# CURRICULUM 2023 (Autonomous)

Version 2.0

## B.TECH
## Mechanical Engineering

## BTech S5,S6 MINORS SYLLABUS

**MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY**

**Mar Ivanios Vidyanagar, Nalanchira, Thiruvananthapuram – 695 015**

# B.Tech MINORS

| Semester | BASKET I<br>Supply Chain and Logistics | | | | BASKET II<br>Unmanned Aerial Vehicle (UAV) | | | | BASKET III<br>Computational Design Engineering | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Course code | Course Name | L-T-P-J | Credits | Course code | Course Name | L-T-P-J | Credits | Course code | Course Name | L-T-P-J | Credits |
| S3 | 23MEL2MA | Supply chain and Logistics Management | 3-0-0-0 | 3 | 23MEL2MC | Introduction to Unmanned Aerial Vehicles (UAV) | 2-1-0-0 | 3 | 23MEL2ME | Computer Aided Design | 2-1-0-0 | 3 |
| S4 | 23MEL2MB | Emerging Technologies in SCM | 2-1-0-0 | 3 | 23MEL2MD | Basics elements of UAV system | 2-1-0-0 | 3 | 23MEL2MF | Finite Element Method | 2-1-0-0 | 3 |
| S5 | 23MEL3MA | Green Logistics and operations management | 2-1-0-0 | 3 | 23MEL3MC | Design and Simulation of UAV | 2-1-0-0 | 3 | 23MEL3ME | Computational Mechanics | 2-1-0-0 | 3 |
| S6 | 23MEL3MB | Digital Manufacturing Transformation | 2-1-0-0 | 3 | 23MEL3MD | Fabrication and Testing of UAV | 2-1-0-0 | 3 | 23MEL3MF | Optimization Techniques | 2-1-0-0 | 3 |
| S7 | 23MEL4MA | Mini Project | 0-0-6-0 | 3 | 23MEL4MA | Mini Project | 0-0-6-0 | 3 | 23MEL4MA | Mini Project | 0-0-6-0 | 3 |
| S8 | 23MEL4MB | Mini Project | 0-0-6-0 | 3 | 23MEL4MB | Mini Project | 0-0-6-0 | 3 | 23MEL4MB | Mini Project | 0-0-6-0 | 3 |

## 2023 SCHEME

# S5 MINORS

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of introduction |
|---|---|---|---|---|---|---|---|---|
| 23MEL3MA | Green Logistics and Operations Management | VAC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**

Objective of the course is to develop knowledge of Green Logistics and operations in practices.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain and reflect on concepts of Logistics and Supply chain management. | Understand |
| CO2 | Critically review the impact on social, ethical and environmental issues of logistics management | Apply |
| CO3 | Demonstrate various models and theories in relation to green logistics strategies | Understand |
| CO4 | Explain concepts in the current business practises of logistics operations | Understand |
| CO5 | Solve problems involving innovative strategies and technologies for future operations of an organisation | Apply |

**iii) SYLLABUS**

**Fundamentals of Logistics and Supply chain management**: : Basic concepts of logistics and Supply chain, Introduction to Green Logistics: Concept Environmental Impact of Logistics , Protocols for Green Logistics , Green Logistics Strategies Towards Green logistics: Challenges

**Measuring impact of Logistics**: Social impact. Labor rights and workplace safety - Impact on communities and urban spaces Ethical impact - Supply chain transparency- Corruption and ethical sourcing- Data privacy in logistics, and environmental impact- missions and climate change.. Case studies - Amazon, Maersk, FedEx: sustainability and ethical practices.

**Green logistics strategies:** Designing Green Operations Supply Chain: Distance reduction, Model shifts, cleaner equipment, Circular supply chains in action. Green logistics and reverse logistics- Sustainable packaging and waste management.

**Business operations and Practices**: A green framework - 3PL issues in sustainable supply chain. Reverse Logistics, Lean Supply Chain, Green Supply Chain, Responsive and Efficient Supply Chains

**Innovative Technologies and Green policy trends**: Developing a green smart factory. Product Modularity and the Design of Closed Loop Supply Chains. Government

regulations and ESG compliance - Technological innovations (AI, IoT, blockchain)- Building a sustainable logistics strategy.

### iv) a) TEXTBOOKS


1. **Luca Urciuoli, Peerasit Patanakul, Peter Gustavsson (Editors)**, *"Sustainable Logistics: A Multidisciplinary Perspective"*, Springer, 2020.
2. **Martin Christopher**, *"Logistics and Supply Chain Management"*, Pearson Education, 2016.
3. **David B. Grant, Alexander Trautrims, Chee Yew Wong**, *"Sustainable Logistics and Supply Chain Management"*, Kogan Page, 2017


### b) REFERENCES


1. **Joseph Sarkis (Editor)**, *"Greening the Supply Chain"*, Springer, 2006.
2. **Seyed Mohammadreza Davoodi, Aydin Azizi**, *"Green Supply Chain: Fundamentals and Applications"*, Nova Science Publishers, 2020
3. **Srivastava Samir K., R. Srivastava**, *"Green Supply Chain Management: A Strategy Perspective"*, Springer, 2020


### v) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | **Fundamentals of Logistics and Supply chain management**: : Basic concepts of logistics and Supply chain, Introduction to Green Logistics: Concept Environmental Impact of Logistics , Protocols for Green Logistics , Green Logistics Strategies Towards Green logistics: Challenges. | 9 |
| II | **Measuring impact of Logistics**: Social impact. Labor rights and workplace safety - Impact on communities and urban spaces Ethical impact - Supply chain transparency- Corruption and ethical sourcing- Data privacy in logistics, and environmental impact- missions and climate change.. Case studies - Amazon, Maersk, FedEx: sustainability and ethical practices. | 9 |
| III | **Green logistics strategies:** Designing Green Operations Supply Chain: Distance reduction, Model shifts, cleaner equipment, Circular supply chains in action. Green logistics and reverse logistics- Sustainable packaging and waste management. | 11 |
| IV | **Business operations and Practices**: A green framework - 3PL issues in sustainable supply chain. Reverse Logistics, Lean Supply Chain, Green Supply Chain, Responsive and Efficient Supply Chains. | 7 |
| V | **Innovative Technologies and Green policy trends**: Developing a green smart factory. Product Modularity and the Design of Closed | 9 |

| | | |
|---|---|---|
| | Loop Supply Chains. Government regulations and ESG compliance - Technological innovations (AI, IoT, blockchain)- Building a sustainable logistics strategy. | |
| | **Total** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40 : 60

| **Continuous Assessment** | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**viii CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of introduction |
|---|---|---|---|---|---|---|---|---|
| 23MEL3MC | DESIGN AND SIMULATION OF UAV | VAC | 2 | 1 | 0 | 0 | 3 | 2023 |

## i) COURSE OVERVIEW

The course guides participants through the principles of UAV design. Utilizing advanced simulation tools, students will learn to optimize UAV performance and reliability. By the end of the course, participants will be equipped with practical skills to design and simulate parts of an UAV for various applications.

## ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain geometric modelling of an unmanned aerial vehicle parts. | Understand |
| CO2 | Apply modelling software to develop geometric models of UAV parts. | Apply |
| CO3 | Explain the properties, load and performance of structural framework design. | Understand |
| CO4 | Explain the flow around an unmanned aerial systems and its flow properties. | Understand |
| CO5 | Make use of structural and flow analysis tools to determine the impact of flow around UAV systems. | Apply |

## iii) SYLLABUS

**Conceptual Design of UAV systems**. Tools and physical features. Wing Design and basic design parameters.Geometric modelling of parts of an unmanned aerial vehicles using modelling tools.

**Introduction to modeling and design tools**. Creating and Managing Projects. Basic modelling operations - sketching: Drawing profiles for UAV components.

**Types of Simulation.** Structural analysis of UAV systems - Tools and Analysis techniques, materials and structures. Structural Loads on UAVs. Methods, parameters and processing steps.

**Flow Analysis**. Computational Fluid Dynamics – Tools and processes. Importance of Flow Analysis - characteristics and performance features. Analysis of flow over UAV under varying geometric and flow parameters.

