



(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)
S.P.G.Chidambara Nadar - C.Nagammal Campus
S.P.G.C. Nagar, K.Vellakulam – 625 701 (Near VIRUDHUNAGAR).

**B.E. MECHANICAL ENGINEERING
REGULATIONS – 2021
AUTONOMOUS SYLLABUS
CHOICE BASED CREDIT SYSTEM
V & VI SEMESTER CURRICULUM AND SYLLABUS**

VISION:

To make the Department of Mechanical Engineering the unique of its kind in the field of Research and Development activities in the prominent field of Mechanical Engineering in this part of the world.

MISSION:

To impart highly innovative and technical knowledge in the field of Mechanical Engineering to the urban and unreachable rural student folks through Total Quality Education.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

- PEO 1:** Graduates of the Programme will excel in Technical Knowledge and Apply Innovative skills in the field of Mechanical Engineering.
- PEO 2:** Graduates will contribute to the Technological Development and Research Activities through “Total Quality Education”.
- PEO 3:** Graduates of the Programme will accomplish Leadership Qualities and Social Responsibilities through “Life Long Learning”.

PROGRAM OUTCOMES:

After going through the four years of study, the Mechanical Engineering graduates will have the ability to

POs	Graduate Attribute	Programme Outcome
1	Engineering knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2	Problem analysis	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3	Design/development of solutions	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4	Conduct investigations of complex problems	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5	Modern tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6	The engineer and society	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7	Environment and sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9	Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	Communication	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11	Project management and finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12	Life-long learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs):

PSO:1 Graduates will be able to Create and Analyze the Research and Development activities related to Design and Manufacturing.

PSO:2 Graduates will be able to Design and Develop need based products in Mechanical Engineering and Allied Industries.

REGULATIONS - 2021
CHOICE BASED CREDIT SYSTEM
B.E. MECHANICAL ENGINEERING
V TO VI SEMESTER CURRICULUM
SEMESTER V

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	ME2301	Design of Machine Elements	PC	3	3	0	0	3
2	ME2302	Fluid Power Automation [#]	PC	4	2	0	2	3
3	ME2303	Metrology and Measurements [#]	PC	4	2	0	2	3
4		Professional Elective I	PE	3	3	0	0	3
5		Professional Elective II	PE	3	3	0	0	3
6		Professional Elective III	PE	3	3	0	0	3
PRACTICALS								
7	ME2304	CAD and 3D Printing Laboratory	PC	3	0	0	3	1
8	ME2305	IC Engine and Steam Laboratory	PC	3	0	0	3	1
9	EM2301	Internship**	EM	-	0	0	0	1
10	EM2252	An Introduction to Advanced Reading and writing	EM	2	0	0	2	1
TOTAL				28	16	0	12	22

[#] Theory cum Lab

**** Two weeks Internship carries one credit and it will be done during IV semester summer vacation and same will be evaluated in V semester.**

SEMESTER VI

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	ME2351	Heat and Mass Transfer	PC	3	3	0	0	3
2		Professional Elective IV	PE	3	3	0	0	3
3		Professional Elective V	PE	3	3	0	0	3
4		Professional Elective VI	PE	3	3	0	0	3
5		Professional Elective VII	PE	3	3	0	0	3
6		Open Elective 1	OE	3	3	0	0	3
PRACTICALS								
7	ME2352	Heat Transfer and Refrigeration and Air Conditioning Laboratory	PC	3	0	0	3	1
8	ME2353	Simulation and Analysis Laboratory	PC	3	0	0	3	1
9	ME2354	Design Project and Prototyping	EM	3	0	0	3	1
TOTAL				27	18	0	9	21

