NOIDA INSTITUTE OF ENGINEERING AND TECHNOLOGY, GREATER NOIDA, GAUTAM BUDDH NAGAR

(An Autonomous Institute)

Affiliated to

DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY, UTTAR PRADESH LUCKNOW

Evaluation Scheme & Syllabus

For

B.Tech in Mechanical Engineering (ME)

Third Year

(Effective from the Session: 2026-27)

NOIDA INSTITUTE OF ENGINEERING & TECHNOLOGY, GREATER NOIDA
(An Autonomous Institute)

B. TECH (ME)
Evaluation Scheme
SEMESTER V

Sl. No.	Subject Codes	Subject Name	Types of Subjects	Periods			Evaluation Schemes				End Semester		Total	Credit
				L	T	P	CT	TA	TOTAL	PS	TE	PE		
1	BME0501N	Theory of Machines	Mandatory	3	1	0	30	20	50		100		150	4
2	BME0504	Mechatronics & Robotics	Mandatory	3	1	0	30	20	50		100		150	4
3		Deprtmental Elective - II	Deprtmental Elective	3	0	0	30	20	50		100		150	3
4		Deprtmental Elective - III	Deprtmental Elective	3	0	0	30	20	50		100		150	3
5	BME0551Y	Theory of Machines Lab	Mandatory	0	0	4				50		50	100	2
6	BME0554	Mechatronics & Robotics Lab	Mandatory	0	0	2				25		25	50	1
7		Deprtmental Elective Lab - I	Deprtmental Elective	0	0	2				25		25	50	1
8	BME0555	Automotive Mechatronics	Mandatory	0	0	6				50		100	150	3
9	BCSCC0501Y	Design Thinking - II	Mandatory	2	0	0	60	40	100				100	2
10	BCSCC0552	Research Methodology, Ethics and Writing	Mandatory	0	0	2				50			50	1
11	BME0559X	Internship-I	Mandatory	0	0	2				50			50	1
12	BVAC0551	Professional Practice & Employability - I	*MOOCs	0	0	6								NA
13		*Massive Open Online Courses (For B.Tech. Hons. Degree)	Compulsory Audit											
		TOTAL		**14**	**2**	**24**	**180**	**120**	**300**	**250**	**400**	**200**	**1150**	**25**

*** List of MOOCs (Infosys Springboard) Based Recommended Courses for Third year B. Tech Students**

S. No.	Subject Code	Course Name	University/ Industry Partner Name	N. of Hours	Credits
1.	BMC0088	Lean Six Sigma Green Belt - 2022	Infosys Wingspan (Infosys Springboard)	11h 7 m	0.5
2.	BMC0071	CAD automation using CATIAv5VBA	Infosys Wingspan (Infosys Springboard)	15h	1
3.	BMC0086	Java Programming Fundamentals	Infosys Wingspan (Infosys Springboard)	36h 10m	3

PLEASE NOTE: -

- **A 3-4 weeks Internship shall be conducted during summer break after semester-IV and will be assessed during semester-V.**
- **Compulsory Audit (CA) Courses (Non-Credit - BVAC0551)**
  - ➢ All Compulsory Audit Courses (a qualifying exam) do not require any credit.
  - ➢ The Total and obtained marks are not added in the Grand Total.

Abbreviation Used:

L: Lecture, T: Tutorial, P: Practical, CT: Class Test, TA: Teacher Assessment, PS: Practical Sessional, TE: Theory End Semester Exam.
CE: Core Elective, OE: Open Elective, DE: Departmental Elective, PE: Practical End Semester Exam, CA: Compulsory Audit,
MOOCs: Massive Open Online Courses.

NOIDA INSTITUTE OF ENGINEERING & TECHNOLOGY, GREATER NOIDA
(An Autonomous Institute)
B. TECH (ME)
Evaluation Scheme
SEMESTER VI

Sl. No.	Subject Codes	Subject Name	Types of Subjects	Periods			Evaluation Schemes				End Semester		Total	Credit
				L	T	P	CT	TA	TOTAL	PS	TE	PE		
1	BME0601N	Refrigeration and HVAC	Mandatory	3	1	0	30	20	50		100		150	4
2	BME0604	Industrial Engineering & Management	Mandatory	3	1	0	30	20	50		100		150	4
3		Deprtmental Elective - IV	Deprtmental Elective	3	0	0	30	20	50		100		150	3
4		Deprtmental Elective - V	Deprtmental Elective	3	0	0	30	20	50		100		150	3
5		Open Elective - I	Open Elective	2	0	0	30	20	50		50		100	2
6	BME0651N	Refrigeration and HVAC Lab	Mandatory	0	0	4				50		50	100	2
7	BME0655	Energy Systems	Mandatory	0	0	4				50		50	100	2
8		Deprtmental Elective Lab 2	Deprtmental Elective	0	0	2				25		25	50	1
9	BME0652	Product Lifecycle Management	Mandatory	0	0	6				50		100	150	3
10	BME0659X	Applied Research with Mini Project	Mandatory	0	0	2				50			50	1
11	BVAC0651	Professional Practice & Employability - II	Compulsory Audit	0	0	6								NA
12		*Massive Open Online Courses (For B.Tech. Hons. Degree)	*MOOCs											
13		**TOTAL**		**14**	**2**	**24**	**150**	**100**	**250**	**225**	**450**	**225**	**1150**	**25**

*** List of MOOCs (Infosys Springboard) Based Recommended Courses for Third year B. Tech Students**

S. No.	Subject Code	Course Name	University/ Industry Partner Name	N. of Hours	Credits
1.	BMC0123	Internet of Things	Infosys Wingspan (Infosys Springboard)	30h 9m	2
2.	BMC0124	Manufacturing Sustainability A to Z | with ODOO Systems AI	Infosys Wingspan (Infosys Springboard)	7h 39m	0.5
3.	BMC0125	MATLAB - Advance Your Career with MATLAB Programming	Infosys Wingspan (Infosys Springboard)	8h 9m	0.5

PLEASE NOTE: -

- **A 3-4 weeks Internship shall be conducted during summer break after semester-VI and will be assessed during Semester-VII**
- **Compulsory Audit (CA) Courses (Non-Credit - BVAC0651)**
  - All Compulsory Audit Courses (a qualifying exam) do not require any credit.
  - The Total and obtained marks are not added in the Grand Total.

Abbreviation Used:

L: Lecture, T: Tutorial, P: Practical, CT: Class Test, TA: Teacher Assessment, PS: Practical Sessional, TE: Theory End Semester Exam.
CE: Core Elective, OE: Open Elective, DE: Departmental Elective, PE: Practical End Semester Exam, CA: Compulsory Audit,
MOOCs: Massive Open Online Courses.

List of Department Elective (if any):-

S.No.	Subject Code	Subject Name	Types of Subjects	Bucket Name	Semester
1	BME0513	Industrial Robots	DE II	Industry 4.0 (Robotics and Automation)	V
2	BME0515	Additive & Sustainable Manufacturing	DE III	Industry 4.0 (Robotics and Automation)	V
3	BME0514N	Automotive Engines	DE II	Automotive Engineering	V
4	BME0516	Automotive Transmission & Suspension Systems	DE III	Automotive Engineering	V
5	BME0513P	Industrial Robotics Lab	DE lab I	Industry 4.0 (Robotics and Automation)	V
6	BME0514P	IC Engine Testing & Analysis Lab	DE lab I	Automotive Engineering	V
7	BME0613	Machine Learning in Manufacturing	DE IV	Industry 4.0 (Robotics and Automation)	VI
8	BME0615	Industrial IoT	DE V	Industry 4.0 (Robotics and Automation)	VI
9	BME0614	Automotive Manufacturing & Materials	DE IV	Automotive Engineering	VI
10	BME0616	Hybrid and Electric Vehicles	DE V	Automotive Engineering	VI
11	BME0615P	Industrial IoT Lab	DE lab II	Industry 4.0 (Robotics and Automation)	VI
12	BME0616P	Advanced E-Mobility System Lab	DE lab II	Automotive Engineering	VI

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AICTE Guidelines in Model Curriculum:

A student will be eligible to get Under Graduate degree with Honours only, if he/she completes the additional MOOCs courses such as Infosys Springboard/NASSCOM/CISCO (as applicable) certifications, or any other online courses recommended by the Institute (Equivalent to 20 credits). During Complete B.Tech. Program Guidelines for credit calculations are as follows.

1. For 6 to 12 Hours =0.5 Credit
2. For 13 to18 =1 Credit
3. For 19 to 24 =1.5 Credit
4. For 25 to 30 =2 Credit
5. For 31 to 35 =2.5 Credit
6. For 36 to 41 =3 Credit
7. For 42 to 47 =3.5 Credit
8. For 48 and above =4 Credit

For registration to MOOCs Courses, the students shall follow Infosys Springboard/NASSCOM/CISCO (as applicable) registration details as per the assigned login and password by the Institute these courses may be cleared during the B. Tech degree program (as per the list provided). After successful completion of these MOOCs courses, the students shall provide their successful completion status/certificates to the Controller of Examination (COE) of the Institute through their coordinators/Mentors only.

The students shall be awarded Honours Degree as per following criterion.

i. If he / she secures 7.50 as above CGPA.

ii. Passed each subject of that degree program in the single attempt without any grace.

iii. Successful completion of MOOCs based 20 credits

Course Code: BME0501N	Course Name: Theory of Machines	L	T	P	C
Course Offered in: ME		**3**	**1**	**0**	**4**

Pre-requisite: Engineering Mathematics, Engineering Mechanics & Strength of Materials

Course Objectives:

The course Theory of Machines aims to provide students with fundamental and comprehensive knowledge of the kinematic and dynamic behavior of mechanisms and machine elements. It enables students to analyze and design linkages, cams, gears, and gear trains, and to perform velocity, acceleration, force, and motion analyses of mechanical systems. The course also covers flywheels, balancing of rotating and reciprocating masses, governors, gyroscopic effects, and dynamometers to evaluate the performance, stability, and efficiency of machines. By integrating these concepts, the course equips students with the ability to design and analyze mechanical systems for reliable and effective operation in a wide range of engineering applications.

Course Outcome: After completion of the course, the student will be able to	
1. Analyze the fundamentals of mechanisms and machines, and determine the velocity and acceleration of planar mechanisms using relative velocity, instantaneous center, and Coriolis acceleration concepts.	K4
2. Apply the principles of cam-follower motion, law of gearing, and gear trains to design and construct cam profiles and gear train configurations used in mechanical systems.	K3
3. Analyze static and dynamic forces in mechanisms evaluate the performance of flywheels for controlling fluctuation of energy and speed.	K4
4. Apply the principles of balancing and governors, and assess their role in reducing vibration and maintaining speed stability in rotating and reciprocating systems.	K3
5. Apply the gyroscopic effects and the operating principles of various dynamometers for evaluating stability and measuring power in mechanical applications.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	2	1	–	–	–	–	2	3	2	1
CO2	3	2	3	2	3	1	–	–	–	1	2	3	3	2
CO3	3	3	2	3	2	1	–	–	–	1	2	3	2	1
CO4	3	3	2	2	2	2	–	–	–	1	2	3	2	1
CO5	3	2	2	2	3	2	–	–	–	1	2	3	3	2

Course Contents / Syllabus

Unit 1	Mechanisms, Velocity and Acceleration	14 hours

Mechanism:

Introduction, mechanisms and machines, kinematics and kinetics, kinematic link and its types, kinematic pairs and their classification, kinematic chain, constraint motion, degrees of freedom of planar mechanism, Grobler’s equation, inversion of four bar chain, single slider crank chain and double slider crank chain.

Velocity Analysis:

Introduction, velocity of point in mechanism, relative velocity and instantaneous centre method, Kennedy’s theorem, velocities in four bar and slider crank mechanism.

Acceleration Analysis:

Introduction, acceleration of a point on a link, Coriolis’s component of acceleration, acceleration in four bar and slider crank mechanism.

Unit 2	Cam, Follower and Gears	12 hours

Cam and Follower:

Introduction, classification of cams and followers, terminology of cam, cam profiles for knife edge, roller and flat faced followers for uniform velocity, simple harmonic motion, uniform acceleration, and retardation.

Gears and Gear Trains:

Introduction, classification of gears, terminology of gear, law of gearing, tooth forms and their comparisons, systems of gear teeth, length of path of contact and arc of contact, contact ratio, minimum number of teeth on gear and pinion to avoid interference, simple, compound, reverted and epicyclic gear trains.

Unit 3	**Force Analysis and Flywheel**	**12 hours**

Force Analysis:

Static force analysis of mechanisms, D'Alembert's principle, dynamic force analysis of planar mechanisms, engine force analysis, piston effort, crank effort and turning moment on crankshaft.