**Analysis and optimization.** Key Considerations and Performance Metrics. Design and operational effectiveness.

**iv) a) TEXTBOOKS**

1. John D. Anderson, Introduction to Flight, McGraw-Hill Higher Education, 2015.
2. Richard Cozzens, CATIA V5 Workbook Release V5-6R2013, 2013.
3. Daniel P. Raymer, Aircraft Design : A Conceptual Approach , American Institute of Aeronautics & Astronautics, 2018.
4. Versteeg, H. Pearson, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2022.

**b) REFERENCES**

1. Anderson, J., Computational Fluid Dynamics, 2019.
2. Reg Austin, Unmanned Aircraft Systems: UAVs Design Development and Deployment, Wiley, 2008.
3. Russell M. Cummings, William H. Mason, Scott A. Morton, and David R. McDaniel, Applied computational aerodynamics: a modern engineering approach, Cambridge University Press, 2015.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| **I** | Conceptual Design of UAV systems. Introduction to geometric modelling – Tools and physical features. Introduction to modelling different parts of UAVs - Wing Design and basic design parameters. Aerofoil Selection, Configuration Layout, Weight distribution. | **8** |
| **II** | Introduction to modeling and design tools. User Interface – Toolbars, menus, workbenches. Creating and Managing Projects – Setting up a workspace for UAV design. Basic modelling operations - sketching: Drawing profiles for UAV components. Airframe & Wing Structure - Aerofoil Modelling and Assembly. | **8** |
| **III** | Types of Simulation. Structural analysis of UAV systems - Tools and Analysis techniques, materials and structures. Structural Loads on UAVs. Methods, parameters and processing steps. Numerical problems. | **10** |
| **IV** | Fluid Properties and Fluid Statics and Kinematics, Types of flows. Computational Fluid Dynamics – Tools and processes. Numerical problems. Importance of Flow Analysis - characteristics and performance features. Aerodynamics case studies. Analysis of flow over UAV under varying geometric and flow parameters. | **10** |
| **V** | Conduct studies of structural and flow analysis. Iterative Design Process. Challenges and Limitations. Emerging Technologies and Future Trends. | **9** |

| | | |
|---|---|---|
| | Introduction to simulation testing. Analysis of UAV for geometric optimization - Key Considerations and Performance Metrics. Design and operational effectiveness. Energy Efficiency Studies. | |
| | **Total** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of introduction |
|---|---|---|---|---|---|---|---|---|
| **23MEL3ME** | Computational Mechanics | VAC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**

Objective of the course is to develop the ability to model, analyze, and solve problems of mechanical systems using numerical methods and computational tools.

**ii COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the numerical methods to develop computational models of mechanical systems and their behaviour. | Understand |
| CO2 | Make use of the constitutive relations for mechanical systems in motion or at rest, including particles and rigid bodies, to solve real world problems. | Apply |
| CO3 | Make use of computational simulations for the informed decisions on mechanical system design and optimization. | Apply |
| CO4 | Solve static and dynamic problems of mechanical systems using a commercial multibody dynamics and motion analysis software ADAMS. | Apply |

**iii) SYLLABUS**

**Kinematics and statics**: Fundamentals of Mechanics and Motion Analysis- Introduction to statics and equilibrium, Free body diagrams, Equilibrium of particles and rigid bodies, Computational aspects of solving kinematics and statics problems of real-world systems.

**Introduction to kinetics**: Fundamentals of kinetics and their application to mechanical systems. Computational aspects of solving problems on kinetics of particles.

**Kinetics of Rigid bodies**: Fundamentals of kinetics and their application on rigid bodies, Introduction to Euler-Lagrange and Newton-Euler equations for solving rigid body dynamics of simple mechanical systems.

**Introduction to multibody dynamics and motion analysis software:** Introduction to commercial simulation tool (ADAMS), Basics of model buildings tools and techniques, ADAMS model from CAD solid model geometry.

**Static equilibrium and Natural Frequency Analysis**: Modelling and analysis of one degree of freedom of pendulum-pendulum frequency, spring mass damper system, force in spring damper at static equilibrium and natural frequency.

**iv) a) TEXTBOOKS**

1. B. S. Choo and S. H. Han ,"Introduction to Computational Mechanics" -

2005, 1st edition

2. J.L. Meriam and L.G. Kraige, "Engineering Mechanics: Dynamics" - 2016, 8th edition
3. J.L. Meriam and L.G. Kraige, "Engineering Mechanics: Statics"- 2016, 8th edition
4. Ferdinand P. Beer and E. Russell Johnston Jr, "Vector Mechanics for Engineers: Statics and Dynamics"- 2015, 11th edition

**b) REFERENCES**

1. David Morin, "Introduction to Classical Mechanics: With Problems and Solutions"- 2008, 1st edition
2. James M. Gere and Barry J. Goodno, "Mechanics of Materials"- 2018, 9th edition
3. Irving H. Shames, “Engineering Mechanics: Statics and Dynamics"–2002, 4th edition

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Kinematics and statics:** Position, velocity, and acceleration of particles, Newton's laws of motion, Work and energy, Rigid body kinematics, Translations and Rotations, Alternate representations of Rigid body Rotation - Rotation matrices, Euler angles, Axis-angle representations. Introduction to statics and equilibrium, Free body diagrams, Equilibrium of particles and rigid bodies, Computational aspects of solving kinematics and statics problems of real-world systems. | 9 |
| II | **Introduction to kinetics**: Cross product of two vectors, Inertial and Non-Inertial frame of reference, Linear momentum, Center of mass, Coriolis, Inertial and Centripetal forces, Acceleration in polar coordinates, Angular velocity, Angular momentum and Torque on particles, Computational aspects of solving kinetics problems of particles. | 9 |
| III | **Kinetics of Rigid bodies**: Two particle system angular momentum, Inertia matrix, Moment and product of inertia, Principal axes theorem, Principal axes as eigenvector of Inertia matrix, Parallel axes theorem, Computational aspects of solving kinetics problems of particles, Introduction to Euler-Lagrange and Newton-Euler equations for solving rigid body dynamics. Euler-Lagrange equation derivation using one dimensional point mass example, Application of Euler Lagrange equation for solving dynamics of simple mechanical systems. | 9 |

| | | |
|---|---|---|
| IV | **Introduction to ADAMS**: Introduction to simulation tool (ADAMS), Basics of model buildings tools and techniques, ADAMS model from CAD solid model geometry. | 9 |
| V | **Static equilibrium and Natural Frequency Analysis**: Modelling and analysis of one degree of freedom of pendulum-pendulum frequency, spring mass damper system, force in spring damper at static equilibrium and natural frequency. | 9 |
| | **Total** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40: 60

| **Continuous Assessment** | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**viii CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours

## 2023 SCHEME

# S6 MINORS

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of introduction |
|---|---|---|---|---|---|---|---|---|
| 23MEL3MB | Digital Manufacturing Transformation | VAC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**

Objective of the course is to develop knowledge of digital transformation practices in Manufacturing industries.

**ii COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the theoretical aspects of Digital Manufacturing | Understand |
| CO2 | Explain the Additive Technologies in Digital manufacturing | Understand |
| CO3 | Illustrate Product Lifecycle Management and reverse engineering | Understand |
| CO4 | Explain the application of Value chain management | Understand |
| CO5 | Solve problems involving in creation of a smart factory using modellers and address the challenges. | Apply |

**iii) SYLLABUS**

**Introduction to Digital Manufacturing:** Definition of digital manufacturing, Historical perspective on industrial production and outlook, Industrial Revolutions, Industry 4.0, Cyber physical system, Factory of the future, Operation Mode and Architecture of Digital Manufacturing System.

**Additive Manufacturing for Digital Transformation:** Introduction to additive manufacturing, Additive manufacturing process chain, Material selection, Manufacturing, Post processing, Additive manufacturing technologies and processes, Vat photo polymerization, Material extrusion, Material jetting, Sheet lamination, Powder bed fusion, Binder jetting, Planning and slicing additive manufacturing software.