PROFESSIONAL ELECTIVE COURSES : VERTICALS

VERTICAL I Advanced Product Design	VERTICAL II Digital Manufacturing	VERTICAL III E-Vehicles and Energy Systems	VERTICAL IV Industry 4.0
New Product Development	Modern Robotics	Conventional and Electric vehicles	Artificial Intelligence in Mechanical Engineering
Design for X	Automation for Manufacturing	Electric vehicle design	IOT in Industrial Automated Systems
Piping Design	Robots and Systems in Smart Manufacturing	Battery management system for Electric vehicles	Fundamentals of Industry 4.0
Drone Technology	Additive Manufacturing	Thermal management of batteries and fuel cells	Embedded System Design for Industrial Automation
Reverse Engineering	Digital Manufacturing and IoT	Vehicle health monitoring, maintenance and safety	Programming for Robotics and CNC Machines
CAD/CAE	Advanced Manufacturing Systems	Bioenergy conversion technologies	Data Analytics in Manufacturing
Product life Cycle Management	Processing and Characterization of Composite Materials	Energy audit and Management	Scientific Computations using Software Tools

PROFESSIONAL ELECTIVE COURSES : VERTICALS

VERTICAL 1 : ADVANCED PRODUCT DESIGN

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	VME311	New Product Development	PE	3	3	0	0	3
2	VME312	Reverse Engineering	PE	3	3	0	0	3
3	VME313	Piping Design	PE	3	3	0	0	3
4	VME314	Drone Technology	PE	3	3	0	0	3
5	VME315	Design For X	PE	3	3	0	0	3
6	VME316	CAD/CAE	PE	3	3	0	0	3
7	VME317	Product life Cycle Management	PE	3	3	0	0	3

VERTICAL 2 : DIGITAL MANUFACTURING

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	VME321	Modern Robotics	PE	3	3	0	0	3
2	VME322	Automation for Manufacturing	PE	3	3	0	0	3
3	VME323	Robots and Systems in smart Manufacturing	PE	3	3	0	0	3
4	VME324	Additive Manufacturing	PE	3	3	0	0	3
5	VME325	Digital Manufacturing and IoT	PE	3	3	0	0	3
6	VME326	Advanced Manufacturing Systems	PE	3	3	0	0	3
7	VME327	Processing and characterization of Composite Materials	PE	3	3	0	0	3

VERTICAL 3 : E-VEHICLES AND ENERGY SYSTEMS

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	VME331	Conventional and Electric vehicles	PE	3	3	0	0	3
2	VME332	Electric vehicle design	PE	3	3	0	0	3
3	VME333	Battery management system for Electric vehicles	PE	3	3	0	0	3
4	VME334	Thermal management of batteries and fuel cells	PE	3	3	0	0	3
5	VME335	Vehicle health monitoring, maintenance and safety	PE	3	3	0	0	3
6	VME336	Bioenergy conversion technologies	PE	3	3	0	0	3
7	VME337	Energy audit and Management	PE	3	3	0	0	3

VERTICAL 4 : INDUSTRY 4.0

S.NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	VME341	Fundamentals of Industry 4.0	PE	3	3	0	0	3
2	VME342	IOT in Industrial Automated Systems	PE	3	3	0	0	3
3	VME343	Artificial Intelligence in Mechanical Engineering	PE	3	3	0	0	3
4	VME344	Embedded System Design for Industrial Automation	PE	3	3	0	0	3
5	VME345	Programming for Robotics and CNC Machines	PE	3	3	0	0	3
6	VME346	Data Analytics in Manufacturing	PE	3	3	0	0	3
7	VME347	Scientific Computations using Software Tools [#]	PE	4	2	0	2	3

[#] Theory cum Lab

OPEN ELECTIVE - I

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	OME781	Industrial Safety	OE	3	3	0	0	3
2	OME782	World Class Manufacturing	OE	3	3	0	0	3

VERTICALS FOR MINOR DEGREE - 3D Printing
(In addition to all the verticals of other programmes)

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	MME101	Introduction to Product Design	OE	3	3	0	0	3
2	MME102	3D Printing and Design	OE	3	3	0	0	3
3	MME103	Design for Additive Manufacturing	OE	3	3	0	0	3
4	MME104	Reverse Engineering	OE	3	3	0	0	3
5	MME105	Business value enhancement with Additive Manufacturing	OE	3	3	0	0	3
6	MME106	Standards and Quality attributes of 3D-Printing	OE	3	3	0	0	3

VERTICAL : ENTREPRENEURSHIP (Minor Degree – Institute Level)

S.NO.	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	MEN001	Foundations of Entrepreneurship	OE	3	3	0	0	3
2	MEN002	Team Building & Leadership Management for Business	OE	3	3	0	0	3
3	MEN003	Engineering Economics and Cost Analysis	OE	3	3	0	0	3
4	MEN004	Creativity & Innovation in Entrepreneurship	OE	3	3	0	0	3
5	MEN005	Principles of Marketing Management for Business	OE	3	3	0	0	3
6	MEN006	Financial Markets and Services	OE	3	3	0	0	3

Course Code	Course Name	L	T	P	C
ME2301	DESIGN OF MACHINE ELEMENTS (Usage of PSG Design Data Book is permitted)	3	0	0	3

Category: Professional Core

a. Preamble

This course introduces the basic design concepts and to learn the designing of shaft , couplings, temporary and permanent joints, helical, leaf springs, flywheels , bearings , gears and gear box. It comprehensively details the usage of PSG design data book for selecting the standard sizes of machine components and also design procedure for most complex machine design problems.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the influence of steady and variable stresses in machine component design.	K2
CO2	Apply the concepts of design to shafts, key and couplings.	K3
CO3	Apply the concepts of design to bolted, Knuckle, Cotter, riveted and welded joints.	K3
CO4	Apply the concept of design to helical, leaf springs, flywheels and select the bearings.	K3
CO5	Select the gears and gear boxes for appropriate power transmission.	K3

c. Course Syllabus

Total : 45 Periods

FUNDAMENTAL CONCEPTS IN DESIGN

9

Introduction to the design process - factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers- Direct, Bending and torsional loading- Modes of failure - Factor of safety – Combined loads – Principal stresses – Eccentric loading – curved beams – crane hook and ‘C’ frame- theories of failure – stress concentration – Fluctuating stresses – Endurance limit –Design for finite and infinite life under variable loading.

DESIGN OF SHAFTS AND COUPLINGS 9

Shafts and Axles - Design of solid and hollow shafts based on strength, rigidity and critical speed – Keys and splines – Rigid and flexible couplings.

DESIGN OF TEMPORARY AND PERMANENT JOINTS 9

Fasteners - Bolted joints including eccentric loading, Knuckle joints, Cotter joints – Welded joints - Butt, Fillet and parallel transverse fillet welds – welded joints subjected to bending, torsional and eccentric loads, riveted joints for structures - theory of bonded joints.

DESIGN OF ENERGY STORING COMPONENTS AND BEARINGS 9

Types of springs, design of helical springs–surge in springs, Design of laminated springs - rubber springs - Flywheels considering stresses in rims and arms for engines and punching machines – Selection of Sliding contact and rolling contact bearings.

GEARS AND GEAR BOXES 9

Usage of Manufactures catalogue for selection of parallel axis and perpendicular axis gear drives (Spur, Bevel) – Types of Gear box - Design of gear box.

d. Activities

Students shall be exposed to learn the design fundamentals of various machine components and standard procedures. Students will be practiced to solve the real time machine design problems in tutorial hours.

e. Learning Resources

Text Books

1. Bhandari V B, *Design of Machine Elements*, 4th Edition , Tata McGraw-Hill Book Co, 2016.
2. Joseph Shigley, Richard G. Budynas and J. Keith Nisbett, *Mechanical Engineering Design*, 10th Edition, Tata McGraw-Hill , 2015.

Reference Books

1. Ansel C Ugural., *Mechanical Design – An Integral Approach*, 1st Edition, Tata McGraw-Hill Book Co, 2004.
2. Merhyle Franklin Spotts., Terry E. Shoup, and Lee EmreyHornberger, *Design of Machine Elements*, 8th Edition, Printice Hall, 2004.

3. Robert C. Juvinall and Kurt M. Marshek., *Fundamentals of Machine component Design*, 6th Edition, Wiley, 2017.
4. Sundararamoorthy T. V. and Shanmugam. N., *Machine Design*, Anuradha Publications, Chennai, 2003.
5. Prabhu. T.J., *Design of Transmission Elements*, Mani Offset, Chennai, 2000.

