL Course: "Total Quality Management" https://archive.nptel.ac.in/noc/courses/noc20/SEM1/noc20-mg34/

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is conducted and evaluated for 10 marks.

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz 1/AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO652.1	2	1				1	1	1		1	3	2			2
CO652.2	2	1				1	1	1		1	3	2			2
CO652.3	2	1				1	1	1		1	3	2			2
CO652.4	2	1				1	1	1		1	3	2			2
CO652.5	2	1				1	1	1		1	3	2			2
Average	2	1				1	1	1		1	3	2			2

Low - 1: Medium - 2: High - 3

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SEMESTER – VI
Course: Environmental Science

Course Code	22CIV66	CIE Marks	50
Hours/Week (L: T: P)	1:0:0	SEE Marks	50
No. of Credits	1	Examination Hours	1 hour

Course Objectives: Students will be taught:

CLO1	The fundamentals of environmental science.
CLO2	The types of natural resources
CLO3	The various global environmental concerns.
CLO4	The types of wastes generated and their handling at a basic level
CLO5	The area of environmental law and policies with a few important acts in the field

Content	No. of Hours/ RBT Levels
Module 1 **Environment:** • Definition, scope & importance • Components of Environment Ecosystem: Structure and function of various types of ecosystems • Human Activities – Food, Shelter, and Economic & Social Security. • Population - Growth, variation among nations – population explosion and impact on environment **Biodiversity:** Types, Value, Hot spots, Threats and Conservation of biodiversity, Forest Wealth, and Deforestation.	**04 Hours / L2**
Module 2 **Natural Resources**: Forest, Water, Mineral, Food, Energy, Land Environmental Pollution - Definition – causes, effects and control measures of: (a) Air pollution (b) Water pollution (c) Soil pollution (d) Marine pollution (e) Noise pollution (f) Thermal pollution (g) Nuclear hazards.	**04 Hours / L2**
Module 3 **Global Environmental Concerns** (Concept, policies and case-studies): Ground water depletion/recharging, Climate Change; Acid Rain; Ozone Depletion; Radon and Fluoride problem in drinking water; Resettlement and rehabilitation of people, Environmental Toxicology.	**04 Hours / L2**
Module 4 **Sources:** Sources of Solid waste, Types of solid waste, Physical and Chemical composition of municipal solid waste. Solid Waste Management Rules in India, Sources and management of E – Waste, Biomedical Waste, Hazardous waste, and construction waste at individual and community level. Socio-economic aspect of waste management Environmental Toxicology.	**04 Hours / L2**

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Module 5	04 Hours / L2
Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): Environment Impact Assessment, Environmental Management Systems, ISO14001; Environmental Stewardship, NGOs.	

Textbooks:

1. Environmental studies, Benny Joseph, Tata Mcgraw-Hill 2nd edition 2012
2. Environmental studies, S M Prakash, pristine publishing house, Mangalore 3rd edition-2018
3. Gilbert M.Masters, Introduction to Environmental Engineering and Science, 2nd edition, Pearson Education, 2004

Reference books:

1. Benny Joseph, Environmental studies, Tata Mcgraw-Hill 2nd edition 2009
2. M.Ayi Reddy Textbook of Environmental Science and Technology, BS publications 2007
3. Dr. B.S Chauhan, Environmental Studies, University of science press 1st edition

Web References:

https://www.hzu.edu.in/bed/E%20V%20S.pdf

https://onlinecourses.nptel.ac.in/noc23_hs155/preview

https://onlinecourses.swayam2.ac.in/cec19_bt03/preview

Scheme of Examination:

Semester End Examination (SEE): SEE Question paper is to be set for 50 marks with multiple choice questions of 1 mark each covering all aspects of the syllabus.

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 50 marks each. The average of the three tests are taken for computation of CIE. Question paper for each of the CIE is to be of the multiple-choice type with 50 question each.

Typical Evaluation pattern for regular courses is shown in Table.

Table 1: Distribution of weightage for CIE & SEE for 1 credit course

	Component	Marks	Total Marks
CIE	CIE Test-1	**50**	**50**
	CIE Test-2	**50**	
	CIE Test-2	**50**	
SEE	Semester End Examination	**50**	**50**
		Grand Total	**100**

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
22CIV66.1	2	-	-	-	-	-	3	-	-	-	-	-	1	-	-
22CIV66.2	2	1	-	-	-	-	3	-	-	-	-	1	1	-	1
22CIV66.3	2	-	2	-	-	2	3	1	-	-	-	1	1	-	1
22CIV66.4	2	2	-	-	-	2	3	-	-	-	-	-	-	-	1
22CIV66.5	2	-	-	-	-	2	3	-	-	-	-	-	-	1	1
Average	**2**	**2**	**2**	**-**	**-**	**2**	**3**	**1**	**-**	**-**	**-**	**1**	**1**	**1**	**1**

Low-1: Medium-2: High-3

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SEMESTER – VI

Course: Universal Human Values

Course Code	22UHV66	CIE Marks	50
Hours/Week (L: T: P)	1:0:0	SEE Marks	50
No. of Credits	1	Examination Hours	1 hour

Course Objectives: Students will be taught:

CLO1	To create an awareness on Engineering Ethics and Human Values.
CLO2	To understand social responsibility of an engineer.
CLO3	To appreciate ethical dilemma while discharging duties in professional life.

Content	No. of Hours
Module 1 **Introduction to Value Education** • Value Education, Definition, Concept and Need for Value Education. • The Content and Process of Value Education. • Basic Guidelines for Value Education, Self-exploration as a means of Value Education. • Happiness and Prosperity as parts of Value Education.	**05 Hours**
Module 2 **Harmony in the Human Being** • Human Being is more than just the Body, Harmony of the Self ('I') with the Body. • Understanding Myself as Co-existence of the Self and the Body. • Understanding Needs of the Self and the needs of the Body. • Understanding the activities in the Self and the activities in the Body.	**05 Hours**
Module 3 **Harmony in the Family and Society and Harmony in the Nature** • Family as a basic unit of Human Interaction and Values in Relationships. • The Basics for Respect and today's Crisis: Affection, Guidance, Reverence, Glory, Gratitude and Love, • Comprehensive Human Goal: The Five Dimensions of Human Endeavour. • Harmony in Nature: The Four Orders in Nature. • The Holistic Perception of Harmony in Existence.	**05 Hours**
Module 4 **Social Ethics** • The Basics for Ethical Human Conduct, Defects in Ethical Human Conduct. • Holistic Alternative and Universal Order, • Universal Human Order and Ethical Conduct, • Human Rights violation and Social Disparities.	**05 Hours**
Module 5 **Professional Ethics** • Value based Life and Profession., Professional Ethics and Right Understanding. • Competence in Professional Ethics. • Issues in Professional Ethics – The Current Scenario. • Vision for Holistic Technologies, Production System and Management Models.	**05 Hours**

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COURSE OUTCOMES: Upon completion of this course, student will be able to:

22UHV66.1	Understand the significance of value inputs in a classroom and start applying them intheir life and profession
22UHV66.2	Distinguish between values and skills, happiness and accumulation of physical facilities,the Self and the Body, Intention and Competence of an individual, etc.
22UHV66.3	Understand the role of a human being in ensuring harmony in society and nature.
22UHV66.4	Distinguish between ethical and unethical practices and start working out the strategy toactualize a harmonious environment wherever they work.

Textbooks:

1. A.N Tripathy, New Age International Publishers, 2003.
2. Bajpai. B. L, New Royal Book Co, Lucknow, Reprinted, 2004
3. Bertrand Russell Human Society in Ethics & Politics

Reference books:

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. Corliss Lamont, Philosophy of Humanism.
4. Gaur. R.R., Sangal. R, Bagari G.P, A Foundation Course in Value Education,Excel Books, 2009.
5. Gaur. R.R., Sangal R, Bagaria G.P, Teachers Manual, Excel Books, 2009.
6. I.C. Sharma, Ethical Philosophy of India, Nagin & co, Julundhar
7. William Lilly- Introduction to Ethics -Allied Publisher

Scheme of Examination:

Semester End Examination (SEE): SEE Question paper is to be set for 50 marks with multiple choice questions of 1 mark each covering all aspects of the syllabus.

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 50 marks each. The average of the three tests are taken for computation of CIE. Question paper for each of the CIE is to be of the multiple-choice type with 50 question each.

Typical Evaluation pattern for regular courses is shown in Table.

Table 1: Distribution of weightage for CIE & SEE for 1 credit course

	Component	Marks	Total Marks
CIE	CIE Test-1	**50**	**50**
	CIE Test-2	**50**	
	CIE Test-2	**50**	
SEE	Semester End Examination	**50**	**50**
		Grand Total	**100**

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
22UHV66.1	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
22UHV66.2	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
22UHV66.3	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
22UHV66.4	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
Average	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**

Low-1: Medium-2: High-3

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SEMESTER – VI

Course: Mini-Project

Course Code	22MEDMP67	CIE Marks	50
Hours/Week (L: T: P)	0: 0: 4	SEE Marks	50
No. of Credits	2	Examination Hours	

Mini-project work:
Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini- project can be assigned to an individual student or to a group having not more than 4 students.

CIE procedure for Mini-Project:
(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the Mini-project work shall be based on the evaluation of project report, project presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.
(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all the guides of the college. The CIE marks awarded for the Mini-Project shall be based on the evaluation of project report, project presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batchmates.

SEE for Mini-Project:
(i) Single discipline: Contribution to the Mini-project and the performance of each group member shall be assessed individually in the semester end examination (SEE) conducted at the department.
(ii) Interdisciplinary: Contribution to the Mini-project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted separately at the departments to which the student/s belong.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	Review-1	-	50
	Review-2	50	
SEE	Semester End Examination	50	50
Grand Total			100

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VII - VIII SEMESTER
SCHEME AND SYLLABUS
Department of
MECHANICAL ENGINEERING

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Scheme of UG Autonomous Program – 2022 Batch

VII SEMESTER

Sl. No.	Course Code	Course Title	Course Type	Teaching Dept.	Teaching Hours/Week			Examination			CREDITS
					L	T	P	CIE	SEE	Total	
1	22MED71	Project & Operations Management	PC	Respective Department	3	0	0	50	50	100	3
2	22MED72	Advanced Manufacturing Systems (Integrated)	IPC		3	0	2	50	50	100	4
3	22MED73	Refrigeration & Air Conditioning	PC		3	0	0	50	50	100	3
4	22MED74X	Program Elective 3	PEC		2	2	0	50	50	100	3
5	22MED75X	Open Elective 2	OEC	Offering Department	3	0	0	50	50	100	3
6	22MEDP76	Project Phase 1	MP	Two Contact hours per week				100	-	100	2
7	22MEDL77	Dynamics Laboratory	PC		0	0	1	50	50	100	1
				TOTAL				**400**	**300**	**700**	**19**

Program Elective 3*			
22MED741	Control Engineering	22MED743	Computational Fluid Dynamics
22MED742	Tribology	22MED744	Industry 4.0
Open Elective 2 (Offered to other branch students)			
22MED751	Additive Manufacturing	22MED752	Supply Chain Management

*__NPTEL for Credit transfer__: Students can take 12 weeks NPTEL course as an equivalent to Program elective. The NPTEL courses of duration less than 12 weeks will not be considered for credit transfer. The courses (only technical) taken are as per the recommendation of BOS of respective department. The similarity of the contents as offered by NPTEL should not exceed a maximum of 40% of the courses being registered by the student. The NPTEL course need to be completed before the registration of the elective. Any certificate obtained after the registration of elective would not be considered. The validity of NPTEL certificate is for two years and it cannot be used more than once to avail the benefit. The student is eligible to transfer a maximum of nine credits in the entire duration of the program. The grades will be awarded as equivalent to the grades obtained in the NPTEL course.

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Scheme of UG Autonomous Program – 2022 Batch

VIII SEMESTER

Sl. No.	Course Code	Course Title	Course Type	Teaching Dept.	Teaching Hours/Week			Examination			CREDITS
					L	T	P	CIE	SEE	Total	
1	22MED81	Supply Chain Management	PC	Respective Department	3	2	0	50	50	100	4
2	22MED82X	Program Elective 4	PEC		3	0	0	50	50	100	3
3	22MED83X	Program Elective 5	PEC		3	0	0	50	50	100	3
4	22MEDP84	Project work phase – II	MP	Two Contact hours per week				50	50	100	8
5	22MEDS85	Technical Seminar	MP	One Contact hour per week				100	--	100	1
6	22INT86	Internship	INT	Completed during the intervening period of VI and VII Semester				50	50	100	2
				TOTAL				**350**	**250**	**600**	**21**

Program Elective 4*			
22MED821	Non-Traditional Machining	22MED823	Operations Research
22MED822	Thermal Management of Electronic Equipment's	22MED824	Artificial Intelligence
Program Elective 5*			
22MED831	Smart Materials and MEMS	22MED833	Total Quality Management
22MED832	Composite Material Technology	22MED834	Theory of Elasticity

***NPTEL for Credit transfer**: Students can take 12 weeks NPTEL course as an equivalent to Program elective. The NPTEL courses of duration less than 12 weeks will not be considered for credit transfer. The courses (only technical) taken are as per the recommendation of BOS of respective department. The similarity of the contents as offered by NPTEL should not exceed a maximum of 40% of the courses being registered by the student. The NPTEL course need to be completed before the registration of the elective. Any certificate obtained after the registration of elective would not be considered. The validity of NPTEL certificate is for two years and it cannot be used more than once to avail the benefit. The student is eligible to transfer a maximum of nine credits in the entire duration of the program. The grades will be awarded as equivalent to the grades obtained in the NPTEL course.

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VII SEMESTER

SYLLABUS

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SEMESTER – VII

Course: Project & Operations Management

Course Code	22MED71	CIE Marks	50
Hours/Week (L: T: P)	3 : 0 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Management and Entrepreneurship

Course Objectives: This course will enable the students to,

CLO1	To instill Project Management principles and practices to create/develop a unique product, a unique service or capability to perform a service, unique result, such as an outcome or document and/or a unique combination of one or more products, services or results.
CLO2	To inculcate the S.M.A.R.T deliverables of a project and evaluate the impact of these deliverables on the states of nature viz. economic, material, social, and environmental.
CLO3	To elucidate the benefits of Project Management and its applications on business value creation comprising tangible (Monetary assets, Stakeholder equity, Utilities and Market share etc.) and intangible elements (Strategic alignment, Goodwill and Brand recognition etc.).

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Project Management:** Understanding Project Management, Defining the Project Manager's Role, Defining the functional Manager's role, the project manager as the planning agent, Project Sponsor Interface, project Champions, Project Driven v/s Non-project Driven Organizations. Classifications of Projects, Differing views of Project Management, Concurrent Engineering: A project Management approach, informal Project Management Product v/s Project management, Project Life cycles, Many faces of failure.	**10 Hours /L3**
Module 2 **Planning:** Phases of Project Life Cycle: Initiating Process (Engineering Quote Process, The Project Award, Project with a Kick-off), Planning Process (Information Sharing, Development & Updating in Project Plan), Executing Process, Monitoring and Controlling Process and Closing Process. Scope Management: Development of Work Breakdown Structure (WBS) and Resources Management. Estimation of WBS effort.	**10 Hours /L3**
Module 3 **Network Scheduling Techniques:** Network Fundamentals, Slack time, Network planning, estimating total project time, Total PERT/CPM planning, Crashing of Networks, PERT/CPM Numericals.	**10 Hours /L3**
Module 4 **Project Development Models:** Introduction and Comparison between Waterfall	**10 Hours /L3**

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Methodology and Agile Methodology. Waterfall Model: Stages of Waterfall methodology (Requirements, Design, Implementation, verification or testing and Deployment & Maintenance), Prominent Uses of Waterfall Methodology, Advantages and Disadvantages of Waterfall Methodology. **Agile Methodology:** Overview, Agile Manifesto, 3C's of Agile (Card, Conversation and Confirmation), Benefits of Agile Model.	
Module 5 **Forecasting:** Nature and Use of Forecast, Forecasting Models and methods – Selection of Forecasting Techniques, measures of Forecasting accuracy, simple moving average, weighted moving average, double moving average, simple exponential smoothening, adjusted exponential smoothening, Linear regression method. **Inventory Control**: Inventory Decisions, Costs, Inventory Models.	**10 Hours /L3**

COURSE OUTCOMES: Upon completion of this course, students will be able to

CO71.1	Recognize the significance of Project Management in complex business setups and describe an organized flow structure for effective accomplishment of predetermined objectives of organization.
CO71.2	Understand the Project life cycle processes and construct appropriate action plan for optimizing resources of the underlying project deliverables.
CO71.3	Apply the knowledge of construction of networks and the estimation of time of completion of the project
CO71.4	Distinctively of elaborate the difference between the Waterfall Methodology and Agile Methodology and apply the appropriate Project development models
CO71.5	Understand the costs and models of forecasting and inventory techniques.

Textbooks:

1. **Harold Kerzner:** Project Management **-** A Systems Approach to Planning, Scheduling, and Controlling, 10th edition.
2. A Guide to the Project Management Body of Knowledge – Project Management Institute.
3. **Kalpesh Asher:** Project Management and Agile Essentials – A Practical Self-Study Guide, Vibrant Publishers.
4. Pannerselvam, Production and Operations Management – Third Edition, PHI

Reference books:

1. **Mark C. Layton, Steven J. Ostermiller**: Agile Project Management for Dummies.
2. **Prasanna Chandra:** Project Management – Planning & Control, TMH.

E-Books / Web References

1. https://opentextbc.ca/projectmanagement/
2. https://pm-guide.netguru.com/

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MOOCs

1. https://www.edx.org/course/introduction-to-project-management?index=product&search_index=product&webview=false&campaign=Introduction+to+Project+Management&source=edX&product_category=course&placement_url=https%3A%2F%2Fwww.edx.org%2Flearn%2Fproject-management

Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 40.

CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

Some possible AATs: Assignments / Oral presentations / Group activity/Projects

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	QUIZ/OAT	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO71.1	2	1	2	3	3					2	3	2			2
CO71.2	3	3	3	3	1					2	3	2			2
CO71.3	2	3	3	2	1					2	3	2			2
CO71.4	2	2	3	2	1					2	3	2			2
CO71.5	2	2	2	2	2					2	3	2			2
Average	**2**	**3**	**3**	**3**	**2**					**2**	**3**	**2**			**2**

Low - 1: Medium - 2: High - 3

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SEMESTER – VII

Course: ADVANCED MANUFACTURING SYSTEMS (Integrated)

Course Code	21MED72	CIE Marks (Theory + Lab)	30 + 20 = 50
Hours/Week (L: T: P)	3 : 0 : 2	SEE Marks	50
No. of Credits	4	Examination Hours	03

Prerequisites: Elements of Mechanical Engineering

Course Objectives: This course will enable the students to:

CLO1	Impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.
CLO2	Make students to understand working of automated flow lines with ad without storage buffers.
CLO3	Expose students to automated flow lines, assembly lines, Line Balancing Techniques, and Flexible Manufacturing Systems.
CLO4	Expose students to computer aided process planning, material requirement planning, capacity planning etc.
CLO5	Expose the students to CNC Machine Tools, CNC part programming and CNC machine elements

Content	No. of Hours/ RBT levels
Module 1 **Introduction to CIM and Automation:** Automation in Production Systems, types of layouts, types of automation, reasons for automation, automation principles and strategies, Computer Integrated Manufacturing, computerized elements of a CIM system, CAD/CAM and CIM, **Mathematical models and metrics:** Production rate, Production capacity, utilization, and availability, manufacturing lead time, work-in- process, numerical problems.	**10 Hours / L3**
Module 2 **Automated Production Lines and Assembly Systems:** Fundamentals, system configurations, applications, automated flow lines, buffer storage, control of production line, analysis of transfer lines, analysis of flow lines without storage, partial automation, analysis of automated flow lines with storage buffer, fundamentals of automated assembly systems, numerical.	**10 Hours / L3**
Module 3 **Line Balancing:** Line balancing algorithms, methods of line balancing, numerical problems on largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights method, Mixed Model line balancing, computerized line balancing methods **Flexible Manufacturing Systems:** Fundamentals of Group Technology and Flexible Manufacturing Systems, types of FMS, FMS components, Material handling and storage system, applications, benefits, computer control systems, FMS planning and design issues, Automated Storage and Retrieval Systems, AS/RS and Automatic parts identification systems and data capture.	**10 Hours / L3**

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Module 4 **Computer Aided Process Planning**: Process Planning, Retrieval and Generative CAPP Systems, benefits of CAPP, Production Planning and Control Systems, typical activities of PPC System, Material Requirement Planning, structure of MRP, inputs and outputs of MRP, benefits, Capacity Planning **Computer Numerical Control:** Introduction, components of CNC, CNC Machine Elements: Guide ways and types: Friction guideways, Antifriction Linear Motion (LM) guideways, Frictionless guideways – Hydrostatic and Aerostatic guideways, Bearings: Hydrostatic bearings, hydrodynamic bearings, antifriction bearings. Re-circulating ball screws.	**10 Hours / L3**
Module 5 **Cutting tool materials** – HSS, Carbides, Ceramics, CBN, PCD, classification of inserts PMK, NSH, qualified, semi qualified and preset tooling, tooling system for CNC Machining centre and Turning centre, Automatic Tool changers, work holding devices for rotating and fixed work parts, Automatic Pallet changer, economics of CNC, maintenance of CNC machines. Feedback devices **CNC Programming** CNC programming, manual part programming, G Codes, M Codes, programming of simple components in milling systems, programming with canned cycles.	**10 Hours / L3**

Laboratory Exercises:

1. Programming of Vertical Machining Centre (Manual programming + Simulation)
    a. Face milling
    b. Slotting
    c. Pocketing
    d. Drilling
    e. Tapping
2. Operating Vertical Machining Center
    a. Loading the workpiece and tools
    b. Offsets
    c. Machine maintenance
    d. Loading and editing the program
    e. Developing the part as per given specifications

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO72.1	Describe types of production systems and types of automation, mathematical models in production systems.
CO72.2	Determine the line efficiency of an automated production line using upper bound and lower bound approaches with and without storage buffers
CO72.3	Determine the balance delay and balance of flexible manufacturing systems, material handling and storage systems used in production systems
CO72.4	Explain the applications of computers in process planning (CAPP) and numerical control (CNC)
CO72.5	Analyze the performance of different cutting tool materials and evaluate and address maintenance and economic factors to enhance manufacturing efficiency and effectiveness.
CO72.6	Develop CNC Programs for milling components using canned cycles.

Textbooks:

1. Automation, Production Systems and Computer-Integrated Manufacturing, by Mikell P Groover, 4th Edition, 2015, Pearson Learning.
2. CAD / CAM Principles and Applications by P N Rao, 3rd Edition, 2015, Tata McGraw-Hill.
3. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist, A Press, 1st Edition, 2016.

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Reference books:

1. CAD/CAM" by Ibrahim Zeid, Tata McGraw Hill.

2. Industry 4.0: The Industrial Internet of Things, Apress, 2017, by Alasdair Gilchrist

3. Computer Integrated Manufacturing by James A. Rehg, Henry W Kraebber , Pearson, 3rd Edition, 2017

E-Books / Web References

1. https://freevideolectures.com/course/3193/advanced-manufacturing-processes
2. https://freevideolectures.com/course/2367/industrial-engineering
3. https://freevideolectures.com/course/2367/industrial-engineering/24
4. https://freevideolectures.com/course/2367/industrial-engineering/27
5. https://freevideolectures.com/course/2367/industrial-engineering/28
6. https://freevideolectures.com/course/2367/industrial-engineering/36
7. https://freevideolectures.com/course/2367/industrial-engineering/37

MOOCs

1. https://onlinecourses.nptel.ac.in/noc22_me10/preview
2. https://www.classcentral.com/course/swayam-computer-integrated-manufacturing-17550

Scheme of Examination: (Integrated courses)

Semester End Examination (SEE): SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.** ***Note: The laboratory assessment would be restricted to only the CIE evaluation.***

Continuous Internal Evaluation (CIE): Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 30, the CIE would also include laboratory evaluation for 20 marks. The laboratory marks of 20 would comprise of 10 marks for regular laboratory assessment to include lab record and observation. 10 marks would be exclusive for laboratory internal assessment test to be conducted at the end of the semester. Typical Evaluation pattern for integrated courses is shown in the Table below

Table: Distribution of weightage for CIE & SEE of Integrated courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**30**	**50**
	CIE Test-2	**30**	
	CIE Test-3	**30**	
	Laboratory	**20**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO72.1	3	2	2	-	-	-	-	-	2	-	2	2	-	-	3
CO72.2	3	2	2	2	-	-	-	-	2	-	2	2	-	-	3
CO72.3	3	2	2	-	-	-	-	-	2	-	2	2	-	-	3
CO72.4	3	2	2	-	-	2	-	-	2	-	2	2	-	-	3
CO72.5	3	2	2	-	-	-	-	-	2	-	2	2	-	-	3
CO72.6	3	2	2	-	3	2	-	2	2	2	2	2	-	-	3
Average	3	2	2	2	3	2	-	2	2	2	2	2	-	-	3

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SEMESTER – VII

Course: Refrigeration and Air conditioning

Course Code	22MED73	CIE Marks	50
Hours/Week (L: T: P)	3 : 0 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: BTD, ATD, Heat transfer

Course Objectives: The students will be taught:

CLO1	The basic refrigeration and air-conditioning systems.
CLO2	To analyse simple vapour compression system and vapour absorption systems
CLO3	The usage of psychrometric charts and estimation of cooling loads.
CLO4	The applications of refrigeration and air-conditioning and ducting calculations

Content	No. of Hours/ RBT levels
Module 1 **Vapour Compression Refrigeration System** Review of thermodynamic principles of refrigeration, classification of refrigerants, desirable properties of refrigerants, leak detection, lubricants, Bootstrap air-cooling system with and without evaporative cooling, Performance of simple vapour compression system, single and multistage compression system, multi-evaporator system, simple numericals on VCR system.	**8 Hours / L1, L2, L3**
Module 2 **Absorption Refrigeration System** Basic absorption system, COP, Refrigerator, Advantage and limitation over vapour compression system, Binary mixtures, Temperature concentration diagram, Aqua ammonia system, LiBr Systems, Steam Jet Refrigeration, Thermo Electric Refrigeration, Air Refrigeration cycles, simple numericals on VAR system	**8 Hours / L1, L2, L3**
Module 3 **Refrigeration Equipment and Control** Main system components, Compressor types, principle of operation, specifications, condenser – types and specification, selection, Evaporator types, Refrigeration controls, safety devices, defrosting introduction and its methods.	**8 Hours / L1, L2, L3**
Module 4 **Psychrometric Charts and Cooling Loads** Psychometric processes, Use of Charts, sensible heating and cooling, humidification and dehumidification, adiabatic mixing of fluids, evaporative cooling. Cooling load and heating load estimation, solar radiation, heat gain, factors considered in load estimation, design of cold storage simple numericals on using psychrometric chart.	**8 Hours / L1, L2, L3**

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Module 5	
Introduction to HVAC System Main parts of air conditioning equipment, classification of air conditioning systems, Central, zoned, unitary, summer and winter air conditioning. General aspects of duct system, pressure and pressure loss in ducts, duct design, Air- distribution system, simple numericals Principles of ice production, food preservation, milk chilling plant	**8 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO73.1	Analyze the principles of vapor compression refrigeration systems by applying advanced principles of refrigeration.
CO73.2	Evaluate and innovate the performance of vapor absorption refrigeration systems to enhance efficiency and application in various contexts.
CO73.3	Implement advanced control strategies for various components of refrigeration equipment to improve system reliability and performance.
CO73.4	Apply advanced psychrometric analysis techniques to optimize air conditioning processes for improved indoor air quality and energy efficiency.
CO73.5	Evaluate various air conditioning systems and their applications to meet specific environmental and operational requirements effectively.