**Reverse Engineering:** Product Lifecycle Management and Value Chain Management Need, Reverse engineering process, Reverse engineering hardware and software, Geometric model development. Computer Aided Manufacturing: Component modelling, Machine and tool selection, Defining process and parameters, Tool path generation, Simulation, Post processing.

**Value Chain Management in Digital transformation**: Industry 4.0 Adoption in India, Six design Principles in Industry 4.0, , Comparison of Models and adaptability in Digital Manufacturing, Digital Resource Modelling and Simulation - Factory Model, Digital Manufacturing Planning process- ERP and Value Chain Management, Validation & Virtual Commissioning.

**Concept Modelers, Translators and 3D Printing Software:** Introduction, Principle, Materials used in 3D printing Benefits & Challenges in 3D printing. Thermo jet printer, Sander's model market, 3- D printer, Genisys Xs printer, JP system 5, object

quadra System-Rapid proto typing. Standard interface to convey geometric description from CAD package to Rapid prototyping system, Stereo Lithography (STL)file, Initial Graphics Exchange Specification (IGES)file, STEP file.

**iv) a) TEXTBOOKS**

1. Alp Ustundag, Emre Cevikcan (Editors), *"Industry 4.0: Managing the Digital Transformation"*, Springer, 2018.
2. Ian Gibson, David W. Rosen, Brent Stucker, Mahyar Khorasani, *"Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing"*, Springer, 2021.
3. Alasdair Gilchrist, *"Industry 4.0: The Industrial Internet of Things"*, Apress, 2016

**b) REFERENCES**

1. Amit Bandyopadhyay, Susmita Bose (Editors), *"Additive Manufacturing"*, CRC Press, 2015.
2. Rajkumar Roy, Essam Shehab, Jennifer Harding (Editors), *"Product Lifecycle Management: Driving the Next Generation of Lean Thinking"*, Springer, 2008.
3. Wego Wang, *"Reverse Engineering: Technology of Reinvention"*, CRC Press, 2010.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction to Digital Manufacturing:** Definition of digital manufacturing, Historical perspective on industrial production and outlook, Industrial Revolutions, Industry 4.0, Cyber physical system, Factory of the future, Operation Mode and Architecture of Digital Manufacturing System. | 9 |
| II | **Additive Manufacturing for Digital Transformation:** Introduction to additive manufacturing, Additive manufacturing process chain, Material selection, Manufacturing, Post processing, Additive manufacturing technologies and processes, Vat photo polymerization, Material extrusion, Material jetting, Sheet lamination, Powder bed fusion, Binder jetting, Planning and slicing additive manufacturing software. | 9 |
| III | **Reverse Engineering:** Product Lifecycle Management and Value Chain Management Need, Reverse engineering process, Reverse engineering hardware and software, Geometric model development. Computer Aided Manufacturing: Component modelling, Machine and tool selection, Defining process and parameters, Tool path generation, Simulation, Post processing. | 11 |
| IV | **Value Chain Management in Digital transformation**: Industry 4.0 Adoption in India, Six design Principles in Industry 4.0, , Comparison of Models and adaptability in Digital Manufacturing, Digital Resource Modelling and Simulation - Factory Model, Digital | 7 |

| | | |
|---|---|---|
| | Manufacturing Planning process- ERP and Value Chain Management, Validation & Virtual Commissioning | |
| V | **Concept Modelers, Translators and 3D Printing Software:** Introduction, Principle, Materials used in 3D printing Benefits & Challenges in 3D printing. Thermo jet printer, Sander's model market, 3- D printer, Genisys Xs printer, JP system 5, object quadra System-Rapid proto typing. Standard interface to convey geometric description from CAD package to Rapid prototyping system, Stereo Lithography (STL)file, Initial Graphics Exchange Specification (IGES)file, STEP file. | 9 |
| | **Total** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40 : 60

| **Continuous Assessment** | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**viii CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of introduction |
|---|---|---|---|---|---|---|---|---|
| 23MEL3MD | FABRICATION AND TESTING OF UAV | VAC | 2 | 1 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**

This course aims to provide students with a comprehensive understanding of the design, manufacturing, and testing of UAV (Unmanned Aerial Vehicle) components. By the end of this course, students will leave equipped with the necessary skills to contribute to the UAV industry.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Identify and apply the steps, materials, methods involved in manufacturing of UAV systems. | Apply |
| CO2 | Explain various integration techniques for UAV subsystem assembly. | Understand |
| CO3 | Apply appropriate testing procedures to assess UAV performance and ensure compliance with design specifications. | Apply |
| CO4 | Apply different mission objectives and operational strategies for successful flight execution. | Apply |
| CO5 | Explain the fundamental rules and best practices related to UAV flight safety and maintenance. | Understand |

**iii) SYLLABUS**

**Manufacturing techniques** - Traditional Manufacturing Methods, Design considerations, Steps in additive manufacturing (AM), Classification and Advantages, Types of materials for AM and 3D printing.

**Introduction to UAV assembly and subsystems**. Integrating systems - circuits, tools for assembly, functionality and positioning. Integration Techniques. Prototype Development. Essential features and indications. Working stages and modes.

**Testing Methodologies**. Introduction to test equipment and instrumentation, Ground and flight tests. Testing plan and procedure.

**Flight operations** - UAS simulators - purpose and types, real flight. Basics of piloting and maneuvering. FPV and Non-FPV systems. Prototype demonstration. Mission Planning and execution. Flight scenarios, constraints, obstacle avoidance and fail-safe mechanisms, integrating feedback.

**Maintenance of UAV systems** - Debugging and repairing. Operation of UAV systems for different applications. Flight safety rules and types.

**iv) a) TEXTBOOKS**

1. Reg Austin, Unmanned Aircraft Systems: UAVs Design Development and Deployment, Wiley, 2008.
2. F.N. Stoliker, Introduction to Flight Test Engineering, RTO Publications, 2005.
3. Daniel P. Raymer, Aircraft Design : A Conceptual Approach, American Institute of Aeronautics & Astronautics, 2018.

**b) REFERENCES**

1. A. R. Jha, Theory, Design, and Applications of Unmanned Aerial Vehicles, CRC Press, 2016.
2. Franck Cazaurang, Kelly Cohen and Manish Kumar, Multi-Rotor Platform based UAV Systems, ISTE Press – Elsevier, 2020.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | Manufacturing techniques - Traditional Manufacturing Methods, Design considerations, Steps in additive manufacturing (AM), Classification and Advantages, Types of materials for AM and 3D printing.<br>Design to development - Detailed sizing, Case studies on UAV systems. Sustainable production. | 10 |
| II | Introduction to UAV assembly and subsystems. Integrating systems - circuits, tools for assembly, functionality and positioning. Integration Techniques. Prototype Development. Essential features and indications. Working stages and modes. | 8 |
| III | Testing Methodologies, Types - functional, environmental, and structural. Introduction to test equipment and instrumentation, Ground and flight tests. Testing plan and procedure. Performance Assessment - Methods for Measuring Performance, Data Collection and Analysis Techniques. | 10 |
| IV | Flight operations - Pre and Post flight. UAS simulators - purpose and types, real flight. Basics of piloting and maneuvering. FPV and Non-FPV systems. Prototype demonstration. Mission Planning and execution. Flight scenarios, constraints, obstacle avoidance and fail-safe mechanisms, integrating feedback. | 9 |
| V | Maintenance of UAV systems - Debugging and repairing. Operation of UAV systems for different applications. Flight safety rules and types. Emerging trends, Future of unmanned aerial vehicles. Legal considerations - Negligence, liability, privacy etc. | 8 |
| | **Total** | **45** |

### vi) ASSESSMENT PATTERN

Continuous Assessment: End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

### vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

### viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of introduction |
|---|---|---|---|---|---|---|---|---|
| 23MEL3MF | Optimization Techniques | VAC | 2 | 1 | 0 | 0 | 3 | 2023 |

i) **COURSE OVERVIEW**

This course provides the basic knowledge of optimization techniques and achieving optimal output. It also explores design optimization methods aimed at obtaining the best results in comparison to conventional design approaches.

ii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Apply the appropriate optimization method that is more efficient to the problem at hand. | Apply |
| CO2 | Solve constrained and unconstrained optimization problems. | Apply |
| CO3 | Apply the linear and nonlinear programming methods of optimization. | Apply |
| CO4 | Apply the use of computational tools for solving optimization problems. | Apply |
| CO5 | Explain the different intelligent optimization techniques. | Understand |

iii) **SYLLABUS**

Introduction to Optimization: Engineering application of Optimization, Optimal Problem formulation.