Flywheel:

Flywheels and its function, turning moment diagrams for single cylinder double acting steam engine, four stroke IC engine and multi-cylinder engines, fluctuation of energy and speed, energy stored by flywheel.

Unit 4	**Balancing and Governors**	**12 hours**

Balancing:

Introduction, static balancing, and dynamic balancing, Introduction to vibration, balancing of rotating masses in same plane and different plane, graphical and analytical methods, balancing of reciprocating masses.

Governor:

Introduction, governor and its function, types of governors, centrifugal governors and inertia governors, dead weight and spring controlled centrifugal governors, sensitivity and stability of governor, isochronous governor, hunting of centrifugal governors, effort, and power of governor.

Unit 5	**Gyroscope and Dynamometer**	**10 hours**

Gyroscope:

Gyroscopic couples, Gyroscopic stabilization of shaft bearing, aero plane and ships, stability of four wheel and two-wheel vehicles moving on curved paths.

Dynamometers:

Dynamometers, types of dynamometers, prony brake and rope brake dynamometer, belt transmission, epicyclic and torsion dynamometer.

Total Lecture Hours	**60 hours**

Textbook:

S. No	**Books Title**
1.	Theory of Machines by S.S. Rattan, McGraw Hill.
2.	Theory of Machines by R. K. Bansal, Laxmi Publications.
3.	Theory of Machines by Khurmi & Gupta, S. Chand Publication.
4.	Kinematics of Machines by Dr. Sadhu Singh, S.K. Kataria & Sons.
5.	Theory of Machines by V. P. Singh, Dhanpat Rai Publishing Co. Pvt. Ltd.

Reference Books:

S. No	**Books Title**
1.	Mechanics of Machines by V. Ramamurti, Alpha Science.
2.	Theory of Machines and Mechanisms by Rao & Dukkipati, bohem press.
3.	Theory of Mechanisms and Machines by Amitabha Ghosh and Ashok Kumar Mallik, Third Edition Affiliated East-West Press.
4.	Theory of Machines and Mechanisms by Joseph Edward Shigley and John Joseph Uicker, Jr. Oxford University Press.

Self-Study Content Links:		Duration (in Hrs)
MOOCs	https://nptel.ac.in/courses/112104121	25
Video Lectures	https://www.youtube.com/watch?v=e9oMqjmWzsc	15
Web References	https://drive.google.com/file/d/1Dl-nPf_jR38GbjQjmEwN9DclzVR7Yee0/view?pli=1	10

Course Code: BME0504	Course Name: Mechatronics & Robotic	L	T	P	C
Course Offered in: ME		**3**	**1**	**0**	**4**

Pre-requisite: Basic knowledge of electrical, electronics and mechanism.

Course Objectives:

To develop an understanding of mechatronics systems, sensors, transducers, actuators, drive systems, hydraulic and pneumatic automation, and PLC programming, enabling students to apply mechatronic principles and automation technologies in real-world engineering applications.

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

1.	Identify key elements of mechatronics and its representation by block diagram.	K2
2.	Understand the concept of sensors and use of interfacing systems.	K3
3.	Understand the concept and applications of different actuators.	K3
4.	Analyze the performance of hydraulic and pneumatic actuation system.	K4
5.	Understand PLC ladder programming and implementation in real life problem.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO3	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO4	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO5	3	2	2	1	3	2	1	1	1	1	3	3	2	2

Course Contents / Syllabus

Unit 1	**Introduction to Mechatronics and Robotic**	**10 hours**

Introduction: Introduction to Mechatronics, Evolution of Mechatronic, Function of Mechatronic, Representation of Mechatronic System in block Diagram, Advantages and disadvantages of Mechatronics, Scope & Application of Mechatronics, Introduction to Robotics.

Control System: Introduction to Control Systems, Elements of control system, Basic of open and closed loop control with example, Concept of transfer function for each element of Mechatronic.

Unit 2	**Sensors and transducers**	**9 hours**

Sensors and Transducers: Signal Conditioning, Principle of Sensing, Sensors & Transducer with classification, types of sensors used in Robotics, Development in Transducer technology, Criteria for selection of sensors based on requirements, Performance chart, Static and Dynamic characteristics, Principle of working and application of Inductive Proximity, Capacitive Proximity, Photoelectric, Ultrasonic, Magnetic, Hall Effect, Tactile Sensor, load cell, LVDT and interfacing sensors.

Unit 3	**Actuators and Drive system**	**8 hours**

Actuators: Actuation system, Classification of Actuators, Selection of Actuators, Micro actuators, End effectors, Types of Grippers – Mechanical, Magnetic, vacuum, pneumatic and hydraulic.

Electrical Actuation Systems: Introduction to Switching devices, Concept of Electromechanical Actuation, Solenoids and Solenoid Operated Control Valves, Relay, Stepper motors and Servo Motors.

Unit 4	Hydraulic & Pneumatic Actuation System	9 hours

Hydraulic Actuation System: Different types of valves such as flow, Direction control valve, Hydraulic pumps, Actuators and Auxiliary elements in Hydraulics, their applications and use of their Graphical Symbols, Synthesis and design of circuits (up to 2 cylinders), Hydraulic system design, Electro-Hydraulics.

Pneumatic Actuation System: Production and Distribution of Compressed air, Components of Pneumatic System, Different types of Valves, Graphical symbols, Graphical representation and design of Pneumatic system, Electro- Pneumatics.

Unit 5	Controller & Programming Techniques	9 hours

Controller: Automatic Control and Real Time Control Systems, types of controllers, PID controller, adaptive control, P, PI, PD and PID control systems, Programmable Logic Devices: Microprocessor, Microcontroller and PLC, selection of PLC, Architecture, Latching, Timers, Counter.

Programming Techniques: Ladder Logic programming for different types of logic gates, Ladder diagram: Concept of Contacts and Coil, Latching/ Holding Circuit, Memory Bits, Timers, and Counter.

Total Lecture Hours	**45 hours**

Textbook:

1. Mechatronics Systems", Springer, 2005 by Rolf Isennann
2. "Mechatronics", Pearson Education 2003 by W. Bolten
3. Mechatronics - Integrated Mechanical Electronic Systems, Wiley by P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram

Reference Books:

1. Mechatronics System Design by Devdas Shetty & Richard A. Kolk
2. Mechatronics: A Multidisciplinary Approach by William Bolton.

Self-Study Content Links:		Duration (in Hrs)
MOOCs	https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_me179	30
Video Lectures	https://nptel.ac.in/courses/112107298	30
Web References	https://infobooks.org/free-pdf-books/engineering/mechatronics-engineering/	18

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

Course Code: BME0551Y	Course Name: Theory of Machines Lab	L	T	P	C
Course Offered in: ME		0	0	4	2

Pre-requisite: Engineering Mathematics, Engineering Mechanics & Strength of Materials

Course Objectives:

The course Theory of Machines Laboratory aims to provide students with practical experience that complements the theoretical concepts of mechanisms and machine dynamics through hands-on experiments. Students investigate linkages, inversions of kinematic chains, cam-follower systems, gear trains, gyroscopic effects, shaft whirling, balancing of rotating masses, governors, and vibration characteristics. The laboratory enables students to compare theoretical predictions with experimental observations, thereby strengthening their understanding of the kinematic and dynamic behavior of mechanical systems. By bridging the gap between theory and practice, the course develops the skills required to analyze, design, evaluate, and maintain machines effectively for real-world engineering applications.

Course Outcome: After completion of the course, the student will be able to	
1. Apply the principles of kinematic analysis to investigate different types of linkages and inversions of kinematic chains, and compare experimental observations with theoretical predictions.	K3
2. Analyze the motion characteristics and performance of cam-follower mechanisms and epicyclic gear trains through experimental studies and theoretical validation.	K4
3. Analyze the dynamic behavior of mechanical systems by conducting experiments on gyroscopic effects, shaft whirling, and static and dynamic balancing of rotating masses.	K4
4. Evaluate the performance characteristics of governors and vibration systems by interpreting experimental data and validating theoretical relationships related to speed regulation and oscillatory motion.	K5

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	1	–	1	2	–	2	3	3	2
CO2	3	3	2	3	3	2	–	1	2	–	2	3	3	2
CO3	3	3	2	3	2	1	–	1	2	1	2	3	2	3
CO4	3	3	2	3	3	1	–	1	2	–	2	3	3	2

List of Practical's:		**CO**
Mandatory Practical's:		
1.	To study of simple linkage models/mechanisms.	CO1
2.	To study of inversions of four bar chain.	CO1
3.	To study of inversions of single/double slider crank mechanisms	CO1
4.	To find out the angular displacement of various cam follower pairs and to plot the h - θ (follower displacement vs. angle of cam rotation) curves for different cam follower pairs.	CO2
5.	To study the gyroscopic effect of a rotating disc & experimental justification of the equation $T = I\ \omega\ \omega_p$ for calculating the gyroscopic couple by observation and measurement of results for independent variation in applied couple T and precession ω_p.	CO3
6.	To determine the whirling speed of the shaft with various end conditions for various diameters and to compare its theoretical and actual speeds.	CO3
7.	Determination of characteristics curves of sleeve position against speed and radius of rotation against controlling force for Watt Governor.	CO4
8.	Determination of characteristics curves of sleeve position against speed and radius of rotation against controlling force for Porter Governor.	CO4
9.	To balance the masses Statically & Dynamically of a simple rotating mass system and observe the effect of unbalance in a rotating mass system.	CO3

10.	To measure epicyclic gear ratio between input shaft & output shaft and measure input torque, holding torque and output torque.	CO2
Additional Practical's:		
11.	Determination of characteristics curves of sleeve position against speed and radius of rotation against controlling force for Proell Governor.	CO4
12.	Determination of characteristics curves of sleeve position against speed and radius of rotation against controlling force for Hartnell Governor.	CO4
13.	To study the longitudinal vibration of helical spring and to determine the frequency and time period of oscillation theoretically and actually by experiment.	CO4
14.	To study the Torsional Vibrations of single rotor system.	CO4
		Total Hours: 60 hrs.

Course Code: BME0554	LAB Course Name: Mechatronics & Robotic Lab	L	T	P	C
Course Offered in: ME		0	0	2	1

Pre-requisite: Basic knowledge of mechanism, electrical and electronics

Course Objectives:

To provide practical knowledge and develop skills in pneumatic and electro-pneumatic systems, including their industrial applications, while introducing PLC operations involving logic gates, timers, and counters.

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

1. Implement and analysis the various operation of pneumatic actuation system.	K3
2. Implement and analysis the various operation of electro-pneumatic actuation system.	K4
3. Understand and Identify the basic concept of PLC perform simple operations.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	1	1	1	1	3	3	2	3
CO2	3	2	2	1	2	2	1	1	1	1	3	3	2	3
CO3	3	2	2	1	2	2	1	1	1	1	3	3	2	3

List Of Practical's (Indicative & Not Limited To)	CO
1. To study of various types of switching devices.	CO1
2. To study of various ISO symbol for pneumatic/ hydraulic circuit.	CO1
3. To study of pneumatic actuation system and various components.	CO1
4. To practically verify truth tables of various logic gates on pneumatic actuation system.	CO1
5. To practically verify truth tables of various logic gates on Electro-pneumatic actuation system.	CO3
6. To practically verify truth tables of various logic gates with help of ladder programming.	CO4
7. To study and implement inductive proximity sensor with ideal characteristics.	CO3
8. To study and implement roller operated limit switch on pneumatic actuation system.	CO2
9. To operate multi cycle double acting cylinder with use of timer with different time span.	CO2
10. To operate multi cycle double acting cylinder with use of counter with different count.	CO2
Additional:	
11. To operate a double acting cylinder using quick exhaust valve and flow control valve.	CO2
12. To operate a double acting cylinder using limit switch and memory valve with multiple cycle.	CO2
13. To implement single cycle automation of multiple cylinders using cascading method in sequence of motion: A+A-B+B-	CO2
14. To operate a single and double acting pneumatic cylinder using solenoid DCV.	CO3
15. To operate multiple cycle of double acting cylinder using electro pneumatic automation	CO3
16. To write a ladder program of 3 phase motor with overload coil, start and stop switch.	CO4
17. To operate multi cycle double acting cylinder with use of electro-pneumatic timer with different time span.	CO3
18. To operate multi cycle double acting cylinder with use of electro-pneumatic counter with different count.	CO3
19. To write a ladder program to operate a double acting pneumatic cylinder using solenoid DCV.	CO4

20. To write a ladder program to implement single cycle automation of multiple cylinders using cascading method in sequence of motion: A+B+A-B-	CO4
Total Hours: 30 hrs.	

Course Code: BME0555	Course Name: Automotive Mechatronics(Theory)	L	T	P	C
Course Offered in: ME		0	0	6	3

Pre-requisite: Basic knowledge of automobile engineering, electronics, and control systems.

