5thSemester

HSMS Management & Entrepreneurship		Semester	5
Course Code	**BAU501**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- Explain management functions of a manager. Also explain planning and decision-making processes, organizational structure, staffing and leadership processes, understanding of motivation and different control systems in management.
- Identify various types of supporting agencies and financing available for an entrepreneur
- Prepare project report and decide selection of industrial ownership.

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby plants, start -up ecosystem, incubation centers or MSME industries to give information about the industry culture and demand.
3. Show Video/animation films to explain functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

Management: Introduction - Meaning - nature and characteristics of Management, Scope and Functional areas of management - Management as art or science, art or profession - Management & Administration - Roles of Management, Levels of Management, Development of Management Thought - early management approaches - Modem management approaches.

Planning: Nature, importance and purpose of planning process objectives - Types of plans (meaning only) - Decision making, Importance of planning - steps in planning & planning premises - Hierarchy of plans.

Module-2

Organizing and Staffing: Nature and purpose of organization, Principles of organization – Types of organization-Departmentation Committees-Centralization Vs Decentralization of authority and responsibility - Span of control Nature and importance of staffing: Process of Selection & Recruitment (in brief).

Controlling & meaning and steps in controlling - Essentials of a sound control system - Methods of establishing control (in brief). **Directing:** Meaning and nature of directing Leadership styles, Motivation, Theories, Communication -Meaning and importance - coordination, meaning and importance and Techniques of coordination.

Module-3

Entrepreneur: Meaning of Entrepreneur; Functions of an Entrepreneur, Types of Entrepreneurs, Entrepreneur - an emerging. Class. Concept of Entrepreneurship Stages in entrepreneurial process; Role of entrepreneurs in Economic Development; Entrepreneurship in India; Entrepreneurship - its Barriers.

Module-4

Planning a Start-up Enterprise: Forms of business organization/ ownership; Financing new enterprises – sources of capital for early-stage technology companies; Techno-Economic Feasibility Assessment; Preparation of Business Plan for grants, loans and venture capital. Operational Issues for new enterprises: Financial management issues;

Operational/ project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

Module-5

Small Scale Industries: Definition; Characteristics; Need and rationale; Objectives; Scope; role of SSI in Economic Development. Advantages of SSI, Steps to start and SSI - Government policy towards SSI; Ancillary Industry and Tiny Industry (Definition Only).

Institutional support: Different Schemes; TECKSOK; KIADB; KSSIDC; KSIMC; DIC Single Window Agency; SISI; NSIC; SIDBI; KSFC.

Industrial ownership: Definition and meaning of Partnership, Characteristics of Partnership, Kinds of Partners, Partnership Agreement or Partnership Deed, Registration of Partnership Firm, Rights, Duties and Liabilities of Partners, Advantages and Disadvantages of Partnership, Sole Proprietorship, Features, Scope

Course outcome (Course Skill Set)

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

1. Understand functions, structure, functional areas and processes of management
2. Identify various types of supporting agencies and financing available for an entrepreneur.
3. Understand and plan a start-up ecosystem /enterprise
4. Prepare project report and decide on industrial ownership.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Principles of Management P. C. Tripathi, P.N. Reddy, Tata McGraw Hill., 6th edition, 2017
2. Management Fundamentals Concepts, Application, Skill Development, RobersLusier, Thomson., South western Cengage learning USA, 2012
3. Entrepreneurship Development S. S. Khanka S. Chand & Co. New Delhi. 2015.

Web links and Video Lectures (e-Resources):

1. Management and Entrepreneurship MSc - Cranfield University
2. https://library.shu.edu/entrepreneurship.
3. https://library.soton.ac.uk/business
4. https://www.startupindia.gov.in/content/sih/en/startup-scheme.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Identify the schemes and the support for start-up ecosystem by GOI- https://startuptalky.com/list-of-government-initiatives-for-startups/
2. **Business Simulation Game:** Introduce students to a business simulation game that simulates the operation of a company in a competitive market environment.
3. **Role-Playing Exercises:**
   Objective: Understand different managerial roles and develop problem-solving skills.
   Activity: Role-play scenarios such as conflict resolution, negotiation, or team management.
4. **Entrepreneurship Projects**
   Objective: Experience the lifecycle of a business.
   Activity: Students start and run a small business or social enterprise.
5. **Guest Lectures and Interviews**
   Objective: Gain insights from industry experts.
   Activity: Invite successful entrepreneurs and business managers to share their experiences.

IPCC **Fundamentals Of Electrical Vehicles**		Semester	5
Course Code	**BAU502**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	3
Examination nature (SEE)	Theory		

Course objectives:

- Learn and compute the drive train requirements and vehicle performance parameters
- Basics of vehicle dynamics and power and torque calculations
- Understand the battery basics of EVs and the traction control mechanisms
- Understand the concepts of fuel cell and its application as an alternate energy source

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby power plants, receiving station and substations to give brief information about the electrical power generation.
3. Show Video/animation films to explain functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

MODULE-1

Vehicles and Energy Sources , Electro mobility and the Environment , A Brief History of the Electric Powertrain , Energy Sources for Propulsion and Emissions , Carbon Emissions from Fuels, Greenhouse Gases and Pollutants, The Impact of NOx , Drive Cycles, EPA Drive Cycles , BEV Fuel Consumption, Range, and mpge, Carbon Emissions for Conventional and Electric Powertrains,

An Overview of Conventional, Battery, Hybrid, and Fuel Cell Electric Systems, Conventional IC Engine Vehicle , BEVs, HEVs , Series HEV , Parallel HEV, Series-Parallel HEV, FCEV , A Comparison by Efficiency of Conventional, Hybrid, Battery and Fuel Cell Vehicles,

MODULE-2

Vehicle Dynamics:

Vehicle Dynamics: Traction force, Forces acting on a vehicle in motion and traction power Forces acting on a vehicle in motion, Aerodynamic drag, Rolling Resistance and uphill Resistance, Power and Torque to accelerate: , Power required for acceleration (pick-up), Average Power required for acceleration, Average Power required for acceleration, Numerical on 2W, 4W EVs

Vehicle Acceleration :

Regenerative Braking of the Vehicle, Traction Motor Characteristics, Acceleration of the Vehicle Time-Step Estimation of Vehicle Speed , A Simplified Equation Set for Characterizing Acceleration by Ignoring Load

MODULE-3

Batteries

Introduction to Batteries , Batteries Types and Battery Packs, Recent EVs and Battery Chemistries , Basic Battery Operation, Basic Electrochemistry, Lead-Acid Battery , Nickel-Metal Hydride, Lithium-Ion , Units of Battery Energy Storage , Capacity Rate, Battery Parameters and Comparisons , Cell Voltage, Specific Energy , Cycle Life, Specific Power, Self-Discharge, Lifetime and Sizing Considerations, Examples of Battery Sizing, BEV Battery Sizing and PHEV Battery Sizing , Battery Pack Discharge Curves and Aging ,

Battery Charging,

Protection, and Management Systems , Battery Charging , Battery Failure and Protection , Battery Management System , Battery Models, A Simple Novel Curve Fit Model for BEV Batteries , Voltage, Current, Resistance, and Efficiency of Battery Pack Numerical Examples on determining the Pack Voltage Range for a BEV, A Simple Curve-Fit Model for HEV Batteries , Determining the Pack Voltage Range for a HEV Charging , , Determining the Cell/Pack Voltage for a Given Output\Input Power , Numerical Examples on Battery Discharge, Battery Charge , Cell Energy and Discharge Rate, Cell Capacity

MODULE-4

Introduction to Traction Machines

Propulsion Machine Overview: DC Machines, AC Machines, Comparison of Traction Machines; Machine Specifications - Four-Quadrant Operation, Rated Parameters , Rated Torque, Rated and Base Speeds, Rated Power, Peak Operation, Starting Torque, Numerical Examples

Characteristic Curves of a Machine, Constant-Torque Mode, Constant-Power Mode, Maximum-Speed Mode, Efficiency Maps, Conversion Factors of Machine Factor units, Numerical Examples

MODULE-5

Fuel Cells

Introduction to Fuel Cells -: Fuel Cell Vehicle Emissions and Upstream Emissions, Hydrogen Safety Factors; Basic Operation - Fuel Cell Model and Cell Voltage, Power and Efficiency of Fuel Cell and Fuel Cell Power Plant System, Fuel Cell Characteristic Curves ; Sizing the Fuel Cell Plant, Balance of Plant, Boost DC-DC Converter, Fuel Cell Combination, Fuel Economy of Fuel Cell Electric Vehicle

Conventional and Hybrid Powertrains

Introduction to HEVs, Brake Specific Fuel Consumption, Energy Consumption, Power Output, Efficiency, and BSFC

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl. NO	Experiments
1	A Case Study Comparison of Conventional, Hybrid, Battery, and Fuel Cell Vehicles
2	A Comparison of Automotive and Other Transportation Technologies
3	Demonstration of wiring layout of electric vehicle,
4	Construction of IDC and MIDC for a typical 2-wheeler in a Spread-sheet
5	Construction of IDC and MIDC for a typical 4-wheeler in a Spread-sheet
6	Construction of IDC and MIDC for a typical mini -truck in a Spread-sheet
7	Control/ voltage control of an electric vehicle
8	Control circuit of induction motor
9	Can be Demo experiments for CIE-Experiment for conversion of DC to DC voltage using converter
10	Can be Demo experiments for CIE-Simulation for AC to DC Conversion

11	**Can be Demo experiments for CIE**-Study of 3 phase Induction motor
12	**Can be Demo experiments for CIE**: Demonstration of layout of Fuel cell electric vehicle

Course outcomes (Course Skill Set):

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

- Understand the basic requirements of an electric vehicle like dynamics, performance parameters, batteries, traction control and fuel sell as an alternative power source.
- Analyse the design parameters of vehicle dynamics and apply the same to arrive at power and torque requirement, battery/fuel cell type and requirement of different segments of EVs,
- Apply the basics of vehicle dynamics, batteries and fuel cell to calculate the performance parameters, the capacity of the cell and the traction controllers.
- Design a small battery pack and test run using a small vehicle prototype.

Assessment Details (both CIE and SEE)

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

The IPCC means the practical portion integrated with the theory of the course. CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.

CIE for the theory component of the IPCC

- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

- The minimum marks to be secured in CIE to appear for SEE shall be 10 (40% of maximum marks-25) in the theory component and 10 (40% of maximum marks -25) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 sub-questions are to be set from the practical component of IPCC, the total marks of all questions should not be more than 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify for the SEE. Marks secured will be scaled down to 50.

The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Suggested Learning Resources:

Books

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, CRC Press, 2018, II Edition.
2. Electric Powertrain- Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles

John G. Hayes ,University College Cork, Ireland ,G. Abas Goodarzi, US Hybrid, California, USA, © 2018 John Wiley & Sons Ltd

Web links and Video Lectures (e-Resources):

1. Introduction to Hybrid and Electric vehicles by Dr. Praveen Kumar and Prof. S. Majhi (IIT Guwahati),
2. NPTEL Course (https://nptel.ac.in/courses/108/103/108103009/).

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **EV Component Analysis**
   Objective: Understand the key components of electric vehicles.
   Activity: Disassemble and analyse an electric vehicle model or component.
2. **Battery Management System (BMS) Workshop**
   Objective: Learn about battery management and safety.
   Activity: Conduct a workshop on designing and testing a BMS.
3. **Design a small battery pack and test run using a small vehicle prototype.**
4. **Construction of IDC and MIDC for a typical 2-wheeler/4 -wheeler and minitruck in a Spreadsheet**
5. **EV Charging Infrastructure Design**
   Objective: Learn about EV charging technologies and infrastructure.
   Activity: Design a charging station network for a given area.

PCC **Design of Automobile components**		Semester	5
Course Code	**BAU503**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	4:0:0	SEE Marks	50
Total Hours of Pedagogy	50 Theory+ Practice	Total Marks	100
Credits	04	Exam Hours	3
Examination nature (SEE)	Theory		

Course objectives:

- Define and explain basic terms related to the design of machine elements.
- Design various machine elements.
- Calculate specifications of springs/gears/clutches.
- Select a suitable size, module & type of gears for a required velocity ratio.
- Design various internal combustion engine parts.