Optimization algorithms for solving unconstrained optimization problems.

Optimum design concepts: Linear programming methods for optimum design, Application of LPP models in design and manufacturing. Optimization algorithms for solving unconstrained optimization problems – Gradient based method:

Optimization algorithms for solving constrained optimization problems. Applications.

Intelligent optimization techniques.

iv) **a) TEXTBOOKS**

1. Singiresu.S.Rao., “Engineering Optimization Theory and Practice” New Age International (P) Limited, Publishers 1996.
2. Johnson Ray.C., “Optimum design of mechanical elements” Wiley, John & Sons, 1990

**b) REFERENCES**

1. Goldberg, DE “Genetic algorithms in search, Optimization and Machine: Barmen, Addison – Wesely, New York 1989.

2. Saravanan.R, “Manufacturing Optimization through intelligent techniques”, Taylor and Francis Publications, CRC Press. 2006.

v) **COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | Introduction, Formulation of optimization problems, examples Classification of optimization problems, Properties of objective function Maxima, minima and points of inflection, Concavity and convexity of one and two variable functions, Taylor's theorem: single variable and multi variable function. Hessian matrix, Unconstrained Optimization of multi variable functions, Lagrange multiplier method. | 9 |
| II | Single variable optimization: optimality criteria, Exhaustive search and dichotomous search. Region elimination methods- Fibonacci search and Golden section search, Gradient based methods- Newton Raphson method, Secant method. | 9 |
| III | Multivariable optimization: optimality criteria, Unidirectional Search, Direct search method-Simplex search method, Powell's conjugate direction method. Gradient based methods- Method of steepest ascent/ steepest descent, conjugate gradient method. | 9 |
| IV | Constrained optimization: Kuhn Tucker conditions, Transformation method- Penalty function method. Linearized search-Frank-Wolfe method. Dynamic programming; Integer programming. Implementing optimization algorithm using Matlab / Programming. | 9 |
| V | Intelligent Optimization Techniques Introduction to Intelligent Optimization, Genetic Algorithm: Types of reproduction operators, crossover & mutation, Simulated Annealing Algorithm, Particle Swarm Optimization (PSO), Genetic Programming (GP): Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, random population generation, solving differential equations using GP. | 9 |
| | **Total** | **45** |

vi) **ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours

# INSTITUTE ELECTIVES – 2023 SCHEME

## BASKET 1

| COURSE CODE | COURSE NAME | L-T-P-J | CREDITS |
|---|---|---|---|
| 23IEL31Q | **3D Printing** | 3-0-0-0 | 3 |
| 23IEL31R | **Maintenance Engineering** | 3-0-0-0 | 3 |
| 23IEL31S | **Renewable and Non-conventional energy engineering** | 3-0-0-0 | 3 |
| 23IEL31T | **Sports Engineering and Management** | 3-0-0-0 | 3 |

## BASKET 2

| COURSE CODE | COURSE NAME | L-T-P-J | CREDITS |
|---|---|---|---|
| 23IEL42Q | **Industrial Engineering** | 3-0-0-0 | 3 |
| 23IEL42R | **Sustainable Manufacturing** | 3-0-0-0 | 3 |
| 23IEL42S | **Marketing Management for Engineers** | 3-0-0-0 | 3 |
| 23IEL42T | **Alternate Fuels** | 3-0-0-0 | 3 |

# BASKET 1 INSTITUTE ELECTIVES

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23IEL31Q | 3D Printing | IEC | 3 | 0 | 0 | 0 | 3 | 2023 |

## i) COURSE OVERVIEW

The objective of this course is to impart students to the fundamentals of various 3D Printing Techniques for application to various industrial needs. The course also intends to convey an idea about STL formats, slicing technique and manufacturing based on liquid, powder and solid based techniques.

## ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | Course Outcomes | Learning Level |
|---|---|---|
| CO 1 | Explain about the prototyping fundamentals, materials used and the procedure of 3D printing. | Understand |
| CO 2 | Demonstrate the various 3D printing techniques and their advantages and applications. | Understand |
| CO 3 | Explain the aspects of data conversion and post processing in 3D printing. | Understand |
| CO4 | Explain about slicing operation and its related parameters. | Understand |
| CO5 | Make use of any slicing software to develop 3D print models. | Apply |

## iii) SYLLABUS

**Introduction:** Prototyping fundamentals. Introduction to 3D printing, its historical development, advantages. Commonly used terms, process chain, 3D modelling

**Data Conversion**, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of 3D printing process, Applications to various fields.

**Stereo lithography apparatus (SLA):** Models and specifications, process, working principle, photopolymers, photo polymerization. Solid ground curing (SGC): Models and specifications.

**Laminated object manufacturing (LOM):** Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies.

**Fused Deposition Modeling (FDM):** Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies.

**Slicing:** Slicing parameters, Slicing software CURA, 3D print model development.

## iv) a) TEXTBOOKS

1. Ian Gibson, Davin Rosen, Brent Stucker “Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.

2. D.T. Pham and S.S. Dimov, "Rapid Manufacturing", Springer, 2001

### b) REFERENCES

1. Paul F. Jacobs, " Rapid Prototyping and Manufacturing"–, ASME Press, 1996
2. Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientific publications, 3rdEd., 2010

### v) COURSE PLAN

| Module | Contents | Hours |
|---|---|---|
| I | Introduction to 3D printing: Importance of 3D printing, Basic principle of 3D printing- Procedure of product development in 3D printing. Classification of 3D printing processes, Materials used in 3D printing Benefits & Challenges in 3D printing | 9 |
| II | Principle, process, advantages and applications of: Fused Deposition Modelling (FDM).Principle, process, advantages and applications of: Selective Laser Sintering (SLS), Stereo Lithography (SLA), Principle, process, advantages and applications of: Laser Engineering Net Shaping (LENS).Principle, process, advantages and applications of: Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM). | 9 |
| III | Basic Concept — Digitization techniques — Model Reconstruction. Data Processing for Additive Manufacturing Technology CAD model preparation — Part Orientation and support generation. Model Slicing —Tool path Generation. Introduction to slicing softwares. | 9 |
| IV | Principle, process, advantages and applications of: Selection Laser Melting (SLM), Jetting, 3D Printing Principle, process, advantages and applications of 3D Printing.STL Format, STL File Problems, consequence of building valid and invalid tessellated models.STL file Repairs: Generic Solution, other Translators, Newly Proposed Formats. | 9 |
| V | Eight Steps in Additive Manufacture, Variations from One 3D Printing Machine to Another, Metal Systems, Maintenance of Equipment, Materials Handling Issues, Design for 3D PRINTING. Introduction to Photopolymerization Processes: Photopolymerization Materials, Reaction Rates, Vector Scan SL, SL Resin Curing Process, SL Scan Patterns, Vector Scan Micro stereolithography, Mask Projection Photopolymerization Technologies and Processes, Two-Photon SL. Development of 3D print models using slicing software (Assignments only). | 9 |
| | **Total** | **45** |

### vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |

| | | |
|---|---|---|
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23IEL31R | Maintenance Engineering | IEC | 3 | 0 | 0 | 0 | 3 | 2023 |

## i) COURSE OVERVIEW

The objective of this course is to enable the student to understand the principles, functions and practices of maintenance activities. This course also intends to introduce the different maintenance categories and failure analysis tools.

## ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | Course Outcomes | Learning Level |
|---|---|---|
| CO 1 | Explain about the fundamentals of maintenance engineering. | Understand |
| CO 2 | Explain about the different types of maintenance strategies and maintenance costs. | Understand |
| CO 3 | Illustrate various aspects of lubricant monitoring and condition monitoring. | Understand |
| CO4 | Explain about reliability centered maintenance, failure modes and failure analysis. | Understand |
| CO5 | Utilize case studies to identify the condition based maintenance required in various scenarios. | Apply |

## iii) SYLLABUS

**Fundamentals of maintenance engineering:** Maintenance Engineering, Its Importance in Material & Energy Conservation, Inventory Control, Productivity, Safety, Pollution Control, etc. Safety Regulations

**Types of maintenance**, Breakdown, Preventive & Predictive Maintenance, Comparison, Advantages & Disadvantages, Total productive maintenance (TPM), TPM and terotechnology.

**Lubrication monitoring:** Lubricant monitoring – components and techniques – filter debris analysis & filter grams. Ferrography – spectroscopic oil analysis program.

**Condition based maintenance:** Performance monitoring – visual, tactile and aural monitoring – leakage monitoring. Temperature monitoring. Case studies

**Reliability testing and failure analysis:** Reliability centred maintenance (RCM) – steps – flow diagram basic guidelines. Defect and failure, basics of failures, failure generation, failure analysis.

## iv) a) TEXTBOOKS

1. Gupta A. K., Reliability, Maintenance and Safety Engineering, University Science Press, New Delhi, 2009.

2. Rao S. S., Reliability-Based Design, McGraw-Hill, Inc, New York, 1992.

**b) REFERENCES**

1. Davies, Handbook of Condition Monitoring, Chapman & Hall, 1996.
2. Garg M. R., Industrial Maintenance, S. Chand & Co., 1986.

**v) COURSE PLAN**

| Module | Contents | Hours |
|---|---|---|
| I | Fundamentals of Maintenance Engineering, Maintenance Engineering, Its Importance in Material & Energy Conservation, Inventory Control, Productivity, Safety, Pollution Control, etc. Principle, benefits and effects of maintenance. Inter relationship between productivity, quality, reliability and maintainability. Maintenance productivity. Computer-aided maintenance management system (CMMS) –functions, applications and advantages of CMMS. | 9 |
| II | Types of Maintenance Strategies, Planned and Unplanned Maintenance, Breakdown, Preventive & Predictive Maintenance, Comparison, Advantages & Disadvantages, Total productive maintenance (TPM), TPM and terotechnology, Maintenance Scheduling, Spare Part Management, Inventory Control, Organization of Maintenance Department. Maintenance costs – classification of maintenance costs – maintenance cost analysis – cost effectiveness analysis. | 9 |
| III | Friction Wear and Lubrication, Friction & Wear Mechanisms, Prevention of Wear, Types of Lubrication Mechanisms, Lubrication Processes. Lubricants-Types, General and Special Purpose, Additives, Testing of Lubricants, Degradation of Lubricants, Seal & Packing. Lubricant monitoring – components and techniques – filter debris analysis & filter grams. Ferrography – spectroscopic oil analysis program. | 9 |
| IV | Condition based maintenance and condition monitoring – monitoring systems. Performance monitoring – visual, tactile and aural monitoring – leakage monitoring. Temperature monitoring – thermography – advantages. smell/odour monitoring. Case studies of condition based maintenance (Assignments or Industrial visit only). | 9 |
| V | Reliability centred maintenance (RCM) – steps – flow diagram basic guidelines. Defect and failure – definitions – basics of failures – failure generation – failure analysis. Fault tree analysis (FTA). Failure modes and effects analysis (FMEA). Failure mode effect criticality analysis (FMECA). Measurement of maintenance work: Mean time to repair, Median time to repair, Mean system down time, Mean time to restore. | 9 |
| | **Total** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |

| | | |
|---|---|---|
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23IEL31S | Renewable and Non Conventional Energy Engineering | IEC | 3 | 0 | 0 | 0 | 3 | 2023 |

i) **COURSE OVERVIEW**:

Students will be able to identify and explain various renewable energy sources and their working principles. They will gain an understanding of the design and operation of renewable energy systems and explore their real-world applications. Students will also develop the ability to critically compare different renewable energy technologies and recommend the most appropriate solutions based on technical, environmental, and local conditions.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO 1 | Explain renewable energy sources and their significance in current energy status of our country, working and types of solar energy collectors | Understand |
| CO 2 | Design solar collectors for various heating applications and measurement of solar radiation at a location | Apply |
| CO 3 | Explain the working of different nuclear reactors. | Understand |
| CO 4 | Explain the different types of wind power machines and the working principles | Understand |
| CO 5 | Explain the ocean energy and geothermal energy harnessing technology | Understand |
| CO6 | Explain biomass energy conversion devices and economic analysis of energy production | Understand |

**iii) SYLLABUS**

**The Energy Scenario-** Commercial energy sources -World's production and reserves

India's Production and reserves, Energy Alternatives, Need for alternatives. Solar Energy collectors- Solar thermal collectors -Flat plate collectors –Solar concentrators.

**Wind Energy-** classification of wind turbines and power performance curve, Energy in wind, calculation of energy content, Power coefficients, Betz limit theory, tip speed ratio, the solidity of turbines and power control strategies.

**Nuclear energy** - review of elementary nuclear physics, Boiling water reactor, structural materials, nuclear fuel, Reactor heat removal, Safety, and waste disposal.

**Ocean Energy** – Devices for Wave Energy Conversion, Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation.

**Geothermal energy**- Introduction, hot dry rock resources, magma resources, vapor, and liquid dominated systems, binary cycle, advantages and disadvantages

**Biomass Energy** - Biomass conversion technologies –Bio Gasification, Bioethanol, Biodiesel, Biogas production from waste biomass. Economic Analysis – Initial and annual cost, basic definitions, present worth calculations

**iv) (a) TEXT BOOKS**


1) S P Sukhatme , J K Nayak, Solar Energy: Principles of Thermal Collection and storage Mc Graw Hill ,2015
2) Tiwari G N, Ghosal M K ,Fundamentals of renewable energy sources, Alpha Science International Ltd.,2007
3) Jefferson W Tester et.a., Sustainable Energy Choosing among options,PHI,2006
4) S. Glasstone and A. Sesonske, Nuclear Reactor Engineering, D. Van Nostrand Company, INC. 1967.


**(b) REFERENCES**


1) D.P. Kothari Renewable energy resources and emerging technologies, Prentice Hall of India Pvt. Ltd,2011
2) Mehmet KanoğluYunus A. Çengel John M. Cimbala , Fundamentals and Applications of Renewable Energy, Mc Graw Hill ,2019


## V) COURSE PLAN

| Module | Contents | No. of hours |
|---|---|---|
| I | The Energy Scenario- Commercial energy sources -World's production and reserves- India' Production and reserves, Energy Alternatives, Need for alternatives.<br>Principles of solar radiation : Solar radiation outside the earth's atmosphere and at the earth's surface , Solar Constant, Basic Sun-Earth Angles, Instruments for measuring solar radiation and sunshine , Solar radiation data | 9 |
| II | Solar Energy collectors: Solar thermal collectors -Flat plate collectors –Solar concentrators –Solar Air Heaters, Solar pond. Solar thermal electric power generation -Thermal Energy storage, sensible and latent heat storage, Thermo chemical storage, photovoltaic system for power generation.<br>Elementary nuclear energy: – Nuclear fission. Nuclear chain reactions .Nuclear reactor principles, sub components of nuclear reactor, Reactor classifications –Control and safety features . | 9 |
| III | Wind Energy- classification of wind turbines and power performance curve, Energy in wind, calculation of energy content, Power coefficients, Betz limit theory, tip speed ratio, solidity of turbine' power control strategies, Basic principles of Wind Energy Conversion Systems (WECS), Classification of WECS, Parts of WECS. | 9 |

| | | |
|---|---|---|
| **IV** | Ocean Energy – Devices for Wave Energy conversion, Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation – Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC).<br>Geothermal energy: Introduction, hot dry rock resources, magma resources, vapor and liquid dominated systems, binary cycle, advantages and disadvantages | **9** |
| **V** | BioMass Energy- Biomass conversion technologies –Bio Gasification, Bio ethanol, Biodiesel , Biogas production from waste biomass, factors affecting biogas generation BioGas -KVIC and Janata model<br>Hydrogen Energy – various routes for production of Hydrogen energy.<br>Economic Analysis – Initial and annual cost, basic definitions, present worth calculations, repayment of loan in equal and annual installments, annual savings, cumulative saving and cycle cost. | **9** |
| | **Total** | **45** |

## VI) ASSESSMENT PATTERN

**Continuous Assessment: End Semester Examination – 40 : 60**

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Continuous Assessment Tests (2 Nos) | : | 20 marks |
| **Total Continuous Assessment** | **:** | **40 marks** |
| **End Semester Examination** | **:** | **60 marks** |
| **Total** | **:** | **100 marks** |

## VII) CONTINUOUS ASSESMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

## VII) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23IEL31T | Sports Engineering and Management | IEC | 3 | 0 | 0 | 0 | 3 | 2023 |

## i) COURSE OVERVIEW

This course will help understand the world of Sports Engineering and Management in depth through various examples, current technologies, and real-life case studies.

