BMS INSTITUTE OF TECHNOLOGY AND MANAGEMENT

(Autonomous Institute affiliated to VTU, Belagavi, Approved by AICTE New Delhi)

Yelahanka, Bengaluru 560064

Bachelor of Engineering

Department of Mechanical Engineering

VII Semester Scheme and Syllabus

2021 Scheme

Effective from the AY 2024-25

Approved in the BoS meeting held on 12.07.2024

Vision and Mission of the Department

Vision

- To develop technically competent Mechanical Engineering professionals for the benefit of the society

Mission

- Impart quality education in Mechanical Engineering and allied areas by state- of- the- art- infrastructure and dedicated faculty.
- Provide conducive environment for both students and faculty to pursue higher education & research and to work ethically for the benefit of society.

Program Educational Objectives (PEOs)

1. Be successful professionals in the field of Mechanical Engineering and allied areas
2. Exhibit skills to work effectively and ethically in multiple domains of engineering as part of a team
3. Excel in higher studies, research and adapt in a world of constantly developing technology

Program Specific Outcomes (PSOs)

1. Design, Analyze and fabricate the mechanisms.
2. Analyze the fluid and thermal aspects of different mechanical systems and components.
3. Develop materials and components through different manufacturing methods with managerial skills.

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BMS Institute of Technology and Management
(An Autonomous Institution, Affiliated to VTU Belagavi)
Avalahalli, Doddaballapur Main Road, Bengaluru, Karnataka – 560064

Ref.: BMSIT&M/Exam/2023-24/ 103 **Date:** 21.09.2024

CONTINUOUS INTERNAL EVALUATION
AND
SEMESTER END EXAMINATION PATTERN
(Applicable to UG students of 2021 Batch, effective from the Academic year 2024-25 onwards)

The UG students admitted during 2021-22 are hereby informed to note the following with reference to Continuous Internal Evaluation and Semester End Examination pattern:

The weightage for Continuous Internal Evaluation (CIE) is 50%, and for Semester End Examinations (SEE), it is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 out of 50), while for the SEE, the minimum passing mark is 35% of the maximum marks (18 out of 50). A student will be declared to have passed the course if they secure at least 40% (40 out of 100) in the combined total of the CIE and SEE.

The details below summarize the CIE and SEE Pattern for the courses of 2021 scheme of various credits:

4 CREDIT COURSES

I. CONTINUOUS INTERNAL EVALUATION (CIE): 50 MARKS

- **Internal Assessment (IA) Tests:** 2 IAs to be conducted for **40 Marks** (90 minutes each). Total of 2 tests will be 80 and the same can be scale down to **30 Marks.**
- **Alternate Assessment Tool (AAT):** 2 AATs each of **10 Marks**, total **20 Marks.** Any Two AATs can be used from the list. If it is project based, one AAT shall be given.
- **Total CIE Marks** = 30 + 20 = **50 Marks**
- Student has to score a minimum of **20 Marks** (40%).

II. SEMESTER END EXAMINATIONS (SEE): 50 MARKS

- SEE is conducted for 100 Marks (3 hours).
- **Question Paper Pattern:**
  - **Part - A:** Comprises 20 objective type questions carrying 1 Mark each with a total 20 Marks.
  - **Part - B:** There will be **5 modules**. Each module will have **TWO questions carrying 16 marks** each. There will be a maximum of three sub section for each question. **Student has to answer any ONE full question.**

- **SEE Marks = 20 + 80 = 100 marks and can be scale down to 50 marks.**

3 CREDIT COURSES

I. CONTINUOUS INTERNAL EVALUATION (CIE): 50 MARKS

- **Internal Assessment (IA) Tests:** 2 IAs to be conducted for **40 Marks** (90 minutes each). Total of 2 tests will be 80 and the same can be scale down to **30 Marks.**
- **Alternate Assessment Tool (AAT):** 2 AATs each of **10 Marks**, total **20 Marks.** Any Two AATs can be used from the list. If it is project based, one AAT shall be given.
- **Total CIE Marks** = 30 + 20 = **50 Marks**
- Student has to score a minimum of **20 Marks** (40%).

II. SEMESTER END EXAMINATIONS (SEE): 50 MARKS

- SEE is conducted for 100 Marks (3 hours).
- **Question Paper Pattern:**
  - **Part - A:** Comprises 20 objective type questions carrying 1 Mark each with a total 20 Marks.
  - **Part - B:** There will be **5 modules**. Each module will have **TWO questions carrying 16 marks** each. There will be a maximum of three sub section for each question. **Student has to answer any ONE full question.**

- **SEE Marks = 20 + 80 = 100 marks and can be scale down to 50 marks.**

2 CREDIT COURSES

I. CONTINUOUS INTERNAL EVALUATION (CIE): 50 MARKS

- Internal Assessment (IA) Tests: 2 IAs of MCQ type to be conducted for 40 Marks (60 minutes each). Total of 2 tests will be 80 and the same can be scale down to **30 marks.**
- **Alternate Assessment Tool (AAT):** 2 AATs each of 10 marks, total **20 marks.** Any Two AATs can be used from the list. If it is project based, one AAT shall be given.
- **Total CIE Marks** = 30 + 20 = **50 Marks**
- Student has to score a minimum of 20 marks (40%).

II. SEMESTER END EXAMINATIONS (SEE): 50 MARKS

SEE is conducted for 100 Marks (2 hours).

Question Paper Pattern:

- The pattern of the question paper is MCQ.
- SEE question paper will be set for 100 questions each of 01 marks. The same is scale down to 50 marks. Minimum SEE Marks: 40% (i.e. 20 Marks out of 50)

1 CREDIT COURSES

I. CONTINUOUS INTERNAL EVALUATION (CIE): 50 MARKS

- **Internal Assessment (IA) Tests:** 2 IAs of MCQ type to be conducted for 40 Marks (60 minutes each). Total of 2 tests will be 80 and the same can be scale down to **30 marks.**
- **Alternate Assessment Tool (AAT):** 2 AATs each of 10 marks, total **20 marks.** Any Two AATs can be used from the list. If it is project based, one AAT shall be given.
- **Total CIE marks** = 30 + 20 = **50 Marks**
- Student has to score a minimum of **20 Marks** (40%).

II. SEMESTER END EXAMINATIONS (SEE): 50 MARKS

- SEE is conducted for **50 Marks** (1 hours).
- **Question Paper Pattern:**
  - The pattern of the question paper is MCQ.
  - SEE question paper will be set for 50 questions each of 01marks. The same is scale down to **50 Marks**.

1 CREDIT LABORATORY COURSE / PROFESSIONAL CORE LABORATORY / ABILITY ENHANCEMENT COURSE

I. CONTINUOUS INTERNAL EVALUATION (CIE): 50 MARKS

- **Cumulative Assessment (CA)** of each experiment is 20 Marks (Conduction 10 marks + Records 5 marks +Viva 5marks). The average of all the experiments to be taken for **20 Marks.**
- **Open Ended Experiments (OE) 10 Marks.**
- **2 IAs Test** to be conducted for 100 marks. General rubrics suggested for SEE are: Writeup 20 marks, Conduction of the experiments, calculations, graphs, results, etc.: 60 marks and Viva: 20 marks. The average of 2 IA marks is scale down to **20 Marks**.
- **CIE marks** =20 (CA) +10 (OE) + 20 (IA test) = **50 Marks**.
- Student has to score a minimum of **20 Marks** (40%).

II. SEMESTER END EXAMINATIONS (SEE): 50 MARKS

- SEE is conducted for 100 Marks.
- Examinations to be conducted jointly by Two examiners.
- All the experiments are to be included for practical examination.
- General rubrics suggested for SEE are: Writeup 20 marks, Conduction of the experiments, calculations, graphs, results, etc.,: 60 marks and Viva: 20 marks.

Learning Activities for AATs:

A faculty member may choose the following AATs based on the needs of the course:

1. Course project
2. Literature review
3. MOOC
4. Case studies
5. Tool exploration
6. GATE-based aptitude test
7. Open book tests
8. Industry integrated learning
9. Analysis of Industry / Technical / Business reports
10. Programming assignments with higher Bloom level
11. Group discussions
12. Industrial / Social / Rural projects

CoE 21/09/2024

Dean AA 21.09.24

Principal 21/9/2024

Copy To:

1. The Vice-Principal, Deans, HoDs, and Associate HoDs
2. All faculty members and students of 2021 batch.
3. Examination Section

BMS INSTITUTE OF TECHNOLOGY & MANAGEMENT

(Autonomous Institution Affiliated to VTU, Belagavi)

B. E. in Mechanical Engineering

Scheme of Teaching and Examinations – 2021 Scheme

Outcome-Based Education (OBE) and Choice Based Credit System (CBCS)

VII Semester

Sl. No.	Course Category	Course Code	Course Title	Teaching Department (TD) and Question Paper Setting Board (PSB)	Credits Distribution				Examination				Contact Hours/week
					L	T	P	Total	CIE Marks	SEE Marks	Total Marks	SEE Duration (H)	
1	HSMC	21HSS71	Research Methodology	TD: ME PSB: ME	2	0	0	2	50	50	100	3	2
2	PCCL	21MEL72	Internet of Things(IoT) Lab		0	0	2	1	50	50	100	3	2
3	PEC	21ME73X	Professional Elective – III		3	0	0	3	50	50	100	3	3
4	PEC	21ME74X	Professional Elective – IV		3	0	0	3	50	50	100	3	3
5	OE	21ME75X	Open Elective		3	0	0	3	50	50	100	3	3
6	PW	21MEP76	Project Work Phase-1		0	0	10	5	100	--	100	3	10
TOTAL								**17**	**350**	**250**	**600**	-	23

HSMC: Humanities, Social Sciences and Management Course, **PCC**: Professional Core Courses, **PCCL**: Professional Core Course laboratory, **PEC:** Professional Elective Course, **PW:** Project Work, **AEC**: Ability Enhancement Course, **MC:** Mandatory Course, **NCMC**: Non-Credit Mandatory Course, **L:** Lecture, **T**: Tutorial, **P**: Practical, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Evaluation.