Teaching-Learning Process (General Instructions)

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

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only the traditional lecture method. Still, different teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby automobile component manufacturing plants and other OEMs to give brief information about the design aspects of automobile components.
3. Show Video/animation films to explain the functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher-order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than recall it.
7. Topics will be introduced in multiple representations.
8. Show the different ways to solve the same problem and encourage the students to come up with creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the= students' understanding.
10. Individual teachers can devise innovative pedagogy to improve teaching-learning.

MODULE-1

Introduction: Designation and Mechanical Properties of Engineering Materials, design considerations, basic design concept (strength consideration), Failure of brittle materials, Failure of ductile materials, design of simple machine members subjected to static loading (including eccentric load) [limited to biaxial stresses].

Theories of Failure: Maximum normal stress theory, Maximum shear stress theory.

Design for fatigue strength: fatigue and endurance limit, S-N Diagram, Low & High cycle fatigue, modifying factors: load, size and surface factors, Soderberg and Goodman relationship

MODULE-2

Design of Simple Machine Elements: Design of Knuckle joints. Design of keys, design of flange type of rigid coupling.

Design of Shaft: shafts subjected to combined bending and twisting, shaft design based on strength & torsional rigidity, ASME code for shaft design, Torsion in shafts, torsional moment of resistance, twist in shaft sections.

Shear forces & bending moments: Shear forces and bending moments introductions, shear forces and bending moments of cantilever beams subjected to udl,uvl and point loads

MODULE-3

Springs: Introduction, types of springs, terminology, stresses and deflection in helical coil springs of circular and non-circular cross-sections, springs under fluctuating loads, concentric springs. Leaf Springs: stresses in leaf springs, equalized stresses and length of spring leaves.

Clutches & Brakes: Introduction, design of Clutches (single plate, multi-plate clutches). Brakes, energy absorbed by a brake, heat dissipated during braking, design of brake shoes.

MODULE-4
Connecting Rod: Length of the rod, Cross-section, Buckling, drilled connecting rods, piston pin bearing, offset connecting rods, effects of whipping, bearing materials and lubrication, calculation of significant dimensions. **Crank Shaft:** Balance weights, local balance, Crankshaft proportions, oil holes drilled in crank shafts, balancing, vibration-dampers, firing order, bearings and lubrication Types of crank shafts, design of the centre crank shaft, moments on crank shafts, centre crank shaft at TDC, centre crank shaft at an angle of maximum torque. Design of side crankshaft (overhang), side crank shaft at TDC, side crank shaft at an angle of maximum torque, calculation of significant dimensions.
MODULE-5
Fundamentals of Battery Pack Design for EV: Battery Pack Development Process, Stages of Battery Pack Design, Major Components of a Battery Pack, Electrical Design of Battery Pack, Type of Cell and Hierarchy of a Battery Pack, Making Modules from Cells, Assembling Modules to Make Pack, Design Criteria, Busbar sizing, Busbar Sizing for 2P Cells, Current Equalization in Parallel Path **Mechanical Design of Battery Pack:** Calculating pack capacity, Forces on the Battery Pack, Base Plate Thickness Calculations, Base Plate Calculations, Battery Swelling, Thermal management, Structural stability, Vibrations in battery pack, **Thermal Design of Battery Pack,** Required Functions of Thermal Design, Battery Pack Temperature Considerations, Heat Generation in Battery Pack, Heat Load Determination, Active Thermal Management, Selection of a Thermal Management Method, Passive Thermal Management, PCM Mass Calculation

Course outcome (Course Skill Set)

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

- Understand and explain the working of machine elements and EV component.
- Identify vital IC engine and EV components.
- Analyse the design considerations of ICE and EV components.
- Apply the fundamentals to design basic components of IC engine and EVs.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.

Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

Design Data Hand Books:

1. Design Data Hand Book K. Mahadevan and K. Balaveera Reddy, CBS, Publication. 4th edition
2. Design Data Hand Book K. Lingaiah McGraw Hill, 2nd Ed. 2003.
3. Lecture notes of NPTEL course "Electric Vehicles and Renewable Energy " for Module 5

Text books:

1. Mechanical Engineering Design Joseph E Shigley and Charles R. Mischke McGraw Hill Int. edition. 2003
2. Design of Machine Elements V. B. Bhandari Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.
3. Strength of Materials, S.S. Bhavikatti, Vikas Publications house, Pvt. Ltd. 2006

Reference Books:

1. Machine Design- Norton Robert L. Pearson Education Asia 2001.
2. Machine Design Hall, Holowenko, and Laughlin, Tata McGraw Hill Publishing Company Ltd, 2010

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=mzWMdZZaHwI
2. https://youtu.be/rK6Bey_loiw?si=RJPKYY2nz9e72pFg

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning.

1. Laboratory activities related to design laboratory
2. **Collaborative Design Projects:** Foster collaboration among students by assigning group design projects that require them to work together to conceptualize, design, and prototype automobile components or EV battery pack configurations.
3. **Component Analysis and Reverse Engineering**
   Objective: Understand the design and function of various automobile components.
   Activity: Disassemble and analyze automobile components such as engines, transmissions, and suspension systems.
4. **CAD Design Projects**
   Objective: Develop skills in computer-aided design (CAD) for automobile components.
   Activity: Design a specific automobile component using CAD software (e.g., SolidWorks, CATIA).
5. **Finite Element Analysis (FEA)**
   Objective: Understand the stress and strain analysis of automobile components.
   Activity: Perform FEA on designed components to evaluate their performance under various conditions.

PCCL Automotive Engine Components Lab		Semester	5
Course Code	**BAU504**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2	SEE Marks	50
Total Hours of Pedagogy	12-14 sessions	Total Marks	100
Credits	1	Exam Hours	3

Course objectives:

- To study the hand tools, understand the application of materials and to write technical specifications of all types of engines
- Dismantling and assembling of SI and CI engines for dimension comparison, wear and tear inspection
- Calculate and compare the brake power, torque and mechanical efficiency of IC Engine and electrical motor of same configuration.
- Study the speed control of different types of electric drives/motors used in Electric Vehicles.

Sl. NO	Experiments
1	Study of Hand tools- sketching , material and their application
2	Writing Technical specifications and description of all types of engines
3	Dismantling and assembly of engines (SI and CI), identification of major components, and inspection of different components for wear, cracks, measurement and comparison of dimensions of major components with standard
4	Compression and vacuum test on diesel and petrol engines.
5	Assembly and Disassembly of Electric Motors
6	Speed control of DC motor using IGBT.
7	To perform speed reversal of DC Shunt motor
8	Plot torque-speed curves for different motors to understand their performance characteristics.
9	Voltage/frequency control of 3 phase induction motor
10	Speed control of BLDC Motor in two-wheeler
11	Measure the efficiency of electric motors at different loads and speeds.
12	Measure the efficiency of controllers in converting battery power to motor output.
	Demonstration Experiments (For CIE)
13	Performance test on PEM fuel cell
14	Performance test on DMFC fuel cell
15	Demonstration of controllers and actuators in an electric vehicle
16	Test how controllers handle faults and errors in the system.

Course outcomes (Course Skill Set):

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

- Thorough understanding of major components, their working and location identification of EVs and automobile engines.
- Inspect and analyse the automobile components for functional defectiveness, wear and tear
- Diagnose specific problem and make efforts to find the solution /troubleshooting.
- Compare dimensional specifications of various but similar components of the automobile , both EVs and ICE from various manufacturers

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- **SEE shall be conducted by the two examiners. One from the same institute as an internal examiner and another from a different institute as an external examiner, appointed by the university.**
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.
- General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)
- Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

- NPTEL course. You tube videos

PEC **Propulsion System for Electric and Hybrid Vehicles**		Semester	5
Course Code	**BAU515A**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination type (SEE)	Theory		

Course objectives:

- To provide necessary information/knowledge to students about the energy storage technologies, drive systems, control systems and energy management strategies in electric and hybrid electric vehicles

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby power plants, receiving station and substations to give brief information about the electrical power generation.
3. Show Video/animation films to explain functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class.
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters student's Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

Energy Storage Technologies:

Battery Systems- Lead-acid, Nickel metal hydride, Lithium ion.

Capacitor Systems- Symmetrical ultra-capacitors, Asymmetrical ultra-capacitors, Ultra-capacitors combined with batteries, Ultra-capacitor cell balancing, Electro-chemical double layer capacitor specification and test;

Hydrogen Storage- Metal hydride, High pressure gas. Flywheel systems; Pneumatic systems.

Module-2

Electric Drive System Technologies:

Electric motors – Permanent Magnets, Brushless Machines, Interior Permanent Magnet, Asynchronous Machine, Variable Reluctance Machine, Relative Merits of Electric Machine Technologies. Hub motors - Construction and uses.

Electric Drive Trains - basic calculation of torque and speed for electric vehicle.

Module-3

Electric Drive Control System:

Need - Types – Controller components - DC to DC converter, Alternator - Requirements of the Charging System - Charging System Principles - Charging methods

- **Regenerative power generation methods –** Electric two-wheeler wiring circuit.

Module-4

Hybrid Vehicle Architecture:

Series Configuration, Pre-transmission parallel configuration, post-transmission parallel configuration, Hydraulic post-transmission hybrid, Flywheel systems

Concept of hybrid electric drive train; Architecture of Hybrid Electric Vehicle Architecture- Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains-Torque-Coupling Parallel Hybrid Electric Drive Trains-Speed-Coupling Parallel Hybrid Electric Drive Trains, Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drive Trains

Module-5
Energy Management System: Energy management strategies with optimization techniques used in electric and hybrid electric vehicles. Classification of different energy management strategies. Comparison of different energy management strategies. Implementation issues of energy management strategies.
Course outcome (Course Skill Set) **At the end of the course the student will be able to:** 1. Understand and explain the various energy storage, management systems , drive systems and Architecture of electric and hybrid electric vehicles 2. Differentiate between the working principles of various types of drives , controllers etc used in electric and hybrid electric vehicles 3. Analyse and compare the architecture of electric and hybrid electric vehicles 4. Apply the basics to design basic system parameters of electric and hybrid electric vehicles
Assessment Details (both CIE and SEE) The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together. **Continuous Internal Evaluation:** • There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component. • Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks • Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks) • The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks. **Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.** **Semester-End Examination:** Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).** 1. The question paper will have ten questions. Each question is set for 20 marks. 2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module. 3. The students have to answer 5 full questions, selecting one full question from each module. 4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Modern Electric, Hybrid Electric and Fuel Cell Vehicles – Fundamentals, Theory and Design- Mehrdad Ehsani, Yimin Gao, Sebastian E Gay, Ali Emadi- CRC Press
2. Propulsion Systems for Hybrid Vehicles - John M Miller- The Institute of Engineering and Technology, Stevenage England -2011

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=6H5vtu5_SF4 (types of motors used in EV)
2. https://www.youtube.com/watch?v=k1N2LyXtK-k (battery management system)

https://nptel.ac.in/courses/108106170 (NPTEL Course- Fundamentals of Electric Vehicles: Technology & Economics)

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Building electric bicycles/ mini two-wheeler using kits
2. Industry / field visits
3. Laboratory demonstrations and through experiential learning.

PEC **Principles of Alternative Energies**		Semester	5
Course Code	**BAU515B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

1. To understand role and significance of solar energy.
2. To discuss the importance of Wind Energy.
3. To be aware of the role geothermal energy in the Energy Generation.
4. To know the significance of ocean energy
5. To realize utilization of hydrogen energy and hydroelectric energy

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby power plants, receiving station and substations to give brief information about the electrical power generation.
3. Show Video/animation films to explain functioning of various power generating machines
4. Encourage collaborative (Group Learning) Learning in the class .
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

SOLAR ENERGY

Introduction, Solar constant, Solar radiation measurements, Solar thermal conversion: Basics, Flat plate collectors- liquid and air type. Theory of flat plate collectors, Concentrators:, Solar radiation geometry, solar radiation data, Estimation of average solar radiation

Applications of solar energy: solar water heater, solar dryers, Solar ponds, solar cooling, Solar thermal power generation. Solar photovoltaic: Principle of photovoltaic conversion of solar energy. Solar cells, Solar PV pumps, Solar energy storage options.