## ii COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | Course Outcomes | Learning Level |
|---|---|---|
| CO 1 | Explain concepts of sports engineering | Understand |
| CO 2 | Explain the scope of Emotion control and psychology in sports | Understand |
| CO 3 | Apply Data Capturing Techniques in Sports Sciences | Apply |
| CO 4 | Explain the role of Engineering Design in Sports | Understand |
| CO5 | Explain the concepts of Sports Marketing | Understand |

## ii SYLLABUS

**Introduction Sports Engineering:** -Introduction to Sports Engineering, Motion Analysis & Forces in Sport (Biomechanics), Human Movement and Injury Prevention, Equipment Design & Materials Innovation, Introduction to wearable devices and Data Tools.

**Emotion and sports Psychology** - Introduction to Sports Psychology- Motivation: Meaning, Types, Theories (Drive Theory, Achievement Motivation, etc.). Anxiety: Definition, Types, and Impact on Performance- Exercise, Well-being & Mental Health, Developing a Champion Mindset, Role & Challenges of Sports Psychologists.

**Data Capturing Techniques in sports science:** Introduction to Wearable Technologies, Type of devices, Information processing Decision making using data analysis on performance, injury, engagement, tools used for data collection – cameras, sensors, GPS trackers etc. Case examples.

**Sports Engineering design:** Introduction to Sports Product designs and Human-Cantered Design in Sport, Design Tools and Techniques, Materials in Sports Products,

Basics of Sports Science- Anatomy and physiology related to sports performance. Kinematics and kinetics in sports movements.

**Sports Marketing & Merchandising:** fundamentals of sports marketing, including the 4/5 Ps of marketing, consumer behaviour, branding, sponsorship, digital marketing, and merchandising strategies, along with the practical application of these concepts in the sports industry.

**iv a) TEXTBOOKS**

1. Weinberg, R. S. & Gould, D. (2007). Foundations of Sport and Exercise Psychology. U.S.A.: Human Kinetics.
2. Bowers, J.E., & Sinclair, P.J. (2020). *Sports Materials and Technology*. Cambridge: Woodhead Publishing
3. Fujii, K. (2025). *Machine Learning in Sports: Open Approach for Next Play Analytics*. Springer Singapore.
4. (Eds.). (2025). *Recent Trends in Sports Engineering: Select Proceedings of ICSE 2023*. Springer Singapore.

**b) REFERENCES**

1. Fuss, F.K., Subic, A., & Mehta, R. (2018). *Routledge Handbook of Sports Technology and Engineering*. London: Routledge.
2. Morgan, C. (2017). Introduction to Psychology. McGraw Hill Education
Harper, K. (2017). *Design and Innovation in Sports Engineering*. London: Springer.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| **I** | **Introduction Sports Engineering:** -Introduction to Sports Engineering, Motion Analysis & Forces in Sport (Biomechanics), Human Movement and Injury Prevention, Equipment Design & Materials Innovation, Introduction to wearable devices and Data Tools. | **9** |
| **II** | **Emotion and sports Psychology** - Introduction to Sports Psychology- Motivation: Meaning, Types, Theories (Drive Theory, Achievement Motivation, etc.). Anxiety: Definition, Types, and Impact on Performance- Exercise, Well-being & Mental Health, Developing a Champion Mindset, Role & Challenges of Sports Psychologists. | **9** |
| **III** | **Data Capturing Techniques in sports science:** Introduction to Wearable Technologies, Type of devices, Information processing Decision making using data analysis on performance, injury, engagement, tools used for data collection – cameras, sensors, GPS trackers etc. Case examples. | **9** |
| **IV** | **Sports Engineering design::** Introduction to Sports Product designs and Human-Centered Design in Sport , Design Tools and Techniques, Materials in Sports Products, Basics of Sports Science- Anatomy and physiology related to sports performance. Kinematics and kinetics in | **9** |

| | | |
|---|---|---|
| | sports movements. | |
| **V** | **Sports Marketing & Merchandising:** fundamentals of sports marketing, including the 4/5 Ps of marketing, consumer behaviour, branding, sponsorship, digital marketing, and merchandising strategies, Understanding sports distribution and media promotion mix for sports events, along with the practical application of these concepts in the sports industry. Sports sector in India and around the world. Globalization of sports product. | **9** |
| | **TOTAL** | **45** |

**vi) CONTINUOUS ASSESMENT EVALUATION PATTERN**

| | | |
|---|---|---|
| Attendance | : | **5 marks** |
| Continuous Assessment Tests (2 Nos) | : | **20 marks** |
| Assignments/Project/Case study etc. | : | **15 marks** |
| **Total** | : | **40 marks** |

**vii) CONTINUOUS ASSESMENT EXAMINATION PATTERN**

**Two tests** of **30 marks each** (2.5 modules to be covered in each exam)

Duration – **1.5 hours**

**viii) END SEMESTER EXAMINATION PATTERN**

- Maximum Marks: 60
- Exam Duration: 3 hours

# BASKET 2 INSTITUTE ELECTIVES

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of introduction |
|---|---|---|---|---|---|---|---|---|
| 23IEL42Q | INDUSTRIAL ENGINEERING | IEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**

The objective of this course is to understand the concepts related to work place design and inventory planning for improving productivity. The course also intends to familiarize the logistics, supply chain and scheduling problems of the production process.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Explain the principle and concepts of Industrial management | Understand |
| CO2 | Explain importance of work place design and ergonomics for improving productivity. | Understand |
| CO3 | Explain the inventory planning and material handling techniques | Understand |
| CO4 | Explain the logistics system and decision making in supply chain network. | Understand |
| CO5 | Solve scheduling machine problems during production. | Apply |

**iii) SYLLABUS**

**Principles of Industrial Management :** Role of Industrial Engineering in organisations, Industrial Engineering in the modern world, principles of management, management functions, Industrial ownership, different scales and levels of industries.

**Introduction to Human factors and Ergonomics** –Ergonomics and productivity. Design of cognitive work . Engineering anthropometry. Work-space design . Work environment design, Work rest scheduling. Workplace and systems safety.

**Inventory planning** -Inventory costs, types of warehouses, warehousing functions. Material handling -selection of material handling equipments. Packaging materials, Control of Stock Levels Forecasting techniques in relation to demand and lead times, Materials requirements planning (MRP) and Manufacturing resource planning (MRPII)

**Introduction to logistics management** - Role of logistics in the Supply chain - Logistics & customer service, Role of logistics in competitive strategy, Logistics organization & performance measurement, Reverse logistics,application of IT in logistics- automatic identification technologies- Logistics outsourcing 3PL & 4PL, Global logistics

**Scheduling -**Single machine models - Scheduling function and theory – scheduling problem,SPT, EDD sequence ,Parallel machine models -

Independent jobs .Flow shop models -Johnson's problem – Extension of Johnsons's rule for 3 machineproblem ,Palmer's method.Job shop models . Branch and Bound method – Scheduling of continuous production –Line balancing.