Course Objectives:

To develop an understanding of automotive mechatronics by integrating mechanical, electrical, electronic, and control systems, while providing knowledge of sensors, actuators, ECUs, vehicle communication protocols, automotive control systems, and mechatronic applications in electric and hybrid vehicles, including battery management, regenerative braking, and diagnostics.

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

1. Apply the fundamentals of automotive mechatronics and analyze the integration of sensors, actuators, and ECUs in modern vehicle systems.	K3
2. Apply the working principles, characteristics, and applications of automotive sensors and actuators used in vehicle control and monitoring systems.	K3
3. Apply the concepts of Electronic Control Units (ECUs), vehicle networking protocols, and diagnostic systems for automotive communication and fault analysis.	K3
4. Analyze automotive control systems such as ABS, TCS, cruise control, and drive-by-wire systems using open-loop and closed-loop control principles.	K4
5. Evaluate the integration of mechatronic systems in electric and hybrid vehicles, including motor control, Battery Management Systems (BMS), regenerative braking, and vehicle diagnostics.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	-	-	-	1	1	-	3	2	2
CO2	3	3	2	2	2	-	-	-	1	1	-	3	2	2
CO3	3	3	2	2	3	-	-	-	1	1	-	3	3	2
CO4	3	3	3	3	2	-	-	-	1	1	-	3	2	2
CO5	3	3	3	2	3	1	2	-	1	1	-	3	3	3

Course Contents / Syllabus

Unit 1	Introduction	9 hours

Introduction to Automotive Mechatronics- Definition, scope, and importance of mechatronics in automobiles Key components: sensors, actuators, ECUs, Apply mechatronic concepts to automotive subsystems such as engine management, transmission control, braking, steering, and infotainment systems. Overview of automotive systems (engine, chassis, transmission, braking, and infotainment) Trends in automotive mechatronics (e.g., ADAS, electrification, autonomy),

Unit 2	Automotive Sensors and Actuators	9 hours

Automotive Sensors and Actuators-Common sensors in vehicles: temperature, position, speed, pressure, oxygen sensors, etc. Apply the principles of automotive sensors and actuators in vehicle applications. Working principles and characteristics Actuators: solenoids, motors, hydraulic and pneumatic types Signal conditioning and data acquisition basics

Unit 3	Electronic Control Units (ECU) and Communication Protocols	9 hours
Electronic Control Units (ECU) and Communication Protocols- Architecture and functions of ECUs in vehicles Memory organization, Input/Output handling Overview of in vehicle networks: CAN, LIN, FlexRay, and MOST Diagnostics and OBD-II basics Apply ECU concepts in automotive electronic systems.		
Unit 4	**Control Systems and Applications in Vehicles**	**9 hours**
Control Systems and Applications in Vehicles- Basics of control theory in automotive context Open-loop vs closed-loop systems Cruise control, ABS, TCS, and electronic stability control Drive-by-wire systems, Analyze the operation of ABS, TCS, ESC, and cruise control systems.		
Unit 5	**Mechatronics in Electric and Hybrid Vehicles**	**9 hours**
Mechatronics in Electric and Hybrid Vehicles-Powertrain components overview Integration of motor control with ECUs Battery Management Systems (BMS) Regenerative braking and energy recovery systems Introduction to vehicle diagnostics and fault detection, Analyze battery management and regenerative braking systems.		
	Total Lecture Hours	**45 hours**

Textbook:

1. Automotive Mechatronics: Operational and Practical Issues by William B. Ribbens, published by Elsevier.
2. Automotive Mechatronics by Konrad Reif, published by Springer.

Reference Books:

1. Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering by W. Bolton, published by Pearson Education.
2. Understanding Automotive Electronics by William B. Ribbens, published by Butterworth-Heinemann.

Self-Study Content Links:		Duration (in Hrs)
MOOCs	https://onlinecourses.nptel.ac.in/e-learning/preview/noc21_de02	15 Hrs
Video Lectures	https://www.youtube.com/watch?v=4lilX8cHDHI&t=18s https://nptel.ac.in/courses/107106080	5 Hrs 5 Hrs
Web References	https://moticristo.pt/en/automotive-mechanics-what-it-is-how-it-works-and-why-it-matters-1/	5 Hrs

Course Code:	LAB Course Name: Automotive Mechatronics Lab	L	T	P	C
Course Offered in: ME		**0**	**0**	**6**	**3**

Pre-requisite: Basic knowledge of automobile engineering, electronics, and control systems.

Course Objectives:

To develop a comprehensive understanding of automotive mechatronics through the integration of mechanical, electrical, electronic, and control systems, including automotive sensors, actuators, ECUs, vehicle communication protocols, control systems, and mechatronic applications in electric and hybrid vehicles for intelligent vehicle operation, diagnostics, and performance enhancement.

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

1. Apply the fundamentals of automotive mechatronics and analyze the integration of sensors, actuators, and ECUs in modern vehicle systems.	K3
2. Apply the working principles, characteristics, and applications of automotive sensors and actuators used in vehicle control and monitoring system.	K3
3. Apply the concepts of Electronic Control Units (ECUs), vehicle networking protocols, and diagnostic systems for automotive communication and fault analysis.	K3
4. Analyze automotive control systems such as ABS, TCS, cruise control, and drive-by-wire systems using open-loop and closed-loop control principles.	K4
5. Evaluate the integration of mechatronic systems in electric and hybrid vehicles, including motor control, Battery Management Systems (BMS), regenerative braking, and vehicle diagnostics.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	-	-	-	1	1	-	3	2	2
CO2	3	3	2	2	2	-	-	-	1	1	-	3	2	2
CO3	3	3	2	2	3	-	-	-	1	1	-	3	3	2
CO4	3	3	3	3	2	-	-	-	1	1	-	3	2	2
CO5	3	3	3	2	3	1	2	-	1	1	-	3	3	3

List Of Practical's (Indicative & Not Limited To, the third practical of each CO is optional)	CO
1. Study and identification of mechatronic systems used in modern automobiles 2. Demonstration of integration of sensors, actuators, and ECUs in automotive systems 3. Analysis of ADAS and autonomous vehicle features through case studies and simulations	**CO1**
4. Study of automotive sensors such as temperature, speed, pressure, and oxygen sensors 5. Demonstration of working of actuators including solenoids, DC motors, and stepper motors 6. Testing and analysis of sensor signals using basic signal conditioning circuits	**CO2**
7. Study of ECU architecture and identification of ECU components in vehicles 8. Demonstration of CAN bus communication and OBD-II diagnostic tools 9. Analysis of vehicle fault codes and diagnostic data using OBD-II scanner	**CO3**
10. Study of open-loop and closed-loop control systems in automobiles 11. Demonstration of ABS, TCS, and cruise control system operation 12. Analysis of drive-by-wire systems and feedback control mechanisms using simulation tools	**CO4**

13. Study of electric and hybrid vehicle powertrain components 14. Demonstration of Battery Management System (BMS) and regenerative braking setup 15. Analysis of fault detection and diagnostic techniques in EV/HEV systems	**CO5**
Total Hours: 45 hrs.	

Course Code: BME0513	Course Name: Industrial Robots	L	T	P	C
Course Offered in: ME		**3**	**0**	**0**	**3**

Pre-requisite: Engineering Mathematics, Control Systems, Basic Mechanics, Basic of Electrical Engineering, Sensors, Manufacturing Processes

Course Objectives:

By the end of this course, students will be able to identify and describe various types of industrial robots and their applications. They will develop an understanding of robot kinematics concepts and be able to apply them to real-world scenarios. Additionally, students will learn to apply basic dynamics and control principles to robotic systems. The course also covers the development of trajectory planning strategies and the implementation of vision-based applications. Finally, students will gain experience using robot simulation tools and implementing applications using the Robot Operating System (ROS).

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

1. Identify and describe various industrial robot types and their applications.	K2
2. Analyze robotic kinematics concepts and apply them to real-world scenarios.	K4
3. Apply basic dynamics and control principles to robotic systems.	K3
4. Develop trajectory planning strategies and implement vision-based applications.	K5
5. Use robot simulation tools to implement ROS.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	1	1	1	3	2	2
CO2	3	3	3	2	2	1	1	1	1	1	1	3	3	3
CO3	3	3	3	2	2	1	1	1	1	2	1	3	2	3
CO4	3	3	3	3	3	1	1	1	1	2	2	3	3	3
CO5	3	3	3	3	3	1	1	1	1	2	2	3	3	3

Course Contents / Syllabus

Unit 1	Introduction to Industrial Robotics	06 hours

Introduction to Industrial Robots, Evolution of robots, International Robotic Standards, Types of robots, Selection of robots, Robot Classifications, Configuration &Specification of industrial Robots, Robot feedback controls: Point to point control and Continuous path control, Control system for robot joint, Adaptive control, Types of end effectors with application, Operation and programming, Economics of robotics, Workcell design principles and system integration, Robot installation, peripheral devices of robot.

Unit 2	Kinematics of Robots	10 hours

Direct Kinematics

link, Robot coordinates system, D-H Representation, Geometric transformation, Direct kinematic analysis for articulated manipulator, SCARA Robot.

Inverse Kinematics

Need of inverse kinematics, inverse kinematics for articulated manipulator, Multiple solutions and singularities, Robot reachability and dexterity measures, Tool configuration and positioning.

Unit 3	Dynamics of Robots and Control System	9 hours

Dynamics

Introduction to Robot dynamics, Static forces and torques in robot manipulators, Gravity compensation and payload considerations, Lagrange's equation kinetic and potential energy.

Control system

Control system architecture for industrial robots, Open-loop vs. closed-loop control concepts, PID control, Proportional, integral, and derivative actions, Effects of controller parameters, Tuning methods and stability considerations, Force/torque control concepts and applications, Adaptive control strategies for changing conditions, Performance evaluation of control systems.

Unit 4	Trajectory Planning & Machine Vision	10 hours

Trajectory Planning

Fundamentals of trajectory planning, Joint space vs. Cartesian space planning, Point-to-point motion vs. continuous path motion, Interpolation methods (linear, circular, spline), Path constraints and optimization, Motion profiles (trapezoidal, S-curve, polynomial), Collision detection and avoidance strategies, Multi-point path planning.

Machine vision

Machine vision fundamentals for robotics, Camera types and selection, Camera calibration concepts, Image processing basics for robotics, Object detection and recognition, Pose estimation techniques, Vision-guided robot applications, Pick and place from vision, Visual servoing concepts, Quality inspection systems, Bin picking applications, Sensor fusion and multi-sensor integration.

Unit 5	Programming & Robot Operating System	10 hours

Robot Programming
Introduction to robot programming methods, Teach pendant programming, Lead-through programming, Textual programming languages, Robot program structure and syntax, Programming motion commands, I/O handling in robot programs, Program flow control and logical operations, Subroutines and modularity in robot programming,

ROS
architecture and philosophy, ROS concepts: nodes, topics, services, and actions, Publisher-subscriber communication pattern, Workspace setup and package management, Robot modeling in ROS, Coordinate frames and transformations using TF, ROS-Industrial framework, Integration with commercial robots, Developing applications with ROS, Basic programming patterns, Navigation and manipulation, Sensor integration in ROS, Creating custom ROS packages, Deployment of ROS applications to physical robots.

Total Lecture Hours	**45 hours**

Textbook:
1. "Industrial Robotics Technology programming and Applications", McGraw-Hill by M.P. Groover, M. Weiss, R.N. Nagel, and N.G. Odrey
2. Robotics: Fundamental Concepts and Analysis by, Oxford University Press by Ashitava Ghosal

Reference Books:
1. Robotic Engineering: An Integrated Approach, Pearson Education, 1st Edition (2003), ISBN: 9788120325124. By Richard D. Klafter, Thomas A. Chmielewski, and Michael Negin,
2. Learning ROS for Robotics Programming, Packt Publishing, 2nd Edition (2015), ISBN: 9781783987443. By Aaron Martinez and Enrique Fernández,

Self-Study Content Links:		Duration (in Hrs)
MOOCs	Industrial Robotics, Infosys Springboard	6
Video Lectures	Industrial Robotics: Theories for Implementation, IIT-ISM Dhanbad, Prof. Arun Dayal Udai, NPTEL	19
Web References	diag.uniroma1.it/~deluca/rob1_en/01_IndustrialRobots.pdf	20

Course Code: BME0515	Course Name: Additive and Sustainable Manufacturing	L	T	P	C
Course Offered in: ME		**3**	**0**	**0**	**3**

Pre-requisite: Basics of manufacturing technology and materials science

Course Objectives:

This course provides a comprehensive understanding of Additive Manufacturing technologies, materials, design principles, and their integration with sustainable manufacturing and circular economy concepts. It equips students to evaluate AM processes, address environmental impacts, and implement sustainable practices across key industries.

Course Outcome: After completion of the course, the student will be able to	
CO1: Explain the principles, technologies, workflow, and applications of Additive Manufacturing processes.	K2
CO2: Analyze various materials used in AM, their properties, printability, defects, and optimization methods.	K3
CO3: Apply Design for Additive Manufacturing (DfAM) principles and evaluate emerging trends and Industry 4.0 integration in AM.	K3
CO4: Describe the concepts, tools, and techniques of sustainable manufacturing and its linkages with green and lean manufacturing.	K2
CO5: Evaluate circular economy principles, environmental impact assessment methods, and case studies of sustainable Additive Manufacturing in industrial sectors.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	1	-	1	-	2	3	2	2
CO2	3	3	2	2	2	2	1	-	1	-	2	3	2	1
CO3	2	2	3	2	3	2	1	1	2	1	3	3	3	3
CO4	2	2	2	1	1	3	2	1	1	1	2	2	2	2
CO5	2	2	2	2	1	3	2	1	2	2	3	3	3	3

Course Contents / Syllabus

Unit 1	Foundations of Additive Manufacturing	8 hours

Introduction to Additive Manufacturing, AM vs. subtractive/formative manufacturing, Applications in key industries: aerospace, biomedical, automotive, tooling, consumer goods.

3D Printing / Rapid Prototyping (RP): Principle of RP, various RP technologies (Stereolithography Apparatus (SLA), Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), Laminated Object Manufacturing (LOM), Laminated Manufacturing (LM), etc.), Product accuracy and surface quality, Speed.

Metal based AM Processes: LPBF/SLM, Binder Jetting, DED/WAAM, hybrid manufacturing.

AM/RP workflow: CAD modelling, Reverse Engineering, Introduction to STL format, Pre & Post-processing methods, Various slicing methods.

Unit 2	Materials for Additive Manufacturing	8 hours

AM Materials : Various materials (strength, homogeneity and isotropy), Economic analysis.
Polymer filaments/powders (PLA, ABS, PETG, Nylon, etc) properties and printability. Reinforced filaments (short and continuous natural fibre/carbon/glass fibre).
Metal powders (morphology, flowability, quality impact). Common alloys (stainless steel, titanium, nickel superalloys, aluminium, etc),
Composites and ceramics (binder-jetting ceramics, continuous-fibre composites, multi-material),
Emerging Materials (bio-inks, 4D smart materials, functionally graded materials).
Common defects: porosity, warping, delamination, anisotropy — root causes, identification, optimization.

Unit 3	Design for AM & Emerging Trends	8 hours

Design for Additive Manufacturing (DfAM): DfAM philosophy, Industrial trends in RP, Design Applications & Advancement in Manufacturing, Tooling & Production. Batch Production and Associated Technologies: Vacuum Casting, Thermo Forming etc.
Interdisciplinary Applications: Biomedical, Dental, Prosthetics, Fashion, Food, Architecture etc.
AM and Industry 4.0 Integration: Digital twins, Cloud AM platforms, AI/ML in AM, Large-format AM, Bioprinting, Electronics AM, Space AM.

Unit 4	Principles of Sustainable Manufacturing	8 hours
Concepts of sustainability and sustainable development – Need for sustainable development - Components of sustainability- Social, Economic, Environmental dimensions – Linkages between technology and sustainability - Sustainable Manufacturing –Scope, Need and Benefits. **Tools and Techniques** of Sustainable Manufacturing – Environmental Conscious Quality Function Deployment, Life cycle assessment, Design for Environment, Design for Disassembly -Sustainable Product Development – Various Phases. **Design for recycling –** Eco friendly product design methods – Methods to infuse sustainability in early product design phases – Multi-Criteria Decision Making in Sustainability. Relation between green, lean and sustainable manufacturing.		
Unit 5	**Circular Economy, Environmental Impact & Case Studies**	**9 hours**
Circular Economy, R-hierarchy (Refuse, Reduce, Re-use, Repair, Refurbish, Remanufacture, Recycle, Recover), Remanufacturing process, Product-as-a-Service, Reverse logistics, take-back programmes. **Environmental conscious-** quality function deployment-R3 and R6 cycles-Environmental impact assessment methds- CML, EI 95 and 99, ISO 14001, EMS and PAS 2050 standards, environmental impact parameters. Sustainability assessment-concept models and various approaches, product sustainability and risk assessment-corporate social responsibility. **Industry Case Studies:** One case study from Automotive sector , one case study from Aviation/Aerospace sector, focusing on Additive manufacturing with sustainability.		
	Total Lecture Hours	**45 hours**

Textbook:

1. Sanjay Kumar, "Additive Manufacturing Processes", Springer 2020.
2. Atkinson G, Dietz S, Neumayer E, "Handbook of sustainable manufacturing" Edward Elgar Publishing limited, 2007

Reference Books:

1. Gibson, I., Rosen, D., Stucker, B. & Khorasani, M. Additive Manufacturing Technologies, 3rd ed., Springer, 2021.
2. Rodick, D, " Industrial Development for the 21 st century: Sustainable development perspectives" UN New York,2007

Self-Study Content Links:		**Duration (in Hrs)**
MOOCs	Additive Manufacturing — NPTEL (IIT Jodhpur): https://nptel.ac.in/courses/112108098 Sustainable Development — NPTEL (IIT Kharagpur): https://nptel.ac.in/courses/124105002	20
Video Lectures	How 3D Printing Works — MIT OpenCourseWare (YouTube): https://youtube.com/@mitocw AM Processes Explained — Coursera, Additive Manufacturing Series (TU Delft): https://coursera.org/learn/additive-manufacturing Sustainable Manufacturing — UNEP Resource Efficiency Videos: https://youtube.com/@unenvironment	15
Web References	ASTM AM Standards & Resources: https://www.astm.org/additive-manufacturing Wohlers Associates Industry Reports: https://wohlersassociates.com Ellen MacArthur Foundation — CE Resources: https://ellenmacarthurfoundation.org ecoinvent LCA Database (Academic Access): https://ecoinvent.org Formlabs AM Learning Hub: https://formlabs.com/blog	10

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

Course Code: BME0514N	Course Name: Automotive Engines	L	T	P	C
Course Offered in: ME		**3**	**0**	**0**	**3**

Pre-requisite: Basic knowledge of Thermodynamics, Heat Transfer, and Fluid Mechanics. An understanding of the fundamentals of internal combustion engines, as covered in the Theory of Machines and Engineering Thermodynamics courses, is also required.

Course Objectives:

To develop a comprehensive understanding of internal combustion engines, including their classifications, components, operating principles, fuel and ignition systems, combustion processes, performance characteristics, auxiliary systems, emissions, modern engine technologies, and testing methods for performance evaluation.

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

1. Understand engine types, components, and operating principles of SI and CI engines, including cycle analysis and emissions.	K2	
2. Analyse fuel delivery and ignition systems, including carburetor's, fuel injectors, nozzles, and ignition mechanisms.	K4	
3. Evaluate combustion processes in SI and CI engines and identify factors affecting knocking and combustion chamber design.	K3	
4. Explain engine cooling, lubrication, supercharging, turbocharging, and exhaust systems and their impact on performance.	K3	
5. Conduct engine testing, measure performance parameters, and interpret results using standard testing methods.	K3	

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	2	2	2	2	1	1	2	3	2
CO2	3	2	2	2	2	2	3	2	2	1	1	3	3	3
CO3	3	2	2	1	2	2	2	2	1	1	1	2	3	2
CO4	3	2	3	2	2	1	2	2	2	1	1	2	3	2
CO5	3	2	1	1	2	2	2	2	1	1	1	3	3	3

W2Course Contents / Syllabus

Unit 1	**Introduction to I.C Engines and Cycles**	**08 hours**

Introduction to I.C Engines: Principle of working, Classification, Air std. Fuel, air and actual cycles, two and four-stroke, SI and CI engines, main parts, valve and port timing diagram

Unit 2	**Combustion Phenomenon in SI engines**	**10 hours**

Combustion Phenomenon in SI engines: Principles of combustion in SI engines, effect of engines and operating variables on ignition delay & flame propagation, combustion chamber for SI engines, cycle-to-cycle variation, pre-ignition, abnormal combustion, theories of detonation, effect of engine and operating variables on detonation, surface ignition, adiabatic flame temperature, ignition systems.

Unit 3	**Combustion phenomenon in CI engines**	**10 hours**

Combustion phenomenon in CI engines: Principles of combustion in CI engine, delay period, variables affecting delay period, diesel knock, methods of controlling diesel knock, combustion process & combustion chambers for CI engines.

Unit 4	**Fuel system and Mixture requirement in SI and CI Engines**	**08 hours**

Fuel system and Mixture requirement in SI and CI Engine: Carburetion- working principles, chemically correct air-fuel ratio and load variation, compensating devices, venturi and jet dimension calculation, modern fuel induction system, multi-point fuel injection system, fuel injection: common rail direct injection.

Unit 5	**Engine Testing, Supercharging, Lubrication and Engine Cooling**	**09 hours**

Engine Testing, Supercharging, Lubrication and Engine Cooling: Engine performance and testing, measurement of power, supercharging limits of SI &CI engines, methods of supercharging, superchargers, turbo charging, lubrication principles, function of lubricating system, properties of lubricating oil, additives, cooling system, air cooling, water cooling.

Total Lecture Hours	**45 hours**

Textbook:

1. Internal Combustion Engines by John B. Heywood
2. Internal Combustion Engines by V. Ganesan

Reference Books:

3. Advanced engine technology by Heinz Heisler
4. Internal Combustion Engine analysis and Practice by Obert, E.F.

Self-Study Content Links:		Duration (in Hrs)
MOOCs	NPTEL: IC Engines & Gas Turbines Course (https://www.youtube.com/playlist?list=PLT7nZHsCM2mxVhbXn7BeHTXg4w7btBf5I) NPTEL: Engine Combustion & Emissions (https://www.youtube.com/playlist?list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC) NPTEL Fundamentals of Combustion (https://www.youtube.com/playlist?list=PLwdnzlV3ogoXHbVNKWL1BYOo_8PpyNtnC) NPTEL IC Engines (Fuel System Lectures) (https://www.youtube.com/watch?v=ry3hnaDvW3M) NPTEL IC Engines Full Course (https://www.youtube.com/watch?v=NVYSMRU1P7M)	**15 hours**
Video Lectures	#1 course overview & classification of internal combustion engines | part 01 lec 1: introduction to engine systems and its types: a focus on ignition system lec 16: fuels and combustion (part i) noc19-ae02 lec 13 - cooling and exhaust system (lab session) ic engine- performance and testing of ic engine numerical	**15 hours**
Web References	https://nptel.ac.in/courses/112103262 https://nptel.ac.in/courses/112104033 https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_me29 https://gpahmedabad.ac.in/uploads/2/coursedetails/studymaterials/4330201_Unit3.pdf	**15 hours**

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

Course Code: BME0516	Course Name: Automotive Transmission & Suspension Systems	L	T	P	C
Course Offered in: ME		**3**	**0**	**0**	**3**

Pre-requisite: Basic knowledge of Mechanics of Machines and Automotive Engineering

Course Objectives:

To develop an understanding of automotive transmission, driveline, and suspension systems, including clutch mechanisms, gearboxes, power transmission components, axle and differential systems, and advanced suspension technologies, enabling students to analyze their operation, performance, ride comfort, and vehicle handling characteristics.

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

1. Explain transmission system types, clutch applications, and torque converter functions.	K2
2. Analyze gear train layouts, gear ratios, and compare manual vs. automatic transmissions.	K4
3. Describe propeller shafts, differentials under dynamic conditions, and 4WD/AWD systems.	K2
4. Identify suspension types, their geometry impact on vehicle dynamics, and spring-damper use.	K2
5. Distinguish suspension types, understand electronic control systems, and analyze advanced suspension applications.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	-	-	-	1	1	-	3	2	2
CO2	3	3	2	2	2	-	-	-	1	1	-	3	3	2
CO3	3	3	3	2	3	-	-	-	1	1	-	3	3	2
CO4	3	3	2	3	2	-	1	-	1	1	-	3	2	3
CO5	3	3	3	3	3	1	2	-	1	1	-	3	3	3

Course Contents / Syllabus

Unit 1	**Clutch Systems and Fundamentals of Automotive Transmission**	**08 hours**

Function and necessity of transmission in automobiles; Classification of transmission systems (manual, automatic, CVT, etc.); Layout of power transmission from engine to wheels; Clutches: Single Plate Clutch, Multi-Plate Clutch, Cone Clutch, Centrifugal Clutch, Diaphragm Clutch Working principle and comparison of clutches; Torque Converters and Fluid Couplings; Clutch lining materials, friction considerations, and heat dissipation.