Module-2

WIND ENERGY

Introduction, Basic principles of wind energy conversion, the nature of wind, power in the wind, wind energy conversion, wind data and energy estimation, site selection considerations, basic components of WECS, classification of WEC systems, wind energy collectors, horizontal axis machines, vertical axis machines, relative advantages and disadvantages, performances of wind machines, generating systems, Energy storage, applications of wind energy**.**

Module-3

GEOTHERMAL ENERGY

Introduction, estimates of Geothermal power, nature of Geothermal fields, Geothermal sources, hydrothermal resources, vapor dominated power plant, liquid dominated systems, characteristics of ggeothermal steam electric plants, Geopressured resources, heat extraction from hot dry rocks, Magma resources

Prime movers for geothermal energy conversion, advantages and disadvantages of geothermal energy, applications of Geothermal energy**,** Geothermal exploration, operational and environmental problems

Module-4

OCEAN ENERGY

Introduction, Methods of ocean thermal electric power generation, open OTEC system, closed OTEC system, site selection**.**

Principle of Tidal power generation, components of Tidal power plants, operation methods of utilization of Tidal energy site requirements, storage, advantages and limitations of Tidal power.

Wave energy-introduction, advantages and disadvantages of wave energy, energy and power from the waves, wave energy conversion devices.

Module-5

HYDROGEN AND HYDROELECTRIC ENERGY

Hydrogen Energy – introduction and application, General introduction to infrastructure requirement for hydrogen production, storage, dispensing & utilization. Electrochemical: Electrolysis, Photo electro chemical, Hydrogen storage methods, Hydrogen transportation, hydrogen utilization

Small scale hydroelectric stations, classification, components, Design considerations for mini and micro hydel projects, bulb and tube turbine for small scale hydroelectric, advantages and limitations of small-scale hydro electric.

Course outcome (Course Skill Set)

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

1. Understand the role and significance of alternative energy.
2. Explain the basic principles of operation of alternate energy.
3. Identify various energy sources, their major components and their choice based on their availability and magnitude
4. Analyse and apply the basics to design power generating capacities and efficiencies of various forms of alternate energy based plants.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Fundamental of Renewable Energy Sources, Tiwari GN. Ghoshal MK. Narosa Publishers 2007
2. Power Plant Engineering Nag P K Tata McGraw Publishers Hill 2008
3. Solar Energy Sukatme, Tata McGraw Hill Publishers
4. Non Conventional Energy Sources G.D.Rai Khanna Publishers, New Delhi 2011
5. Chemical and Electrochemical Energy Systems, Narayan R. Biswanathan B University Press (India) Ltd. 1998.
6. Present and Future Automotive Fuels Osamu Hairo and Richard K John Wiley and Sons 1988
7. Renewable Energy Resources J W Twidell& A D Weir ELBS, 2006

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=BWqjPHGM5D0&list=PLwdnzlV3ogoUtaGiq-lVJc4CC6x_czs9D
2. https://www.youtube.com/watch?v=mh51mAUexK4&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk
3. https://www.youtube.com/watch?v=7Ry643d3deE&list=PL3QMEfkolRFbGhXveCE7RFDBgY0_gRxkh
4. https://www.youtube.com/watch?v=ie2bm3zHcxA&list=PLbjTnj-t5Gkl95LdB7O3bjUsstn5xg5MU

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Solar Panel Design and Installation: Divide students into groups and task each group with designing a solar panel array for a specific location (e.g., rooftop, solar farm).**
2. **DIY Wind Turbine Construction: Students can work in groups to design and build small-scale wind turbines using PVC pipes, DC motors, and wooden blades.**
3. Tidal Power Simulation: **Using numerical modeling software, students can simulate tidal currents and power generation from tidal turbines.**
4. **Hydrogen Production Experiment:** Students can design and conduct experiments to produce hydrogen gas through electrolysis, biomass gasification, or steam methane reforming.
5. **Geothermal Heat Pump Design:** Assign students the task of designing geothermal heat pump systems for residential or commercial buildings.
6. https://www.teachengineering.org/lessons/view/cub_environ_lesson09

PEC Mechatronics		Semester	5
Course Code	**BAU515C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination type (SEE)	Theory		

Course objectives:

To acquire a strong foundation in science and focus in mechanical, electronics, control, software, and computer engineering, and a solid command of the newest technologies.

- To understand the evolution and development of Mechatronics as a discipline.
- To substantiate the need for interdisciplinary study in technology education
- To understand the applications of microprocessors in various systems and to know the functions of each element.
- To demonstrate the integration philosophy in view of Mechatronics technology
- To be able to work efficiently in multidisciplinary teams.

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby industry, guest lectures, invited talks etc
3. Show Video/animation films
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

Introduction: Scope and elements of mechatronics, mechatronics design process, measurement system, requirements and types of control systems, feedback principle, Basic elements of feedback control systems, Classification of control system. Examples of Mechatronics Systems such as Automatic Car Park system, Engine management system, Antilock braking system (ABS) control, Automatic washing machine.

Transducers and sensors: Definition and classification of transducers, Difference between transducer and sensor, Definition and classification of sensors, Principle of working and applications of light sensors, Potentiometers, LVDT, Capacitance sensors, force and pressure sensors, Strain gauges, temperature sensors, proximity switches and Hall Effect sensors

Module-2

Signal Conditioning: Introduction – Hardware – Digital I/O, Analog to digital conversions, resolution, Filtering Noise using passive components – Registers, capacitors, amplifying signals using OP amps. Digital Signal Processing – Digital to Analog conversion, Low pass, high pass, notch filtering. Data acquisition systems (DAQS), data loggers, Supervisory control and data acquisition (SCADA),

Communication methods. Electro-Mechanical Drives: Relays and Solenoids – Stepper Motors – DC brushed motors – DC brushless motors – DC servo motors – 4-quadrant servo drives, PWM's – Pulse Width Modulation.

Module-3

Microprocessor & Microcontrollers: Introduction, Microprocessor systems, Basic elements of control systems, Microcontrollers, Difference between Microprocessor and Microcontrollers. Microprocessor Architecture: Microprocessor architecture and terminology-CPU, memory and address, I/O and Peripheral devices, ALU, Instruction and Program, Assembler, Data Registers, Program Counter, Flags, Fetch cycle, write cycle, state, bus interrupts. Intel's 8085A Microprocessor.

Module-4

Programmable Logic Controller: Introduction to PLCs, Basic structure of PLC, Principle of operation, input and output processing, PLC programming language, ladder diagram, ladder diagrams circuits, timer counters, internal relays, master control, jump control, shift registers, data handling, and manipulations, analogue input and output, selection of PLC for application.

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

Module-5

Mechatronics in Computer Numerical Control (CNC) machines: Design of modern CNC machines - Machine Elements: Different types of guideways, Linear Motion guideways. Bearings: anti-friction bearings, hydrostatic bearing and hydrodynamic bearings. Re-circulating ball screws.

Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Mechatronics Design process: Stages of design process – Traditional and Mechatronics design concepts – Case studies of Mechatronics systems – Pick and place Robot – Automatic car park barrier.

Course outcomes:

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

CO1: Understand the various components of Mechatronics systems.

CO2: Assess various control systems used in automation.

CO3: Design and conduct experiments to evaluate the performance of a mechatronics system or component with respect to specifications, as well as to analyse and interpret data.

CO4: Apply the principles of Mechatronics design to product design.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Nitaigour , Premchand, Mahalik, ' Mechatronics-Principles Concepts and Applications', Tata McGraw Hill 1stEdition,2003.
2. W.Bolton , 'Mechatronics–Electronic Control Systems in Mechanical and Electrical Engineering', Pearson Education 1stEdition, 2005

Reference Books:

1. 'Mechatronics' HMT Ltd Tata Mc Graw Hill 1st Edition, 2000 ISBN:978007 4636435
2. K.P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram 'Mechatronics: Integrated Mechanical Electronic Systems', Wiley India Pvt. Ltd. New Delhi 2008
3. David G. Aldatore, Michael B. Histand 'Introduction to Mechatronics and Measurement Systems' McGraw-Hill Inc USA 2003
4. Saeed B. Niku, , 'Introduction to Robotics: Analysis, Systems, Applications'. Person Education 2006
5. 5 Devdas Shetty, Richard A Kolk , Mechatronics System Design Cengage publishers. second edition

Web links and Video Lectures (e-Resources):
1. https://youtu.be/zVVITxiec7g 2. https://www.udemy.com/course/introduction-to-mechatronics/ 3. https://mechatronics.colostate.edu/
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning 1. **Arduino Robotics Project**: Divide students into small groups and provide them with Arduino microcontrollers, basic electronic components (such as motors, sensors, and actuators), and a simple robotics kit 2. **PLC Programming and Automation Challenge**: Introduce students to Programmable Logic Controllers (PLCs), which are widely used in industrial automation 3. **Mechanical Design and Rapid Prototyping**: Task students with designing a mechanical system or component using Computer-Aided Design (CAD) software, such as SolidWorks or AutoCAD

PEC **Factory Physics**		Semester	5
Course Code	**BAU515D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination type (SEE)	Theory		

Course objectives:

- To introduce the concepts of factory physics, highlighting its effectiveness over other established techniques
- To introduce the governing principles of factory physics with an understanding of the behavior of manufacturing systems and improve the management practice.

Teaching-Learning Process (General Instructions)

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

1. The lecturer method (L) does not mean only the traditional lecture method. Still, different teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby plants, start-up ecosystems, incubation centers or MSME industries to give information about the current practices of industry culture and demand.
3. Encourage collaborative (Group Learning) Learning in the class
4. Ask at least three HOTS (Higher-order Thinking) questions in the class, which promotes critical thinking
5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develops thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
6. Topics will be introduced in multiple representations.
7. Show the different ways to solve the same problem and encourage the students to come up with creative ways to solve them.
8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
9. Individual teachers can devise innovative pedagogy to improve teaching-learning.

Module-1

Introduction to Factory Physics: Introduction and need for factory physics with an example, Science of Manufacturing, Basics and importance of Factory Physics, Strategic and Operational Objectives, Models and Performance Measures, A Methodology for Improvement

Basic Factory Dynamics: Definitions and Parameters, Best-Case Performance, Worst-Case Performance, Practical Worst-Case Performance, Bottleneck Rates and Cycle Time

Module-2

Variability Basics: Variability and Randomness, Process Time Variability (measures and Classes of Variability & Low and Moderate Variability), Causes of Variability, Flow Variability, Queueing Notation and Measures, Fundamental Relations, The M/M/l Queue & Performance Measures

The Corrupting Influence of Variability: Examples of Good and Bad Variability, Variability Laws (Buffering Examples & Pay Me Now or Pay Me Later), Flow Laws, Batching Laws, Diagnostics and Improvements

Module-3

Push and Pull Production Systems: Perceptions of Pull, Reducing Manufacturing Costs, Reducing Variability, Facilitating Work, CONWIP, Comparisons of CONWIP with MRP, Comparisons of CONWIP with Kanban

The Human Element in Operations Management: Basic Human Laws, Planning versus Motivating, Responsibility and Authority

Module-4

A Pull Planning Framework: Disaggregation, Forecasting, Hierarchical Production Planning (Capacity/Facility Planning, Workforce Planning, Aggregate Planning, Real-Time Simulation, Production Tracking),

Shop Floor Control: General Considerations, CONWIP Configurations (Basic CONWIP, Tandem CONWIP Lines, Multiple-Product Families, CONWIP Assembly Lines), Pull-from-the-Bottleneck Methods, Long-Range Capacity Tracking

Module-5
Production Scheduling: Goals of Production Scheduling, Review of Scheduling Research (MRP, MRP II, and ERP, Classic Machine Scheduling, Dispatching, Why Scheduling Is Hard), Linking Planning and Scheduling, Production Scheduling in a Pull Environment **Aggregate and Workforce Planning:** Basic Aggregate Planning, Product Mix Planning, Workforce Planning (An LP Model, A Combined AP/WP Example) **Synthesis-Pulling It All Together:** Strategic Importance of Details, Practical Matter of Implementation, Focusing Teamwork
Course outcome (Course Skill Set) At the end of the course the student will be able to : 1. Understand the work culture of engineers with the natural tendencies of manufacturing systems 2. Identify opportunities for improving existing systems 3. Design effective new systems 4. Make the trade-offs needed to coordinate policies from disparate areas

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Factory Physics: Foundations of Manufacturing Management, first edition, 1996. 668pp. ISBN 0-256-15464-3

Web links and Video Lectures (e-Resources):

1. http://cdsweb.cern.ch/record/2790354?ln=no

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Process Mapping and Analysis:** Assign students to analyze real-world manufacturing processes using techniques such as value stream mapping or flowcharting.
2. **Supply Chain Management Simulation:** Create a supply chain simulation game where students play the roles of manufacturers, suppliers, and distributors.
3. **Process Mapping and Analysis:** Assign students to analyze real-world manufacturing processes using techniques such as value stream mapping or flowcharting.
4. **Factory Floor Observation:** Arrange visits to manufacturing facilities where students can observe real-world production processes in action.
5. **Workshops on Factory Physics Concepts:** Conduct interactive workshops on topics such as capacity planning, inventory management, and production control strategies

Mini Project		Semester	5
Course Code	**BAU586**	CIE Marks	100
Teaching Hours/Week (L:T:P: S)	0:0:4	SEE Marks	-
Total Hours of Pedagogy	03 HRS/WEEK	Total Marks	100
Credits	02	Exam Hours	3
Examination type (SEE)	practical		

Mini-project work: Mini Project is a laboratory-oriented/hands on course that will provide a platform to students to enhance their practical knowledge and skills by the development of small systems/applications etc. Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini- project can be assigned to an individual student or to a group having not more than 4 students.