**iv) a) TEXTBOOKS**

1. A Bhatia, Industrial Engineering and Operations Management, S.K. Kataria & Sons Company Limited
2. Sunil Chopra and Peter Meindl, SUPPLY CHAIN MANAGEMENT – STRATEGY, PLANNING AND OPERATION, PHI, 4th Edition, 2010

**b) REFERENCES**

1. Philip E. Hicks, Introduction to Industrial engineering and Management Science, McGraw Hill.
2. Gavriel Salvendy, Hand Book of Industrial Engineering & Management, John Willey & Sons Prentice-Hall

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Principles of Industrial Management :**Application and role of Industrial Engineering in organisations, Industrial Engineering in the modern world, principles of management, management functions, Industrial ownership:Introduction, types of ownership, partnership, joint stock company, private limited company, public limited company, public sector and private sector, different scales and levels of industries | 9 |
| II | **Introduction to Human factors and Ergonomics** – Ergonomics, work and health, Ergonomics and productivity .Design of cognitive work – information theory – human information processing , Engineering anthropometry. Work-space design – Principles of work design – workplace, machines, tools and equipment, design for standing and seated workers. Work environment design – working conditions . Stress,fatigue and work environment – Work rest scheduling. Workplace and systems safety, Occupational Safety and Health Administration | 9 |
| III | **Inventory planning**- Inventory costs, classifying inventory, types of warehouses, warehousing functions, warehouse layout & design. Material handling -objectives, guidelines & principles,selection of material handling equipments. Packaging-role of packaging, packaging materials,material handling efficiency. Role of and function in | 11 |

| | | |
|---|---|---|
| | determining stock range, Control of StockLevels Forecasting techniques in relation to demand and lead times; Independent demand<br>situations and the use of fixed order quantity and periodic review systems; Materials requirements planning (MRP) and manufacturing resource planning (MRPII) | |
| IV | **Introduction to logistics management-** Definition, scope, functions, objectives – Integrated logistics management, role of logistics in the Supply chain - Logistics & customer service, Role of logistics in competitive strategy, Logistics organization & performance measurement, Reverse logistics- scope, design, e-logistics- application of IT in logistics- automatic identification technologies- bar coding, RFID, Logistics outsourcing3PL & 4PL, Global logistics- operational & strategic issues. | 7 |
| V | **Scheduling -**Single machine models - Scheduling function and theory – scheduling problem: objectives,constraints – SPT, EDD sequence – minimization of mean flow time, mean tardiness etc –Parallel machine models - Independent jobs Minimizing makespan.Flow shop models -<br>Johnson's problem – Extension of Johnsons's rule for 3 machineproblem ,Palmer's method.Job shop models . Branch and Bound method – Scheduling of continuous production –Line balancing. | 9 |
| | **Total** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40 : 60

| **Continuous Assessment** | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**viii CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23IEL42R | Sustainable Manufacturing | IEC | 3 | 0 | 0 | 0 | 3 | 2023 |

## i) COURSE OVERVIEW

The objective of this course is to introduce the concept of sustainable manufacturing. This course also intends to enable them to interpret on the impact of various decisions on sustainability.

## ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | Course Outcomes | Learning Level |
|---|---|---|
| CO 1 | Explain the importance of economic sustainability and sustainable practices. | Understand |
| CO 2 | Demonstrate various barriers and strategies to overcome in sustainable manufacturing. | Understand |
| CO 3 | Explain about social sustainability and work management. | Understand |
| CO4 | Explain about various principles of sustainable operations. | Understand |
| CO5 | Build sustainability practices and awareness referring to various case studies. | Apply |

## iii) SYLLABUS

**ECONOMIC SUSTAINABILITY:** Industrial Revolution-Economic sustainability: globalization and international issues Sustainability status

**SOCIAL AND ENVIRONMENTAL SUSTAINABILITY**. Social sustainability – Introduction-Work management -Human rights - Societal commitment -Customers -Business practices -Modelling and assessing social sustainability

**SUSTAINABILITY PRACTICES** Sustainability awareness - Measuring Industry Awareness-Drivers and barriers -Availability of sustainability indicators -Analysis of sustainability practicing

**MANUFACTURING STRATEGY FOR SUSTAINABILITY**. Concepts of competitive strategy and manufacturing strategies and development of a strategic improvement programme - Manufacturing strategy in business success strategy formation and formulation

**TRENDS IN SUSTAINABLE OPERATIONS**. Principles of sustainable operations - Life cycle assessment manufacturing and service activities - Influence of product design on operations.

## iv) a) TEXTBOOKS

1. Davim J.P., “Sustainable Manufacturing”, John Wiley & Sons., United States, 2010, ISBN: 978-1-848-21212-1.

2. Ibrahim Garbie, “Sustainability in Manufacturing Enterprises Concepts, Analyses and Assessments for Industry 4.0”, Springer International Publishing., United States, 2016, ISBN-13: 978-3319293042.

**b) REFERENCES**

1. Jovane F., Ęmper, W.E. and Williams, D.J., “The ManuFuture Road: Towards Competitive and Sustainable High-Adding-Value Manufacturing”, Springer,2009, United States, ISBN 978-3-540-77011-4.
2. Kutz M., “Environmentally Conscious Mechanical Design”, John Wiley & Sons., United States, 2007, ISBN: 978-0-471-72636-4.

## v) COURSE PLAN

| Module | Contents | Hours |
|---|---|---|
| I | Industrial Revolution-Economic sustainability: globalization and international issues Sustainability status - Emerging issues- Innovative products- Reconfiguration manufacturing enterprises - Competitive manufacturing strategies - Performance evaluation- Management for sustainability -Assessments of economic sustainability | 9 |
| II | Social sustainability – Introduction-Work management -Human rights - Societal commitment -Customers -Business practices -Modelling and assessing social sustainability. Environmental issues pertaining to the manufacturing sector: Pollution - Use of resources - Pressure to reduce costs - Environmental management: Processes that minimize negative environmental impacts - environmental legislation and energy costs - need to reduce the carbon footprint of manufacturing Operations-Modelling and assessing environmental sustainability | 9 |
| III | Sustainability awareness - Measuring Industry Awareness-Drivers and barriers -Availability of sustainability indicators -Analysis of sustainability practicing -Modelling and assessment of sustainable practicing - Sustainability awareness -Sustainability drivers and barriers - Availability of sustainability indicators- Designing questionnaires- Optimizing Sustainability Indexes-Elements –Cost and time model. Case studies of sustainability practicing. | 9 |
| IV | Concepts of competitive strategy and manufacturing strategies, development of a strategic improvement programme - Manufacturing strategy in business success strategy formation and formulation - Structured strategy formulation - Sustainable manufacturing system design options - Approaches to strategy formulation - Realization of new strategies/system designs | 9 |
| V | Principles of sustainable operations - Life cycle assessment manufacturing and service activities - Influence of product design on operations - Process analysis - Capacity management - Quality management -Inventory management - Just-In-Time systems - Resource efficient design - Consumerism and sustainable well-being. | 9 |
| | **Total** | **45** |

## vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

## vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

## viii) END SEMESTER EXAMINATION

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23IEL42S | Marketing Management for Engineers | IEC | 3 | 0 | 0 | 0 | 3 | 2023 |

## i) COURSE OVERVIEW

The course aims at introducing the basic concepts of marketing to the undergraduate students in engineering. The learning shall help the students in better designing, manufacturing and selling product/ service packages keeping competitive market, customers and cost in view.

## ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | Course Outcomes | Learning Level |
|---|---|---|
| CO 1 | Explain the concept and processes in marketing management. | Understand |
| CO 2 | Explain the bases of segmenting consumers and aspects of demand forecasting. | Understand |
| CO 3 | Explain the objectives, factors and strategies associated with pricing decisions. | Understand |
| CO4 | Explain the concepts of marketing communication, advertising, sales promotion and promotion mix. | Understand |
| CO5 | Apply marketing management principles and strategies to a specific project or product. | Apply |

## iii) SYLLABUS

Introduction: Marketing Management: Concept, Process, Functions and relevance in the current context Market Segmentation, Targeting and Positioning. Pricing Decision: Objectives and Factors influencing pricing, Pricing method and strategies. Trends in Marketing: Green Marketing, Customer Relationship Management Integrated Marketing Communication(IMC)-Concept of IMC, the marketing communication process, Promotion Mix.