Unit 2	**Gearboxes and Automatic Transmission Systems**	**10 hours**

Gearbox types: Sliding mesh, Constant mesh, Synchromesh gearboxes; Gear ratio and torque multiplication; Epicyclic gear trains: working and gear calculations; Construction and working of automatic transmissions; Overview of CVT and Dual Clutch Transmissions (DCT); Comparison of manual vs. automatic transmissions in terms of performance, efficiency, and control.

Unit 3	**Propeller Shafts, Differentials, and Axle Systems**	**09 hours**

Propeller shafts: construction and balancing; Universal joints and slip joints; Differentials: Open, Limited slip, Locking; Rear and front axle layouts; Working of 4WD and AWD systems; Transaxles: integration of gearbox and differential; Transfer case, torque split control, and cross-axle locking.

Unit 4	**Conventional Suspension Systems and Vehicle Dynamics**	**08 hours**

Suspension objectives: ride comfort, stability, load isolation; Types of suspension systems: dependent and independent; Springs: Leaf, Coil, Torsion bar, Air springs; Suspension geometry and vehicle dynamics: Camber, Caster, Toe-in and Toe-out, Kingpin inclination; Shock absorbers and dampers: hydraulic, gas-charged, twin-tube, mono-tube; Suspension kinematics and effect on handling.

Unit 5	**Advanced and Active Suspension Systems**	**10 hours**

Active Suspension Systems: components and working; Semi-active and adaptive suspensions; Hydro pneumatic and electro-pneumatic suspension systems; Electronic control systems for suspension: Sensors (accelerometers, position sensors), Actuators, ECU (Electronic Control Unit); Case Studies: McPherson Strut, Multi-link suspension; Introduction to ride and handling simulation, suspension testing methods

Total Lecture Hours	**45 hours**

Textbook:

1. Automobile Engineering Vol. I & II, Standard Publishers 2. Automobile Engineering, Satya Prakashan 3. Advanced Vehicle Technology, Butterworth-Heinemann		
Reference Books: 5. Automotive Suspension and Steering Systems, Delmar Cengage 6. Automotive Mechanics, Tata McGraw Hill 7. Transmission, Chassis and Related Systems, Butterworth-Heinemann		
Self-Study Content Links:		Duration (in Hrs)
MOOCs	https://onlinecourses.nptel.ac.in/noc24_de03/preview https://archive.nptel.ac.in/courses/107/106/107106088/ https://nptel.ac.in/courses/107106088	20 HRS
Video Lectures	https://www.youtube.com/watch?v=GinzMttVE1M http://kcl.digimat.in/nptel/courses/video/107106088/L66.html	15 Hrs
Web References	https://www.q8oils.com/automotive/automatic-transmission-systems/	10 Hrs

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

LAB Course Code: BME0513P	LAB Course Name: Industrial Robots Lab	L	T	P	C
Course Offered in: ME		0	0	2	1

Pre-requisite: No Prerequisites required

Course Objectives:

To develop an understanding of industrial robot construction, operation, programming, and workcell setup, enabling students to perform robotic trajectory planning, motion control, and industrial automation tasks such as welding, pick-and-place, and object sorting applications.

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

1. Understand the components and working principles of robotic welding systems.	K2
2. Develop and implement KUKA Robot Language (KRL) programs for linear, circular, and zigzag welding paths.	K4
3. Optimize robot motion parameters such as velocity, acceleration, and tool orientation for smooth welding operations.	K6

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	2	1	1	-	-	-	2	3	2	2
CO2	3	3	3	2	3	-	-	1	1	-	2	3	3	3
CO3	3	3	2	3	3	1	-	1	-	-	2	3	2	3

List Of Practical's (Indicative & Not Limited To)	CO
1. Study of the KUKA KR 10 Robot and Welding Tool Setup	**CO1**
2. Basic KRL Programming for Robot Movement	**CO2**
3. Straight-Line Welding Path Simulation	**CO2**
4. Circular Welding Path Simulation Using CIRC Motion	**CO2**
5. Zigzag Welding Pattern Simulation for Wide Seams	**CO2**
6. Velocity Control in Welding Path Execution	**CO3**
7. Pick and place of object	**CO3**
8. Sorting of objects from Bin	**CO3**

Total Hours: 30 hrs.

LAB Course Code: BME0514P	LAB Course Name: IC Engine Testing & Analysis Lab	L	T	P	C
Course Offered in: ME		**0**	**0**	**2**	**1**

Pre-requisite: Basic knowledge of Thermodynamics, Heat Transfer, and Fluid Mechanics. An understanding of the fundamentals of internal combustion engines, as covered in the Theory of Machines and Engineering Thermodynamics courses, is also required.

Course Objectives:

1. To provide a practical understanding of the construction, components, and working principles of petrol and diesel internal combustion engines.
2. To develop knowledge of engine operating characteristics through valve timing, port timing, and fuel injection systems.
3. To perform engine performance evaluation using tests such as performance, heat balance, Morse test, and retardation/Willan's line method.
4. To analyse engine efficiency and emission characteristics through exhaust gas analysis and interpretation of experimental results.

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

1. Explain the construction, working principles, and subsystems of various internal combustion (IC) engines.	K2
2. Analyse valve timing, port timing diagrams, and performance characteristics of IC engines.	K3
3. Perform performance, heat balance, and emission tests on IC engines to evaluate efficiency, losses, and environmental impacts.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	1	1	-	1	2	3	3
CO2	3	3	2	-	-	-	-	2	2	-	2	1	3	3
CO3	3	3	2	3	2	-	-	1	2	2	-	3	3	3

List of Practical's (Indicative & Not Limited To)	CO
1. Study of I.C. Engine Components (Diesel & Petrol engine)	**CO1**
2. Valve Timing Diagram of a 4-Stroke Diesel Engine	**CO2**
3. Port Timing Diagram of a 2-Stroke Petrol Engine	**CO2**
4. Performance Test on a 4-Stroke Single-Cylinder Diesel Engine	**CO3**
5. Performance Test on a 4-Stroke Petrol Engine	**CO3**
6. Heat Balance Test on a 4-Stroke Diesel Engine	**CO3**
7. Morse Test on Multi-Cylinder Petrol Engine	**CO3**
8. Retardation Test / Willan's Line Method	**CO3**
9. Exhaust Gas Analysis for Emission Measurement	**CO2**
10. Study of Fuel Injection Systems (MPFI / CRDI)	**CO1**

Total Hours: 30 hrs.

Course Code: BME0601N	Course Name: Refrigeration and HVAC	L	T	P	C
Course Offered in: B.Tech Mechanical engineering		3	1	0	4

Pre-requisite: Thermodynamics and Heat Transfer

Course Objectives:

To develop an understanding of the principles, methods, and applications of refrigeration and HVAC systems, including refrigerants, vapor compression refrigeration systems, psychrometric processes, air conditioning systems, load calculations, and their industrial and commercial applications

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

1. Illustrate the basic concepts of refrigeration systems and refrigeration cycles and properties, applications and environmental issues of different refrigerants	K3
2. Analyze the simple vapour compression refrigeration systems, multi stage vapour compression refrigeration systems	K4
3. Familiarize about the various psychrometric processes employed in refrigeration HVAC systems.	K3
4. Calculate the heating and cooling load requirements of HVAC systems.	K4
5. Apply scientific and engineering principles to familiarize equipment that relate to refrigeration and HVAC systems. 1.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1	1	2	2	2	1	2	2	2
CO2	3	3	2	1	1	2	1	2	2	2	1	2	2	2
CO3	3	2	2	1	1	1	2	1	1	1	1	1	2	2
CO4	3	3	3	1	1	2	2	2	2	2	1	2	2	2
CO5	3	3	3	1	1	1	2	2	2	2	1	2	2	2

Course Contents / Syllabus

Unit 1	Basics of refrigeration and Refrigerants	10 hours

Introduction: Brief history and need of refrigeration and air conditioning, methods of refrigeration, unit of refrigeration, coefficient of performance, types and application of refrigeration. Reversed Carnot cycle and its limitation and applications. Air refrigeration systems, Absorption and other refrigeration systems.

Refrigerants: Classification, nomenclature, desirable properties, secondary refrigerants, future industrial refrigerants, recent trends in refrigerants and its environmental impact.

Unit 2	Vapour compression refrigeration systems	15 hours

Vapour Compression system: Simple system on P-h and T-s diagrams, analysis of the simple cycle, factors affecting the performance of the cycle, actual cycle. Compound Compression System: Compound compression with intercooler, flash gas removal and flash intercooler, Multistage vapour compression system requirement, Different configuration of multistage system, cascade refrigeration system.

Unit 3	Psychrometry and HVAC	15 hours
Psychrometry: Psychometric properties and their definitions, Psychrometric chart, Different Psychrometric processes, Thermal analysis of human body, Effective temperature and comfort chart, Cooling and heating load calculations, Selection of inside & outside design conditions, Heat transfer through walls & roofs, Infiltration & ventilation, Internal heat gain, Sensible heat factor (SHF), By pass factor, Grand Sensible heat factor (GSHF), Apparatus dew point (ADP).		
Unit 4	**HVAC Systems**	**10 hours**
Introduction: Factors Affecting Comfort Air-Conditioning, Air-Conditioning System, Equipment Used in an Air Conditioning System. Classification of Air Conditioning Systems: Comfort Air Conditioning Systems, Industrial Air Conditioning System, Winter Air Conditioning System, Summer Air Conditioning System, Year-Round Air Conditioning System, Unitary Air Conditioning System, Central Air Conditioning System Cooling load estimation: Components of a Cooling load, Sensible Heat Gain through Building Structure by Conduction, Heat Gain from Solar Radiation, Solar Heat Gain (Sensible) through Outside Walls and Roofs, Heat Gain due to Infiltration, Heat Gain due to Ventilation, Heat Gain from Occupants, Heat Gain from Appliances, Heat Gain from Products, Heat Gain from lighting Equipment Heat Gain from Power Equipment		
Unit 5	**Applications of Refrigeration and HVAC**	**10 hours**
Domestic Refrigerator and Freezer: Defrosting in Refrigerators, Controls in Refrigerator Room Air Conditioner, Water Coolers: Capacity of Water Coolers, Applications of Air Conditioning in Industry, Refrigerated Trucks, Marine Air-conditioning, Ice Manufacture, Cooling of Milk (Milk Processing), Cold Storages, Quick Freezing, Cooling and Heating of Foods, Freeze Drying, Heat and Mass Transfer through the Dried Material.		
	Total Lecture Hours	**60 hours**

Textbook:

1. Refrigeration and Air Conditioning, McGraw-Hill India Publishing Ltd. by C P Arora,
2. Refrigeration and Air-conditioning, Prentice Hall of India by Ramesh Arora
3. Refrigeration and Air Conditioning, New Age International Publisher by Manohar Prasad
4. Principles of Refrigeration, Pearson Education by Roy. J Dossat
5. Refrigeration and Air Conditioning, Prentice Hall of India Pvt. Ltd. By Jordon and Prister

Reference Books:

8. Refrigeration and Air Conditioning by R.S. Khurmi & J.K.Gupta, S.Chand Publication

Self-Study Content Links:		Duration (in Hrs)
MOOCs	https://nptel.ac.in/courses/112105129	10
Video Lectures	https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_me114	40
Web References	https://www.ashrae.org/technical-resources/ashrae-handbook/ashrae-handbook-online	10

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

Course Code: BME0604	Course Name: Industrial Engineering &Management	L	T	P	C
Course Offered in: ME		3	1	0	4

Pre-requisite: Computer block diagram, Generation of programming languages, Translators, Flowchart

Course Objectives: Production engineering

The objective of the Industrial Engineering & Management course is to provide students with a comprehensive understanding of the principles and functions of industrial engineering and management. It aims to equip students with the knowledge of modern industrial practices such as ERP, logistics. Students will learn project management techniques using CPM and PERT, including network diagram construction, critical path determination. students will explore the use of operations research in management decision-making.

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

1. Apply the principles of industrial engineering and management, and modern industrial practices such as ERP, logistics, JIT, and supply chain management, to enhance efficiency and decision-making in industrial environments.	K3
2. Apply the principles of Production Planning and Control (PPC), and project management tools such as Gantt charts, CPM, and PERT to effectively plan, and schedule.	K4
3. Understand the principles of material management and inventory control and apply techniques inventory models to optimize resource utilization and cost efficiency.	K3
4. Apply the concepts of work study, including method study and work measurement techniques to improve productivity and value through value analysis methods	K3
5. Apply operations research techniques such as linear programming, transportation and assignment models to solve decision-making problems in various functional areas of management using graphical, simplex, Hungarian and MODI methods.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	2	1	1	1	2	1	2	3	2	1
CO2	3	3	2	2	2	1	1	1	2	2	3	3	3	2
CO3	3	3	1	2	2	1	1	1	2	1	3	3	3	2
CO4	3	3	2	2	2	3	1	3	2	2	1	3	2	1
CO5	3	3	3	3	2	1	2	1	1	2	3	3	3	2

Course Contents / Syllabus

Unit 1	Introduction to industrial management, operation management	10 hours

Introduction to industrial engineering, Management, functions of industrial management.