Professional Elective Course– III

Course Code	Course Name	Course Code	Course Name
21ME731	Design for Manufacturing	21ME732	Fluid Power Systems
21ME733	Electric Vehicle Technology	21ME734	Composite Materials Technology
21ME735	Automation in Manufacturing	21ME736	Combustion in IC Engines

Professional Elective Course – IV

Course Code	Course Name	Course Code	Course Name
21ME741	Product Design & Manufacturing	21ME742	Operations Research
21ME743	Energy Storage Systems	21ME744	Additive Manufacturing Technology
21ME745	Control Engineering	21ME746	Smart Materials and Structures

Open Elective – II

Course Code	Course Name	Course Code	Course Name
21ME751	Innovative Product Development	21ME752	Fundamentals of Automotive Technology
21ME753	Smart Manufacturing	21HSS71	Organisational Behaviou
21ME755	Energy Engineering		

BMS Institute of Technology and Management
B.E MECHANICAL ENIGINEERING
Choice Based Credit System (CBCS)
(Humanity Science)

Research Methodology (2:0:0) 2
Common to all Branches
(Effective from the academic year 2024-25 for 2021 Scheme)

Course Code	**21HSS71**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**2:0:0**	CIE Marks	**50**
Total Number of Lecture Hours	**26**	SEE Marks	**50**
Examination Nature	**MCQ**	Exam Hours	**02**

Course Objectives:

This course will enable students to

1. Give an overview of the research methodology, research problem.
2. Gain knowledge on research design.
3. Design of sampling survey and measurement & scaling.
4. Understand data collection and data preparation.
5. Familiarize interpretation and writing research reports.

Module – 1

Introduction: Importance of Research and Development (R&D) for development of Nation, Introduction to research and research methodology.
Meaning of Research, objectives of Research, Types of research, Research Approaches, Significances of Research, Research Process, Criteria of Good Research.

Defining the Research Problem: What is a Research Problem? Selecting the Research Problem, Necessity of Defining the Problem, Techniques Involved in Defining a problem. **(06 Hours)**

Module – 2

Research Design: Meaning of Research Design, need for Research design, Feature of a Good design, Important concepts relating to Research Design: Dependent, independent and extraneous variable, Control, Confounded relationship. Research Design in case of exploratory research studies, in case of descriptive and diagnostic research studies Basic Principles of Experimental Designs.

(05 Hours)

Module – 3

Design of sampling survey: Sample Design: Objective, sampling units and frame, size of sample, parameter of interest, selection of proper sample design, pilot survey and budgetary constraints. Sampling errors, non-sampling errors, Sample survey vs. census survey, on-probability samplings.

Measurement and scaling: Quantitative and qualitative data, Classification of measurement scales. Goodness of measurement scales: Techniques of developing measurement tools, scaling, Scale classification bases, scaling techniques. **(05 Hours)**

Module – 4

Data Collection: Experiments and Surveys, collection of primary data: observation method, Interview method. Collection of data through questionnaires, Collection of data through schedules. Collection of secondary data. Selection of appropriate method for data collection, case study method.

Data Preparation: Questionnaire checking, editing, coding, tabulation, data cleaning, data adjusting, problems in preparation process, missing values and outliers, type of analysis.

(05 Hours)

Module – 5

Interpretation and Report Writing

Meaning of Interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of Research Report, Types of Reports: Technical report, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research. **(05 Hours)**

Course outcomes:

The students will be able to:

CO1: Describe research methodology and research problem.
CO2: Illustrate research design and various types.
CO3: Discuss sampling survey and measurement.
CO4: Summarise data collection and preparation.
CO5: Explain techniques of interpret research reports.

Text Book:

1. CR Kothari and Gaurav Garg, Research Methodology, New Age International Publishers, 2020.

References:

1. Panneerselvam R, Research Methodology, Prentice Hall of India, New Delhi, 2004.
2. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U K, An introduction to Research Methodology, RBSA Publishers, 2002**.**
3. Ranjit Kumar, Research Methodology, 4th Edition, SAGE Publications Ltd. 2014.

B.E MECHANICAL ENIGINEERING
Choice Based Credit System (CBCS)
Ability Enhancement Course

Internet of Things (IoT) Lab (0:0:1) 1
(Effective from the academic year 2021-2022)

Course Code	**21MEL72**	Semester	**VII**
Teaching Hours/Week (L: T:P: S)	0:0:1	CIE Marks	50
Total Hours of Pedagogy	24	SEE Marks	50
Credits	01	Total Marks	100
Examination Pattern (SEE)	**Practical**	Exam Hours	03

Course Objectives: Students will be able to

1. Acquire basic knowledge on Internet of Things
2. Gain hands-on exposure on physical computing devices, sensors and actuators.
3. Practice the process of connecting things to internet and exchange data and information.

Preamble:

Internet of things (IoT) is the network of physical objects, devices, vehicles, buildings and other items embedded with electronics, software, sensors and network connectivity that enables these objects to collect and exchange data. The IoT allows to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer. This course is intended to equip students with basic theory and hands-on experience with embedded system, sensors and actuators which are part of an IoT system.

List of Experiments

Following experiments to be conducted by individual student:

1. Interfacing the RGB LED with the Arduino
2. Controlling the LED blink rate with the potentiometer interfacing with Arduino
3. Interfacing of temperature sensor LM35 with Arduino
4. Interfacing Servo Motor with the Arduino
5. Interfacing of the relay with Arduino
6. Building Intrusion Detection System with Arduino and Ultrasonic Sensor
7. Directional Control of the DC motor using Arduino
8. Upload humidity & temperature data to Thing Speak, periodically logging ambient light level to Thing Speak
9. Displaying various sensor readings on a simple web page hosted on the ESP32
10. Controlling LEDs/Motors from an Android/Web app, Controlling AC Appliances from an android/web app with the help of relay.

(10 hours)

Course Outcomes:

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

CO 1. Build the circuits with physical computing boards, sensor and actuators and program them to perform a given task

CO 2. Exchange the data and information between the connected devices through the internet and control IoT devices by remote systems.

CO 3. Apply concept of IoT on real-time applications to solve the problems/enhance the functionality.

References

1. IoT Lab Manual

B.E MECHANICAL ENIGINEERING

Choice Based Credit System (CBCS)

Program Core Course (PCC)

Product Design and Manufacturing (3:0:0) 3

(Effective from the academic year 2021-2022)

Course Code	**21ME741**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Lecture Hours	**40 hours**	SEE Marks	**50**
Examination nature (SEE)	**Descriptive**	Exam Hours	**03**

Course Objectives:

This course enables the students

1. To understand and simulate the different phases of product design with relevant flow charting and industrial practices in the area of product design.
2. To understand the various material properties and loading conditions for the product design based on the manufacturing possibilities.
3. To understand the product design optimization by using different approaches such as differential Calculus, Lagrange Multipliers,
4. To understand the safety, reliability, manufacturing, and environmental aspects related to the economics of the product design
5. To understand the value engineering by adopting the various steps in problem solving leading to the effective solution for the challenge.

Preamble: This course presents an overview of the product design and development process along with the manufacturing systems aspects. The concepts of optimization, economics and manufacturing would help the students learn to conceptualize, design and manufacture competitively-priced quality products.

Module – 1

Product Design: **Asimow's model**: Concepts of product design, Design by Evolution, Design by Innovation, Essential Factors of Product design, Production-Consumption Cycle, Flow and Value Addition in the Production-Consumption Cycle, The Morphology of Design (The seven phases), Primary Design Phases and Flowcharting,

Product Design Practice: Product Strategies, Time to Market, Analysis of the Product, The S's Standardization, Simplification, Role of Aesthetics in Product Design, Functional Design Practice.

Strength Consideration in Product Design: Principal Stress Trajectories (Force-Flow Lines), Balanced Design, Criteria and Objectives of Design, Material Toughness: Resilience Designing for Uniform Strength, Tension vis-a-vis Compression **(09 Hours)**

Self- Study: Industrial design considerations, Types of models designed by Industrial Designers.

Module-2

Design for Production- Metal Parts: Producibility requirements in the Design of machine Components, Forging Design, Pressed components Design, Casting Design, and Design for Machining Ease, The Role of Process Engineer, Ease of Location and clamping, Casting and Special Casting.

Designing with Plastic, Rubber, And Ceramics: Approach to design with plastics, plastic bush bearings, gears in plastics, rubber parts, design recommendations for rubber parts, Production design factors for ceramic and glass parts. **(07 Hours)**

Self -Study: Design of powder metallurgical parts, Expanded metals and wire forms

Module-3

Human Engineering Considerations in Product Design: Human being as Applicator of Forces, Anthropometry; Man as occupant of Space, The Design of Controls, of controls, the Design of Displays, Man/Machine Information Exchange.

Optimization in Design: Siddal's Classification of Design Approaches, Optimization by Differential Calculus, Lagrange Multipliers, Linear Programming (Simplex Method), Geometric Programming, Johnson's Method of Optimum Design. **(08 Hours)**

Self- Study: Workplace layout from ergonomic consideration

Module-4

Economic Factors Influencing Design: Product Value, Design for Safety, Reliability and Environmental Considerations, Manufacturing Operations in relation to Design, Economic Analysis, Profit and Competitiveness, Break – even Analysis.

Value Engineering and Product Design: Historical Perspective, what is Value? Nature and Measurement of Value, Normal Degree of Value, Importance of Value, The Value analysis Job Plan, Creativity, Steps to Problems-solving and Value Analysis, Value Analysis Test, Value Engineering Idea Generation Check-list Cost Reduction through value engineering, Material and Process Selection in Value Engineering.

(09 Hours)

Self- Study: Economics of a New Product Design, Case study on Tap Switch Control Assembly

Module-5

Modern Approaches to Product Design: Concurrent Design and Quality Function Deployment (QFD).

Product Design for Environment: Importance, Environmental Factors, Scope of environmental impact, Design guidelines, Life cycle assessment, Techniques to reduce environmental impact, Design to minimize material usage, Design for disassembly. **(07 Hours)**

Self- Study: Rapid Prototyping in Product design.

Course Outcomes:

At the end of the course, students will be able to

1. Explain the design principles and practices related to metallic and nonmetallic products.
2. Apply suitable design guidelines in developing a product based on strength and environmental issues.
3. Utilize the optimization techniques and human engineering concepts in designing a new product.
4. Analyze the economic factors and value engineering in product design.

Textbooks

1. A.C. Chitale and R.C. Gupta -Product Design and Manufacturing, PHI, 5th Edition, 2011.
2. Karl T. Ulrich & Steven D., Epinger -Product Design and Development –Tata Mc Graw Hill,

5th Edition, 2012.

Reference Books

1. Geofferry Boothroyod, Peter Dew Hurst and Winston Knight - Product Design for Manufacture and Assembly -3rdEdition, Taylor & Francis Group,2011
2. Tim Jones, Butterworth Heinmann-New Product Development, Oxford, UIC1997.

B.E. MECHANICAL ENGINEERING

Choice Based Credit System (CBCS)

Professional Elective – Group III

Fluid Power Systems (3:0:0) 3

(Effective from the academic year 2020-21)

Course Code	**21ME732**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Lecture Hours	**40**	SEE Marks	**50**
Examination nature (SEE)	**Descriptive**	Exam Hours	**03**

Course Objectives:

This course will enable students:

1. To gain knowledge on how pressurised fluid generates power, the types of fluid power control systems and its applications.
2. Be familiar with the construction and function of the components
3. Know how the components are selected and integrated into a system.
4. Know how to read basic circuits, troubleshoots and analyse the operation of basic circuits.

Preamble: Practically every industrial process requires objects to be moved, manipulated or be subjected to some form of force. For example, fluid power steers and automobiles, drives machine tools, controls airplanes, processes food, drills teeth, and even transport and delivers drugs to the infected areas in the human body efficiently and effectively. In fact, it is almost impossible to find a manufactured product that hasn't been fluid powered in some way at some stages of its production or distribution. This course provides a comprehensive introduction to fluid power, including both oil hydraulics and pneumatics.

Module – 1

Fluid Power: Fundamentals of fluids and Pascal's law. Types of fluid power control systems, structure of hydraulic system and pneumatic system - Advantages, limitations and applications. Numerical on Pascal's law.

Hydraulic Pumps:

Pumping theory & types of positive displacement pumps, Construction and working of gear, vane and piston pumps. Pump performance and pump selection, Graphic symbols. Numericals.

Self-study: Types of fluids, Properties of liquids and gases, type of hydraulic oil. **(08 Hours)**

Module – 2

Hydraulic Actuators: Linear actuators and hydraulic cylinder cushioning. Rotary actuators- Gear, Vane and Piston motors and hydraulic motor performance and Graphic symbols. Numericals.

Control devices:

Types of control devices. DCV-Check, shuttle valve, pilot operated check valve and spool valves (2-way valve, 3-way valve, 4- way valve), solenoid valve. PCV – Pressure relief valve, pilot operated pressure relief valve. FCV- Needle valve. Graphic symbols.

Self-study: Hydraulic system safety and maintenance -Sealing devices, Reservoir system, Filters and strainers, Wear of moving parts due to solid particle contamination, Temperature control.

(08 Hours)

Module – 3

Accumulators: Types of accumulators, Construction and working of weighted loaded, spring loaded type and gas loaded type.

Design of hydraulic circuits: Direct control of single and double acting cylinders, regenerative circuits, cylinders synchronization circuits, pump unloading circuit, double pump hydraulic system, meter-in, meter-out/bleed-off circuits, and accumulator circuits.

Self-study: Distribution system & fittings: Steel pipes, steel and plastic tubes, flexible hoses & couplings. **(08 Hours)**

Module – 4

Pneumatic system components: Control valves: Direction, flow and pressure control valves -DCV such as poppet, spool, suspended seat type slide valve, needle valve, time delay valve and quick exhaust valve, FRL unit. **Pneumatic Actuators**: Linear actuators – types of cylinders, working, and end position cushioning and types of rotary actuators. Graphic symbols.

Pneumatic control circuits: Direct and indirect actuation single and double cylinders, speed control of cylinders - supply air throttling, exhaust air throttling and application of time delay valve. Applications - Circuit diagram for pneumatic braking system.

Self-study: Characteristics of compressed air, seals, mounting arrangements, and control valves.

(08 Hours)

Module – 5

Signal Processing Elements: Use of Logic gates - OR and AND gates in pneumatic applications. Practical examples and circuits involving the use of logic gates.

Multi- Cylinder Application: Coordinated and sequential motion control, motion and control diagrams. Circuits for automatic control applications-Cascading method- principle, Practical application examples (upto two cylinders).

Electro- Pneumatic Control: Principles - Signal input and output, use of relay and contactors. Control circuitry for simple signal cylinder application.

Self-study: Pneumatics safety and maintenance. Heat exchangers, pressure switches, trouble shooting.

(08 Hours)

Course Outcomes: The students will be able to:

CO1: **Understand** the theoretical concepts of Pascal's law, types of fluids and its properties.
CO2: **Apply** the fluid power control system concepts for industrial applications.
CO3: **Analyse** the operation of simple hydraulic and pneumatic circuits.
CO4: **Design** a fluid power system for a given industrial / societal problem.

Textbooks:

1. Anthony Esposito., "Fluid Power with Applications", 7th Edition, Pearson Education, 2008.
2. James Johnson., "Introduction to Fluid Power", 1st Edition, Cengage Learning, 2002.
3. Andrew Parr., "Hydraulics and Pneumatics: A Technician's and Engineer's Guide", 3rd Edition, Heinemann, Imprint of Elsevier, 2011.
4. S. Majumdar., "Pneumatic Systems: Principles and Maintenance", 2nd Edition, McGraw Hill Education, 2017.

Reference Books:

5. EurIng Ian C. Turner., "Engineering Applications of Pneumatics and Hydraulics", 1st Edition, Butterworth-Heinemann, 1996.
6. S. Majumdar., "Oil Hydraulic Systems: Principles and Maintenance", 2nd Edition, McGraw Hill Education, 2017.

Department of Mechanical Engineering
Choice Based Credit System (CBCS)
Professional Elective Course - III

Electric Vehicle Technology (3:0:0) 3
(Effective from the academic year 2021-2022)

Course Code	**21ME733**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Contact Hours	**40**	SEE Marks	**50**
Examination Nature (SEE)	**Descriptive**	Exam Hours	**03**

Course objectives:

This course will enable students to:

1. Acquire basic understanding about electric vehicles and its architecture.
2. Study the power management systems and understand various energy storage systems.
3. Obtain the knowledge of various motor and control system for electric vehicles and its characteristics.
4. Impart various domains related to power grid interconnections of electric vehicle.
5. Develop a skill for components, motor, control, and charging system selection considering environmental concern.

Preamble: Importance of sustainable vehicle in today's scenario, adaptability and scalability of electric technology.

Module – 1

Environmental Impact of Vehicles : History, Developments towards the End of the Twentieth Century and the Early Twenty-First Century, Electric Vehicles and the Environment, Energy Saving and Overall Reduction of Carbon Emissions, Reducing Local Pollution, Reducing Dependence on Oil, Usage Patterns for Electric Road Vehicles.

Electric Vehicle Architecture: Types of Electric Vehicles – EV Architecture, Battery Electric Vehicles, The IC Engine/Electric Hybrid Vehicle and architectures, Fuel cell EVs, EVs using Supply Lines, EVs with Flywheels and Supercapacitors, Solar-Powered Vehicles, Linear Motor Vehicles.

(08 Hours)

Self-study: Study on Market Trend for Electric Vehicle in India.

Module – 2

Energy Storage for EVs: Battery Parameters, Cell and Battery Voltages, Charge Capacity, Energy Stored, Specific Energy, Energy Density, Specific Power, Amp-Hour Efficiency, Energy Efficiency, Self-discharge Rates, Battery Geometry, Battery Temperature, Heating and Cooling Needs, Battery Life and Number of Deep Cycles, Battery Management Systems (BMS),

Fuel cells for EVs: Types, Characteristics, Fuel Cell Technologies, hybridization of various energy storage devices. Selection of the energy storage technology.

Hands on Training: Demo on Electrical vehicle systems and component.

Self-study topics: Study on Super capacitor-based energy storage, high-speed flywheel.

(08 Hours)

Module – 3

DC and AC Machines & Drives: Various types of motors, selection and size of motors, **Permanent magnet** motor drives and characteristics, **Brushed & Brushless** DC motor drive and characteristics, **Switched reluctance motors** and characteristics, **IPM motor drives** and characteristics, mechanical and electrical connections of motors.

Regenerative Breaking: Maximum Braking Force, Slip in braking, Vehicle Maximum Deceleration during braking, Braking energy on front and rear axle, Parallel Hybrid Braking, Fully controllable hybrid braking

(08 Hours)

Self- study topics: Study on Induction motor drives and control characteristics.

Module – 4

Design Considerations of EV components: Design parameters of batteries and ultra-capacitors, aerodynamic considerations, calculation of the rolling resistance and the grade resistance, calculation of the acceleration force, total tractive effort, torque required on the drive wheel, transmission efficiency, consideration of vehicl **(08 Hours)**

Hands on Training: Industry integrated learning – quiz based expert talk on modern trends of electric vehicles.

Self-study topics: Study on Retrofitting of Electrical Vehicle.

Module – 5

Electric Vehicles charging architecture: Electricity Supply, Normal Existing Domestic and Industrial Electricity Supply, Infrastructure Needed for Charging Electric Vehicles, Electricity Supply Rails, Inductive Power Transfer for Moving Vehicles, Battery Swapping.

Smart charging: Grid to vehicle and vehicle to grid, smart metering and ancillary services, introduction to battery charging stations (level 1, 2 and 3) and its installation and commissioning, preliminary discussion on estimation on station capacity and associated technical issues, different connectors.

(08 Hours)

Self-study topics: Study on vehicle to vehicle and vehicle to personal communication systems,

Course outcomes: The students will be able to:

Apply the knowledge of electric vehicles to distinguish their architecture.

Appraise the power management systems for electric vehicles using various energy storage systems.

Select appropriate motor and control system for electric vehicles

Analyze various domains related to Component, systems and power grid interconnections of electric vehicle.

Demonstrate ability to acquire the knowledge by self-learning and communicate the same with lager group, Evaluate and compare various design features for electric vehicles with environmental concern.

Textbooks:

Iqbal Hussain, **"Electric and Hybrid Vehicles Design Fundamentals",** 1st Edition, CRC Press, 2003.

James Larminie, John Lowry "Electric Vehicle Technology Explained", 1st Edition, John Wiley and Sons, 2003.

Reference Books:

Chris Mi, M. Abul Masrur, David Wenzhong Gao, **"Hybrid Electric Vehicles**: Principles and Applications with Practical Perspectives", Wiley publication ,2011.

Allen Fuhs, "Hybrid Vehicles and the future of personal transportation", CRC Press, 2009.

Web links and Video Lectures (e-Resources):

Web course on "Introduction to Hybrid and Electric Vehicles" by Dr. Praveenkumar

and Prof. S Majhi, IIT Guwahati available on NPTEL at

https://nptel.ac.in/courses/108/103/108103009/

Video Course on "Electric Vehicles" by Prof. Amitkumar Jain, IIT Delhi available on

NPTEL at https://nptel.ac.in/courses/108/102/108102121/

B.E MECHANICAL ENGINEERING
(**Choice Based Credit System (CBCS)**
Professional Elective Group - III

Composite Materials Technology (3:0:0) 3
(Effective from the academic year 2021-22)

Course Code	**21ME734**	Semester	**VII**
Teaching Hours/Week (L: T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Contact Hours	**40**	SEE Marks	**50**
Examination nature (SEE)	**Descriptive**	Exam Hours	**03**

Course Objectives:

This course will enable students to:

1. To know the behaviour of constituents in the composite materials.
2. To Enlighten the students in different types of reinforcement and matrices.
3. To understand the various characterization techniques.
4. To Enlighten on maintenance of composites using various types of inspection and repair operations.

Preamble: Composite materials, classification and development of different types of composite materials, Important properties and applications of composite materials

Module – 1

Introduction to Composite Materials: Function of the matrix and reinforcement in composites, classification of composite materials, Types of matrices & reinforcements, characteristics & selection, Fiber composites, laminated composites, particulate composites, Advantages and application of composites.

Metal Matrix Composites (MMCs): Reinforcement materials: types, Characteristics & Selection, base metals-selection, applications. Processing of MMCs: Liquid state process, solid state process. Properties & Applications of MMCs.

(08 Hours)

Module – 2

Polymer Matrix Composites (PMC): Polymer matrix materials, Thermoset Matrix Composites, Thermoplastic Matrix Composites, prepregs, Advantages and disadvantages. Applications of Polymer matrix composites,

Manufacturing methods: Thermoset Composite manufacturing- Layup processes, Spray up process, Resin transfer moulding, Vacuum moulding, Compression moulding process, Filament winding. Thermoplastic Composite manufacturing- Sheet moulding, Injection moulding, rotational moulding,

(08 Hours)

Module – 3

Ceramic Matrix Composites (CMCs): Matrix and reinforcement materials of CMCs, properties and applications of CMC's. Processing of CMC's: Sintering, Hot Pressing, Infiltration, In Situ Chemical Reaction Technique, Sol-Gel Polymer Infiltration & Pyrolysis.

Carbon-Carbon Composites: Advantages and limitations of carbon-carbon composites, processing of carbon-carbon composites, oxidation protection of carbon-carbon composites, properties and application of carbon-carbon composites. **(08 Hours)**

Module – 4

Nonconventional Composites: Nanocomposites; Polymer clay nanocomposites, self-healing composites, self-reinforced composites. Biocomposites, Laminates; Ceramic Laminates, Hybrid Composites.

Machining of composites: Machining of PMCs: Drilling, milling, Waterjet machining, Electric discharge Machining.

(08 Hours)

Module – 5

Maintenance of Composites: Damage assessment, Inspection Methodology, Repair operation, Repair procedures. Types of Repairs – Repair failures, Typical repair procedures, Delamination, Damage to laminate structures, Repair to sandwich structures, Repair to Honeycomb structures.

(08 Hours)

Course outcomes:

The students will be able to:

CO1: Identify the types of composite materials and their characteristic features.
CO2: Understand the methods employed in composite fabrication.
CO3: Develop the nonconventional composites for specific applications.
CO4: Illustrate the machining process used in composites
CO5: Apply the different procedures to inspect and repair the damaged composites.

Textbooks:

1. Krishan K. Chawla, Composite Material Science and Engineering, Springer, Third Edition First Indian Reprint 2015.
2. P.K. Mallick, Fibre-Reinforced Composites, Materials, Manufacturing, and Design, CRC Press, Taylor & Francis Group, Third Edition.

Reference Books:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Taylor & Francis, 2nd Ed, 2005.
2. Michael W, Hyer, Stress analysis of fiber Reinforced Composites Materials, Mc-Graw Hill International, 2009

B.E. MECHANICAL ENGINEERING

Choice Based Credit System (CBCS) applicable for 2021 Scheme

SEMESTER – VII

AUTOMATION IN MANUFACTURING (3:0:0) 3

(Effective from the academic year 2024-25)

Course Code	21ME735	CIE Marks	50
Teaching Hours/Week (L:T:P)	3:0:0	SEE Marks	50
Total Number of Contact Hours	40	Exam Hours	3

Course Objectives:

This course will enable students to:

1. Understand about the Automation and types of Automations in the industries.
2. Understand the different Automated manufacturing and assembly systems.
3. Perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts.
4. Perform a sequence of automated or mechanized assembly operations using a Flexible Manufacturing System (FMS)

Preamble: This course equips students with a comprehensive understanding of the principles, technologies, and applications of automation in the manufacturing sector. By the end of this course, students will have a solid foundation in the key concepts and technologies driving automation in manufacturing.

Module – 1

Introduction to Automation: Manufacturing industries and products, Manufacturing operations, Production facilities: Production quantity and types, Product variety and types, Product /Production relationships.

Definition and Types of Automation, Automation principles & Strategies: USA Principles, Ten strategies for automation, Automation migration strategy. Basic elements of an automated system: power to accomplish the automated process, Program of instructions, Control system. Advanced automation functions, Levels of Automation.

(08 hours)

Module – 2

Automated Manufacturing Systems: Components of a Manufacturing systems, Factors to distinguish the types of Manufacturing Systems, Classification of Manufacturing systems. Single Station Manned cells, Single Station Automated Cells.

Automated Assembly Systems: Fundamentals of automated assembly systems, Systems configurations/ types of automated assembly system, Parts feeding devices, Elements of parts delivery system: Hopper, Parts feeder, Selectors, Orientors, Feed track, Escapement and placement device. Partial automation.

(08 hours)

Module – 3

Group Technology: Definition, Part families and Machine groups, Part family, Parts classification and coding, Production Flow Analysis, Cellular manufacturing, Types of machine cells, Machine cell layouts, Applications of Group Technology.

Flexible Manufacturing Systems: Fundamentals of Flexible Manufacturing Systems, Types of flexibility tests, Types of FMS, FMS components, FMS layout configurations, FMS Applications, FMS planning issues, FMS design issues, FMS operations management issues, FMS benefits.

(08 hours)

Module – 4

Material Transport Systems: Fundamentals of Material handling, Material handling equipment, Design considerations in Materials handling, Material transport equipment's, Industrial trucks, Automated Guided Vehicles (AGVs): Introduction, Types of AGVs, Vehicle guidance technologies, Vehicle management, Vehicle safety. Rail guided vehicles, Conveyors and types of conveyors, Cranes and Hoists.

Material Storage Systems: Introduction to Storage systems, Storage system performance, Conventional storge methods and Equipment, Automated Storage and Retrieval Systems (AS/RS), AS/RS types, AS/RS applications, Components and operating features of an AS/RS.

(08 hours)

Module – 5

Automatic Identification and Data Capture (AIDC): Overview of Automatic identification methods, Bar code technology, Radio frequency identification, Magnetic stripes, Optical Character Recognition (OCR), Machine vision: Components and applications.

Manufacturing support systems: Concurrent Engineering, Design for Manufacturing and Assembly, Advanced Manufacturing Planning, Shop Floor Control: Order release, Order Scheduling, Order Progress, Lean Production and Waste in manufacturing, Structure of Lean production, Just In Time production systems.

(08 hours)

Course Outcomes:

The students will be able to:

CO 1	Illustrate the concept of Automation principles and strategies for the development of Automated manufacturing and Assembly systems.
CO 2	Apply the concept of Group Technology & Flexible Manufacturing Systems for automated systems development.
CO 3	Identify the types of Automated material handling and storage methods for efficient automated systems.
CO 4	Analyze the various Automatic identification techniques and manufacturing support systems.

Textbooks:

1. Mikell P Groover, "Automation, Production Systems and Computer-Integrated Manufacturing", Pearson Publications, 4th Edition, 2020.

References:

1. P. N. Rao, "CAD/CAM Principles and Application", Tata McGraw Hill, International, 3rd Edition, 2014.
2. Frank Lamb, "Industrial Automation", Mc Graw Hill Publications, 2013.
3. Dr. P. Radhakrishnan, "CAD/CAM/CIM",3rdEdition, New Age International Publishers, 2004.
4. Ibrahim Zeid, "CAD/CAM", 3rdEdition, Tata McGrawHill Publications, 2015.

Alternate Assessment Tools (AATs) suggested:

- Technical report anaysis
- Modern tool usage
- Industrial visits
- Case study on "Implementation of Automation in a manufacturing industry" and report submission.

Web links / e – resources:

- ✓ https://nptel.ac.in/courses/112104288
- ✓ https://onlinecourses.nptel.ac.in/noc24_mg117/preview
- ✓ https://onlinecourses.nptel.ac.in/noc24_me139/preview

B.E MECHANICAL ENGINEERING

Choice Based Credit System (CBCS)

Professional Elective Course - III

COMBUSTIONS IN IC ENGINES (3:0:0) 3

(Effective from the academic year 2021-2022)

Course Code	**21ME736**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Lecture Hours	**40**	SEE Marks	**50**
Examination nature (SEE)	**Descriptive**	Exam Hours	**03**

Course Objectives:

1. Study the different properties of fuels and also study the evaluating procedure of properties of fuel.
2. Identify the suitable oils and fuels required for particular engines.
3. Differentiate CI and SI engine in terms of combustion phenomenon.
4. Know about the fuel supply methodology and the method to control the combustion.

Preamble: Internal Combustion engine refers to heat engine where combustion takes place in closed chamber. For the combustion process to occur, heat, hydrocarbon and oxygen is required. Properties of fuels, method of supplying the fuel and air into the combustion chamber is major focus of the course.

Module – 1

Liquid Fuels: Origin, Chemistry of petroleum, Refining of petroleum, Properties and tests for petroleum products, Various petroleum products.

Fuel Treatment: Production of liquid fuels, Removal of sulphur compounds, Contaminants, Asphaltenes, Gum, Sediment, Ash, Water, Sodium, Vanadium, Additives, Gum prevention, Corrosion inhibition/lubricity improvers, Anti icing, Antistatic and static dessipators, Metal deactivators, Antismoke**.** **(08 hours)**

Module-2

Combustion: Deflagration, Detonation, Classification of flames, Physics of combustion chemistry, Fammability limits, Weak mixture, Rich mixture, Laminar premixed flames.

Laminar and turbulent flame: Burning velocity, Measurement techniques for flam velocity, Factors influencing laminar flam speed, Equivalence ratio, Initial temperature and pressure of laminar diffusion flames, Turbulent premixed flames, Flam propagation in heterogeneous mixture of fuel drops, Fuel vapor and air. **(08 hours)**

Module-3

Automotive Control Systems: Digital Engine Control System, Vehicle Motion Control System: Typical Cruise Control System, Stepper Motor-Based Actuator for Cruise Control, Antilock Braking Systems, Traction Control System, Electronically controlled power steering systems. **(08 hours)**

Module-4

Combustion in SI Engines: Limits and stages of combustion, Factors affecting ignition lag, Flame propagation, Effect of engine variable on flame propagation, Abnormal combustion, Effect of detonation, Detonation and engine variables and other factors affecting knocking and its prevention, Theory of detonation in SI engines and chemistry of detonation, Ignition advance, Control of detonation surface ignition **(08 hours)**

Module-5

Combustion in CI Engines: Stages of combustion in CI engines, Air fuel ratio, Delay period or ignition lag, Variables effecting delay period, Diesel knock, Methods of controlling diesel knock, Effect of fuel injection parameters, CI engine combustion chamber requirements, Types of combustion chambers, Cold starting of CI engine and cold starting aids. **(08 hours)**

Textbooks:

1. JohnB. Heywood, "Internal combustion engines fundamentals", McGraw – Hill international editions.
2. Edward F. Obert, "Internal combustion engines and air pollutions", Intext education publishers.

Reference Books:

1. Richard stone, "Introduction to internal combustion engines" 3rd edition, society of automotive engineers.
2. S P Sharma and Chander Mohan, "Fuels and Combustion", McGraw – Hill Publishing Company Limited.
3. A M.L.Mathur and R.P.Sharma, "Course internal combustion engines", Dhanapat Rai publications.

Course Outcomes:

The students will be able to:

CO 1: Classify the fuels based on their properties, able to determine the properties of fuels, and understand the working of IC engines components.

CO 2: Apply the concept of engineering to understand the flame behavior and combustion phenomenon in IC engines.

CO 3: Analyze the reason for malfunctioning of IC engines.

CO 4: Evaluate the properties of oils and performance of IC engines operated with biodiesel or hydrogen.

B.E MECHANICAL ENIGINEERING

Choice Based Credit System (CBCS)

Product Design and Manufacturing (3:0:0) 3

(Effective from the academic year 2021-2022)

Course Code	**21ME741**	Semester	**VII**
Teaching Hours/Week (L:T:P)	3:0:0	CIE Marks	50
Total Number of Lecture Hours	40 hours	SEE Marks	50
Examination nature (SEE)	Descriptive	Exam Hours	3 Hrs

Course Objectives:

This course enables the students

1. To understand and simulate the different phases of product design with relevant flow charting and industrial practices in the area of product design.
2. To understand the various material properties and loading conditions for the product design based on the manufacturing possibilities.
3. To understand the product design optimization by using different approaches such as differential Calculus, Lagrange Multipliers,
4. To understand the safety, reliability, manufacturing, and environmental aspects related to the economics of the product design
5. To understand the value engineering by adopting the various steps in problem solving leading to the effective solution for the challenge.

Preamble: This course presents an overview of the product design and development process along with the manufacturing systems aspects. The concepts of optimization, economics and manufacturing would help the students learn to conceptualize, design and manufacture competitively-priced quality products.

Module – 1

Product Design: **Asimow's model**: Concepts of product design, Design by Evolution, Design by Innovation, Essential Factors of Product design, Production-Consumption Cycle, Flow and Value Addition in the Production-Consumption Cycle, The Morphology of Design (The seven phases), Primary Design Phases and Flowcharting,

Product Design Practice: Product Strategies, Time to Market, Analysis of the Product, The S's Standardization, Simplification, Role of Aesthetics in Product Design, Functional Design Practice.

Strength Consideration in Product Design: Principal Stress Trajectories (Force-Flow Lines), Balanced Design, Criteria and Objectives of Design, Material Toughness: Resilience Designing for Uniform Strength, Tension vis-a-vis Compression **(09 Hours)**

Self- Study: Industrial design considerations, Types of models designed by Industrial Designers.

Module-2

Design for Production- Metal Parts: Producibility requirements in the Design of machine Components, Forging Design, Pressed components Design, Casting Design, and Design for Machining Ease, The Role of Process Engineer, Ease of Location and clamping, Casting and Special Casting.

Designing with Plastic, Rubber, And Ceramics: Approach to design with plastics, plastic bush bearings, gears in plastics, rubber parts, design recommendations for rubber parts, Production design factors for ceramic and glass parts. **(07 Hours)**

Self -Study: Design of powder metallurgical parts, Expanded metals and wire forms

Module-3

Human Engineering Considerations in Product Design: Human being as Applicator of Forces, Anthropometry; Man as occupant of Space, The Design of Controls, of controls, the Design of Displays, Man/Machine Information Exchange.

Optimization in Design: Siddal's Classification of Design Approaches, Optimization by Differential Calculus, Lagrange Multipliers, Linear Programming (Simplex Method), Geometric Programming, Johnson's Method of Optimum Design. **(08 Hours)**

Self- Study: Workplace layout from ergonomic consideration

Module-4

Economic Factors Influencing Design: Product Value, Design for Safety, Reliability and Environmental Considerations, Manufacturing Operations in relation to Design, Economic Analysis, Profit and Competitiveness, Break – even Analysis.

Value Engineering and Product Design: Historical Perspective, what is Value? Nature and Measurement of Value, Normal Degree of Value, Importance of Value, The Value analysis Job Plan, Creativity, Steps to Problems-solving and Value Analysis, Value Analysis Test, Value Engineering Idea Generation Check-list Cost Reduction through value engineering, Material and Process Selection in Value Engineering.

(09 Hours)

Self- Study: Economics of a New Product Design, Case study on Tap Switch Control Assembly

Module-5

Modern Approaches to Product Design: Concurrent Design and Quality Function Deployment (QFD).

Product Design for Environment: Importance, Environmental Factors, Scope of environmental impact, Design guidelines, Life cycle assessment, Techniques to reduce environmental impact, Design to minimize material usage, Design for disassembly.

Self- Study: Rapid Prototyping in Product design. **(07 Hours)**

Course Outcomes:

At the end of the course, students will be able to

1. Explain the design principles and practices related to metallic and nonmetallic products.

2. Apply suitable design guidelines in developing a product based on strength and environmental issues.
3. Utilize the optimization techniques and human engineering concepts in designing a new product.
4. Analyze the economic factors and value engineering in product design.

TEXT BOOKS

1. A.C. Chitale and R.C. Gupta -Product Design and Manufacturing, PHI, 5th Edition, 2011.
2. Karl T. Ulrich & Steven D., Epinger -Product Design and Development –Tata Mc Graw Hill, 5th Edition, 2012.

REFERENCES

1. Geofferry Boothroyod, Peter Dew Hurst and Winston Knight - Product Design for Manufacture and Assembly -3rdEdition, Taylor & Francis Group,2011
2. Tim Jones, Butterworth Heinmann-New Product Development, Oxford, UIC1997.

B.E MECHANICAL ENIGINEERING
Choice Based Credit System (CBCS)
Professional Elective Course - IV

Energy Storage Systems (2:1:0) 3
(Effective from the academic year 2022-2023

Course Code	**21ME743**	Semester	**VII**
Teaching Hours/Week (L: T:P: S)	2:2:0	CIE Marks	50
Total Hours of Pedagogy	40	SEE Marks	50
Examination Pattern (SEE)	**Descriptive**	Exam Hours	03

Course objectives: students will be able to

1 Acquire knowledge on energy demand and supply with respect to variations in the energy cycle.
2 Gain knowledge of various energy storage systems.
3 Understand the power conversion systems for various energy applications.
4 Evaluate the energy conversion through windmills and Photovoltaic panels and design flywheel as energy storage system.

Preamble:

Energy sector is facing various challenges due to highly fluctuated demand and supply. Most of the renewable energy systems are with variable conversion rates throughout the day and throughout the year causing loss of energy while power transmission. This course will highlight the necessity for various type of energy storage systems. It also emphasizes on analysis of energy conversion for windmills and solar power plants

Module-1

Fundamentals of Energy Storage: Major sources and uses of Energy, storage in distribution system, Periodic Storage, Problem of load leveling and variation in energy demand. The catalog of storage technologies.

Power Conversion Systems for Electrical Storage: Normal topology for power conversion systems, Energy storage technologies are key in the field of electromobility, Power Conversion for Fixed/Variable Speed Wind Turbines, Power Conversion of Photovoltaic Panels **(08 hours)**

Module-2

Energy Storage in Organics Fuels: Solar energy in Biomass, Storage via animals, Synthetic liquid fuels, Gaseous fuel in liquid form, other materials used as energy storage. Bioethanol, Bio-diesel and Biogas

Thermal energy storage: Sensible Heat, Latent Heat, Inorganic Phase Change material, Organic Phase Change materials, Molten Salts as a Thermal Storage Medium, solar power plant coupled with Molten salt storage system, Paraffin as heat storage material, Salt hydrates, Anhydrous Salts

(08 hours)

Module-3

Mechanical Energy Storage: Potential energy storage, principle of compressed air energy storage, Hydroelectric storage: Pumped hydro storage, Kinetic Energy (KE) in moving water. KE in Mechanical System, Linear KE, Rotational KE, Shape factor on disk shapes, Flywheel Characteristics, Superconducting Magnetic Energy Storage. Design of flywheel for energy storage.

(08 hours)

Module-4

Hydrogen Energy Storage: Power to Gas Concept, general concept of the ideal hydrogen economy, Gaseous Hydrogen in High-Pressure Tanks, Liquid Hydrogen in Insulated Tanks, Hydrogen as Protons in Solids: Metal Hydrides, concept of the Regenerative Fuel Cell. **(08 hours)**

Module-5

Electrochemical Energy Storage: Energy Storage in (Parallel Plate) Capacitors, topology of a supercapacitor, Types of Reaction Mechanisms in Electrochemical Cells, Components of battery cell, Charge Storage in batteries, Comparison of the variation of the potential, Lead acid, Nickel-Cadmium, Sodium–Sulfur, Lithium-Ion Batteries, operating principle of flow batteries **(08 hours)**

Course Outcome:

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

- **CO 1.** Describe the requirement for energy storage and power conversion systems in terms load leveling and variation in energy demand.
- **CO 2.** Appraise various energy conversion techniques to store the renewable energy in the form of mechanical, thermal, electrochemical energy.
- **CO 3.** Analyze the energy conversion rate for windmills and solar power plants.
- **CO 4.** Estimate the performance parameter of a flywheel and wind turbine based mechanical energy system.

Textbooks and Reference Books

1. Robert A. Huggins, (2016), Energy Storage - Fundamentals, Materials and Applications, 2nd Edition, Springer Cham Heidelberg New York
2. Francisco D´ıaz-Gonzalez , Andreas Sumper, Oriol Gomis-Bellmunt, ((2016), Energy Storage in Power Systems, 1st Edition, John Wiley & Sons Ltd

Web links and Video Lectures (e-Resources)

Power Plant System Engineering NPTEL IIT Guwahati (Energy Storage)

1. https://www.youtube.com/watch?v=f3omtoSIgKA&list=PLwdnzlV3ogoXZIxDYHM3aavBr5E8kDvH8&index=33
2. https://www.youtube.com/watch?v=VN59E-gNouw&list=PLwdnzlV3ogoXZIxDYHM3aavBr5E8kDvH8&index=34
3. https://www.youtube.com/watch?v=bntWDDHW2hU&list=PLwdnzlV3ogoXZIxDYHM3aavBr5E8kDvH8&index=35

B.E MECHANICAL ENIGINEERING
Choice Based Credit System (CBCS)

Additive Manufacturing Technology (3:0:0) 3
(Effective from the academic year 2021-2022)

Course Code	**21ME744**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Lecture Hours	**40**	SEE Marks	**50**
Examination nature (SEE)	**Descriptive**	Exam Hours	**03**

Course objectives:
This course will enable students:
1. To understand why additive manufacturing is necessary.
2. To comprehend the numerous additive manufacturing processes.
3. To know various rapid tooling techniques using additive manufacturing processes.
4. To comprehend additive manufacturing tools and minimize errors.

Preamble: Additive manufacturing, also referred to as 3D printing, is a cutting-edge technology that makes it possible to construct three-dimensional objects from a digital model layer by layer. By providing more design flexibility, lower waste, and quicker production periods than conventional manufacturing techniques, this ground-breaking approach has revolutionised a number of industries.

Module – 1

Principles of Additive Manufacturing: Need for Additive Manufacturing, AM classification, Generic AM process, benefits of AM, distinction between AM and CNC machining, other related technologies- reverse engineering technology.

Photo polymerization processes: Stereolithography (SL) process, materials, Process parameter, advantages and limitations, applications.

(08 hours)

Self-study component: History of additive manufacturing systems

Module – 2

Powder bed fusion processes: Introduction, Selective laser Sintering (SLS) process, materials, process parameters, powder fusion mechanism, Electron Beam melting (EBM), advantages and limitations, applications.

Extrusion-based systems: Fused Deposition Modelling (FDM) process, process parameters, materials, Process parameters, advantages and limitations, applications.

(08 hours)

Self-study component: Use of FDM to make human organs

Module – 3

Laminated Object Manufacturing: Principle, Process details, materials, advantages, limitations, applications.

Printing Processes: evolution of printing as an additive manufacturing process, research achievements in printing deposition, technical challenges of printing, printing process modelling, material modification methods, three-dimensional printing, and advantages of binder printing.

(08 hours)

Self-study component: Development of 3D ink printing

Module – 4

Indirect Rapid Tooling: Introduction, Indirect rapid tooling - silicone rubber tooling, vacuum casting, aluminum filled epoxy tooling, spray metal tooling.

Direct Rapid tooling - Direct AIM, quick cast process, rapid tool, copper polyamide, DMLS, sand casting tooling, laminate tooling, soft tooling v/s hard tooling.

(08 hours)

Self-study component: Cast Kirksite, 3D Keltool process.

Module – 5

Post- Processing: Support material removal, surface texture improvements, preparation for use as a pattern, property enhancements using non-thermal techniques and thermal techniques.

Rapid Manufacturing Process Optimization: Factors influencing accuracy, Data preparation-errors due to tessellation, errors due to slicing, Part building errors, Part finishing, Selection of part build orientation.

(08 hours)

Self-study component: Aesthetic improvements for AM.

Course outcomes: The students will be able to:

CO 1: Choose appropriate additive manufacturing processes to build the part
CO 2: Interpret the process parameters that affect the additive manufacturing processes.
CO 3: Apply the various additive manufacturing processes in direct and indirect rapid tooling.
CO 4: Infer the benefits, drawbacks and uses of various additive manufacturing processes.

Textbooks:

1. Dr. Ian Gibson., Dr. David. W. Rosen., Dr. Brent Stucker., "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", Springer, 2nd Edition, 2014
2. D T Pham., S. S. Dimov., "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", 1st edition, Springer, 2001.

References:

1. Andreas Gebhardt., "Rapid Prototyping", Hanser Pub Inc, 1st Edition, 2003.
2. Chua Chee Kai., Leong Kah Fai., Chu Sing Lim., "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", 2nd edition, World Scientific, 2010.

B.E MECHANICAL ENIGINEERING

Choice Based Credit System (CBCS)

Professional Elective Group - IV

Control Engineering (3:0:0) 3

(Effective from the academic year 2021-2022)

Course Code	**21ME745**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Lecture Hours	**40**	SEE Marks	**50**
Examination nature (SEE)	**Descriptive**	Exam Hours	**03**

Course Objectives:

1. To identify the needs of different types of controllers
2. To understand the concepts of mathematical modeling, feedback control
3. To understand the transfer function using block diagram and signal flowgraphs
4. To understand the time response of the system for standard input functions
5. To understand the nature of stability of the system

Preamble: This course is designed to understand the fundamental principles of control systems essential for various engineering fields. Through this course students will gain the knowledge necessary to analyze, and implement control systems that ensure the stability, performance, and efficiency of various engineering applications and preparing them to solve real-world problems in fields such as robotics, process control and automation.

Module – 1

Automatic Control:: Significance and Scope of control engineering , Importance of the control engineering , Recent trends in control system, Concept of automatic controls, Open loop and closed loop systems, Concepts of feedback, requirements of an ideal control system.

Controllers: Types of controllers, Proportional, Integral, Differential, Proportional and Integral, Proportional Differential and Proportional Integral Differential controllers**. (08 hours)**

Self-Study Component: Applications of PID controller.

Module-2

Modeling of Physical Systems: Mathematical Models of Mechanical, Electrical, Thermal systems.

Analogous Systems: Direct and inverse analogous for mechanical systems. **(08 hours)**

Self-Study Component: Hydraulic and Pneumatic systems modelling.

Module-3

Block Diagram Representation: General representation of a feedback control system, transfer functions, rules of block diagram, reduction of block diagram to obtain closed loop transfer function.

Signal Flow Graphs : Transfer function using Mason's gain formula. **(08 hours)**

Self-Study Component: Block diagram representation for MIMO systems.

Module-4

Time Response Analysis: First order and second order system response to step, ramp and impulse inputs, concepts of time constant, Routh's stability criterion for a control system.

Root Locus Plots: Significance of Root locus, construction of Root locus using general rules and steps and stability analysis using Root Locus. **(08 hours)**

Self-Study Component: Effect on the stability by adding pole and /or zero to the system.

Module-5

Frequency Domain Analysis: Relationship between time and frequency response, Polar plot, Bode's Plot, Nyquist plot and Nyquist stability criterion, Relative Stability, Phase and Gain Margins. **(08 hours)**

Self-Study Component: Gain margin and phase margin calculation using analytical method.

Course outcomes: At the end of the course students will be able to:

1. Describe the elements of control systems and controllers.
2. Determine the system governing equations for physical models.
3. Find the transfer function using the block diagram reduction rules and Mason's gain formulae.
4. Analyze the time response of first and second order system.
5. Evaluate the stability of the control system using Root locus, Bode plots & Nyquist plots.

Text Books:

1. Katsuhiko Ogatta, "Modern Control Engineering", 4th edition, , Pearson Education Publishers,2002.
2. B.C.Kuo, F.Golnaraghi, "Automatic Control Systems", 9th edition, Wiley publishers,2014.

Reference Books:

1. Norman S. Nise, "Engineering control systems", India Edition, Wiley publishers, 2018.
2. Schaum's Series, "Feedback Control System", 3rd edition, McGraw-Hill Education,2013.
3. Nagrath & Gopal, "Control Systems Engineering", 6th Edition, New Age International Publishers, 2018

B.E MECHANICAL ENIGINEERING
Choice Based Credit System (CBCS)
Professional Elective Group - IV

Smart Materials and Structure (3:0:0) 3
(Effective from the academic year 2024-25)

Course Code	**21ME746**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Contact Hours	**40**	SEE Marks	**50**
Nature of examination	**Descriptive**	Exam Hours	**03**

Course Objectives:

This course will enable students to:

1. Study various types of smart materials used in engineering application.
2. Study basics of smart sensors, actuators deployed in engineering application.
3. Understand the coupling properties and underlying physical phenomena of different active materials.
4. Describe the basic principles and mechanisms of the stimuli-response for the most important smart materials.
5. Propose improvement on the design, analysis, manufacturing and application issues involved in integrating smart materials and devices under various engineering structures and products.
6. Demonstrate knowledge and understanding of the physical principles underlying the behaviour of Shape Memory Alloy and piezoelectric materials.

Module – 1

Preamble: Relevance of material science in day today activities, Importance of materials in industrial, defence and research application and its economic implications.

Smart Materials and Structures: Introduction to Smart Materials, need of smart materials, types of smart materials, difference between smart materials and structure, components of smart materials, properties of smart materials, advantages and disadvantages of smart materials, applications of smart structures.

(08 Hours)

Self-study: Smart clothes and Smart Shoes.

Module – 2

Shape Memory Alloys: Introduction shape memory alloys, Shape memory effect, Processing and characteristics. Experimental Phenomenology: one way and two way memory, advantages and disadvantages and applications

(08 Hours)

Self- Study: NiTiNOL shape Memory

Module – 3

Piezoelectric Smart Materials: Introduction, Inchworm Linear motor, Properties of Piezoelectric materials, Applications, Comparison of major sensing and actuation methods.

MEMS: Introduction to MEMS, Intrinsic characteristics, advantages and disadvantages of MEMS, applications.

(08 hours)

Self- Study: Accelerometers, gyroscopes used in cell phones

Module – 4

FibreOptics: Introduction, Physical Phenomenon, Characteristics, Fibre optic strain sensors (types only), Optical fibres as load bearing elements, Crack detection applications.

Biomimetics: Characteristics of Natural structures. Fibre reinforced: Organic matrix natural composites, Natural creamers, Mollusks. Biomimetic sensing.

(08 hours)

Self- Study: Elephant trunk.

Module – 5

Electro rheological (ER) and Magneto rheological (MR) Fluids: Mechanisms and Properties, Characteristics, Fluid composition and behaviour, Application of ER and MR fluids (Only Brakes, Clutches and Dampers).

Environmental and sustainable concerns: Lead free smart materials for energy harvesting applications.

(08 hours)

Self- Study: Application of Rheological fluids for valves

Course Outcomes:

The students will be able to:

CO1: Describe the physical phenomenon, properties, and characteristics of various smart materials.
CO2: Identify and analyze various smart materials and components for their properties based on the applications.
CO3: Summarize the latest developments in the field of smart materials and system.
CO4: Discuss on environmental and sustainable concerns with respect to smart material.

Textbooks:

1. Smart Structures –Analysis and Design, A.V.Srinivasan, Cambridge University Press, New York, 2001, (ISBN:139780521154383).
2. Smart Materials and Structures, M.V.Gandhi and B.S.Thompson Chapmen & Hall, London, 1992 (ISBN:0412370107)

Reference Books:

1. Smart Structures: Physical Behaviour, Mathematical Modelling and Applications, P. Gauenzi, Wiley, 2009.
2. Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors, Materials and Amplifiers, G. Gautschi, Springer, Berlin, New York, 2002.
3. Analysis and Performance of Fiber Composites, B. D. Agarwal and L. J. Broutman, John Wiley & Sons, 2015.
4. Engineering aspects of Shape memory Alloys, T. W. Duerig, K. N. Melton, D. Stockel,C, Mayman, Butterworth, Heinemann, 1990.
5. Smart Structures and Materials, Brian Culshaw, Artech House, 2000
6. Engineering Analysis of Smart Material Systems by Donald J. Leo, 2007.

B.E MECHANICAL ENIGINEERING
Choice Based Credit System (CBCS)

Innovative Product Development (3:0:0) 3
(Effective from the academic year 2022-23)

Course Code	**21ME751**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Contact Hours	**40**	SEE Marks	**50**
Examination nature (SEE)	**Descriptive**	Exam Hours	**03**

Course objectives:
This course will enable students to:
Course outcomes: The students will be able to:

1. Understand innovation and innovation portfolio.
2. Develop innovative culture and critical thinking.
3. Gain knowledge on problems analysis and creative process.
4. Explain synthesis and design process.
5. Illustrate product development and prototype.

Preamble: Preamble: This course provides an insight into innovation, critical thinking, Problems analysis, synthesis, product design and development process.

Module – 1

Innovation: Concepts and importance of innovations, innovation strategy, mapping innovation opportunities. A framework for innovation strategy. Challenges of innovation. Types of innovations: disruptive, radical, Architectural, incremental, product and process innovations.
Creating Innovation Portfolio: Value creation, unmet customer needs, existing technology paradigm improvement, building complementary technological capabilities, rapid routine innovation, Creative Constructive Leader**:** Outward looking, view innovation as the competitive weapon, Embrace being different, short and long –term innovation opportunities. **(08Hours)**

Module – 2

Innovative Cultures: Tolerance for failure, willingness to experiment, psychological safety, collaboration, tolerance for failure, willingness to experiment, psychologically safe, Collaborative, flat but with strong leadership.
Critical Thinking: The basics of critical thinking, Creative critical thinking, benefits of critical thinking, guidelines for critical thinking, Elements of critical thinking, how to develop critical thinking skills. Barriers to critical thinking. **(08Hours)**

Module – 3

Problems Analysis: Blind spot knowledge and awareness, Ishikawa diagram. problem clarification according to Kepner. Innovation as hunt for problems and solutions, Mix the Gene pool workforce, learn through analogies, challenge sacred assumptions, experiment and iterate.

Creative Process: Preparation, incubation, illumination and ideation. Success factor for creative process, Intuitive creative techniques, Systematic-analytical techniques, Theory of inventive problem solving(TRIZ), introduction, increasing the degree of ideality, increased dynamics and controllability.

(8 Hours)

Module – 4

Synthesis: Innovation as synthesis, building a capacity for synthesis, Develop and retain the synthesis, Process: design for exploration and experimentation, Organizational structure, Understanding collaboration in design.

Design Process: Engineering Design Process, Pahl and Beitz's model of the design process, Engineering design interface, Levels of design: Visceral design, behavioral design, and reflective design. Empathetic design and its role in design, mind map on innovation culture**. (8 Hours)**

Module – 5

Product Development: Characteristics of successful product development, who designs and develops of products, ergonomics and aesthetics, Agility in product development, The Scrum Guide for product development, Design Heuristic.

Building Prototype: Understanding, types of prototypes, purpose of prototypes: Learning, communication, integration and milestones. Principles of prototyping, Free-form fabrication. Lean startup method for prototype development: Principles and benefits, how to lean Startup, Kano Model. **(8 Hours)**

Course outcomes: The students will be able to:

CO 1: Summarize innovation and innovation portfolio.

CO2: Develop innovative culture and critical thinking.

CO 3: Discuss problems analysis and creative process.

CO4: Describe synthesis and concept generation and product design

CO 5: Illustrate product development and prototype.

Textbooks:

1. Gary P. Pisano, Creative Construction: DNA of Sustained Innovation, BBS Public Affairs, New York, 2019
2. Karl T. Ulrich, Steven D. Eppinger, Product Design and Development, McGraw-Hill Higher Education, 2016.

Reference Books:

1. Steven Schuster, The Critical Thinker, Jaico Publishing House, 2022
2. Ken S. Hurst, Engineering Design Principles, Elsevier Ltd, 2010.
3. Christian Mueller-Rotorberg, Handbook of Design Thinking, Copyright© 2018 Christian Mueller-Rotorberg

B.E MECHANICAL ENIGINEERING
Choice Based Credit System (CBCS)
Open Elective Course

Fundamentals of Automotive Technology (3:0:0) 3
(Effective from the academic year 2022-2023)

Course Code	**21ME752**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**(3:0:0)**	CIE Marks	**50**
Total Number of Lecture Hours	**03**	SEE Marks	**50**
Examination nature (SEE)	**Descriptive**	Exam Hours	**03**

Course Objectives:

This course will enable students to:

- Understand the layout and arrangement of principal parts of an automobile.
- Understand the working of transmission and brake systems.
- Comprehend operation and working of steering and suspension systems.
- Analyze the Injection system and its advancements.
- Enumerate the automobile emissions and its effects on environment

Preamble: The course gives an insight to the various parts and functioning of the automobile. The functioning of the automobile systems like transmission, steering, ignition etc are highlighted to ensure that the student gets an overall picture of the working of the automobile. The prevention of emission and the government regulations pertaining to emissions are also discussed along with the recent advancements in automotive technology.

Module – 1

Engine Components And It's Principle Parts: Spark Ignition (SI) & Compression Ignition (CI) engines, cylinder – arrangements and their relatives merits, Liners, Piston, connecting rod, crankshaft, valves, valve actuating mechanisms, valve and port timing diagrams, Types of combustion chambers for S.I.Engine and C.I.Engines, methods of a Swirl generation, engine positioning. Concept of HCCI engines, Hybrid engines, Twin spark engine, Electric car.

Cooling And Lubrication: Cooling requirements, Types of cooling- Thermo siphon system, Forced circulation water cooling system, Water pump, Radiator, Significance of lubrication, Splash and Forced feed **(08 hours)**

Module-2

Transmission Systems: Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints. Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

Brakes: Types of brakes, mechanical compressed air, vacuum and hydraulic braking systems, construction and working of master and wheel cylinder, brake shoe arrangements, Disk brakes, drum brakes, Antilock – Braking systems, purpose and operation of antilock-braking system, ABS Hydraulic Unit, Rear-wheel antilock, & Numerical

(08 hours)

Module-3

Steering And Suspension Systems: Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Suspension, Torsion bar suspension systems, leaf spring, coil spring, independent suspension for front wheel and rear wheel, Air suspension system.

Ignition System: Battery Ignition system, Magneto Ignition system, electronic Ignition system**.**

(08hours)

Module-4

Superchargers And Turbochargers: Naturally aspirated engines, Forced Induction, Types of superchargers, Turbocharger construction and operation, Intercooler, Turbocharger lag.

Fuels, Fuel Supply Systems For SI And CI Engines: Conventional fuels, Alternative fuels, Normal and Abnormal combustion, Cetane and Octane numbers, Fuel mixture requirements for SI engines, Types of carburetors, C.D.& C.C. carburetors, Multi point and Single point fuel injection systems, fuel transfer pumps, Fuel filters, fuel injection pumps and injectors. Electronic Injection system, Common Rail Direct Injection

(08 hours)

Module-5

Title of the chapter

Automotive Emission Control Systems: Different air pollutants, formation of photochemical smog and causes. Automotive emission controls, Controlling crankcase emissions, Controlling evaporative emissions, Cleaning the exhaust gas, Controlling the air-fuel mixture, Controlling the combustion process, Exhaust gas recirculation, Treating the exhaust gas, Air-injection system, Air-aspirator system, Catalytic converter.

Emission Standards: Euro I, II, III and IV norms, Bharat Stage II, III, IV, VI norms. Motor Vehicle Act.

(08 hours)

Course Outcomes:

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

CO 1: Recognize the various parts of an automobile and its functioning.
CO 2: Illustrate the working principle of various automobile system**.**
CO 3: Comprehend the knowledge of steering,ignition,suspension and transmission systems
CO 4: Analyze the fuel injection systems and its advancements.
CO5: Appraise the importance of various emission norms and the methods of controlling emission

B.E MECHANICAL ENIGINEERING

Choice Based Credit System (CBCS)

Open Elective Group – II

Smart Manufacturing (3:0:0) 3

(Effective from the academic year 2021-2022)

Course Code	**21ME753**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Lecture Hours	**40**	SEE Marks	**50**
Examination Nature (SEE)	**Descriptive**	Exam Hours	**03**

Course objectives:

This course will enable students:

1. To get acquainted with the basic aspects of Industry 4.0.
2. To comprehend predictive analytics and IoT for value creation.
3. To understand supportive technologies in industry 4.0 their interactions and functions.
4. To impart knowledge of cyber security and smart factories to know its importance in digital transformation.

Preamble: Industry 4.0 is an example of efficiency and innovation. This ground-breaking idea is the result of combining advanced digital technology with conventional manufacturing techniques to create networked systems that enable previously unheard-of degrees of automation, data sharing, and real-time decision-making. The Internet of Things (IoT), cloud computing, cognitive computing, and cyber-physical systems are all coming together to form Industry 4.0, which is completely transforming industrial production and administration.

Module – 1

Introducing Industry 4.0: why industry 4.0, Characteristics of Industry 4.0, The Value Chain, Differential Prospective, Benefits to Business, Design Principles, Building Blocks of Industry 4.0, Reference Architecture, Smart Manufacturing, Axioms, The Solution Space, The Fabrication Space, and The IoT Space.

(08 hours)

Self-study component: History of Industrial Revolutions

Module – 2

Data Analytics in Manufacturing: Introduction, Power Consumption in Manufacturing, Anomaly Detection in Air Conditioning, Smart Remote Machinery Maintenance Systems with Komatsu, Quality Prediction in Steel Manufacturing, Predicting Drilling Efficiency, Estimation

Internet of Things and New Value Proposition: Introduction, Internet of Things (IoTs), Examples for IoT Value Creation in Different Industries, IoTs Value Creation Barriers: Standards, Security, Privacy Concerns.

(08 hours)

Self-study component: Neural Networks used in Predictive Analytics

Module – 3

Additive Manufacturing Technologies and Applications: Introduction, Additive Manufacturing (AM) Technologies, Application Areas of Additive Manufacturing, Impact of Additive Manufacturing Techniques on Society.

Advances in Robotics in the Era of Industry 4.0: Introduction, Recent Technological Components of Robots- Advanced Sensor Technologies, Internet of Robotic Things, Cloud Robotics, and Cognitive Architecture for Cyber-Physical Robotics, Industrial Robotic Applications-

Manufacturing, Maintenance and Assembly.

(08 hours)

Self-study component: Part building errors in AM

Module – 4

The Role of Augmented Reality in the Age of Industry 4.0: AR Hardware and Software Technology, Industrial Applications of AR, Maintenance, Assembly, Collaborative Operations, Training.

Digital Traceability Through Production Value Chain: Digital Traceability Technologies, Applications, Project Management in Digital Traceability

(08 hours)

Self-study component: Local connectivity for industries

Module – 5

Smart Factories: Introducing the Smart Factory, Smart Factories in Action, Why Smart Manufacturing Is Important, Winners and Losers? Real-World Smart Factories.

The Way Forward Getting From Here to There: Digital Transformation, Transforming Operational Processes, Transforming Business Models, Develop New Business Models, Adopt Smart Architectures and Technologies.

(08 hours)

Self-study component: Impact of smart factories on economy.

Course outcomes: The students will be able to:

CO 1: Understand the fundamentals of industry 4.0

CO 2: Apply the concept of industry 4.0, its technologies, and data analytics to solve problems in industries.

CO 3: Analyse industry 4.0 systems to deliver better productivity.

CO 4: Analyse the impact of cyber security and smart factories.

Textbooks:

1. Alp Ustundag, Emre Cevikcan, "Industry 4.0: Managing The Digital Transformation", 1st Edition, Springer, 2018.
2. Alasdair Gilchrist, "Industry 4.0-The Industrial Internet of Things", 1st Edition, Apress, 2016.

Reference Books:

1. Christoph Jan Bartodziej, "The Concept Industry 4.0", 1st Edition, Springer Gabler, 2017.
2. UNIDO team members, "Industry 4.0- Opportunities Behind The Challenge", UNIDO, UNIDO General conference, 2017.

B.E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS)
Open Elective Course - II

Organization Behavior (3:0:0) 3
(Effective from the academic year 2021-2022)

Course Code	**21HSS71**	Semester	**VII**
Teaching Hours/Week (L:T:P)	**3:0:0**	CIE Marks	**50**
Total Number of Contact Hours	**40**	SEE Marks	**50**
Examination nature (SEE):	**Descriptive**	Exam Hours	**03**

Course objectives:

This course will enable students to:

1. To know and recognize the importance of human behaviour at work in organizations.
2. To relate human behaviour with learning and demonstrate how the two go together.
3. To recognize the importance of motivation in learning and other performance attributes.
4. To know and locate the importance of group interactions and group behaviour in organizations.
5. To manage and resolve conflicts through effective communication

Preamble: Oorganizational behaviour and its impact focuses on the individual factors such as personality, attitude, learning, perception, motivation and ability with respect to organizational behaviour and commitment

Module – 1

Historical development, Environmental context (Information Technology and Globalization, Diversity and Ethics, Design and Cultural, Reward Systems).The Individual: Foundations of individual behaviour, individual differences. Ability. Attitude, Aptitude, interests. Values – Types of Values, hanging Values. **(08 Hours)**

Module – 2

Learning: Theories of learning, individual decision making, classical conditioning, operant conditioning, social learning theory, continuous and intermittent reinforcement. Perception: Definition, Factors influencing perception, attribution theory, selective perception, projection, stereotyping, Halo effect. **(08Hours)**

Module – 3

Motivation: Maslow's Hierarchy of Needs theory, Mc-Gregor's theory X and Y, Hertzberg's motivation Hygiene theory, David Mc-Clelland's three needs theory, Victor Vroom's expectancy theory of motivation. **(08 Hours)**

Module – 4

Groups Behavior:

Classification of groups, Factors affecting group formation, stages of group development, Norms, Hawthorne studies, group processes, group tasks, group decision making. **(08 Hours)**

Module – 5

Conflict & Stress Management: Functional and dysfunctional conflict, stages of conflict process. Sources of stress, fatigue and its impact on productivity. Job satisfaction, job rotation, enrichment, job enlargement and reengineering work process.

Communication: Principles of Communication: Useful definitions, communication principles, communication system, role of communication in management, barriers in communication, how to overcome the barriers, rule of effective communication. **(08 Hours)**

Course outcomes:

This course will enable students to:

1.Illustrate human behavior at work.

2. Analyse how learning depends on behavioral aspects.

3. Describe Value motivation and work and demonstrate their motivational skills.

4. Asses to manage organizational conflict and be able to produce results

Textbooks:

1. Organizational Behaviour, Stephen P Robbins, 9th Edition, Pearson Education Publications, ISBN-81-7808-561-5 2002.
2. Organizational Behaviour, Fred Luthans, 9th Edition, Mc Grew Hill International Edition, ISBN-0-07-04-002.

Reference Books

1. Organizational Behaviour, Aswathappa - Himalaya Publishers, 2001.
2. Organizational Behaviour, (Human behaviour at work) 9th Edition, John Newstron/ Keith Davis, 2002.
3. Organizational Behaviour,Hellriegel, Srocum and Woodman, Thompson Learning, 9th Edition, Prentice Hall India, 2001.
4. Organizational Behaviour, VSP Rao and others, Konark Publishers, 2002.

B. E. MECHANICAL ENGINEERING
Choice Based Credit System (CBCS)

ENERGY ENGINEERING (3:0:0) 3
(Effective from the academic year 2021-22)

Course Code	**21ME745**	Semester	**VII**
Teaching Hours/Week (L: T:P)	**3:0:0**	CIE Marks	**50**
Total Number of lecture hours	**03**	SEE Marks	**50**
Examination nature	**Descriptive**	Exam Hours	**03**

Course Objectives:

This course will enable students to:

1. Understand the working of coal handling, ash handling and various boilers for the steam generation.
2. Learn about various energy sources such as solar energy, biomass energy, geothermal energy, tidal energy, wind energy and OTEC.
3. Study the principles of energy conversion systems.
4. Understand the different types and working of hydro-electric power plant.
5. Know the different components of nuclear reactor, hazards, nuclear wastes and their disposal methods.

Preamble:

Energy sector is critical for socio-economic development. In the Indian context, the challenge is to provide affordable energy services. This broad field of engineering deals with energy efficiency, energy services, facility management, environmental compliance, and alternative energy technologies.

Module-1

Steam generators: Coal handling and ash handling, generation of steam using high pressure boilers: La Mont, Benson, Velox, Loeffler, Schmidt-Hartmann boiler, Cooling towers and ponds, boiler accessories such as economizers, air preheaters, super-heaters, and reheaters.

(08 Hours)

Self-Study Component: Efficiency assessment and improvement measures for thermal power plants in India.

Module-2

Solar Energy: Introduction, solar radiation at the earth's surface, solar radiation measurements, flat plate collectors, focusing collectors, solar pond, solar photo-voltaic cell.

Biomass Energy: Photosynthesis, photosynthetic oxygen production, energy plantation.

Bio Chemical Route: Biogas production from organic wastes by anaerobic fermentation, bio gas plants-KVIC, Janata, Deenbhandu models, factors affecting bio gas generation, thermal gasification of biomass, updraft and downdraft gasifiers.

(08 Hours)

Self-Study Component: Generation of bio mass energy using agricultural residues.

Module-3

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

Tidal energy: tidal power, site selection, single basin and double basin systems, advantages and

disadvantages of tidal energy.

Wind energy: wind energy-advantages and limitations, horizontal and vertical axis wind mills, coefficient of applications of wind energy.

(08 Hours)

Self-Study Component: Resources and utilization of geo thermal energy in India.

Module-4

Hydroelectric plants: classification of hydroelectric plants, storage and pondage, hydrographs, flow duration curve, mass curve, numerical, general layout of hydel power plants – components such as penstock, surge tanks, spill way, water hammer, draft tube and their applications, advantages, disadvantages of hydroelectric power plants.

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

(08 Hours)

Self-Study Component: The present status and features of OTEC (Ocean Thermal Energy Conversion) system.

Module-5

Nuclear Energy: principles of release of nuclear energy, fusion and fission reactions, nuclear fuels used in the reactors, general components of nuclear reactor and materials, brief description of pressurized water reactor, boiling water reactor, liquid metal cooled reactor, fast breeder reactor, homogeneous graphite reactor, gas cooled reactor, reactor shielding, radiation hazards, radioactive waste disposal, advantages and disadvantages of nuclear power plants

(08 Hours)

Self-Study Component: Purposes, benefits, opportunities and challenges with reference to nuclear power development.

Course Outcomes:

The student will be able to:

CO1: Summarize the construction and working of steam generators and their accessories.

CO2: Identify the various renewable energy sources and their utilization.

CO3: Illustrate the principles of energy conversion from alternative sources including solar, biomass, geothermal, tidal and wind energy.

CO4: Analyze the working of hydroelectric power plants and various curves like hydrographs, flow duration curve and mass curve.

CO5: Interpret the principle of nuclear energy generation, nuclear hazards and waste disposal system.

Textbooks:

1. R.K.Rajput, "Power Plant Engineering", 5th Edition, Laxmi publications, 2016.
2. Arora and Domkundwar, "Power Plant Engineering", 6th Edition, Dhanpat Rai & Co publications, 2012.
3. G.D.Rai, "Non-conventional Sources of Energy", 5th edition, Khanna Publishers, 2015.

Reference Books:

1. P. K. Nag, "Power Plant Engineering", 3rd edition, Tata McGraw Hill publications, 2012
2. P B Nagaraj, **"**Energy Engineering", 1st edition, Sudha publications, 2008.
3. M.M.El-Wakil", "Power Plant Technology", 1st edition, Mc-Graw Hill Educations, 2017.