## iv) a) TEXTBOOKS

1. Etzel , Walker ,Stanton and Pandit, Marketing, 14/e, Tata McGraw Hill.
2. Saxena, “Marketing Management” Tata McGraw Hill, 4/e.

## b) REFERENCES

1. Grewal, Levy, „Marketing“ Tata McGraw Hill, special Indian edition
2. Kotler, Keller, Koshy and Jha, “Marketing Management”, 13/e, Pearson Education

## v) COURSE PLAN

| Module | Contents | Hours |
|---|---|---|
| I | Introduction to marketing - concept of market and marketing – marketing environment - controllable factors - factors directed by top management - factors directed by marketing - uncontrollable factors - demography, economic conditions, competition. Social and Marketing planning - marketing planning process - Boston consultancy group model | 9 |
| II | marketing mix - marketing mix variables. Developing, testing and launching of new products. Market segmentation and market targeting - introduction to segmentation - targeting and product positioning. Marketing research - need and scope - marketing research process – research objectives, developing research plan, collecting information, analysis, and findings | 9 |
| III | Consumer behaviour - factors influencing consumer behaviour - perceived risks Product life cycle - marketing strategies for different stages of product life cycle. Marketing communication - marketing mix variables - steps in developing effective communication - identification of target audience - determination of communication objectives | 9 |
| IV | Designing the message - selecting the communication channels - promotion mix evaluation. Product Pricing and Marketing Research: Objectives, pricing, decisions and pricing methods, pricing management. Introduction, uses, process of marketing research. New trends in marketing- Brand management - significance of branding to consumers and firms. | 9 |
| V | Advertising Sales Promotion and Distribution: Characteristics, impact, goals, types, and sales promotions – point of purchase – unique selling proposition. Characteristics, wholesaling, retailing, channel design, logistics, and modern trends in retailing. Marketing Planning and Strategy Formulation: Components of marketing plan-strategy formulations and the marketing process, implementations, portfolio analysis | 9 |
| | **Total** | **45** |

## vi) ASSESSMENT PATTERN

Continuous Assessment : End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

## vii) CONTINUOUS ASSESSMENT TEST

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|---|
| 23IEL42T | Alternate Fuels | IEC | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**:

The aim of the course is to impart the knowledge about application of alternative fuels in Internal combustion engines. The course also intends to familiarise the methods of production of Bio gas, methanol, ethanol, Bio diesel and various aspects of electrical and Hybrid vehicles.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | Course Outcomes | Learning Level |
|---|---|---|
| CO 1 | Analyse the various aspects and parameters of fuels for Internal combustion engine. | Apply |
| CO 2 | Explain the need of alternate fuels in internal combustion engines. | Understand |
| CO 3 | Explain various properties, sources, methods of production of methanol, ethanol and Bio diesel. | Understand |
| CO 4 | Explain the sources, method of production and use of hydrogen as alternative fuels for internal combustion engine. | Understand |
| CO 5 | Explain the various aspects of fuel cells, electrical and hybrid vehicles. | Understand |

**iii) SYLLABUS**

**Introduction:** Working process of I.C. Engine. Various parameters related to properties of different types of fuel: Rating of fuel, Air / Fuel ratio, Calorific Value, Fuel efficiency, Fuel requirement, Engine efficiency and Engine life. Sources of fossil fuel, scope of availability of fossil fuel in future.

**Need for Alternative Fuels**: Effects of constituents of Exhaust gas emission on environmental condition of earth. Pollution created by Exhaust gas emission in atmosphere. Greenhouse effect, Factors affecting greenhouse effect. Global Carbon Budget, Carbon foot print and Carbon credit. Bharat stages emission standards.

**Alcohol**: Sources of Methanol and Ethanol, methods of production. Properties of methanol & ethanol as engine fuels, Use of alcohols in S.I. and C.I. engines. **Bio Diesels**: Base materials used for production of Bio Diesel, Process of separation of Bio Diesel. Properties of Diesel blended with bio diesel.

**Hydrogen** as a substitute fuel. Properties, Sources and methods of Production of Hydrogen, Storage and Transportation of hydrogen. Application and Advantages of hydrogen as fuel for IC engine/ hydrogen car. Layout of a hydrogen car.

**Fuel Cells:** Concept of cells based on usage of Hydrogen and Methanol. Power rating. Layout of fuel cell vehicle. **Electric & Hybrid Vehicles**: Layout of an electric vehicles,

advantages & limitations. Systems components, electronic controlled systems, high energy and power density batteries. Types of hybrid vehicles.

**(a) TEXT BOOKS**

1) Anand Krishnasamy, Saurabh K Gupta, *Alternate fuels for IC engines*, McGraw Hill Education, 1st Edition, 2024.
2) SS. Thipse*, Alternate Fuels*, Jaico Publishing House; First Edition, 2010.

**(b) REFERENCES**

1) Richard L. Bechtold, *Alternate Fuels Guide Book*, SAE International.
2) John B Heywood., *Internal Combustion Engine Fundamentals*, McGraw Hill Education, 1st Edition, 2017.
3) V. Ganesan, *Internal Combustion Engines*, Mc Graw Hill Education, 4th Edition, 2012.

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | **Introduction:** Working process of I.C. Engine. Various parameters related to properties of different types of fuel: Rating of fuel, Air / Fuel ratio, Calorific Value, Fuel efficiency, Fuel requirement, Engine efficiency and Engine life. Sources of fossil fuel, scope of availability of fossil fuel in future. | 9 |
| II | **Need for Alternative Fuels:** Effects of constituents of Exhaust gas emission on environmental condition of earth ($N_2$ , $CO_2$, CO, NOx, $SO_2$, $O_2$) Pollution created by Exhaust gas emission in atmosphere. Green house effect, Factors affecting green house effect. Study of Global Carbon Budget, Carbon foot print and Carbon credit calculations. Emission norms as per Bharat Standard upto BS – VI. | 9 |
| III | **Alcohols:** Sources of Methanol and Ethanol, methods of it's production. Properties of methanol & ethanol as engine fuels, Use of alcohols in S.I. and C.I. engines, performance of blending methanol with gasoline. Emulsification of alcohol and diesel.<br>**Biodiesel:** Base materials used for production of Bio Diesel (Karanji oil, Neemoil, Sunflower oil, Soyabeen oil, Musturd oil, Palm oil, Jatropha seeds). Process of separation of Bio Diesel. Properties Diesel blended with vegetable oil, and difference in performance of Engine. Various Vegetable oils for Engines – Esterification – Performance and emission characteristics. | 9 |
| IV | **Hydrogen:** Hydrogen as a substitute fuel. Study Properties, Sources and methods of Production of Hydrogen, Storage and Transportation of hydrogen. Also, the economics of Application and Advantages of hydrogen (Liquid hydrogen) as fuel for IC engine/ hydrogen car. Layout of a hydrogen car. | 9 |
| V | **Fuel Cells**: Concept of fuel cells based on usage of Hydrogen and Methanol. Power rating, and performance. Heat dissipation, Layout of fuel cell vehicle. **Electric & Hybrid Vehicles**: Layout of an electric vehicles, advantages & limitations. Systems components, electronic controlled systems, high energy and power density batteries. Types of hybrid vehicles. | 9 |

| | | |
|---|---|---|
| | **Total** | **45** |

**VI) ASSESSMENT PATTERN**

**Continuous Assessment: End Semester Examination – 40 : 60**

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Continuous Assessment Tests (2 Nos) | : | 20 marks |
| **Total Continuous Assessment** | **:** | **40 marks** |
| **End Semester Examination** | **:** | **60 marks** |
| **Total** | **:** | **100 marks** |

**VII) CONTINUOUS ASSESMENT TEST**

- No. of tests: 02
- Maximum Marks: 30
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**VII) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours