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MAHARAJA INSTITUTE OF TECHNOLOGY MYSORE

Autonomous Institution Affiliated to VTU

Competency Based Syllabus (CBS)

for

Mechanical Engineering

(Under Outcome Based Education (OBE) and

Choice-Based Credit System (CBCS))

Offered from 5th to 6th Semesters of Study

in

Partial Fulfillment for the Award of Bachelor's Degree in

Mechanical Engineering

2023 Scheme

Scheme Effective from the academic year 2023-24

Dean Academics
MIT Mysore

APPROVED
Dean Academics

Principal
MIT Mysore

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5th Semester

5th Semester	Professional Course (PC) DYNAMICS OF MACHINES	M23BME501

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Basic Science	• Fundamental concepts of force, motion, energy, and equilibrium. • Understanding forces, moments, and their effects on stationary and moving bodies.
2	Mathematics	• Understanding of solving linear and quadratic equations • Familiarity with geometric shapes, angles, trigonometric functions, and their properties.
3	Engineering Mechanics	• Grasp of mechanical principles such as Newton's laws, free-body diagrams, and vector operations. • Equilibrium of particles and rigid bodies.
4	Dynamics, vector calculus	• Strong foundation in dynamics and kinematics. • Understanding of vector calculus. • Ability to analyse rotating systems.
5	Differential equations	• Strong foundation in dynamics and differential equations. • Ability to solve differential equations. • Understanding of energy methods.

2. Competencies

S/L	Competency	KSA Description
1	**Understand static force analysis**	**Knowledge:** Principles of statics, equilibrium, free body diagrams, force analysis of mechanisms. **Skills:** Drawing free body diagrams, applying equilibrium equations, analyzing mechanisms **Attitudes:** Curiosity about mechanical systems, attention to detail, logical reasoning.
2	**Analyze friction and its effects**	**Knowledge:** Types of friction, laws of friction, friction in bearings, belt drives **Skills:** Calculating frictional forces, analyzing belt drives, determining power transmission **Attitudes:** Critical thinking, problem-solving, practical application.
3	**Balance rotating masses**	**Knowledge:** Concepts of static and dynamic balancing, balancing methods **Skills:** Balancing masses, analyzing unbalanced forces, applying balancing techniques **Attitudes:** Desire for accuracy and precision, systematic approach
4	**Understand gyroscopic principles**	**Knowledge:** Vectorial representation of angular motion, gyroscopic couple, effects of gyroscopic couple **Skills:** Analyzing gyroscopic effects, solving related problems **Attitudes:** Interest in understanding rotational motion, willingness to visualize complex scenarios, excitement about applying knowledge to real-world applications
5	**Analyze undamped free**	**Knowledge:** Concepts of SHM, work done by harmonic force, superposition principle, methods

	vibrations	of analysis **Skills:** Deriving equations of motion, calculating natural frequencies, analyzing spring-mass systems **Attitudes:** Systematic approach, attention to detail, perseverance
6	**Analyze damped free vibrations**	**Knowledge:** Types of damping, overdamped, critically damped, and underdamped systems, logarithmic decrement **Skills:** Analyzing damped systems, determining damping coefficients, solving vibration problems **Attitudes:** Analytical skills, problem-solving, critical thinking

3. Syllabus

DYNAMINCS OF MACHINES **SEMESTER – V**			
Course Code	**M23BME501**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:2:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**50 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Objectives: The students will be able to,

1. Analyze static forces in mechanisms, focusing on equilibrium, free body diagrams, and static force analysis of mechanisms.
2. Evaluate the performance, stability, and power of Porter and Hartnell governors, including force analysis and key characteristics like sensitiveness and isochronism.
3. Apply the laws of friction to mechanical systems, including bearings and belt drives, and calculate related parameters such as belt tensions and power transmission.
4. Perform static and dynamic balancing of rotating masses, ensuring smooth operation by balancing in both the same plane and different planes.
5. Analyze gyroscopic effects on rotating systems, including their impact on planes, ships, and other vehicles.
6. Model and solve problems related to free vibrations in mechanical systems, covering both undamped and damped conditions, and applying various methods of analysis.

Module -1

Static force analysis: Introduction, Static equilibrium, Equilibrium of two force, three force members, Members with two forces and torque, Free body diagrams, Static force analysis (graphical) of four bar mechanism and slider-crank mechanism without friction.

Governors: Types of Governors; Force Analysis of Porter and Hartnell Governors. Controlling Force, Stability, Sensitiveness, Isochronism, Effort and Power.

Module -2

Friction: Definitions, Types of friction, laws of friction, Friction in pivot and collar bearings.

Belt drives: Flat belt drives, ratio of belt tensions, centrifugal tension, and power transmitted.

Module -3

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 same plane and in different planes.

Gyroscope: Vectorial representation of angular motion, Gyroscopic couple. Effect of gyroscopic Couple on plane disc, ship, aeroplane.

Module -4

Introduction: Types of vibrations, Definitions, Simple Harmonic Motion (SHM), Work done by harmonic force, Principle of super position applied to SHM. **Undamped free Vibrations (Single Degree of Freedom)**: Methods of analysis – (Newton's, Energy & Rayleigh's methods). Derivations for spring mass systems, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and problems.
Module -5
Damped free Vibrations (Single Degree of Freedom): Types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and numerical problems.
TEXTBOOKS: 1. Theory of Machines, Sadhu Singh, Pearson Education, 3rd Edition. 2012. 2. The Theory of Machines, Rattan S.S. Tata McGraw Hill Publishing Company Ltd., New Delhi, 5th Edition, 2019. 3. Mechanical Vibrations, V. P. Singh, Dhanpat Rai and Company. 4. Mechanical Vibrations, G. K.Grover, 8th Edition. **REFERENCE BOOKS:** 1. Mechanical Vibrations, S. S. Rao, Pearson Education Inc, 6th edition, 2020. 2. Robert L. Norton, "Kinematics & Dynamics of Machinery," Tata Mc Graw Hill., 1st Edition, 2009, ISBN: 9780071278522. **VIDEO LINKS:** 1. https://dom-nitk.vlabs.ac.in/ 2. https://www.youtube.com/playlist?list=PLGiGNMkNq6Qtc0mWdbG2qGyoJlqoDYFse

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3: Static force analysis, Governors	Introduction to Static equilibrium, Understanding Equilibrium of two force, three force members, Members with two forces and torque, Free body diagrams, Static force analysis (graphical) of four bar mechanism and slider-crank mechanism without friction. Studying different types of Governors; Force Analysis of Porter and Hartnell Governors.
2	Week 4-6: Friction, Belt drives	Understanding the concepts of friction, types of friction and friction in pivot and collar bearing. Understanding Flat belt drives, ratio of belt tensions, centrifugal tension, and power transmitted through flat belt drives.
3	Week 7-8: Balancing of rotating Masses, Gyroscope	Introduction to 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 same plane and in different planes. Studying vectorial representation of angular motion, analyzing Effect of gyroscopic Couple on plane disc, ship, and airplane.
4	Week 9-10: Introduction, Undamped free Vibrations	Introduction to vibration, types of vibrations, Principle of super position applied to SHM. Understanding different Methods of analysis – (Newton's, Energy & Rayleigh's methods). Derivations for spring mass systems, analyzing springs in series and parallel, effect of mass of spring and problems.
5	Week 11-12: Damped free Vibrations	Understanding types of damping, Analysis with viscous damping - Derivations for over, critical and under damped systems, Logarithmic decrement and numerical problems.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
6	Laboratory Learning	Utilize the facilities available in the laboratories to understand the concepts by performing experiments.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understand the principles of static equilibrium	Apply equilibrium equations to analyze forces acting on static bodies and determine unknown forces.
2	Analyze forces in simple mechanisms	Draw free body diagrams and apply equilibrium equations to determine forces in linkages and mechanisms.
3	Understand the concept of friction and its effects	Differentiate between types of friction, calculate frictional forces, and analyze friction in machine elements.
4	Analyze power transmission through belt drives	Calculate belt tensions, power transmitted, and analyze factors affecting belt drive performance.
5	Balance rotating masses to eliminate vibrations	Determine the magnitude and location of balancing masses to eliminate static and dynamic unbalance.
6	Understand the principles of gyroscopic motion	Analyze the gyroscopic couple and its effects on rotating bodies.
7	Analyze undamped free vibrations of single-degree-of-freedom systems	Derive equations of motion for spring-mass systems, determine natural frequencies, and analyze free vibration response.
8	Analyze damped free vibrations of single-degree-of-freedom systems	Analyze the effects of damping on vibration response, calculate damping coefficients, and determine system behavior.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME501.1	**Analyze** the static equilibrium of force systems acting on mechanical components to determine unknown forces and reactions.
M23BME501.2	**Apply** principles of friction to evaluate the performance of machine elements and power transmission systems.
M23BME501.3	**Evaluate** the balance of rotating masses in mechanical systems to minimize vibrations and ensure smooth operation.
M23BME501.4	**Construct** models of dynamic systems involving gyroscopic effects to predict and analyze their behavior.
M23BME501.5	**Implement** vibration control strategies based on an understanding of damped and undamped free vibrations.

CO-PO-PSO Mapping

COs/POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
M23BME501.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME501.2	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME501.3	-	-	3	-	-	-	-	-	-	-	-	-	3	-
M23BME501.4	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME501.5	-	-	3	-	-	-	-	-	-	-	-	-	3	3
M23BME501	3	3	3	-	-	-	-	-	-	-	-	-	3	3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

Dynamics of Machines is a cornerstone in engineering, providing a solid foundation for understanding the behavior of mechanical systems. As technology advances, this field will continue to be vital in:

- **Driving Innovation:** Dynamics will play a crucial role in developing cutting-edge technologies like autonomous vehicles, robotics, and aerospace systems.
- **Solving Global Challenges:** Addressing issues such as climate change and resource scarcity will require innovative solutions, many of which will rely on a deep understanding of dynamics.
- **Enhancing Efficiency:** Optimizing the performance of machinery and systems through dynamic analysis will lead to increased productivity and reduced energy consumption.
- **Advancing Healthcare:** The field of biomechanics, heavily reliant on dynamics, will continue to improve medical devices and treatments.

5th Semester	Professional Core course (IPC) TURBO MACHINES	M23BME502

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Thermodynamics	To excel in turbo machines, students need to understand thermodynamic systems and properties, including open, closed, and isolated systems, as well as state properties like pressure, volume, temperature, and specific heats. They should be able to apply laws of thermodynamics, encompassing concepts of internal energy, work, heat, and energy conservation, covering entropy, irreversibility, and the Carnot cycle. Additionally, proficiency in analyzing thermodynamic processes (isothermal, adiabatic, isobaric, and isochoric) and fundamental cycles such as Carnot and Rankine is essential.
2	Fluid mechanics	To excel in turbo machines, students should have knowledge of fluid properties, including density, viscosity, surface tension, and compressibility. They should grasp the principles of fluid statics, such as pressure distribution in a fluid at rest and the concept of buoyancy. Proficiency in fluid dynamics is crucial, involving the study of continuity, momentum, and energy equations (Bernoulli's equation). Students should also be familiar with flow characteristics, including laminar and turbulent flow, Reynolds number, and boundary layer theory. Understanding and applying concepts like fluid flow in pipes, head loss, and the analysis of various flow regimes, as well as proficiency in dimensional analysis and similitude, are essential for mastering the subject turbo machines.
3	Physics (Mechanics)	Understanding concepts like force, pressure, work, and energy. These principles form the foundation for analyzing fluid forces, pressure distributions, and energy transfer within fluids
4	Calculus (Differential and Integral)	Proficiency in differentiation (finding rates of change) and integration (finding total quantities) to understand concepts like fluid motion, pressure variations, and flow rates
5	Units and its conversions	Familiarity with converting between different units of measurement (e.g., meters to centimetre's, kilograms to grams) as fluid properties and calculations involve various units
6	Problem-solving skills	Fluid mechanics involves applying concepts and equations to solve real-world problems. Strong problem-solving skills will be essential for analyzing scenarios and manipulating equations to find solutions

2. Competencies

S/L	Competency	KSA Description
1	**Introduction to Turbo machines and Thermodynamics of fluid flow**	**Knowledge:** Differentiate turbo machines from positive displacement machines and understand dimensionless parameters.. Apply the first and second laws of thermodynamics to turbo machines. **Skills:** Classify turbo machines and apply dimensionless parameters for performance analysis. Derive thermodynamic relationships and calculate different efficiencies. **Attitudes:** Think critically about the impact of dimensionless parameters. Persist in solving complex thermodynamic problems in turbo machines.
2	**Energy**	**Knowledge:**

	Exchange in Turbo machines	Understand Euler's turbine equation and its alternate form. Learn about velocity triangles, degree of reaction, and their relationships with energy transfer.. **Skills:** Apply Euler's turbine equation and analyse velocity triangles for various degrees of reaction and solve problems involving energy transfer and utilization factors.. **Attitudes:** Persist in understanding and solving problems related to turbo machine performance.
3	**Steam Turbines**	**Knowledge:** Understand the classification of steam turbines and the concepts of impulse and reaction turbines. **Skills:** Analyze and solve problems related to single-stage and multi-stage impulse turbines. Apply conditions for maximum utilization factor in reaction turbines. **Attitudes:** Solving complex problems related to steam turbine performance and compounding.
4	**Hydraulic Turbines**	**Knowledge:** Design parameters and velocity triangles for Pelton, Francis, Kaplan, and Propeller turbines. **Skills:** Analyze and solve problems involving velocity triangles, design parameters, and turbine efficiency. Apply knowledge of draft tube types and functions in turbine design. **Attitudes:** Solving complex problems related to hydraulic turbine design and efficiency.
5	**Centrifugal Pumps**	**Knowledge:** Understand the classification, parts, and key concepts such as heads, efficiencies, NPSH, and cavitation. Learn about the operation of pumps in series and parallel, and the need for priming. **Skills:** Analyze the performance of pumps in different configurations (series and parallel). **Attitudes:** Understanding and solving complex problems related to pump operation

3. Syllabus

TURBO MACHINES **SEMESTER – V**			
Course Code	**M23BME502**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours + 12 Laboratory session**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course Objectives:

1. The course aims at giving an overview of different types of turbo machinery used for energy transformation, such as pumps fans compressors as well as hydraulic and steam turbines.
2. Apply knowledge of various efficiencies, velocity triangles, and design parameters to analyze and solve problems related to the performance of turbines and pumps.
3. Develop problem-solving skills for complex scenarios involving cavitation, suction lift, stalling, and performance analysis in centrifugal and axial flow machines.
4. Apply principles of design and optimization to enhance the performance of turbo machines, including consideration of parameters like blade efficiency, compounding, and operational factors.

Module -1

Introduction: Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification, Dimensionless parameters and their significance, Effect of Reynolds number, Unit and specific quantities, model studies. (Note: Since dimensional analysis is covered in Fluid Mechanics subject, questions on dimensional analysis may not be given. However, dimensional parameters and model studies may be given more weightage.) **Thermodynamics of fluid flow**: Application of first and second law of thermodynamics to turbo machines, Efficiencies of turbo machines, Static and Stagnation states, Incompressible fluids and perfect gases, overall isentropic efficiency, stage efficiency (their comparison) and polytropic efficiency for both compression and expansion processes. Reheat factor for expansion process

Module -2

Energy exchange in Turbo machines: Euler's turbine equation, Alternate form of Euler's turbine equation, Velocity triangles for different values of degree of reaction, Components of energy transfer, Degree of reaction, utilization factor, Relation between degree of reaction and Utilization factor, Problems. General Analysis of Turbo machines: Radial flow compressors and pumps – general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance, Theoretical head – capacity relationship, General analysis of axial flow pumps and compressors, degree of reaction, velocity triangles, Problems.

Module -3

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. Reaction turbine – Parsons's turbine, condition for maximum utilization factor, reaction staging. Problems.

Module -4

Hydraulic Turbines: Classification, various efficiencies. Pelton turbine – velocity triangles, design parameters, Maximum efficiency. Francis turbine - velocity triangles, design parameters, runner shapes for different blade speeds. Draft tubes- Types and functions. Kaplan and Propeller turbines - velocity triangles, design parameters. Problems.

Module -5

Centrifugal Pumps: Classification and parts of centrifugal pump, different heads and efficiencies of centrifugal pump, Minimum speed for starting the flow, Maximum suction lift, Net positive suction head, Cavitation, Need for priming, Pumps in series and parallel. Problems.

PRACTICAL COMPONENT

1. Determination of coefficient of friction of flow in a pipe.
2. Determination of minor losses in flow through pipes.
3. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades
4. Calibration of flow measuring devices.
5. Performance on hydraulic Turbines a. Pelton wheel b. Francis Turbine c. Kaplan Turbines
6. Performance hydraulic pumps.
7. Performance test on a two stage Reciprocating Air Compressor and Performance test on an Air Blower.

TEXTBOOKS:

1. An Introduction to Energy Conversion, Volume III, Turbo machinery, V. Kadambi and Manohar Prasad, New Age International Publishers, reprint 2008.
2. Turbo Machines, B. U. Pai, 1st Editions, Wiley India Pvt, Ltd.
3. Turbines, Compressors & Fans, S. M. Yahya, Tata McGraw Hill Co. Ltd., 2nd edition, 2002

REFERENCE BOOKS:

1. Principals of Turbo machines, D. G. Shepherd, The Macmillan Company (1964).
2. Fluid Mechanics & Thermodynamics of Turbo machines, S. L. Dixon, Elsevier (2005).
3. Text Book of Turbo machines, M. S. Govindegouda and A. M. Nagaraj, M. M. publications, 4Th Ed, 2008.

VIDEO LINKS:

1. https://archive.nptel.ac.in/courses/112/104/112104305/
2. https://www.youtube.com/watch?v=5AQQAuJwHi0&list=PLGiGNMkNq6QtXl6N4Qcuu6F4iCVJaoju7

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3: Introduction to Turbo machines and Thermodynamics of fluid flow	Covers the fundamentals of turbo machines, including their definitions, components, classifications, and the significance of dimensionless parameters and model studies. It also explores the application of thermodynamic principles, such as the first and second laws, to analyze efficiencies, fluid states, and performance metrics like isentropic, stage, and polytropic efficiencies for both compression and expansion processes.
2	Week 4-6: Energy Exchange in Turbo machines	The syllabus addresses energy exchange in turbo machines through Euler's turbine equations and their alternate forms, focusing on velocity triangles, degree of reaction, and the relationship between degree of reaction and utilization factor. It also includes general analysis of radial and axial flow compressors and pumps, examining energy transfer, blade discharge angles, performance effects, and theoretical head-capacity relationships.
3	Week 7-8: Steam Turbines	The syllabus covers steam turbines, including their classification, single-stage and multi-stage impulse turbines, and the conditions for achieving maximum blade and utilization efficiency. It also explores the need for compounding, methods of compounding, and reaction turbines such as the Parsons turbine, with a focus on reaction staging and efficiency.
4	Week 9-11: Hydraulic Turbines	The syllabus covers hydraulic turbines, including their classification and efficiencies. It includes detailed analysis of Pelton, Francis, Kaplan, and Propeller turbines, focusing on velocity triangles, design parameters, maximum efficiency, runner shapes, and draft tubes' types and functions.
5	Week 11-12: Centrifugal Pumps	The syllabus covers centrifugal pumps, including their classification, components, various heads and efficiencies, and key operational aspects such as minimum starting speed, maximum suction lift, net positive suction head, cavitation, and the need for priming. It also explores the use of pumps in series and parallel configurations.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of thermodynamics concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies
5	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
6	Laboratory Learning	Utilize the facilities available in the laboratories to perform experiments of determining the coefficient of friction and minor losses in pipes, applying momentum equations to jet impact on blades, calibrating flow measuring devices, and testing the performance of hydraulic turbines, centrifugal and reciprocating pumps, a two-stage air compressor, and an air blower.

6. Assessment Details (both CIE and SEE)

CIE

Components		Number	Weightage	Max. Marks	Min. Marks
Theory (A)	Internal Assessment-Tests (A)	2	**60%**	**15**	**06**
	Assignments/Quiz/Activity (B)	2	**40%**	**10**	**04**
	Total Marks		**100%**	**25**	**10**

Components		Number	Weightage	Max. Marks	Min. Marks
Laboratory(B)	Record Writing	Continuous	**60%**	15	06
	Test at the end of the semester	1	**40%**	10	04
	Total Marks		**100%**	**25**	**10**

Final CIE Marks = (A) + (B)

SEE

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. The question paper may include at least one question from the laboratory component.
5. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Introduction to Turbo machines and Thermodynamics of fluid flow	Understand the fundamental concepts of turbo machines, including their classification, components, and performance metrics, while applying thermodynamic principles to analyze efficiencies, fluid states, and energy transfer processes in both compression and expansion operations.
2	Energy Exchange in Turbo machines	To understand the principles of energy exchange in turbo machines by applying Euler's turbine equations, analyzing velocity triangles, and evaluating the effects of degree of reaction and utilization factors on performance and energy transfer.
3	Steam Turbines	The learning objective is to understand the classification and operation of steam turbines, including single-stage and multi-stage impulse turbines, reaction turbines, and compounding methods, while analyzing conditions for maximum efficiency and utilization.
4	Hydraulic Turbines	The learning objective is to understand the classification, design parameters, and performance metrics of hydraulic turbines, including Pelton, Francis, Kaplan, and Propeller turbines, and to evaluate the function of draft tubes and the impact of various design factors on turbine efficiency.
5	Centrifugal Pumps	The learning objective is to understand the classification, components, and operational characteristics of centrifugal pumps, including their heads, efficiencies, suction lift, net positive suction head, cavitation, priming needs, and performance in series and parallel configurations.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME502.1	Apply the fundamental concepts of turbo machines and thermodynamic principles to evaluate their performance and energy transfer processes..
M23BME502.2	Apply Euler's turbine equations and concept of velocity triangles to determine the effects of degree of reaction and utilization factors on energy exchange and performance in turbo machines.
M23BME502.3	Analyze the operation, efficiency, and compounding methods of various steam turbines, including single-stage and multi-stage impulse turbines, and reaction turbines.
M23BME502.4	Evaluate the design, performance, and efficiency of hydraulic turbines such as Pelton, Francis, Kaplan, and Propeller turbines, including the role of draft tubes and design parameters.
M23BME502.5	Assess the classification, components, and operational characteristics of centrifugal pumps, including their performance metrics, efficiency, and behavior under different operational conditions.
M23BME502.6	Conduct experiments to analyze flow characteristics, measure performance and efficiency of hydraulic turbines, pumps, and compressors, and calibrate flow measurement devices.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME502.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME502.2	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME502.3	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME502.4	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME502.5	-	**3**	-	-	-	-	-	-	-	-	-	-	-	3
M23BME502.6	-	**3**	-	-	-	-	-	-	-	-	-	-	-	3
M23BME502	**3**	**3**	-	-	-	-	-	-	-	-	-	-	3	3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**CO6**	**Total**
Module 1	**5**						**5**
Module 2		**5**					**5**
Module 3			**5**				**5**
Module 4				**5**			**5**
Module 5					**5**		**5**
Lab Component						**25**	**25**
Total	**5**	**5**	**5**	**5**	**5**	**25**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

- **Energy Efficiency and Sustainability**: Enhancements in turbo machine design will contribute to improved energy efficiency in power generation, including more efficient gas turbines and steam turbines for reducing fuel consumption and emissions.
- **Renewable Energy Technologies:** Turbo machinery will play a crucial role in optimizing wind turbines and hydroelectric generators, enabling more effective harnessing of renewable energy sources and contributing to sustainable energy solutions.
- **Customized Energy Solutions**: The future will see tailored turbo machine designs for specific applications, including customized solutions for diverse energy needs and environments, enhancing efficiency and performance across various sectors.
- **Healthcare and Medical Applications**: Turbo machinery principles can be applied to develop advanced medical devices, such as high-performance pumps for cardiovascular systems and more efficient ventilators for respiratory support.

5th Semester	Professional Course (PC) Computer Aided Design and Manufacturing	M23BME503

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Mathematics	Linear Algebra: Essential for understanding transformations, modelling, and manipulation of 3D objects.
2	Materials Science	Knowledge about different materials and their properties is crucial when designing products.
3	Geometric Dimensioning and Tolerance (GD&T):	Knowledge of GD&T is important for precise manufacturing.
4	Manufacturing Techniques	Familiarity with different manufacturing processes (e.g., machining, casting), helps in designing manufacturable parts.

2. Competencies

S/L	Competency	KSA Description
1	CAD Fundamentals:	**Knowledge:** Familiarity with key CAD software (e.g., AutoCAD, Solid Works, CATIA, Fusion 360) and their capabilities. **Skills:** Ability to create detailed 2D technical drawings and 3D models using CAD software. **Attitudes:** Willingness to meticulously check and refine designs to ensure quality.
2	Manufacturing Processes	**Knowledge:** Knowledge of traditional and modern manufacturing processes (e.g., CNC machining, 3D printing, injection molding). **Skills:** Basic programming skills to customize and automate tasks within CAD/CAM software. **Attitudes:** A proactive approach to exploring creative design solutions and innovative manufacturing techniques.

3. Syllabus

Computer Aided Design and Manufacturing SEMESTER –V			
Course Code	**M23BME503**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:1:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**50 hours Theory**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course Objectives:

1. To impart knowledge of different concepts of production system by developing mathematical models
2. To make students to understand the Computer Applications in Design and Manufacturing [CAD /CAM) leading to Computer integrated systems. Enable them to perform various transformations of entities on display devices.
3. To expose students to computer aided process planning, material requirement planning, and capacity planning etc. Flexible Manufacturing Systems.
4. To expose the students to CNC Machine Tools, CNC part programming.
5. To introduce the students to concepts of Additive Manufacturing, Internet of Things, and Industry 4.0 lead to Smart Factory.

Module -1

Product design and CAD/CAM in the production system: Product design and CAD, the design process application of computers in design, Computer aided Manufacturing, computerized elements of a CIM system, CAD/CAM and CIM.

Mathematical models and Matrices in Production Systems automated manufacturing systems- types of automation, reasons for automating, Mathematical models and matrices: production rate, production capacity, utilization and availability, manufacturing lead time, work-in- process, numerical problems.

Module -2

CAD and Computer Graphics Software: The design process, applications of computers in design, software configuration, functions of graphics package, constructing the geometry. Transformations: 2D transformations, translation, rotation and scaling, homogeneous transformation matrix, concatenation, numerical problems on transformations.
Module -3
Group Technology and Cellular Manufacturing: Part families, parts classifications and coding, Production flow Analysis, cellular Manufacturing- composite part concept, machine cell design, applications of group technology, Grouping parts and machines by Rank order clustering technique, Arranging machines in a G.T. cell. **Computer-Aided Process Planning:** Retrieval and Generative Systems, benefits of CAPP, Material Requirement Planning, inputs to MRP system, working of MRP, outputs and benefits, Capacity Planning.
Module -4
Computer Numerical Control: Introduction, components of CNC, CNC programming, manual part programming, G Codes, M Codes, programming of simple components in turning, drilling and milling systems, programming with canned cycles. Cutter radius compensations. **Flexible Manufacturing :**Introduction, FMS components, Flexibility in Manufacturing – machine, Product, Routing, Operation, types of FMS, FMS layouts, FMS planning and control issues, deadlock in FMS, FMS benefits and applications
Module -5
Additive Manufacturing Systems: Basic principles of additive manufacturing, slicing CAD models for AM, advantages and limitations of AM technologies, Additive manufacturing processes: Photo polymerization, material jetting, binder jetting, material extrusion, Powder bed sintering techniques, sheet lamination, applications of AM. **Future of Automated Factory:** Industry 4.0, functions, applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing
TEXTBOOKS: 1 Automation, Production Systems and Computer-Integrated Manufacturing Mikell P Groover Pearson Learning. 4th Edition,2015 2 CAD/CAM/CIM Dr. P. Radhakrishnan New Age International Publishers, New Delhi. 3rd edition **REFERENCE BOOKS:** 1 "CAD/CAM" Ibrahim Zeid Tata McGraw Hill. 2 Internet of Things (IoT): Digitize or Die: Transform your organization. Embrace the digital evolution. Rise above the competition Nicolas Windpassinger Amazon. 3 Internet of Things: A Hands-on Approach" ArshdeepBahga and Vijay Madisetti Universities Press 4 Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Ian Gibson, David W. Rosen, Brent Stucker 2nd Ed. (2015)

5. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3:	**Product design and CAD/CAM in the production system:** Product design and CAD, the design process application of computers in design, Computer aided Manufacturing, computerized elements of a CIM system, CAD/CAM and CIM. **Mathematical models and Matrices in Production Systems**, automated manufacturing systems- types of automation, reasons for automating, Mathematical models and matrices: production rate, production capacity, utilization and availability, manufacturing lead time, work-in- process, numerical problems.
2	Week 4-6:	**CAD and Computer Graphics Software:** The design process, applications of computers in design, software configuration, functions of graphics package, constructing the geometry. Transformations: 2D transformations, translation, rotation and scaling, homogeneous transformation matrix, concatenation, numerical problems on transformations.
3	Week 8-11:	**Group Technology and Cellular Manufacturing:** Part families, parts classifications and coding, Production flow Analysis, cellular Manufacturing-composite part concept, machine cell design, applications of group technology, Grouping parts and machines by Rank order clustering technique, Arranging machines in a G.T. cell. **Computer-Aided Process Planning:** Retrieval and Generative Systems, benefits of CAPP, Material Requirement Planning, inputs to MRP system, working of MRP, outputs and benefits, Capacity Planning.

4	Week 7-8:	**Computer Numerical Control**: Introduction, components of CNC, CNC programming, manual part programming, G Codes, M Codes, programming of simple components in turning, drilling and milling systems, programming with canned cycles. Cutter radius compensations. **Flexible Manufacturing :**Introduction, FMS components, Flexibility in Manufacturing – machine, Product, Routing, Operation, types of FMS, FMS layouts, FMS planning and control issues, deadlock in FMS, FMS benefits and applications
5	Week 9-12:	**Additive Manufacturing Systems:** Basic principles of additive manufacturing, slicing CAD models for AM, advantages and limitations of AM technologies, Additive manufacturing processes: Photo polymerization, material jetting, binder jetting, material extrusion, Powder bed sintering techniques, sheet lamination, direct energy deposition techniques, applications of AM. **Future of Automated Factory:** Industry 4.0, functions, applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing

6. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Computer Aided Design and Manufacturing concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

7. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	TotalMarks			**50**	**20**

FinalCIE Marks =(A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME503.1	Apply mathematical modelling for manufacturing systems and impart knowledge of Product design, CAD/CAM and CIM
M23BME503.2	Apply computers in design and transformations of graphics
M23BME503.3	Analyse group technology for Grouping parts, machines and process planning procedure
M23BME503.4	Interpret CNC programming for various contours machines and FMS systems
M23BME503.5	Identify modern trends like additive manufacturing ,industry 4.0 and IOT leading to smart manufacturing

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME503.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME503.2	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME503.3	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME503.4	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME503.5	**3**	**-**	-	-	-	-	-	-	-	-	-	-	3	-
	3	**3**	-	-	-	-	-	-	-	-	-	-	3	3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

Integration of AI and Machine Learning: CADM tools will increasingly incorporate AI to optimize designs, predict failures, and reduce the need for physical prototyping. This will lead to more efficient and accurate design processes.

Digital Twin Technology: The use of digital twins—virtual replicas of physical products—will allow engineers to simulate real-world conditions, leading to better product designs and maintenance strategies.

Additive Manufacturing (3D Printing): CADM software is essential for designing components for 3D printing. As additive manufacturing becomes more mainstream, mechanical engineers will need to be proficient in CADM tools to design complex, lightweight, and optimized components that traditional manufacturing methods can't produce.

Automation and Customization: The integration of automation in manufacturing processes is growing. CADM tools will be able to directly interface with CNC machines, robots, and other automated systems, enabling seamless production from design to manufacturing. **Mass Customization**: CADM will play a key role in the trend toward mass customization, where products are tailored to individual customer specifications but still produced at scale.

Integration with IoT (Internet of Things): As products become more connected, CADM systems will integrate IoT data, allowing engineers to design products that can be monitored and updated in real-time after they are deployed. This will lead to more adaptive and intelligent product designs.

5th Semester	Professional Course Lab (PCL) Machining and Foundry Lab	M23BMEL504

1. Prerequisites

S/L	Proficiency	Prerequisites
1	**Basic Understanding of Engineering Drawing**	Students should be familiar with interpreting engineering drawings, dimensions, tolerances, and symbols for machining and foundry work.
2	**Fundamentals of Material Science**	A foundational knowledge of materials science, including the properties of metals, alloys, and other materials used in machining and foundry processes, is essential for understanding how materials behave during machining and casting.
3	**Fundamentals of Manufacturing Processes**	Knowledge of basic manufacturing processes, including turning, milling, drilling, and casting
4	**Basic Workshop Practice**	Knowledge of use of basic hand tools, measurement instruments like callipers gauges and safety practices.
5	**Basic Mathematics and Geometry**	Understanding of basic mathematical concepts and geometric principles is essential for calculating dimension and other parameters

2. Competencies

S/L	Competency	KSA Description
1	**Lathe operations**	**Knowledge:** Understanding of different lathe operations like plain turning, facing, knurling, drilling, taper turning, step turning, and thread cutting. Familiarity with material properties and their impact on machining processes. Awareness of safety protocols specific to lathe operations. **Skills:** Proficiency in setting up and operating a lathe machine. Ability to measure and achieve precise dimensions using measuring tools. Competence in selecting appropriate tools and machining parameters for different operations. **Attitude:** Attention to detail in machining tasks. Patience and persistence in achieving accurate results. Responsibility in following safety guidelines and maintaining the equipment
2	**Shaper operations**	**Knowledge:** Understanding the principles of shaping machine operations. Knowledge of different cutting techniques for grooves. **Skills:** Competence in setting up a shaping machine and securing the work piece. Ability to produce accurate grooves with the desired surface finish. **Attitude:** Precision and care in machine setup and operation. Commitment to following safety practices during the shaping process.
3	**Foundry Model**	**Knowledge:** Understanding the properties of molding sand mixtures and the role of different components. Familiarity with various foundry tools and equipment. Knowledge of mold-making techniques using different patterns. **Skills:** Ability to prepare green sand molds and use foundry tools effectively. Proficiency in creating molds with complex patterns and ensuring they are ready for pouring. **Attitude:** Meticulousness in preparing sand mixtures and molds. Collaboration and teamwork in handling foundry tasks.

		Awareness of safety and environmental considerations in foundry work.
4	**Sand Test Experiments**	**Knowledge:** Understanding of permeability in relation to sand molds and its importance in casting. Understanding the significance of AFS fineness number and its impact on casting quality. Understanding how clay and moisture content influence the properties of sand molds. Familiarity with the procedure for determining permeability, sand grain size distribution and moisture content of sand. **Skills:** Proficiency in conducting permeability tests and interpreting results. Competence in conducting sieve analysis and calculating fineness number. Ability to design and conduct experiments to study mold properties. Proficiency in analyzing the results and making adjustments. **Attitude:** Analytical mindset in testing and interpreting data. Attention to detail in conducting experiments accurately. Precision in conducting tests and handling equipment.

3. Syllabus

Machining and Foundry Lab **SEMESTER – V**			
Course Code	**M23BMEL504**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(0:0:2:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**12 session**	Total Marks	**100**
Credits	**01**	Exam Hours	**03**

Course objectives:

The objectives of this course is to

- To provide an insight to different machine tools, accessories and attachments.
- To train students into machining operations to enrich their practical skills.
- To provide an insight into different sand preparation and foundry equipment
- To provide training to students to enhance their practical skills in foundry

Sl.NO	Experiments
1	Preparation of one model on lathe involving - Plain turning, Facing, Knurling, Drilling, Taper turning, Step turning, Thread cutting operations.
2	One Job, Cutting of V Groove/ Rectangular groove using a shaper.
3	Foundry Practice: Use of foundry tools and other equipment for Preparation of molding sand mixture. Preparation of green sand molds kept ready for pouring in the following cases: 1. Using two molding boxes (hand cut molds). 2. Using patterns (Single piece pattern / Split pattern).
4	To determine permeability number of green sand, core sand and raw sand.
5	To determine AFS fineness no. and distribution coefficient of given sand sample
6	Studying the effect of the clay and moisture content on sand mould properties
Demonstration Experiments	
7	Demonstration / Experiment on Cutting of Gear Teeth using Milling Machine.
8	Demonstration / Experiment of Simple operations on the drilling and grinding machine.
9	Demonstration/Experimentation of simple programming of CNC machine operations.

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to Machining & Foundry	Introduction to different Machine tools and foundry tools and its usage, laboratory safety procedures. operating of lathe and shaper. Demonstration of the model
2	Week 3-4: Lathe Machine	Preparation of lathe model covering the operations such as turning, step turning, taper turning and thread cutting
3	Week 5-6: Shaper	Preparation of shaper model covering the operations such V groove and rectangular groove.
4	Week 7-8: Foundry	Preparation of Foundry model with hand cut and use of pattern.
5	Week 9-10: Sand Test Experiments	Conducting experiment to determine permeability No, AFS fines No and moisture, clay content of sand used in mould
6	Week 11-12: Demonstration Machine tools	Demonstration of gear cutting teeth on milling machine, operations on drilling and grinding machine.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Animations or videos showcasing gear teeth cutting and drilling operations.
3	Collaborative Learning	Encourage students in group interaction, sharing responsibility, active participation and interdepency
4	Lab Manuals	Lab manuals outlining the objectives, procedures, safety guidelines, and expected outcomes of each experiment or task.
5	Industry Visits	Arrange visits to local industries which helps students connect their lab experiences with real-world applications and industry standards.

6. Assessment Details (both CIE and SEE)

The weight-age of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

Continuous Internal Evaluation (CIE): CIE marks for the practical course is 50 Marks.

Class Work:-A

CIE Split up for Laboratory

SL. No.	Description	% of Marks	In Marks
1	Write-up, Conduction, result and model preparation	60%	30
2	Viva-Voce	40%	20
Total		**100%**	**50**

The Class work marks should be scaled down to 30marks (60% of the maximum Marks)

Laboratory Test: -B

Internal test for laboratory course with write up and conduction of experiments for a total of 100 mark at the end the semester and the assessment pattern is

Marks distribution for Practical Course for CIE

Sl. No.	Description	% of Marks	In Marks
1	Observation, write-up./conduction of experiment	80% of the maximum	80
2	Viva-Voce	20% of the maximum	20
Total		100%	100

Marks scored by the student for 100 are scaled down to 20 marks.

Final CIE for Laboratory

SL. No.	Description	% of Marks	In Marks
1	Scaled Down marks of record	60% of the maximum	30
2	Scaled Down marks of test-B	40% of the maximum	20
Total		**100%**	**50**

Final CIE Marks = (A) + (B)

Semester End Evaluation (SEE):

1. SEE marks for practical course shall be 50 marks

Marks distribution for Experiment based Practical Course for Final CIE

SL. No.	Description	% of Marks	Marks
1	Write-up, Procedure	20%	20
2	Model preparation, Conduction and result	60%	60
3	Viva-Voce	20%	20
Total		**100%**	**100**

2. SEE for practical course is evaluated for 100 marks and scored marks shall be scaled down to 50 marks.
3. Change of experiment/program is allowed only once and 20% marks allotted to the procedure/write-up part to be made zero.
4. Duration of SEE shall be 3 hours

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understand Lathe Machine Operations	Gain knowledge of lathe machine components, safety protocols, and the principles of various machining operations.
2	Develop Tool Handling Skills	Learn to select and handle appropriate tools for different machining tasks, ensuring precision and accuracy.
3	Understand Shaper Machine Operations	Learn the principles of shaping machine operations, including setting up the machine and selecting the appropriate tools for groove cutting.
4	Implement Safe Shaping Practices	Apply safety protocols while operating the machine tools to ensure safe and efficient operations.
5	Develop Mould Making Skills	Practice preparing green sand molds using hand cut molds and patterns, ensuring readiness for pouring.
6	Understand Permeability Testing, Sieve finess no and role of clay and moisture in sand mould	Learn the importance of permeability in sand moulds, Gain knowledge of AFS fineness number and its significance how clay and moisture content affect the properties of sand moulds.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME504.1	**Demonstrate** Integral parts of various machine tools and develop the models by procedural adaption of machine tools through various operations.
M23BME504.2	**Demonstrate** shills in preparation of foundry models involving hand cutting and use of pattern
M23BME504.3	**Evaluate** the properties of foundry sand through experiments

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME504.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME504.2	3		-	-	-	-	-	2	-	-	-	-	3	-
M23BME504.3	-	3	-	-	-	-	-	2	-	-	-	-	-	3
M23BME504	**3**	**3**	-	-	-	-	-	2	-	-	-	-	3	3

9. Assessment Plan

Continuous internal Evaluation

CO1	CO2	CO3	Total
17	17	16	50

Semester End Examination

CO1	CO2	CO3	Total
40	40	20	100

10. Future with this Subject:

The Machining and Foundry laboratory in fifth semester of B.E mechanical program will lay the foundation on future with a focus on machining and foundry technologies which holds significant promise and potential for students to specialize in these areas. Here's an overview of what the future could look like for students who pursue this subject

1. Advancements in Technology:

Integration of Industry 4.0:

The ongoing shift towards Industry 4.0, which emphasizes automation, data exchange, and smart manufacturing, will increasingly incorporate advanced machining and foundry processes. Students with expertise in these areas will be well-positioned to work with technologies like IoT, robotics, and AI in manufacturing environments.

2. Additive Manufacturing (3D Printing):

The growth of additive manufacturing is transforming traditional machining and foundry techniques. Future professionals will need to integrate 3D printing with conventional methods to create hybrid manufacturing solutions that offer enhanced flexibility and efficiency.

3. Innovation and Research Opportunities:

R&D in New Materials:

The future of machining and foundry will involve working with new materials, including composites, advanced alloys, and smart materials. Students with a deep understanding of these processes will be at the forefront of research and development, driving innovations in material science and manufacturing techniques.

Process Optimization:

Continuous improvement in machining and foundry processes will be critical to enhancing productivity and reducing costs and professionals will be involved in optimizing production lines, developing new machining strategies, and implementing advanced process controls.

5th Semester	Professional Elective (PE) AUTOMOBILE ENGINEERING	M23BME505A

1. Prerequisites

S/L	Proficiency	Prerequisites
	Fundamentals of mathematics	Basic understanding of calculus, algebra and statistics to solve mathematical equations to simulate how components will perform under various conditions
2.	**Chemistry**	Basic knowledge of chemistry can be beneficial, especially for understanding materials and fuels used in automobiles.
3.	**Fundamentals of thermodynamics**	Basic principles of thermodynamics are foundational for understanding and improving various aspects of vehicle performance and efficiency. It also helps in interpretation of heat management via cooling and fuel injection systems
4.	**Fundamentals of Mechanics**	Understanding of fundamental mechanical concepts such as force, work, energy, and power. And knowledge of statics and dynamics, including Newton's laws of motion, torque, and equilibrium of forces to assure the design is safe and stable
5.	**Material Science**	Understanding the properties of materials helps in selecting the right materials for different automotive components. Also to analyze and prevent failure of components improving reliability and safety
6.	**Engineering drawing**	Familiarity with technical drawing or CAD (Computer-Aided Design) is often useful for visualizing and designing automotive components.

2. Competencies

S/L	Competency	KSA Description
1.	**Fundamentals of automobile engineering**	**Knowledge:** Understanding the history of automobiles and functionality of various components resulting in automobiles **Skill:** Identify the type of automobile based on their features and components. **Attitude:** Openness to adapt to various emission norms and automotive guidelines
2.	**Types of transmission and suspension systems**	**Knowledge:** Understanding the functionality of various types of transmission and suspension systems adapted in automobiles **Skill:** Ability to analyze the functioning of transmission and suspension systems **Attitude:** Demonstrating a proactive approach to diagnosing and solving issues related to transmission and suspension systems.
3.	**Adaptability of Electrical systems in automobiles**	**Knowledge:** Understanding the circuitry related to power supply from battery to various components in automobiles **Skill:** Ability to assess the functionality alternators, starter motors and additional featured electrical support systems like sunroof, power windows, DRL etc **Attitude:** Identifying potential issues leading to malfunctioning of components and troubleshooting.
4.	**Influence of Ignition system**	**Knowledge:** Understanding of the role of ignition system in internal combustion engines

		Skill: Ability to select type of ignition systems to automobiles based on their operating frequency **Attitude:** Carefully following diagnostic procedures and installation guidelines to avoid errors.
5	**Vehicle stability**	**Knowledge:** Understanding the operating principles of various steering mechanisms and braking systems that control the direction and vehicle traction stability **Skills:** Select various types of steering and braking system based on vehicle types **Attitudes:** Evaluate the wheel balancing issues and braking components to enhance their operating conditions
6	**Road wheels**	**Knowledge:** Fundamental understating of various types of tyres, their designation and types of wheels **Skills:** Select the tyre and wheel type based on the type of travel **Attitude:** Evaluate the life of tyre based on wear and tear and suggest for its replacement
7	**Safety**	**Knowledge:** Understanding the modern vehicle safety measures **Skill**: Analyze the occupant protection features and choose additional safety features **Attitude:** Explore the technological advantages and suggest for its implementation in occupant safety
8	**Alternate to IC Engines**	**Knowledge:** Comparative understanding of the automobiles that are alternates to IC Engines like Solar, Hybrid, Electric vehicles **Skill:** Assess the performance of various types of automobiles and compare their effectiveness **Attitude:** Recommend the selection of vehicles based on proper understanding of vehicle capacities

3. Syllabus

AUTOMOBILE ENGINEERING SEMESTER – V			
Course Code	**M23BME505A**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives:
This course will enable students to:

1. Understand the main components of automobile
2. Interpret the emission norms as per the standards
3. Understand the working of transmission and control system employed in automobiles
4. Understand the alternative automotive technologies
5. Understand the recent technologies introduced in automobiles towards facilities and safety systems

MODULE - 1 (8 Hours)

History of Automobile, Classification of Automobile based on Usage, Chassis, Body, Power Sources, capacity, main components of Internal Combustion Engines and their Functions, Fuel supply system, Cooling System, Lubrication System, Engine Management System, super charged engines, hybrid engines, modern GT engines. Emission standards and norms

MODULE 2 (8 Hours)

Gear Box - Gear Shifting mechanism, synchromesh Gear box, Torque converter
Automatic Manual Transmission (AMT), Automatic Transmission (AT), Intelligent Manual Transmission (IMT) Continuously Variable Transmission (CVT), Infinitely Variable Transmission (IVT), Working of Differential, Rear Axle -

types & construction.
Suspension – working principle and functions of Hydraulic & Air suspension, Independent suspension, Leaf Spring, Coil Spring, Telescopic Shock Absorber, Torsion Bar

MODULE 3 (8 Hours)

Electrical systems - Types of batteries, mode of charging battery - electric circuit, principle and working of an alternator, types of starter motor, recent technologies - sunroof, power windows, DRL & cornering headlights
Ignition system - Battery type, Magneto type and Electronic type

MODULE 4 (8 Hours)

Steering system – Construction and working of Rack & pinion, worm & wheel and power Steering, steering geometry, Wheel balancing
Braking System- principle of operation in Mechanical Brakes, Hydraulic Brakes, Parking brakes and ABS,
Tyres and Wheels - Classification of Tyres, Tyre size designation, Tubeless tyres, Alloy wheels,
Case studies on 2Wheel drive and 4Wheel drive mechanisms

MODULE 5 (8 Hours)

Safety system - Safety measures in modern vehicles, safety frames, working of an air bags, seat belt, collapsible steering, spoilers, defoggers, fire safety measures in heavy vehicles, bullet proof vehicles, advanced driver assistance systems (ADAS)
Alternate vehicles – layout and functionality of Ethanol engines, CNG vehicles, Hydrogen - fuel cell vehicles, Solar powered vehicles , Electric vehicles and Hybrid vehicles

Text Book(s)

1. Automobile engineering, Kirpal Singh, Vol I and II (12th Edition) Standard Publishers 2011
2. Automobile Engineering, R. B. Gupta, Satya Prakashan, (4th Edition) 1984.

Reference Books

1. Automotive Mechanics, Joseph Heitner, Second Edition, East-West Press, 1999.
2. Automobile Engineering, S K Gupta, S Chand Publishing, Second Edition, 2020
3. Automotive Engineering, David A. Crolla, Elsevier, 2009.

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc20_de06/preview
- https://nptel.ac.in/courses/107106088
- https://www.youtube.com/watch?v=LZ82iANWBL0&list=PLbMVogVj5nJTW50jj9_gvJmdwFWHaqR5J

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to history of automobiles, components and emission standards	Know about the history of automobiles and their classification, Layout of an automobile , Functionality of various components in automobiles , Principle of operation in super charged , hybrid and modern GT engines, Emission standards and norms up to recent times
2	Week 3-5: Gear Box, Transmission And Suspension systems	Understand the gear shifting mechanism and synchromesh gear box, Operating principles of various types of transmission systems and differential, Various types of rear axles and their construction, Operating principles of various types of suspension system
3	Week 6-7: Electrical system and Ignition systems	Know about different types of batteries, Understanding the concept of battery charging, Working principle of alternators and starter motors, Operating circuits in sunroof , power windows, DRL & cornering headlights, Operating principles of various types of ignition systems
4	Week 8-10: Steering system, braking system and Tyres & Wheels	Understand the construction and working of various types of steering mechanisms and wheel balancing, Operating principle of various types of braking systems, Classification of tyres and their designation, Study on tubeless tyres and alloy wheels, Basic understanding on 2wheel drive and 4wheel drive mechanisms as case studies
5	Week 11-12: Safety system and Alternate vehicles	Study on safety features like air bags, seat belt, collapsible steering, fire safety measures, bullet proof vehicles and ADAS, general layout and operating conditions in CNG, Fuel cell, solar powered, electric and hybrid vehicles

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize Chalk and talk lecture format to reinforce competencies related to automobile engineering
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding the functionality and operations of various components in automobile engineering
3	Collaborative Learning	Encourage collaborative learning through groups for improved understanding about recent developments in automobile engineering.
4	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies like repair and maintenance of vehicle parts
5	Multiple Representations	Introduce topics related to technological developments in automobiles via various representations like verbal, graphical and mathematical to improve the competency
6	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies in various categories of automobile across the globe
7	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate enhanced comprehension by students
8	Socratic Questioning	Pose questions like what? Why? Is it true? Is that the only way? to stimulate critical thinking among students and encourage meaningful discussions

6. **Assessment Details (both CIE and SEE)**

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Fundamentals of automobile engineering	Understand the fundamental principles of various components and operations in automobile engineering and assess different power sources
2	Emission norms	Know about the emissions norms and standards setup as per the automotive act and interpret the same on various sectors of automobiles
3	Transmission and control systems	Explore the concept of gear box, transmission, suspension, braking systems, and steering mechanisms and their functions

4	Electrical system	Understand the influence of electrical circuits on alternators, starter motors and other features provided in automobiles
5	Tyres and Wheels	Know about various types of tyres and their designation, various types of wheels and their utilization based on their operating capacities
6	Facilities and Safety system	Understand about various facilities provided in automobiles for the occupants and their safety
7	Alternate vehicles	Comparative understanding of automobiles available as alternatives for IC engines

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME505A.1	Apply the acquired knowledge of automobile engineering to describe the functionality of various components and emission standards
M23BME505A.2	Asses the operation features of transmission and suspension systems
M23BME505A.3	Analyze the automotive electrical systems and ignition systems
M23BME505A.4	Infer the effectiveness of steering and braking systems, tyres and wheels in automobiles
M23BME505A.5	Analyze the safety features provided for occupants and various alternate vehicles for IC engines

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME505A.1	3						3							
M23BME505A.2		3											2	
M23BME505A.3		3											2	
M23BME505A.4		3											2	
M23BME505A.5		3				3								2
M23BME505A	**3**	**3**				**3**	**3**						**2**	**2**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

The future of automobile engineering, particularly for mechanical engineers, is evolving rapidly due to advancements in technology, shifts in consumer demands, and global trends. Here are some key areas where the field is heading and how they might shape future automobile engineering courses:

1. Electric Vehicles (EVs): Courses will increasingly cover the design, development, and integration of electric power trains, battery technology, and electric drive systems.
2. Hybrid Systems: Emphasis on understanding hybrid power trains, energy management, and regenerative braking systems.
3. Autonomous Driving: Learning about the principles of autonomous vehicle technology, including sensor integration, machine learning, and artificial intelligence (AI).
4. Alternative Fuels: Study of alternative fuel technologies, including hydrogen fuel cells, biofuels, and synthetic fuels.
5. Eco-Friendly Design: Emphasis on sustainable design practices, lightweight materials, and energy-efficient technologies to reduce the environmental impact of vehicles.
6. Material Science: Exploring new materials such as advanced composites, high-strength alloys, and smart materials used in automotive design.
7. Manufacturing Innovations: Learning about advanced manufacturing techniques, including 3D printing, automation, and robotics in vehicle production.
8. User Experience (UX): Designing intuitive and user-friendly interfaces for vehicle controls, infotainment systems, and display technologies.
9. Ergonomics: Ensuring that vehicle designs meet the ergonomic needs of users for safety and comfort.
10. Cutting-Edge Research: Opportunities for involvement in research and development projects focused on breakthrough technologies and innovative solutions in automobile engineering.
11. Entrepreneurship: Encouragement of entrepreneurial thinking and innovation to drive new business ventures and startups in the automotive sector.

5th Semester	Professional Course (PC) MECHATRONICS	M23BME505B

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Fundamental Mechanical engineering course	Basic knowledge of statics, dynamics and mechanical system at different scenarios.
2	Fundamental Electrical engineering courses	Knowledge of basic electronic components and circuits. Knowledge of basic electrical circuits, including AC and DC motors.
3	Measurement and metrology	Knowledge of techniques and tools used to measure physical quantities like temperature, pressure, and displacement.
4	System Integration	Ability to integrate various subsystems (mechanical, electrical, and software) into a cohesive system.
5	Basic Concepts of Project management	Understanding of project management principles to handle multidisciplinary projects effectively

2. Competencies

S/L	Competency	KSA Description
1	Mechatronic System design	**Knowledge**: Fundamental knowledge of mechanical and electrical system. **Skills**: Integration of mechatronics components into system. **Attitudes:** Proficiency in integration of design of mechatronics system.
2	Data Acquisition and signal conditioning	**Knowledge**: Understanding Digital signals, Implementation of Signal conditioning methods **Skills**: Ability to use DAQ systems and its interfacing with systems. **Attitudes**: Understanding SCADA system and its interfaces.
3	Ladder Programming and PLC	**Knowledge**: Basics of Digital Logics, **Skills**: Ability to program and interface PLC into the systems **Attitudes**: Interface the PLC systems with mechanical, electrical, pneumatic and hydraulic systems.
4	Fault Finding and Diagnostics	**Knowledge**: Identify the components of mechatronics system **Skills**: Ability to identify the fault and repair. **Attitudes:** Able to detect fault and diagnose the mechatronic system

3. Syllabus

MECHATRONICS SEMESTER – V			
Course Code	M23BME505B	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students to:

- To Gain knowledge of basics of Mechatronics systems and mechatronics design process
- To substantiate the need for interdisciplinary study in technology education
- To demonstrate the integration philosophy in view of Mechatronics technology using PLC.
- To be able to work efficiently in multidisciplinary teams.

Module -1

Introduction: Definition, Multidisciplinary Scenario, Basic elements of mechatronics system, Measurement systems, Objectives, advantages and disadvantages of Mechatronics Examples of Mechatronics Systems such as Automatic Car Park system, Engine management system, Antilock braking system (ABS) control, Automatic washing machine,

Mechatronics Design process: Stages of design process – Traditional and Mechatronics design process.

Pedagogy	Chalk and Talk, Power point Presentations, Real time examples	**08 Hours**

Module -2

Transducers and sensors: Definition of transducers and sensors, Smart sensor, Performance Terminology, Static and dynamic characteristics of sensors, Classification of transducers, Difference between transducer and sensor, Classification of sensors, Potentiometers, Strain gauges, Capacitance sensors, LVDT, Proximity Switches, force and pressure sensors, Principle of working and applications of light sensors, temperature sensors, Hall Effect sensors. Encoders.

Pedagogy	Chalk and Talk, Power point Presentations, Real time examples, Lab demonstration	**08 Hours**

Module -3

Actuation Systems: Electrical systems, Relays and Solenoids, Solid state switches-Diodes, Transistor, thyristor and triacs, MOSFET, DC Motors, Permanent magnet DC motor, DC Motor with field coils, Brushless DC Motors, Stepper Motors, DC servo motors – 4-quadrant Servo-drives

Signal Conditioning: Introduction, Signal conditioning processes, filtering- Low pass, high pass, notch filtering, Pulse width modulation, Analogue and digital signals, Digital to analogue Conversion (DAC's), Analog to digital conversions (ADC's), Data acquisition (DAQ), Data acquisition systems (DAQS), data loggers, Supervisory control and data acquisition (SCADA).

Pedagogy	Chalk and Talk, Power point Presentations, Real time examples, Lab demonstration	**08 Hours**

Module -4

Programmable Logic Controller: Introduction to PLCs, Basic structure of PLC, Principle of operation, input and output processing, PLC programming language, ladder diagram, ladder diagrams circuits using logic gates, timer counters, selection of PLC for application.

Application of PLC control: Extending and retracting a pneumatic piston using latches, control of two pneumatic pistons, control of process motor, control of vibrating machine, control of process tank, control of conveyer motor etc.

Pedagogy	Chalk and Talk, Power point Presentations, Real time examples	**08 Hours**

Module -5

Fault Finding: Fault - Detection Techniques, Watch Dog Timer, Parity and Error Coding Checks, Common Hardware Faults, Microprocessor Systems-Fault finding techniques, in micro-processor, Systematic fault location methods, Self testing, Emulation and Simulation,

PLC Systems- Program testing, Testing inputs and outputs, PLC as a monitor system.

Pedagogy	Chalk and Talk, Power point Presentations, Real time examples	**08 Hours**

TEXT BOOKS:

1. Mechatronics–Electronic Control Systems in Mechanical and Electrical Engineering, W.Bolton Pearson Education 1st Edition, 2005
2. Mechatronics System Design by Devdas Shetty and Richard A Kolk, Second edition, Thomson Learning Publishing Company, Vikas publishing house, 2001.

REFERENCE BOOKS:

1. Mechatronics by HMT Ltd. – Tata McGrawHill, 1st Edition, 2000. ISBN:9780074636435.
2. Nitaigour Premchand Mahalik , Mechatronics-Principles, Concepts and Applications, Tata McGraw Hill, 1st Edition, 2003 ISBN.No. 0071239243, 9780071239240.
3. Introduction to Programmable Logic Controllers by Garry Dunning, 2nd edition, Thomson, ISBN:981-240-625-5
4. Programmable Logic Controllers by W.Bolton

E-Resources

https://onlinecourses.nptel.ac.in/noc21_me27/preview

https://www.youtube.com/watch?v=5cBpwaLdmcg&list=PLGiGNMkNq6QtPIsDxbTnCBtro4Ghttwx0

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to Mechatronics & Mechatronics design process	**Introduction:** Definition, Multidisciplinary Scenario, Basic elements of mechatronics system, Measurement systems, Objectives, advantages and disadvantages of Mechatronics Examples of Mechatronics Systems **Mechatronics Design process: S**tages of design process – Traditional and Mechatronics design process.
2	Week 3-4: Transducers and Sensors	**Transducers and sensors:** Definition of transducers and sensors, Smart sensor, Performance Terminology, Static and dynamic characteristics of sensors, Classification of transducers, Difference between transducer and sensor, Classification of sensors, Potentiometers, Strain gauges, Capacitance sensors, LVDT, Proximity Switches, force and pressure sensors, Principle of working and applications of light sensors, temperature sensors, Hall Effect sensors. Encoders.
3	Week 5-6: Actuation systems	**Actuation Systems:** Electrical systems, Relays and Solenoids, Solid state switches-Diodes, Transistor, thyristor and triacs, MOSFET, DC Motors, Permanent magnet DC motor, DC Motor with field coils, Brushless DC Motors, Stepper Motors, DC servo motors – 4-quadrant Servo-drives
4	Week 7-8: Signal Conditioning	**Signal Conditioning:** Introduction, Signal conditioning processes, filtering-Low pass, high pass, notch filtering, Pulse width modulation, Analogue and digital signals, Digital to analogue Conversion (DAC's), Analog to digital conversions (ADC's), Data acquisition (DAQ), Data acquisition systems (DAQS), data loggers, Supervisory control and data acquisition (SCADA).
5	Week 9-10: PLC and its Applications	**Programmable Logic Controller:** Introduction to PLCs, Basic structure of PLC, Principle of operation, input and output processing, PLC programming language, ladder diagram, ladder diagrams circuits using logic gates, timer counters, selection of PLC for application. **Application of PLC control:** Extending and retracting a pneumatic piston using latches, control of two pneumatic pistons, control of process motor, control of vibrating machine, control of process tank, control of conveyer motor etc.
6	Week 11-12: Fault Finding	**Fault Finding:** Fault - Detection Techniques, Watch Dog Timer, Parity and Error Coding Checks, Common Hardware Faults, Microprocessor Systems-Fault finding techniques, in micro-processor, Systematic fault location methods, Self testing, Emulation and Simulation, PLC Systems- Program testing, Testing inputs and outputs, PLC as a monitor system.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method Chalk and talk, PPT	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of mechatronics components.
3	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies like automatic washing machine, digital cameras, temperature control etc.
4	Lab Demonstration	The working of transducers, sensors and actuators can be demonstrated in mechatronics laboratory

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

5. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
6. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
7. The students have to answer 5 full questions selecting one full question from each module.
8. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Basics of Mechatronics system and mechatronic design process	Students will grasp the fundamental concepts of mechatronic systems and implement the same in mechatronic design process. and Students will create a detailed analysis framework for choosing the right sensors and transducers , Signal conditioning methods based on specific needs and constraints
2	Integration philosophy in Mechatronics	Students will critically examine real-world applications, identifying and explaining the interface circuitry or interfacing devices like micro-processor, micro-controllers, PLC systems.
3	Multi-disciplinary team	Students will become proficient in. developing diverse skills, broaden their perspectives, and tackle complex problems collaboratively in multi-discipline scenarios.
4	Project-Based Learning	A small mini projects can be taken up for better understanding of sensors, actuators and micro-processor systems.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME505B.1	Interpret the components of mechatronics systems in mechatronic system design
M23BME505B.2	Analyze the working principles of various sensors and transducers, and differentiate between their applications in real-world scenarios.
M23BME505B.3	Make use of the knowledge on signal conditioning methods and actuation methods in real time interfacing of mechatronics system.
M23BME505B.4	Evaluate the principles of ladder logics and PLC programming in mechatronics system
M23BME505B.5	Utilize the principles of the fault detection in mechatronics system.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME505B.1	**3**												**3**	
M23BME505B.2		**3**											**3**	
M23BME505B.3	**3**												**3**	
M23BME505B.4		**3**			**3**								**3**	
M23BME505B.5	**3**												**3**	
M23BME505B	**3**	**3**			**3**								**3**	

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

The "Mechatronics" course in the 5th semester of the B.E program lays a strong foundation for several future courses in the undergraduate program. The contributions of this subject extend across Industry 4.0 and smart manufacturing, Automation and robotics, Healthcare and diagnostics, automotive industry, etc

Mechatronics, an interdisciplinary field combining mechanical engineering, electronics, computer science, and control engineering, has a promising future with numerous opportunities for innovation and application.

In summary, the "Mechatronics" course serves as a stepping stone, equipping students with the opportunities across multiple industries. As technology advances, the role of mechatronics in creating smarter, more efficient, and more reliable systems will continue to grow, driving innovation and improving quality of life. The fundamental knowledge and skills that is essential for the subsequent courses in their B.E program and for their future careers in various technology-related fields.

5th Semester	Professional Elective (PE) SUPPLY CHAIN MANAGEMENT & INTRODUCTION TO SAP	M23BME505C

1. Prerequisites

S/L	Proficiency	Prerequisites
	Mathematics	Basic understanding of calculus, algebra and statistics is often required for optimizing supply chain processes.
2.	**Statistics**	Basic knowledge of probability and statistics is useful for analyzing data and making informed decisions in SCM
3.	**Economics**	Understanding microeconomics, supply and demand, and market structures can be helpful
4.	**Management Principles**	Familiarity with general management concepts and organizational behavior will aid in grasping SCM strategies.
5.	**Production Processes**	Basic knowledge of manufacturing processes and logistics can provide a solid foundation.
6.	**Software Tools**	Experience with tools like Excel, ERP systems, or SCM software can be beneficial.

2. Competencies

S/L	Competency	KSA Description
1.	**Fundamentals of Supply chain management**	**Knowledge:** Understanding the evolution of supply chain, its components and importance in manufacturing sector **Skill:** Ability to analyze data related to supply chain metrics such as inventory levels, lead times, and demand forecasts. **Attitude:** Create and evaluate different scenarios to understand the impact of changes in the supply chain.
2.	**Sourcing strategy**	**Knowledge:** Understanding about various sourcing entails and its objectives within the supply chain **Skill:** Ability to differentiate between various sourcing strategies **Attitude:** Build strategies for establishing and maintaining strong relationships with key suppliers.
3.	**Distribution network design**	**Knowledge:** Understanding the concept of distribution network design and its role in overall supply chain **Skill:** Ability to decide parameters in network design such as the number and location of facilities, transportation modes, and inventory policies. **Attitude:** Using simulation and modeling techniques to evaluate different network design scenarios and their impact on performance.
4.	**Network**	**Knowledge:**

	optimisation models	Understanding the basic principles of optimization, including objectives, constraints, and feasible regions. **Skill:** Ability to analyze the flow of goods through the network and model these flows in optimization problems **Attitude:** Formulate supply chain optimization models, including defining objective functions, constraints, and decision variables.
5	**Supply chain integration**	**Knowledge:** Understanding the importance of supply chain integration and its criticality for improving supply chain performance and competitiveness. **Skills:** Ability to integrate with external partners, including suppliers, distributors, and customers. **Attitudes:** Build techniques for developing and managing partnerships with suppliers and customers to enhance integration.
6	**Supply chain restructuring**	**Knowledge:** Understanding of the key objectives of restructuring such as optimizing the supply chain network, improving service levels, and enhancing flexibility. **Skills:** Identifying the gaps between current performance and desired outcomes to validate the need for restructuring. **Attitude:** Evaluate cost-benefit analyses to understand the impact of restructuring decisions on overall supply chain performance.
7	**Fundamentals of material management and SAP**	**Knowledge:** Understanding the history of SAP, system architecture including its layers such as presentation, application and database, and its role in enterprise resource planning (ERP) **Skill**: Ability to analyze the interaction within the various modules in SAP and with enterprise systems **Attitude:** Build techniques for migrating data into SAP from other systems, including data extraction, transformation, and loading (ETL) processes.

3. Syllabus

SUPPLY CHAIN MANAGEMENT & INTRODUCTION TO SAP SEMESTER – V			
Course Code	**M23BME505C**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives:

This course will enable students :

11. To acquaint with key drivers of supply chain performance and their inter-relationships with strategy.
12. To impart analytical and problem-solving skills necessary to develop solutions for a variety of supply chain management & design problems.
13. To study the complexity of inter-firm and intra-firm coordination in implementing programs such as e-collaboration, quick response, jointly managed inventories and strategic alliances.
14. To understand the usage of SAP material management system

MODULE - 1 (8 Hours)

Introduction: Supply Chain – Fundamentals, Evolution, Role in Economy, Importance, Decision Phases, Supplier Manufacturer - Customer chain, Enablers/ Drivers of Supply Chain Performance, Supply chain strategy , Supply Chain Performance Measures.

Strategic Sourcing Outsourcing: Make Vs buy - Identifying core processes - Market Vs Hierarchy - Make Vs buy continuum -Sourcing strategy, Supplier Selection and Contract Negotiation. Creating a world class supply base-Supplier Development - World Wide Sourcing.

MODULE 2 (8 Hours)
Warehouse Management Stores management-stores systems and procedures-incoming materials control stores accounting and stock verification Obsolete, surplus and scrap-value analysis-material handling transportation and traffic management -operational efficiency-productivity-cost effectiveness-performance measurement. Supply Chain Network Distribution Network Design – Role - Factors Influencing Options, Value Addition – Distribution Strategies - Models for Facility Location and Capacity allocation. Distribution Center Location Models.
MODULE 3 (8 Hours)
Supply Chain Network optimization models. Impact of uncertainty on Network Design - Network Design, decisions using Decision trees. Planning Demand, -multiple item -multiple location inventory management. Pricing and Revenue Management.
MODULE 4 (8 Hours)
Current Trends: Supply Chain Integration - Building partnership and trust in Supply chain Value of Information: Bullwhip Effect - Effective forecasting - Coordinating the supply chain. Supply Chain restructuring, Supply Chain Mapping - Supply Chain process restructuring, Postpone the point of differentiation – IT in Supply Chain - Agile Supply Chains -Reverse Supply chain. Future of IT in supply chain- E Business in supply chain.
MODULE 5 (8 Hours)
Introduction to SAP, SAP Material Management, Procurement process, Organization structure, Enterprise structure, Master data management, purchase Info record, source list, procurement cycle, purchase requisition, request for quotation, purchase order, inventory management, invoice verification, service management, transaction code
Text Books
3. Janat Shah, Supply Chain Management– Text and Cases, Pearson Education, 2nd edition 4. Sunil Chopra and Peter Meindl, Supply Chain Management-Strategy Planning and Operation, PHI Learning / Pearson Education, 6th edition. 5. Martin Murray & Jawad Akhtar, Materials Management with SAP ERP: Functionality and Technical Configuration, SAP Press; Fourth edition.
Reference Books
4. Dr Jorg Thomas Dickersbach, Supply chain management with SAP APO, Springer, 3rd edition 2008 **5.** Ashfaque Ahmed, The SAP Materials Management Handbook, CRC Press Publication. 2014 edition.
Web links and Video Lectures (e-Resources): • https://onlinecourses.nptel.ac.in/noc21_mg45/preview • https://nptel.ac.in/courses/110106045 • https://www.udemy.com/course/sap-mm-training/ • https://www.udemy.com/course/sap-s4hana-mm-sourcing-and-procurement/ • https://nptel.ac.in/courses/110105095

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to SCM and Strategy sourcing	Introduction: Supply Chain – Fundamentals, Evolution, Role in Economy, Importance, Decision Phases, Supplier Manufacturer - Customer chain, Enablers/ Drivers of Supply Chain Performance, Supply chain strategy , Supply Chain Performance Measures. Strategic Sourcing Outsourcing: Make Vs buy - Identifying core processes - Market Vs Hierarchy - Make Vs buy continuum, Supplier Selection and Contract Negotiation. Creating a world class supply base-Supplier Development - World Wide Sourcing.
2	Week 3-5: Warehouse management and Supply chain network design	Warehouse Management Stores management-stores systems and procedures-incoming materials control stores accounting and stock verification Obsolete, surplus and scrap-value analysis-material handling transportation and traffic management -operational efficiency-productivity-cost effectiveness-performance measurement. Supply Chain Network Distribution Network Design, Models for Facility Location and Capacity allocation. Distribution Center Location Models.

3	Week 6-7: Supply chain network optimization models	Supply Chain Network optimization models. Impact of uncertainty on Network Design - Network Design, decisions using Decision trees. Planning Demand, -multiple item -multiple location inventory management. Pricing and Revenue Management.
4	Week 8-10: Current trends in SCM	Know about Supply Chain Integration - Building partnership and trust in Supply chain, Value of Information: Bullwhip Effect, Supply Chain restructuring, Supply Chain Mapping, Supply Chain process restructuring, Postpone the point of differentiation – IT in Supply Chain - Agile Supply Chains -Reverse Supply chain. Future of IT in supply chain- E Business in supply chain.
5	Week 11-12: SAP	Understanding the fundamentals of SAP Material Management, Procurement process, Organization structure, Enterprise structure, Master data management, purchase Info record, source list, procurement cycle, purchase requisition, request for quotation, purchase order, inventory management, invoice verification, service management, transaction code

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize Chalk and talk lecture format to reinforce competencies related to supply chain management and SAP
2	Video demonstration	Incorporate video demonstrations to enhance understanding the functionality and operations of various tools and software's used in SCM & SAP
3	Collaborative Learning	Encourage collaborative learning through group's preferably case studies discussion for improved understanding about SCM and materials management
4	Problem-Based Learning (PBL)	Implement PBL to enhance analytical skills and practical application of competencies inventory, supply chain and materials management
5	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies like Amazon, Flipkart, DMart etc
6	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate enhanced comprehension by students
7	Socratic Questioning	Pose questions like what? Why? Is it true? Is that the only way? to stimulate critical thinking among students and encourage meaningful discussions

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.

3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Fundamentals of supply chain management (SCM)	Understand the basic knowledge of SCM and Explain how each participant contributes to the value chain and impacts overall supply chain performance.
2	Key drivers of SCM	Identify the key drivers that impact the efficiency and effectiveness of supply chain management.
3	Strategy sourcing and decision	Understand the concept of strategic sourcing and its alignment with overall supply chain strategies and organizational goals.
4	SCM network design	Understand the contribution and effectiveness of the key components and elements of a supply chain network, including suppliers, manufacturing facilities, distribution centres, and customers
5	SCM optimization models	Gain proficiency in different types of network optimization models, such as linear programming (LP), integer programming (IP), mixed-integer programming (MIP), and network flow models.
6	Current trends	Learn about different strategies and approaches for supply chain restructuring, including network redesign, process reengineering, and technology adoption.
7	SAP	Understand the primary SAP modules, their functionality and interrelationships of these modules in SAP system
8	Modern tools	Comprehensive understanding of various software's and IT tools preferred in SCM and SAP platforms

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME505C.1	Apply the acquired knowledge of supply chain management to interpret the importance, performance and strategy sourcing
M23BME505C.2	Build and manage a competitive supply chain using strategies, models, techniques and information technology
M23BME505C.3	Make use of the concepts demand, inventory and supply to optimize supply chain network.
M23BME505C.4	Analyze the aspects of supply chain integration and restructuring
M23BME505C.5	Assess Systems Applications and Products (SAP) modules using data processing and material management

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME505C.1	3	-	-	-	-	-	-	-	-	-	-	-	-	-
M23BME505C.2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
M23BME505C.3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
M23BME505C.4	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME505C.5	-	3	-	-	3	-	-	-	-	-	-	-	3	-
M23BME505C	**3**	**3**	-	-	**3**	-	-	-	-	-	-	-	**3**	**3**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

Studying supply chain management (SCM) and SAP as a mechanical engineering student can be highly advantageous. The future of these fields is promising due to the increasing complexity and globalization of supply chains.

1. Integration of Technologies: SCM increasingly integrates advanced technologies like AI, IoT, and block chain. Knowledge of these technologies through SAP can enhance your understanding of modern SCM practices.
2. Career Opportunities: Combining mechanical engineering with SCM and SAP opens up diverse career paths in industries like manufacturing, logistics, and consulting, where systems optimization and process management are keys.
3. Holistic Skill Set: This combination provides a comprehensive skill set, merging engineering problem-solving with strategic and operational management, making you highly competitive in the job market.
4. Global Trends: The emphasis on digital transformation and data-driven decision-making in SCM aligns with global trends, making expertise in SAP valuable for navigating these changes effectively.

5th Semester	Professional Elective (PE) ENERGY ENGINEERING	M23BME505D

1. Prerequisites

S/L	Proficiency	Prerequisites
1.	Basic Physics	• Basic understanding of classical mechanics, thermodynamics, and electromagnetism. • Knowledge of energy forms, energy conversion, and basic principles of heat transfer.
2.	Basic Chemistry	• Understanding of chemical reactions and processes. • Understanding the materials and reactions involved in energy storage, bioenergy, and fuel cells.
3.	Basic Biology	• Basics of plant biology and ecology for bioenergy.
4.	Environmental Science	• Basic understanding of Ecology, Pollution & Environmental Impact and Sustainability. • Understanding of the impact of energy production and consumption on the environment.
5.	Conventional Sources	• Basic knowledge of fossil fuels, coal, hydro & nuclear.

2. Competencies

S/L	Competency	KSA Description
1.	**Energy Sources & its availability**	**Knowledge:** • Understanding knowledge of different energy sources. • Understanding of the business aspects of energy, including the ability to identify market opportunities and develop new energy-related ventures. **Skills:** • Ability to analyze alternative solutions to overcome the problems of conventional energy sources. **Attitudes:** • Recognizing the significances of energy sources availabity.
2.	**Design and Implementation**	**Knowledge:** • Knowledge of system integration and the ability to work with hybrid energy systems. • Understanding of energy storage solutions and their integration with renewable sources. **Skills:** • Ability to design and implement renewable energy systems such as solar, wind, hydro, and biomass energy systems. • Identifying and solving technical issues in renewable energy systems. **Attitudes:** • Perform economic and environmental impact analyses of renewable energy solutions.
3.	**Innovative Thinking**	**Knowledge:** • Proficiency in making informed decisions based on data analysis, technical feasibility, economic viability, and environmental impact. **Skills:** • Ability to develop creative solutions to challenges in the renewable energy sector. **Attitudes:** • Openness to think creative ideas for improvisation for renewable sources.

4.	**Ethical and Sustainable Practices**	**Knowledge:** • Understanding of ethical issues related to energy production and consumption. • Understanding of sustainability principles and their importance in the energy sector. **Skills:** • Adaptability to evolving industry trends and emerging challenges. **Attitudes:** • Commitment to promoting the awareness of the ethical implications of energy choices and their impact on the environment and society.

3. Syllabus

ENERGY ENGINEERING SEMESTER – V			
Course Code	**M23BME505D**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Objectives:

1. Understand energy scenario, energy sources and their utilization
2. Learn about energy conversion methods
3. Study the principles of renewable energy conversion systems.

Module -1

Steam Generators: Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures, LaMount, Benson, Velox, Loeffer, Schmidt steam generators, Cooling towers and Ponds, Accessories such as Superheaters, De-superheater, Economizers, Air preheaters.

Module -2

Solar Energy: Introduction, Solar radiation at the earth's surface, Solar radiation measurements, Flat plate collectors, Focussing collectors, Solar pond, Solar electric power generation-Solar photovoltaics.

Biomass Energy: Photosynthesis, photosynthetic oxygen production, energy plantation. Bio Chemical Route: Biogas production from organic wastes by anaerobic fermentation, Bio gas plants-KVIC, Janta, Deenbhandu models, factors affecting bio gas generation.

Module -3

Geothermal Energy: Forms of geothermal energy, Dry steam, wet steam, hot dry rock and magmatic chamber systems.

Tidal Energy: Tidal power, Site selection, Single basin and double basin systems, Advantages and disadvantages of tidal energy.

Wind Energy: Wind energy-Advantages and limitations, wind velocity and wind power, Basic components of wind energy conversion systems, horizontal and vertical axis wind mills, coefficient of performance of a wind mill rotor, Applications of wind energy.

Module -4

Hydroelectric plants: Advantages & disadvantages of water power, Hydrographs and flow duration curves numericals, 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, water hammer.

Ocean Thermal Energy: Ocean thermal energy conversion, Principle and working of Rankine cycle, Problems associated with OTEC.

Module -5

Nuclear Energy: Principles of release of nuclear energy-Fusion and fission reactions. Nuclear fuels used in the reactors, Chain reaction, Moderation, breeding, Multiplication and thermal utilization factors. General components of a nuclear reactor and materials, Brief description-Pressurized water reactor, Boiling water reactor, Sodium graphite reactor, Fast Breeder reactor, Homogeneous graphite reactor and gas cooled reactor, Radiation hazards, Shielding, Nuclear waste, Radioactive waste disposal.

Text Books:

1. Power Plant Engineering, P. K. Nag, Tata McGraw Hill Education Private Limited, New Delhi, Third Edition, 2012.
2. Power Plant Engineering, Arora and Domkundwar, Dhanpat Rai & Co. (P)Ltd., 1996, Sixth Edition, 2012.
3. Non-conventional Sources of Energy, G.D.Rai, Khanna Publishers, New Delhi Fifth Edition.
4. Non-conventional energy resources, B H Khan, McGraw Hill Education, 3rd Edition.

Reference Books:

1. Principles of Energy Conversion, A. W. Culp Jr, McGraw Hill, 1996.
2. Power Plant Technology, M.M. EL-Wakil, McGraw Hill Internationa,l 1994.

Links

https://archive.nptel.ac.in/courses/103/103/103103206/
https://archive.nptel.ac.in/courses/121/106/121106014/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Steam Generators	Introduction to energy sources, Classification of Energy Sources, Sustainable development, social implications, worldwide renewable energy availability, renewable energy availability in India, brief descriptions on energy alternatives. Introduction to Internet of energy (IOE).
2	Week 3-4: Fundamentals of Solar Energy & Solar electric power generation	Introduction, Solar radiation at the earth's surface, Solar radiation measurements, Flat plate collectors, Focussing collectors, Solar pond, Solar electric power generation-Solar photovoltaics.
3	Week 5-6: Biomass Energy, Geothermal Energy & Tidal Energy.	Photosynthesis, photosynthetic oxygen production, energy plantation. Bio Chemical Route: Biogas production from organic wastes by anaerobic fermentation, Bio gas plants-KVIC, Janta, Deenbhandu models, factors affecting bio gas generation. Forms of geothermal energy, Dry steam, wet steam, hot dry rock and magmatic chamber systems. Tidal power, Site selection, Single basin and double basin systems, Advantages and disadvantages of tidal energy. Forms of geothermal energy, Dry steam, wet steam, hot dry rock and magmatic chamber systems. Tidal power, Site selection, Single basin and double basin systems, Advantages and disadvantages of tidal energy.
4	Week 7-8: Wind Energy	Wind energy-Advantages and limitations, wind velocity and wind power, Basic components of wind energy conversion systems, horizontal and vertical axis wind mills, coefficient of performance of a wind mill rotor, Applications of wind energy.
5	Week 9-10: Hydroelectric plants & Ocean Thermal Energy	Advantages & disadvantages of water power, Hydrographs and flow duration curves numericals, 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, water hammer. Ocean thermal energy conversion, Principle and working of Rankine cycle, Problems associated with OTEC.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	**1.** Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	**2.** Incorporate visual aids like videos/animations to enhance understanding of the concepts.
3	Collaborative Learning	**3.** Encourage collaborative learning for improved competency application.
4	Real-World Application	**4.** Discuss practical applications to connect theoretical concepts with real-world competencies.

5	Flipped Class Technique	**5.** Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

Professional Elective Course (PE)

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Steam generation	Students will learn the properties of steam, including the phases of water (liquid, vapor), and the thermodynamic properties such as temperature, pressure, enthalpy, and entropy.
2	Solar Energy	Students will learn the principles of solar radiation and its interaction with the Earth's atmosphere. And also able to describe various solar energy technologies, including photovoltaic (PV) systems and solar thermal systems.
3	Wind Energy	Students will learn the construction & working principle of wind energy conversion and the design of wind turbines. Also analyze the factors affecting wind energy potential, such as wind speed, turbine placement, and environmental considerations.
4	Bioenergy	Students will learn the different types of bioenergy sources, including biomass, biogas, and biofuels & also to describe the processes involved in converting biomass into usable energy.
5	Ocean Energy	Students will understand the principles and technologies related to tidal, wave, and ocean thermal energy conversion.
6	Geothermal energy	Students will learn the construction & working principle of geothermal energy conversion and the major problems associated with it.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME505D.1	**Interpret** the working principles of different types of boilers and steam turbines used in power generation.
M23BME505D.2	**Identify** and describe the main components of a solar power system, including solar panels and explain the concept of Solar Radiation.
M23BME505D.3	**Infer** the concepts related to types and working of wind and biomass energy.
M23BME505D.4	**Illustrate** the operational conditions and utilization of energy in water resources
M23BME505D.5	**Utilize** the knowledge acquired on geothermal & nuclear resources and identify their key operating principles with relative merits and demerits.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME505D.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME505D.2	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME505D.3	3	-	-	-	-	-	-	-	-	-	-	-	-	2
M23BME505D.4	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME505D.5	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME505D	**3**	-	-	-	-	-	-	-	-	-	-	-	**3**	**2**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

❖ Energy Efficiency and Management

- **Building Energy Efficiency**: Design and retrofitting of energy-efficient buildings, including HVAC systems, lighting, insulation, and smart energy management systems.
- **Industrial Energy Efficiency**: Optimization of energy use in industrial processes, waste heat recovery, and implementation of energy-saving technologies.
- **Energy Auditing**: Conducting energy audits to assess energy consumption and recommend improvements for residential, commercial, and industrial facilities.

❖ Power Generation and Distribution

- **Conventional Power Plants**: Design, operation, and optimization of fossil-fuel-based power plants, including coal, natural gas, and oil-fired plants.
- **Nuclear Energy**: Engineering of nuclear reactors, safety systems, waste management, and development of next-generation nuclear technologies like small modular reactors (SMRs) and fusion energy.
- **Smart Grids**: Integration of renewable energy sources, demand-side management, and advanced grid technologies to create more resilient and flexible power systems.
- **Microgrids**: Design and implementation of microgrids for decentralized power generation, particularly in remote areas or as backup systems.

5th Semester	Project Work (PW) MINI PROJECT	M23BXX506

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Basic Engineering Principles	Fundamental courses in the respective engineering stream
2	Application of Theoretical Knowledge in Practical Scenarios	Knowledge of the core subjects of the respective stream
3	Project Design and Planning	Familiarity with design tools and project management techniques.
4	Multidisciplinary Collaboration	Basic knowledge of related disciplines (e.g., Mechanical students should have a basic understanding of Electronics, etc.).
5	Technical Communication	Writing technical reports and presenting technical content

2. Competencies

S/L	Competency	KSA Description
1	Problem Identification and Analysis	**Knowledge:** Understanding the problem domain and relevant engineering concepts. **Skill:** Ability to analyze and break down complex problems into manageable parts. **Attitude:** Attention to detail and a systematic approach to problem-solving.
2	Solution Design and Implementation	**Knowledge:** Familiarity with design methodologies and tools. **Skill:** Proficiency in creating prototypes or models using appropriate technologies. **Attitude:** Creativity and innovation in developing solutions.
3	Interdisciplinary Collaboration	**Knowledge:** Understanding of basic concepts from other engineering disciplines. **Skill:** Effective communication and teamwork in a multidisciplinary environment. **Attitude:** Openness to different perspectives and willingness to collaborate.
4	Technical Documentation and Presentation	**Knowledge:** Standards and practices for technical writing and reporting. **Skill:** Ability to document the project effectively and present it to an audience. **Attitude:** Confidence and clarity in communication.
5	Project Management	**Knowledge:** Understanding of project timelines, resource allocation, and risk management. **Skill:** Ability to plan, execute, and monitor a project from start to finish. **Attitude:** Responsibility and accountability in managing project tasks.

3. Project Timeline

S/L	Timeline	Description
1	**Week 1-2:** Introduction and Problem Definition	Students will define their project problem, scope, and objectives with the guidance of their mentors.
2	**Week 3-4:** Research and Feasibility Study	Conduct background research, explore existing solutions, and evaluate the feasibility of different approaches.
3	**Week 5-6:** Design and Planning	Develop a detailed project plan, including design specifications, timelines, and resource requirements.
4	**Week 7-8:** Prototype Development	Begin building the initial prototype or model, focusing on core functionalities.
5	**Week 9-10:** Testing and	Test the prototype, identify issues, and refine the design to improve

	Refinement	performance.
6	**Week 11:** Final Implementation and Documentation	Complete the final implementation of the project and prepare detailed documentation.
7	**Week 12:** Presentation and Evaluation	Present the project to a committee for evaluation, followed by a Q&A session.

5. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:
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, shall be based on the evaluation of the project work 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.

SEE: There shall be no SEE.

6. Learning Objectives

S/L	Learning Objectives	Description
1	Identify and Analyze Engineering Problems	Students will learn to identify real-world engineering problems, analyze them, and propose feasible solutions.
2	Design and Implement Solution(s)	Students will gain experience in designing and implementing engineering solutions using appropriate tools and methodologies.
3	Collaborate Effectively in Teams	Students will develop teamwork skills through collaboration with peers from different engineering disciplines.
4	Communicate Technical Information	Students will enhance their ability to document and present technical information effectively.

7. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BXX506.1	Apply engineering principles to identify, formulate, and solve real-world problems.
M23BXX506.2	Design and develop prototypes or models that address specific engineering challenges.
M23BXX506.3	Collaborate with team members to complete the project successfully.
M23BXX506.4	Document and present the project effectively, demonstrating clear communication skills.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BXX506.1														
M23BXX506.2														
M23BXX506.3														
M23BXX506.4														
M23BXX506														

8. Future with this Subject

The mini-project course will serve as a foundation for more complex and comprehensive project work in the final year, such as the capstone project. The skills developed here, including problem-solving, design, teamwork, and communication, will be crucial for successful completion of future courses and for professional practice in engineering.

5th Semester	Ability Enhancement Course (AE) RESEARCH METHODOLOGY AND INTELLECTUAL PROPERTY RIGHTS	M23BRMK507

1. Prerequisites

S/L	Proficiency	Prerequisites
1	**Basic Understanding of Research Concepts**	Before delving into the specifics of engineering research and intellectual property rights, students should have a foundational understanding of what research is, its objectives, and its significance, particularly in the context of engineering.
2	**Familiarity with Ethics in Research**	Basic knowledge of ethics, including common ethical dilemmas and misconduct in research, is essential. This includes understanding issues related to authorship and ethical considerations in the research process.
3	**Literature Review Skills**	Students should have prior experience in conducting literature reviews, including familiarity with bibliographic databases such as Web of Science, Google Scholar, and effective search strategies. This will help them in understanding and analyzing existing knowledge in their research field.
4	**Introduction to Intellectual Property Rights**	A preliminary understanding of intellectual property rights, including patents, copyrights, trademarks, and industrial designs, would be beneficial. This knowledge should include the role of IP in society and basic IP laws, especially in the Indian context.
5	**Technical Reading and Writing Skills**	Competence in reading and comprehending technical documents, including research papers, datasheets, and legal texts, is crucial. Additionally, students should have basic knowledge of how to structure a journal paper and the importance of proper citation and attribution in academic writing.

2. Competencies

S/L	Competency	KSA Description
1	**Understand the research process**	**Knowledge:** Types of research (exploratory, descriptive, explanatory, etc.) Research methodologies (qualitative, quantitative, mixed) Research design (experimental, correlation, causal-comparative) Research ethics principles **Skills:** Identify research problems, Formulate research questions and objectives, Develop research proposals, Conduct literature reviews **Attitudes:** Curiosity and inquisitiveness, Critical thinking and problem-solving, Intellectual honesty and integrity
2	**Apply ethical principles to research**	**Knowledge:** Ethical guidelines for research Ethical issues in research (plagiarism, data fabrication, etc.) Researcher-participant relationships **Skills:** Identify potential ethical dilemmas in research Develop ethical protocols for research Obtain informed consent from participants **Attitudes:** Respect for human subjects, Commitment to research integrity Responsibility for the ethical conduct of research
3		**Knowledge:** Sources of research literature (databases, journals, books) Literature review structure and organization

	Conduct effective literature reviews	Critical appraisal of research articles **Skills:** Search for relevant research literature, Evaluate and synthesize research findings, Organize and present literature review findings **Attitudes:** Persistence and thoroughness, Open-mindedness to different perspectives, Attention to detail
4	**Design research studies**	**Knowledge:** Research designs (experimental, correlational, causal-comparative), Sampling techniques, Data collection methods (surveys, interviews, observations) **Skills:** Develop research instruments, Select appropriate research design, Develop data collection plans **Attitudes:** Creativity and innovation, Flexibility and adaptability, Attention to detail
5	**Understand the concept of intellectual property**	**Knowledge:** Definition and types of intellectual property (patents, copyrights, trademarks, trade secrets, industrial designs) Legal framework for intellectual property protection Economic and social importance of intellectual property **Skills:** Identify intellectual property assets within an organization or project Understand the basics of intellectual property valuation **Attitudes:** Appreciation for the value of intellectual property, Respect for intellectual property rights, Awareness of intellectual property issues in business and research

3. Syllabus

RESEARCH METHODOLOGY & INTELLECTUAL PROPERTY RIGHTS **SEMESTER – V**			
Course Code	**M23BRMK507**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(1:2:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**25 hours Theory**	Total Marks	**100**
Credits	**02**	Exam Hours	**03**

Course Objectives:

1. To know the meaning of engineering research.
2. To know the procedure of Literature Review and Technical Reading.
3. To know the fundamentals of patent laws and drafting procedure.
4. To gain awareness of the copyright laws and subject matters of copyrights and designs.
5. To interpret and learn the basic principles of design rights.

Module -1

Introduction: Meaning of research, objectives of engineering research, and motivation in engineering research, types of engineering research, finding and solving a worthwhile problem.

Ethics in engineering research: Ethics in engineering research practice, types of research misconduct, and ethical issues related to authorship.

Module -2

Journal Paper document: structure and approach, Literature Review and Technical Reading: New and existing knowledge in research field, analysis and synthesis of prior art. Bibliographic databases like web of science, Google and Google scholar. Effective search: the way forward, introduction to technical reading conceptualizing research, critical and creative reading, taking notes while reading, reading mathematics and algorithms, reading a datasheet.

Attributions and Citations: Giving credit wherever due, citations: functions and attributes, impact of title and keywords on citations, knowledge flow through citation, styles for citations, citing datasets,

acknowledgments and attributions, what should be acknowledged, acknowledgments in books and dissertations, dedication vs. acknowledgments.

Module -3

Introduction to Intellectual Property (IP): Role of IP in the economic and cultural development of the society, IP governance, IP as a global indicator of innovation, origin of IP, history of IP in India. Major amendments IP laws and acts in India. IP Organizations in India, schemes and programs.

Patents: Conditions for obtaining a patent protection, to patent or not to patent an invention. Rights associated with patents and enforcement of patent rights. Non-patentable matters. Patent infringements and avoiding public disclosure of an invention before patenting.

Process of Patenting: Prior art search, choice of application to be filed, patent application forms, fee structure, types of patent applications. Jurisdiction of filing patent application, publication, pre-grant opposition, examination, and grant of a patent. Validity of patent protection, post-grant opposition, and commercialization of a patent. Need for a patent attorney/ agent. Can a worldwide patent be obtained? Do I need first to file a patent in India? Commonly used terms in patenting, National bodies dealing with patent affairs, utility models.

Case Studies on Patents. Case study of Curcuma (Turmeric) Patent, Case study of Neem Patent, Case study of Basmati patent.

Module -4

Copyrights and Related Rights: Classes of copyrights, criteria for copyright, ownership of copyright, and copyrights of the author. Copyright infringement a criminal offence and cognizable offence. Fair use doctrine. Copyrights and internet. Non-copyright work. Copyright registration. Judicial powers of the registrar of copyrights. Fee structure, copyright symbol, validity of copyright, copyright profile of India. Transfer of copyrights to a publisher. Copyrights and the words 'adaptation', 'Indian work', 'joint authorship', 'publish'. Copyright society, copyright board, and copyright enforcement advisory council (CEAC). International copyright agreements, conventions and treaties.

Case Studies of Copyrights cases: Hawkins Cooker Ltd. vs. Magicook Appliances, KSRTC copyright case.

Trademarks registration: prior art search, eligibility criteria, who can apply for a trademark. Acts and laws. Designation of trademark symbols. Classification of trademarks. Registration of a trademark is not compulsory. Validity of trademark. Types of trademark registered in India. Trademark registry and process for trademarks registration. **Case Studies on Trademarks:** Coca-cola company vs. Bisleri international PVT. Ltd, and Yahoo! Inc. vs. Akash Arora & Anr

Module -5

Industrial Designs: Eligibility criteria, Acts and laws to govern industrial designs. Design rights. Enforcement of design rights. Non-protectable industrial designs India. Protection term. Procedure for registration of industrial designs: Prior art search, application for registration, duration of the registration of a design. Importance of design registration. Cancellation of the registered design. Application forms. Classification of industrial designs. Designs registration trend in India. International treaties.

Famous case of: Apple inc. vs. Samsung electronics co.

Geographical Indications (GI): acts, laws and rules pertaining to GI. Ownership of GI. Rights granted to the holders. Registered GI in India. Identification of registered GI. Classes of GI. Non-registerable GI. Protection of GI. Collective or certification marks. Enforcement of GI rights. Procedure for GI registration documents required for GI registration. GI ecosystem in India.

Case Studies on GI tags: Case Study of Mysore Silk, Darjeeling Tea, Kancheepuram Silk Sarees, case of Goa's Feni

Text Books:

1. Dipankar Deb • Rajeeb Dey, Valentina E. Balas "Engineering Research Methodology", ISSN 1868-4394 ISSN 1868-4408 (electronic), Intelligent Systems Reference Library, ISBN 978-981-13- 2946-3 ISBN 978-981-13-2947-0 (eBook), https://doi.org/10.1007/978-981-13-2947-0
2. KOTHARI, C. R. (2004). "Research methodology: Methods and techniques". New age international.
3. Intellectual Property A Primer for Academia by Prof. Rupinder Tewari Ms. Mamta Bhardwa

Reference Book:

1. David V. Thiel "Research Methods for Engineers" Cambridge University Press, 978-1-107-03488- 4
2. Intellectual Property Rights by N.K. Acharya Asia Law House 6th Edition. ISBN: 978-93 81849-30-9

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3: Introduction to Research and Intellectual Property	Week 1: Research fundamentals, types of research, research process, ethics Week 2: Intellectual property overview, patents, trademarks Week 3: Copyrights, industrial designs, geographical indications
2	Week 4-6: Literature Review, Research Design, and Data Analysis	Week 4: Literature review, bibliographic databases, citation styles Week 5: Research design, sampling, data collection methods Week 6: Data analysis techniques, research ethics case study
3	Week 7-9: Intellectual Property Law and Enforcement	Week 7: Patent law, patent search, patent drafting Week 8: Trademark law, trademark search, brand management Week 9: Copyright law, fair use, digital copyright
4	Week 10-12: Intellectual Property and Business	Week 10: Intellectual property valuation, licensing, and commercialization Week 11: Intellectual property strategy and management Week 12: Case studies on intellectual property disputes
5	Week 13	Review and Final Exam

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of research methodology concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understand the fundamental principles of research methodology.	Research objectives should be clear and based on curiosity. A systematic approach, inspired by the scientific method, ensures transparency and replication. The goal should be to add something new or distinctive, exploring and questioning existing knowledge.
2	Apply ethical considerations in engineering research.	Students as researchers must obtain informed consent from study participants, ensure voluntary participation, protect participant identities and confidentiality, prevent harm to participants, and submit proposals to an institutional review board (IRB) for ethical approval before data collection, ensuring compliance with research objectives and balancing safety with research objectives.
3	Conduct effective literature reviews and technical reading.	Students will learn to conduct a literature review, start by searching for relevant sources, evaluating and selecting them based on quality and relevance, identifying themes, debates, and gaps, outlining your findings logically, and writing your review. Analyze, critique, and compare different sources, highlighting how your research contributes to the ongoing scholarly conversation.
4	Identify and utilize proper attribution and citation styles.	Different disciplines use specific citation styles, such as APA, MLA, or Chicago. In-text citations include author's name and publication year. Reference lists or bibliographies should be compiled at the end of the work. Book citations include author(s), title, publisher, and publication year. Journal article citations include author(s), title, journal name, volume, issue, and publication year.
5	Gain knowledge of different forms of intellectual property (IP) protection.	Patents, copyrights, and trade secrets are legal rights granted by government agencies to inventors, protecting novel processes, machines, and compositions of matter. Trademarks safeguard brand names and symbols, while trade secrets provide confidential information for competitive advantage.
6	Understand the patenting process and its importance. Recognize the significance of copyrights, trademarks, industrial designs, and geographical indications.	A patent is a legal shield granted by a government authority to inventors, providing exclusive rights to an original invention. There are three main types: utility patents, plant patents, design patents, trademarks, copyrights, industrial designs, and geographical indications. Utility patents cover inventions like machines, software, and chemical formulations, while plant patents safeguard unique plant characteristics. Design patents protect product ornamental appearance. Trademarks help build brand identity and prevent confusion.
7	Identify relevant IP organizations and government schemes in India.	The Indian government initiatives include CIPAM, IPRs in School Syllabus, Patent Facilitation Program, National IPR Policy, Technology and Innovation Support Centers, Start-up India, Make in India, National IP Awards, Patent Prosecution Highway, border measures, and support for startups and MSMEs.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BRMK507.1	**Interpret** the ethical issues in engineering research, including identifying types of research misconduct and evaluating the impact of ethical practices on research outcomes.
M23BRMK507.2	**Analyze literature from diverse bibliographic databases, critically appraise existing research, and synthesize prior art to develop a comprehensive understanding of a chosen research topic.**
M23BRMK507.3	**Apply** appropriate citation styles and techniques, ensuring proper attributions in academic writing to maintain ethical standards and enhance the credibility of research work.
M23BRMK507.4	**Apply the principles of intellectual property rights, including patents, copyrights, and trademarks, to assess the eligibility of an invention or creative work for protection, and navigate the processes for registration and enforcement.**
M23BRMK507.5	**Analyze** the role of intellectual property in economic and cultural development, and explain the historical evolution and contemporary relevance of IP laws and acts, particularly in the Indian context.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BRMK507.1	3	-	-	3	-	-	-	3	-	-	-	3	-	-
M23BRMK507.2	-	3	-	3	3	-	-	-	-	3	-	3	3	3
M23BRMK507.3	-	-	-	-	3	-	-	3	-	3	-	3	-	-
M23BRMK507.4	-	3	-	3	-	-	-	-	-	3	-	-	3	-
M23BRMK507.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
M23BRMK507	3	3	-	3	3	-	-	3	-	3	-	3	3	3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

1. Advanced Research Opportunities:

- PhD and Postdoctoral Research: The course equips mechanical engineers with essential research skills, making them strong candidates for advanced studies. This can lead to specialization in emerging fields like computational mechanics, renewable energy systems, and smart manufacturing.

- Interdisciplinary Research: Understanding research methodology enables mechanical engineers to collaborate on interdisciplinary projects, combining mechanical engineering with fields like materials science, robotics, and artificial intelligence.

2. Innovation and Product Development:

- Patentable Innovations: Knowledge of intellectual property rights allows engineers to protect their innovations, leading to the development of patentable technologies. This is particularly relevant in industries like automotive, aerospace, and manufacturing, where innovation is key to competitiveness.

- Start-ups and Entrepreneurship: The course provides a foundation for engineers to start their own ventures, focusing on innovative mechanical products or services. Understanding IP can help secure funding and protect their business ideas.

3. Career in Research and Development (R&D):

- Industry R&D Roles: Mechanical engineers with strong research methodology skills are valuable assets in R&D departments. They can lead projects that require rigorous research, data analysis, and the development of new technologies or processes.

- Government and Private Research Organizations: Opportunities in organizations like CSIR (Council of Scientific & Industrial Research), DRDO (Defense Research and Development Organization), or private research labs, where engineers can contribute to national and international projects.

4. Consulting and Advisory Roles:

- IP Consulting: Engineers with expertise in intellectual property rights can work as consultants, advising companies on patenting strategies, IP management, and innovation protection.

- Research Methodology Expert: Mechanical engineers can also serve as advisors or consultants for research projects, helping organizations design and implement robust research methodologies.

5. Teaching and Academia:

- Faculty Positions: With advanced knowledge in research methodology and IP, mechanical engineers can pursue teaching careers in universities or technical institutes, contributing to the next generation of engineers.

- Curriculum Development: They can also be involved in developing or enhancing engineering curricula, incorporating modern research methods and IP considerations into mechanical engineering programs.

6. Contribution to Sustainable Development:

- Innovations for Sustainability: Mechanical engineers can apply their research skills to develop sustainable technologies, focusing on renewable energy, energy efficiency, and reducing the environmental impact of mechanical systems.

- Policy Making: With an understanding of the societal impact of engineering solutions, they can contribute to policy-making processes, particularly in areas related to environmental sustainability and technology regulation.

This course lays the foundation for mechanical engineers to not only excel in their current roles but also to explore new horizons in research, innovation, and entrepreneurship, making a significant impact on their field and society.

5th Semester	Basic Science (BS) ENVIRONMENTAL STUDIES	M23BESK508

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Understanding Ecosystems	Basic knowledge of biology, environmental science, and ecological systems.
2	Comprehending Natural Resource Management	Familiarity with energy systems, environmental management, and global sustainability practices.
3	Knowledge of Environmental Pollution	Understanding of chemical processes, industrial impacts, and environmental science fundamentals.
4	Addressing Global Environmental Concerns	Knowledge of climate science, environmental policies, and global ecological challenges.
5	Awareness of Environmental Legislation	Familiarity with national and international environmental laws, policies, and regulations.

2. Competencies

S/L	Competency	KSA Description
1	Ecosystem Analysis	**Knowledge**: Ecosystem structure, sustainability principles, SDGs. **Skills**: Identifying ecosystem components, and understanding sustainability targets. **Attitudes**: Appreciating biodiversity, and promoting sustainability.
2	Resource Management	**Knowledge**: Renewable and non-renewable energy systems, sustainable practices. **Skills**: Analyzing case studies, and evaluating energy systems. **Attitudes**: Supporting sustainable resource use, and critical thinking on global issues.
3	Pollution Mitigation	**Knowledge**: Pollution sources, impacts, and legislation. **Skills**: Assessing pollution control measures, and implementing waste management strategies. **Attitudes**: Advocating for environmental protection, and responsible waste disposal.
4	Global Environmental Awareness	**Knowledge**: Climate change, groundwater depletion, global policies. **Skills**: Investigating global environmental challenges, and proposing solutions. **Attitudes**: Engaging in global environmental discussions, and supporting international efforts.
5	Environmental Legal Framework	**Knowledge**: Key environmental acts and regulations. **Skills**: Applying legal knowledge to environmental issues, and understanding EIA processes. **Attitudes**: Valuing legal frameworks, and ensuring compliance with environmental laws.