CIE procedure for Mini project:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two faculty members of the Department, one of them being the Guide. The CIE marks awarded for the Mini-project work shall be based on the evaluation of the project report, project presentation skill, and question and answer session in the ratio of 50:25:25. The marks awarded for the project report shall be the same for all the batches mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group-wise at the college level with the participation of all the guides of the project.

The CIE marks awarded for the Mini project, shall be based on the evaluation of the project report, project presentation skill, and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

No SEE component for Mini-Project.

AEC Research Methodology and IPR		Semester	5
Course Code	**BRMK557**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	03	Exam Hours	2
Examination type (SEE)	Theory		
REFER TO VTU WEBSITE -COMMON TO ALL BRANCHES- Common Syllabus for 3rd to 8th Semester (2022 Scheme)			

MC Environmental Studies		Semester	5
Course Code	**BESK508**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:0:0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	02	Exam Hours	2
Examination type (SEE)	Theory/practical/Viva-Voce /Term-work/Others		
REFER TO VTU WEBSITE -COMMON TO ALL BRANCHES- Common Syllabus for 3rd to 8th Semester (2022 Scheme)			

6TH SEMESTER

IPCC **Heat Transfer**		Semester	6
Course Code	**BAU601**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	3
Examination nature (SEE)	Theory		

Course objectives:

- Explain fundamental principles and laws of conduction, convection and radiation modes of heat transfer and mass transfer.
- Analyse all modes of heat transfer and mass transfer under different conditions.
- Calculate heat exchange through heat exchanger.
- Apply laws of radiation heat transfer to solve engineering problems.

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby power plants, storage plants, chemical plants etc to give brief information about the major heat transfer equipment and processes.
3. Show Video/animation films.
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

MODULE-1

Introductory concepts: Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; Thermal conductivity; convective heat transfer coefficient; radiation heat transfer; combined heat transfer mechanism. Simple numerical , Boundary conditions of 1st, 2nd and 3rd Kind(No Numerical)

Conduction: Derivation of 1dimensional and 3- dimensional conduction equation in Cartesian coordinate, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems. (No derivation). One dimensional conduction in plane and composite walls, cylinders and spheres without heat generation. Overall heat transfer coefficient. Thermal contact resistance. Numerical problems

MODULE-2

Heat transfer in extended surfaces of uniform cross-section without heat generation, long fin, and short fin with insulated tip and without insulated tip and fin connected between two heat sources. Fin efficiency and effectiveness. Numerical problems.

One-dimensional Transient Conduction: Conduction in solids with a negligible internal temperature gradient (Lumped system analysis), Use of Transient temperature charts (Heisler's charts) for transient conduction in slab; use of transient temperature charts for transient conduction in semi-infinite solids. Numerical Problems.

MODULE-3

Free or Natural Convection: Application of dimensional analysis for free convection- physical significance of Grashoff number; use of correlations free convection from or to vertical and horizontal plates, cylinders and spheres, Numerical problems.

Forced Convections: Applications of dimensional analysis for forced convection. Physical significance of Reynolds, Prandtl, Nusselt and Stanton numbers. Use of various correlations for hydro dynamically and thermally developed flows inside a duct use of correlations for flow over a flat plate, over a cylinder and sphere. Numericals.

MODULE-4
Heat Exchangers: Classification of heat exchangers; overall heat transfer coefficient, fouling and fouling factor; LMTD, Effectiveness-NTU methods of analysis of heat exchangers. Numerical problems. **Condensation and Boiling:** Types of condensation (discussion only) Nusselt's theory for laminar condensation on a vertical flat surface; use of correlations for condensation on vertical flat surfaces, horizontal tube and horizontal tube banks; Reynolds number for condensate flow; regimes of pool boiling pool boiling correlations, Numerical.
MODULE-5
Thermal radiation: Definitions of various terms used in radiation heat transfer; Stefan-Boltzmann law, Kirchoff's law, Planck's law and Wein's displacement law. **Radiation heat exchange** between two parallel infinite black surfaces, between two parallel infinite Gray surfaces; effect of radiation shield; intensity of radiation and solid angle; Lambert's law; radiation heat exchange between two finite surfaces- Numerical problems.

PRACTICAL COMPONENT OF IPCC *(May cover all / major modules)*

Sl.NO	Experiments
1	Determination of Thermal Conductivity of a Metal Rod.
2	Determination of Overall Heat Transfer Coefficient of a Composite wall.
3	Determination of Effectiveness on a Metallic fin.
4	Experiment on Transient Conduction Heat Transfer
5	Determination of Heat Transfer Coefficient in a free Convection on a vertical tube.
6	Determination of Heat Transfer Coefficient in a Forced Convection Flow through a Pipe.
7	Determination of LMDT and Effectiveness in Parallel Flow and Counter Flow Heat Exchangers
8	Experiments on Boiling of Liquid and Condensation of Vapour
9	Determination of Emissivity of a Surface.
10	Determination of Stefan Boltzmann Constant.

Course outcome (Course Skill Set)

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

- Explain fundamental principles and laws of conduction, convection and radiation modes of heat transfer and mass transfer.
- Calculate basic design parameters of heat and mass transfer equipment and appliances.
- Analyse all modes of heat transfer and mass transfer under different conditions.
- Apply concept of heat transfer to design simple and complex engineering problems.

Assessment Details (both CIE and SEE)

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

The IPCC means the practical portion integrated with the theory of the course. CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.

CIE for the theory component of the IPCC

- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

- The minimum marks to be secured in CIE to appear for SEE shall be 10 (40% of maximum marks-25) in the theory component and 10 (40% of maximum marks -25) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 sub-questions are to be set from the practical component of IPCC, the total marks of all questions should not be more than 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify for the SEE. Marks secured will be scaled down to 50.

- The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Suggested Learning Resources:

Books

1. Heat transfer P. K. Nag, Tata McGraw Hill, New Delhi, 2002.
2. Heat transfer-A basic approach Ozisik, Tata McGraw Hill, 2002.
3. Heat transfer, a practical approach, Yunus A, Cengel,Tata McGraw Hill, 2001
4. Principles of heat transfer Kreith Thomas Learning 2001 ,
5. Heat & Mass transfer Tirumaleshwar, Pearson education 2006
6. Heat Transfer – R K.Hegde, Sapna Publications , ISBN: 978-93-87-308-96-1, First Edition, 2018,

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/112101097

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Practical based learning by conducting experiments in a Heat Transfer lab and analysing the experimental Data
2. **Case Studies and Problem-Solving Sessions**: Present case studies of heat and mass transfer applications in various industries such as HVAC systems, chemical processes, and thermal management in electronics
3. **Problem-Based Learning (PBL) Scenarios**: Present students with real-life scenarios or engineering problems related to heat and mass transfer and guide them through the problem-solving process.
4. **Field Trips or Industry Visits**: Organize field trips to manufacturing facilities, power plants, or research laboratories where heat and mass transfer principles are applied.
5. **Design Projects**: Assign design projects related to real-world heat and mass transfer problems.
6. **Computer Simulations**: Utilize software like MATLAB, COMSOL Multiphysics, or ANSYS Fluent to simulate heat and mass transfer phenomena.

Course Code	**BAU602**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	4:0:0	SEE Marks	50
Total Hours of Pedagogy	50 hours Theory	Total Marks	100
Credits	04	Exam Hours	3
Examination nature (SEE)	Theory		

Course objectives:

- Classify the vehicles and define basic terms.
- Select appropriate body material.
- Calculate various aerodynamic forces and moments acting on vehicle, load distribution in vehicle body.
- Explain the ergonomics, stability the vehicle.
- Identify various sources of noise and methods of noise separation and various safety aspects in a given vehicle.

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby Auto Dealer, Manufacturing Facility/ plants, Service Workshops/centres
3. Show Video/animation films
4. Encourage collaborative (Group Learning) Learning in the class.
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

MODULE-1

Classification of Coachwork: Styling forms, coach and bus body style, layout of cars, buses and coach with different seating and loading capacity, types of commercial vehicles, vans and pickups, etc. Terms used in body building construction, angle of approach, Angle of departure, ground clearance, Cross bearers, floor longitudes, posts, seat rail, waist rail, cant rail, Roof stick, Roof longitude, Rub rail, skirt rail, truss panel, wheel arch structure, wheel arch, post diagonals, gussets.

MODULE-2

Vehicle Body Materials: Aluminium alloys, Steel, alloy steels, plastics, Metal matrix composites, structural timbers - properties, glass reinforced plastics and high strength composites, thermoplastics, ABS and styrene's, load bearing plastics, semi rigid PUR foams and sandwich panel construction. Paints adhesives and their properties, corrosion and their prevention.

MODULE-3

Aerodynamics: Basics, Vehicle drag and types, Various types of forces and moments, effects of forces and moments, various body optimization techniques for minimum drag, Principle of wind tunnel technology, flow visualization techniques, tests with scale models, aerodynamic study for heavy vehicles.
Load Distribution: Type of body structures, Vehicle body stress analysis, vehicle weight distribution, Calculation of loading for static loading, symmetrical, longitudinal loads, side loads, stress analysis of bus body structure under bending and torsion.

MODULE-4

Interior Ergonomics: Introduction, Seating dimensions, Interior ergonomics, ergonomics system design, seat comfort, suspension seats, split frame seating, back passion reducers, dashboard instruments, electronic displays, commercial vehicle cabin ergonomics, mechanical package layout, goods vehicle layout. Visibility, regulations, drivers' visibility, methods of improving visibility, Window winding and seat adjustment mechanisms.

Vehicle Stability: Introduction, Longitudinal, lateral stability, vehicle on a curvilinear path, critical speed for toppling and skidding. Effect of operating factors on lateral stability, steering geometry and stabilization of steerable wheels, mass distribution and engine location on stability.

MODULE-5

Noise and Vibration: Noise characteristics, Sources of noise, noise level measurement techniques, Body structural vibrations, chassis bearing vibration, designing against fatigue, methods of noise suppression. **Impact protection:** Basics, physics of impact between deformable bodies, design for crash worthiness, occupant and cargo restraint, passive restraint systems, side impact analysis, bumper system, energy absorbent foams, laws of mechanisms applied to safety.

Course outcome (Course Skill Set)

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

- Understand the basics of vehicle body engineering and safety.
- Calculate various aerodynamic forces and moments acting on vehicle, load distribution in vehicle body.
- Classify the vehicles and define basic terms, select appropriate body material.
- Identify various sources of noise and methods of noise separation and various safety aspects in a given vehicle, analyse the problem and address the possible causes.

Assessment Details (both CIE and SEE)

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

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CIE for the theory component of the IPCC

- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.

- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

- The minimum marks to be secured in CIE to appear for SEE shall be 10 (40% of maximum marks-25) in the theory component and 10 (40% of maximum marks -25) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 sub-questions are to be set from the practical component of IPCC, the total marks of all questions should not be more than 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify for the SEE. Marks secured will be scaled down to 50.
- The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Suggested Learning Resources:

Books

1. Vehicle body engineering Giles J Pawlowski, Business books limited 1989
2. Vehicle body layout and analysis John Fenton Mechanical Engg. Publication ltd, London.1990Hand book on vehicle body design SAE publication.
3. Automotive chassis P.M. Heldt Chilton & Co 1970
4. Vehicle Safety 2002 Cornwell press Town bridge, UKISBN 1356 - 1448
5. Aerodynamics of Road Vehicles W.H. Butterworth's 1987 4th Edition

Web links and Video Lectures (e-Resources):

- https://www.slideshare.net/friendsrtg/vehicle-body-engineering-introduction
- https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SAU1403.pdf
- https://www.youtube.com/watch?v=Qf6S9ApzNLQ
- https://www.youtube.com/watch?v=B9p2CWpu7VE
- http://www.gpmanesar.ac.in/GPContent/CBT-.pdf
- https://www.jstor.org/stable/44720562?seq=1#metadata_info_tab_contents

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Model Building and Simulation ;**
   Objective: Understand vehicle structure and aerodynamics.
   Students work in teams to build scaled models of different vehicle body designs using materials like cardboard, foam, or 3D printing.
2. **Crash Testing Simulations:**

Use simulation software to perform virtual crash tests. Students analyze the results to understand crumple zones, energy absorption, and safety improvements.

