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. 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. 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). 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 Hydrogen Energy – various routes for production of Hydrogen energy. 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 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 - 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. **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