Textbooks:

1. Refrigeration and Air-conditioning, **Arora. C.P**., 3rd Edition, 2009 , Tata McGraw Hill,
2. ISBN: 978007008390-5
3. A Text Book of Refrigeration and Air-Conditioning, **Rajput. R.K.**, 2019, S.K. Kataria and sons, New Delhi, ISBN: 978-93-5014-255-4

Reference books:

1. Refrigeration and Air conditioning, **Stoecker**. W.F., Jones. J.W, 2nd Edition, 1982 , Tata McGraw Hill , ISBN: 0070616191
2. Principles of Refrigeration, **Dossat. R.J. Horan. T.J**., 5th Edition, 2006 , Prentice Hall, ISBN: 013027270
3. "Principles of Air Conditioning", V Paul Lang, Delmar Cengage Learning, 1995. "Refrigeration & Air Conditioning Data Hand book" , Manohar Prasad , New Age International, 2nd Edition. 2013.

E-Books / Web References

1. https://archive.nptel.ac.in/courses/112/107/112107208/
2. https://freevideolectures.com/course/2372/refrigeration-and-air-conditioning

MOOCs

https://onlinecourses.nptel.ac.in/noc19_me58/preview

Scheme of Examination:
Semester End Examination (SEE):
SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced

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to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE. The assignment component would be for 10 marks. CIE is executed by way of quizzes / Alternate Assessment Tools (AATs), and three tests.

Some possible methods of assessment for assignments: Assignments / Oral presentations / Group activity/Projects.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignment/Quiz /AAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO73.1	3	2	1	1	2	1	1				1	1		1	
CO73.2	3	2	1	1	2	1	1				1	1		1	
CO73.3	3	2	1	2	1	1	1				1	1		1	
CO73.4	3	2	1	2	1	1	1				1	1		1	
CO73.5	3	2	1	1	1	1	1				1	1		1	
Average	3	2	1	2	2	1	1				1	1		1	

Low - 1: Medium - 2: High - 3

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SEMESTER – VII

Course: CONTROL ENGINEERING

Course Code	22MED741	CIE Marks	50
Hours/Week (L: T: P)	3: 0: 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Basic Mathematics

Course Objectives: The students will be taught to:

CLO1	Appreciate the importance of control systems in mechanical engineering.
CLO2	Represent the vibration system as electrical systems.
CLO3	Draw the Root locus, Bode, Polar and Nyquist plot for the given transfer system for further analyses.

Content	No. of Hours/ RBT levels
Module 1 **Introduction:** Concepts of automatic controls, Types of control systems, open and closed loop systems with examples, feedback system. Requirement of an ideal control system. **Mathematical Models:** Models of vibration systems, Transfer function, Numerical on F-I and F-V analogy of vibration systems.	**08 Hours / L1, L2, L3**
Module 2 **Block Diagrams Algebra:** block representation of system elements, reduction of block diagrams, Transfer function of SFG using Mason's formula. **Transient and Steady State Response Analysis:** Different types of inputs, Response of first order and second order to step, ramp and impulse inputs (no derivation), time response specifications and concepts of time constant, numerical problems.	**08 Hours / L1, L2, L3**
Module 3 **Root Locus Plots:** Definition, general rules for constructing root loci, Numerical on plotting the root locus for given transfer function.	**08 Hours / L1, L2, L3**
Module 4 **Frequency Response Analysis:** Relationship between time and frequency response, Bode attenuation plot, Phase and gain margins. **Polar and Nyquist plot:** Simple numerical Phase and gain margins**.**	**08 Hours / L1, L2, L3**
Module 5 **Controllers and System Compensation**: Different types of controllers (P, I, D, PI, PD and PID)**,** Series and feedback compensation.	**08 Hours / L1, L2, L3**

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State Variable Characteristics of Linear Systems: Introduction to state concepts, state equation of linear system. Matrix representation of state equations, controllability and observability, Kalman and Gilbert's test for controllability and observability.	

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO741.1	Explain different types of control systems and convert the vibrational systems to electrical systems.
CO741.2	Derive the transfer function for the control systems using Block diagram reduction techniques and signal flow graphs.
CO741.3	Deduce the time domain response analysis of 1st and 2nd order control systems.
CO741.4	Construct the root locus, Bode, Polar and Nyquist plot for the given transfer function.
CO741.5	Explain the different types of controllers and system compensation.
CO741.6	Determine the observability and controllability of a system

Textbooks:

1. **Farid G., Kuo B. C**, Automatic Control Systems, McGraw Hill Education, 10th Edition,2018
2. **K. Ogata**, Modern control Engineering, Pearson, 5th Edition, 2010

Reference books:

1. **I J Nagrath, M Gopal,** Control Systems Engineering, New Age International (P) Ltd, 2018.
2. **M.Gopal**, Control systems Principles and Design, 3rd Edition, TMH, 2000.

E-Books / Web References

1. https://www.pdfdrive.com/electrical-and-electronics-engineering-u-bakshi-v-bakshi-d188397301.html
2. https://www.pdfdrive.com/electrical-and-electronics-engineering-u-bakshi-v-bakshi-d188397301.html

MOOCs

1. https://nptel.ac.in/courses/108106098
2. https://onlinecourses.nptel.ac.in/noc20_ee90/preview

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. CIE is executed by way of three tests and a quiz / Alternate Assessment Tools (AATs) for 10 marks.

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Some possible AATs:
Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz /AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO741.1	2	2	2	2		1	1					1	2		
CO741.2	2	2	2	2		1	1					1	2		
CO741.3	2	2	2	2		1	1					1	2		
CO741.4	2	2	2	2		1	1					1	2		
CO741.5	2	2	2	2		1	1					1	2		
CO741.6	2	2	2	2		1	1					1	2		
Average	2	2	2	2		1	1					1	**2**		

Low - 1: Medium - 2: High – 3

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SEMESTER – VII

Course: Tribology

Course Code	22MED742	CIE Marks	50
Hours/Week (L: T: P)	2 : 2 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Fluid Mechanics

Course Objectives: Guide the students to,

CLO1	Understand the knowledge and importance of Tribology in Design, friction, wear and lubrication aspects of machine components.
CLO2	Demonstrate basic understanding of friction, lubrication, and wear processes.
CLO3	Understand the principles of lubrication, lubrication regimes, theories of hydrodynamic and the advanced lubrication techniques.
CLO4	Select compatible materials for minimizing friction and wear.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to tribology:** Historical background, practical importance, and subsequent use in the field. Lubricants: Types and specific field of applications. Properties of lubricants, viscosity, its measurement, effect of temperature and pressure on viscosity, lubrication types, standard grades of lubricants, and selection of lubricants.	**08** **L3**
Module 2 **Friction:** Origin, friction theories, measurement methods, friction of metals and non-metals. **Introduction of Wear and Wear Mechanism:** Introduction of Wear, Pitting, Classification and mechanisms of wear- Abrasive wear- Two – Body Abrasion, Three body abrasion, Adhesive Wear, Laws of adhesive wear by Archard, Corrosive Wear, Fatigue wear, Erosive wear, Fretting wear, Percussion,, delamination theory, debris analysis, wear testing methods -Abrasive wear test, Rolling sliding wear test, Pin on disk wear test.	**08** **L3**
Module 3 **Hydrodynamic journal bearings:** Friction forces and power loss in a lightly loaded journal bearing, Petroff's equation, mechanism of pressure development in an oil film, and Reynold's equation in 2D. **Hydrostatic Lubrication:** Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing, numerical examples.	**08** **L3**

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Module 4 **Tribological Components and Applications**, Common Tribological Components, Sliding-Contact Bearings, Rolling-Contact Bearings, Seals, Gears, BioMEMS, Industrial Applications-Automotive Engines, Magnetic Storage Devices. **Modern Applications of Tribology**- Biomedical (Bio tribology), Nanotribology, Green Tribology.	**08** **L3**
Module 5 **Bearing Materials:** Commonly used bearings materials, and properties of typical bearing materials. Advantages and disadvantages of bearing materials. **Introduction to Surface engineering:** Concept and scope of surface engineering. **Surface modification –**transformation hardening, surface melting, thermo chemical processes. **Surface Coating –**plating, fusion processes, vapor phase processes. Selection of coating for wear and corrosion resistance.	**08** **L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO742.1	*Understand* the fundamentals of tribology and associated parameters.
CO742.2	*Apply* concepts of tribology for the wear and friction analysis and design of components experiencing relative motion.
CO742.3	*Analyse* the requirements and design hydrodynamic journal and Hydrostatic bearings for a given application.
CO742.4	*Investigate* the prevalent tribological components utilized in industrial applications.
CO742.5	*Select* proper bearing materials and lubricants for a given tribological application.

Textbooks:

1. "Introduction to Tribology", B. Bhushan, John Wiley & Sons, Inc., New York, 2002
2. "Engineering Tribology", Prasanta Sahoo, PHI Learning Private Ltd, New Delhi, 2011.
3. "Engineering Tribology", J. A. Williams, Oxford Univ. Press, 2005.

Reference books:

1. "Introduction to Tribology in bearings", B. C. Majumdar, Wheeler Publishing.
2. "Tribology, Friction and Wear of Engineering Material", I. M. Hutchings, Edward Arnold, London,1992
3. "Engineering Tribology", G. W. Stachowiak and A. W. Batchelor, Butterworth-Heinemann,1992.
4. "Friction and Wear of Materials", Ernest Rabinowicz, John Wiley & sons,1995.
5. "Basic Lubrication Theory", A. Cameron, Ellis Hardwoods Ltd., UK.
6. "Handbook of tribology: materials, coatings and surface treatments", B. Bhushan, B.K. Gupta, McGraw-Hill,1997.

E-Books / Web References

1. https://www.pdfdrive.com/introduction-to-tribology-d52737530.html

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2. https://www.pdfdrive.com/tribology-friction-and-wear-of-engineering-materials-d158254335.html

MOOCs

1. https://nptel.ac.in/courses/112102015
2. https://nptel.ac.in/courses/112102014
3. https://onlinecourses.nptel.ac.in/noc20_mm12/preview

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any five full questions choosing at least one full question from each module.

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is to be conducted and evaluated for 10 marks

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz /AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO742.1	2	2	1	1		2	1					1	1		
CO742.2	2	2	1	1		2	1					1	1		
CO742.3	2	2	1	1		2	1					1	1		
CO742.4	2	2	1	1		2	1					1	1		
CO742.5	2	2	1	1		2	1					1	1		
Average	**2**	**2**	**1**	**1**		**2**	**1**					**1**	**1**		

Low - 1: Medium - 2: High - 3

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SEMESTER – VII

Course: COMPUTATIONAL FLUID DYNAMICS

Course Code	**22MED743**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**2 : 2 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Fluid Mechanics

Course Objectives: The students will be taught:

CLO1	One dimensional (1D) computation by finite difference method (FDM), finite element method (FEM) and finite volume method (FVM)
CLO2	The basic governing equations of CFD, different finite difference schemes and accuracy of FD solution
CLO3	Different solution methodologies for FD equations and stability analysis

Content	No. of Hours/ RBT levels
Module 1 **Introduction to CFD**: The need for computer simulations of fluid flows; Brief history of CFD, Relative merits with respect to Experimental and Theoretical Fluid Dynamics, Concept of Transport process – Importance in design, major elements of a CFD Code, - Preprocessor, Flow Equation Solver and Postprocessor - One-dimensional computations by finite difference methods, finite element methods and finite volume methods; Boundary conditions – Neumann and Dirichlet boundary conditions.	**08 Hours / L3**
Module 2 **Governing Equations for CFD:** Brief introduction to Vectors & Tensors, Mathematical behaviour of partial differential equations relevant to CFD, Conservation Equations for mass, momentum and energy in cartesian coordinates, equation of state, Navier-Stokes equations for a Newtonian fluid, general transport equations, fluid flow equations.	**08 Hours / L3**
Module 3 **The Finite Volume Method for Diffusion Problems**: one, two and three - dimensional steady state diffusion; Finite Volume Method for Convection-Diffusion Problems: Steady one-dimensional convection and diffusion, differencing scheme, power law scheme, higher order differencing scheme for convection-diffusion problems.	**08 Hours / L3**
Module 4 **Solution Algorithms for Pressure-Velocity Coupling in steady flows and Discretised Equations:** the staggered grid, the momentum equations, SIMPLE, SIMPLER, SIMPLEC and PISO algorithm, general comments on the algorithms, Tri-diagonal matrix algorithm.	**08 Hours / L3**

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Module 5	08 Hours / L3
Finite Volume Method for Unsteady Flows: One-dimensional unsteady heat conduction, Explicit scheme, Crank-Nicolson Scheme, fully implicit scheme, Discretization of transient convection-diffusion equation. Solution procedures for unsteady flow calculations.	

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO743.1	Understand the importance of computational fluid dynamics in solving fluid flow problems and Discern the concepts of 1D computations by FDM, FEM, and FVM
CO743.2	Explain basic governing equations of CFD and employ different finite difference schemes
CO743.3	Explicate the application of FVM to solve convection and diffusion problems
CO743.4	Elucidate different solution methodologies used for solving and hyperbolic, parabolic and elliptic governing equations
CO743.5	Analyze various FVM schemes applied in solving unsteady flows

Textbooks:

1. **T J Chung,** Computational Fluid Dynamics Production Technology Volume-II, Dhanpat Rai Publications, 2017.
2. **John D Anderson, Computational Fluid Dynamics, McGraw-Hill International Edition, 1995.**

Reference books:

1. J. Tu, G. Yeoh, C. Liu, Computational Fluid Dynamics: A Practical Approach, 2nd Edition, 2013
2. Jiyuan Tu, Guan Heng Yeoh and Chaoqun Liu, Butterworth- Heineman, "Computational Fluid Dynamics – A Practical Approach", Third Edition, 2008.

E-Books / Web References

1. https://www.pdfdrive.com/page-2-computational-fluid-dynamics-page-3-john-f-wendt-ed-computational-fluid-dynamics-d39904215.html

MOOCs

1. https://nptel.ac.in/courses/112105045
2. Introduction to CFD - Course (nptel.ac.in)

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE. The assignment component would be for 10 marks. CIE is executed by way of quizzes / Alternate Assessment Tools (AATs), and three tests.

Some possible methods of assessment for assignments: Assignments / Oral presentations / Group activity/Projects.

Typical Evaluation pattern for regular courses is shown in Table 2.

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Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignment/Quiz /AAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO743.1	3	2	2	1	2	1	1	-	-	1	-	1	-	2	-
CO743.2	3	2	2	1	2	1	1	-	-	1	-	1	-	2	-
CO743.3	3	2	2	1	2	1	1	-	-	1	-	1	-	2	-
CO743.4	3	2	2	1	2	1	1	-	-	1	-	1	-	2	-
CO743.5	3	2	2	1	2	1	1	-	-	1	-	1	-	2	-
Average	3	2	2	1	2	1	1	-	-	1	-	1	-	2	-

Low - 1: Medium - 2: High – 3

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SEMESTER – VII

Course: Industry 4.0

Course Code	22MED744	CIE Marks	50
Hours/Week (L: T: P)	3 : 0 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Course Objectives: This course will enable the students to,

CLO1	Identify the drivers and enablers of Industry 4.0
CLO2	Outline the various systems needed to convert the enterprises into Industry 4.0
CLO3	Analyze the technologies involved in Industry 4.0 for developing a sustainable environment.
CLO4	Identify the different views for generating the taxonomy of industry 4.0.
CLO5	Discuss the case studies and solve the problems for industry 4.0.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Industry 4.0:** Historical evolution of industry, Industry 4.0: origin and key understandings, Industry 4.0 design principles, Current Status and Future Trends. **The industry 4.0 pillars:** Collaborative robots, Augmented reality, Simulation modeling, Additive manufacturing, integration (Horizontal and vertical value chain), Cybersecurity, IoT, cloud computing, Big Data, Artificial Intelligence, 5G network.	**08 Hours / L1, L2, L3**
Module 2 **Transforming a small and medium enterprise (SMEs) into Industry 4.0**: Automation and improving of process, migration, and investment return, taxes, Standardisation, economy, legal challenges in Industry 4.0, Future trends: Industry 5.0 or Society 5.0, Circular economy.	**08 Hours / L1, L2, L3**
Module 3 **Industry 4.0 Technologies**: Cyber-physical systems, Cloud manufacturing, Big Data analytics, Augmented reality, Smart sensors, Location detection, Industrial Internet of Things (IIoT), Additive manufacturing. Environmental Management in Industry 4.0 and potential technologies, Challenges for environmental and sustainable beneficiation through technologies 4.0.	**08 Hours / L1, L2, L3**
Module 4 **A Taxonomy of Industry 4.0 and Related Technologies:** Introduction, Methodology used for generating the taxonomy, Taxonomy of industry 4.0, Strategic view of Industry 4.0, Managerial view, Technical view, Human resource view.	**08 Hours / L1, L2, L3**
Module 5 IoT Physical Devices and Endpoints - Arduino UNO: Introduction to Arduino, Arduino UNO, Installing the Software, Fundamentals of Arduino Programming, RaspberryPi:	**08 Hours / L1, L2, L3**

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Applications and Case Studies, Industry 4.0 laboratories, IIoT case studies, Case studies from smart industries, factories: manufacturing, production, design and IT. Business issues in Industry 4.0.Industry 4.0 in the automobile industry in European countries. Case Study -Renault - An industry 4.0, Industrial company transformation into Smart Factory with an accent on internal logistics and production.	

COURSE OUTCOMES: Upon completion of this course, student will be able to

CO744.1	Analyze the evolution and constituting elements of Industry 4.0 and evaluate their impact on modern manufacturing and business processes.
CO744.2	Identify and assess the key factors responsible for transforming small and medium enterprises into Industry 4.0 and develop strategies for successful implementation.
CO744.3	Evaluate various technologies enabling Industry 4.0 and synthesize approaches to create a sustainable environment through these technologies.
CO744.4	Analyze the different perspectives representing the taxonomy of Industry 4.0 and formulate a comprehensive understanding of its framework.
CO744.5	Interpret various case studies associated with Industry 4.0 and evaluate their outcomes to derive best practices and lessons learned.

Textbooks:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", 1st Edition, Pearson Education (Cisco Press Indian Reprint). (ISBN: 978-9386873743)
2. Srinivasa K G, "Internet of Things",CENGAGE Leaning India, 2017

Reference books:

1. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1 stEdition, VPT, 2014. (ISBN: 978-8173719547)
2. Raj Kamal, "Internet of Things: Architecture and Design Principles", 1 st Edition, McGraw Hill Education, 2017. (ISBN: 978-9352605224)

E-Books / Web References

1. https://nptel.ac.in/courses/106105166

MOOCs

1. NPTEL Course: "Internet of Things" https://nptel.ac.in/courses/106105166

Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 40.

CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

Some possible AATs: Assignments / Oral presentations / Group activity/Projects

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Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	QUIZ/OAT	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO744.1	3	2	2	1		1	1	1				1			2
CO744.2	3	2	2	1		1	1	1				1			2
CO744.3	3	2	2	1		1	2	1				1			2
CO744.4	3	2	2	1		1	1	1				1			2
CO744.5	3	2	2	1		1	1	1				1			2
Average	3	2	2	1		1	1	1				1			2

Low - 1: Medium - 2: High – 3

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SEMESTER – VII

OPEN ELECTIVE- 2

Course: Additive Manufacturing

Course Code	22MED751	CIE Marks	50
Hours/Week (L: T: P)	3 : 0 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Elements of Mechanical Engineering

Course Objectives: The students will be taught.

CLO1	The classification and steps involved in Additive Manufacturing
CLO2	The various techniques and applications of additive manufacturing.
CLO3	The various types of raw materials used in additive manufacturing process.
CLO4	The Process parameters and the common faults confronted in additive manufacturing equipment and process design.
CLO5	The post processing techniques involved in additive manufacturing.

Content	No. of Hours/ RBT levels
Module 1 Introduction, Process, Classification, Advantages, Additive V/s Conventional Manufacturing processes, Applications. CAD for Additive Manufacturing: CAD Data formats, Data translation, Data loss, STL format.	**8 Hours / L1, L2, L3**
Module 2 Additive Manufacturing Techniques: Fusion Deposition Modelling: Process, Process parameter, Process Selection for various applications. Introduction to Stereo-Lithography, LOM, SLS, SLM. Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defence, Automotive, Construction, Food Processing, Machine Tools	**8 Hours / L1, L2, L3**
Module 3 Materials: Polymers, Metals, Non-Metals, Ceramics, Various forms of raw material- Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their properties. Support Materials	**8 Hours / L1, L2, L3**
Module 4 Additive Manufacturing Equipment: Process Equipment- Design and process parameters, Governing Bonding Mechanism, Common faults and troubleshooting, Process Design	**8 Hours / L1, L2, L3**
Module 5 Post Processing: Requirement and Techniques, Product Quality: Inspection and testing, Defects and their causes	**8 Hours / L1, L2, L3**

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LIST OF PRACTICALS

1. 3D Modelling of a single component.
2. Assembly of CAD modelled Components
3. Exercise on CAD Data Exchange.
4. Generation of .stl files.
5. Identification of a product for Additive Manufacturing and its AM process plan.
6. Printing of identified product on an available AM machine.
7. Post processing of additively manufactured product.
8. Inspection and defect analysis of the additively manufactured product.
9. Comparison of Additively manufactured product with conventional manufactured counterpart

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO751.1	Synthesize complex CAD models for 3D printing, effectively manage CAD data interchange, and generate optimized .stl files for advanced additive manufacturing applications.
CO751.2	Integrate the generic processes and working principles of additive manufacturing to innovate and enhance production methodologies.
CO751.3	Justify the selection of specific materials for given applications, optimizing their properties and performance in additive manufacturing.
CO751.4	Troubleshoot complex issues in 3D printing hardware, ensuring optimal operation and maintenance of advanced additive manufacturing systems.
CO751.5	Implement advanced post-processing techniques and perform thorough inspections to identify and rectify defects in 3D printed parts, ensuring high-quality outputs.

Textbooks:

1. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer.
2. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, 2013.of Materials, 3rd Edition, CBS Publishers.

Reference books:

1. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers.
2. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: Principles and applications, 3rd Edition, World Scientific.
3. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGrawHill, 2021.

E-Books / Web References

- **https://www.nist.gov/additive-manufacturing**
- **https://www.metal-am.com/**
- **http://additivemanufacturing.com/basics/**
- **https://www.3dprintingindustry.com/**

MOOCs

- NPTEL Course: ''Fundamentals of Additive Manufacturing Technologies'' https://nptel.ac.in/courses/112103306
- NPTEL Course: "Rapid Manufacturing" https://onlinecourses.nptel.ac.in/noc20_me50/preview

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- MOOC Course: “Principle and development of additive manufacturing technologies”, (https://onlinecourses.nptel.ac.in/noc19_me47/preview)

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full questionfrom each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE. The assignment component would be for 10 marks. CIE is executed by way of quizzes / Alternate Assessment Tools (AATs), and three tests.

Some possible methods of assessment for assignments: Assignments / Oral presentations / Group activity/Projects.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignment/Quiz /AAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO751.1	3	2	1	1	3	2	-	-	-	-	-	1			3
CO751.2	3	2	1	1	-	2	-	-	-	-	-	1			3
CO751.3	3	1	1	1	-	2	3	-	-	-	-	1			3
CO751.4	3	2	1	1	-	2	-	-	-	-	-	1			3
CO751.5	3	1	1	1	-	2	-	-	-	-	-	1			3
Average	**3**	**2**	**1**	**1**	**3**	**2**	**3**	**-**	**-**	**-**	**-**	**1**			**3**

Low - 1: Medium - 2: High - 3

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SEMESTER – VII

OPEN ELECTIVE - 2

Course: Supply Chain Management

Course Code	**22MED752**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3: 0 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Management and Entrepreneurship

Course Objectives:

CLO1	Understand the stages, decision phases and process views in supply chain management
CLO2	Identify the major drivers of supply chain performance.
CLO3	Describe inventory management, transportation and the key factors considered in designing a distribution network.
CLO4	Develop a frame work for making network design decisions and coordination in supply chain.
CLO5	Discuss the importance of supply chain restructuring and the future of IT in supply chain management.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Supply Chain:** Fundamentals of Supply Chain, Stages, Objectives, Importance, Decision Phases and Process Views in Supply chain. Competitive and Supply Chain strategies, Achieving strategic fit, Supply Chain performance measures. **Case Studies:** Example- Toyota: A global Auto Manufacturer, Amazon.com: An E-Business.	**8 Hours / L1, L2, L3**
Module 2 **Supply Chain Drivers and Metrics:** Drivers of Supply Chain Performance, Framework for structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing and Pricing. **Case Studies:** Example- Seven Eleven Japan Company, E- Sourcing at Marico.	**8 Hours / L1, L2, L3**
Module 3 **Material Flow in Supply Chains:** Inventory Management- Types of Inventory, Inventory-related Costs. Transportation- Drivers of Transportation Decisions Comparison of modes of transportation on Supply Chain performance measures. **Designing Distribution Networks and Application to E-Business**: Role of distribution, factors influencing distribution network design, design options for a distribution network, E-Business and the distribution network.	**8 Hours / L1, L2, L3**

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Module 4 **Network Design in the Supply Chain:** Role of network design in the supply chain, factors influencing network design decisions, framework for network design decisions. **Coordination in a supply chain:** Lack of supply chain coordination and Bullwhip Effect, Effect on performance due to lack of coordination, obstacles to coordination in a supply chain.	**8 Hours / L1, L2, L3**
Module 5 **Supply Chain Restructuring:** Supply Chain Mapping, Supply Chain process restructuring, Postponement Case Studies: Hewlett-Packard: postponement of product differentiation, Benetton: postponement by re sequencing of processes. **Information Technology in supply chain:** Role of IT in a supply chain, Customer relationship management, Internal supply chain management, Supplier relationship management, Future of IT in supply chain and Risk management in IT.	**8 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO752.1	Analyze the fundamentals and scope of supply chain management and evaluate their significance in business operations.
CO752.2	Assess the roles and performance of various drivers in supply chain management and determine their impact on overall efficiency.
CO752.3	Design material flow, inventory management, and transportation systems for effective distribution networks in E-business, and optimize their performance.
CO752.4	Evaluate the role of network design and coordination in supply chain management and formulate strategies for enhancing integration and performance.
CO752.5	Assess the importance of supply chain restructuring and analyze the impact of information technology on supply chain operations and efficiency.

Textbooks:

1. **Sunil Chopra and Peter Meindl**, Supply Chain Management, 3rdEdition, Pearson Education 2007.
2. **Janat Shah**, Supply Chain Management, Text and Cases, Pearson Education 2009.

Reference books:

1. Supply Chain Management Theories & Practices, R. P. Mohanty, S. G. Deshmukh, Dreamtech Press, 19-A, Anari Road, Daryaganj, New Delhi.
2. Total Supply Chain Management by Ron Basu, J. Nevan Wright.
3. Supply Chain Management, Chopra, Pearson
4. David Simchi-Levi, Philp Kamintry and Edith Simchy Levy, Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, 2nd Edition, Tata-McGraw Hill.

E-Books / Web References

1. **E - Books:** "Strength of Materials", (http://freeengineeringbooks.com/Civil/Strength-of-Material-Books.php)
2. https://www.pdfdrive.com/global-supply-chain-management-and-international-logistics-d162358148.html
3. https://www.pdfdrive.com/innovative-methods-in-logistics-and-supply-chain-management-d34408414.html

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NPTEL

1. NPTEL Course: "Global Supply Chain Management"
   https://nptel.ac.in/courses/110108056
2. NPTEL Course: "Operations and Supply Chain Management"
   https://nptel.ac.in/courses/110106045
3. NPTEL Course: "Modelling and Analytics for Supply Chain Management''
   https://nptel.ac.in/courses/110105141

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is conducted and evaluated for 10 marks.

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz 2/AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO752.1	2	2	1			3	3	1				2			
CO752.2	2	2	1			3	3	1				2			
CO752.3	2	2	1			3	3	1				2			
CO752.4	2	2	1			3	3	1				2			
CO752.5	2	2	1			3	3	1				2			
Average	**2**	**2**	**1**			**3**	**3**	**1**				**2**			

Low - 1: Medium - 2: High – 3

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SEMESTER – VII

Course: Project Phase - I

Course Code	22MEDP76	CIE Marks	100
Hours/Week (L: T: P)	0: 0: 2	SEE Marks	-
No. of Credits	2	Examination Hours	

Project work Phase-I: Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary project can be assigned to an individual student or to a group having not more than 4 students. In extraordinary cases, like the funded projects requiring students from different disciplines, the project student strength can be 5 or 6.

1. **Single discipline**: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide. The CIE marks awarded for the project work phase -1, shall be based on the evaluation of the project work phase -1 Report (covering Literature Survey, Problem identification, Objectives and Methodology), project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the Project report shall be the same for all the batch mates.

2. **Interdisciplinary**: Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable. The CIE marks awarded for the project work phase -1, shall be based on the evaluation of project work phase -1 Report (covering Literature Survey, Problem identification, Objectives and Methodology), project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates as per rubrics covering all Program Outcomes.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	Preliminary review	-	100
	Review-1	100	
Grand Total			**100**

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SEMESTER – VII

Course: Dynamics Laboratory

Course Code	22MEDL77	CIE Marks	50
Hours/Week (L: T: P)	0 : 0 : 2	SEE Marks	50
No. of Credits	1	Examination Hours	03

Prerequisites: Strength of materials, Mechanical Vibrations, Theory of machines

Course Objectives: The students will be taught to :

CLO1	Demonstrate the concepts discussed in Mechanical Vibrations & Dynamics of Machines courses.
CLO2	Visualize and understand the development of stresses in structural members and experimental determination of stresses in members utilizing the optical method of reflected photoelasticity.

Content	No. of Hours/ RBT levels
Part-A 1. Determination of natural frequency of a spring mass system. 2. Determination of natural frequency logarithmic decrement, damping ratio and damping Co-efficient in a single degree of freedom vibrating systems (longitudinal and torsional). 3. Determination of critical speed of rotating shaft. 4. Balancing of rotating masses.	**14** **L1, L2, L3**
Part-B 5. Determination of fringe constant of Photo-elastic material using Circular disk subjected diametric compression, Pure bending specimen (four-point bending) 6. Determination of principle stresses and strain in a member subjected to combined loading using strain rosettes. 7. Determination of equilibrium speed, sensitiveness, power, and effort of Porter/Watt Governor. 8. Determination of pressure distribution in Journal bearing 9. Experiments on Gyroscope (Demonstration only)	**14** **L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO77.1	Understand the working principles of machine elements such as Governors, Gyroscopes etc.
CO77.2	Identify forces and couples in rotating mechanical system components.
CO77.3	Identify vibrations in machine elements and design appropriate damping methods and to determine the critical speed of a rotating shaft.
CO77.4	Measure strain in various machine elements using strain gauges.
CO77.5	Determine the minimum film thickness, load carrying capacity, frictional torque and pressure distribution of journal bearing
CO77.6	Determine strain induced in a structural member using the principle of photo-elasticity.

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Reference books:

1. "Shigley"s Mechanical Engineering Design", Richards G. Budynas and J. Keith Nisbett, McGraw-Hill Education, 10th Edition, 2015.
2. "Design of Machine Elements", V.B. Bhandari, TMH publishing company Ltd. New Delhi, 2nd Edition 2007.
3. "Theory of Machines", Sadhu Singh, Pearson Education, 2nd Edition, 2007.
4. "Mechanical Vibrations", G.K. Grover, Nem Chandand Bros, 6th Edition, 1996.

E-Books / Web References

1. https://www.youtube.com/watch?v=Ujtv5NY4Sq8&list=PL21BB25670CDC2AEB

Vibration simulation videos

1. https://www.youtube.com/watch?v=qcHjDLCJxfI
2. https://www.youtube.com/watch?v=Vj1xmze3GlE
3. https://www.youtube.com/watch?v=-BPbfRX4j0A

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be reduced to 50.

Continuous Internal Evaluation (CIE): Weekly Performance – Lab participation and report will be evaluated for 30 Marks and one Internal assessment is conducted at the end of semester for 20 Marks.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	Weekly Performance – Lab participation and report	**30**	**50**
	One IA at the end of semester	**20**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO77.1	2	1	1	1		1	1	2	3	3		1	2		
CO77.2	2	1	1	1		1	1	2	3	3		1	2		
CO77.3	2	1	1	1		1	1	2	3	3		1	2		
CO77.4	2	1	1	1		1	1	2	3	3		1	2		
CO77.5	2	1	1	1		1	1	2	3	3		1	2		
CO77.6	2	1	1	1		1	1	2	3	3		1	2		
Average	**2**	**1**	**1**	**1**		**1**	**1**	**2**	**3**	**3**		**1**	**2**		

Low - 1: Medium - 2: High – 3

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VIII SEMESTER

SYLLABUS

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SEMESTER – VIII

Course: Supply Chain Management

Course Code	22MED81	CIE Marks	50
Hours/Week (L: T: P)	3: 2 : 0	SEE Marks	50
No. of Credits	4	Examination Hours	03

Prerequisites: Management and Entrepreneurship

Course Objectives:

CLO1	Understand the stages, decision phases and process views in supply chain management
CLO2	Identify the major drivers of supply chain performance.
CLO3	Describe inventory management, transportation and the key factors considered in designing a distribution network.
CLO4	Develop a frame work for making network design decisions and coordination in supply chain.
CLO5	Discuss the importance of supply chain restructuring and the future of IT in supply chain management.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Supply Chain:** Fundamentals of Supply Chain, Stages, Objectives, Importance, Decision Phases and Process Views in Supply chain. Competitive and Supply Chain strategies, Achieving strategic fit, Supply Chain performance measures. **Case Studies:** Example- Toyota: A global Auto Manufacturer, Amazon.com: An E-Business.	**10 Hours / L1, L2, L3**
Module 2 **Supply Chain Drivers and Metrics:** Drivers of Supply Chain Performance, Framework for structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing and Pricing. **Case Studies:** Example- Seven Eleven Japan Company, E- Sourcing at Marico.	**10 Hours / L1, L2, L3**
Module 3 **Material Flow in Supply Chains:** Inventory Management- Types of Inventory, Inventory-related Costs. Transportation- Drivers of Transportation Decisions Comparison of modes of transportation on Supply Chain performance measures. **Designing Distribution Networks and Application to E-Business**: Role of distribution, factors influencing distribution network design, design options for a distribution network, E-Business and the distribution network.	**10 Hours / L1, L2, L3**

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Module 4 **Network Design in the Supply Chain:** Role of network design in the supply chain, factors influencing network design decisions, framework for network design decisions. **Coordination in a supply chain:** Lack of supply chain coordination and Bullwhip Effect, Effect on performance due to lack of coordination, obstacles to coordination in a supply chain.	**10 Hours / L1, L2, L3**
Module 5 **Supply Chain Restructuring:** Supply Chain Mapping, Supply Chain process restructuring, Postponement Case Studies: Hewlett-Packard: postponement of product differentiation, Benetton: postponement by re sequencing of processes. **Information Technology in supply chain:** Role of IT in a supply chain, Customer relationship management, Internal supply chain management, Supplier relationship management, Future of IT in supply chain and Risk management in IT.	**10 Hours / L1, L2, L3**

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO81.1	Analyze the fundamentals and scope of supply chain management and evaluate their significance in business operations.
CO81.2	Assess the roles and performance of various drivers in supply chain management and determine their impact on overall efficiency.
CO81.3	Design material flow, inventory management, and transportation systems for effective distribution networks in E-business, and optimize their performance.
CO81.4	Evaluate the role of network design and coordination in supply chain management and formulate strategies for enhancing integration and performance.
CO81.5	Assess the importance of supply chain restructuring and analyze the impact of information technology on supply chain operations and efficiency.

Textbooks:

1. **Sunil Chopra and Peter Meindl**, Supply Chain Management, 3rdEdition, Pearson Education 2007.
2. **Janat Shah**, Supply Chain Management, Text and Cases, Pearson Education 2009.

Reference books:

1. Supply Chain Management Theories & Practices, R. P. Mohanty, S. G. Deshmukh, Dreamtech Press, 19-A, Anari Road, Daryaganj, New Delhi.
2. Total Supply Chain Management by Ron Basu, J. Nevan Wright.
3. Supply Chain Management, Chopra, Pearson
4. David Simchi-Levi, Philp Kamintry and Edith Simchy Levy, Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, 2nd Edition, Tata-McGraw Hill.

E-Books / Web References

1. **E - Books:** "Strength of Materials", (http://freeengineeringbooks.com/Civil/Strength-of-Material-Books.php)
2. https://www.pdfdrive.com/global-supply-chain-management-and-international-logistics-d162358148.html

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3. https://www.pdfdrive.com/innovative-methods-in-logistics-and-supply-chain-management-d34408414.html

NPTEL

1. NPTEL Course: "Global Supply Chain Management" https://nptel.ac.in/courses/110108056
2. NPTEL Course: "Operations and Supply Chain Management" https://nptel.ac.in/courses/110106045
3. NPTEL Course: "Modelling and Analytics for Supply Chain Management'' https://nptel.ac.in/courses/110105141

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each modulecarrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full questionfrom each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is conducted and evaluated for 10 marks.

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz 2/AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO81.1	2	2	1			3	3	1			2	2			3
CO81.2	2	2	1			3	3	1			2	2			3
CO81.3	2	2	1			3	3	1			2	2			3
CO81.4	2	2	1			3	3	1			2	2			3
CO81.5	2	2	1			3	3	1			2	2			3
Average	**2**	**2**	**1**			**3**	**3**	**1**			**2**	**2**			**3**

Low - 1: Medium - 2: High - 3

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SEMESTER – VIII

Course: NON-TRADITIONAL MACHINING

Course Code	**22MED821**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3 : 0 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Manufacturing Process (Integrated)

Course Objectives:

CLO1	Understand the need of Non Traditional Machining Processes and able to Classify various processes.
CLO2	Recognize the role of mechanical energy in non-traditional manufacturing processes.
CLO3	Understand the concept of machining the hard material using Chemical energy and Electrochemical energy.
CLO4	Describe the concepts of Electrical discharge and plasma arc machining process in non-traditional machining process.
CLO5	Determine the basic principles and operation of electron beam machining and laser beam machining.