3. **Safety System Analysis**
   Provide students with decommissioned vehicles or parts. Have them disassemble and study safety features like airbags, seat belts, and ABS (Anti-lock Braking System). Discuss their mechanisms and importance in vehicle safety.
4. **Field Trips and Guest Lectures**
   Organize visits to automotive manufacturing plants or crash test facilities. Students can see the production process and safety testing in action.
5. **Use of Modern Tools and Technologies**
   Utilize AR and VR tools to create immersive learning experiences. For instance, virtual workshops on crash analysis or interactive 3D models of vehicle components can provide a deeper understanding of complex concepts.

PEC Hybrid Vehicle Technology		Semester	6
Course Code	**BAU613A**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0 -0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- Understand the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
- Explain hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
- Analyze various electric drives suitable for hybrid electric vehicles. Discuss different energy storage technologies used for hybrid electric vehicles and their control.
- Demonstrate different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management.

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby plants, industries etc
3. Show Video/animation films to explain functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

INTRODUCTION:

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drivetrains on energy supplies. Hybridization of the Automobile: Vehicle Basics, Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV), Basics of Fuel Cell Vehicles (FCVs).

HEV Fundamentals: Introduction, Vehicle Model, Vehicle performance, EV Power train Component Sizing, Series Hybrid Vehicle, Parallel Hybrid Vehicle

Module-2

HYBRID ELECTRIC VEHICLES

Introduction to Hybrid Electric vehicles – Classification – Micro, Mild, Full, Plug-in, EV. Layout and Architecture – Series, Parallel and Series-Parallel Hybrid, Propulsion systems and components. Regenerative Braking, Economy, Vibration and Noise reduction. Hybrid Electric Vehicles System – Analysis and its Types, Controls.

Module-3

ELECTRIC MACHINES AND DRIVES IN HEVS:

Introduction, BLDC motors, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors, Thermal Analysis and Modelling of Traction Motors.

Module-4
ENERGY STORAGE: Batteries, Ultra capacitor, Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System. **FUEL CELL** Introduction, Technologies & Types, Obstacles. Operation principles, Potential and I-V curve, Fuel and Oxidation Consumption, Fuel cell Characteristics – Efficiency, Durability, Specific power, Factors affecting, Power design of fuel Cell Vehicle and freeze capacity.
Module-5
INTEGRATION OF SUBSYSTEMS: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems. **ENERGY MANAGEMENT STRATEGIES:** Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies
Course outcome (Course Skill Set) At the end of the course the student will be able to : 1. Understand the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals. 2. Analyze the use of different power electronics devices and electrical machines in hybrid electric vehicles. 3. Explain the use of different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology 4. Interpret the working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis and Energy Management strategies in HEVs.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press , 2003
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press , 2004
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley , 200
4. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=3E1SXG7VkQk&list=PLHRG-unM84XgZd9HKQAmKdE__12-1eRSe
2. https://www.youtube.com/watch?v=rK6Bey_loiw&list=PLdzIIxVTz4AsglVyHhZJ6Jj7tnpa3NL0n
3. https://www.youtube.com/watch?v=q6BYr5-fq5U
1. https://www.youtube.com/watch?v=UgtjRob5qMg&list=PLyqSpQzTE6M9spod-UH7Q69wQ3uRm5thr

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Hands-On Component Analysis**
   Certification course by Provide students with access to hybrid vehicle components such as electric motors, battery packs, and power electronics. Have them disassemble and study these components, discussing their roles and interconnections.
2. **System Simulation and Modeling**
   Use simulation software to model different hybrid vehicle configurations (series, parallel, and series-parallel). Students can simulate various driving conditions to understand how energy flows between the internal combustion engine, electric motor, and battery.
3. **Field Trips and Guest Lectures**
   Organize field trips to automotive manufacturing plants or research centers specializing in hybrid technology. This allows students to observe the production process and advanced research in hybrid systems.
4. NPTEL https://nptel.ac.in/courses/108103009

PEC **Energy Storage Systems for Electric Vehicles**		Semester	6
Course Code	**BAU613B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination type (SEE)	Theory		

Course objectives:

- Identify the energy storage system for the electric vehicles.
- Compare different energy storage systems.
- Analyse the data and design simple battery pack

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby plants, service centre , dealership show rooms etc., start -up ecosystem, incubation centers or MSME industries to give information about the industry culture and demand.
3. Show Video/animation films to explain functioning.
4. Encourage collaborative (Group Learning) Learning in the class.
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking.
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

Energy Source: Battery: Battery Basics, Lead-Acid Battery: Cell Discharge Operation, Cell Charge Operation, Construction,

Alternative Batteries: Nickel-Cadmium Battery, Nickel-Metal-Hydride (NiMH), Battery, Li-Ion Battery, Li-Polymer Battery, Zinc-Air Battery, Sodium-Sulphur Battery, Sodium-Metal-Chloride Battery ,

Module-2

Battery Parameters, Battery Capacity, Discharge Rate, State of Charge, State of Discharge, Depth of Discharge

Technical Characteristics, Practical Capacity, Capacity Redefined, Battery Energy, Constant Current Discharge, Specific Energy, Battery Power, Specific Power, Battery Pack Design, Ragone Plots, Targets and Properties of Batteries, Numerical problems on the above wherever applicable

Battery Modelling: Constant Current Discharge Approach, Fractional Depletion Model, Standard Driving Cycles, Power Density Approach,

Module-3

Fuel Cells - Introduction to Fuel Cells, Fuel Cell Vehicle Emissions and Upstream Emissions, Hydrogen Safety Factors; Basic Operation - Fuel Cell Model and Cell Voltage , No-Load and Load Voltages of a PEM Fuel Cell , Power and Efficiency of Fuel Cell and Fuel Cell Power Plant System, Full-Load Power and Efficiency of PEM Fuel Cell Stack , Fuel Cell Characteristic Curves , Numerical problems on the above wherever applicable

Sizing the Fuel Cell Plant - Sizing a Fuel Cell, Balance of Plant , Boost DC-DC Converter; Fuel Cell Aging , Fuel Economy of Fuel Cell Electric Vehicle , Numerical problems on the above wherever applicable

Module-4
Fuel Cell Types - Alkaline Fuel Cell (AFC), Proton Exchange Membrane (PEM), Direct Methanol Fuel Cell (DMFC) , Phosphoric Acid Fuel Cell (PAFC) , Molten Carbonate Fuel Cell (MCFC) , Solid Oxide Fuel Cell (SOFC, ITSOFC) , Hydrogen Storage Systems, Reformers, Fuel Cell EV, Flywheel storage
Module-5
Battery Charging - Basic Requirements for Charging System, Charger Architectures, Grid Voltages, Frequencies, and Wiring, Charger Functions, Real Power, Apparent Power, and Power Factor. Charging Standards and Technologies, SAE J1772 422, VDE-AR-E 2623-2-2 425, CHAdeMo, Tesla; Wireless Charging - Inductive , Wireless ; The Boost Converter for Power Factor Correction , The Boost PFC Power Stage ,Sizing the Boost Inductor , Average Currents in the Rectifier , Switch and Diode Average Currents , Switch, Diode, and Capacitor RMS Currents, Power Semiconductors for Charging , Silicon MOSFET and SiC Diode Power Losses
Course outcome (Course Skill Set) At the end of the course the student will be able to: 1. Identify the energy storage system for the electric vehicles 2. Compare different energy storage systems 3. Analyse the data pertaining to energy storage systems 4. Apply the concept to design simple storage systems like battery pack, fuel cell etc.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Mehrdad Ehsani, Yimin Gao, Stefano Longo and Kambiz Ebrahimi, CRC Press, 2018, II Edition.
2. Electric Powertrain- Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John G. Hayes, University College Cork, Ireland ,G. Abas Goodarzi, US Hybrid, California, USA, © 2018 John Wiley & Sons Ltd
3. Electric Vehicle Technology Explained, 2nd Edition, James Larminie, John Lowry, ISBN: 978-1-119-94273-3, Wiley , July 2012

Web links and Video Lectures (e-Resources):

1. https://onlinecourses.nptel.ac.in/noc21_ee112/preview
2. https://www.digimat.in/limesurvey/index.php/108106182

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Component Analysis and Hands-On Experiments**

Provide students with used or sample battery packs to disassemble. Have them identify and study components like cells, BMS (Battery Management System), cooling systems, and safety features.

2. **System Simulation and Modelling**

Use simulation software to model a BMS. Students can explore algorithms for state of charge (SoC) estimation, balancing, and thermal management. They can simulate different scenarios to see how the BMS responds.

3. **Project-Based Learning**

Assign a capstone project where students design and build a prototype ESS. This includes selecting cells, designing the BMS, implementing thermal management, and integrating the system into an EV model.

4. **Field Trips and Guest Lectures**

Organize field trips to battery manufacturing plants, research labs, or EV companies. Students can see the production process, advanced testing methods, and the latest innovations in energy storage technology.

PEC **Industry 4.0 for Automotive Vehicles**		Semester	6
Course Code	**BAU613C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination type (SEE)	Theory		

Course objectives:

- Understand the Industry 4.0 concept, globalization and emerging issues
- Understand the concept of IIOT, study the elements of IIOT application of IIOT under industry context
- Learn the development procedures involved in IIOT

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby power plants, receiving station and substations to give brief information about the electrical power generation.
3. Show Video/animation films to explain functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teachers can device the innovative pedagogy to improve the teaching-learning.

Module-1

Introduction to Industry 4.0: Industry 4.0: Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories,

Industry 4.0: Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis

Module-2

Introduction to IIoT: Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals Devices and gateways, Data management, Business processes in IoT, Everything as a Service (XaaS), Role of Cloud in IoT, Security aspects in IoT.

Module-3

Elements of IIoT: Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API‟s (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

Module-4

IIoT Application Development: Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices

Module-5

Case Studies: IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation

Course outcome (Course Skill Set)

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

1. Explore how Industry 4.0 will change the current manufacturing technologies and processes by digitizing the value chain.
2. Understand the drivers and enablers of Industry 4.0.
3. Learn about various IIoT-related protocols.
4. Build simple IIoT Systems using Arduino and Raspberry Pi.
5. Analyse and implement the concept in real life applications

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Arshdeep Bahga, Vijay Madiset Internet of Things, "A Hands on Approach University Press 1st **Edition,** 2015
2. Pethuru Raj and Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases , CRC Press, **1stEddition,** 2017.
3. SRN Reddy, Rachit Thukral and Manasi Mishra, Introduction to Internet of Things: A practical Approach ETI Labs, **Edition,** 2017
4. Adrian McEwen , Designing the Internet of Things, Wiley**1st Edition,** 2013.
5. Raj Kamal Internet of Things : Architecture and Design McGraw Hill **1st Edition,** 2017

Web links and Video Lectures (e-Resources):

1. http://library.fes.de/pdf-files/bueros/indien/15840.pdf
2. https://www.youtube.com/watch?v=ZYPpTWtQTFY
3. https://www.youtube.com/watch?v=3WykDG5L_5A
4. https://www.youtube.com/watch?v=etuDLZfUImQ
5. https://www.youtube.com/watch?v=APFuXkMbwGE&vl=en
6. https://www.youtube.com/watch?v=IrtH38nK8fo

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Certification course by NPTEL:https://nptel.ac.in/courses/106105195
2. Certification course by NPTEL:https://onlinecourses.nptel.ac.in/noc20_cs69/preview
3. **Hands-On Component Analysis and Implementation**
   Provide students with various IoT sensors (e.g., temperature, pressure, accelerometer). Have them integrate these sensors into a small-scale vehicle model or system. Students can collect and analyze data to monitor vehicle performance and health**.**
4. **PLC Programming and Automation**
   Use PLC kits to teach students how to program and automate manufacturing processes. Set up small-scale assembly lines and have students automate different stages, focusing on efficiency and error reduction.
5. **Field Trips and Guest Lectures**
   Organize field trips to automotive plants that have implemented Industry 4.0 technologies. Students can see advanced manufacturing techniques, smart logistics, and real-time data analytics in action.

Finite Element Methods			
Course Code	**BAU613D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0 -0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To comprehend the formulation methods in FEM.
- To Identify the application of FEA elements
- To be able to apply suitable boundary conditions to a global equation for heat transfer, fluid flow, axi symmetric and dynamic problems
- To solve displacements, stress and strains induced.

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Show Video/animation films to explain functioning of FEM tools
3. Encourage collaborative (Group Learning) Learning in the class
4. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
6. Topics will be introduced in a multiple representation.
7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
9. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

Introduction to Finite Element Method:

General description of the finite element method. Engineering applications of finite element method. Boundary conditions: homogeneous and non-homogeneous for structural, heat transfer and fluid flow problems. Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretization process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions, temperature effects.

Interpolation models:

Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.

Module-2

One-Dimensional Elements-Analysis of Bars and Trusses, Linear interpolation polynomials in terms of local coordinate's for1D, 2Delements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA8), 2D iso-parametric element, Lagrange interpolation functions, Numerical integration: Gaussian quadrature one point, two-point formulae, 2D integrals. Fore terms: Body force, traction force and point loads,

Numerical Problems:

Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of trusses

Module-3

Beams and Shafts:

Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.

Torsion of Shafts:

Finite element formulation of shafts, determination of stress and twists in circular shafts.

Module-4

Heat Transfer:

Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored in solid, 1D finite element formulation using vibrational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.

Module-5

Axi-symmetric Solid Elements:

Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels.

Dynamic Considerations:

Formulation for point mass and distributed masses, Consistent element mass matrix of one-dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

Course outcome (Course Skill Set)

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

1. Understand the concepts behind formulation methods in FEM.
2. Identify the application and characteristics of FEA elements
3. Develop element characteristic equation and generation of global equation.
4. Able to apply suitable boundary conditions to a global equation for different components

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
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- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Logan, D. L., A first course in the finite element method,6th Edition, Cengage Learning, 2016.
2. Rao, S. S., Finite element method in engineering, 5th Edition, Pergamon Int. Library of Science, 2010.
3. Chandrupatla T. R., Finite Elements in engineering, 2nd Edition, PHI, 2013.

REFERENCE BOOKS

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

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112104116
2. https://nptel.ac.in/courses/105105041

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Software Simulation Sessions**: Introduce students to FEM software like ANSYS, Abaqus, or COMSOL Multiphysics. Allow them to experiment with creating finite element models, applying boundary conditions, and analysing results.
2. **Hands-On Workshops**: Organize workshops where students can work with physical models or conduct experiments related to FEM principles.
3. **Peer Teaching and Presentations**: Assign topics related to FEM to student groups and have them prepare presentations or demonstrations for the class.
4. **Coding Exercises**: If applicable, incorporate programming exercises using MATLAB, Python, or other programming languages commonly used in FEM.
5. **Problem-Based Learning**: Present students with open-ended problems or projects that require them to apply FEM concepts creatively. Use open source/student edition CFD software and solve simple problems. and analyse the results

OEC **Renewable Energy**		Semester	6
Course Code	**BAU654A**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3-0 -0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

1. To Understand the Need, importance and scope of non-conventional and alternate energy resources.
2. To understand the role significance of solar energy.
3. To provide importance of Wind Energy. 4. To understand the role of ocean energy in the Energy Generation.
4. To get the utilization of Biogas plants and geothermal energy.
5. To understand the concept of energy Conservation

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby power plants, receiving station and substations to give brief information about the electrical power generation.
3. Show Video/animation films to explain functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

SOLAR ENERGY

Introduction, Solar constant, Solar radiation measurements, Solar thermal conversion: Basics, Flat Plate and Concentrating Collectors, Solar radiation geometry, solar radiation data.

Applications of solar energy: solar water heater, solar dryers, Solar ponds, solar cooling, Solar thermal power generation- Basic type, **Solar photovoltaic:** Principle of photovoltaic conversion of solar energy. Solar cells, No numerical problems

Module-2

INTRODUCTION TO WIND ENERGY

Atmospheric circulations, Factors influencing wind, Variation of wind speed with height and time, Turbulence, Causes of turbulence, Power estimation in wind, Wind energy conversion principles, Components of wind energy Conversion Systems (WECS), Horizontal Axis Wind Turbine (HAWT) & Vertical Axis Wind Turbine (VAWT), Wind electric generators: Aero generators classification: Synchronous generators, Induction generators, Variable speed generators. - Simple numerical problems

Module-3

OCEAN ENERGY

Introduction to Ocean Thermal Energy Conversion (OTEC), Temperature Gradient Curve with Ocean Depth, Methods of Ocean Thermal Electric Power Generation: Open OTEC, Closed OTEC and Hybrid OTEC, Merits and Demerits of OTEC, Introduction to Tides, Basic Principles of Tidal Power, Components of Tidal Power Plants, Methods of Utilization of Tidal Energy: Single Basin and Double Basin. – No numerical problems

Wave energy-introduction, advantages and disadvantages of wave energy, energy and power from the waves, wave energy conversion devices- No numerical problems

Module-4

SMALL HYDRO POWER PLANT

Hydrological cycle, Essential elements of hydraulic electric power plant, Hydraulic Machine: Turbines, General Layout of hydroelectric power plant, Classification of Hydraulic turbine: Impulse Turbine- Pelton Turbine, Reaction Turbine- Francis, Kaplan and Propeller Turbine;(Only theory with basic power and efficiency calculations, No velocity triangles) Small Hydro power plant, classification, overview of micro, mini and small hydro systems, components of small hydro power plant– Simple numerical problems on efficiency , power etc. – No numerical problems on velocity triangles

Module-5

GEOTHERMAL ENERGY POWER PLANT

Introduction of Geothermal Energy, Geothermal Resources, Nature of geothermal fields, Hydrothermal Power Plant: Vapour Dominated - High Pressure and Low Pressure & Liquid Dominated – Single Flash, Double Flash and Binary System; No numerical

HYDROGEN ENERGY

Hydrogen Energy – Introduction and application, General introduction to infrastructure requirement for hydrogen production, storage, dispensing & utilization. , Hydrogen storage methods, Hydrogen transportation, hydrogen utilization, No numerical

Course outcome (Course Skill Set)

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

1. To Describe the use of solar energy and the various components used in the energy production with respect to applications
2. To appreciate the need for Wind Energy and the various components used in energy generation and know the classifications.
3. To realize the role of ocean energy and hydro power plants in the energy generation.
4. To understand the concept of Biomass energy resources geothermal energy principles and applications.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Fundamental of Renewable Energy Sources, Tiwari GN. Ghoshal MK. Narosa Publishers 2007
2. Power Plant Engineering Nag P K Tata McGraw Publishers Hill 2008
3. Solar Energy Sukatme, Tata McGraw Hill Publishers
4. Non-Conventional Energy Sources G.D.Rai Khanna Publishers, New Delhi 2011
5. Chemical and Electrochemical Energy Systems, Narayan R. Biswanathan B University Press (India) Ltd. 1998.
6. Present and Future Automotive Fuels Osamu Hairo and Richard K John Wiley and Sons 1988
7. Renewable Energy Resources J W Twidell& A D Weir ELBS, 2006

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=BWqjPHGM5D0&list=PLwdnzlV3ogoUtaGiq-lVJc4CC6x_czs9D
2. https://www.youtube.com/watch?v=mh51mAUexK4&list=PLwdnzlV3ogoXUifhvYB65lLJCZ74o_fAk
3. https://www.youtube.com/watch?v=7Ry643d3deE&list=PL3QMEfkolRFbGhXveCE7RFDBgY0_gRxkh
4. https://www.youtube.com/watch?v=ie2bm3zHcxA&list=PLbjTnj-t5Gkl95LdB7O3bjUsstn5xg5MU

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Interactive Workshops**
   Conduct workshops focusing on the economic viability, incentives, and regulatory frameworks for renewable energy. Students can analyse case studies and propose policies to support renewable energy adoption**.**
2. **Project-Based Learning**
   Assign a capstone project where students design and build a prototype renewable energy system. This could be a solar-powered device, a small wind turbine, or a bioenergy generator. Emphasize creativity, efficiency, and sustainability.
3. **Use of Modern Tools and Technologies**
   Use AR and VR tools to create simulations of renewable energy systems. For example, AR can be used to overlay digital information on physical models of solar panels or wind turbines, while VR can simulate the operation of a renewable energy plant.
4. **Field Trips and Guest Lectures**
   Organize field trips to solar farms, wind farms, hydroelectric plants, or bioenergy facilities. Students can see real-world implementations and understand the scale and challenges of renewable energy production**.**

OEC **Fundamentals Of IC Engines**		Semester	6
Course Code	**BAU654B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0 -0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- Explain constructional details and working of various components of internal combustion engine scavenging systems for two stroke engines.
- Explain types of fuel system used for internal combustion engine.
- Choose cooling and lubrication system for internal combustion engine
- Analyze effect of supercharging and turbo charging on engine performance.

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby manufacturing units, service stations and automotive vehicle dealers to give brief information about the IC Engines.
3. Show Video/animation films to explain functioning of various engines.
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

Construction and Operation: Engine classification, Constructional details of four stroke spark ignition (SI) and compression ignition (CI) engines. Working principles. Comparison of SI and CI engines, theoretical and actual valve timing diagrams for engines.

Module-2

Engine Cycles: Theoretical Otto, diesel and dual cycles, Ideal cycle analysis , Efficiency and work ratio, p-V and T-s diagrams, Simple numerical

Performance parameters: Efficiencies – Brake Thermal, Indicated thermal, Volumetric , Air-standard and Mechanical efficiencies, Brake and Indicated power, Simple numerical problems

Module-3

Cooling System: Necessity, Heat rejected to coolant, quantity of water required, air cooling, water cooling, thermostats, pressurized water cooling, regenerative cooling, comparison of air and water cooling, Working principle of a radiator, antifreeze solution, types of coolant.

Lubrication System: Lubricants, lubricating systems, Lubrication of piston rings, bearings, oil consumption, additives and lubricity improvers, oil filters, pumps, and crankcase ventilation –types.

Module-4

Combustion in SI and CI Engines: Stages of combustion in engines, Knocking and pre-ignition, Factors affecting knocking and Control of knocking, Combustion chamber requirements, Engine emissions – Various types of pollutants from the Petrol and Diesel Engines. Engine emissions and emission standards

Module-5

Supercharging and Turbo charging: Purpose, thermodynamic cycle, effect on the performance, turbo charging, limits of supercharging for petrol and diesel engines.

Hydrogen as alternate fuel : Production , Transportation and storage. Advantages and dis advantages

Course outcome (Course Skill Set)

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

1. To explain constructional details and working of various components of internal combustion engine scavenging systems for two stroke engines.
2. To describe types of fuel system used for internal combustion engine.
3. To Choose cooling and lubrication system for internal combustion engine
4. To analyze effect of supercharging and turbo charging on engine performance.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Internal Combustion Engines, V. Ganesan, Tata McGraw Hill, 2007.
2. Internal Combustion Engines, Ramalingam K. K. Sci-Tech Publications, 2005.
3. Internal Combustion Engines, Mathur and Sharma Dhanpat Rai and Sons, 2002.
4. Fundamentals of Internal Combustion Engines, John B. Heywood. McGraw Hill International Edition, 1998.
5. A course in I. C. Engines Mathur & Sharma Dhanpat Rai& sons, New Delhi 1994.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=rvpMbBB6RrU&list=PL6kB4KeyhXc6GN3Gcvhl9YQEcMGD9M_Ym
- https://www.youtube.com/watch?v=DozLR0q6sUU&list=PLOEB17hxXqrYYTJQ67X83r2pIruXby6cp
- https://www.youtube.com/watch?v=CO2StedJtAc&list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Hands-On Component Analysis and Experiments**
   Provide students with different types of IC engines (e.g., single-cylinder, multi-cylinder). Have them disassemble the engines, identify each component (pistons, crankshaft, camshaft, valves, etc.), and then reassemble them. Discuss the function of each component and how they work together.
2. **System Simulation and modelling**
   Use software tools to simulate different engine cycles (Otto, Diesel, Dual). Students can vary parameters like compression ratio, air-fuel ratio, and ignition timing to see their effects on engine performance and efficiency.
3. **Experimental Labs**
   Conduct experiments using an engine test stand to measure parameters such as power output, torque, fuel consumption, and emissions. Students can compare these metrics under different operating conditions.
4. **Visit to Automotive Workshops or Engine Manufacturing Plants**
   Organize field trips to workshops or manufacturing plants where students can see the assembly, testing, and maintenance of IC engines. Discuss the latest technologies and trends in engine design and manufacturing**.**

OEC Basics of Thermal Engineering		Semester	6
Course Code	**BAU654C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3 -0 -0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To introduce the fundamentals of basic thermodynamics and governing laws
- To introduce the fluid mechanics fundamentals and definitions
- To introduce the governing laws of heat transfer

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby plants, industry stations
3. Show Video/animation films to explain the basics of Thermal Engineering
4. Encourage collaborative (Group Learning) Learning in the class.
5. Ask at least three HOTS (Higher Order Thinking) questions in the class, which promotes critical thinking.
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teachers can devise the innovative pedagogy to improve the teaching-learning.

Module-1

Fundamentals of Thermodynamics:
Thermodynamic definition and scope, Microscopic and Macroscopic approaches. Thermodynamic properties. definition and units, intensive, extensive properties, specific properties, pressure, specific volume, Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic. Processes
Zeroth law of thermodynamics, Work and Heat: Thermodynamic definition of work; examples, sign convention, Shaft work, Electrical work, other types of work. Heat; definition, units, and sign convention.
Note: No numerical problems on the above

Module-2

Laws of Thermodynamics:
Joules experiments, Statement of the First law of thermodynamics, steady state-steady flow energy equation, important applications, analysis of unsteady processes such as filling and evacuation of vessels with and without heat transfer.
Keivin –Planck &Clausius statement of Second law of Thermodynamics, PMM II and PMM I. Clausius Theorem & thermodynamic equivalence of the two statements; reversible and irreversible processes; factors
Note: No numerical problems on the above

Module-3

Properties of fluids: Introduction, Properties of fluids, viscosity, thermodynamic properties, surface tension, capillarity, vapor pressure and cavitation.
Fluid Statics: Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, absolute, gauge, atmospheric and vacuum pressures, simple manometers, and differential manometers.
Buoyancy: Buoyancy, centre of buoyancy, meta centre and meta-centric height, conditions of equilibrium of floating and submerged bodies,
Note: No numerical problems on the above

Module-4
. Introductory concepts: Modes of heat transfer: Basic laws governing conduction, convection, and radiation. heat transfer; Thermal conductivity; convective heat transfer coefficient; radiation heat transfer; combined heat transfer mechanism. **Thermal radiation:** Definitions of various terms used in radiation heat transfer; Stefan-Boltzmann law, Kirchoff's law, Planck's law and Wein's displacement law. **Note: No numerical problems on the above**
Module-5
Refrigeration: **vapor compression refrigeration system:** description, analysis, refrigerating effect, capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties. Vapor absorption refrigeration system, description, COP, steam jet refrigeration, **Note: Simple numerical problems on the above**
Course outcome (Course Skill Set) At the end of the course, the student will be able to: 1. Understand the basic concepts of thermal engineering. 2. Compare the governing laws and analyse different processes. 3. Use the governing equations of thermodynamics, fluids and heat transfer. 4. Able the adopt the concepts to analyse the various applications pertaining to thermal engineering in their own domain of study.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Logan, D. L., A first course in the finite element method,6th Edition, Cengage Learning, 2016.
2. Rao, S. S., Finite element method in engineering, 5th Edition, Pergaman Int. Library of Science, 2010.
3. Chandrupatla T. R., Finite Elements in engineering, 2nd Edition, PHI, 2013.

REFERENCE BOOKS

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

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/112104116
2. https://nptel.ac.in/courses/105105041

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Heat Transfer Experiments**
   Objective: Understand the principles of heat transfer (conduction, convection, and radiation).
   Activity: Conduct experiments to observe and measure different modes of heat transfer.
2. **Thermal Efficiency of Engines**
   Objective: Understand the thermal efficiency of different types of engines.
   Activity: analyse the efficiency of various engines such as internal combustion engines, steam engines, and gas turbines.
3. Use open source/student edition CFD software and solve simple problems. and analyse the results
4. **Hands-On Workshops**
   Objective: Enhance practical skills and understanding through hands-on activities.
   Activity: Conduct workshops on specific thermal engineering topics, such as insulation materials or renewable energy systems.
5. **Thermodynamics Lab Sessions**
   Objective: Apply the laws of thermodynamics in practical scenarios.
   Activity: Perform lab experiments to demonstrate the first and second laws of thermodynamics.

OEC Engineering Economics		Semester	6
Course Code	**BAU654D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination type (SEE)	Theory		

Course objectives:
On completion of this subject students will be able to

- Understand the criterion to choose the best economic model from various available alternatives
- Understand various interest rate methods and implement the suitable one.
- Estimate various depreciation values of commodities using present, future and annual worth comparison methods
- Understand the contents of a balance sheet and scope of finance.

Teaching-Learning Process (General Instructions)
These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Show Video/animation films to explain basic concepts and terms
3. Encourage collaborative (Group Learning) Learning in the class
4. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
6. Topics will be introduced in a multiple representation.
7. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
9. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

Introduction: Engineering Decision-Makers, Engineering and Economics, Problem solving and Decision making, Intuition and Analysis, Tactics and Strategy

Law of demand and supply, Law of returns, Interest and Interest factors: Interest rate, Simple interest, Compound interest, Cash - flow diagrams, Personal loans and EMI Payment, Exercises and Discussion

Module-2

Present-Worth Comparisons: Conditions for present worth comparisons, Basic Present worth comparisons, Present-worth equivalence, Net Present-worth, Assets with unequal lives, infinite lives,

Future-worth comparison, Pay-back comparison, Exercises, Discussions, and problems

Module-3

Equivalent Annual-Worth Comparisons: Equivalent Annual-Worth Comparison methods, Situations for Equivalent Annual-Worth Comparisons, Consideration of asset life, Comparison of assets with equal and unequal lives, Use of shrinking fund method, Annuity contract for guaranteed income, Exercises, Problems

Module-4
Costing and depreciation: Components of costs, estimation of selling price, marginal cost, first cost, all kinds of overheads, indirect cost estimation with depreciation, mensuration and estimation of material cost, **Depreciation:** Causes of depreciation, methods of computing, depreciation charges, straight line method, declining balance method, sum of years method, sinking fund method, Discussions, and problems.
Module-5
Introduction, Scope Of Finance, Finance Functions: Statements of Financial Information: Introduction, Source of financial information, **Financial statements,** Balance sheet, Profit and Loss account, relation between Balance sheet and Profit and Loss account. Simple Numerical
Course outcome (Course Skill Set) At the end of the course the student will be able to : 1. Select the best economic model from various available alternatives 2. Understand various interest rate methods and implement the suitable one. 3. Choose the right depreciation method and estimate various depreciation values of commodities using appropriate -worth comparison methods 4. Apply the knowledge of economics and finance to evaluate interest, cost of components, depreciation balance sheet.

Assessment Details (both CIE and SEE)

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

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

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

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Engineering Economy, Riggs J.L., 4TH ed. , McGraw Hill, 2002
2. Engineering Economy, Thuesen H.G. PHI , 2002
3. Engineering Economy, Tarachand, 2000.
4. Industrial Engineering and Management, OP Khanna, Dhanpat Rai & Sons. 2000
5. Financial Management, Prasanna Chandra, 7th Ed., TMH, 2004
6. Financial Management, IM PANDEY, Vikas Pub. House, 2002

Web links and Video Lectures (e-Resources):

1. .https://www.youtube.com/watch?v=9yj6CtMUsYU
2. https://www.youtube.com/playlist?list=PLRW1FgIW06IpkWmpIl_1qrXIPPzZdc7-V
3. https://nptel.ac.in/courses/110101005
4. https://www.youtube.com/watch?v=RaXQ8wQ6TUs

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Compare the Present worth, Annual worth and Future worth methods and analyse their relevance
2. Prepare a balance sheet for the company, Prepare the profit and loss account
3. **Case Studies Analysis**: Provide students with real-world case studies involving engineering projects.
4. **Cost Estimation Exercises**: Assign students to estimate the costs of hypothetical engineering projects.
5. **Budgeting and Financial Planning Simulation**: Organize a simulation activity where students act as project managers tasked with developing budgets and financial plans for engineering projects
6. **Debates on Engineering Economic Issues**: Organize debates or discussions on controversial engineering economic topics, such as the trade-offs between cost, quality, and sustainability in project decision-making.

Project - Phase I		Semester	6
Course Code	**BAU685**	CIE Marks	100
Teaching Hours/Week (L:T:P: S)	0:0:4	SEE Marks	-
Total Hours of Pedagogy	03 HRS/WEEK	Total Marks	100
Credits	02	Exam Hours	3
Examination type (SEE)	Theory/practical/Viva-Voce /Term-work/Others		

Project Phase-I : Students have to discuss with the mentor /guide and with their help he/she has to complete the literature survey and prepare the report and finally define the problem statement for the project work.

PROJECT WORK (BAU685 and BAU786): The objective of the Project work is

(i) To encourage independent learning and the innovative attitude of the students.

(ii) To develop interactive attitude, communication skills, organization, time management, and presentation skills.

(iii) To impart flexibility and adaptability.

(iv) To inspire team working.

(v) To expand intellectual capacity, credibility, judgment and intuition.

(vi) To adhere to punctuality, setting and meeting deadlines.

(vii) To install responsibilities to oneself and others.

(viii) To train students to present the topic of project work in a seminar without any fear, face the audience confidently, enhance communication skills, involve in group discussion to present and exchange ideas.

CIE procedure for Project Work:

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

The CIE marks awarded for the project work, shall be based on the evaluation of the project work Report, project presentation skill, and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

(2) Interdisciplinary: Continuous Internal Evaluation shall be group-wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable. The CIE marks awarded for the project work, shall be based on the evaluation of project work Report, project presentation skill, and question and answer session in the ratio 50:25:25. The marks awarded for the project report shall be the same for all the batch mates.

SEE procedure for Project Work: SEE for project work will be conducted by the two examiners appointed by the University. The SEE marks awarded for the project work shall be based on the evaluation of project work Report, project presentation skill, and question and answer session in the ratio 50:25:25.

PCCL- Modelling & Analysis Lab		Semester	6
Course Code	**BAUL606**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0:0:2	SEE Marks	50
Total Hours of Pedagogy	12 to 14 sessions	Total Marks	100
Credits	01	Exam Hours	3
Examination type (SEE)	Practical		

Course objectives:

The course is intended to provide basic understanding of Modeling and Analysis technique students with following aspects:

- To acquire basic understanding of Modelling and Analysis software
- To understand the different kinds of analysis and apply the basic principles to find out the stress and other related parameters of bars, beams loaded with loading conditions.
- To apply the basic principles to carry out dynamic analysis to know the natural frequency of different kind of beams.

Sl. NO	Experiments
1	Bars of constant cross section area, tapered cross section area and stepped bar
2	Trusses – (Minimum 2 exercises of different types)
3	Beams – Simply supported, cantilever, beams with point load, UDL, beams with varying load etc (Minimum 6 exercises different nature)
4	Stress analysis of a rectangular plate with a circular hole
5	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises of different types)
6	Dynamic Analysis to find for natural frequency determination of Fixed – fixed beam
7	Dynamic Analysis to find frequency of Bar subjected to forcing function
8	Dynamic Analysis to find frequency of Fixed – fixed beam subjected to forcing function
	Demonstration Experiments (For CIE)
9	Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver
10	Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis.
11	Demonstrate at least two different types of examples to model and analyse bars or plates made from composite material

Course outcomes (Course Skill Set):

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

- Demonstrate the basic features of an analysis package.
- Use the modern tools to formulate the problem, and able to create geometry, discretize, apply boundary condition to solve problems of bars, truss, beams, plate to find stress with different loading conditions.
- Demonstrate the appropriate tool usage to solve various engineering problems.
- analyse the given problem by applying basic principle to solve and demonstrate 1D and 2D engineering problems

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course are **50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment is to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments are designed by the faculty who is handling the laboratory session and are made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- Total marks scored by the students are scaled down to **30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- The marks scored shall be scaled down to **20 marks** (40% of the maximum marks).

The Sum of scaled-down marks scored in the report write-up/journal and marks of a test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

- SEE marks for the practical course are 50 Marks.
- **SEE shall be conducted by the two examiners. One from the same institute as an internal examiner and another from a different institute as an external examiner, appointed by the university.**
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of the University.
- All laboratory experiments are to be included for practical examination.
- (Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.
- Students can pick one question (experiment) from the questions lot prepared by the examiners jointly.
- Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.
- General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)
- Change of experiment is allowed only once and 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

Suggested Learning Resources:

- You tube videos
- VTU e-resources

AEC **Automotive Heating, Ventilation and Air Conditioning**		Semester	6
Course Code	**BAU657A**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1-0-0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	1
Examination type (SEE)	**MCQ**		

Course objectives:

- To understand the basics of automotive heating, ventilation and air conditioning
- To study the fundamentals of air-conditioning system used in vehicles
- To classify and choose the right refrigerant for the vehicle air conditioning
- To learn the basics of psychrometry
- To expose to the maintenance and service of air conditioning systems used in vehicles

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby power plants, receiving station and substations to give brief information about the electrical power generation.
3. Show Video/animation films to explain functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

Air conditioning fundamentals: Fundamentals of refrigeration, basics of vehicle air conditioning system, location of air conditioning component in a car – schematic layout of a refrigeration system, component like compressor, condenser, fan blower, expansion device – expansion valve calibration, evaporator pressure regulator, low- and high-pressure switch.

Module-2

Air conditioning heating system: Automotive heaters – manually controlled air conditioner – heater system – automatically control air conditioner – air conditioning protection with heater diagnosis chart.

Module-3

Refrigerants: Introduction, classification, properties, selection criteria, commonly used refrigerants, eco-friendly refrigerants, global warming and ozone forming potential of refrigerants, containers, handling of refrigerants.

Module-4

Psychrometry: Introduction, Psychometric properties, Inside and outside design conditions of air conditioning system. Air distribution: introduction, factors affecting design of air distribution system, types of air distribution system, air flow through the dashboard recalculating unit, duct system, ventilation, vacuum reserve.

Module-5

Air conditioning maintenance and service: Cause of air conditioner failure, trouble shooting of air conditioning system, servicing heater system, removing and replacing components, leak testing, compressor service, charging and discharging, performance testing.

Course outcome (Course Skill Set)

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

1. Understand the basics of automotive heating, ventilation and air conditioning
2. Identify different components of heating, ventilation and air conditioning systems used in vehicles
3. Analyse the problems heating, ventilation and air conditioning systems used in vehicles and take up the basic service to rectify them

Assessment Details (both CIE and SEE)

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

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

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

Semester End Examinations (SEE)

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

Suggested Learning Resources:

Books

1. Automotive air Conditioning William H. Crouse, Tata McGraw Hill publication.
2. Automotive air Conditioning, Mitchell information service, PHI.
3. Hucho. W.H. - "Aerodynamic of Road Vehicles" - Butterworths Co.,

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=nHZEAe08sE8
- https://www.youtube.com/watch?v=04MlTepEIz4
- https://www.youtube.com/watch?v=ODYEyAl8ztE
- https://www.youtube.com/watch?v=oAjGHaQ-tn0
- https://www.youtube.com/watch?v=NSUeRlJ2P0g

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Watch http://www.digimat.in/nptel/courses/video/112105128/L42.html
2. NPTEL course certification
3. **System Assembly and Disassembly:**
   Activity: HVAC System Assembly/Disassembly
   Objective: Learn how to assemble and disassemble an HVAC system.

AEC Digital Twin		Semester	6
Course Code	**BAU657B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1-0-0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	1
Examination type (SEE)	**MCQ**		

Course objectives:

- To understand the Big Picture of Digital Twins, Applications of Digital Twins, Early Adopters of Digital Twins & Use Cases
- To understand Implementing Digital Twin Aggregate (DTA), Digital Twins Tools & Technologies

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby plants, start -up ecosystem, incubation centers or MSME industries to give information about the industry culture and demand.
3. Show Video/animation films to explain functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

INTRODUCTION, The Big Picture of Digital Twins, Applications of Digital Twins, Early Adopters of Digital Twins & Use Cases

Module-2

DIGITAL TWINS ARCHITECTURE, Digital Twins – The Fundamentals, The Advanced Concepts of Digital Twins, Digital Twins Architecture, Design of Digital Twin for a Rotary Kiln in the Cement Industry

Module-3

Implementing Digital Twin Aggregate (DTA), Digital Twins Tools & Technologies, Digital Twins vs Simulation – The Common Misconception

Module-4

THE FUTURE OF DIGITAL TWINS, Digital Twins & Quantum Computing, Digital Twins & Blockchain, Digital Twins & Brain-Computer Interface

Module-5

Digital Twin: Towards Internet of Drones, Digital Twin in Agriculture Sector: Detection of Disease using Deep Learning, , Crop Diseases Detection and Prevention using AI and Machine Learning Techniques

Digital Twin and the Detection and Location of DoS attacks to Secure Cyber-Physical UAS

Chapter 8: Digital twin techniques in Recognition of Human Action using the fusion of Convolutional Neural Network

Course outcome (Course Skill Set)

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

1. Understand the basics of Digital Twin Technology
2. Analyze the problems in the upcoming technology applications like drones, medical and Agri sector
3. Apply the concepts to address the societal related issues.

Assessment Details (both CIE and SEE)

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

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

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

Semester End Examinations (SEE)

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

Suggested Learning Resources:

Books

1. Digital Twin Technology, Edited By Gopal Chaudhary, Manju Khari, Mohamed Elhoseny, Copyright Year 2022, , ISBN 9781003132868 , Published October 5, 2021 by CRC Press

2. Digital Twin: A Complete Guide For The Complete Beginner, by Vijay Raghunathan , Santanu Deb Barma , Kindle Edition, 2021,

Web links and Video Lectures (e-Resources):

1. .https://dspace.mit.edu/bitstream/handle/1721.1/107989/04.Digital%20Twins.pdf?sequence=14
2. https://www.tcs.com/content/dam/tcs/pdf/discover-tcs/research-book/Digital%20Twin.pdf
3. https://www.ge.com/digital/industry/automotive
4. https://www.ge.com/digital/applications/digital-twin
5. https://virtualdutchman.com/category/digital-twin/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Introduction to Digital Twin Concepts**
   Activity: Concept Mapping
   Objective: Understand the foundational concepts of Digital Twin technology.
   Procedure: Create a concept map as a class to visually organize and represent the key components, uses, and benefits of Digital Twins. Include sensors, data analytics, simulation models, and real-time monitoring.
2. **Data Collection and Integration**
   Activity: Sensor Integration and Data Streaming
   Objective: Understand how to collect and integrate data from physical assets.
   Procedure: Equip a small-scale physical model (e.g., a model car, building, or machinery) with various sensors (temperature, humidity, motion). Stream the collected data to a cloud platform and visualize it in real-time.

AEC **Programming for Automobile Engineers**		Semester	6
Course Code	**BAU657C**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	0-0-2-0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	3
Examination type (SEE)	**Practical Lab Exam**		

Course objectives:

- To understand basics of programming
- To implement the programming techniques to solve & visualize the numerical solutions for various engineering subjects

Teaching-Learning Process (General Instructions)

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

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby power plants, receiving station and substations to give brief information about the electrical power generation.
3. Show Video/animation films to explain functioning of various programming techniques
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning

Module-1

Basics of Programming-1: Variables, Scripts & Functions, Control statements: Conditional/Selection statements, Iteration/Loop statements, Jump statements

Module-2

Basics of Programming 2: Functions & Visualizing data (Various trigonometric signals such as sine, cosine, square etc.)

Module-3

Programming engineering Math: Solving ODE (Linear and Bernoulli's differential equations, Newton's law of cooling), Solving PDE (Solution of one-dimensional heat equation), Numerical methods (Newton-Raphson methods & Taylor Series)

Module-4

Programming Mechanics: Solving conditions of limiting friction, impending motion on the horizontal and inclined planes, finding centroid and area moment of inertia, Numerical problems on support reactions for statically determinate beams (UDL, UVL and point loads)

Module-5

Programming Mechanics of materials: Visualizing and analysing for various parameters for a typical stress-strain curves for ductile and brittle materials, calculating shear forces on beams for different loading and boundary conditions, calculating normal stresses in beams for rectangular and I sections

Course outcome (Course Skill Set)

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

1. Learn key concepts of programming
2. Visualize and analyse engineering problems analytically
3. Analyse and write and execute simple codes.

Assessment Details (both CIE and SEE)

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

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

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

Semester End Examinations (SEE)

SEE shall be conducted as Lab. **The duration of the examinations shall be 3 hrs**

Suggested Learning Resources:

Books

1. Automate the Boring Stuff with Python: Practical Programming for Total Beginners, Al Sweigart, No starch press
2. The Art of Clean Code, Christian Mayer
3. MATLAB for Beginners: A Gentle Approach, **Peter I. Kattan,** Petra Books, ISBN: 978-1438203096
4. Introduction to GNU Octave, Jason Lachniet

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=kqtD5dpn9C8
2. https://www.youtube.com/watch?v=XM0CtrJYM2A
3. https://www.youtube.com/watch?v=2-OTwA7KeDQ&list=PL6xqi8nKo2yA98zG2moudwZpuWQK-iHmn&index=1

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Practical based

AEC **Battery management system**		Semester	6
Course Code	**BAU657D**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1-0-0	SEE Marks	50
Total Hours of Pedagogy	15	Total Marks	100
Credits	01	Exam Hours	1
Examination type (SEE)	**MCQ**		

Course objectives:
At the end of the course, students will be able to understand

- Basics and functionalities of battery management systems
- Battery Pack sensing factors
- Knowledge on Battery Protection and Interface with Energy estimation

Teaching-Learning Process (General Instructions)
These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) does not mean only traditional lecture method, but different type of teaching methods may be adopted to develop the outcomes.
2. Arrange visits to nearby plants, start -up ecosystem, incubation centers or MSME industries to give information about the industry culture and demand.
3. Show Video/animation films to explain functioning of various machines
4. Encourage collaborative (Group Learning) Learning in the class
5. Ask at least three HOTS (Higher order Thinking) questions in the class, which promotes critical thinking
6. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyze information rather than simply recall it.
7. Topics will be introduced in a multiple representation.
8. Show the different ways to solve the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.
10. Individual teacher can device the innovative pedagogy to improve the teaching-learning.

Module-1

Introduction to BMS and BMS functionality- discussion of BMS functionality with sub-divisions, Battery pack topology,

Module-2

Battery-pack sensing in terms Voltage, Temperature, Current. Hall effect sensors.

Module-3

High-voltage contactor control, Isolation sensing and thermal control, Protection and interface

Module-4

Charger control, Communication via CAN bus, Logbook function, Range estimation, State-of-charge estimation

Module-5

Energy and power estimation, Pack total energy and pack total power, Diagnostics

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

1. Basics and functionalities of battery management systems
2. Battery Pack sensing factors
3. Knowledge on Battery Protection and Interface with Energy estimation

Assessment Details (both CIE and SEE)

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

Continuous internal Examination (CIE)

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

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

Semester End Examinations (SEE)

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

Suggested Learning Resources:

Books

1. Advanced Battery Management Technologies for Electric Vehicles by Rui Xiong, Weixiang Shen, Wiley Publications
2. NBattery Management System for Future Electric Vehicles, by Dirk Söffker and BedatriMoulik, MDPI publishers

Web links and Video Lectures (e-Resources):

1. http://mocha-java.uccs.edu/ECE5720/ECE5720-Notes01.pdf
2. https://www.youtube.com/watch?v=cS5tkvbC4ts

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. **Component Identification and Functionality**
   Activity: Hands-On Component Examination
   Objective: Learn the functions of different components in a BMS.
   Procedure: Provide students with various BMS components such as battery cells, sensors, control units, and communication modules. Allow them to examine these parts, discussing their features and roles in the system.
2. **Battery Pack Assembly and Configuration**
   Activity: Assembling a Battery Pack
   Objective: Learn how to assemble and configure a battery pack.
   Procedure: Provide students with individual battery cells, interconnects, and a casing. Guide them through the process of assembling a battery pack, ensuring proper connections and configuration for optimal performance.
3. https://www.udemy.com/course/complete-battery-management-system-course-level-1/
4. https://training.ti.com/introduction-battery-management