3. Syllabus

ENVIRONMENTAL STUDIES SEMESTER – V			
Course Code	**M23BESK508**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(2:0:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**25 hours Theory**	Total Marks	**100**
Credits	**02**	Exam Hours	**02**
Course Objectives: Students will be able 1.Understand the structure and function of various ecosystems like forests, deserts, wetlands, rivers, oceans,			

and lakes.
2. Explore natural resource management techniques, including energy systems and disaster management, and assess their sustainability.
3.Examine environmental pollution sources and impacts, and learn corrective and preventive measures alongside waste management strategies.
4.Investigate global environmental issues such as climate change and groundwater depletion, and the role of environmental legislation in addressing these issues.

Module -1

ECOSYSTEMS (STRUCTURE AND FUNCTION): Forest, Desert, Wetlands, River, Oceanic and Lake. Sustainability: 17 SDGs- History, targets, implementation , Capacity Development

Module -2

NATURAL RESOURCE MANAGEMENT

Advances in Energy Systems (Merits, Demerits, Global Status and Applications): Hydrogen, Solar, OTEC, Tidal and Wind.

Natural Resource Management (Concept and case-studies): Disaster Management, Sustainable Mining - case studies and Carbon Trading.

Module -3

ENVIRONMENTAL POLLUTION & WASTE MANAGEMENT Environmental Pollution (Sources, Impacts, Corrective and Preventive measures, Relevant Environmental Acts, Case-studies): Surface and Ground Water Pollution; Noise pollution; Soil Pollution and Air Pollution. Waste Management: Bio-medical Wastes; Solid waste; Hazardous wastes; E-wastes; Industrial and Municipal Sludge.

Module -4

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.

Module -5

ENVIRONMENTAL LEGISLATION : Water Act 1974, Air Act 1981, Environmental Protection Act 1984, Solid Waste Management Rules-2016, E- Waste management Rule - 2022, Biomedical Waste management- 2016. Environmental Impact Assessment

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

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

VIDEO LINKS:

3. Weblink: https://sdgs.un.org/goals Video Lectures
4. https://archive.nptel.ac.in/courses/109/105/109105190/ .

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	**Week 1-2**	Introduction to ecosystems, exploring their structure and function with a focus on sustainability and SDGs.
2	**Week 3-4**	Understanding natural resource management, advances in energy systems, and disaster management through case studies.
3	**Week 5-6**	Examination of environmental pollution sources, impacts, and preventive measures, along with waste management strategies.
4	**Week 7-8**	Exploration of global environmental concerns such as climate change, groundwater depletion, and related policies.
5	**Week 9-10**	Study of environmental legislation, including key environmental acts and the process of Environmental Impact Assessment (EIA).
6	**Week 11-12**	Revision

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Interactive Lectures:	Utilize chalk and talk along with PowerPoint presentations and animations to engage students in theoretical and practical understanding
2	Case Study Analysis:	Present real-world scenarios and case studies to help students apply theoretical knowledge to practical situations, particularly in natural resource management and pollution control.
3	Fieldwork and Site Visits	Encourage hands-on learning through field visits to environmental labs, green buildings, and treatment plants, followed by documentation and analysis of the processes observed.
4	Collaborative Learning	Promote group projects and discussions, enabling students to collaborate and learn from each other, particularly in global environmental concerns and energy systems.

6. Assessment Details (both CIE and SEE)

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous internal Examination (CIE)

1. For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
2. The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
3. Any two assignment methods mentioned in the regulations, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
4. For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

The sum of two tests, two assignments, will be out of 100 marks and will be scaled down to 50 marks.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examinations (SEE)

SEE paper shall be set for **50 questions**, each of the 01 marks. **The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is 01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

7. Learning Objectives

S/L	Learning Objectives	Description
1	Analyze the structure and function of various ecosystems.	Students will learn about the characteristics and interactions within ecosystems such as forests, deserts, wetlands, rivers, oceans, and lakes.
2	Evaluate natural resource management techniques.	Students will assess the merits and demerits of various energy systems and learn sustainable management practices through case studies.
3	Investigate environmental pollution and waste management.	Students will understand the sources and impacts of environmental pollution, along with strategies for pollution control and waste management.
4	Explore global environmental concerns and policies.	Students will study global issues like climate change and groundwater depletion, and examine the role of environmental legislation in addressing these challenges.
5	Understand	Students will gain insights into key environmental acts and regulations,

	environmental legislation and its application.	and learn how to apply them in real-world scenarios.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BESK508.1	Analyze the structure and functions of various ecosystems and evaluate their sustainability
M23BESK508.2	Apply knowledge of natural resource management and advances in energy systems to assess their global impacts
M23BESK508.3	Investigate environmental pollution sources and apply waste management strategies in real-world scenarios
M23BESK508.4	Critically analyze global environmental concerns and assess the effectiveness of environmental policies
M23BESK508.5	Demonstrate an understanding of environmental legislation and apply it to ensure sustainable practices

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
M23BESK508.1	3	-	-	-	-	-	-	-	-	-	-	3
M23BESK508.2	-	3	-	-	-	-	-	-	-	-	-	3
M23BESK508.3	-	-	3	-	-	-	-	-	-	-	-	3
M23BESK508.4	-	-	-	3	-	-	-	-	-	-	-	3
M23BESK508.5	-	-	-		3	-	-	-	-	-	-	3
M23BESK508	**3**	**3**	**3**	**3**	**3**	-	-	-	-	-	-	**3**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

This course provides a foundational understanding of environmental science that is crucial for advanced studies in environmental engineering, sustainability, and policy-making. It equips students with the knowledge and skills to tackle global environmental challenges and supports interdisciplinary research, making it a valuable asset for careers in environmental management, consulting, and advocacy. The insights gained from this course will also be beneficial in professional roles requiring compliance with environmental legislation and sustainable development practices.

5th Semester	Non-Credit Mandatory Course (NCMC) NATIONAL SERVICE SCHEME (NSS)	M23BNSK509

National Service Scheme (NSS)			
Course Code	**M23BNSK509**		
Number of Lecture Hours/Week(L: T: P: S)	0:0:2:0	CIE Marks	100
Total Number of Lecture Hours		SEE Marks	-
Credits	**0**	Total Marks	100
Activities Report Evaluation by College NSS Officer at the end of every semester (3rd to 6th semester)			

Course objectives:

National Service Scheme (NSS) will enable students to:

1. Understand the community in general in which they work.
2. Identify the needs and problems of the community and involve them in problem –solving.
3. Develop among themselves a sense of social & civic responsibility & utilize their knowledge in finding practical solutions to individual and community problems.
4. Develop competence required for group-living and sharing of responsibilities & gain skills in mobilizing community participation to acquire leadership qualities and democratic attitudes.
5. Develop capacity to meet emergencies and natural disasters & practice national integration and social harmony in general.

General Instructions - Pedagogy :

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the activities will develop students' theoretical and applied social and cultural skills.
2. State the need for NSS activities and its present relevance in the society and Provide real-life examples.
3. Support and guide the students for self-planned activities.
4. You will also be responsible for assigning homework, grading assignments and quizzes, and documenting students' progress in real activities in the field.
5. Encourage the students for group work to improve their creative and analytical skills.

Contents :

1. Organic farming, Indian Agriculture (Past, Present and Future) Connectivity for marketing.
2. Waste management– Public, Private and Govt organization, 5 R's.
3. Setting of the information imparting club for women leading to contribution in social and economic issues.
4. Water conservation techniques – Role of different stakeholders– Implementation.
5. Preparing an actionable business proposal for enhancing the village income and approach for implementation.
6. Helping local schools to achieve good results and enhance their enrolment in Higher/ technical/ vocational education.
7. Developing Sustainable Water management system for rural areas and implementation approaches.
8. Contribution to any national level initiative of Government of India. For eg. Digital India, Skill India, Swatch Bharat, Atmanirbhar Bharath, Make in India, Mudra scheme, Skill development programs etc.
9. Spreading public awareness under rural outreach programs.(minimum5 programs).
10. Social connect and responsibilities.
11. Plantation and adoption of plants. Know your plants.
12. Organize National integration and social harmony events /workshops /seminars. (Minimum 02 programs).
13. Govt. school Rejuvenation and helping them to achieve good infrastructure.

NOTE:

1. Student/s in individual or in a group Should select any one activity in the beginning of each semester till end of that respective semester for successful completion as per the instructions of NSS officer with the consent of HOD of the department.
2. At the end of every semester, activity report should be submitted for evaluation.

Distribution of Activities - Semester wise from 3rd to 6th semester

Sem	Topics / Activities to be Covered
3rd Sem for 25 Marks	1. Organic farming, Indian Agriculture (Past, Present, and Future) Connectivity for marketing. 2. Waste management– Public, Private and Govt organization, 5 R's. 3. Setting of the information imparting club for women leading to contribution in social and economic issues.
4th Sem for 25 Marks	1. Water conservation techniques – Role of different stakeholders– Implementation. 2. Preparing an actionable business proposal for enhancing the village income and approach for implementation. 3. Helping local schools to achieve good results and enhance their enrolment in Higher/ technical/ vocational education.
5th Sem for 25 Marks	1. Developing Sustainable Water management systems for rural areas and implementation approaches. 2. Contribution to any national-level initiative of the Government of India. Foreg. Digital India, Skill India, Swachh Bharat, Atmanirbhar Bharath, Make in India, Mudra scheme, Skill development programs etc. 3. Spreading public awareness under rural outreach programs.(minimum 5 programs). 4. Social connect and responsibilities.
6th Sem for 25 Marks	1. Plantation and adoption of plants. Know your plants. 2. Organize National integration and social harmony events /workshops /seminars. (Minimum 02 programs). 3. Govt. school Rejuvenation and helping them to achieve good infrastructure.

Course outcomes (Course Skill Set):

At the end of the course, the student will be able to:

Cos	Description
M23BNSK509.1	Understand the importance of his / her responsibilities towards society.
M23BNSK509.2	Analyse the environmental and societal problems/issues and will be able to design solutions for the same.
M23BNSK509.3	Evaluate the existing system and to propose practical solutions for the same for sustainable development.
M23BNSK509.4	Implement government or self-driven projects effectively in the field.
M23BNSK509.5	Develop capacity to meet emergencies and natural disasters & practice national integration and social harmony in general.

Pedagogy – Guidelines :

It may differ depending on local resources available for the study as well as environment and climatic differences, location, and time of execution.

Sl No	Topic	Group size	Location	Activity execution	Reporting	Evaluation of the Topic
1.	Organic farming, Indian Agriculture (Past, Present, and Future) Connectivity for marketing.	May be individual or team	Farmers land/ Villages/ roadside/ community area /College campus etc	Site selection / proper consultation/ Continuous monitoring/ Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
2.	Waste management– Public, Private and Govt organization, 5 R's.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers /	Site selection / proper consultation/ Continuous monitoring/ Information board	Report should be submitted by an individual to the concerned evaluation	Evaluation as per the rubrics of the scheme and syllabus by NSS officer

			campus etc…		authority	
3.	Setting of the information imparting club for women leading to contribution in social and economic issues.	May be individual or team	Women empowerment groups/ Consulting NGOs & Govt Teams / College campus etc…	Group selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
4.	Water conservation techniques – Role of different stakeholders– Implementation.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers, campus etc…	Site selection / Proper consultation/ Continuous monitoring/ Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
5.	Preparing an actionable business proposal for enhancing the village income and approach for implementation.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers, campus etc…	Group selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
6.	Helping local schools to achieve good results and enhance their enrolment in Higher/ technical/ vocational education.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers, campus etc…	School selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
7.	Developing Sustainable Water management system for rural areas and implementation approaches.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Site selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
8.	Contribution to any national-level initiative of the Government of India. For eg. Digital India, Skill India, Swachh Bharat, Atmanirbhar Bharath, Make in India, Mudra scheme, Skill development programs etc.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Group selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer

9.	Spreading public awareness under rural outreach programs.(minimum5 programs). ///// Social connect and responsibilities.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Group selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
10.	Plantation and adoption of plants. Know your plants.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Place selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
11.	Organize National integration and social harmony events /workshops /seminars. (Minimum 02 programs).	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Place selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
12.	Govt. school Rejuvenation and helping them to achieve good infrastructure.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Place selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer

Plan of Action ((Execution of Activities For Each Semester)

Sl. No	Practice Session Description
1	Lecture session by NSS Officer
2	Students' Presentation on Topics
3	Presentation - 1 , Selection of topic, PHASE - 1
4	Commencement of activity and its progress - PHASE - 2
5	Execution of Activity
6	Execution of Activity
7	Execution of Activity
8	Execution of Activity
9	Execution of Activity
10	Case study-based Assessment, Individual performance
11	Sectorwise study and its consolidation
12	Video-based seminar for 10 minutes by each student At the end of the semester with a Report.

- In every semester from 3rd semester to 6th semester, Each student should do activities according to the scheme and syllabus.
- At the end of every semester student performance has to be evaluated by the NSS officer for the assigned activity progress and its completion.
- At last in 6th semester consolidated report of all activities from 3rd to 6th semester, compiled report should be submitted as per the instructions.

Assessment Details:

Weightage	**CIE – 100%**	• Implementation strategies of the

Presentation - 1 Selection of topic, PHASE - 1	**10 Marks**	project (NSS work). • The last Report should be signed by the NSS Officer, the HOD, and the principal. • At last Report should be evaluated by the NSS officer of the institute. • Finally, the consolidated marks sheet should be sent to the university and made available at the LIC visit.
Commencement of activity and its progress - PHASE - 2	**10 Marks**	
Case Study-based Assessment Individual Performance with Report	**10 Marks**	
Sector-wise study & its consolidation	**10 Marks**	
Video based seminar for 10 minutes by each student At the end of semester with Report. Activities.	**10 Marks**	
Total marks for the course in each semester	**50 Marks**	
Marks scored for 50 by the students should be Scale down to 25 marks In each semester for CIE entry in the VTU portal.		
25 marks CIE entry will be entered in University IA marks portal at the end of each semester 3rd to 6th sem, Report and assessment copy should be made available in the department semester wise		
Students should present the progress of the activities as per the schedule in the prescribed practical session in the field. There should be positive progress in the vertical order for the benefit of society in general.		
Suggested Learning Resources: **Books** : 1. NSS Course Manual, Published by NSS Cell, VTU Belagavi. 2. Government of Karnataka, NSS cell, activities reports and manual. 3. Government of India, NSS cell, Activities reports and manual.		

5th Semester	Non-Credit Mandatory Course (NCMC) PHYSICAL EDUCATION (SPORTS & ATHLETICS) — I	M23BPEK509

Semester - III			
PHYSICAL EDUCATION (SPORTS & ATHLETICS) — I			
Course Code	M23BPEK509	CIE Marks	100
Number of Lecture Hours/Week(L: T: P: S)		SEE Marks	
Total Number of Lecture Hours		Total Marks	100
Credits	0	Exam Hours	-

Course Outcomes: At the end of the course, the student will be able to

Cos	Description
M23BPEK509.1	Understand the fundamental concepts and skills of Physical Education, Health, Nutrition and Fitness.
M23BPEK509.2	Familiarization of health-related Exercises, Sports for overall growth and development.
M23BPEK509.3	Create a foundation for the professionals in Physical Education and Sports.
M23BPEK509.4	Participate in the competition at regional/state / national / international levels.
M23BPEK509.5	Create consciousness among the students on Health, Fitness and Wellness in developing and maintaining a healthy lifestyle.

Module-1

Orientation: **(5 hours)**

A. Lifestyle
B. Fitness
C. Food & Nutrition
D. Health & Wellness
E. Pre-Fitness test.

Module-2

General Fitness & Components of Fitness: **(15 hours)**

A. Warming up (Free Hand exercises)
B. Strength — Push-up / Pull-ups
C. Speed — 30 Mtr Dash
D. Agility — Shuttle Run
E. Flexibility — Sit and Reach
F. Cardiovascular Endurance — Harvard step Test

Module-3

Recreational Activities: **(10 hours)**

A. Postural deformities.
B. Stress management.
C. Aerobics.
D. Traditional Games.

Scheme and Assessment for auditing the course and Grades:

Sl. No.	Activity	Marks
1.	Participation of student in all the modules	20
2.	Quizzes — 2, each of 15 marks	30
3.	Final presentation/exhibition / Participation in competitions/practical on specific tasks assigned to the students	50
	Total	100

Semester - IV
PHYSICAL EDUCATION (SPORTS & ATHLETICS) — II
Course Outcomes: At the end of the course, the student will be able to CO1.Understand the ethics and moral values in sports and athletics CO2.Perform in the selected sports or athletics of the student's choice.

CO3.Understand the roles and responsibilities of organisation and administration of sports and games.
Module-1
Ethics and Moral Values: **(5 hours)** A. Ethics in Sports B. Moral Values in Sports and Games
Module-2
Specific Games (Any one to be selected by the student): **(20 hours)** A. Volleyball — Attack, Block, Service, Upper Hand Pass and Lower hand Pass. B. Throwball — Service, Receive, Spin attack, Net Drop & Jump throw. C. Kabaddi — Hand touch, Toe Touch, Thigh Hold, Ankle hold and Bonus. D. Kho-Kho — Giving Kho, Single Chain, Pole dive, Pole turning, 3-6 Up. E. Table Tennis — Service (Fore Hand & Back Hand), Receive (Fore Hand & Back Hand), Smash. F. Athletics (Track / Field Events) — Any event as per availability of Ground.
Module-3
Role of Organisation and administration: **(5 hours)**

Scheme and Assessment for auditing the course and Grades:

Sl. No.	Activity	Marks
1.	Participation of student in all the modules	20
2.	Quizzes — 2, each of 15 marks	30
3.	Final presentation/exhibition / Participation in competitions/practical on specific tasks assigned to the students	50
	Total	100

5th Semester	Non-Credit Mandatory Course (NCMC) YOGA	M23BYOK509

Yoga			
Course Code	**M23BYOK509**		
Number of Lecture Hours/Week(L: T: P: S)	**0:0:2:0**	CIE Marks	**100**
Total Number of Lecture Hours		SEE Marks	**-**
Credits	**0**	Total Marks	**100**
Evaluation Method: Objective type Theory / Practical / Viva-Voce			

Course objectives:

1. To enable the student to have good Health.
2. To practice mental hygiene.
3. To possess emotional stability.
4. To integrate moral values.
5. To attain a higher level of consciousness.

The Health Benefits of Yoga

The benefits of various yoga techniques have been supposed to improve

- body flexibility,
- performance,
- stress reduction,
- attainment of inner peace, and
- self-realization.

The system has been advocated as a complementary treatment to aid the healing of several ailments such as

- coronary heart disease,
- depression,
- anxiety disorders,
- asthma, and
- extensive rehabilitation for disorders including musculoskeletal problems and traumatic brain injury.

The system has also been suggested as behavioral therapy for smoking cessation and substance abuse (including alcohol abuse).

If you practice yoga, you may receive these physical, mental, and spiritual benefits:

- Physical
  1. Improved body flexibility and balance
  2. Improved cardiovascular endurance (stronger heart)
  3. Improved digestion
  4. Improved abdominal strength
  5. Enhanced overall muscular strength
  6. Relaxation of muscular strains
  7. Weight control
  8. Increased energy levels
  9. Enhanced immune system
- Mental
  1. Relief of stress resulting from the control of emotions
  2. Prevention and relief from stress-related disorders
  3. Intellectual enhancement, leading to improved decision-making skills
- Spiritual
  1. Life with meaning, purpose, and direction
  2. Inner peace and tranquility
  3. Contentment

Yoga Syllabus

Semester III

- Yoga, its origin, history and development. Yoga, its meaning, definitions.
- Different schools of yoga, Aim and Objectives of yoga, importance of prayer
- Yogic practices for a common man to promote positive Health
- Rules to be followed during yogic practices by the practitioner
- Yoga its misconceptions,
- Difference between yogic and non-yogic practices

- Surya namaskar prayer and its meaning, Need, importance and benefits of Surya namaskar 12 count, 2 rounds
- Asana, Need, importance of Asana. Different types of asanas. Asana its meaning by name, technique, precautionary measures and benefits of each asana
- Different types of Asanas
  a. Sitting
     1. Padmasana
     2. Vajrasana
  b. Standing
     1. Vrikshana
     2. Trikonasana
  c. Prone line
     1. Bhujangasana
     2. Shalabhasana
  d. Supine line
     1. Utthitadvipadasana
     2. Ardhahalasana

Semester IV

- Patanjali's Ashtanga Yoga, its need and importance.
- Yama :Ahimsa, satya, asteya, brahmacarya, aparigraha.
- Niyama :shoucha, santosh, tapa, svaadhyaya, Eshvarapranidhan
- Suryanamaskar12 count- 4 rounds of practice
- Asana, Need, importance of Asana. Different types of asana. Asana its meaning by name, technique, precautionary measures and benefits of each asana.
- Different types of Asanas
  a. Sitting
     1. Sukhasana
     2. Paschimottanasana
  b. Standing
     1. Ardhakati Chakrasana
     2. Parshva Chakrasana
  c. Prone line
     1. Dhanurasana
  d. Supine line
     1. Halasana
     2. Karna Peedasana
- Meaning, importance and benefits of Kapalabhati.
- 40 strokes/min 3 rounds
- Meaning, Need, importance of Pranayama. Different types. Meaning by name, technique, precautionary measures and benefits of each Pranayama.
- Pranayama
  1. Suryanuloma –Viloma
  2. Chandranuloma-Viloma
  3. Suryabhedana
  4. Chandra Bhedana
  5. Nadishodhana

Semester V

- Patanjali'sAshtanga Yoga its need and importance.
- Ashtanga Yoga
  1. Asana
  2. Pranayama
  3. Pratyahara
- Asana its meaning by name, technique, precautionary measures and benefits of each asana
- Different types of Asanas
  a. Sitting 1. Ardha Ushtrasana 2. Vakrasana 3. Yogamudra in Padmasana
  b. Standing 1. UrdhvaHastothanasana 2. Hastapadasana 3. ParivrittaTrikonasana 4. Utkatasana
  c. Prone line 1. Padangushtha Dhanurasana 2. Poorna Bhujangasana / Rajakapotasana
  d. Supine line 1. Sarvangasana 2. Chakraasana 3. Navasana/Noukasana 4. Pavanamuktasana
- Revision of practice 60 strokes/min 3 rounds
- Meaning by name, technique, precautionary measures and benefits of each Pranayama 1. Ujjayi

2. Sheetali 3. Sheektari

Semester VI

- Ashtanga Yoga
  1. Dharana
  2. Dhyana (Meditation)
  3. Samadhi
- Asana by name, technique, precautionary measures and benefits of each asana
- Different types of Asanas
  a. Sitting 1. Bakasana 2. Hanumanasana 3. Ekapada Rajakapotasana 4. Yogamudra in Vajrasana
  b. Standing 1. Vatayanasana 2. Garudasana
  c. Balancing 1. Veerabhadrasana 2. Sheershasana
  d. Supine line 1. Sarvangasana 2. Setubandha Sarvangasana 3. Shavasanaa (Relaxation poisture).
- Revision of Kapalabhati practice 80 strokes/min - 3 rounds
- Different types. Meaning by name, technique, precautionary measures and benefits of each Pranayama 1. Bhastrika 2. Bhramari
- Meaning, Need, importance of Shatkriya.
- Different types. Meaning by name, technique, precautionary measures and benefits of each Kriya 1. Jalaneti & sutraneti 2. Nouli (only for men) 3. Sheetkarma Kapalabhati

Course outcomes (Course Skill Set):
At the end of the course, the student will be able to:

- Understand the meaning, aim and objectives of Yoga.
- Perform Suryanamaskar and able to Teach its benefits.
- Understand and teach different Asanas by name, its importance, methods and benefits.
- Instruct Kapalabhati and its need and importance.
- Teach different types of Pranayama by its name, precautions, procedure and uses
- Coach different types of Kriyas , method to follow and usefulness.

Assessment Details (both CIE and SEE)

- Students will be assessed with internal test by a. Multiple choice questions b. Descriptive type questions (Two internal assessment tests with 25 marks/test)
- Final test shall be conducted for whole syllabus for 50 marks.
- Continuous Internal Evaluation shall be for 100 marks (including IA test)

Suggested Learning Resources:
Books:
1. Yogapravesha in Kannada by Ajitkumar
2. Light on Yoga by BKS Iyengar
3. Teaching Methods for Yogic practices by Dr. M L Gharote & Dr. S K Ganguly
4. Yoga Instructor Course hand book published by SVYASA University, Bengaluru
5. Yoga for Children –step by step – by Yamini Muthanna

Web links and Video Lectures (e-Resources):
Refer links
1. https://youtu.be/KB-TYlgd1wE
2. https://youtu.be/aa-TG0Wg1Ls

6th Semester

6th Semester	Integrated Professional Course (IPC) HEAT TRANFER	M23BME601

1. Prerequisites

S/L	Proficiency	Prerequisites
1	**Calculus**	A strong foundation in calculus is essential for understanding heat transfer equations, which often involve derivatives and integrals. Topics like differentiation, integration, partial derivatives, and differential equations are crucial.
2	**Physics**	Physics provides the fundamental principles underlying heat transfer. Topics such as thermodynamics, mechanics, and fluid mechanics are particularly relevant.
3	**Thermodynamics**	A deep understanding of thermodynamic concepts like temperature, heat, work, and energy is necessary for comprehending heat transfer processes.
4	**Fluid Mechanics**	Knowledge of fluid properties, fluid dynamics, and heat transfer in fluids is crucial, especially for convective heat transfer.
5	**Mathematics**	Beyond calculus, linear algebra and vector calculus can be helpful in certain heat transfer calculations, particularly for complex geometries.
6	**Engineering Fundamentals**	A basic understanding of engineering principles, problem-solving methodologies, and units is essential for applying heat transfer concepts to real-world problems.

2. Competencies

S/L	Competency	KSA Description
1	**Modes of Heat Transfer**	**Knowledge:** Understand the different modes of heat transfer and their governing equations. Know the concepts of thermal conductivity, thermal resistance, and thermal diffusivity. **Skills:** Apply Fourier's law to calculate heat transfer rates in one-dimensional conduction. Determine temperature distributions in simple conduction problems **Attitudes:** Develop a systematic approach to solving heat transfer problems. Show attention to detail in applying boundary conditions. Demonstrate curiosity to explore different heat transfer scenarios.
2	**Extended surfaces and 1D transient conduction**	**Knowledge:** Understand the concept of fins and their role in augmenting heat transfer Know the different types of fins and their applications. **Skills:** Determine the temperature distribution and heat transfer rate in fins. Calculate fin efficiency and effectiveness. Select appropriate fin materials and dimensions for specific applications. **Attitudes:** Appreciate the importance of fins in thermal management systems. Demonstrate critical thinking in fin design and optimization. Show interest in exploring advanced fin configurations and materials.
3	**Radiation heat transfer**	**Knowledge:** Understand the fundamental concepts of thermal radiation, including blackbody radiation, emissivity, absorptivity, reflectivity, and transmissivity. Know the radiation laws (Stefan-Boltzmann, Planck, Wien's displacement, and Kirchhoff's) and their applications. **Skills:** Calculate radiative heat exchange between black and gray surfaces using radiation networks. Determine view factors for different geometries. **Attitudes:**

		Appreciate the importance of radiation heat transfer in various engineering systems. Develop a systematic approach to solving radiation heat transfer problems.
4	**Forced Convection and Free Convection**	**Knowledge:** Understand the concept of boundary layers and their influence on heat transfer. Know the difference between forced and natural convection. **Skills:** Apply dimensional analysis to develop correlations for convective heat transfer. Use appropriate correlations to calculate heat transfer coefficients for various flow conditions. Use appropriate correlations to calculate heat transfer coefficients for various flow conditions. **Attitudes:** Develop a systematic approach to solving convection problems. Show interest in exploring different convection regimes and applications. Appreciate the importance of convection in engineering systems.
5	**Heat exchangers Thermal management of electronic equipment**	**Knowledge:** Understand the classification of heat exchangers and their operating principles Understand the classification of heat exchangers and their operating principles **Skills:** Select appropriate heat exchanger types for specific applications Perform thermal design calculations using LMTD and NTU methods. Analyze the impact of fouling and scaling on heat exchanger performance. **Attitudes:** Appreciate the importance of heat exchangers in industrial processes. Demonstrate a systematic approach to heat exchanger design and analysis.

3. Syllabus

HEAT TRANSFER **SEMESTER – VI**			
Course Code	**M23BME601**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:2:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**50 hours**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course Objectives:

Student will be able to learn

1. Principles of heat transfer.
2. Steady and transient heat transfer, obtain the differential equation of heat conduction in various coordinate system.
3. Physical mechanism of convection and visualize the development of velocity and thermal boundary layers during flow over a surface.
4. Radiation heat transfer mechanism
5. Performance parameters of heat exchangers.

Module -1

Introduction and Concepts: Modes of heat transfer, Fourier's, Newton's and Stefan Boltzmann's Laws, Combined modes of heat transfer, thermal resistance, thermal diffusivity, Appropriate Numerical Examples. General form of conduction equations in Cartesian coordinates, Reduction of the equation with simpler conduction problems. Boundary conditions of I, II and III kinds, Conduction equations is cylindrical and spherical coordinates (no derivations), Overall heat transfer coefficient, Critical radius of insulation

Module -2

Extended surfaces: Steady state conduction in fins of uniform cross section long fin, fin with insulated tip and fin with convection at the tip; fin efficiency & effectiveness, Discussion on engineering applications. **One dimensional Transient conduction:** Conduction in solids with negligible internal temperature gradients (lumped system analysis) Use of transient temperature charts (Heisler's charts) for Transient conduction in slab, long cylinder and sphere; concept of semi-infinite solids, Discussion on engineering applications.

Module -3

Radiation Heat transfer: Thermal radiation. Definitions of various terms used in radiation heat transfer. Stefan-Boltzmann law, Kirchhoff's law, Planck's law, Wein's displacement law. Intensity of radiation & solid angle,; Concept of thermal radiation resistance, Radiation network, view factor, Radiation heat exchange between two parallel infinite black surfaces, between two parallel infinite gray surfaces; Effect of radiation shield; Discussion on engineering applications.

Module -4

Introduction & Concepts; Boundary layers: Velocity boundary layer & thermal boundary layer for flow over bodies, General expression for local heat transfer co-efficient & average heat transfer coefficient.
Forced Convection: Application of dimensional analysis for convection problems. Use of correlations for the flow over a flat plate & over a cylinder, and flow inside ducts (Numerical Problems).
Free or Natural Convection: Use of correlations for free convection from vertical & horizontal flat plates (Numerical Problems).

Module -5

Heat Exchangers: Classification of heat exchangers; Overall heat transfer coefficient, Fouling, Scaling factors; LMTD and NTU methods of analysis of heat exchangers, Compact heat exchangers. Numerical problems **Thermal Management of Electronic Equipment:** Introduction, thermal cooling load on electronic equipment, conduction cooling, conduction in printed circuit boards, air cooling, Liquid Cooling, Micro-channel Cooling.

PRACTICAL COMPONENT OF IPCC

S/N	Experiments
1	Determination of Thermal Conductivity of a Metal Rod.
2	Determination of Thermal Conductivity of a Composite wall
3	Determination of Heat Transfer Coefficient in Free Convection
4	Determination of Heat Transfer Coefficient in a Forced Convention
5	Determination of Emissivity of a Surface and Determination of Stefan Boltzmann Constant**.**
6	Emissivity of Metal Surface
7	Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.

TEXTBOOKS:

1. Heat and Mass Transfer, R.K Rajput, Revised edition, S. Chand and Company-2008 Edition.
2. Principals of heat transfer Frank Kreith, Raj M. Manglik, Mark S. Bohn Cengage learning Seventh Edition 2011.
3. Heat transfer, a practical approach Yunus A. Cengel Tata McGraw Hill Fifth edition

REFERENCE BOOKS:

1. Heat and mass transfer Kurt C, Rolle Cengage learning second edition
2. Heat Transfer A Basic Approach M. Necati Ozisik McGraw Hill, New York 2005
3. Fundamentals of Heat and Mass Transfer Incropera, F. P. and De Witt, D. P John Wiley and Sons, New York 5th Edition 2006
4. Heat Transfer Holman, J. P. Tata McGraw Hill, New York 9th Edition 2008

VIDEO LINKS:

1. https://online.vtu.ac.in/course-details/Heat-Transfer

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3: Introduction and Concepts of heat transfer	Modes of heat transfer, Fourier's, Newton's and Stefan Boltzmann's Laws, Combined modes of heat transfer, thermal resistance, thermal diffusivity, Appropriate Numerical Examples. General form of conduction equations in Cartesian coordinates, Reduction of the equation with simpler conduction

		problems. Boundary conditions of I, II and III kinds, Conduction equations is cylindrical and spherical coordinates (no derivations), Overall heat transfer coefficient, Critical radius of insulation
2	Week 4-6: Extended surfaces, 1D Transient conduction	Steady state conduction in fins of uniform cross section long fin, fin with insulated tip and fin with convection at the tip; fin efficiency & effectiveness, Discussion on engineering applications. Conduction in solids with negligible internal temperature gradients (lumped system analysis) Use of transient temperature charts (Heisler's charts) for Transient conduction in slab, long cylinder and sphere; concept of semi-infinite solids, Discussion on engineering applications.
3	Week 7-8: Radiation Heat transfer	Thermal radiation. Definitions of various terms used in radiation heat transfer. Stefan-Boltzmann law, Kirchhoff's law, Planck's law, Wein's displacement law. Intensity of radiation & solid angle,; Concept of thermal radiation resistance, Radiation network, view factor, Radiation heat exchange between two parallel infinite black surfaces, between two parallel infinite gray surfaces; Effect of radiation shield; Discussion on engineering applications.
4	Week 9-10: Introduction & Concepts; Boundary layers Forced Convection Free Convection	Velocity boundary layer & thermal boundary layer for flow over bodies, General expression for local heat transfer co-efficient & average heat transfer coefficient. Application of dimensional analysis for convection problems. Use of correlations for the flow over a flat plate & over a cylinder, and flow inside ducts (Numerical Problems). Use of correlations for free convection from vertical & horizontal flat plates (Numerical Problems).
5	Week 11-12: Heat Exchangers Thermal Management of Electronic Equipment	Classification of heat exchangers; Overall heat transfer coefficient, Fouling, Scaling factors; LMTD and NTU methods of analysis of heat exchangers, Compact heat exchangers. Numerical problems Introduction, thermal cooling load on electronic equipment, conduction cooling, conduction in printed circuit boards, air cooling, Liquid Cooling, Micro-channel Cooling.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Heat transfer concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
6	Laboratory Learning	Utilize the facilities available in the laboratories to understand the different modes of heat transfer.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
Theory (A)	Internal Assessment-Tests	2	**60%**	**15**	**06**
	Assignments/Quiz/Activity	2	**40%**	**10**	**04**
	Total Marks		**100%**	**25**	**10**
Components		**Number**	**Weightage**	**Max. Marks**	**Min. Marks**
Laboratory(B)	Record Writing	Continuous	**60%**	15	06
	Test at the end of the semester	1	**40%**	10	04
	Total Marks		**100%**	**25**	**10**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Fundamental principles of heat transfer.	Apply the knowledge of different heat transfer modes, governing equations, and thermal properties to analyse and solve basic heat transfer problems, including conduction in various coordinate systems and combined heat transfer processes.
2	Heat transfer in extended surfaces and transient conditions.	Analyze the heat transfer through fins of various configurations to calculate fin performance metrics, and apply these concepts to practical applications. Additionally, Apply the fundamentals of transient heat conduction, utilizing lumped capacitance and Heisler charts to determine temperature variations in solids over time.
3	Principles of radioactive heat transfer and its applications.	Apply the knowledge of radiation fundamentals, including radiation properties, laws, and geometry to analyze radioactive heat exchange between surfaces, considering factors like view factors and radiation shields. Applications of radiation heat transfer in engineering systems will be explored.
4	Convective heat transfer mechanisms and their applications.	To develop a comprehensive understanding of boundary layer theory, forced and natural convection phenomena. Apply dimensional analysis and empirical correlations to determine heat transfer coefficients for various flow conditions and geometries, enabling them to analyze convective heat transfer problems.
5	Heat exchanger design, performance, & thermal management in electronic equipment.	To classify, analyze, and design heat exchangers using LMTD and NTU methods. Also understand the challenges of thermal management in electronic systems and explore various cooling techniques, including conduction, air cooling, liquid cooling.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME601.1	Apply the concept modes of heat transfer and related governing equations to thermal systems.
M23BME601.2	Interpret conduction heat transfer phenomenon for extended surfaces and transient processes.
M23BME601.3	Evaluate the parameters of radiative heat exchange process between surfaces.
M23BME601.4	Assess the convective heat transfer coefficient for free and forced convection
M23BME601.5	Analyse the heat transfer process in the heat exchangers. Also analyse thermal management of electronic equipment.
M23BME601.6	Investigate heat transfer phenomenon using basic experiments of heat flow

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME601.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME601.2	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME601.3	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME601.4	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME601.5	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME601.6	-	3	3	-	-	-	-	-	-	3	-	-	-	3
M23BME601	3	3	3	-	-	-	-	-	-	3	-	-	3	3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	CO6	Total
Module 1	**05**						**05**
Module 2		**05**					**05**
Module 3			**05**				**05**
Module 4				**05**			**05**
Module 5					**05**		**05**
Practical Component						**25**	**25**
Total	**05**	**05**	**05**	**05**	**05**	**25**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

- **Electronics Cooling**: Development of novel cooling techniques for increasingly powerful microprocessors. Thermal management of electric vehicles.
- **Energy Efficiency:** Improved insulation materials and building envelope design. Enhanced heat recovery systems in industrial processes. Development of more efficient heat pumps and air conditioning systems.
- **Materials Science:** Creation of advanced materials with tailored thermal properties. Nano-materials for enhanced heat transfer applications.
- **Renewable Energy:** Efficient thermal energy storage systems for solar and wind power. Advanced heat transfer fluids for solar thermal power plants. Thermal management of batteries and fuel cells.