Organizational structure: Introduction, types, Advantages and disadvantages.

Operations management: Objectives Types of production system (Job, Batch and Mass Production). Plant Location, Factors, Urban & Rural sites Comparison, Types of plant Layouts, Design of product Layout, Line balancing.

Recent trends in industrial management: ERP (Enterprise resource planning) concept, features and applications, Logistics: concept, need and benefits, Just in Time (JIT):, concept and benefits, Supply chain management: concept and benefits

Unit 2	Production planning and control (PPC) , Scheduling Techniques	15 hours

PPC: Definition and functions of PPC, introduction to scheduling, GANTT chart, Forecasting methods. MRP I&MRPII

CPM & PERT: meaning, features, difference, applications. Understand different terms used in network diagram. Draw network diagram Determination of critical path on network. Floats, its types and determination of floats. Crashing of network..

Unit 3	Materials Management and Queuing theory	15 hours

Material management: definition, functions, importance, relationship with other departments.

Inventory control: Definition. Objectives. Derivation for expression for Economic Order Quantity (EOQ) and numeric examples. ABC analysis and other modern methods of analysis. Various types of inventory models, Break Even analysis.

Queuing Theory: Basis of Queuing theory, elements of queuing theory, Operating characteristics of a queuing system, Classification of Queuing model. numerical problems on queuing models.

Unit 4	Work study and value engineering	10 hours

Work study: Introduction Definition-Objectives, Steps in work study, Method Study definition, objectives- steps of method study. Work measurement: purpose, types of study, stop watch methods, steps, key rating, allowances, standard time calculations, work sampling.
Value Analysis: definition, terms used, process and importance. value analysis flow diagram. DARSIRI method of value analysis. Waste- types, sources and ways to reduce them.

Unit 5	Operational Analysis	10 hours

Linear programming problems: Introduction and applications of operations research in functional areas of management. Linear Programming-formulation, solution by graphical methods.
Transportation Models: (Minimizing and Maximizing Problems), Balanced Problems, Initial Basic feasible solution by N-W Corner Rule, least cost and Vogel's approximation methods. Check for optimality. Solution by MODI Case of Degeneracy.
Assignment Models: (Minimising and Maximising Problems), Balanced Problems. Solution by Hungarian and Branch and Bound Algorithms. Travelling Salesman problem.

Total Lecture Hours	**60 hours**

Textbook:
1. Industrial Engineering Management by Ravi Shankar.
2. Industrial Engineering and Production management. By Martand T Telsang.

Reference Books:
9. Modern Production Management by Buffa.
10. Materials Management by N. Nair.
11. Operations research: An Introduction by Hamdy A. Taha
12. Operations research PK Gupta, DS Hira.
13. Production and Operations Management: Concepts, Models and Behavior by Evertt E. Adam, Jr. Ronald J. Ebert

Self-Study Content Links:		Duration (in Hrs)
MOOCs	NPTEL :: Mechanical Engineering - NOC:Principles of Industrial Engineering	20
Video Lectures	NPTEL :: Mechanical Engineering - NOC:Work System Design NPTEL :: Management - NOC:Management of Inventory Systems	20
Web References	https://www.newtondesk.com/wp-content/uploads/2018/05/Industrial-Engineering-study-notes.pdf	20

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

Course Code: BME0651N	Course Name: Refrigeration and HVAC Lab	L	T	P	C
Course Offered in: B.Tech Mechanical engineering		0	0	4	2

Pre-requisite: Thermodynamics and Heat Transfer

Course Objectives:

To develop a comprehensive understanding of refrigeration and HVAC systems, including refrigeration principles, refrigerants, vapor compression systems, psychrometric processes, air conditioning systems, comfort load calculations, and their applications in residential, commercial, and industrial sectors.

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

2. Demonstrate practical understanding of Simple vapour compression refrigeration system. [K3]
3. Demonstrate working understanding of types of evaporators, condensers, compressors and expansion devices used in refrigeration system. [K3]
4. Analyze and calculate the performance of vapour compression refrigeration system. [K4]
5. Calculate coefficient of performance of air-conditioning systems. [K4]
6. Demonstrate the complete working of window air conditioner.[K3]

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	2	1	1	1	1	1	3	2	2
CO2	3	2	1	2	1	2	1	1	1	1	1	3	2	2
CO3	3	3	2	1	1	2	1	1	1	1	1	3	2	2
CO4	3	2	2	1	1	2	1	1	1	1	1	3	2	2
CO5	3	2	2	1	1	2	1	1	1	1	1	3	2	2

List of Experiments

1. Experiment for calculation of various performance parameters of vapour compression systems
2. To study different types of expansion devices used in refrigeration system.
3. To study different types of evaporators used in refrigeration systems.
4. To study basic components of air-conditioning system.
5. Experiment for calculation of various performance parameters of air conditioning systems
6. Experiment for calculation of various performance parameters of water-cooling tower.
7. Study of window air conditioner.
8. To study different types of compressors used in refrigeration and air conditioning systems.
9. To study different types of condensers used in refrigeration and air conditioning systems.
10. Experiment for calculation of various performance parameters on Desert coolers.

Additional List of Experiments

1. General study of vapour compression refrigeration system.

2. To study Refrigeration test rig and find out C.O.P.

3. General study of Ice Plant.

4. General study and working of cold storage.

5. General study of Air Condition (Package Type).
Total Hours: 30 hrs.
Mode of Evaluation:

Course Code: BME0655	Course Name: Energy System	L	T	P	C
Course Offered in: ME		**0**	**0**	**4**	**2**

Students should have basic knowledge of Engineering Thermodynamics, Heat Transfer, Renewable Energy Systems, and Energy Conversion Processes. Familiarity with fundamental mechanical engineering concepts will help in understanding the design and analysis of energy systems.

Course Objectives:

To develop an understanding of conventional and renewable energy systems, their design, operation, performance characteristics, energy storage technologies, and hybrid energy systems, enabling students to evaluate and apply sustainable energy solutions for modern applications.

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

1. Explain the basics of conventional and renewable energy systems and their applications.	K2
2. Analyse the performance of solar, wind, and biomass energy systems.	K3
3. Perform basic design calculations for thermal and cooling systems.	K3
4. Evaluate energy storage and hybrid energy systems for practical applications.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	-	-	2	-	2	-	-	-	-	2	3	3
CO2	3	3	2	2	2	-	3	-	-	-	-	3	3	3
CO3	2	3	3	2	2	-	1	-	-	-	1	3	2	2
CO4	2	3	3	3	3	1	2	-	1	-	2	2	2	2

Course Contents / Syllabus

Unit 1	Introduction to Energy Systems	09 hours

Energy sources, conventional and renewable energy systems, energy conversion principles, energy demand and consumption, applications of energy systems in daily life and industries

Unit 2	Solar Energy and Applications	09 hours

Solar Radiation and Solar Thermal Energy Collection: Flat Plate and Focusing Collectors, Their Materials, and Performance. Solar Thermal Energy Storage, **Applications:** heating, cooling, and Power Generation; Solar Photovoltaic Conversion, solar dryers.

Unit 3	Conventional Power Plants	08 hours

Overview of power generation methods, **Hydro Power Plants** (working, components, advantages & disadvantages), **Steam (Thermal) Power Plants**: working, components, Comparison of hydro and steam power plants, **Nuclear Power Plant:** Working principle (fission), Components and advantages/disadvantages; **Gas Turbine Power Plant**: Brayton cycle, Open and closed cycle gas turbines; **Diesel Power Plant:** Working principle, Applications

Unit 4	Energy Resources and Renewable Energy Technologies	10 hours

Wind Energy Fundamentals: Wind Energy Conversion Systems (WECS), Types of Wind Turbines (HAWT and VAWT), Applications, Advantages and Limitations of Wind Energy; **Biomass Resources and Classification:** Biomass Conversion Technologies, Biogas Plants and Biofuels, Applications, Advantages and Limitations of Biomass Energy; **Tidal Energy Fundamentals:** Tidal Barrage and Tidal Stream Systems; **Ocean Thermal Energy Conversion (OTEC); Wave Energy Systems:** Applications, Advantages and Limitations of Tidal and Ocean Energy; **Geothermal Energy Resources:** Geothermal Power Plants, Dry Steam, Flash Steam and Binary Cycle Systems, Applications, Advantages and Limitations of Geothermal Energy

Total Lecture Hours	**36 hours**

Textbook:

1. Energy Systems Engineering by Michael C. Georgiadis et al., Wiley-VCH.
2. Design of Thermal Energy System by Pradip Majumdar, Wiley Publications

Reference Books:

1. Handbook of Energy Engineering by Albert Thumann and D. Paul Mehta.
2. Advances in Energy Systems Engineering, by Georgios M. Kopanos, Pei Liu, and Michael C. Georgiadis, Springer

Self-Study Content Links:		Duration (in Hrs)
MOOCs	NPTEL Course: Design and Optimisation of Energy Systems NPTEL: Sustainable Energy Technology NPTEL Syllabus and Study Material Lecture: Concepts and Basic Principles of Energy Integration Lecture 21: Optimization – Basic Ideas Lecture 24: Constrained Optimization Problems	**08 hours**
Video Lectures	Lecture 1: Introduction to Optimization Lecture 2: System Design and Analysis Lecture: Overview of Renewable Energy Technology Lecture 3: Workable System Lecture 4: System Simulation	**08 hours**
Web References	Renewable Energy Lecture Notes (KAU) Renewable Energy Systems Notes (St. Anne's College) KIIT Renewable Energy Notes Solar Water Heating Systems (PDF) Renewable Energy Systems PDF Notes Solar Thermal Course (Free Online) Energy Audit Handbook (SEAI) Industrial Energy Audit Guidebook (LBNL) Energy Management & Audit Notes	**08 hours**

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

Course Code: BME0652	Course Name: Product Lifecycle Management (Workshop Mode)	L	T	P	C
Course Offered in: ME		**0**	**0**	**6**	**3**

Pre-requisite: Students should have basic knowledge of product design & development and manufacturing.

Course Objectives:

To integrate systematic approaches of innovative product lifecycle management using design thinking, business considerations, advanced technologies, risk management, quality and safety practices, project monitoring, and supply chain strategies to develop efficient products and processes while achieving proficiency in PLM.

Course Outcome: After completion of the course, the student will be able to	
1. To integrate systematic approaches of innovative product lifecycle management using design thinking with an awareness of business considerations needed to produce products.	K3
2. To develop ability to employ state-of-the-art technology in product and process development and be PLM proficient.	K3
3. To develop skills to support product realization, including prototype, testing, validation and marketing.	K3
4. To introduce the latest trends and technology in digital manufacturing.	K3
5. To familiarize with the concepts of PLM strategy and application.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	3	1	2	1	2	1	2	3	3	2
CO2	3	2	2	2	3	1	3	1	2	1	2	3	3	2
CO3	3	2	1	1	2	1	1	2	2	1	3	3	3	2
CO4	3	2	2	2	2	2	2	1	2	1	3	2	3	2
CO5	3	3	2	2	2	1	1	1	2	2	2	3	3	3

List of Practical's:		**CO**
Mandatory Practical's:		
Module 1.1	**Introduction to Product Life Cycle Management (PLM):** Definition, PLM Lifecycle Model, Threads of PLM, Need for PLM, Opportunities and Benefits of PLM.	CO1
Module 1.2	Views, Components and Phases of PLM, PLM feasibility Study, PLM Visioning.	CO1
1.3	**Introduction to PTC Windchill,** Windchill Environment	CO1
1.4	Homepage Interface, Locating Information, Viewing Information,	CO1
1.5	Introduction to Visualization, Managing Your Work	CO1
1.6	Oracle and Windchill Installation	CO1
1.7	Creating and Managing Documents	CO1
1.8	Creo Parametric Data Administration, Part & CAD Data Management,	CO1
Module 1.9	**PLM Concepts, Processes and Workflow:** Characteristics of PLM, Environment Driving PLM, PLM Elements, Drivers of PLM, Conceptualization.	CO1
Module 1.10	Design, Development, Validation, Production, Support of PLM.	CO1
1.11	Manage Design Development	CO1
1.12	Working With CAD Data	CO1
1.13	Manage Family Tables	CO1
1.14	Change Management	CO1
1.15	Exercises on Change Management	CO1
1.16	Introduction to Windchill Business Administration, Quiz-1	CO1

Module 2.1	**Collaborative Product Development:** Engineering Vaulting, Product Reuse, Smart Parts, Engineering, Change Management.	CO2
Module 2.2	Prototype Development, Design for Environment, Virtual Testing and Validation, Marketing Collateral.	CO2
2.3	Managing Objects, Object Types, and Object Attributes	CO2
2.4	Managing Domain Policies and Access Control	CO2
2.5	Object Initialization Rules OIRs	CO2
2.6	Exercises on Object Initialization Rules OIRs	CO2
2.7	Lifecycle Template Administration	CO2
2.8	Exercises on Lifecycle Template Administration,	CO2
Module 2.9	**Digital Manufacturing – PLM:** Digital Manufacturing, Benefits of Digital Manufacturing, Manufacturing the First-One.	CO2
Module 2.10	Ramp Up, Virtual Learning Curve, Manufacturing the Rest, Production Planning.	CO2
2.11	Policy Administration Preferences	CO2
2.12	Exercises on Policy Administration Preferences	CO2
2.13	Type and Attribute Management	CO2
2.14	Exercises on Type and Attribute Management	CO2
2.15	Workflow Administration	CO2
2.16	Exercises on Workflow Administration, Quiz-2	CO2
Module 3.1	**Developing a PLM Strategy:** Strategy, Impact of strategy, implementing a PLM strategy, PLM Initiatives to Support Corporate Objectives.	CO3
Module 3.2	**Conducting a PLM Assessment:** Infrastructure Assessment, Assessment of Current Systems and Applications.	CO3
3.3	Windchill API, Data models	CO3
3.4	Exercises on Windchill API, Data models	CO3
3.5	Listeners	CO3
3.6	Exercises on Listeners	CO3
3.7	Form Processor, Validator and Filter	CO3
3.8	Exercises on Form Processor, Validator and Filter,	CO3
Module 3.9	**Supply Chain Management:** Basic Concepts and Introduction – Procurement, Supply Chain Management, Project Procurement and Subcontract Management.	CO3
Module 3.10	Vendor Management, Inventory Management.	CO3
3.11	Eclipse and debugger configurations	CO3
3.12	Exercises on Eclipse and debugger configurations	CO3
3.13	Windchill Customization Basics	CO3
3.14	The Windchill Development Environment	CO3
3.15	User Interface Customization	CO3
3.16	MCV Builders, Quiz-3	CO3
Module 4.1	**Project Cost Management:** Essentials of Cost Management, Cost Estimation, Cost Budget and Variance Analysis.	CO4
Module 4.2	Cost Monitoring and Control, Essentials of Project Cash Flows.	CO4
4.3	Managing Windchill Services	CO4
4.4	Managing Windchill Properties	CO4
4.5	File Vaulting and Replication Overview	CO4
4.6	Tuning Windchill Server	CO4
4.7	Windchill Backup and Recovery	CO4

4.8	Managing Log Files and Alerts,	CO4
Module 4.9	Quality & EHS Management: Defining Quality, Construction Project Quality, Quality Management System, 7 Quality Tools.	CO4
Module 4.10	Control Chart & Cost of Quality. Introduction to Occupational Health, Safety and Environment.	CO4
4.11	Windchill License Management	CO4
4.12	Daily System Monitoring Tasks	CO4
4.13	Weekly System Monitoring Tasks	CO4
4.14	Monthly System Monitoring Tasks	CO4
4.15	Setting Up the Client Environment	CO4
4.16	Miscellaneous System Enhancements, Quiz-4	CO4
Module 5.1	**Project Risk Management:** Risk Introduction, Risk Analysis.	CO5
Module 5.2	Risk Response Strategy and Implementation.	CO5
5.3	Revision and Doubt Clearing with Project Work	CO5
5.4	Revision and Doubt Clearing with Project Work	CO5
5.5	Revision and Doubt Clearing with Project Work	CO5
5.6	Revision and Doubt Clearing with Project Work	CO5
5.7	Revision and Doubt Clearing with Project Work	CO5
5.8	Revision and Doubt Clearing with Project Work	CO5
Module 5.9	**Project Monitoring & Control:** Introduction to Project Monitoring and Controlling, Analysis Techniques.	CO5
Module 5.10	Visualization Techniques, Elements of Control, Monitor and Control Schedule, Cost and Resources.	CO5
5.11	Project Work	CO5
5.12	Project Work	CO5
5.13	Project Work	CO5
5.14	Project Work	CO5
5.15	Project Work	CO5
5.16	Project Work, Quiz-5	CO5
		Total Hours: 60 hrs.

Course Code: BME0613	Course Name: Machine Learning in Manufacturing	L	T	P	C
Course Offered in: ME		**3**	**0**	**0**	**3**

Pre-requisite: Statistics & Probability

Course Objectives:

To develop an understanding of fundamental Machine Learning concepts and applications, enabling students to apply supervised and unsupervised learning techniques, neural networks, evolutionary optimization methods, genetic algorithms, and reinforcement learning to solve real-world engineering problems.

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

1. Understand ML concepts, types, performance measures, and applications in manufacturing systems.	K2
2. Apply supervised learning techniques such as regression, classification, SVM, and decision trees in engineering problems.	K3
3. Apply clustering and dimensionality reduction techniques for data analysis in manufacturing.	K3
4. Understand neural networks and evolutionary algorithms for solving complex optimization problems in manufacturing.	K3
5. Apply genetic algorithms and reinforcement learning techniques for real-time industrial and manufacturing applications.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO3	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO4	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO5	3	2	2	1	3	2	1	1	1	1	3	3	2	2

Course Contents / Syllabus

Unit 1	**Introduction to Machine Learning**	**8 hours**

Introduction to Machine Learning, Types of Machine Learning, and Applications of ML in Mechanical Engineering, Designing a Learning System, Performance Measures for ML Model, Issues in Machine Learning, application of machine learning in manufacturing.

Unit 2	**Supervised Learning**	**10 hours**

Supervised Learning, Classification, Regression Analysis and its Types, Model Selection Procedures, Bayesian Decision Theory, Naïve Bayes Classifier, Bayes Optimal Classifier, evaluating an Estimator: Bias and Variance, Support Vector Machines, Types of Support Vector Kernel (Linear Kernel, Polynomial Kernel, Gaussian Kernel, Issues in SVM, use of regression and classification approach in manufacturing. Decision Trees: Basics of Decision Tree, Issues in Decision Tree Learning, ID3 Algorithm, Information Gain, and Entropy.

Unit 3	**Unsupervised Learning**	**9 hours**

Unsupervised Learning: Introduction to Unsupervised Learning, Cluster Analysis, K-Means Clustering, KNN, Expectation-Maximization Algorithm, Dimensionality Reduction: Principal Components Analysis, Independent Component Analysis, Multidimensional Scaling, Linear Discriminant Analysis, implementation and analysis of clustering in manufacturing.

Unit 4	**Neural Networks & Evolutionary Computing**	**9 hours**

Introduction to Neural Networks: ANN, RNN, Perceptron, The Back Propagation Algorithm, Concept of Convolution Neural Networks, Types of Layers of CNN, case study: Neural network used to build an autonomous manufacturing system, Evolutionary Computing, Simulated Annealing, Random Search, Downhill Simplex Search, Swarm optimization, ant colony optimization, bee colony optimization.		
Unit 5	**Genetic Algorithms & Reinforcement Learning**	**9 hours**
Genetic Algorithm: Introduction, Components of Genetic Algorithm, Cross Over, Mutation, Model of Evolution and Learning, Applications of Genetic Algorithm Reinforcement Learning: Introduction to Reinforcement Learning, Learning task, Model-Based Learning, Q- Learning, Markov Decision Process, Q-Learning Function, Temporal Difference Learning, Generalization, Case study: reinforcement learning will transform manufacturing process.		
	Total Lecture Hours	**45 hours**

Textbook:

1. "Machine Learning", McGraw-Hill, 2010 by Tom M. Mitchell
2. Machine Learning: The New AI, MIT Press-2016 by Ethem Alpaydin
3. Machine Learning: A Constraint-Based Approach, Morgan Kaufmann. 2017 by Marco Gori, Alessandro Betti, Stefano Melacci

Reference Books:

14. Machine Learning: An Artificial Intelligence Approach, Volume 1, Elsevier. 2014 by Ryszard, S., Michalski, J. G. Carbonell and Tom M. Mitchell.
15. Introduction to Machine Learning (Adaptive Computation and Machine Learning)", The MIT Press by Ethem Alpaydin.

Self-Study Content Links:		Duration (in Hrs)
MOOCs	https://nptel.ac.in/courses/106106139	15
Video Lectures	https://www.youtube.com/watch?v=zjkxQoC6J_A&list=PLEq2lkfJdUyYM5SjuwlC-fBSgLVfrg8gr	15
Web References	https://www.tutorialspoint.com/machine_learning/index.htm	15

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

Course Code: BME0615	Course Name: Industrial IOT	L	T	P	C
Course Offered in: ME		**3**	**0**	**0**	**3**

Pre-requisite: Basic knowledge of electronics and network.

Course Objectives:

To develop an understanding of Industrial IoT architecture, data acquisition using sensors and embedded systems, connectivity and data management, implementation of IoT solutions using Arduino and Raspberry Pi, and the application of IoT communication protocols with awareness of security challenges.

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

6. Understand the fundamental concepts and architecture of IoT systems used in industrial applications.	K2
7. Apply data acquisition techniques to collect and process industrial data using sensors and embedded systems.	K3
8. Understand the connectivity technologies, gateways, and storage mechanisms in Industrial IoT systems.	K2
9. Apply basic IoT using Arduino and Raspberry Pi platforms.	K3
10. Understand IoT communication protocols and analyze security challenges in industrial systems.	K3

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO2	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO3	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO4	3	2	2	1	2	2	1	1	1	1	3	3	2	2
CO5	3	2	2	1	3	2	1	1	1	1	3	3	2	2

Course Contents / Syllabus

Unit 1	Basic IoT & Architecture	8 hours

Introduction to IoT and Industrial IoT (IIoT), Evolution of Industry 4.0 and smart manufacturing, IoT architecture: layered architecture (perception, network, application), Components: sensors, actuators, controllers, gateways, Cyber-Physical Systems (CPS), IoT applications in industrial environment.

Unit 2	Data Acquisition	10 hours

Sensors and transducers (temperature, pressure, flow, vibration), Signal conditioning and interfacing techniques, Data acquisition systems (DAQ), Sampling techniques and real-time data collection, Embedded systems basics (Arduino/Raspberry Pi interface), Data pre-processing and filtering, Introduction to edge computing.

Unit 3	Connectivity, Gateway & Storage	9 hours

IoT connectivity models (Device-to-Device, Device-to-Cloud, Gateway-based), Gateways and their role in IIoT systems, Wired communication: Ethernet, Industrial bus systems, Wireless technologies: Wi-Fi, Bluetooth, ZigBee, LoRaWAN, Network topology in industrial IoT, Storage devices: Edge storage, cloud storage, local servers, Data communication architecture in IIoT.

Unit 4	Embedded systems like Arduino & Raspberry Pi	9 hours

Introduction to embedded systems, Overview of Arduino and Raspberry Pi, Architecture of Arduino (UNO, Mega etc.), Architecture of Raspberry Pi, Arduino programming (basic syntax, I/O operations, sensor interfacing), Raspberry Pi programming basics, Interfacing sensors and actuators with Arduino/Raspberry Pi, Serial communication and data logging, IoT system development using embedded platforms.		
Unit 5	**Security and Protocols**	**9 hours**
IoT communication protocols: MQTT, CoAP, HTTP, OPC-UA, Open Systems Interconnection Model, Transmission Control Protocol/Internet Protocol, Addressing (IPv4, IPv6, 6LoWPAN), Security issues in IoT (data privacy, attacks, vulnerabilities), Authentication and authorization, Encryption basics and secure communication, Challenges in IIoT security.		
	Total Lecture Hours	**45 hours**

Textbook:

1. “Internet of Things”, Khanna Publications. 1st Edition Jan 2018 by Jeeva Jose
2. “INTERNET OF THINGS”, McGraw-Hill, 2nd Edition, May 2022 by Raj Kamal
3. "The Internet of Things" by Pearson 4. Raj Kamal "INTERNET OF THINGS", McGrawHill, 1ST Edition, 2016 by Michael Miller

Reference Books:

16. “Rethinking the Internet of Things: A Scalable Approach to Connecting Everything”, 1st Edition, A press Publications, 2013 by Francis daCosta
17. “The Internet of Things key applications and protocols”. 1st Edition Dec 2011 by Olivier Hersent, David Boswarthick, Omar Elloumi

Self-Study Content Links:		Duration (in Hrs)
MOOCs	https://nptel.ac.in/courses/106105195	8
Video Lectures	https://www.youtube.com/playlist?list=PLdYcKdE5uRf1lvXANoaOaYQTe4DrINPZO	8
Web References	https://tutorialsfreak.com/internet-of-things-iot-tutorial	8

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

Course Code: BME0614	Course Name: Automotive Materials and Manufacturing	L	T	P	C
Course Offered in: ME		3	0	0	3

Pre-requisite: Foundational knowledge in mechanical engineering and materials science

Course Objectives:

To provide fundamental knowledge of automotive manufacturing processes and material properties, enabling students to evaluate and select suitable materials and apply appropriate manufacturing techniques for the design and production of automotive components.

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

1. Understand the fundamentals of automotive manufacturing, its history, and the materials involved.	K2
2. To understand the manufacturing processes applicable to automotive component production.	K2
3. To study the integration of automation, robotics, and quality control in vehicle manufacturing.	K3
4. Describe the stages of vehicle assembly and integration, and explain the design and optimization of various types of automotive assembly lines.	K3
5. Analyze the role of automation, Industry 4.0 tools, and quality assurance techniques in enhancing vehicle manufacturing efficiency and reliability.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	1	–	–	1	–	1	3	2	2
CO2	3	3	2	2	3	2	–	–	2	1	2	3	3	3
CO3	2	2	3	2	3	2	–	–	2	1	2	3	3	3
CO4	2	3	3	3	3	3	–	2	3	3	3	3	3	3
CO5	1	2	3	3	3	3	–	2	3	3	3	3	3	3

Course Contents / Syllabus

Unit 1	Introduction to Automotive Manufacturing Systems and Materials	08 hours

Overview of automotive manufacturing; Evolution of automotive manufacturing technologies; Manufacturing systems in the automotive industry; Materials used in automotive manufacturing; Process selection criteria; Automation and Robotics in automotive manufacturing.

Unit 2	Manufacturing of Chassis, Powertrain, and Vehicle Systems	10 hours

Chassis & Frame: Steel/aluminum; stamping, welding, hydroforming, coating, **BIW:** Steel/aluminum/composites; stamping, welding, bonding; **Engine & Powertrain:** Cast iron/aluminum; casting, forging, machining, heat treatment; **Transmission:** Alloy steel/aluminum; gear cutting, broaching, forging; **Suspension:** Steel/aluminum/rubber; forging, heat treatment, molding; **Brakes:** Cast iron/aluminum; casting, sintering, machining; **Steering:** Steel/aluminum; machining, casting, molding, assembly

Unit 3	Manufacturing of Fuel, Electrical, Interior, and Exterior Systems	08 hours

Fuel & Exhaust: Steel/plastic/ceramic; forming, welding, molding, coating. Electrical Systems: Copper/plastic; harnessing, PCB soldering, molding; **Interior:** ABS/foam/leather; molding, stitching, welding. **Exterior:** Sheet metal/plastics; stamping, injection molding, painting

Unit 4	Vehicle Assembly, Integration, and Production Line Design	10 hours

Vehicle Assembly and Integration: Assembly stages: Body-in-white (BIW), Paint Shop, Trim, Chassis, and Final Assembly Subsystem assembly: engine, transmission, suspension, electricals, interiors, **HVAC Tools and equipment:** jigs, fixtures, robots, fastening techniques (welding, adhesives, bolts, rivets); **Assembly Line Design and Optimization:** Types of lines: Manual, Semi-automated, fully automated; Takt time, line balancing, synchronous and asynchronous flow systems Ergonomics, material handling, and conveyor systems in line design

Unit 5	Automation, Smart Manufacturing, and Quality Assurance	09 hours

Automation and Smart Manufacturing: Use of robotics and AGVs in body and final assembly; **Industry 4.0 tools:** sensor networks, PLCs, IoT, and AI integration; Predictive maintenance and real-time data monitoring in smart factories; **Quality Assurance and Testing:** In-line and end-of-line inspection techniques; Functional testing: emissions, brakes, water leak, roadworthiness; Statistical Process Control (SPC), Six Sigma, and defect management

Total Lecture Hours	**45 hours**

Textbook:
1. Automotive Materials and Manufacturing by P.K. Mallick
2. Manufacturing Processes for Engineering Materials by Serope Kalpakjian & Steven R. Schmid

Reference Books:
1. Manufacturing Processes for Engineering Materials, Pearson. (2019), by Serope Kalpakjian, Steven R. Schmid
2. Fundamentals of Engineering Materials, McGraw-Hill. (2014) by Jain, R.K.

Self-Study Content Links:		Duration (in Hrs)
MOOCs	https://nptel.ac.in/courses/112107144?utm https://nptel.ac.in/courses/106105195?utm https://www.coursera.org/specializations/digital-manufacturing-design-technology?utm https://www.edx.org/learn/manufacturing?utm https://nptel.ac.in/courses/112103174?utm_	20 hours
Video Lectures	https://www.youtube.com/watch?v=SGJ5cZnoodY&utm https://www.youtube.com/watch?v=vVSw3KSevEc&utm https://www.youtube.com/watch?v=SQNn0KHV7mM&utm https://www.youtube.com/watch?v=SQNn0KHV7mM&utm https://www.youtube.com/watch?v=l5Sx3X5R4f4&utm	15 hours
Web References	https://www.sme.org?utm https://www.sme.org?utm_ https://www.bosch-mobility.com?utm https://www.automotiveworld.com?utm https://www.automationworld.com?utm	10 hours

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

Course Code: BME0616	Course Name: Hybrid and Electric Vehicles	L	T	P	C
Course Offered in: ME		3	0	0	3

Pre-requisite: Basic knowledge of automobile engineering, electrical machines, and power electronics.

Course Objectives:

To develop an understanding of the fundamentals, architecture, drive-train topologies, propulsion systems, energy storage technologies, and energy management strategies of hybrid and electric vehicles, enabling students to analyze power flow, size drive systems, and evaluate vehicle efficiency, fuel economy, and sustainability.

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

1. Apply the fundamentals of hybrid and electric vehicles, vehicle performance analysis, and drivetrain characteristics to evaluate modern transportation systems.	K3
2. Apply hybrid and electric drive-train topologies, power flow control strategies, and fuel efficiency characteristics of HEVs and EVs.	K3
3. Apply the configuration and control principles of electric propulsion systems including DC, induction, permanent magnet, and switched reluctance motor drives.	K3
4. Apply various energy storage technologies, drive system sizing methods, and hybridization techniques used in hybrid and electric vehicles.	K3
5. Evaluate different energy management strategies and their impact on fuel economy, emissions, battery performance, and overall vehicle efficiency.	K4

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	2	-	1	1	-	3	2	2
CO2	3	3	2	3	3	1	2	-	1	1	-	3	3	2
CO3	3	3	3	2	3	-	1	-	1	1	-	3	3	2
CO4	3	3	3	3	3	1	2	-	1	1	-	3	3	3
CO5	3	3	2	3	2	2	3	-	1	1	-	3	2	3

Course Contents / Syllabus

Unit 1	**Introduction to Hybrid Electric Vehicles**	**08 hours**

Introduction: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Apply the concepts of sustainable transportation and evaluate the social and environmental impact of hybrid and electric vehicles. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.

Unit 2	**Hybrid & Electric Drive-trains**	**09 hours**

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Apply the principles of hybrid traction and electric traction systems in vehicle applications.

Unit 3	**Electric Propulsion Unit**	**10 hours**

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency Apply electric motor drive concepts in hybrid and electric vehicles.

Unit 4	**Energy Storage**	**09 hours**

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: 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. Examine communication systems and supporting subsystems in HEV and EV architectures.

Unit 5	**Energy Management Strategies**	**09 hours**

Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Analyze different energy management strategies and their implementation.	
Total Lecture Hours	**45 hours**

Textbook:

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

Reference Books:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
2. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd., 2011

Self-Study Content Links:		Duration (in Hrs)
MOOCs	https://nptel.ac.in/courses/108103009	20 Hrs
Video Lectures	https://youtu.be/WfiTscWVfWI	15 Hrs
Web References	https://afdc.energy.gov/vehicles/electric-basics-hev	10 Hrs

Note: Self-study material may include assignments, seminars, micro projects, industrial visits, any other student activities, etc.

LAB Course Code: BME0615P	LAB Course Name: Industrial IOT Lab	L	T	P	C
Course Offered in: ME		**0**	**0**	**2**	**1**

Pre-requisite: Basic knowledge of electronics.

Course Objectives:

To develop an understanding of computing, sensing, and actuating components in IoT systems and enable students to design, implement, analyze, and deploy real-time IoT applications and projects using Arduino IDE.

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

1. Understand the functionality of computing, sensing and actuating components of Internet of things.	K3
2. Implement and analysis the various applications of IOT.	K4
3. Design, develop and deploy real time mini projects of IoT Applications using Arduino IDE.	K6

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	1	1	1	1	3	3	2	3
CO2	3	2	2	1	2	2	1	1	1	1	3	3	2	3
CO3	3	2	2	1	2	2	1	1	1	1	3	3	2	3

List of Practical's (Indicative & Not Limited To)	CO
1. Study of Sensing and Actuating systems used in Industrial IOT	CO1
2. Study of Healthcare based sensors such as:- ECG – Electrocardiogram ACC – Accelerometer, TEMP – Temperature, RESP – Respiration, Heartbeat sensor.	CO1
3. Study of Agriculture based sensors such as:- Temperature, Humidity, Pressure Sensor, Soil Temperature, Soil Moisture, Rain sensor.	CO1
4. Introduction to IoT, Arduino platform and perform necessary software installation.	CO2
5. Study Hardware Architecture and Pin Out of Arduino UNO Board. Compare Arduino Uno, Arduino Nano, and Arduino Mega.	CO2
6. To interface motor using relay with Arduino and write a program to turn motor ON/OFF.	CO3
7. To interface sensors to Arduino and display the sensor data.	CO3
8. To interface sensor with Arduino and write a program to turn ON/OFF Solenoid valve when sensor data is detected.	CO3
9. To interface sensor with Arduino and write a program to turn ON/OFF Linear Actuator when sensor data is detected.	CO4
10. To interface Arduino to a Bluetooth Module and send sensor data to a smart phone using Bluetooth.	CO4
Additional: 11. Develop an IoT based Smart water flow system. 12. Develop an IoT based smart lock system for Motor cycle/Car/Household door	CO4

Total Hours: 30 hrs.

LAB Course Code: BME0616P	LAB Course Name: Advanced E-Mobility System Lab	L	T	P	C
Course Offered in: ME		**0**	**0**	**2**	**1**

Pre-requisite: Basic knowledge of automobile systems, electronics, and electrical engineering fundamentals.

Course Objectives:

To provide practical knowledge of electric vehicle components, battery systems, electric drives, power electronic converters, charging systems, BMS, regenerative braking, and propulsion systems, enabling students to analyze, test, simulate, and evaluate the performance of electric mobility systems under various operating conditions.

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

1. Explain the construction, operation, and functions of electric vehicle components such as battery packs, motors, controllers, sensors, and Battery Management Systems (BMS).	K2
2. Describe the operation and performance characteristics of electric motors, regenerative braking systems, DC-DC converters, and EV drive systems through testing and demonstrations.	K2
3. Interpret data obtained from EV testing, charging systems, and simulation tools for analyzing the performance of electric mobility systems.	K2

CO-PO Mapping (Scale 1: Low, 2: Medium, 3: High)

CO-PO Mapping	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	2	-	1	-	1	1	-	3	2	2
CO2	3	3	2	2	3	-	1	-	1	1	-	3	3	2
CO3	2	3	2	3	3	-	1	-	1	1	-	2	3	3

List Of Practical's (Indicative & Not Limited To)	CO
1. Study and identification of major Electric Vehicle (EV) components	**CO1**
2. Study of BLDC and PMSM motors used in electric vehicles	**CO1**
3. Demonstration of Battery Management System (BMS) operation and battery monitoring	**CO1**
4. Study of EV battery charging methods and charging characteristics	**CO1**
5. Performance testing of BLDC/PMSM motors for speed–torque characteristics	**CO2**
6. Study and testing of regenerative braking system in EVs	**CO2**
7. Design and testing of step-up and step-down DC-DC converters	**CO2**
8. Study of motor controller operation using microcontroller/DSP-based drive systems	**CO3**
9. Data acquisition and analysis of EV parameters using sensors and DAQ systems	**CO3**
10. Simulation of electric vehicle drive system using MATLAB/Simulink or equivalent software	**CO3**
Total Hours: 30 hrs.	