Content	No. of Hours/ RBT levels
Module 1 **INTRODUCTION TO NTM** Introduction to Non-traditional machining, Need for Non-traditional machining process, Comparison between traditional and non-traditional machining. General classification Non-traditional machining processes, classification based on nature of energy employed in machining, selection of non-traditional machining processes, Specific advantages, limitations and applications of non-traditional machining processes.	**08 Hours / L2**
Module 2 **Ultrasonic Machining (USM):** Introduction, Equipment and material process, Effect of process parameters: Effect of amplitude and frequency, Effect of abrasive grain diameter, effect of slurry, tool & work material. Process characteristics: Material removal rate, tool wear, accuracy, surface finish, applications, advantages & limitations of USM. **Abrasive Jet Machining (AJM):** Introduction, Equipment and process of material removal, process variables: carrier gas, type of abrasive, work material, stand-off distance (SOD). Process characteristics-Material removal rate, Nozzle wear, accuracy & surface finish. Applications, advantages & limitations of AJM.	**08 Hours / L2**

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Module 3 **Electrochemical Machining (ECM):** Introduction, Principle of electro chemical machining, ECM equipment, elements of ECM operation, Chemistry of ECM. ECM Process characteristics: Material removal rate, accuracy, surface finish. Process parameters: Current density, Tool feed rate, Gap between tool & work piece, velocity of electrolyte flow, type of electrolyte, its concentration temperature, and choice of electrolytes. Applications of ECM. Electrochemical grinding and electrochemical honing process, advantages, disadvantages and application of ECG, ECH. **CHEMICAL MACHINING (CHM):** Elements of the process, Resists (maskants), Etchants. Types of chemical machining process-chemical blanking process, chemical milling process. Process characteristics of CHM: Material removal rate, accuracy, surface finish, advantages, limitations and applications of chemical machining process.	**08 Hours / L2**
Module 4 **ELECTRICAL DISCHARGE MACHINING (EDM):** Introduction, Classification of EDM, EDM principle, mechanism of metal removal. EDM equipment: Spark erosion generators (relaxation type), Electrode feed control system. Flushing types: pressure flushing, suction flushing, side flushing, pulsed flushing. EDM process parameters: Spark frequency, current & spark gap, surface finish, heat affected Zone. Advantages, limitations & applications of EDM. Electrical discharge grinding, Traveling wire EDM. **PLASMA ARC MACHINING (PAM):** Introduction, non-thermal generation of plasma, equipment mechanism of metal removal, Plasma torch, process parameters, process characteristics. Safety precautions, applications, advantages and limitations.	**08 Hours / L2**
Module 5 **LASER BEAM MACHINING (LBM):** Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations of LBM. **ELECTRON BEAM MACHINING (EBM):** Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations of EBM.	**08 Hours / L2**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO821.1	Analyze advanced concepts of modern machining processes and their applications to innovate and enhance manufacturing techniques.
CO821.2	Evaluate non-traditional machining (NTM) processes utilizing mechanical energy to optimize manufacturing efficiency and precision.
CO821.3	Synthesize a comprehensive understanding of electrochemical and chemical machining processes to develop and optimize applications for complex material removal.
CO821.4	Assess the application of electrical discharge machining and plasma arc machining processes in modern manufacturing to solve specific machining challenges.
CO821.5	Evaluate the roles of laser beam and electron beam machining in non-traditional manufacturing processes to advance precision and functionality in complex production environments.

Textbooks:

1. Modern Machining Process by P.C Pandey and H S Shah McGraw Hill Education India Pvt. Ltd.
2. Production technology HMT McGraw Hill Education India Pvt. Ltd

Reference books:

1. New Technology by Dr. Amitabha Bhattacharyya The Institute of Engineers (India).

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2. Modern Machining Processes by Anand Pandey, Ane Books Pvt. Ltd., New Delhi, India.

E-Books / Web References

1. https://www.youtube.com/watch?v=-Nf8f6ky-B8
2. nptel.ac.in/courses/112104195/3
3. https://www.youtube.com/watch?v=cxU1zUOpGLk
4. nptel.ac.in/courses/112105126/40
5. nptel.ac.in/courses/112105126/39

MOOCs

1. https://onlinecourses.nptel.ac.in/noc22_me119/preview

Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is conducted and evaluated for 10 marks.

Some possible methods of assessment for assignments: Assignments/ Oral presentations / Group activity/Projects

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz/AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO821.1	3	2	1	1		2	2				1	1			3
CO821.2	3	2	1	1		2	2				1	1			3
CO821.3	3	2	1	1		2	2				1	1			3
CO821.4	3	2	1	1		2	2				1	1			3
CO821.5	3	2	1	1		2	2				1	1			3
Average	3	2	1	1		2	2				1	1			3

Low - 1: Medium - 2: High - 3

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SEMESTER – VIII

Course: THERMAL MANAGEMENT OF ELECTRONIC EQUIPMENT

Course Code	22MED822	CIE Marks	50
Hours/Week (L: T: P)	3 : 0 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Heat Transfer

Course Objectives: Students will be taught:

CLO1	The semiconductor technology and the importance of thermal management in electronics
CLO2	Various thermal transfer process and properties of the surfaces affecting the thermal management
CLO3	Advanced cooling methodologies and thermal design
CLO4	To perform and analyze computer simulations for solution of real-world thermal management problems

Content	No. of Hours/ RBT levels
Module 1 **Introduction**: Semiconductor Technology Trends. Temperature –Dependent Failures, Importance of heat transfer in electronics. Thermal design process. Heat Transfer mechanisms, thermal resistance network.	**08 Hours / L1, L2, L3**
Module 2 **Heat Conduction Equation-Fins and Heat sinks Radiation Heat Transfer**: General heat Conduction equation. Boundary and initial conditions. Steady state, Transient heat, Micro scale heat conduction. Fin equation, Heat sinks, Blackbody radiation, Radiation heat transfer from plate-fin heat sinks, simple numericals.	**08 Hours / L1, L2, L3**
Module 3 **Convective Heat Transfer:** Velocity and thermal boundary layer. Friction coefficient, Heat transfer coefficient. External and Internal flows, Natural convection heat transfer, simple numericals.	**08 Hours / L1, L2, L3**
Module 4 **Advanced Cooling Technologies:** Experimental Techniques and Thermal design: Heat pipes, Heat pipe selection and modeling, Jet impingement on flat surfaces and heatsinks, Liquid immersion cooling, Thermo-syphons, Loop heat pipes, Thermoelectric coolers, cooling using phase change– cooling with PCM materials, piezoelectric fans, Electro hydrodynamic flow, Synthetic Jets, Single phase and two-phase flow micro channels- Thermal design.	**08 Hours / L1, L2, L3**

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Module 5	
Temperature measurement: Thermocouples, overview, reference junction, proper connections, types, special limits of error wire, time constants, sheathing, potential problems, DAQ setup **RTDs**: overview, bridges, calibration, accuracy, response time, potential problems **Thermistors**: Infrared Thermometry fundamentals, emissivity determination, field of view, Other Non-electronic measurement, thin-film heat flux gauge Temperature Controllers How to Choose; Standards, cost, accuracy, stability, sensitivity, size, contact/non-contact, temperature range, fluid type **Thermal interface materials**, types, ideal and actual TIM, TIM test methods	**08 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO822.1	Apply advanced heat transfer principles to design and optimize thermal management solutions for electronic components, devices, and systems to enhance performance and reliability.
CO822.2	Apply the concept of thermal resistance in designing and optimizing thermal management systems to improve heat dissipation and component efficiency.
CO822.3	Interpret first-order analyses of heat transfer from electronic systems to develop effective cooling strategies and improve system performance
CO822.4	Evaluate advanced cooling technologies, discussing their impact on electronic system efficiency and thermal management.
CO822.5	Compare various temperature measurement instruments and thermal interface materials to select and implement optimal solutions for precise temperature control and effective thermal management.

Textbooks:

1. **Shabany Younes** "Heat Transfer-Thermal Management in Electronics", CRC Press, First Edition, 2010
2. **Steinberg, Dave S., "Cooling Techniques for Electronic Equipment",** John Wiley & Sons, 1991
3. Ravi Kandasamy and Arun S. Mujumdar, Thermal Management of Electronic Components, Lambert Academic Publishing, 2010.

Reference books:

1. G N Ellison, Van Nostrand Reinhold, "Thermal Computations for Electronic Equipment", First Edition, 1984
2. A D Kraus and A Bar Cohen, "Thermal Analysis and Control of Electronic Equipment", McGraw-Hill, Hemisphere, Second Edition, 1983

E-Books / Web References

1. **https://www.pdfdrive.com/thermal-management-of-microelectronic-equipment-heat-transfer-theory-analysis-methods-and-design-practices-e185972760.html**
2. https://www.pdfdrive.com/heat-pipe-design-and-technology-modern-applications-for-practical-thermal-management-d176024584.html

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MOOCs

1. NPTEL Course: "Electronic enclosures Thermal issues" (https://onlinecourses.nptel.ac.in/noc21_ee46/preview)
2. Free Video Lectures: "Thermal Design and Cooling", (https://www.youtube.com/watch?v=m7LVcog4bpc)

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE. The assignment component would be for 10 marks. CIE is executed by way of quizzes / Alternate Assessment Tools (AATs), and three tests.

Some possible methods of assessment for assignments: Assignments / Oral presentations / Group activity/Projects.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Assignment/Quiz /AAT	**10**	
SEE	Semester End Examination	**100**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO822.1	3	2	1	1	1	1	1			1		1		1	
CO822.2	3	2	1	1	1	1	1			1		1		1	
CO822.3	3	2	1	1	1	1	1			1		1		1	
CO822.4	3	2	1	1	1	1	1			1		1		1	
CO822.5	3	2	1	1	1	1	1			1		1		1	
Average	3	2	1	1	1	1	1			1		1		1	

Low - 1: Medium - 2: High – 3

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SEMESTER – VIII

Course: OPERATIONS RESEARCH

Course Code	22MED823	CIE Marks	50
Hours/Week (L: T: P)	3 : 2 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Basic Mathematics

Course Objectives: The students will be taught to:

CLO1	Convert the real life situations to mathematical form and find optimal solutions.
CLO2	Draw the network showing the flow of activities and determine the completion of project.
CLO3	Predict the characteristics of queues like probability of waiting, waiting times, number of customers etc.

Content	No. of Hours/ RBT levels
Module 1 **Introduction:** Definition and Scope of OR, Applications, Advantages and Disadvantages, Phases of OR. **Linear Programming:** Formulation of LP problems and solution by graphical method.	**08Hours / L1, L2, L3**
Module 2 **Solution to LP problems:** Simplex method, Big-M method, Degeneracy in LPP, Concept of Duality, Solution to primal from dual	**08 Hours / L1, L2, L3**
Module 3 **Transportation Models:** Formulation of transportation matrix (both balanced and unbalanced), Initial basic feasible solution (NWCR and VAM only), Optimality by MoDi method, Degeneracy and resolving degeneracy in TP, Maximization in TP. **Assignment Problems:** Solution by Hungarian method, Variation in Assignment Problems (Unbalanced, Restricted Assignments)	**08 Hours / L1, L2, L3**
Module 4 **PERT-CPM techniques:** Differences between PERT and CPM, Network construction, Node numbering using Fulkerson's rule, Determination of critical path and duration, CPM –Prediction of project completion **(No numericals on crashing of networks)**. **Game Theory:** Definitions of terminologies used in Game theory, Formulation of payoff matrix, Maximin and Minimax principles for Games of Pure strategy, Algebraic method for games of mixed strategy, Graphical method to solve 2xn and mx2 games, Dominance principle for mxn games.	**08 Hours / L1, L2, L3**
Module 5 **Queuing Theory:** Introduction, Characteristics of Queueing systems, Representation of Queueing models by Kendal's Notation, Numericals on single channel queueing systems only. **Sequencing:** Definitions and assumptions, Sequencing of 'n' jobs on 'm' (m=2, 3 and greater than 3) machines, Graphical method for sequencing of '2' jobs on 'm' machines.	**08 Hours / L1, L2, L3**

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COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO823.1	Formulate real-life problems using concepts Linear Programming and obtain the optimum solutions.
CO823.2	Formulate real-life transportation and assignment problems to find the optimum solution.
CO823.3	Construct the precedence diagram to find the duration of project.
CO823.4	Formulate the competitive situations to find the winner of the game.
CO823.5	Analyze the Queueing model for satisfaction of customer.
CO823.6	Determine the sequence of jobs so as to minimize the total elapsed time for completion.

Textbooks:

1. **S D Sharma**, Operations Research, KNBN publishers
2. **Hamdy A.Taha**, Operations Research, PHI Private Limited, Seventh Edition, 2006

Reference books:

1. **A M Natarajan, P Balasubramani,** Operations Research, Pearson Education, 2005
2. **Hillier and Lieberman,** Introduction to Operations Research, McGraw Hill, 8th edition

E-Books / Web References

1. https://www.bbau.ac.in/dept/UIET/EME-601%20Operation%20Research.pdf
2. https://www.pdfdrive.com/introduction-to-operations-research-d14995994.html

MOOCs

1. https://nptel.ac.in/courses/110106062
2. https://nptel.ac.in/courses/111107128

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. CIE is executed by way of three tests and a quiz / Alternate Assessment Tools (AATs) for 10 marks.

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz /AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

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CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO823.1	2	2	1	1		1						1			2
CO823.2	2	2	1	1		1						1			2
CO823.3	2	2	1	1		1					2	1			2
CO823.4	2	2	1	1		1					2	1			2
CO823.5	2	2	1	1		1						1			2
CO823.6	2	2	1	1		1						1			2
Average	2	2	1	1		1					2	1			2

Low - 1: Medium - 2: High – 3

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SEMESTER – VIII
Course: Artificial Intelligence

Course Code	**22MED824**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3 : 0 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Course Objectives: This course will enable the students to,

CLO1	Understand the significance of Artificial Intelligence (AI) along with basic principles, techniques and its applications .
CLO2	Define the principles involved in various searching algorithms.
CLO3	Recognise the complexity involved in searching process under certain unfavourable conditions.
CLO4	Explain the principles involved in adversarial search problems.
CLO5	Categorize the information based on level of uncertainty involved.

Content	No. of Hours/ RBT levels
Module 1 **Fundamental concepts of AI:** Introduction to AI - Foundations of Artificial Intelligence - History of Artificial Intelligence - State of the Art - Risks and Benefits of AI Intelligent Agents - Agents and Environments - Concept of Rationality - Nature of Environments - Structure of Agents.	**08 Hours / L1, L2, L3**
Module 2 **Uninformed and Informed search Algorithms:** Breadth-First Search, Depth-First Search, Best First Search, A*, AO*, Hill Climbing, Generate & Test, Alpha-Beta pruning, Min-max search	**08 Hours / L1, L2, L3**
Module 3 **Learning** Forms of Learning, Introduction to Supervised, Unsupervised, Semi Supervised, Self-Supervised, Weakly Supervised and Reinforcement Learning. Types of Data: Structured and Unstructured Data, Quantitative and Qualitative Data, Four Levels of data (Nominal, Ordinal, Interval, Ratio Level). Introduction to Feature Engineering Techniques	**08 Hours / L1, L2, L3**
Module 4 Natural Language Processing: Introduction, Syntactic Processing, Semantic Analysis, Discourse and Pragmatic Processing, Statistical NLP.	**08 Hours / L1, L2, L3**
Module 5 **Expert Systems** What an expert system is; how it works and how it is built, basic components of an expert system, Expert System Architectures, Examples of Expert Systems. Rule-based Expert systems: Structure of rule based expert system, Conflict resolution, Uncertainty Management, Advantages & disadvantages of rule-based. Introduction to Frame-based Expert systems.	**08 Hours / L1, L2, L3**

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COURSE OUTCOMES: Upon completion of this course, student will be able to

CO824.1	Elucidate the reasons behind AI for being an important field of study, and understand the types of agents, environments, and their relationships
CO824.2	Describe the uninformed and Informed search algorithms that make up the fundamental building blocks of AI.
CO824.3	Understand different forms of learning and the importance of structure of the data used by the agent.
CO824.4	Understand the fundamental concepts of Natural Language Processing used by the agent in the environment.
CO824.5	Explore the application of AI ideas in the development of expert systems.

Textbooks:

1. Artificial Intelligence: A Modern Approach (3rd edition) by Stuart Russell and Peter Norvig,
2. Winston, Patrick Henry. Artificial Intelligence. 3rd ed. Addison-Wesley, 1992. ISBN: 9780201533774.

Reference books:

1. Artificial Intelligence and Intelligent Systems, OXFORD University Press, New Delhi, 2005- N. P. Padhay.
2. Nils J. Nilsson, "Artificial Intelligence: A new Synthesis", Harcourt Asia Pvt. Ltd., 2000.
3. Elaine Rich and Kevin Knight, "Artificial Intelligence", 2nd Edition, Tata McGraw-Hill, 2003.
4. George F. Luger, "Artificial Intelligence-Structures and Strategies For Complex Problem Solving", Pearson Education / PHI, 2002.

E-Books / Web References

1. https://www.ibm.com/blogs/think/category/artificial-intelligence/
2. https://www.uipath.com/blog/ai
3. https://ai.googleblog.com/

MOOCs

1. https://www.coursera.org/professional-certificates/applied-artifical-intelligence-ibm-watson-ai
2. https://www.coursera.org/learn/introduction-to-ai

Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 40.

CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

Some possible AATs: Assignments / Oral presentations / Group activity/Projects

Typical Evaluation pattern for regular courses is shown in Table 2.

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Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	QUIZ/OAT	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO824.1	3	3	3		2							2			1
CO824.2	3	3	3		2							2			1
CO824.3	3	3	3		2							2			1
CO824.4	3	3	3		2							2			1
CO824.5	3	3	3		2							2			1
Average	3	3	3		2							2			**1**

Low - 1: Medium - 2: High – 3

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SEMESTER – VIII

Course: SMART MATERIALS and MEMS

Course Code	**22MED831**	**CIE Marks**	**50**
Hours/Week (L: T: P)	**3 : 0 : 0**	**SEE Marks**	**50**
No. of Credits	**3**	**Examination Hours**	**03**

Prerequisites: Material Science and Basic Electronics

Course Objectives: This course will enable the students to:

CLO1	Gain knowledge of smart materials, piezoelectric materials structures, and its characteristics.
CLO2	Understand smart structures and modelling which helps in Vibration control using smart materials for various applications.
CLO3	Analyze the properties of smart structures, MEMS, with the applications and select suitable procedure for fabrication.
CLO4	Understand the principles and concepts of using MEMS, ER & MR Fluids for various applications.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to smart materials:** Closed loop and Open loop Smart Structures. Applications of Smart structures, Piezoelectric properties. Inchworm Linear motor, Shape memory alloys, Shape memory effect-Application, Processing, and characteristics. **Shape Memory Alloys:** Introduction, Phenomenology, Modelling of shape memory effect.	**08 / L2**
Module 2 **Electro Rheological and Magneto Rheological Fluids**: Mechanisms and Properties, Characteristics, Fluid composition and behavior. **Discovery and Early developments:** Summary of material properties. Applications of ER and MR fluids.	**08 / L2**
Module 3 **Biomimetics:** Design Spiral of Biomimicry**,** Characteristics of Natural structures. Fiber reinforced organic matrix natural composites, Natural creamers, Mollusks. Biomimetic sensing, Challenges, and opportunities.	**08 / L2**
Module 4 **MEMS**: History of MEMS, Intrinsic Characteristics, Devices: Sensors and Actuators. Microfabrication: Photolithography, Thermal oxidation, thin film deposition, etching types, Doping, Dicing, Bonding surface microfabrication, Bulk microfabrication, LIGA technique.	**08 / L2**

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Module 5	
Polymer MEMS & Microfluidics: Introduction, Polymers in MEMS Polyimide, SU-8, LCP, PDMS, PMMA, Parylene, Others. Applications (Acceleration, Pressure, Flow, Tactile sensors). Motivation for micro fluidics. **MEMS applications:** MEMS Magnetic actuators, BP sensors, Microphone.	**08 / L2**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO831.1	**Analyze** the properties, uses, and design of smart structures and shape memory materials.
CO831.2	**Examine** and compare the mechanisms and applications of ER and MR fluids and **describe** the types and uses of fiber optic sensors.
CO831.3	**Compare** different vibration absorbers and describe the characteristics of natural materials like wood, ceramics, bones, and mollusks.
CO831.4	**analyze** various microfabrication techniques and **assess** the effectiveness of sensing and actuation methods involving magnetization and piezoelectricity through detailed case studies.
CO831.5	**Compare** different fabrication techniques and evaluate case studies of MEMS devices such as pressure sensors, microphones, accelerometers, and gyroscopes to understand their practical impacts and innovations.

Textbooks:

1. "Smart Structures –Analysis and Design", A.V.Srinivasan, Cambridge University Press, New York, 2001, (ISBN:0521650267).
2. "Smart Materials and Structures", M.V.Gandhi and B.S.Thompson Chapmen & Hall, London, 1992 (ISBN:0412370107)

Reference books:

1. "Foundation of MEMS, by Chang Liu. Pearson Education. (ISBN:9788131764756)

E-Books / Web References

1. https://www.youtube.com/watch?v=5s6-1uREV4A
2. https://www.youtube.com/watch?v=yXHIIowQntk
3. https://www.youtube.com/watch?v=nE1C4ghfvac&list=PLgMDNELGJ1CbufZjqWa8uoSlQWKqVwPN7

MOOCs

1. https://nptel.ac.in/courses/117105082

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any five full questions choosing at least **one full question from each module**.

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is to be conducted and evaluated for 10 marks

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Some possible AATs:
Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-2	**40**	
	Quiz /AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO831.1	3	2	1			2	2					1			1
CO831.2	3	2	1			2	2					1			1
CO831.3	3	1	1			2	2					1			1
CO831.4	3	2	2			2	2					1			1
CO831.5	3	2	1			2	2					1			1
Average	**3**	**1**	**1**			2	2					1			1

Low - 1: Medium - 2: High - 3

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SEMESTER – VIII

Course: Composite Material Technology

Course Code	22MED832	CIE Marks	50
Hours/Week (L: T: P)	3: 0: 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Material science & Metallurgy

Course Objectives: The students are enabled to:

CLO1	Understand the behaviour of constituents in the composite materials and its applications
CLO2	Explain the different types of reinforcement and matrices used in composites
CLO3	Understand the various manufacturing processes of Composite materials
CLO4	Gain the knowledge in the Processing & structure of Multi filamentary superconducting composites
CLO5	Know the use of SEM, XRD, TEM, and AFM and observe the surface morphology and composition of materials

Content	No. of Hours/ RBT levels
Module 1 **Introduction to Composite Materials:** Definition, classification & need of composite materials. Advantages, limitations, and applications. **Constituent of composite materials:** Reinforcements, Matrix. **Reinforcements:** Introduction, Glass Fibers, Boron Fibers, Carbon Fibers, Organic Fibers, Ceramic Fibers, and Whiskers, **Matrix Materials:** Polymers, Metals and Ceramic Matrix Materials.	**08 Hours / L1, L2, L3**
Module 2 **Fiber Reinforced Plastic Processing:** fabricating process, open and closed mould processes, hand layup techniques; structural laminate bag molding, production procedures for bag molding; filament winding, pultrusion, injection molding, blow molding.	**08 Hours / L1, L2, L3**
Module 3 **Metal Matrix Composites:** Reinforcement materials, types, characteristics, and selection of base metals. Need for production MMC's and its application. **Fabrication Process for MMC's:** Powder metallurgy technique, liquid metallurgy technique and secondary processing, special fabrication techniques.	**08 Hours / L1, L2, L3**
Module 4 **Ceramic Matrix Composites (CMC): Processing of CMC's;** Cold Pressing & Sintering, Hot Pressing, Infiltration, In Situ Chemical Reaction Technique, applications of CMC's.	**08 Hours / L1, L2, L3**

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Carbon Fiber/Carbon Matrix Composites: Processing of Carbon/Carbon Composites, Oxidation protection of Carbon/Carbon Composites, Properties of Carbon/Carbon Composites, and application of Carbon/Carbon Composites.	
Module 5 **Multifilamentary Superconducting Composites:** Types of Super Conductor, Processing & structure of Multi filamentary superconducting composites. Applications of multifilamentary superconducting composites. Characterization of Composites- Scanning Electronic Microscope (SEM), X-Ray Diffraction Analysis (XRD), Transmission electron microscopy (TEM) & Atomic Force Microscopy (AFM)	**08 Hours / L1, L2, L3**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO832.1	Evaluate the fundamental constituents of diverse composite materials to make informed decisions on material selection for specific applications.
CO832.2	Apply the various production processes for Fiber Reinforced Plastic composites to optimize manufacturing efficiency and product performance.
CO832.3	Justify the selection of suitable fabrication processes for Metal Matrix Composites, considering application-specific requirements and performance criteria.
CO832.4	Evaluate advanced processing techniques for Ceramic Matrix Composites and Carbon-Carbon Composites to enhance their structural integrity and functional properties.
CO832.5	Apply advanced methods for processing and characterizing Multi-Filamentary Superconducting Composites to improve their performance and evaluate their structural and functional properties effectively.

Textbooks:

1. Composite Material Science and Engineering, **Krishan K. Chawla**, Springer, Third Edition, First Indian
2. Fibre-Reinforced Composites, Materials, Manufacturing, and Design, P.K. Mallick, Third Edition, CRC.Press, Taylor & Francis Group.

Reference books:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Taylor & Francis, 2nd Ed, 2005.
2. Robert M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1999.
3. Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press,2004.

E-Books / Web References

1. **E - Books:** https://www.pdfdrive.com/mechanics-of-composite-materials-second-edition-d39890371.html
2. https://vdoc.pub/download/composite-materials-science-and-engineering-7fs1b0mgdis0
3. https://www.pdfdrive.com/fiber-reinforced-composites-materials-manufacturing-and-design-third-edition-d164990316.html

MOOCs

1. NPTEL Course: “Composite materials” https://nptel.ac.in/courses/112104168
2. NPTEL Course: https://onlinecourses.nptel.ac.in/noc20_me95/preview

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3. NPTEL Course: “Polymer composites”https://www.digimat.in/nptel/courses/video/112107221/L40.html
4. NPTEL Course: “Carbon composites” https://nptel.ac.in/courses/113105081
5. NPTEL Course: “Carbon composites “ https://nptel.ac.in/courses/112107086

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is conducted and evaluated for 10 marks.

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz 1/AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO832.1	3	2	1			2	2					1			2
CO832.2	3	2	1			2	2					1			2
CO832.3	3	2	1			2	2					1			2
CO832.4	3	2	1			2	2					1			2
CO832.5	3	2	1			2	2					1			2
Average	3	1	1			2	2					1			2

Low - 1: Medium - 2: High - 3

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SEMESTER – VIII

Course: TOTAL QUALITY MANAGEMENT

Course Code	22MED833	CIE Marks	50
Hours/Week (L: T: P)	3: 0: 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Management & Entrepreneurship

Course Objectives: the students are taught to

CLO1	Understand the various approaches to TQM and Quality management system.
CLO2	Explain The characteristics of quality leader and his role.
CLO3	Know the Develop feedback and suggestion systems for quality management.
CLO4	the knowledge in Tools and Techniques of quality management

Content	No. of Hours/ RBT levels
Module 1 **Principles and Practice:** Definition, basic approach, gurus of TQM, TQM Framework, awareness, defining quality, historical review, obstacles, benefits of TQM. **Quality Management Systems**: Introduction, benefits of ISO registration, ISO 9000 series of standards, ISO 9001 requirements.	**08 Hours / L2**
Module 2 **Leadership:** Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making.	**08 Hours / L2**
Module 3 **Customer Satisfaction and Customer Involvement**: Customer Satisfaction: customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, case studies. **Employee Involvement** – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward, gain sharing, performance appraisal, unions and employee involvement, case studies.	**08 Hours / L2**
Module 4 **Continuous Process Improvement:** process, the Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem-solving methods, Kaizen, reengineering, six sigma. **Statistical Process Control:** Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, Control charts, state	**08 Hours / L2**

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of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams, case studies.	
Module 5 **Tools and Techniques:** Benching marking, information technology, quality management systems, environmental management system, and quality function deployment, quality by design, failure mode and effect analysis, product liability, total productive maintenance.	**08 Hours / L2**

COURSE OUTCOMES: Upon completion of this course, student will be able to:

CO833.1	Evaluate various approaches to Total Quality Management (TQM) and analyze the standards and requirements of ISO 9000 and ISO 9001, including the benefits of implementing the ISO 9000 series.
CO833.2	Assess the characteristics of quality leaders, effective individuals, and ethical considerations.
CO833.3	Examine the importance of customer satisfaction and employee involvement through detailed case studies.
CO833.4	Apply statistical tools for the continuous improvement of quality systems, and evaluate their effectiveness in real-world scenarios.
CO833.5	Implement tools and techniques for effective TQM, and identify areas for quality improvement using Quality Function Deployment (QFD) and Failure Mode and Effects Analysis (FMEA).

Textbooks:

1. Dale H. Besterfield et al, Total Quality Management, Third edition, Pearson Education. (First Indian Reprints 2004).
2. Shridhara Bhat K, Total Quality Management – Text and Cases, Himalaya Publishing House, First Edition 2002.

Reference books:

1. M. Zairi, Total Quality Management for Engineers, Woodhead Publishing.
2. A New American TQM, four revolutions in management, ShojiShiba, Alan Graham, David Walden, Productivity press, Oregon.
3. 100 Methods for Total Quality Management: Gopal K. Kanji and Mike Asher, ISBN: 0803977476, Publisher: Sage Publications, Inc.;Edition – 1

E-Books / Web References

1. **Gurus of TQM**
   - https://www.focusstandards.org/quality-gurus-key-contributions/
2. **TQM Framework**
   - https://www.emeraldinsight.com/doi/abs/10.1108/eb060192
3. **Principles of TQM:**
   - https://study.com/academy/lesson/five-principles-of-total-quality-management-tqm.html
4. **Characteristics of quality leaders**
   - https://www.mechlectures.com/leadership-characteristics-quality-leaders/
   - https://www.briantracy.com/blog/leadership-success/the-seven-leadership-qualities-of-great-leaders-strategic-planning/
5. **Customer Satisfaction and Customer Involvement**
   - https://www.emeraldinsight.com/doi/abs/10.1108/17566691311316248

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- https://study.com/academy/lesson/consumer-involvement-in-the-decision-making-process.html

6. **Statistical Process Control**
   - http://asq.org/learn-about-quality/seven-basic-quality-tools/overview/overview.html
   - https://www.whatissixsigma.net/7-qc-tools/
7. **Design for Six Sigma**
   - https://quality-one.com/six-sigma/

MOOCs

1. NPTEL Course: "Total Quality Management" https://archive.nptel.ac.in/courses/110/104/110104080/
2. NPTEL Course: "Total Quality Management" https://archive.nptel.ac.in/noc/courses/noc20/SEM1/noc20-mg34/

Scheme of Examination:

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. Average of three tests is taken. CIE is executed by way of one quiz / Alternate Assessment Tools (AATs), and average of three tests. One quiz is conducted and evaluated for 10 marks.

Some possible AATs:

Assignments/ group activity / any other.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	Quiz 1/AAT	**10**	
SEE	Semester End Examination	**50**	**50**
Grand Total			**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO833.1	2	1	1			1	1	1		1	3	2			2
CO833.2	2	1	1			1	1	1		1	3	2			2
CO833.3	2	1	1			1	1	1		1	3	2			2
CO833.4	2	1	1			1	1	1		1	3	2			2
CO833.5	2	1	1			1	1	1		1	3	2			2
Average	2	1	1			1	1	1		1	3	2			2

Low - 1: Medium - 2: High - 3

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SEMESTER – VIII

Course: Theory of Elasticity

Course Code	22MED834	CIE Marks	50
Hours/Week (L: T: P)	3 : 0 : 0	SEE Marks	50
No. of Credits	3	Examination Hours	03

Prerequisites: Mechanics of Materials, Engineering Mathematics

Course Objectives: This course will enable the students to

CLO1	Understand the basic concepts of stress, strain, and their relationship for Elasticity problems in engineering members
CLO2	Learn the analytical solution of torsion of shafts.
CLO3	Understand and apply Analytical methods for contact problems.

Content	No. of Hours/ RBT levels
Module 1 **Introduction to general theory of elasticity:** assumptions and applications of linear elasticity. State of stress at a point, Cauchy's stress principle, Principal stresses in three dimensions, stress invariants, octahedral planes and stresses acting on it, Plane stress problems, Numericals.	**8 Hours / L1, L2, L3**
Module 2 **Analysis of strain:** types of strain, strain tensors. Principal strains, strain invariants, octahedral strains, Compatibility equations of TYPE I and II, Stress-strain relations, Generalised Hooke's law, Plane strain problems, Numericals.	**8 Hours / L1, L2, L3**
Module 3 **Two-Dimensional classical elasticity Problems:** Airy's stress functions, Investigation of Airy's stress function for simple beams, bending of a narrow cantilever beam of rectangular cross section under tip load, bending of simply supported beam under UDL **General equations in polar coordinates:** thick wall cylinder subjected to internal and external pressures, Rotating discs and cylinders, Numerical Problems.	**8 Hours / L1, L2, L3**
Module 4 **Elasticity solutions for torsion of shafts:** Torsion of circular, elliptical and triangular bars, Prandtl's membrane analogy, torsion of thin-walled tubes, torsion of thin walled multiple cell closed sections. Numerical Problems.	**8 Hours / L1, L2, L3**
Module 5 **Thermal stresses:** Thermo-elastic stress strain relations, equations of equilibrium, thermal stresses in thin circular discs and in long circular cylinders. **Contact stresses:** deflection of bodies in point and line contact applications, Methods of computing contact stress.	**8 Hours / L1, L2, L3**

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COURSE OUTCOMES: Upon completion of this course, student will be able to

CO834.1	Explain the state of stress in 2D and 3D elastic members under direct loads.
CO834.2	Explain the state of strain in 2D and 3D elastic members.
CO834.3	Describe the analysis of structural members such as beams (Airy's stress functions), thick wall cylinders, and stress-strain relations.
CO834.4	Analyze the structural members such as rotating disks, torsional rigidity of circular and non-circular sections.
CO834.5	Describe the analysis of structural members such as columns, stability of columns, thermo-elastic stress strain relations and thermal stresses.

Textbooks:

1. **Advanced Mechanics of solids**, L. S. Srinath, Tata Mc. Graw Hill,2009.
2. **Theory of Elasticity**, Dr. Sadhu Singh, Khanna Publications, 2004.

Reference books:

1. **Theory of Elasticity**, S. P. Timoshenko and J. N Goodier, Mc. Graw, Hill International, 3rd Ed., 2010.
2. **Applied Elasticity,** Wang C.T.,Mc-Graw Hill Book Company, New York, 1953

E-Books / Web References

1. https://www.pdfdrive.com/elasticity-theory-applications-and-numerics-msaddpdf-d19401775.html
2. https://www.pdfdrive.com/advanced-strength-and-applied-elasticity-d185753366.html

MOOCs

1. https://nptel.ac.in/courses/105105177
2. https://www.coursera.org/courses?query=mechanics%20of%20materials

Scheme of Examination: (Theory courses)

Semester End Examination (SEE):

SEE Question paper is to be set for 100 marks and the marks scored will be proportionately reduced to 50. There will be two full questions (with a maximum of four sub questions) from each module carrying 20 marks each. Students are required to answer any **five full questions** choosing at least **one full question from each module.**

Continuous Internal Evaluation (CIE):

Three Tests are to be conducted for 40 marks each. The average of the three tests are taken for computation of CIE on a scale of 40.

CIE is executed by way of two quizzes / Other Assessment Tools (OATs), and three tests.

Some possible AATs:

Assignments / Oral presentations / Group activity/Projects

Typical Evaluation pattern for regular courses is shown in Table 2.

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Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	CIE Test-1	**40**	**50**
	CIE Test-2	**40**	
	CIE Test-3	**40**	
	QUIZ/OAT	**10**	
SEE	Semester End Examination	**100**	**50**
		Grand Total	**100**

CO/PO Mapping															
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO834.1	3	2	1	1		1	1				1	1	3		
CO834.2	3	2	1	1		1	1				1	1	3		
CO834.3	3	2	1	1		1	1				1	1	3		
CO834.4	3	2	1	1		1	1				1	1	3		
CO834.5	3	2	1	1		1	1				1	1	3		
CO834	**3**	**2**	**1**	**1**		**1**	**1**				**1**	**1**	**3**		

Low - 1: Medium - 2: High - 3

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SEMESTER – VIII

Course: Project phase II

Course Code	22MEDP84	CIE Marks	50
Hours/Week (L: T: P)	0: 0: 2	SEE Marks	50
No. of Credits	08	Examination Hours	03

CIE for Project Phase - II:

1. **Single discipline:** The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates using Rubrics.

2. **Interdisciplinary:** Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable. The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates as per Rubrics covering all Program Outcomes.

SEE for Project Phase - II:

1. **Single discipline:** Contribution to the project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted at the department.
2. **Interdisciplinary:** Contribution to the project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted separately at the departments to which the student/s belong to.

Typical Evaluation pattern for regular courses is shown in Table 2.

Table 2: Distribution of weightage for CIE & SEE of Regular courses

	Component	Marks	Total Marks
CIE	Review-II	50	50
	Review-III	50	
SEE		50	50
Grand Total			100

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SEMESTER – VIII

Course: Technical Seminar

Course Code	22MEDS85	CIE Marks	100
Hours/Week (L: T: P)	1 : 0 : 0	SEE Marks	-
No. of Credits	1	Examination Hours	-

Technical Seminar:

All the students admitted to IV year of BE/B. Tech shall have to do power point presentation on any topic related to Mechanical Engineering during VIII Semester and make a report of the presented topic referring to journals in that area. The prescribed credit shall be included in VIII Semester and shall be considered for the award of bachelor's degree. Those who do not present the Technical Seminar shall be declared fail and shall have to complete during subsequent University examination after satisfying the Technical Seminar requirements.

CIE procedure for Seminar:

The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the Seminar shall be based on the evaluation of Seminar report, presentation skill and question and answer session in the ratio **50:25:25**.

Typical Evaluation pattern for regular courses is shown in Table below.

Distribution of weightage for CIE of Regular courses

	Component	Marks	Total Marks
CIE	Technical Seminar Presentation + Report	**100**	**100**

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SEMESTER – VIII

Course: INTERNSHIP

Course Code	22INT86	CIE Marks	50
Hours/Week (L: T: P)	0 : 0 : 0	SEE Marks	50
No. of Credits	2	Examination Hours	03

Internship:
All the students admitted to III year of BE/B. Tech shall have to undergo mandatory internship of 4 weeks during the vacation of VI and VII semesters and /or VII and VIII semesters. Internship examination shall be conducted during VIII semester and the prescribed credit shall be included in VIII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared fail and shall have to complete during subsequent University examination after satisfying the internship requirements.

CIE procedure for Internship:
The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.
The CIE marks awarded for the Internship shall be based on the evaluation of Internship report, presentation skill and question and answer session in the ratio **50:25:25**.

Typical Evaluation pattern for regular courses is shown in Table.

Table: Distribution of weightage for CIE of Regular courses

	Component	Marks	Total Marks
CIE	Review	**50**	**50**
SEE	Review	**50**	**50**
		Grand Total	**100**

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