6th Semester	Professional Course (PC) MACHINE DESIGN	M23BME602

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Engineering Mechanics	Understanding forces, moments, equilibrium, and their applications in mechanical systems.
2	Strength of Materials	Knowledge of stress, strain, elasticity, plasticity, and material behavior under different loading conditions.
3	Material Science	Understanding the properties of different materials (metals, polymers, ceramics) and their selection for specific applications.
4	Engineering Drawing	Proficiency in reading and interpreting engineering drawings is necessary for visualizing and communicating design ideas.
5	Theory of Machines	Grasp of mechanisms, kinematics, dynamics, and vibrations.

2. Competencies

S/L	Competency	KSA Description
1	Material properties and selection	**Knowledge:** Understanding the factors influencing material selection, such as cost, availability, performance requirements, and environmental impact. **Skill:** Capacity to select the optimal material for a given application considering various factors. **Attitude:** Capacity to work with different materials and adjust approaches as needed.
2	Engineering standards and codes	**Knowledge:** Familiarity with industry standards and regulations related to design and manufacturing. **Skill:** Capacity to adjust to changing design requirements and constraints. **Attitude:** Ability to generate innovative design solutions.
3	Stress Analysis	**Knowledge:** Knowledge of analytical and numerical methods to determine stresses and deformations in structures. **Skill:** Ability to analyze numerical results, interpret stress and deformation patterns, and draw meaningful conclusions. **Attitude:** Ability to break down complex problems into smaller, manageable parts and identify key factors influencing the behavior of a system.
4	Failure Analysis	**Knowledge:** Understanding of stress, strain, and deformation, particularly under cyclic loading conditions. **Skill:** Identifying and resolving issues related to fatigue failures. **Attitude:** Analyzing complex problems and developing innovative solutions.

3. Syllabus

MACHINE DESIGN SEMESTER – VI			
Course Code	**M23BME602**	CIE Marks	**50**
Number of Lecture Hours/Week (L: T: P: S)	**(3:2:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**52 hours Theory**	Total Marks	**100**
Credits	**04**	Exam Hours	**03**

Course Objectives:

1. To explain the principles involved in design of machine elements, subjected to different kinds of forces, from the considerations of strength, rigidity.
2. To understand and interpret different failure modes and application of appropriate criteria for design of machine elements.
3. Develop the capability to design elements like shafts, couplings and welded joints, screwed joints.
4. To learn transmission elements like gears, belts, pulleys, bearings from the manufacturers' catalogue.
5. To produce assembly and working drawings of various mechanical systems involving machine elements like clutches and brakes.

Module -1

Introduction and Review (For CIE only): Definitions: Load (Magnitude, Direction, point of application and sense), normal, shear, Principal Stresses. Engineering Materials and their mechanical properties. Design considerations: Codes and Standards.

Design for static strength: Factor of safety, axial, bending, shear and torsion loading on machine

components, combined loading. **Impact Strength:** Introduction, Impact stresses due to axial and bending loads.

Self-Study and For CIE only:

Stress concentration, Determination of Stress concentration factor.

Module -2

Fatigue loading: Introduction to fatigue failure, Mechanism of fatigue failure, types of fatigue loading, SN Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit. Goodman and Soderberg relationship, stresses due to combined loading.

Design of shafts: Torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under fluctuating loads and combined loads.

Module -3

Riveted joints: Types of rivets, rivet materials, Caulking and fullering, analysis of riveted joints, joint efficiency, failures of riveted joints, boiler joints.

Welded joints: Types, strength of butt and fillet welds, eccentrically loaded welded joints,

Springs: Types of springs - stresses in Helical coil springs of circular cross sections. Tension and compression springs, springs under fluctuating loads,

Self-Study and for CIE only:

Leaf Springs: Stresses in leaf springs. Equalized stresses, Energy stored in springs, Torsion, Belleville and Rubber springs.

Module -4

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, formative number of teeth, design based on strength, dynamic load and wear.

Self-Study and for CIE only:

Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic load and wear.

Worm Gears: Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives.

Module -5

Lubrication and Bearings: Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated.

Antifriction bearings: Types of rolling contact bearings and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship.

Suggested Learning Resources:

Text Books:

1. Shigley's Mechanical Engineering Design Richard G. Budynas, and J. Keith Nisbett McGraw Hill Education 10th Edition, 2015.
2. Fundamentals of Machine Component Design Juvinall R.C, and Marshek K.M John Wiley & Sons Third Edition 2007 Wiley student edition.

Reference Books:

1. Design of Machine Elements V. B. Bhandari Tata Mcgraw Hill 4th Ed 2016.

Web Links:

1. https://en.wikipedia.org/wiki/Machine_element
2. www.nptel.ac.in
3. https://cosmolearning.org
4. www.vtu.ac.in
5. http://nevonprojects.com/miniprojectsformechanicalengineering/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3: **Design for static strength Impact Strength**	Definitions: Load (Magnitude, Direction, point of application and sense), normal, shear, Principal Stresses. Engineering Materials and their mechanical properties. Design considerations: Codes and Standards. Introduction, Impact stresses due to axial and bending loads.

2	Week 4-6: **Fatigue loading Design of shafts**	Introduction to fatigue failure, Mechanism of fatigue failure, types of fatigue loading, SN Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit. Goodman and Soderberg relationship, stresses due to combined loading. Torsion of shafts, design for strength and rigidity with steady loading, ASME codes for power transmission shafting, shafts under fluctuating loads and combined loads.
3	Week 8-11: **Riveted joints, Welded joints, Springs**:	Types of rivets, rivet materials, Caulking and fullering, analysis of riveted joints, joint efficiency, failures of riveted joints, boiler joints. Types, strength of butt and fillet welds, eccentrically loaded welded joints, Types of springs - stresses in Helical coil springs of circular cross sections. Tension and compression springs, springs under fluctuating loads,
4	Week 7-8: **Spur and Helical Gears**	Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear. Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear.
5	Week 9-12: **Lubrication and Bearings, Antifriction bearings**	Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated, and heat dissipated. Types of rolling contact bearings and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of machine design concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:
The minimum CIE marks requirement is 40% of maximum marks in each component.
CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understand the design process	Students should be able to identify design requirements, generate alternative solutions, evaluate design options, and optimize designs.
2	Apply materials science and mechanics	The course emphasizes the application of materials properties, stress analysis, and failure theories to design components.
3	Design for static and dynamic loads	Students should be able to analyze and design components subjected to different loading conditions.
4	Master machine elements	Students should gain in-depth knowledge of various machine elements like shafts, couplings, gears, bearings, springs, and fasteners.
5	Select appropriate materials	Based on material properties and design requirements, students should be able to choose suitable materials.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME602.1	**Apply** the concepts of machine design on loads and corresponding stresses developed in the machine elements.
M23BME602.2	**Analyze** dynamic loading conditions on shafts.
M23BME602.3	**Interpret** potential failure modes in machine components like riveted joints, welded joints and springs.
M23BME602.4	**Design** gear pairs to meet specific power transmission requirements.
M23BME602.5	**Investigate** bearing failures and implement corrective actions.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME602.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME602.2	-	3	-	-	-	-	-	-	-	-	-	-	3	-
M23BME602.3	-	3	-	-	-	-	-	-	-	-	-	-	3	-
M23BME602.4	-	-	3	-	-	-	-	-	-	-	-	-	-	3
M23BME602.5	-	-	3	-	-	-	-	-	-	-	-	-	-	3
M23MBME602	**3**	**3**	3	-	-	-	-	-	-	-	-	-	3	3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

A strong foundation in machine design opens up a wide range of exciting career opportunities. Here are some potential career paths:

Traditional Engineering Roles

- Design Engineer: Core role in developing new products and systems.
- Product Development Engineer: Focuses on bringing new products to market.
- Research and Development Engineer: Involved in innovative product and process development.
- Manufacturing Engineer: Optimizes production processes for efficiency and quality.

Specialized Roles

- Automotive Engineer: Designing components for vehicles.
- Aerospace Engineer: Designing aircraft and spacecraft components.
- Robotics Engineer: Developing robotic systems and components.
- Biomedical Engineer: Designing medical devices and equipment.
- Energy Engineer: Developing systems for power generation and distribution.

Emerging Fields

- Additive Manufacturing Engineer: Working with 3D printing technologies.
- Mechatronics Engineer: Combining mechanical, electrical, and computer engineering.
- Sustainable Design Engineer: Focusing on environmentally friendly designs.

6th Semester	Professional Elective (PE) Additive Manufacturing	M23BME603A

1. Prerequisites

S/L	Proficiency	Prerequisites
1	**Physics**	Basic knowledge of physics, particularly in mechanics and materials science, is essential. Understanding forces, material properties, and thermodynamics can be crucial for comprehending how AM technologies work.
2	**Computer Science**	Familiarity with computer-aided design (CAD) software is often required. Experience with programming or understanding computational concepts can also be beneficial, as AM involves digital design.
3	**Engineering Fundamentals**	A background in general engineering principles is useful. This includes knowledge of materials science, engineering mechanics, and manufacturing processes.
4	**Engineering Graphics or Drawing**	Ability to interpret and create technical drawings can be important for designing parts and understanding how they will be manufactured.
5	**Basic Chemistry**	Understanding the properties of different materials, including polymers, metals, and ceramics, can be important, as AM involves various material types.

2. Competencies

S/L	Competency	KSA Description
1	Fundamentals of Additive Manufacturing	**Knowledge:** Understanding various AM technologies (e.g., FDM, SLA, SLS, etc.), their applications, and the advantages and limitations of each. **Skills:** Proficiency in using CAD software to create and modify 3D models. Familiarity with AM equipment and its operation, including setting up machines and troubleshooting issues. **Attitudes:** A strong desire to explore new technologies and innovative solutions. AM is a rapidly evolving field, and a willingness to experiment and learn is essential.
2	CAD Fundamentals:	**Knowledge:** Familiarity with key CAD software (e.g., AutoCAD, Solid Works, CATIA, Fusion 360) and their capabilities. **Skills:** Ability to create detailed 2D technical drawings and 3D models using CAD software. **Attitudes:** Willingness to meticulously check and refine designs to ensure quality.
3	Manufacturing Processes	**Knowledge:** Knowledge of traditional and modern manufacturing processes (e.g., CNC machining, 3D printing, injection moulding). **Skills:** Basic programming skills to customize and automate tasks within CAD/CAM software. **Attitudes:** A proactive approach to exploring creative design solutions and innovative manufacturing techniques.

3. Syllabus

Additive Manufacturing **SEMESTER –VI**			
Course Code	**M23BME603A**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Objectives:

1. To know the principle methods, areas of usage, possibilities and limitations of the Additive Manufacturing technologies.
2. To be familiar with the characteristics of the different materials those are used in Additive Manufacturing.
3. To know the principles of polymerization and powder metallurgy process, extrusion-based system printing processes, sheet lamination processes, beam deposition processes, direct write technologies and Direct Digital Manufacturing.
4. To get exposed to process selection, software issues and post-processing.

Module -1

Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM. **Vat Photo polymerization AM Processes**: Stereo lithography (SL), Materials, Process Modelling, SL resin curing process, SL scan patterns, Micro-stereo lithography, Applications of Vat Photo polymerization, **Material Jetting and Binder Jetting AM Processes.**
Module -2
AM Data Formats: Tessellated Models, STL Format, STL File Problems, STL File Manipulation and Repair Algorithms, AMF files, 3MF, XML, Meta Data, PLY, STEP for AM Application Protocols (AP). **AM Data Processing:** Part Orientation and Support Structure Generation, Model Slicing and Contour Data Organization, Direct and Adaptive Slicing, Hatching Strategies and Tool Path Generation. Modelling of AM Process: Surface Roughness due to Staircase Effect, Part Build-time, Fabrication Cost, Optimal Orientation, Quantification of Building Inaccuracy and Part Stability.
Module -3
Extrusion - Based AM Processes: **Fused Deposition Modelling (FDM),** Principles, Materials, Process Modelling, Plotting and path control, Applications of Extrusion-Based Processes. **Sheet Lamination** AM Processes: Bonding Mechanisms, Materials**, Laminated Object Manufacturing (LOM),Powder Bed Fusion** AM Processes**: Selective laser Sintering (SLS)**, Materials, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation
Module -4
Directed Energy Deposition AM Processes: Process Description, Material Delivery, **Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD)**, **Electron Beam Based Metal Deposition, Processing**-structure properties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes. **Materials science for AM** - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship
Module -5
Post Processing of AM Parts: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques .**Guidelines for Process Selection**: Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Process Planning and Control.
TEXTBOOKS: 1. Venuvinod, Patri K., and Weiyin Ma. Rapid prototyping: laser-based and other technologies. Springer Science & Business Media, 2013. 2. Ian Gibson, David Rosen, and Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, New York, NY, 2015. **REFERENCE BOOKS:** 1 Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing Andreas Gebhardt Hanser Publishers 2011 2. Additive Manufacturing Technology Hari Prasad, A.V.Suresh Cengage 2019

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3:	**Introduction to Additive Manufacturing:** Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM. **Vat Photo polymerization AM Processes**: Stereo lithography (SL), Materials, Process Modelling, SL resin curing process, SL scan patterns, Micro-stereo lithography, Applications of Vat Photo polymerization, **Material Jetting and Binder Jetting AM Processes.**
2	Week 4-6:	**AM Data Formats:** Tessellated Models, STL Format, STL File Problems, STL File Manipulation and Repair Algorithms, AMF files, 3MF, XML, Meta Data, PLY, STEP for AM Application Protocols (AP).**AM Data Processing:** Part Orientation and Support Structure Generation, Model Slicing and Contour Data Organization, Direct and Adaptive Slicing, Hatching Strategies and Tool Path Generation. **Modelling of AM Process**: Surface Roughness due to Staircase Effect, Part Build-time, Fabrication Cost, Optimal Orientation, Quantification of Building Inaccuracy and Part Stability.
3	Week 8-11:	Extrusion - Based AM Processes: **Fused Deposition Modelling (FDM),**

		Principles, Materials, Process Modelling, and Plotting and path control, Applications of Extrusion-Based Processes. **Sheet Lamination** AM Processes: Bonding Mechanisms, Materials**, Laminated Object Manufacturing (LOM),Powder Bed Fusion** AM Processes**: Selective laser Sintering (SLS)**, Materials, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation
4	Week 7-8:	**Directed Energy Deposition** AM Processes: Process Description, Material Delivery, **Direct Metal Deposition (DMD)**, **Electron Beam Based Metal Deposition, Processing**-structure properties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes. **Materials science for AM** - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of nonequilibrium structure, microstructural studies, Structure property relationship
5	Week 9-12:	**Post Processing of AM Parts:** Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques. **Guidelines for Process Selection**: Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Process Planning and Control.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Additive Manufacturing concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME603A.1	Identify the broad range of AM processes, devices, capabilities and materials that are available
M23BME603A.2	Analyse the data format data processing and data modelling for the various AM processes and techniques that enable advanced/additive manufacturing.
M23BME603A.3	Apply the knowledge of the broad range of AM processes, devices, capabilities and materials that are available.
M23BME603A.4	Interpret the broad range of Directed Energy Deposition processes, devices, capabilities and material science associated with AM process
M23BME603A.5	Analyse the Post Processing of AM Parts requirements and Guidelines for Process Selection

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME603A.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME603A.2	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME603A.3	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME603A.4	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME603A.5	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME603A	**3**	**3**	-	-	-	-	-	-	-	-	-	-	3	3

8. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

9. Future with this Subject:

The future of additive manufacturing (AM) is promising and poised for significant transformation across various industries. Here are some key trends and potential developments to look forward to:

Diverse Material Options: On-going research is expanding the range of materials available for AM, including advanced polymers, high-performance metals, ceramics, and bio-materials. This will enhance the versatility of AM applications. **Functional Materials**: Development of materials with specific properties, such as self-healing, conductive, or bio-compatible materials, will open new avenues for AM in fields like electronics and healthcare.

Enhanced Technologies

Increased Speed and Precision: Advances in AM technology will lead to faster printing speeds and higher precision, improving the quality and efficiency of AM processes.**Multi-Material Printing**: Progress in multi-material and multi-process AM systems will allow for more complex and integrated designs, combining various materials in a single build.

Integration with Other Technologies

Automation and Robotics: Integration with robotics and automation will streamline AM processes, making them more efficient and scalable for large-scale production.**AI and Machine Learning**: Artificial intelligence and machine learning will enhance design optimization, process control, and predictive maintenance, improving overall system performance and reliability.

6th Semester	Professional Elective (PE) Fracture Mechanics	M23BME603B

1. Prerequisites

S/L	Proficiency	Prerequisites
1	**Basic Science:**	• Introduction to Solid Mechanics (stress, strain, and deformation) • Introduction to Thermodynamics (energy, heat transfer, and thermodynamic properties) • Basic understanding of material properties (Young's modulus, Poisson's ratio, and density)
2	**Mathematics:**	• Calculus (differential equations, integral equations, and vector calculus) • Linear Algebra (matrices, determinants, and eigenvectors) • Statistics and Probability Theory (understanding of random variables, probability distributions, and statistical inference)
3	**Mechanics of materials**	• Introduction to Solid Mechanics (stress, strain, and deformation) • Basic understanding of material properties (Young's modulus, Poisson's ratio, and density) • Knowledge of how materials respond to different types of loading, including tension, compression, and torsion, as well as concepts like bending stress and shear stress.
4	**Machine Design**	• Familiarity with engineering design principles and problem-solving techniques • Familiarity with different failure criteria, such as maximum stress, maximum strain, and energy-based approaches, is important for predicting when and how materials might fail.
5	**Material Science**	• Familiarity with the properties of materials, including their microstructure, mechanical properties, and failure mechanisms. • Familiarity with common mechanical testing methods such as tensile testing, hardness testing, and impact testing.
6	**Finite Element Method**	• Experience with computational tools and methods, particularly in the context of solving partial differential equations using FEM. • Understanding numerical approximation techniques, convergence criteria, and error analysis in FEM.
7	**Thermodynamics**	• Basic knowledge of energy principles and thermodynamic laws, including energy conservation and entropy, is necessary to understand concepts like Griffith's energy balance.

2. Competencies

S/L	Competency	KSA Description
1	**Fracture Mechanics Principles**	**Knowledge:** Understand the fundamental concepts of fracture mechanics, including historical context, sources of cracks, and stress concentration. Familiarity with the strengths of ideal materials **Skills:** Ability to analyze and solve numerical problems related to fracture mechanics. Competence in evaluating stress concentration and predicting crack propagation behaviour. **Attitudes:** Respect for the importance of safety and reliability in design and engineering applications Willingness to apply theoretical knowledge to real-world problems
2	**Plasticity**	**Knowledge:**

	effects	Understand the theory of plastic deformation and its effects on fracture mechanics, Methods for estimating stress intensity factors and plane strain fracture toughness **Skills:** Ability to calculate stress intensity factors and plane strain fracture toughness from given data **Attitudes:** Respect for the importance of safety and reliability in engineering design and analysis, with a commitment to applying knowledge of fracture mechanics to improve the safety and reliability of engineering structures.
3	**The energy release rate and Elastic plastic fracture mechanics**	**Knowledge:** understanding the energy release rate and its application in fracture mechanics, Elastic-plastic fracture mechanics and its principles **Skills:** Analyzing the energy release rate and its application in fracture mechanics. Applying criteria for crack growth and crack propagation in real-world problems **Attitudes:** A curiosity to understand the underlying principles of fracture mechanics. A willingness to learn and apply complex fracture mechanics concepts
4	**J integral, Dynamics and crack arrest**	**Knowledge:** Understanding the concept, application and Limitations of J-integral **Skills:** Analyze and apply the J-integral concept to solve problems Evaluate the limitations of J-integral in different scenarios. **Attitudes:** A willingness to apply theoretical knowledge to practical problems An openness to learning new concepts and techniques in fracture mechanics
5	**Fatigue crack propagation and applications of fracture mechanics**	**Knowledge:** factors affecting crack propagation, including material properties, loading conditions, and environmental factors methods and approaches used to provide fail-safety in engineering systems **Skills:** Applying the principles of fracture mechanics to real-world problems and scenarios. Identifying and evaluating the factors that affect crack propagation and stress intensity. **Attitudes:** A commitment to lifelong learning and staying up-to-date with advances in fracture mechanics research and applications.

3. Syllabus

FRACTURE MECHANICS SEMESTER – VI			
Course Code	**M23BME603B**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Objectives:

1. Understand the fundamentals of fracture mechanics of materials.
2. Acquire knowledge of stress and strain, deformation fields near a crack tip, fracture characterizing parameters such as stress intensity factor and J integral, and the kinetics of fatigue crack growth.
3. Exposure to fundamentals of linear elastic fracture mechanics, nonlinear (Elastic-Plastic) fracture mechanics and fatigue crack growth.
4. Determining the fracture toughness by experimental methods (for example, ASTM standard procedure for JIC testing).

5. Analyse the mechanism of failure of structures by fatigue crack growth
Module -1
Fracture mechanics principles: Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, and Griffith's energy balance approach. Fracture mechanics approach to design, NDT and Various NDT methods used in fracture mechanics, Numerical problems. The Airy stress function. Effect of finite crack size. Elliptical cracks, Numerical problems.
Module -2
Plasticity effects: Theory of Plastic deformation, Irwin plastic zone correction. Dugdale's approach. The shape of the plastic zone for plane stress and plane strain cases. The plate thickness effect, numerical problems. Determination of Stress intensity factors and plane strain fracture toughness: Introduction, estimation of stress intensity factors. Experimental method- Plane strain fracture toughness test, The Standard test, size requirements, etc.
Module -3
The energy release rate, Criteria for crack growth. The crack resistance(R curve). Compliance. Tearing Modulus. Stability. **Elastic plastic fracture mechanics:** Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD.
Module -4
J integral: Use of J integral. Limitation of J integral. Experimental determination of J integral and the Parameters affecting J integral. **Dynamics and crack arrest:** Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness.
Module -5
Fatigue crack propagation and applications of fracture mechanics: Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading Means to provide fail-safety, Paris law, Required information for fracture mechanics approach.
TEXTBOOKS: 1. Elements of fracture mechanics by Prasanth Kumar, Wheeter publication 1999 2. Fracture Mechanics: Fundamentals and Applications by Anderson, CRC press publication,3rd Ed.,2005 **REFERENCE BOOKS:** 1. Introduction to fracture mechanics by Karen Hellan, McGraw Hill publication,2nd Ed 2. Engineering fracture mechanics by S.A. Meguid, Elsevier Applied Science publication,1989 **VIDEO LINKS:** 1. https://archive.nptel.ac.in/courses/112/106/112106065/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3: Fracture mechanics principles	Studying Fracture mechanics principles, including historical context, micro/macro crack sources, stress concentration, Griffith's energy balance, and design approaches. Explore NDT methods, Airy stress function, elliptical cracks, finite crack size effects, and numerical problems.
2	Week 4-6: Plasticity effects	Understanding the theory of plastic deformation, Irwin plastic zone correction, Dugdale's approach, plastic zone shapes in plane stress and strain, plate thickness effects, and solve numerical problems. Estimation and experimental determination of stress intensity factors and plane strain fracture toughness.
3	Week 8-11: The energy release rate, Elastic plastic fracture mechanics	Studying the Concepts of the energy release rate, crack growth criteria, crack resistance (R curve), compliance, tearing modulus, and stability. Elastic-plastic fracture mechanics, crack-tip opening displacement (CTOD), CTOD criteria, experimental determination, and factors affecting critical CTOD.
4	Week 7-8: J integral, Dynamics and	Exploring the concept J integral's application, limitations, and experimental determination, along with factors influencing it. It covers dynamics and crack arrest, including crack speed, kinetic energy, dynamic stress intensity, elastic

	crack arrest	energy release, crack branching, and principles of crack arrest.
5	Week 9-12: Fatigue crack propagation and applications of fracture mechanics	Studying the J integral, fatigue crack propagation, and fracture mechanics applications, covering crack growth, stress intensity factors, factors influencing crack propagation, variable amplitude service loading, fail-safe strategies, Paris law, and essential information for a fracture mechanics approach.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Fracture mechanics principles	Understand fundamental principles of fracture mechanics, sources of cracks, stress concentration, and numerical problem-solving techniques
2	Plasticity effects	Exploring plasticity effects, stress intensity factors, and plane strain fracture toughness testing methodologies
3	The energy release rate and Elastic plastic fracture mechanics	Understanding the energy release rate, crack growth, and fracture mechanics beyond general yield point
4	J integral, Dynamics and crack arrest	Analyze crack behaviour, dynamics, and arrest, including limitations and experimental parameters
5	Fatigue crack propagation and applications of fracture mechanics	Examine fatigue crack propagation and the applications of fracture mechanics, focusing on stress intensity factors and safety considerations.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME603B.1	**Analyse the effects of crack like defects on the performance of Aerospace, Civil, and Mechanical Engineering structures**
M23BME603B.2	**Apply the concepts of fracture mechanics to select appropriate materials for engineering structures to insure damage tolerance.**
M23BME603B.3	**Compute stress intensity factor and J integral or nonlinear energy release rate by Understanding mechanics of crack tip fields**
M23BME603B.4	**Determine critical crack sizes and fatigue crack propagation rates in engineering structures leading to life estimation by using the concepts of fracture mechanics**
M23BME603B.5	Understand and **Evaluate** the status of academic research in field of fracture mechanics.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME603B.1	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME603B.2	-	-	3	-	-	-	-	-	-	-	-	-	3	-
M23BME603B.3	-	-	3		-	-	-	-	-	-	-	-	-	3
M23BME603B.4	-	-	3	-	-	-	-	-	-	-	-	-	-	3
M23BME603B.5	-	-	-	3	-	-	-	-	-	-	-	-	-	3
M23BME603B	-	**3**	3	3	-	-	-	-	-	-	-	-	3	3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

- Composite Materials and Mechanics: Examine the fracture mechanics of composite materials, including their unique properties, failure modes, and applications in high-performance structures.
- Non-Destructive Testing (NDT) and Evaluation: Focus on various NDT techniques used to detect cracks and flaws in materials and structures, and how these techniques are applied in quality control and maintenance.
- Materials Science: the study of advanced materials, including composites, ceramics, and polymers, focusing on their fracture behaviors and applications in various industries.
- Computational Mechanics: Explore numerical methods and simulations, such as Finite Element Analysis (FEA), used to model and predict fracture behavior in complex structures.

6thSemester	Professional Course (PC) NON DESTRUCTIVE TESTING	M23BME603C

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Basic knowledge of Manufacturing Process	Basic understanding of manufacturing process and knowledge identifying the defects
2	Electrical Knowledge	Understanding of basic electrical principles like eddy current, magnetism principles,
3	Material Science knowledge	Able identify and compare the different materials like conductive material, non-conductive material, magnetic materials etc.
4	Metrology	Proficiency in measurement of physical quantities
5	Inspection and calibration	Ability to apply the measurement and calibration procedure to the instruments and devices.

2. Competencies

S/L	Competency	KSA Description
1	Advanced manufacturing Techniques and Analysis	**Knowledge:** Proficiency knowledge of defects in materials **Skills:** Ability to identify the defects of material **Attitudes:** Importance of understanding the NDT methods for corresponding defects.
2	Electrical systems knowledge	**Knowledge:** Understanding the working principle of magnetism and eddy current **Skills:** Identifying magnetic lines in MPT. Generating eddy currents **Attitudes:** Importance of generation of magnetic lines of forces and eddy currents
3	Material Properties	**Knowledge:** Learn about the physical and mechanical properties of materials that are commonly tested using NDT methodsalong with defects. Identify the type of Material. **Skills:** Able to differentiate conductive material, non-conductive material, magnetic materials etc **Attitudes:** Importance of understanding material types.
4	Quality and inspection	**Knowledge:** Understand and comply with industry standards and regulations, such as those from ASTM, AWS, and API. **Skills:** Learn how NDT is integrated into quality control processes **Attitudes:** Ability to understand role of NDT in maintaining industry standards.
5	Safety aspects	**Knowledge:** Understand the safety protocols for handling radiographic equipment. **Skills:** Learn the safety procedures for working with other NDT methods and maintaining a safe work environment **Attitudes:** Ability to use safety gadgets and optimize the radiation in radiography

3. Syllabus

NON-DESTRUCTIVE TESTING SEMESTER – VI			
Course Code	M23BME603C	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives: This course will enable students to:

- To introduce the basic principles, techniques, equipment, applications and limitations of Non-Destructive Testing (NDT) methods such as Visual, Penetrant Testing, Magnetic Particle Testing,Ultrasonic Testing, Radiography, Eddy Current.
- To enable selection of appropriate NDT methods.
- To identify pros and cons of NDT methods
- To make aware the developments and future trends in NDT.

Module -1

OVERVIEW OF NDT: NDT Versus Mechanical testing, Overview of the Non-Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. Relative merits & limitations, Various physical characteristics of materials & their applications in NDT. Visual inspection – Unaided and aided.

Pedagogy	Chalk and talk, Power point presentation, Case study	8 Hours

Module -2

SURFACE NDT METHODS: Liquid Penetrant Testing – Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results.

Magnetic Particle Testing- Theory of magnetism, inspection materials, magnetization methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

Pedagogy	Chalk and talk, Power point presentation, Case study, Lab Demonstration	8 Hours

Module -3

THERMOGRAPHY AND EDDY CURRENT TESTING (ET): Thermography- Principles, Contact and non contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infraredradiation and infrared detectors, Instrumentations and methods, applications.

Eddy Current Testing-Generationof eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types ofarrangement, Applications, advantages, Limitations, Interpretation/Evaluation.

Pedagogy	Chalk and talk, Power point presentation, Case study, Lab Demonstration	8 Hours

Module -4

ULTRASONIC TESTING (UT) AND ACOUSTIC EMISSION (AE):

Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction.

Acoustic Emission Technique –Principle, AE parameters, Applications.

Pedagogy	Chalk and talk, Power point presentation, Case study, Lab Demonstration	8 Hours

Module -5

RADIOGRAPHY (RT): Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence.

Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography.

Pedagogy	Chalk and talk, Power point presentation, Case study	8 Hours

TEXT BOOKS:

1. Practical Non-Destructive Testing by Baldev Raj, T.Jayakumar, M.ThavasimuthuNarosa Publishing House 2009
2. Non-Destructive Testing Techniques by Ravi Prakash New Age International Publishers 1st revised edition2010

REFERENCE BOOKS

1. ASM Metals Handbook,"Non-Destructive Evaluation and Quality Control", Volume-17 American Society of Metals, Metals Park, Ohio, USA, 2000
2. Introduction to Nondestructive testing: a training guide by Paul E Mix, Wiley 2nd Edition New Jersey, 2005
3. Handbook of Nondestructive evaluation by Charles, J. Hellier McGraw Hill, New York 2001

ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook,
Vol. 1, Leak Testing,
Vol. 2, Liquid Penetrant Testing
Vol. 3, Infrared and Thermal Testing
Vol. 4, Radiographic Testing,
Vol. 5, Electromagnetic Testing,
Vol. 6, Acoustic Emission Testing,
Vol. 7, Ultrasonic Testing.
Additional Reading:
NPTEL Web Course:
https://nptel.ac.in/courses/112105182/
NPTEL Video Course:
https://nptel.ac.in/courses/112105182/1

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Overview of NDT Methods & Surface NDT Methods LPT	1. **OVERVIEW OF NDT:** NDT Versus Mechanical testing, Overview of the Non-Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. Relative merits & limitations, various physical characteristics of materials & their applications in NDT. **Visual inspection** – Unaided and aided.
2	Week 3-4: Surface NDT Methods MPT	**SURFACE NDT METHODS: Liquid Penetrant Testing** – Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. 2. **Magnetic Particle Testing-** Theory of magnetism, inspection materials, magnetization methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.
3	Week 5-6: Thermography & Eddy Current Testing	**Thermography**- Principles, Contact and non contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infraredradiation and infrared detectors, Instrumentations and methods, applications. 3. **Eddy Current Testing**-Generationof eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types ofarrangement, Applications, advantages, Limitations, Interpretation/Evaluation.
4	Week 7-8: Ultra-Sonic testing	**Ultrasonic Testing**-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction.
5	Week 9-10: Acoustic Emission testing	**ACOUSTIC EMISSION (AE):**Acoustic Emission Technique – Principle, AE parameters, Applications
6	Week 11-12: Radiography	**RADIOGRAPHY (RT):** Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. 4. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Chalk and Talk method	Concepts like block diagram, line diagram and tables are explained using chalk and talk method.
2	Power Point presentations	Most of modules are explained with visualization.
3	Case studies	A real time scenario of testing is explained in each of the NDT Methods.
4	Lab demonstration	Demonstration of magnetic particle testing, ultrasonic testing, and Infrared thermometer is conducted.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks =(A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Basic principles, techniques, equipment, applications and limitations of (NDT) methods	Students will grasp the fundamental knowledge of all NDT methods like Visual testing, Liquid penentrant testing, Magnetic particle testing, Thermography, eddy current testing, ultrasonic testing Acoustic emission testing and radiography. This will enhance them to identify the surface, sub-surface and internal defects in the products.
2	Selection of appropriate NDT methods	Students will learn to choose appropriate testing material based on the severity of defect whether surface defect or sub-surface defect or internal defects.
3	Identify pros and cons of NDT	Students will become proficient in analyzing the pros and cons of NDT based on various defects and material characterization.
4	Awareness about the developments and future trends in NDT	Non-destructive Testing Methods have become a focal point with respect to the advent of Industry 4.0. Improvement of existing technology involves the adoption of embedded systems, advanced sensors, error-free inference, coordinated process flow, and efficient troubleshooting.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME603C.1	Identify defects in components by visual inspection method of Non-destructive testing methods.
M23BME603C.2	Classify surface NDT methods for detecting different surface flaws.
M23BME603C.3	Examine defects using the principles of thermography and eddy current testing methods.
M23BME603C.4	Categorize surface flaws using the principles of ultrasonic effect and acoustic emission techniques.
M23BME603C.5	Inspect subsurface flaws of images using radiography technique of NDT methods.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME603C.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME603C.2	-	3	-	-	-	-	-	-	-	-	-	-	3	-
M23BME603C.3	-	3	-	-	-	-	-	-	-	-	-	-	3	-
M23BME603C.4	-	3	-	-	-	-	-	-	-	-	-	-	3	-
M23BME603C.5	-	3	-	-	-	-	-	-	-	-	-	-	3	-
M23BME603C	**3**	**3**	-	-	-	-	-	-	-	-	-	-	**3**	-

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	**Total**
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

Non-destructive testing (NDT) plays a crucial role in various industries by enabling the inspection and evaluation of materials, components, and structures without causing damage. The future of NDT is expected to be shaped by several key trends and advancements:

- **Advanced Imaging Technologies**:Higher resolution and faster CT scans will provide more detailed images of internal structures, enhancing defect detection and material characterization. Terahertz waves can penetrate a variety of non-metallic materials, offering new possibilities for inspecting composite materials and detecting hidden defects.
- **Artificial Intelligence and Machine Learning**:AI and ML algorithms can analyze vast amounts of NDT data, identifying patterns and anomalies more quickly and accurately.
- **Robotics and Automation**:Automated NDT systems, including drones and robotic crawlers, will perform inspections in hazardous or hard-to-reach areas, improving safety.

6th Semester	Professional Elective (PE) EXPERIMENTAL STRESS ANALYSIS	M23BME603D

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Mechanics of Materials	Understanding the behavior of materials under various loading conditions, stress-strain relationships, and basic failure theories.
2	Engineering Mechanics	Knowledge of statics and dynamics, which is essential for understanding force equilibrium, motion, and the behavior of structures.
3	Mathematics	Proficiency in calculus, differential equations, and linear algebra. These mathematical tools are crucial for modeling and analyzing stress and strain.
4	Materials Science	Basic knowledge of materials properties and behavior, including an understanding of different material types and their mechanical properties.
5	Basic Measurement Techniques	Familiarity with basic measurement tools and techniques used in engineering, such as strain gauges and other sensors.

2. Competencies

S/L	Competency	KSA Description
1	Electrical Resistance Strain Gages	**Knowledge:** • Familiarity with different types of strain gages and their specific applications. • Awareness of materials used in strain gages, such as constantan and nickel-chromium alloys, and their properties. **Skills:** • Proficiency in setting up and operating data acquisition systems to accurately record strain measurements. • Skills in analyzing strain gage data, including interpreting voltage changes and calculating strain values. **Attitude:** • Attention to detail in the calibration and data acquisition process to minimize errors. • Awareness of the importance of strain gage data in critical applications, such as safety testing and structural integrity assessments, and the associated responsibility.
2	Strain Analysis Methods	**Knowledge:** • Familiarity with strain measurement methods, such as, Strain Gauges and Optical Methods **Skills:** • Ability to design and set up experiments to measure strain accurately, including proper selection and installation of strain gauges or other sensors. **Attitude:** • Capability to develop new or improved methods for strain measurement, especially for challenging applications.
3	Photo elasticity	**Knowledge:** • Understanding the basic principles of photoelasticity, including birefringence, optical path difference, and fringe patterns. • Knowledge of stress-optic law and how it relates to the measurement of stress and strain in transparent materials. **Skills:** • Proficiency in setting up and calibrating photoelastic experimental setups, including the alignment of optical components and preparation of models. • Skills in conducting experiments, capturing fringe patterns, and ensuring accurate data acquisition. **Attitude:** • Openness to integrating photoelasticity with other experimental or computational methods for comprehensive stress analysis. • Capability to draw meaningful conclusions from complex fringe patterns and

		stress distributions.
4	Brittle Coatings	**Knowledge:** • Understanding the physical and chemical properties of brittle coatings and how they are applied to different substrates. • Knowledge of the principles behind crack formation in brittle coatings under stress. **Skills:** • Ability to use tools and equipment for observing and recording crack patterns, such as microscopes or high-resolution cameras. • Competence in designing experiments that utilize brittle coatings to investigate stress patterns. **Attitude:** • Creativity in using brittle coatings in combination with other stress analysis methods for comprehensive assessment. • Awareness of safety protocols when handling chemicals used in brittle coatings.

3. Syllabus

Experimental Stress Analysis **SEMESTER – VI**			
Course Code	**M23BME603D**	CIE Marks	**50**
Number of Lecture Hours/Week (L: T: P: S)	3:0:0:0	SEE Marks	**50**
Total Number of Lecture Hours	40	Total Marks	**100**
Credits	3	Exam Hours	**03**

Course objectives

1. To use the method of electrical strain gauges to study and characterize the elastic behavior of solid bodies.
2. To measure displacement and perform stress strain analysis of mechanical systems using electrical resistance strain gauges.
3. To describe the photo elastic method to study and characterize the elastic behavior of solid bodies.
4. To determine stress strain behavior of solid bodies using methods of coating.
5. To conduct stress strain analysis of solid bodies using the methods Holography

Module -1

Introduction: Definition of terms, Calibration, Standards, Dimension and units generalized measurement system. Basic concepts in dynamic measurements, system response, distortion, impedance matching, Analysis of experimental data, cause and types of experimental errors. general consideration in data analysis.
Electrical Resistance Strain Gages: Strain sensitivity in metallic alloys, Gageconstruction, Adhesives and mounting techniques, Gage sensitivity and gage factor, Performance' Characteristics, Environmental effects, Strain Gage circuits. Potentiometer, Wheatstone's bridges, Constant current circuits.

Module -2

Strain Analysis Methods: Two element, three element rectangular and delta rosettes, Correction for transverse strain effects, Stress gage, Plane shear gage, Stress intensity factor gage. **Force, Torque and strain measurements:** Mass balance measurement, Elastic element for force measurements, torque measurement.

Module -3

Photo elasticity: Nature of light, Wave theory of light - optical interference, Stress optic law –effect of stressed model in plane and circular polariscopes, Isoclinic & Isochromatic, Fringe order determination Fringe multiplication techniques, Calibration photo elastic model materials.
Two-Dimensional Photo elasticity: Separation methods: Shear difference method, Analytical separation methods, Model to prototype scaling, Properties of 2D photo elastic model materials, Materials for 2D photo elasticity.

Module -4

Three-Dimensional Photo elasticity: Stress freezing method, scattered light photo elasticity, Scattered light as an interior analyzer and polarizer, Scattered light polariscope and stress data Analyses.
Photo elastic (Birefringent) Coatings: Birefringence coating stresses, Effects of coating thickness: Reinforcing effects, Stress separation techniques: Oblique incidence, Strip coatings.

Module -5

Brittle Coatings: Coatings stresses, Crack patterns, Refrigeration techniques, Load relaxation techniques, Crack detection methods, Types of brittle coatings, Calibration of coating. Advantages and brittle coating applications.
Moire Methods: Moire fringes produced by mechanical interference. Geometrical approach, Displacement field approach to Moire fringe analysis, 0ut of plane displacement measurements, Out of plane slope measurements. Applications and advantages.

Suggested Learning Resources:

Text Books:

1. "Experimental Stress Analysis", Dally and Riley, McGraw Hill.
2. "Experimental Stress Analysis". Sadhu Singh, Khanna publisher.
3. Experimental stress Analysis, Srinath L.S tata Mc Graw Hill.

References:

1. Photoelasticity Vol I and Vol II, M.M.Frocht, John Wiley & sons.
2. Strain Gauge Primer, Perry and Lissner,
3. Photo Elastic Stress Analysis, Kuske, Albrecht & Robertson John Wiley & Sons.
4. Motion Measurement and Stress Analysis, Dave and Adams,
5. Holman, Experimental Methods for Engineers, Tata McGraw-Hill Companies, 7th Edition, New York, 2007.

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/112/106/112106068/
2. http://www.nptelvideos.com/course.php?id=800

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2	**Introduction:** Definition of terms, Calibration, Standards, Dimension and units generalized measurement system. Basic concepts in dynamic measurements, system response, distortion, impedance matching, Analysis of experimental data, cause and types of experimental errors. general consideration in data analysis. **Electrical Resistance Strain Gages:** Strain sensitivity in metallic alloys, Gageconstruction, Adhesives and mounting techniques,
2	Week 3-4	Gage sensitivity and gage factor, Performance' Characteristics, Environmental effects, Strain Gage circuits. Potentiometer, Wheatstone's bridges, Constant current circuits. **Strain Analysis Methods:** Two element, three element rectangular and delta rosettes, Correction for transverse strain effects, Stress gage, Plane shear gage, Stress intensity factor gage.
3	Week 5-6	**Force, Torque and strain measurements:** Mass balance measurement, Elastic element for force measurements, torque measurement. **Photo elasticity:** Nature of light, Wave theory of light - optical interference, Stress optic law –effect of stressed model in plane and circular polariscopes, Isoclinic & Isochromatic, Fringe order determination Fringe multiplication techniques, Calibration photo elastic model materials.
4	Week 7-8	**Two-Dimensional Photo elasticity:** Separation methods: Shear difference method, Analytical separation methods, Model to prototype scaling, Properties of 2D photo elastic model materials, Materials for 2D photo elasticity. **Three-Dimensional Photo elasticity:** Stress freezing method, scattered light photo elasticity, Scattered light as an interior analyzer and polarizer, Scattered light polariscope and stress data Analyses. **Photo elastic (Birefringent) Coatings:** Birefringence coating stresses, Effects of coating thickness: Reinforcing effects, Stress separation techniques: Oblique incidence, Strip coatings.
5	Week 9-10	**Brittle Coatings:** Coatings stresses, Crack patterns, Refrigeration techniques, Load relaxation techniques, Crack detection methods, Types of brittle coatings, Calibration of coating. Advantages and brittle coating applications.
6	Week 11-12	**Moire Methods:** Moire fringes produced by mechanical interference. Geometrical approach, Displacement field approach to Moire fringe analysis, 0ut of plane displacement measurements, Out of plane slope measurements. Applications and advantages.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	**1.** Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	**2.** Incorporate visual aids like videos/animations to enhance understanding of smart materials concepts.

3	Collaborative Learning	**3.** Encourage collaborative learning for improved competency application.
4	Higher Order Thinking (HOTS) Questions:	**4.** Pose HOTS questions to stimulate critical thinking related to each competency.
5	Problem-Based Learning (PBL)	**5.** Implement PBL to enhance analytical skills and practical application of competencies
6	Multiple Representations	**6.** Introduce topics in various representations to reinforce competencies
7	Real-World Application	**7.** Discuss practical applications to connect theoretical concepts with real-world competencies.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

9. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
10. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
11. The students have to answer 5 full questions selecting one full question from each module.
12. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understand Fundamental Concepts	Demonstrate a comprehensive understanding of the principles of stress, strain, and deformation in materials and structures, including key concepts like stress-strain relationships, elastic and plastic behavior, and failure criteria.
2	Apply Experimental Techniques	Utilize various experimental techniques such as strain gauges, photoelasticity, and digital image correlation to measure and analyze stress and strain in materials and structural components.
3	Interpret Experimental Data	Analyze and interpret experimental data to identify stress concentrations, validate theoretical models, and assess the performance of materials and structures under different loading conditions.
4	Design and Conduct Experiments	Design and conduct experiments to measure and evaluate the mechanical behavior of materials and structures, including setting up test equipment, selecting appropriate measurement techniques, and ensuring data accuracy and reliability.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs): Students will be able to

COs	Description
M23BME603D.1	Apply knowledge of strain gages to measure mechanical deformation in various materials and structures
M23BME603D.2	Interpret strain results in the context of material behavior and structural performance.
M23BME603D.3	Analyze the relationship between material properties and their optical response.
M23BME603D.4	Solve complex problems involving stress analysis using photo-elastic coatings.
M23BME603D.5	Interpret moiré methods for practical applications, such as measurement, inspection, and quality control.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME603D.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME603D.2	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME603D.3	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME603D.4	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME603D.5	-	3	-	-	-	-	-	-	-	-	-	-	-	3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject

A student who studies **Experimental Stress Analysis** can look forward to a diverse and rewarding range of career opportunities. This field is critical in many industries where understanding material behavior under stress is essential for design, safety, and innovation. Here are some potential career paths and prospects:

Industry and Manufacturing

- **Aerospace Engineering**: In the aerospace industry, stress analysis is crucial for the design and testing of aircraft and spacecraft components. Students can work on projects involving the safety and performance of structures, leading to roles in companies like Boeing, Airbus, or SpaceX.
- **Automotive Engineering**: Opportunities in the automotive sector involve crashworthiness analysis, durability testing, and design optimization. Companies like Ford, GM, Tesla, and others value skills in experimental stress analysis for vehicle safety and performance.
- **Civil Engineering and Construction**: In this field, stress analysis helps in assessing the structural integrity of buildings, bridges, and other infrastructure. Students can work for engineering consultancies, construction firms, or governmental agencies.
- **Energy Sector**: This includes roles in the design and testing of components for power plants, wind turbines, and oil rigs. Companies in renewable energy, nuclear power, and oil and gas often require expertise in stress analysis.

Research and Development (R&D)

- **Materials Research**: R&D roles in universities, national laboratories, or private companies often focus on developing new materials with specific properties. This can involve studying the mechanical behavior of advanced materials like composites, nanomaterials, or bio-materials.
- **Product Development**: Working in R&D departments, students can contribute to the development of new products by ensuring they can withstand operational stresses, thereby enhancing durability and reliability.

Academia and Education

- **Teaching and Research**: Graduates can pursue advanced degrees (Master's or Ph.D.) and become educators or researchers. They may teach courses related to mechanics, materials science, or stress analysis, and conduct research to advance the field.
- **Consultancy**: Experts in experimental stress analysis may work as consultants, providing specialized knowledge to solve complex engineering problems across various industries.

6th Semester	Open Elective (OE) NON CONVENTIONAL ENERGY RESOURCES	M23BME604A

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Basic Physics	• Basic understanding of classical mechanics, thermodynamics, and electromagnetism. • Knowledge of energy forms, energy conversion, and basic principles of heat transfer.
2	Basic Chemistry	• Understanding of chemical reactions and processes. • Understanding the materials and reactions involved in energy storage, bioenergy, and fuel cells.
3	Basic Biology	• Basics of plant biology and ecology for bioenergy.
4	Environmental Science	• Basic understanding of Ecology, Pollution & Environmental Impact and Sustainability. • Understanding of the impact of energy production and consumption on the environment.
5	Conventional Sources	• Basic knowledge of fossil fuels, coal, hydro & nuclear.

2. Competencies

S/L	Competency	KSA Description
1	**Energy Sources & its availability**	**Knowledge:** • Understanding knowledge of different energy sources. • Understanding the India & Global energy scenario. **Skills:** • Ability to analyze alternative solutions to overcome the problems of conventional energy sources. **Attitudes:** • Recognizing the significances of energy sources availability.
2	**Design and Implementation**	**Knowledge:** • Knowledge of system integration and the ability to work with hybrid energy systems. • Understanding of energy storage solutions and their integration with renewable sources. **Skills:** • Ability to design and implement renewable energy systems such as solar, wind, hydro, and biomass energy systems. • Identifying and solving technical issues in renewable energy systems. **Attitudes:** • Perform economic and environmental impact analyses of renewable energy solutions.
3	**Innovative Thinking**	**Knowledge:** Proficiency in making informed decisions based on data analysis, technical feasibility, economic viability, and environmental impact. **Skills:** Ability to develop creative solutions to challenges in the renewable energy sector. **Attitudes:** Openness to think creative ideas for improvisation for renewable sources.
4	**Ethical and**	**Knowledge:**

	Sustainable Practices	• Understanding of ethical issues related to energy production and consumption. • Understanding of sustainability principles and their importance in the energy sector. **Skills:** • Adaptability to evolving industry trends and emerging challenges. **Attitudes:** • Commitment to promoting the awareness of the ethical implications of energy choices and their impact on the environment and society.
5	**Energy Sources & its availability**	**Knowledge:** • Understanding knowledge of different energy sources. • Understanding the India & Global energy scenario. **Skills:** • Ability to analyze alternative solutions to overcome the problems of conventional energy sources. **Attitudes:** • Recognizing the significances of energy sources availability.

3. Syllabus

NON CONVENTIONAL ENERGY RESOUCRES SEMESTER – VII			
Course Code	**M23BME604A**	CIE Marks	**50**
No. of Lecture Hours/Week(L:T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course objectives:

- To introduce the concepts of solar energy, its radiation, collection, storage and application.
- To introduce the concepts and applications of Wind energy, Biomass energy, geothermal energy and Ocean energy as alternative energy sources.
- To explore society's present needs and future energy demands.
- To examine energy sources and systems, including fossil fuels and nuclear energy, and then focus on alternate, renewable energy sources such as solar, biomass (conversions), wind power, geothermal, etc.
- To get exposed to energy conservation methods.

Module -1

Introduction: Energy source, India's production and reserves of commercial energy sources, worldwide renewable energy availability, need for nonconventional energy sources, energy alternatives, solar, thermal, and photovoltaic, Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal, tar sands and oil shale, nuclear (Brief descriptions); advantages and disadvantages.

Module -2

Solar Energy: Fundamentals; Solar Radiation; 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. Solar radiation Measurements- Pyrheliometers, Pyrometer, Sunshine Recorder.
Solar electric power generation- Principle of Solar cell, Photovoltaic system for electric power generation, Solar Thermal systems: Collection and storage, thermal collection devices, Flat plate collector; Solar distillation; Solar pond electric power plant.

Module -3

Wind Energy: Properties of wind, working, 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 wind mills, elementary design principles;
Biomass Energy: Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, problems involved with bio-gas production, application of bio-gas, , advantages.

Module -4

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, Single basin & double basin system, harnessing tidal energy, limitations.
Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems associated with OTEC.

Module -5
Geothermal Energy Conversion: Principle of working, Hydrothermal Resources, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy. **Hydrogen Energy:** Introduction, Fuel cells: Classification of fuel cells – H2; Operating principles, Zero Energy Concepts. Benefits of Hydrogen Energy, hydrogen production technologies (electrolysis method only).
Text Books: 1 Non-Convention Energy Resources B H Khan McGraw Hill Education (India) Pvt. Ltd. 3rd Edition 2 Solar energy Subhas P Sukhatme Tata McGraw Hill 2 nd Edition, 1996. 3 Non-Conventional Energy Sources G.D Rai Khanna Publishers 2003 **Reference Books:** 1 Renewable Energy Sources and Conversion Technology N.K.Bansal, Manfred Kleeman&MechaelMeliss Tata McGraw Hill. 2004 2 Renewable Energy Technologies Ramesh R & Kumar K U Narosa Publishing House New Delhi 3 Conventional Energy Systems K M, Non Wheeler Publishing Co. Ltd., New Delhi 2003 4 Non-Conventional Energy Ashok V Desai Wiley Eastern Ltd, New Delhi 2003. **Links** **1.** https://archive.nptel.ac.in/courses/103/103/103103206/ **2.** htttps://archive.nptel.ac.in/courses/121/106/121106014/ **3.** https://drive.google.com/file/d/1TezxsWvbHDda45wGLHt7vDS5zFv7kd56/view

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction and Availability of Energy Sources	Introduction to energy sources, Classification of Energy Sources, Sustainable development, social implications, worldwide renewable energy availability, renewable energy availability in India, brief descriptions on energy alternatives. Introduction to Internet of energy (IOE).
2	Week 3-4: Fundamentals of Solar Radiation & Solar electric power generation	Solar radiation, Terrestrial & Extra-terrestrial radiation, Solar radiation Measurements- Pyrheliometers, Pyrometer, Sunshine Recorder. Solar Thermal systems: Flat plate collector; Solar distillation; Solar pond electric power plant.
3	Week 5-6: Wind Energy	Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS- Horizontal axis- single, double and muliblade system. Vertical axis- Savonius and darrieus types.
4	Week 7-8: Biomass Energy	Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies-fixed dome; Urban waste to energy conversion; Biomass gasification (Downdraft)
5	Week 9-10: Tidal Power & OTEC	Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations. Principle of working, OTEC power stations in the world, problems associated with OTEC.
6	Week 11-12: Geothermal Energy & Green Energy	Construction & working of Geothermal Energy. Introduction to Fuel cells: Classification of fuel cells – H2; Operating principles, Zero energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction and Availability of Energy Sources	Introduction to energy sources, Classification of Energy Sources, Sustainable development, social implications, worldwide renewable energy availability, renewable energy availability in India, brief descriptions on energy alternatives. Introduction to Internet of energy (IOE).
2	Week 3-4: Fundamentals of Solar Radiation & Solar electric power generation	Solar radiation, Terrestrial & Extra-terrestrial radiation, Solar radiation Measurements- Pyrheliometers, Pyrometer, Sunshine Recorder. Solar Thermal systems: Flat plate collector; Solar distillation; Solar pond electric power plant.
3	Week 5-6: Wind Energy	Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS- Horizontal axis- single, double and muliblade system. Vertical axis- Savonius and darrieus types.
4	Week 7-8: Biomass Energy	Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies-fixed dome; Urban waste to energy conversion; Biomass gasification (Downdraft)
5	Week 9-10: Tidal Power & OTEC	Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations. Principle of working, OTEC power stations in the world, problems associated with OTEC.
6	Week 11-12: Geothermal Energy & Green Energy	Construction & working of Geothermal Energy. Introduction to Fuel cells: Classification of fuel cells – H2; Operating principles, Zero energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME604A.1	**Make use of** the fundamentals of renewable energy sources in comparison with other energy systems, their prospects and limitations.
M23BME604A.2	**Identify** and describe the main components of a solar power system, including solar panels and Explain the concept of Solar Radiation & its measuring devices.
M23BME604A.3	**Infer** the concepts related to types and performance of wind and biomass energy.
M23BME604A.4	**Illustrate** the operational conditions and utilization of energy in water resources
M23BME604A.5	**Utilize** the knowledge acquired on geothermal resources and identify the key operating principles with relative merits and demerits.
M23BME604A.6	**Assess** the role of engineers in various types of power plants.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
M23BME604A.1	3	-	-	-	-	-	-	-	-	-	-	-
M23BME604A.2	3	-	-	-	-	-	-	-	-	-	-	-
M23BME604A.3	3	-	-	-	-	-	-	-	-	-	-	-
M23BME604A.4	3	-	-	-	-	-	-	-	-	-	-	-
M23BME604A.5	3	-	-	-	-	-	-	-	-	-	-	-
M23BME604A.6	-	-	-	-	-	-	3	-	-	-	-	-
M23BME604A	**3**	**-**	-	-	-	-	**3**	-	-	-	-	-

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	CO6	Total
Module 1	**5**					**5**	**10**
Module 2		**5**				**5**	**10**
Module 3			**5**			**5**	**10**
Module 4				**5**		**5**	**10**
Module 5					**5**	**5**	**10**
Total	**5**	**5**	**5**	**5**	**5**	**25**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

- **Identifying Technology Advancements:**
  Investigate emerging technologies and innovations in renewable energy generation, storage, and distribution. Assess the potential impact of technological advancements on the cost-effectiveness and efficiency of renewable energy systems.
- **Addressing Challenges and Barriers**
  Identify technological barriers and limitations hindering the widespread adoption of renewable energy. Explore research and development efforts aimed at overcoming technical challenges and improving renewable energy technologies.
- **Assessing Environmental Benefits:**
  Investigate the environmental benefits of renewable energy, including reductions in air and water pollution, land use impacts, and ecosystem preservation.
  Analyze the potential for renewable energy to contribute to biodiversity conservation and ecological sustainability.
- **Encouraging Research and Development:**
  Identify areas for further research and innovation in renewable energy technology, policy, and market design. Explore interdisciplinary approaches and collaborations to address complex challenges in the renewable energy sector.

7th Semester	Open Elective (OE) Operations Research	M23BME604C

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Basic Mathematics	Understanding of basic algebra and calculus is essential for grasping linear programming and optimization techniques.
2	Statistics	Familiarity with basic statistical concepts and methods to understand probabilistic models and data analysis.
3	Management Fundamentals:	Knowledge of basic management principles and practices to understand the application of OR in business contexts.
4	Logical Reasoning	Ability to think logically and systematically for problem formulation and solution derivation.
5	Basic Economics	Understanding of economic principles can be helpful, especially in grasping the applications of OR in resource allocation and decision-making.

2. Competencies

S/L	Competency	KSA Description
1	Analytical Skills	**Knowledge**: Understanding of OR models and problem-solving techniques. **Skills:** Ability to analyze complex problems and formulate them as LPPs. **Attitudes:** Attention to detail and precision in calculations and interpretations.
2	Problem-Solving Skills	**Knowledge:** Grasp of Simplex, Big-M, and Two Phase Simplex methods. **Skills:** Applying these methods to derive optimal solutions. **Attitudes:** Systematic approach to tackling complex problems.
3	Project Management Skills	**Knowledge:** Understanding CPM and PERT for project management. **Skills:** Constructing and analyzing project networks, determining critical paths. **Attitudes:** Collaborative mindset for group assignments.
4	Strategic Thinking	**Knowledge:** Concepts of game theory and decision-making strategies. **Skills:** Implementing game theory to devise strategies. **Attitudes:** Critical thinking for evaluating different methods and solutions.
5	Technical Proficiency	**Knowledge:** Familiarity with computational tools and software for OR. **Skills:** Using these tools to solve real-world data problems. **Attitudes:** Systematic and organized approach to technical tasks.
6	Ethical Responsibility	**Knowledge:** Awareness of ethical considerations in OR applications. **Skills:** Ensuring solutions are fair and socially responsible. **Attitudes:** Commitment to ethical practices in professional contexts.

3. Syllabus

Operations Research **SEMESTER – VI**			
Course Code	**M23BME604C**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(3:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**40 hours Theory**	Total Marks	**100**
Credits	**03**	Exam Hours	**03**

Course Objectives:

1. To introduce students to the fundamental concepts and evolution of Operations Research (OR), providing a solid foundation for understanding its scope, applications, and limitations.
2. To enable students to formulate and solve Linear Programming Problems (LPP) using graphical methods, simplex methods, and other optimization techniques.
3. To equip students with the skills to solve complex transportation and assignment problems, including understanding and applying methods like the North-West Corner rule, Vogel's Approximation, MODI method, and the Hungarian method.
4. To develop students' ability to construct and analyze network models, including Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), and network crashing for effective project management.

5. To familiarize students with game theory concepts and sequencing problems, helping them understand and apply strategies to solve pure and mixed strategy games and optimize job scheduling on multiple machines.
Module -1
Introduction: Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Solutions to LPP by graphical method
Module -2
LPP: Simplex method, Canonical and Standard form of LP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.
Module -3
Transportation Problem: Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution (MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem. **Assignment Problem**- Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems. Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems.
Module -4
Network analysis: Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Crashing of networks- Problems.
Module -5
Game Theory: Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2Xn m and mX2 games by graphical method. Formulation of games. **Sequencing:** Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of 2 jobs on 'm' machines using graphical method.
Textbooks: 1. Operations Research, P K Gupta and D S Hira, S. Chand and Company LTD. Publications, New Delhi – 2007 2. Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited, 2006. **Reference books:** 1. Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt. Ltd. 2016. 2. Operations Research, Paneerselvan, PHI 3. Operations Research, A M Natarajan, P Balasubramani, Pearson Education, 2005 4. Introduction to Operations Research, Hillier and Lieberman, 8th Ed., McGraw Hill

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction to Operations Research	Evolution of OR, Definitions, Scope, Applications, Phases in OR study, Characteristics and limitations, Models used in OR.
2	Week 3-4: Linear Programming Problem (LPP) - Formulation and Graphical Solutions	Generalized LPP, Formulation of problems as LPP, Solutions to LPP by graphical method.
3	Week 5-6: Linear Programming Problem (LPP) - Simplex Method	Simplex method, Canonical and Standard form, slack, surplus, and artificial variables, Solutions to LPP by Simplex method, Big-M Method, Two Phase Simplex Method, Degeneracy in LPP.
4	Week 7: Duality in Linear Programming	Concept of Duality, writing Dual of given LPP, Solutions to LPP by Dual Simplex Method.
5	Week 8-9: Transportation Problem:	Formulation, types, initial basic feasible solution (North-West Corner rule, Vogel's Approximation), Optimality by Modified

		Distribution (MODI) method, Unbalanced T.P., Maximization T.P., Degeneracy
6	Week 10: Assignment Problem and Travelling Salesman Problem	Formulation, Hungarian method, Special cases, Maximization assignment problems, Difference between assignment and TSP, Finding best route by Little's method.
7	Week 11-12: Network Analysis	Introduction, Construction of networks, Fulkerson's rule, AON and AOA diagrams, Critical path method, determination of floats, PERT networks, probability of completing a project, predicting completion time, Cost analysis, Crashing.
8	Week 13-14: Game Theory	Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Mixed Strategy problems, Solution of 2X2 games (Arithmetic method), Solution of 2Xn and mX2 games (graphical method).
9	Week 15-16: Sequencing	Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine (priority rules), sequencing using Johnson's rule ('n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines), sequencing of 2 jobs on 'm' machines (graphical method).

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lectures	Deliver detailed lectures on each topic to provide foundational knowledge.
2	Interactive Discussions	Engage students in discussions to deepen understanding and application.
3	Hands-on Practice	Provide students with problems to solve during class to reinforce learning.
4	Real-World Examples	Discuss case studies and examples to show practical applications of concepts.
5	Problem Solving Sessions	Conduct in-class problem solving to practice techniques and methods taught.
6	Homework Assignments	Assign additional problems for practice outside of class to solidify learning.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

CIE Split up

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

Final CIE Marks = (A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understand Fundamental Concepts	Gain a solid understanding of the basic principles, definitions, and scope of Operations Research.
2	Apply Linear Programming Techniques	Formulate and solve Linear Programming Problems using graphical methods, Simplex, and Dual methods.

3	Solve Transportation and Assignment Problems	Develop the ability to model and solve transportation and assignment problems using appropriate methods.
4	Analyze and Optimize Network Structures	Learn to construct and analyze network models, including critical path analysis and project cost management.
5	Utilize Game Theory and Sequencing Methods	Apply game theory to strategic decision-making and use sequencing techniques for job scheduling on various machines.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME604C.1	Identify and explain key Operations Research concepts and methods.
M23BME604C.2	Use Linear Programming, transportation, and assignment methods to solve problems.
M23BME604C.3	Analyse network structures to determine critical paths and project costs.
M23BME604C.4	Assess the effectiveness of OR methods and strategies in different scenarios.
M23BME604C.5	Design integrated solutions for complex OR problems using multiple techniques.

CO-PO-PSO Mapping

COs/POs-PSOs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
M23BME604C.1	3	-	-	-	-	-	-	-	-	-	-	-	3	2
M23BME604C.2	2	3	3	2	-	-	-	-	2	-	-	-	3	
M23BME604C.3	-	-	2	2	-	-	-	-	3	-	2	-	-	
M23BME604C.4	-	-	-	3	-	3	-	-	-	-	3	-	-	3
M23BME604C.5	3	3	-	2	3	2	-	-	2	-	2	-	-	2
M23BME604C	**2.7**	**3.0**	**2.5**	**2.3**	**3.0**	**2.5**	**-**	**-**	**2.3**	**-**	**2.3**	**-**	**3.0**	**2.3**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	10%	10%				20%
Module 2	5%	5%		10%		20%
Module 3		5%		5%	10%	20%
Module 4			20%			20%
Module 5	5%			5%	10%	20%
Total	20%	20%	20%	20%	20%	100%

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	10%	10%				20%
Module 2	5%	5%		10%		20%
Module 3		5%		5%	10%	20%
Module 4			20%			20%
Module 5	5%			5%	10%	20%
Total	20%	20%	20%	20%	20%	100%

10. Future with this Subject:

- **Advanced Studies and Specializations:** Leveraging OR techniques to analyze and interpret large datasets for strategic decision-making **(Data Science and Analytics)** and/ or Integrating optimization algorithms from OR with machine learning models for advanced predictive analytics **(Optimization and Machine Learning)**
- **Career Opportunities:** Working as a consultant in industries such as manufacturing, logistics, finance, and healthcare to optimize operations and solve complex problems **(Consulting)** and/or Utilizing OR skills to analyze data trends, develop models, and support data-driven decision-making in various sectors **(Data Analyst/Scientist)** and/or Applying OR techniques to improve operational efficiency, resource allocation, and process optimization in businesses **(Operations Manager)**

- **Industry Applications:** Using OR models to optimize supply chain logistics, inventory management, and distribution strategies **(Supply Chain Management)** and/or Applying OR methods for risk management, portfolio optimization, and financial planning **(Financial Services)** and/or Implementing OR techniques to improve patient scheduling, resource allocation, and operational efficiency in healthcare systems **(Healthcare)**.
- **Technological Advancements:** Combining OR with artificial intelligence to develop automated systems for real-time decision-making and optimization **(AI and Automation)** and/or Utilizing cloud platforms for scalable computing power to handle large-scale OR problems and simulations **(Cloud Computing)**
- **Research and Development:** Contributing to the development of new OR algorithms and methods to solve emerging and complex problems **(Innovative Algorithms)** and/or Collaborating with researchers from other fields such as economics, engineering, and environmental science to address multifaceted challenges **(Interdisciplinary Research)**
- **Professional Development:** Pursuing certifications in advanced OR techniques, data analytics, and project management to enhance expertise and career prospects **(Certifications)** and/or Joining professional organizations and attending conferences to stay updated with the latest developments and trends in OR **(Networking)**.
- **Educational Pathways:** Enrolling in advanced programs or specializations in Operations Research, Industrial Engineering, or related fields for deeper knowledge and research opportunities **(Graduate Studies)** and/or Engaging in online learning platforms to acquire new skills and knowledge in emerging OR techniques and technologies **(Online Courses and Workshops)**

6th Semester	Project Work (PW) MAJOR PROJECT PHASE-I	M23BXX605

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Understanding Research Methodology	Basic understanding of research methods, gained from prior courses in engineering mathematics and introductory project work.
2	Conducting a Literature Survey	Familiarity with academic databases, journals, and research papers; understanding of the subject matter from core courses.
3	Defining a Problem Statement	Critical thinking and analytical skills, developed through previous coursework in related engineering disciplines.
4	Multidisciplinary Collaboration	Basic knowledge of related disciplines (e.g., Mechanical students should have a basic understanding of Electronics, etc.).
5	Technical Communication	Writing technical reports and presenting technical content

2. Competencies

S/L	Competency	KSA Description
1	Research Skills	**Knowledge:** Understanding of advanced research methods and tools. **Skill:** Ability to identify, review, and synthesize relevant literature. **Attitude:** Commitment to thorough investigation and unbiased analysis.
2	Problem Identification	**Knowledge:** Deep understanding of the chosen topic area. **Skill:** Capability to define and frame a research problem effectively. **Attitude:** Critical and innovative thinking.
3	Technical Writing	**Knowledge:** Familiarity with technical writing conventions. **Skill:** Proficiency in drafting structured, clear, and concise reports. **Attitude:** Attention to detail and accuracy in documentation.
4	Presentation Techniques	**Knowledge:** Understanding of effective communication strategies. **Skill:** Ability to create and deliver engaging presentations. **Attitude:** Confidence and poise in public speaking.

3. Project Timeline

S/L	Timeline	Description
1	**Week 1-2**	Introduction to research methods and tools; exploring literature review techniques.
2	**Week 3-4**	Initiating literature survey; identifying key research papers and sources.
3	**Week 5-6**	Analysis and synthesis of literature; identifying gaps and formulating insights.
4	**Week 7-8**	Defining the problem statement based on literature findings.
5	**Week 9-10**	Drafting the initial report; focusing on structure and content.
6	**Week 11-12**	Finalizing the report and preparing the presentation.
7	**Week 13-14**	Presentation rehearsal; peer review and feedback sessions
8	**Week 15**	Submission of the final report and formal presentation.

4. Course Objectives

- To enable students to conduct a comprehensive literature survey related to their project topic.
- To guide students in defining a clear and feasible problem statement.
- To develop skills in report writing, summarizing findings, and formal presentation.

5. Assessment Details (both CIE and SEE)

CIE procedure for Project Work Phase-I:
(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, shall be based on the evaluation of the project work 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.
(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, shall be based on the evaluation of project work 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.

SEE procedure for Project Work Phase-I: There shall be no SEE.

6. Learning Objectives

S/L	Learning Objectives	Description
1	Understand the process of conducting a literature survey.	Students will gain expertise in identifying and reviewing relevant research literature.
2	To formulate a research problem statement.	Students will learn to define a research problem that is clear, concise, and researchable.
3	To enhance technical writing and presentation skills.	Students will develop the ability to draft detailed reports and present their findings effectively.

7. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BXX605.1	Conduct a comprehensive literature survey and synthesize key findings.
M23BXX605.2	Define a research problem statement based on literature review.
M23BXX605.3	Develop and present a well-structured project report.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BXX605.1														
M23BXX605.2														
M23BXX605.3														
M23BXX605														

8. Future with this Subject

This phase equips students with essential research and analytical skills, forming the foundation for the practical work in Phase II. It also enhances their technical writing and presentation abilities, which are critical for their final year projects and professional careers.

6th Semester	Professional Course Lab (PCL) CNC PROGRAMMING AND 3-D PRINTING LAB	M23BMEL606

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Basic Mathematics and Geometry:	Understanding of basic mathematical concepts and geometric principles is essential for accurate part programming and design.
2	Fundamentals of Manufacturing Processes	Knowledge of basic manufacturing processes, including turning, milling, drilling, and threading.
3	Computer-Aided Design (CAD) Software	Basic proficiency in using CAD software for creating 2D and 3D models
4	Introduction to CNC Machines	Knowledge of CNC machine components, operations, and basic CNC programming concept
5	Mechanical Drawing	Ability to read and interpret basic mechanical drawings, including dimensions, tolerances, and symbols.

2. Competencies

S/L	Competency	KSA Description
1	Manual CNC Part Programming	**Knowledge:** G/M code functions for turning and milling. Tool selection principles for different machining operations. Syntax rules for CNC program writing. **Skills:** Write CNC programs for turning and milling parts using G/M codes. Select and assign appropriate cutting tools for specific tasks. Debug and correct errors in CNC programs. Verify tool paths using simulation software. **Attitudes:** Attention to detail for accurate programming. Problem-solving skills to identify and fix errors. Meticulousness in ensuring program functionality.
2	CAM Software Applications	**Knowledge:** Capabilities of CAM software for turning, drilling, and milling. Simulation principles for visualizing tool paths. **Skills:** Utilize CAM software (MasterCAM, Cadem) to generate CNC programs. Simulate machining processes to identify potential collisions. **Attitudes:** Adaptability to learn and use new software. Ability to interpret simulation results for program optimization. Openness to using technology for efficient programming
3	3D Modeling & Printing	**Knowledge:** Principles of different 3D printing technologies (FDM, SLA, SLS). Basic 3D modeling techniques in CAD software. **Skills:** Create simple 3D models (cube, gear, prism) using CAD software. Operate a 3D printer for model creation. Assemble 3D printed components (nut & bolt, screw jack) **Attitudes:** Spatial visualization skills for designing 3D models. Dexterity and care when handling 3D printed parts. Patience and persistence during the printing and assembly process.
4	Automation Fundamentals	**Knowledge:** Basic concepts of robot programming, pneumatics, hydraulics, and electro-pneumatic systems. Functionality of FMS (Flexible Manufacturing System). **Skills:** Program robots for pick-and-place and stacking tasks (teach pendant & offline). **Attitudes:** Curiosity to understand automation principles. Willingness to learn from practical demonstrations. - Interest in exploring the applications of automation in manufacturing
5	3D Printed Part Testing	**Knowledge:** Importance of testing 3D printed parts for strength **Skills:** Conduct simple strength tests on 3D printed parts. **Attitudes:** Awareness of quality control practices in manufacturing. Attention to detail when performing part evaluation. Commitment to ensuring the functionality and performance of 3D printed components.

3. Syllabus

CNC PROGRAMMING AND 3-D PRINTING LAB

SEMESTER – VI

Course Code	**M23BMEL606**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(0:0:2:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**12 session**	Total Marks	**100**
Credits	**01**	Exam Hours	**03**

Course objectives:

The objectives of this course is to

1. To expose the students to the techniques of CNC programming and cutting tool path generation through CNC simulation software by using G-Codes and M-codes.
2. To educate the students on the usage of CAM packages.
3. To expose the students on the usage of 3D Printing Technology
4. To make the students understand the importance of automation in industries through exposure to FMS, Robotics, and Hydraulics and Pneumatics.

Sl. NO	Experiments
1	Manual CNC part programming using ISO Format G/M codes for 2 turning and 2 milling parts. Selection and assignment of tools, correction of syntax and logical errors, and verification of tool path using CNC program verification software.
2	CNC part programming using CAM packages : Simulation of Turning simulations to be carried out using simulation packages like: Cadem CAMLab-Pro, Master-CAM.
3	CNC part programming using CAM packages : Simulation of Drilling simulations to be carried out using simulation packages like: Cadem CAMLab-Pro, Master-CAM.
4	CNC part programming using CAM packages : Simulation of Milling simulations to be carried out using simulation packages like: Cadem CAMLab-Pro, Master-CAM.
5	Internal and external threading : Write a CNC program to create internal and external threading on a cylindrical blocks.
6	Simple 3D Printing Model : Creating Simple 3D model (example cube, gear, prism etc) in CAD software and printing the model using any 3D Printer (FDM/SLA/SLS printer)
	Demonstration Experiments
7	Robot programming: Using Teach Pendent & Offline programming to perform pick and place, stacking of objects (2 programs).
8	Pneumatics and Hydraulics, Electro-Pneumatics: 3 typical experiments on Basics of these topics to be conducted.
9	FMS (Flexible Manufacturing System): Programming of Automatic storage and Retrieval system (ASRS) and linear shuttle conveyor Interfacing CNC lathe, milling with loading unloading arm and ASRS to be carried out on simple components.
10	Simple strength testing of 3D Printed Parts

Text Books:

1.CNC Fundamentals And Programming By P. M. Agrawal, Dr. V. J. Patel,

2. CNC Programing hand book by Peter Smid

3. The Beginner's Guide to 3D Printing, By Pete Stagman.

4. 3D Printing Technology Fundamentals and Applications, by Prof.H N Pandya

Suggested Learning Resources:

1. **https://nptel.ac.in/courses/112102103**
2. **https://onlinecourses.nptel.ac.in/noc19_me46/preview**
3. **https://nptel.ac.in/courses/112103306**
4. **https://archive.nptel.ac.in/courses/112/105/112105211/**
5. **https://onlinecourses.nptel.ac.in/noc20_me50/preview**

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: Introduction & Fundamentals	Introduction to CNC machining & 3D printing. Workshop safety procedures. Mechanical drawing basics (reading & interpreting).Basic geometry concepts. Introduction to G/M codes and CNC programming principles. Overview of different 3D printing technologies (FDM, SLA, SLS).
2	Week 3-4: Manual CNC Programming & CAM Software	Manual CNC programming for turning and milling operations (G/M codes). Tool selection and assignment for different machining tasks. Syntax rules and error correction in CNC programs. Introduction to CAM software (e.g., MasterCAM, Cadem) functionalities.
3	Week 5-6: Advanced CNC Programming & Simulation	CNC programming for internal and external threading. Advanced features in CAM software (toolpath optimization, tool library management). Utilizing CNC program verification software to simulate tool paths
4	Week 7-8: 3D Modeling & Printing	Basic 3D modeling techniques in CAD software (e.g., SolidWorks). Understanding 3D printing parameters (slicing, infill, support structures). Operating a 3D printer for model creation.
5	Week 9-10: Demonstration Experiments	Introduction to robot programming (teach pendant & offline programming). Basic experiments on pneumatics, hydraulics, and electro-pneumatic systems.
6	Week 11-12: Automation & Project Integration	Flexible Manufacturing Systems (FMS) and its components (ASRS, conveyor).Interfacing CNC machines, loading/unloading arms, and ASRS (basic simulations).Simple strength testing methods for 3D printed parts. Course project presentations and demonstrations

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	animations or videos showcasing CNC machining and 3D printing processes to enhance understanding
3	Collaborative Learning	Encourage students to review each other's CNC programs and 3D models for errors and suggest improvements.
4	Project-Oriented Learning	Develop projects that require students to design a model in CAD software, generate CNC programs, and finally, 3D print and assemble the final product.
5	CAM Software Simulation	Utilize CAM software's simulation capabilities to visualize tool paths and identify potential collisions before running CNC programs on actual machines
6	Hands-On Laboratory Session	Conduct practical lab sessions for CNC programming, CAM software simulations, and 3D printing. Facilitate practice with CNC verification software and robot programming

6. Assessment Details (both CIE and SEE)

The weight-age of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

Continuous Internal Evaluation (CIE): CIE marks for the practical course is 50 Marks.

Class Work:-A

CIE Split up for Laboratory

SL. No.	Description	% of Marks	In Marks
1	Write-up, Conduction, result and Procedure	60%	30
2	Viva-Voce	40%	20
Total		**100%**	**50**

The Test marks should be scaled down to 30marks (60% of the maximum Marks)

Laboratory Test: -B

Internal test for laboratory course with software experiments shall be conducted for a total of 100 mark at the end the semester and the assessment pattern is

Marks distribution for Program based Practical Course for CIE

Sl. No.	Description	% of Marks	In Marks
1	Observation, write-up, algorithm/program/execution	80% of the maximum	80
2	Viva-Voce	20% of the maximum	20
Total		100%	100

Marks scored by the student for 100 are scaled down to 20 marks.

Final CIE for Laboratory

SL. No.	Description	% of Marks	In Marks
1	Scaled Down marks of record/journal-A	60% of the maximum	30
2	Scaled Down marks of test-B	40% of the maximum	20
Total		**100%**	**50**

Final CIE Marks = (A) + (B)

Semester End Evaluation (SEE):

1. SEE marks for practical course shall be 50 marks

Marks distribution for Experiment based Practical Course for Final CIE

SL. No.	Description	% of Marks	Marks
1	Write-up, Procedure	20%	20
2	Conduction and result	60%	60
3	Viva-Voce	20%	20
Total		**100%**	**100**

2. SEE for practical course is evaluated for 100 marks and scored marks shall be scaled down to 50 marks.
3. Change of experiment/program is allowed only once and 20% marks allotted to the procedure/write-up part to be made zero.
4. Duration of SEE shall be 3 hours

7. Learning Objectives

S/L	Learning Objectives	Description
1	Understand CNC Programming Fundamentals	Comprehend the principles of CNC part programming using ISO format G/M codes for turning and milling. Learn to select appropriate tools and correct syntax and logical errors in CNC programs.
2	Develop Proficiency in CAM Software	Gain expertise in using CAM packages like Cadem CAMLab-Pro and Master-CAM for simulating turning, drilling, and milling operations. Understand the process of generating and optimizing CNC programs using CAM software.
3	Master 3D Printing Techniques	Create and modify simple 3D models (e.g., cube, gear, prism) using CAD software. Learn to print 3D models using different types of 3D printers (FDM/SLA/SLS). Develop skills to create and assemble complex 3D CAD models, such as nut and bolt assemblies and multi-part assemblies
4	Enhance Robot Programming Skills	Program robots using Teach Pendant and offline programming methods. Perform tasks like pick and place and stacking of objects with programmed robots.
5	Understand and Apply Principles of Pneumatics and Hydraulics	Conduct experiments to understand the basics of pneumatics and hydraulics, and electro-pneumatics. Apply these principles in practical scenario
6	Learn Flexible Manufacturing Systems (FMS) Operations	Program and operate an Automatic Storage and Retrieval System (ASRS). Interface CNC lathe and milling machines with loading/unloading arms in an FMS setup.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME606.1	Utilize principles of CNC part Programing using ISO format G/M codes for various machining operations including milling, turning, drilling.
M23BME606.2	Apply CAD/CAM software tools to design and simulate Manufacturing process.
M23BME606.3	Create and visualize the 3D print module using additive manufacturing software .

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME606.1	3	-	-	2	-	-	-	-	-	-	-	-	3	-
M23BME606.2	-	3	-	2	-	-	-	-	-	-	-	-	3	-
M23BME606.3	3	-	-	2	-	-	-	-	-	-	-	-	3	-
M23BME606	**3**	**3**	-	2	-	-	-	-	-	-	-	-	3	-

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	Total
Total	**10**	**30**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	Total
Total	**20**	**60**	**20**	**100**

10. Future with this Subject:

The skills learned in a CNC programming and 3-D printing laboratory, students well for a future that is increasingly reliant on advanced manufacturing and automation. Here's a glimpse into the exciting possibilities:

Enhanced Design and Prototyping:

Students will be able to leverage 3D modeling and rapid prototyping capabilities to create innovative designs and test them quickly and efficiently. This will accelerate product development cycles and allow for greater iteration and optimization.

Personalized and Customized Manufacturing:

The ability to program CNC machines and 3D printers allows for small-batch production and on-demand manufacturing. This caters to a growing trend of customization and personalization in various industries.

Career Opportunities:

The demand for skilled CNC programmers, 3D printing technicians, and automation specialists is expected to grow significantly. Students will have access to a wide range of career paths in various industries, including:

- Manufacturing
- Engineering
- Product Design
- Robotics
- Medical Technology
- Aerospace
- Education and Training

Overall, the future for students who master the skills offered by a CNC programming and 3D printing laboratory is bright. They will be instrumental in shaping the future of manufacturing with their ability to design, prototype, and fabricate innovative products with increased efficiency and customization

6th Semester	Ability Enhancement Course (AE) BASICS OF MATLAB	M23BME607A

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Basic knowledge of Mathematics	Understanding Concepts of linear algebra like matrices, vectors, matrix operations, and systems of linear equations is crucial since MATLAB is heavily based on matrix computations. Familiarity with differentiation and integration, as well as numerical methods helps in understanding how MATLAB solves equations, performs interpolations, and integrates functions.
2	Programming Fundamentals	Proficiency Understanding variables, data types, control structures (if-else, loops), and functions is essential. Knowing how to develop and structure algorithms will help in writing efficient MATLAB code.
3	Basic Computers	Understanding data structures and file handling computations.
4	Familiar with Other Programming Language (Optional)	Experience with other programming languages like Python, C, or Java can make it easier to grasp MATLAB's syntax and programming concepts.
5	Domain Specific Knowledge (Optional)	Depending on the intended application of MATLAB, knowledge in fields such as signal processing, control systems, statistics, or finance can be helpful.

2. Competencies

S/L	Competency	KSA Description
1	Basic MATLAB Syntax and Operations	**Knowledge:** Familiarize with the MATLAB interface, including the Command Window, Workspace, Command History, and Editor. **Skills:** Create and manipulate different data types, such as scalars, vectors, matrices, strings, and cell arrays. **Attitudes:** Ideal for handling, analyzing and visualizing large dataset.
2	Mathematical operations and functions	**Knowledge:** Perform addition, subtraction, multiplication, division, and exponentiation with matrices and arrays. **Skills:** Utilize MATLAB's built-in functions for mathematical computations (e.g., **sum**, **mean**, **std**, **max**, **min**). **Attitudes:** Create user defined functions and understand function scope and input/output arguments
3	Data Visualization	**Knowledge:** Create 2D and 3D plots using functions like plot, scatter, bar, hist, surf, and contour. **Skills:** Customize plots with titles, labels, legends, and annotations **Attitudes:** Use more advanced plotting techniques and toolboxes (e.g., plot3, mesh, images, subplots).
4	Programming Structures	**Knowledge:** Implement control flow statements like if, else, switch, for, and while loops. **Skills:** Learn how to vectorize code to make it more efficient by replacing loops

		with matrix and vector operations. **Attitudes:** Read from and write to files using functions such as fopen, fclose, fread, fwrite, fprintf, and fscanf.

3. Syllabus

BASICS OF MATLAB **SEMESTER – VI**			
Course Code	M23BME607A	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(0:0:2*:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**14 Sessions**	Total Marks	**100**
Credits	**01**	Exam Hours	**03**
***One hour per week can be taken additionally**			

Course objectives: This course will enable students to:

1. To introduce MATLAB as a computational tool for solving engineering problems.
2. To develop proficiency in using MATLAB for mathematical modeling, data analysis, and simulation in mechanical engineering.
3. To apply MATLAB programming to solve real-world mechanical engineering problems.
4. To prepare students for advanced courses and projects that requires MATLAB skills.

S/L	Topics	Sessions
1	**Introduction to MATLAB Programming**: o Introduction to the MATLAB environment: Command Window, Workspace, Editor, and Figure Window o Basic operations: Variables, arrays, and matrix manipulation o Understanding MATLAB syntax and arithmetic operations o Hands-on practice: Creating and manipulating variables, arrays, and matrices o Basic operations: Addition, subtraction, multiplication, division of matrices Introduction to MATLAB help and documentation	**02**
2	**MATLAB Programming Basics:** o Introduction to script files and functions in MATLAB o Control structures: Loops (for, while) and conditional statements (if, else) o Introduction to vectorization for efficient coding o Writing simple MATLAB scripts to perform repetitive tasks o Implementation of control structures in solving mechanical engineering problems (e.g., looping through arrays, conditional calculations) Debugging MATLAB code and error handling	**03**
3	**Data Analysis and Visualization:** o Data types in MATLAB: Scalars, vectors, matrices, and cell arrays o Introduction to basic plotting: 2D plots, subplots, and plot formatting o Advanced data visualization techniques: 3D plots, surface plots, and contour plots o Data import/export: Loading data from files and saving results o Creating and customizing 2D and 3D plots o Practical exercises: Plotting data from mechanical engineering experiments (e.g., stress-strain curves, temperature distribution)	**02**
4	**Solving Mathematical Problems in MATLAB:** o Matrix operations and linear algebra in MATLAB o Solving systems of linear and Non Linear equations o Introduction to numerical methods: Differentiation, integration, and root-finding o Solving a system of linear equations related to mechanical structures (e.g., forces in trusses) o Numerical differentiation and integration of engineering functions o Root-finding for mechanical engineering problems (e.g., finding the deflection of beams)	**02**
5	**Simulation of Mechanical Systems:** o Introduction to modeling mechanical systems in MATLAB o Solving Ordinary Differential Equations (ODEs) for dynamic systems o Simulating mechanical systems: Vibration analysis, kinematics, and dynamics o Solving ODEs using MATLAB for mechanical systems (e.g., spring-mass-	**02**

	damper system) o Simulating the dynamics of mechanical components (e.g., pendulum motion, rotational dynamics) o Case study: Vibration analysis of a mechanical structure	
6	**Application of MATLAB:** o Overview of MATLAB toolboxes useful in mechanical engineering (e.g., Control System Toolbox, Simulink) o Introduction to Simulink for modeling and simulation	**03**

Suggested Learning Resources

Text Books:

1. Agam Kumar Tyagi, "**MATLAB and Simulink for Engineers**", OXFORD Higher Education.
2. Dr. Shailendra Jain, "**Modeling& Simulation using MATLAB – Simulink**", Wiley – India.

Reference Book:

1. Won Y.Tang, Wemun Cao, Tae-Sang Ching and John Morris, "**Applied Numerical Methods Using MATLAB**", A JohnWiley& Sons.
2. Steven T. Karris, "**Introduction to Simulink with Engineering Applications**", Orchard Publications.

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-2: **Introduction to MATLAB Programming**	➢ Introduction to the MATLAB environment: Command Window, Workspace, Editor, and Figure Window ➢ Basic operations: Variables, arrays, and matrix manipulation ➢ Understanding MATLAB syntax and arithmetic operations ➢ Hands-on practice: Creating and manipulating variables, arrays, and matrices ➢ Basic operations: Addition, subtraction, multiplication, division of matrices ➢ Introduction to MATLAB help and documentation
2	Week 3-4: **MATLAB Programming Basics**	➢ Introduction to script files and functions in MATLAB ➢ Control structures: Loops (for, while) and conditional statements (if, else) ➢ Introduction to vectorization for efficient coding ➢ Writing simple MATLAB scripts to perform repetitive tasks ➢ Implementation of control structures in solving mechanical engineering problems (e.g., looping through arrays, conditional calculations) ➢ Debugging MATLAB code and error handling
3	Week 5-7: **Data Analysis and Visualization**	➢ Data types in MATLAB: Scalars, vectors, matrices, and cell arrays ➢ Introduction to basic plotting: 2D plots, subplots, and plot formatting ➢ Advanced data visualization techniques: 3D plots, surface plots, and contour plots ➢ Data import/export: Loading data from files and saving results ➢ Creating and customizing 2D and 3D plots ➢ Practical exercises: Plotting data from mechanical engineering experiments (e.g., stress-strain curves, temperature distribution)
4	Week 8-10: **Simulation of Mechanical Systems**	➢ Matrix operations and linear algebra in MATLAB ➢ Solving systems of linear and Non Linear equations ➢ Introduction to numerical methods: Differentiation, integration, and root-finding ➢ Solving a system of linear equations related to mechanical structures (e.g., forces in trusses) ➢ Numerical differentiation and integration of engineering functions ➢ Root-finding for mechanical engineering problems (e.g., finding the deflection of beams)
5	Week 10-12: **Application of MATLAB**	➢ Overview of MATLAB toolboxes useful in mechanical engineering (e.g., Control System Toolbox, Simulink) ➢ Introduction to Simulink for modeling and simulation

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Chalk and Talk method	Mathematical problems are explained using chalk and talk method
2	Videos Demonstration and Simulations	The concept of curve fitting and application based problems is explained with the help of videos and simulations.
3	Software	Assign programming tasks to reinforce practical skills associated with competencies.

6. Assessment Details (both CIE and SEE)

The weight-age of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%.

Continuous Internal Evaluation (CIE): CIE marks for the practical course is 50 Marks.

Class Work:-A

CIE Split up for Laboratory based Ability Enhancement Course

SL. No.	Description	% of Marks	In Marks
1	Write-up, Conduction, result and Procedure	60%	30
2	Viva-Voce	40%	20
Total		**100%**	**50**

The Test marks should be scaled down to 30 marks (60% of the maximum Marks)

Laboratory Test: -B

Internal test for laboratory course with software experiments shall be conducted for a total of 100 mark at the end the semester and the assessment pattern is

Marks distribution for Program based Practical Course for CIE

Sl. No.	Description	% of Marks	In Marks
1	Observation, write-up, algorithm/program/execution	80% of the maximum	80
2	Viva-Voce	20% of the maximum	20
Total		100%	100

Marks scored by the student for 100 are scaled down to 20 marks.

Final CIE for Laboratory based Ability Enhancement Course

SL. No.	Description	% of Marks	In Marks
1	Scaled Down marks of record/journal-A	60% of the maximum	30
2	Scaled Down marks of test-B	40% of the maximum	20
Total		**100%**	**50**

Final CIE Marks = (A) + (B)

Semester End Evaluation (SEE):

1. SEE marks for practical course shall be 50 marks

Marks distribution for Experiment based Practical Course for Final CIE

SL. No.	Description	% of Marks	Marks
1	Write-up, Procedure	20%	20
2	Conduction and result	60%	60
3	Viva-Voce	20%	20
Total		**100%**	**100**

2. See for practical course is evaluated for 100 marks and scored marks shall be scaled down to 50 marks.
3. Change of experiment/program is allowed only once and 20% marks allotted to the procedure/write-up part to be made zero.
4. Duration of SEE shall be 3 hours.

7. Learning Objectives

S/L	Learning Objectives	Description
1	Fundamentals of MATLAB commands	Students must have imagination ideas and need to visualize the component. The students need to capable of implementing standardization as per bureau of Indian standards in any part drawings.

2	Overview of Linear and Non Linear equations in MATLAB	Students need to use the MATLAB scripts and functions to solve the problems on linear and non linear equations.
3	Importance of Numerical methods, ODE	The proficiency of understanding ODE to solve engineering problems. MATLAB optimizes the time, iterations and increases the flexibility to handle more complicated functions with higher order terms. Higher order terms are difficult to solve and time consuming.
4	Application problems on engineering and Simulink	The students can to solve various engineering problems like Engineering mechanics, Vibrations, Control systems, statistics etc. The proficiency of understanding the features of MATLAB tool is must and necessary in industry 4.0 environment.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME607A.1	To implement arrays, loops, branching, control instruction and functions in MATLAB programming environment.
M23BME607A.2	To program curve fitting, numerical differentiation and integration, solution of linear and nonlinear equations in MATLAB.
M23BME607A.3	To implement ode to solve Ordinary differential equations and execute Solutions in MATLAB.
M23BME607A.4	To analyze engineering problems in various fields using MATLAB and make use of MATLAB Simulink libraries.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME607A.1	-	-	-	-	3	-	-	-	-	-	-	-	3	-
M23BME607A.2	3	-	-	-	3	-	-	-	-	-	-	-	3	-
M23BME607A.3	-	3	-	-	3	-	-	-	-	-	-	-	3	-
M23BME607A.4	-	3	-	-	3	-	-	-	-	-	-	-	3	-
M23BME607A	**3**	**3**	-	-	**3**	-	-	-	-	-	-	-	**3**	-

9. Assessment Plan

Continuous Internal Evaluation (CIE)

Topics	CO1	CO2	CO3	CO4	Total
1	**15%**				**10**
2,3,4		**25%**			**20**
5			**15%**		**10**
6				**15%**	**10**
Total	**15%**	**25%**	**15%**	**15%**	**50**

10.

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	Total
Q1	**CO1/CO2**				**40**
Q2			**CO3/CO4**		**40**
Viva					**20**
Total	**40**			**40**	**100**

11. Future with this Subject:

The "Basics of MATLAB" course in the sixth semester of the B.E program lays a strong foundation for several future courses in the undergraduate program.

MATLAB (Matrix Laboratory) is a powerful tool widely used in engineering, scientific research, and mathematics for its robust numerical computation capabilities. The some future-oriented subjects and

trends where MATLAB can be particularly useful for Control systems, Statistics, Machine learning, Robotics, IOT etc. MATLAB contributes to cutting-edge research and development, addressing complex problems and innovating in various high-impact fields.

In summary, the "Basics of MATLAB" course serves as a stepping stone, equipping students with foundational knowledge and skills that are essential for the subsequent courses in their B.E program and for their future careers in various technology-related fields.

6th Semester	Ability Enhancement Course (AE) SIMULATION AND ANALYSIS USING ANSYS WORKBENCH	M23BME607B

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Basic Engineering Principles	• Understanding stress, strain, elasticity, and material behavior is essential for structural analysis. • Fundamental knowledge of heat transfer and thermodynamics is important for thermal simulations. • Basic concepts of fluid flow, pressure, and fluid properties are crucial for computational fluid dynamics (CFD) simulations.
2	Mechanics	• Knowledge of how forces and moments act on stationary bodies, including concepts like equilibrium, free-body diagrams, and support reactions. • Basic understanding of how materials deform under various loads.
3	Mathematics:	• Familiarity with matrices, vectors, and solving linear systems is important since many numerical methods in simulation rely on these concepts. • Understanding how to solve differential equations is critical, as many physical phenomena are described by these equations.
4	Finite Element Analysis (FEA)	• Understanding of the finite element method, including how it approximates solutions to complex problems, is essential for working with ANSYS. • Knowledge of how to create an appropriate mesh for different types of analyses and understanding the impact of mesh quality on results.
5	Software Skills	• Comfort with using computers and software applications, as well as a basic understanding of operating systems and file management. • Experience with CAD tools (e.g., Solid EDGE, AutoCAD, or CATIA) is useful for creating and modifying geometries that will be used in simulations.

2. Competencies

S/L	Competency	KSA Description
1	**Geometry Creation and Importing**	**Knowledge:** • Understanding different types of geometry (2D, 3D) and their applications in simulation. • Understanding files formats supported by ANSYS (e.g., STEP, IGES, Parasolid). **Skills:** • Ability to create, modifies, and prepare geometry using ANSYS Design Modeler. • Importing CAD models from other software (e.g., Solid Works, AutoCAD) and preparing them for simulation. **Attitudes:** Recognize the importance of creating accurate and detailed geometry.
2	**Meshing**	**Knowledge:** • Understanding of global mesh settings, including element size, relevance, and smoothing. • Understanding the impact of poor-quality mesh on simulation accuracy and convergence. **Skills:** • Ability to create and refine meshes, including understanding element types mesh density, and quality metrics. • Using advanced meshing techniques, such as sweep meshing, multizone meshing, and inflation layers. **Attitudes:** • Recognize that meshing is often part of a larger simulation process that

		involves collaboration with other engineers and analysts.
3	**Boundary Conditions**	**Knowledge:** • Understanding the importance of correctly applying boundary conditions to ensure realistic and accurate simulation results. • Understanding the application of boundary conditions in scenarios involving different material properties or behaviors at the interface. **Skills:** • Ability to apply simple boundary conditions to basic models, such as fixed supports, pressure loads, and simple forces. • Ability to define custom boundary conditions, such as user-defined functions (UDFs) for more specific or non-standard scenarios. **Attitudes:** • Proficiency in applying boundary conditions for multi scale simulations.
4	**Material Science**	**Knowledge:** • Knowledge of the physical properties of materials, such as density, elasticity, thermal conductivity, and electrical conductivity. • Understanding the materials behavior under different loading conditions. **Skills:** • Ability to assign standard material properties to components in a model, including Young's modulus, Poisson's ratio, density, and thermal conductivity. • Ability to import material data from external sources or databases into ANSYS Workbench. **Attitudes:** Proficiency in integrating material models with complex multi physics simulations.
5	**Result Analysis**	**Knowledge:** • Understanding and visualizing standard simulation outputs, extracting basic result data, and performing initial validation checks. • Knowledge of reading the graph based results. **Skills:** • Ability to analyze and interpret results from multi physics simulations. • Ability to integrate simulation results into design iteration processes, using results to guide design modifications and improvements. **Attitudes:** Develop skills in detailed result extraction, advanced visualization, post-processing techniques, and intermediate validation.

3. Syllabus

Simulation and Analysis using Ansys workbench **SEMESTER – VI**			
Course Code	**M23BME607B**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(0:0:2)**	SEE Marks	**50**
Total Number of Lecture Hours	**14hours**	Total Marks	**100**
Credits	**01**	Exam Hours	**03**

Course Objectives:

1. To introduce students to the principles and techniques of engineering simulation using ANSYS Workbench.
2. To equip students with the skills necessary to perform structural, thermal, and fluid dynamics simulations.
3. To develop problem-solving skills through real-world engineering case studies and projects.
4. To provide a comprehensive understanding of simulation methodologies and best practices.

Sl. No.	Description.

1	**Module 1: Introduction to Simulation and ANSYS Workbench (4 hours)** • Overview of simulation and its importance in engineering • Introduction to ANSYS Workbench interface and capabilities • Workflow and project setup in ANSYS Workbench
2	**Module-2: Structural Analysis (8 hours)** • Fundamentals of structural mechanics • Setting up and solving static structural problems • Analysis of beams, trusses, and frames • Stress, strain, and deformation analysis of bars • Case studies: Structural analysis of mechanical components.
3	**Module 3: Thermal Analysis (6 hours)** • Introduction to heat transfer principles • Steady-state and transient thermal analysis • Thermal stress analysis • Case studies: Thermal analysis of heat exchangers, electronic components
4	**Module 4: Fluid Dynamics Simulation (8 hours)** • Basics of fluid dynamics • Setting up and solving fluid flow problems using ANSYS Fluent • Laminar and turbulent flow analysis • Heat transfer in fluid systems • Case studies: Simulation of pipe flow, airfoil aerodynamics
5	**Module 5: Multiphysics Simulation (6 hours)** • Coupled field analysis: Thermal-structural, fluid-structural interactions • Introduction to harmonic analysis for dynamic problems • Case studies: Simulation of fluid-structure interaction in real-world applications
6	**Module 7: Case Studies and Projects (6 hours)** • Real-world engineering problems and their simulation solutions • Group projects: Simulate a complex engineering problem using ANSYS Workbench • Presentation and report of simulation results
REFERENCE BOOK: 1. ANSYS Workbench 14.0, Sham Tickoo, CADCIM Technologies. **VIDEO LINKS:** 1. https://youtu.be/vnpq5zzOS48?si=LShOTIOdSFNv0-Ui 2. https://youtu.be/vRLJmr2MTfs?si=_lMrh1iyvOs9taQl	

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3:	Overview of simulation and its importance in engineering, Introduction to ANSYS Workbench interface and capabilities, Workflow and project setup in ANSYS Workbench.
2	Week 4-6:	Fundamentals of structural mechanics, Setting up and solving static structural problems, Analysis of beams, trusses, and frames, Stress, strain, and deformation analysis, Case studies: Structural analysis of mechanical components.
3	Week 8-11:	Introduction to heat transfer principles, Steady-state and transient thermal analysis, Thermal stress analysis, Case studies: Thermal analysis of heat exchangers, electronic components
4	Week 7-8:	Basics of fluid dynamics, Setting up and solving fluid flow problems using ANSYS Fluent, Laminar and turbulent flow analysis, Heat transfer in fluid systems, Case studies: Simulation of pipe flow, airfoil aerodynamics.
5	Week 9-12:	Coupled field analysis: Thermal-structural, fluid-structural interactions,

		Introduction to harmonic analysis for dynamic problems, Case studies: Simulation of fluid-structure interaction in real-world applications. Real-world engineering problems and their simulation solutions Group projects: Simulate a complex engineering problem using ANSYS Workbench Presentation and report of simulation results.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	Lecture Method	Utilize various teaching methods within the lecture format to reinforce competencies.
2	Video/Animation	Incorporate visual aids like videos/animations to enhance understanding of Verilog concepts.
3	Collaborative Learning	Encourage collaborative learning for improved competency application.
4	Real-World Application	Discuss practical applications to connect theoretical concepts with real-world competencies.
5	Flipped Class Technique	Utilize a flipped class approach, providing materials before class to facilitate deeper understanding of competencies
6	Laboratory Learning	Utilize the facilities available in the laboratories to understand the behavior of the materials by performing few experiments.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

Class Work:-A

CIE Split up for Laboratory based Ability Enhancement Course

SL. No.	Description	% of Marks	In Marks
1	Write-up, Conduction, result and Procedure	60%	30
2	Viva-Voce	40%	20
Total		**100%**	**50**

The Test marks should be scaled down to 30marks (60% of the maximum Marks)

Laboratory Test: -B

CIE Split up for Test in Laboratory based Ability Enhancement Course

SL. No.	Description	% of Marks	In Marks
1	Write-up, Conduction, result and Procedure	60%	30
2	Viva-Voce	40%	20
Total		**100%**	**50**

The Test marks should be scaled down to 20marks (40% of the maximum Marks)

Final CIE for Laboratory based Ability Enhancement Course

SL. No.	Description	% of Marks	In Marks
1	Scaled Down marks of record/journal-A	60% of the maximum	30
2	Scaled Down marks of test-B	40% of the maximum	20
Total		**100%**	**50**

Final CIE Marks = (A) + (B)

Semester End Examination:

1. Question paper pattern will be ten questions. Each question is set for 20marks. The medium of the question paper shall be English unless otherwise it is mentioned.
2. There shall be 2 question from each module, each of the two questions under a module (with a maximum of 3 sub questions), may have mix of topics under that module if necessary.
3. The students have to answer 5 full questions selecting one full question from each module.
4. Marks scored will be proportionally scaled down to 50 marks

7. Learning Objectives

S/L	Learning Objectives	Description
1	Structural Analysis	Set up and solve static structural analysis problems using ANSYS Workbench, including the selection of appropriate materials, boundary conditions, and meshing techniques.
2	Create and Design	Develop simulation models for complex engineering systems, integrating multiple physics disciplines. Design and simulate real-world engineering components or systems as part of a final project, demonstrating comprehensive simulation skills.
3	Analyse and Evaluate	Validate simulation results by comparing them with theoretical predictions or experimental data. Analyse stress, strain, and deformation in mechanical components under various loading conditions.
4	Communicate	Present simulation results effectively through detailed technical reports, including graphical representations, numerical data, and clear explanations of findings.
5	Develop Technical Skills	Gain proficiency in using ANSYS Workbench tools for pre-processing, solving, and post-processing simulations.

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME607B.1	**Apply** the simulation tools to solve complex engineering problems.
M23BME607B.2	**Set up and perform** structural simulations using ANSYS Workbench
M23BME607B.3	**Conduct** thermal simulations to analyse heat transfer problems.
M23BME607B.4	**Perform** fluid dynamics simulations and interpret results.
M23BME607B.5	**Communicate** simulation results effectively through technical reports

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME607B.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME607B.2	-	-	-	-	3	-	-	-	-	-	-	-	3	-
M23BME607B.3	3	-	-	-	-	-	-	-	-	-	-	-	-	3
M23BME607B.4	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME607B.5	**-**	**-**	-	-	-	-	-	-	-	3	-	-	3	-
M23BME607B	**3**	**3**	-	-	**3**	-	-	-	-	**3**	-	-	**3**	**3**

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**20**					**20**
Module 2		**20**				**20**
Module 3			**20**			**20**
Module 4				**20**		**20**
Module 5					**20**	**20**
Total	**20**	**20**	**20**	**20**	**20**	**100**

10. Future with this Subject:

- **Integration with Emerging Technologies:**
  - **AI and Machine Learning:** Ansys Workbench is increasingly integrating AI and machine learning to automate simulation processes, optimize designs, and predict outcomes with greater accuracy. This trend is expected to grow, making simulations faster and more intelligent.
  - **Digital Twin Technology:** The platform will play a crucial role in developing and managing digital twins, which are virtual replicas of physical systems. This will help industries in predictive maintenance, real-time monitoring, and optimization of operations.
- **Advanced Multiphysics Simulations:**
  - **Coupled Simulations:** Ansys Workbench is already a leader in multiphysics simulations, and this capability will continue to evolve. More advanced coupled simulations that consider interactions between different physical phenomena (e.g., structural, thermal, fluid, electromagnetic) will become more prevalent.
  - **Real-time Simulations:** The push towards real-time simulation, particularly in sectors like autonomous vehicles and aerospace, will demand more sophisticated and faster simulations, which Ansys Workbench is well-positioned to support.
- **Industry 4.0 and IoT:**
  - **Smart Manufacturing:** As manufacturing processes become more automated and data-driven, Ansys Workbench will be integral in simulating and optimizing these processes, ensuring efficiency and reducing costs.
  - **IoT Integration:** The platform will likely enhance its capabilities to simulate IoT-connected devices and systems, helping industries to optimize their performance and reliability.

6th Semester	Ability Enhancement (AE) INTRODUCTION TO AUGMENTED REALITY	M23BME607C

1. Prerequisites

S/L	Proficiency	Prerequisites
1	Basic Science:	• Understanding of forces, motion, and dynamics can help in understanding sensor data and physical interactions in AR. • Fundamentals of how light interact with different media, lenses, and sensors.
2	Mathematics:	• Understanding vectors, matrices, transformations, and Eigen values • Differentiation and integration, especially in relation to 3D graphics and motion. • Basic understanding for dealing with sensor data and noise
3	Computer Science:	• Proficiency in programming languages such as C++, C#, or Python • Understanding basic data structures (arrays, lists, trees, graphs) and algorithms for efficient data handling and processing. • Understanding user interface design and user experience principles.
4	Electronics:	• Basics of sensors, signal processing, and embedded systems, which are often used in AR hardware. • Understanding how to model and control dynamic systems, which can be useful for interactive AR systems.
5	Image Processing:	• Understanding of techniques for processing and analyzing visual data from cameras.
6	Computer Graphics:	• Fundamental concepts of computer graphics, including rendering, shading, and modeling. • Experience with graphics libraries or engines (such as OpenGL, Unity, or Unreal Engine).
7	User Interface (UI) Design:	• Principles of UI/UX design, especially related to immersive experiences. • Basic understanding of human-computer interaction (HCI).

2. Competencies

S/L	Competency	KSA Description
1	**Augmented Reality Concepts**	**Knowledge:** Define augmented reality and explain its key characteristics. Trace the historical development of augmented reality technologies **Skills:** Analyze the relationship between augmented reality and various media technologies. Examine how augmented reality interacts with other related technologies (e.g., virtual reality, computer vision). **Attitudes:** Attention to detail in Augmented Reality Concepts. Persistence in Analysing the relationship between augmented reality and various media technologies
2	**Augmented Reality Hardware**	**Knowledge:** Understanding of Display Technologies ,processor Architecture and sensor Technologies **Skills:** Analyze the requirements and characteristics of different display, Processor and sensor technologies **Attitudes:** Analyze the requirements and characteristics of different display,Processor and sensor technologies

3	**Tracking**	**Knowledge:** Understand the various tracking techniques including marker tracking, multiple-camera infrared tracking, natural feature tracking by detection, simultaneous localization and mapping, and outdoor tracking **Skills:** Apply computer vision techniques to real-world problems in AR. **Attitudes:** Attention to detail in various tracking technique and persistence in Applying computer vision techniques to real-world problems in AR.
4	**Marker-based and Marker-less tracking techniques**	**Knowledge:** Explain the concept of marker-based tracking and its applications in AR. Describe the different types of markers (template markers, 2D barcode markers, imperceptible markers) and their characteristics. **Skills:** Implement visual tracking, feature-based tracking, and hybrid tracking methods in AR experiences Test different types of markers for use in AR experiences. **Attitudes:** Appreciate the importance of tracking techniques in creating immersive AR experiences. Recognize the potential applications of marker-based and marker-less tracking in various industries (e.g., education, entertainment, healthcare).
5	**AR Devices & Components**	**Knowledge:** Understand the concept of Augmented Reality (AR) and its applications Explain the functions and characteristics of different AR devices **Skills:** Assessing the suitability of different AR devices for specific applications Integrate AR devices with other technologies, such as computer vision and machine learning. **Attitudes:** Appreciate the potential of AR technology to enhance human experience and interaction

3. Syllabus

INTRODUXTION TO AUGMENTED REALITY **SEMESTER – VI**			
Course Code	**M23BME607C**	CIE Marks	**50**
Number of Lecture Hours/Week(L: T: P: S)	**(1:0:0:0)**	SEE Marks	**50**
Total Number of Lecture Hours	**30 hours Theory**	Total Marks	**100**
Credits	**01**	Exam Hours	**01**

Course Objectives:

1. Describe how AR systems work and list the applications of AR.
2. Understand and analyse the hardware requirement of AR.
3. Use computer vision concepts for AR and describe AR techniques
4. Analyse and understand the working of various state of the art AR devices
5. Acquire knowledge of mixed reality

Module -1

Introduction to Augmented Reality (A.R): Defining augmented reality, history of augmented reality, The Relationship between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum between Real and Virtual Worlds, applications of augmented reality

Augmented Reality Concepts- Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience.

Module -2

Augmented Reality Hardware: Augmented Reality Hardware – Displays – Audio Displays, Haptic Displays, Visual Displays, Other sensory displays, Visual Perception, Requirements and Characteristics, Spatial Display Model. **Processors** – Role of Processors, Processor System Architecture, Processor Specifications. **Tracking & Sensors** - Tracking, Calibration, and Registration, Characteristics of Tracking Technology, Stationary Tracking Systems, Mobile Sensors, Optical Tracking, Sensor Fusion
Module -3
Computer Vision for Augmented Reality & A.R. Software: Computer Vision for Augmented Reality - Marker Tracking, Multiple-Camera Infrared Tracking, Natural Feature Tracking by Detection, Simultaneous Localization and Mapping, Outdoor Tracking **Augmented Reality Software** - Introduction, Major Software Components for Augmented Reality Systems, Software used to Create Content for the Augmented Reality Application
Module -4
AR Techniques- Marker based & Marker-less tracking: Marker-based approach- Introduction to marker-based tracking, types of markers, marker camera pose and identification, visual tracking, mathematical representation of matrix multiplication **Marker types**- Template markers, 2D barcode markers, imperceptible markers. **Marker-less approach-** Localization based augmentation, real world examples **Tracking methods-** Visual tracking, feature based tracking, hybrid tracking, and initialization and recovery**.**
Module -5
AR Devices & Components : AR Components – Scene Generator, Tracking system, monitoring system, display, Game scene **AR Devices** – Optical See- through HMD, Virtual retinal systems, Monitor bases systems, Projection displays, and Video see-through systems
TEXTBOOKS: 1. Allan Fowler-AR Game Development‖, 1st Edition, A press Publications, 2018, ISBN 978-1484236178 2. Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education India; First edition (12 October 2016),ISBN-10: 9332578494 **REFERENCE BOOKS:** 1. Designing for Mixed Reality, Kharis O'Connell Published by O'Reilly Media, Inc., 2016, ISBN: 9781491962381 2. Sanni Siltanen- Theory and applications of marker-based augmented reality. Julkaisija – Utgivare Publisher. 2012. ISBN 978-951-38-7449-0 **VIDEO LINKS:** 1.https://www.coursera.org/learn/ar 2.https://www.udemy.com/share/101XPi/

4. Syllabus Timeline

S/L	Syllabus Timeline	Description
1	Week 1-3: Introduction to Augmented Reality and AR Concepts	Introduction to the fundamentals of AR, its history, and connections to media, technologies, and ideas bridging real and virtual worlds. Learn AR concepts, key ingredients of an AR experience, and examine various applications. Develop a comprehensive understanding of AR's role in shaping interactive and immersive experiences.
2	Week 4-6: Augmented Reality Hardware, Processors, Tracking & Sensors	Studying display technologies (audio, haptic, visual, and sensory), visual perception, and spatial display models. It also covers processor roles, architectures, and specifications. Additionally, tracking and sensor technologies are examined, including calibration, registration, and sensor fusion methods Examination of Augmented Reality Hardware including display technologies (audio, haptic visual, and other sensory), visual perception and spatial display models. Processor role and architecture with tracking and sensor technologies including calibration and sensor fusion methods are also covered in the module.
3	Week 7-8:	Studying the fundamentals of Augmented Reality (AR) techniques, focusing on

	AR Techniques- Marker based & Marker-less tracking	marker-based and marker-less tracking. Study marker-based tracking methods, including marker types, camera pose estimation, and visual tracking. Additionally, delve into marker-less tracking approaches, including localization and real-world examples, and analyze various tracking methods, including visual, feature-based, and hybrid tracking."
4	Week 8-11: Computer Vision for Augmented Reality & A.R. Software	Studying the fundamentals of Computer Vision for Augmented Reality, covering marker tracking, infrared tracking, natural feature detection, and simultaneous localization and mapping. Delve into Augmented Reality software, including major components and content creation tools, to develop a comprehensive understanding of AR system development and application
5	Week 9-12: **AR Devices & Components**	Studying the fundamental components of Augmented Reality (AR) technology, including scene generators, tracking systems, monitoring systems, and displays. Additionally, delve into the various types of AR devices, including optical see-through HMDs, virtual retinal systems, and video see-through systems. Hands-on experience and case studies will be incorporated.

5. Teaching-Learning Process Strategies

S/L	TLP Strategies:	Description
1	**Lectures and Presentations**	Deliver lectures that introduce the fundamentals of AR, its history, and applications, using multimedia presentations to illustrate key concepts and real-world examples.
2	**Demonstrations and Practical Sessions**	Conduct practical sessions where students interact with various AR hardware, including displays and sensors, to understand their characteristics and functionalities.
3	**Workshops and Interactive Labs**	Run workshops where students use AR software to develop simple applications and apply computer vision techniques for marker tracking and spatial mapping.
4	**Case Studies and Group Projects**	Assign case studies and group projects focusing on marker-based and marker-less tracking techniques, encouraging students to research, analyze, and present their findings.
5	**Interactive Labs**	Organize lab sessions where students handle and evaluate different AR devices, such as optical see-through HMDs and projection displays, to understand their applications and performance.

6. Assessment Details (both CIE and SEE)

Continuous Internal Evaluation:

The minimum CIE marks requirement is 40% of maximum marks in each component.

Components		Number	Weightage	Max. Marks	Min. Marks
(i)	Internal Assessment-Tests (A)	2	50%	25	10
(ii)	Assignments/Quiz/Activity (B)	2	50%	25	10
	Total Marks			**50**	**20**

The CIE question paper shall have MCQ set for 25 questions, each carrying one mark.

Final CIE Marks =(A) + (B)

Average internal assessment shall be the average of the 2 test marks conducted.

Semester End Examination:

The SEE question paper shall have MCQ set for 50 questions, each carrying one mark. The time duration for SEE is one hour

7. Learning Objectives

S/L	Learning Objectives	Description
1	Introduction to AR Reality and AR Concepts	Describe how AR systems work and list the applications of AR
2	Augmented Reality Hardware, Processors, Tracking & Sensors	Understand and analyse the hardware requirement of AR

3	Computer Vision for Augmented Reality & A.R. Software	Use computer vision concepts for AR and describe AR techniques
4	AR Techniques- Marker based & Marker-less tracking	Analyse and understand the working of various state of the art AR devices
5	AR Devices & Components	Acquire knowledge of mixed reality

8. Course Outcomes (COs) and Mapping with POs/ PSOs

Course Outcomes (COs)

COs	Description
M23BME607C.1	Identify various applications of AR and Explain the functioning of AR systems
M23BME607C.2	Understand and analyse the hardware requirement of AR.
M23BME607C.3	Apply computer vision concepts to augmented reality (AR) and explain various AR techniques.
M23BME607C.4	Investigate and understand the working of various state of the art AR devices
M23BME607C.5	Employ the principles of mixed reality to develop and implement immersive experiences.

CO-PO-PSO Mapping

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
M23BME607C.1	3	-	-	-	-	-	-	-	-	-	-	-	3	-
M23BME607C.2	-	3	-	-	-	-	-	-	-	-	-	-	-	3
M23BME607C.3	3	-			-	-	-	-	-	-	-	-	3	-
M23BME607C.4	-	-	-	3	-	-	-	-	-	-	-	-	-	3
M23BME607C.5	**-**	**-**	3	-	-	-	-	-	-	-	-	-	3	3
M23BME607C	**3**	**3**	3	3	-	-	-	-	-	-	-	-	3	3

9. Assessment Plan

Continuous Internal Evaluation (CIE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

Semester End Examination (SEE)

	CO1	CO2	CO3	CO4	CO5	Total
Module 1	**10**					**10**
Module 2		**10**				**10**
Module 3			**10**			**10**
Module 4				**10**		**10**
Module 5					**10**	**10**
Total	**10**	**10**	**10**	**10**	**10**	**50**

10. Future with this Subject:

- **Mechatronics**: The curriculum will likely incorporate Integrating AR with mechatronics can enhance design and development of intelligent systems
- **Robotics**: The curriculum will likely incorporate. AR to robotics for human-robot interaction and robotic vision.
- **Computer-Aided Design (CAD)**: AR can enhance CAD design and visualization.
- **Digital Manufacturing**: AR can enhance digital manufacturing by providing real-time monitoring and control

6th Semester	Non-Credit Mandatory Course (NCMC) NATIONAL SERVICE SCHEME (NSS)	M23BNSK608

National Service Scheme (NSS)			
Course Code	**M23BNSK608**		
Number of Lecture Hours/Week(L: T: P: S)	0:0:2:0	CIE Marks	100
Total Number of Lecture Hours		SEE Marks	-
Credits	**0**	Total Marks	100
Activities Report Evaluation by College NSS Officer at the end of every semester (3rd to 6th semester)			

Course objectives:

National Service Scheme (NSS) will enable students to:

1. Understand the community in general in which they work.
2. Identify the needs and problems of the community and involve them in problem –solving.
3. Develop among themselves a sense of social & civic responsibility & utilize their knowledge in finding practical solutions to individual and community problems.
4. Develop competence required for group-living and sharing of responsibilities & gain skills in mobilizing community participation to acquire leadership qualities and democratic attitudes.
5. Develop capacity to meet emergencies and natural disasters & practice national integration and social harmony in general.

General Instructions - Pedagogy :

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. In addition to the traditional lecture method, different types of innovative teaching methods may be adopted so that the activities will develop students' theoretical and applied social and cultural skills.
2. State the need for NSS activities and its present relevance in the society and Provide real-life examples.
3. Support and guide the students for self-planned activities.
4. You will also be responsible for assigning homework, grading assignments and quizzes, and documenting students' progress in real activities in the field.
5. Encourage the students for group work to improve their creative and analytical skills.

Contents :

1. Organic farming, Indian Agriculture (Past, Present and Future) Connectivity for marketing.
2. Waste management– Public, Private and Govt organization, 5 R's.
3. Setting of the information imparting club for women leading to contribution in social and economic issues.
4. Water conservation techniques – Role of different stakeholders– Implementation.
5. Preparing an actionable business proposal for enhancing the village income and approach for implementation.
6. Helping local schools to achieve good results and enhance their enrolment in Higher/ technical/ vocational education.
7. Developing Sustainable Water management system for rural areas and implementation approaches.
8. Contribution to any national level initiative of Government of India. For eg. Digital India, Skill India, Swatch Bharat, Atmanirbhar Bharath, Make in India, Mudra scheme, Skill development programs etc.
9. Spreading public awareness under rural outreach programs.(minimum5 programs).
10. Social connect and responsibilities.
11. Plantation and adoption of plants. Know your plants.
12. Organize National integration and social harmony events /workshops /seminars. (Minimum 02 programs).
13. Govt. school Rejuvenation and helping them to achieve good infrastructure.

NOTE:

1. Student/s in individual or in a group Should select any one activity in the beginning of each semester till end of that respective semester for successful completion as per the instructions of NSS officer with the consent of HOD of the department.
2. At the end of every semester, activity report should be submitted for evaluation.

Distribution of Activities - Semester wise from 3rd to 6th semester

Sem	Topics / Activities to be Covered
3rd Sem for 25 Marks	1. Organic farming, Indian Agriculture (Past, Present, and Future) Connectivity for marketing. 2. Waste management– Public, Private and Govt organization, 5 R's. 3. Setting of the information imparting club for women leading to contribution in social and economic issues.
4th Sem for 25 Marks	1. Water conservation techniques – Role of different stakeholders– Implementation. 2. Preparing an actionable business proposal for enhancing the village income and approach for implementation. 3. Helping local schools to achieve good results and enhance their enrolment in Higher/ technical/ vocational education.
5th Sem for 25 Marks	1. Developing Sustainable Water management systems for rural areas and implementation approaches. 2. Contribution to any national-level initiative of the Government of India. Foreg. Digital India, Skill India, Swachh Bharat, Atmanirbhar Bharath, Make in India, Mudra scheme, Skill development programs etc. 3. Spreading public awareness under rural outreach programs.(minimum 5 programs). 4. Social connect and responsibilities.
6th Sem for 25 Marks	1. Plantation and adoption of plants. Know your plants. 2. Organize National integration and social harmony events /workshops /seminars. (Minimum 02 programs). 3. Govt. school Rejuvenation and helping them to achieve good infrastructure.

Course outcomes (Course Skill Set):

At the end of the course, the student will be able to:

Cos	Description
M23BNSK608.1	Understand the importance of his / her responsibilities towards society.
M23BNSK608.2	Analyse the environmental and societal problems/issues and will be able to design solutions for the same.
M23BNSK608.3	Evaluate the existing system and to propose practical solutions for the same for sustainable development.
M23BNSK608.4	Implement government or self-driven projects effectively in the field.
M23BNSK608.5	Develop capacity to meet emergencies and natural disasters & practice national integration and social harmony in general.

Pedagogy – Guidelines :

It may differ depending on local resources available for the study as well as environment and climatic differences, location, and time of execution.

Sl No	Topic	Group size	Location	Activity execution	Reporting	Evaluation of the Topic
1.	Organic farming, Indian Agriculture (Past, Present, and Future) Connectivity for marketing.	May be individual or team	Farmers land/ Villages/ roadside/ community area /College campus etc	Site selection / proper consultation/ Continuous monitoring/ Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
2.	Waste management– Public, Private and Govt organization, 5 R's.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes	Site selection / proper consultation/ Continuous monitoring/ Information board	Report should be submitted by an individual to the concerned	Evaluation as per the rubrics of the scheme and syllabus by NSS officer

			officers / campus etc…		evaluation authority	
3.	Setting of the information imparting club for women leading to contribution in social and economic issues.	May be individual or team	Women empowerment groups/ Consulting NGOs & Govt Teams / College campus etc…	Group selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
4.	Water conservation techniques – Role of different stakeholders– Implementation.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers, campus etc…	Site selection / Proper consultation/ Continuous monitoring/ Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
5.	Preparing an actionable business proposal for enhancing the village income and approach for implementation.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers, campus etc…	Group selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
6.	Helping local schools to achieve good results and enhance their enrolment in Higher/ technical/ vocational education.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers, campus etc…	School selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
7.	Developing Sustainable Water management system for rural areas and implementation approaches.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Site selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
8.	Contribution to any national-level initiative of the Government of India. For eg. Digital India, Skill India, Swachh Bharat, Atmanirbhar Bharath, Make in India, Mudra scheme, Skill development programs etc.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Group selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer

9.	Spreading public awareness under rural outreach programs.(minimum5 programs). ///// Social connect and responsibilities.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Group selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
10.	Plantation and adoption of plants. Know your plants.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Place selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
11.	Organize National integration and social harmony events /workshops /seminars. (Minimum 02 programs).	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Place selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer
12.	Govt. school Rejuvenation and helping them to achieve good infrastructure.	May be individual or team	Villages/ City Areas / Grama panchayat/ public associations/ Government Schemes officers / campus etc…	Place selection / proper consultation / Continuous monitoring / Information board	Report should be submitted by an individual to the concerned evaluation authority	Evaluation as per the rubrics of the scheme and syllabus by NSS officer

Plan of Action ((Execution of Activities For Each Semester)

Sl. No	Practice Session Description
1	Lecture session by NSS Officer
2	Students' Presentation on Topics
3	Presentation - 1 , Selection of topic, PHASE - 1
4	Commencement of activity and its progress - PHASE - 2
5	Execution of Activity
6	Execution of Activity
7	Execution of Activity
8	Execution of Activity
9	Execution of Activity
10	Case study-based Assessment, Individual performance
11	Sectorwise study and its consolidation
12	Video-based seminar for 10 minutes by each student At the end of the semester with a Report.

- In every semester from 3rd semester to 6th semester, Each student should do activities according to the scheme and syllabus.
- At the end of every semester student performance has to be evaluated by the NSS officer for the assigned activity progress and its completion.
- At last in 6th semester consolidated report of all activities from 3rd to 6th semester, compiled report should be submitted as per the instructions.

Assessment Details:

Weightage	**CIE – 100%**	• Implementation strategies of the

Presentation - 1 Selection of topic, PHASE - 1	**10 Marks**	project (NSS work). • The last Report should be signed by the NSS Officer, the HOD, and the principal. • At last Report should be evaluated by the NSS officer of the institute. • Finally, the consolidated marks sheet should be sent to the university and made available at the LIC visit.
Commencement of activity and its progress - PHASE - 2	**10 Marks**	
Case Study-based Assessment Individual Performance with Report	**10 Marks**	
Sector-wise study & its consolidation	**10 Marks**	
Video based seminar for 10 minutes by each student At the end of semester with Report. Activities.	**10 Marks**	
Total marks for the course in each semester	**50 Marks**	
Marks scored for 50 by the students should be Scale down to 25 marks In each semester for CIE entry in the VTU portal.		
25 marks CIE entry will be entered in University IA marks portal at the end of each semester 3rd to 6th sem, Report and assessment copy should be made available in the department semester wise		
Students should present the progress of the activities as per the schedule in the prescribed practical session in the field. There should be positive progress in the vertical order for the benefit of society in general.		
Suggested Learning Resources: **Books** : 1. NSS Course Manual, Published by NSS Cell, VTU Belagavi. 2. Government of Karnataka, NSS cell, activities reports and manual. 3. Government of India, NSS cell, Activities reports and manual.		

6th Semester	Non-Credit Mandatory Course (NCMC) PHYSICAL EDUCATION (SPORTS & ATHLETICS) — I	M23BPEK608

Semester - III			
PHYSICAL EDUCATION (SPORTS & ATHLETICS) — I			
Course Code	M23BPEK608	CIE Marks	100
Number of Lecture Hours/Week(L: T: P: S)		SEE Marks	
Total Number of Lecture Hours		Total Marks	100
Credits	0	Exam Hours	-

Course Outcomes: At the end of the course, the student will be able to

Cos	Description
M23BPEK608.1	Understand the fundamental concepts and skills of Physical Education, Health, Nutrition and Fitness.
M23BPEK608.2	Familiarization of health-related Exercises, Sports for overall growth and development.
M23BPEK608.3	Create a foundation for the professionals in Physical Education and Sports.
M23BPEK608.4	Participate in the competition at regional/state / national / international levels.
M23BPEK608.5	Create consciousness among the students on Health, Fitness and Wellness in developing and maintaining a healthy lifestyle.

Module-1

Orientation: **(5 hours)**

A. Lifestyle
B. Fitness
C. Food & Nutrition
D. Health & Wellness
E. Pre-Fitness test.

Module-2

General Fitness & Components of Fitness: **(15 hours)**

A. Warming up (Free Hand exercises)
B. Strength — Push-up / Pull-ups
C. Speed — 30 Mtr Dash
D. Agility — Shuttle Run
E. Flexibility — Sit and Reach
F. Cardiovascular Endurance — Harvard step Test

Module-3

Recreational Activities: **(10 hours)**

A. Postural deformities.
B. Stress management.
C. Aerobics.
D. Traditional Games.

Scheme and Assessment for auditing the course and Grades:

Sl. No.	Activity	Marks
1.	Participation of student in all the modules	20
2.	Quizzes — 2, each of 15 marks	30
3.	Final presentation/exhibition / Participation in competitions/practical on specific tasks assigned to the students	50
	Total	100

Semester - IV
PHYSICAL EDUCATION (SPORTS & ATHLETICS) — II

Course Outcomes: At the end of the course, the student will be able to

CO1. Understand the ethics and moral values in sports and athletics
CO2. Perform in the selected sports or athletics of the student's choice.

CO3. Understand the roles and responsibilities of organisation and administration of sports and games.
Module-1
Ethics and Moral Values: **(5 hours)** A. Ethics in Sports B. Moral Values in Sports and Games
Module-2
Specific Games (Any one to be selected by the student): **(20 hours)** A. Volleyball — Attack, Block, Service, Upper Hand Pass and Lower hand Pass. B. Throwball — Service, Receive, Spin attack, Net Drop & Jump throw. C. Kabaddi — Hand touch, Toe Touch, Thigh Hold, Ankle hold and Bonus. D. Kho-Kho — Giving Kho, Single Chain, Pole dive, Pole turning, 3-6 Up. E. Table Tennis — Service (Fore Hand & Back Hand), Receive (Fore Hand & Back Hand), Smash. F. Athletics (Track / Field Events) — Any event as per availability of Ground.
Module-3
Role of Organisation and administration: **(5 hours)**

Scheme and Assessment for auditing the course and Grades:

Sl. No.	Activity	Marks
1.	Participation of student in all the modules	20
2.	Quizzes — 2, each of 15 marks	30
3.	Final presentation/exhibition / Participation in competitions/practical on specific tasks assigned to the students	50
	Total	100

6th Semester	Non-Credit Mandatory Course (NCMC) YOGA	M23BYOK608

Yoga			
Course Code	**M23BYOK608**		
Number of Lecture Hours/Week(L: T: P: S)	**0:0:2:0**	CIE Marks	**100**
Total Number of Lecture Hours		SEE Marks	**-**
Credits	**0**	Total Marks	**100**
Evaluation Method: Objective type Theory / Practical / Viva-Voce			

Course objectives:

1. To enable the student to have good Health.
2. To practice mental hygiene.
3. To possess emotional stability.
4. To integrate moral values.
5. To attain a higher level of consciousness.

The Health Benefits of Yoga

The benefits of various yoga techniques have been supposed to improve

- body flexibility,
- performance,
- stress reduction,
- attainment of inner peace, and
- self-realization.

The system has been advocated as a complementary treatment to aid the healing of several ailments such as

- coronary heart disease,
- depression,
- anxiety disorders,
- asthma, and
- extensive rehabilitation for disorders including musculoskeletal problems and traumatic brain injury.

The system has also been suggested as behavioral therapy for smoking cessation and substance abuse (including alcohol abuse).

If you practice yoga, you may receive these physical, mental, and spiritual benefits:

- Physical
  1. Improved body flexibility and balance
  2. Improved cardiovascular endurance (stronger heart)
  3. Improved digestion
  4. Improved abdominal strength
  5. Enhanced overall muscular strength
  6. Relaxation of muscular strains
  7. Weight control
  8. Increased energy levels
  9. Enhanced immune system
- Mental
  1. Relief of stress resulting from the control of emotions
  2. Prevention and relief from stress-related disorders
  3. Intellectual enhancement, leading to improved decision-making skills
- Spiritual
  1. Life with meaning, purpose, and direction
  2. Inner peace and tranquility
  3. Contentment

Yoga Syllabus

Semester III

- Yoga, its origin, history and development. Yoga, its meaning, definitions.
- Different schools of yoga, Aim and Objectives of yoga, importance of prayer
- Yogic practices for a common man to promote positive Health
- Rules to be followed during yogic practices by the practitioner
- Yoga its misconceptions,
- Difference between yogic and non-yogic practices

- Surya namaskar prayer and its meaning, Need, importance and benefits of Surya namaskar 12 count, 2 rounds
- Asana, Need, importance of Asana. Different types of asanas. Asana its meaning by name, technique, precautionary measures and benefits of each asana
- Different types of Asanas
  e. Sitting
    1. Padmasana
    2. Vajrasana
  f. Standing
    1. Vrikshana
    2. Trikonasana
  g. Prone line
    1. Bhujangasana
    2. Shalabhasana
  h. Supine line
    3. Utthitadvipadasana
    4. Ardhahalasana

Semester IV

- Patanjali's Ashtanga Yoga, its need and importance.
- Yama :Ahimsa, satya, asteya, brahmacarya, aparigraha.
- Niyama :shoucha, santosh, tapa, svaadhyaya, Eshvarapranidhan
- Suryanamaskar12 count- 4 rounds of practice
- Asana, Need, importance of Asana. Different types of asana. Asana its meaning by name, technique, precautionary measures and benefits of each asana.
- Different types of Asanas
  e. Sitting
    1. Sukhasana
    2. Paschimottanasana
  f. Standing
    1. Ardhakati Chakrasana
    2. Parshva Chakrasana
  g. Prone line
    2. Dhanurasana
  h. Supine line
    1. Halasana
    2. Karna Peedasana
- Meaning, importance and benefits of Kapalabhati.
- 40 strokes/min 3 rounds
- Meaning, Need, importance of Pranayama. Different types. Meaning by name, technique, precautionary measures and benefits of each Pranayama.
- Pranayama
  1. Suryanuloma –Viloma
  2. Chandranuloma-Viloma
  3. Suryabhedana
  4. Chandra Bhedana
  5. Nadishodhana

Semester V

- Patanjali'sAshtanga Yoga its need and importance.
- Ashtanga Yoga
  1. Asana
  2. Pranayama
  3. Pratyahara
- Asana its meaning by name, technique, precautionary measures and benefits of each asana
- Different types of Asanas
  a. Sitting 1. Ardha Ushtrasana 2. Vakrasana 3. Yogamudra in Padmasana
  b. Standing 1. UrdhvaHastothanasana 2. Hastapadasana 3. ParivrittaTrikonasana 4. Utkatasana
  c. Prone line 1. Padangushtha Dhanurasana 2. Poorna Bhujangasana / Rajakapotasana
  d. Supine line 1. Sarvangasana 2. Chakraasana 3. Navasana/Noukasana 4. Pavanamuktasana
- Revision of practice 60 strokes/min 3 rounds
- Meaning by name, technique, precautionary measures and benefits of each Pranayama 1. Ujjayi

2. Sheetali 3. Sheektari

Semester VI

- Ashtanga Yoga
  1. Dharana
  2. Dhyana (Meditation)
  3. Samadhi
- Asana by name, technique, precautionary measures and benefits of each asana
- Different types of Asanas
  a. Sitting 1. Bakasana 2. Hanumanasana 3. Ekapada Rajakapotasana 4. Yogamudra in Vajrasana
  b. Standing 1. Vatayanasana 2. Garudasana
  c. Balancing 1. Veerabhadrasana 2. Sheershasana
  d. Supine line 1. Sarvangasana 2. Setubandha Sarvangasana 3. Shavasanaa (Relaxation poisture).
- Revision of Kapalabhati practice 80 strokes/min - 3 rounds
- Different types. Meaning by name, technique, precautionary measures and benefits of each Pranayama 1. Bhastrika 2. Bhramari
- Meaning, Need, importance of Shatkriya.
- Different types. Meaning by name, technique, precautionary measures and benefits of each Kriya 1. Jalaneti & sutraneti 2. Nouli (only for men) 3. Sheetkarma Kapalabhati

Course outcomes (Course Skill Set):
At the end of the course, the student will be able to:

- Understand the meaning, aim and objectives of Yoga.
- Perform Suryanamaskar and able to Teach its benefits.
- Understand and teach different Asanas by name, its importance, methods and benefits.
- Instruct Kapalabhati and its need and importance.
- Teach different types of Pranayama by its name, precautions, procedure and uses
- Coach different types of Kriyas , method to follow and usefulness.

Assessment Details (both CIE and SEE)

- Students will be assessed with internal test by a. Multiple choice questions b. Descriptive type questions (Two internal assessment tests with 25 marks/test)
- Final test shall be conducted for whole syllabus for 50 marks.
- Continuous Internal Evaluation shall be for 100 marks (including IA test)

Suggested Learning Resources:
Books:
1. Yogapravesha in Kannada by Ajitkumar
2. Light on Yoga by BKS Iyengar
3. Teaching Methods for Yogic practices by Dr. M L Gharote & Dr. S K Ganguly
4. Yoga Instructor Course hand book published by SVYASA University, Bengaluru
5. Yoga for Children –step by step – by Yamini Muthanna

Web links and Video Lectures (e-Resources):
Refer links
1. https://youtu.be/KB-TYlgd1wE
2. https://youtu.be/aa-TG0Wg1Ls