Course Code	Course Name	L	T	P	C
ME2302	FLUID POWER AUTOMATION	2	0	2	3

Category: Professional Core (Theory cum Lab)

a. Preamble

This course is designed to provide the knowledge on the working principles of fluid power systems. It familiarizes the fluids and components used in modern industrial fluid power system. It enables to develop the design, construction and operation of fluid power circuits This course is also designed to provide hands-on experience in the fundamental principles of fluid power, along with a practical working knowledge of the components used in designing, installing and operating hydraulic and pneumatic fluid power systems.

b. Course Outcome (for Theory)

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the working principles of fluid power systems and hydraulic pumps.	K2
CO2	Explain the working principles of hydraulic actuators and control components.	K2
CO3	Design and develop hydraulic circuits and systems.	K3
CO4	Apply the working principles of pneumatic circuits and systems.	K3
CO5	Identify various troubles shooting methods in fluid power systems.	K2

Course Outcome (for Laboratory)

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Design of simple hydraulic circuits.	K3
CO2	Design of hydraulics circuits using Automaiton studio.	K3

CO3	Design of Pnuematic circuits.	K3
CO4	Design of pneumatic circuits using Cascade method.	K3
CO5	Design of pneumatic circuits using Automaiton studio.	K3

c. Course Syllabus (for Theory)

Total : 30 Periods

FLUID POWER PRINCIPLES AND HYDRAULIC PUMPS 6

Introduction to Fluid power – Advantages and Applications – Fluid power systems and its components – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Sources of Hydraulic power - Pumping Theory – Pump Classification – Gear Pump, Piston pump, Vane pump – Construction, Working, Advantages, Disadvantages, Selection criteria of pumps – Fixed and Variable displacement pumps.

HYDRAULIC ACTUATORS AND VALVES 6

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Rotary Actuators – Semi-rotary actuators - Control Components: Direction Control, Flow control, Pressure control valves and Pressure compensated flow control valves – Types, Construction and Operation – Fluid Power ANSI Symbols; Accumulators, Intensifiers.

DESIGN OF HYDRAULIC CIRCUITS 6

Simple Industrial hydraulic circuits – Regenerative, Pump Unloading, Pressure Intensifier, Air-over oil, Sequence, Synchronization, Fail-Safe, Speed Control – Servo and Proportional valves – Applications – Mechanical-Hydraulic servo systems, Electrical-Hydraulic servo system (Theory only).

DESIGN OF PNEUMATIC SYSTEMS 6

Properties of air –Air preparation and distribution – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit – single cylinder and multi cylinder circuits-Cascade method – Truth table method – Karnaugh Map method – Introduction to PLC.

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Conditioning of hydraulic fluids Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications- mobile hydraulics; Design of Pneumatic circuits for a Pick and Place application and tool handling in a CNC machine.

Course Syllabus (for laboratory)

Total : 30 Periods

LIST OF EXPERIMENTS

1. Design of hydraulic circuit using double acting cylinder.
2. Design of hydraulic circuit using hydraulic motor.
3. Design of hydraulic circuit for controlling speed of hydraulic motor.
4. Design of hydraulic two cylinder sequencing circuit with sequence valve using Automation Studio.
5. Design of hydraulic Pressure Intensifier circuit for Punch Press application using Automation studio.
6. Design of Pneumatic circuit using Push button actuator.
7. Design of Pneumatic circuit using Pilot control valve.
8. Design of Pneumatic circuit using Solenoid valve.
9. Design a Pneumatic two-cylinder sequencing circuit using Cascade method.
10. Design a Pneumatic three-cylinder sequencing circuit using Cascade method.
11. Design a pneumatic two-cylinder sequencing circuit using automation studio software.
12. Design a pneumatic three-cylinder sequencing circuit using automation studio software.

d. Activities

Students shall be exposed to design and develop hydraulic and pneumatic circuits. Students will learn to develop a measurable degree of competence in the design, construction and operation of fluid power circuits.

e. Learning Resources (for both Theory and Laboratory)

Text Books

1. Anthony Esposito., *Fluid Power with Applications*, Prentice Hall, 2009.

- James A. Sullivan., *Fluid Power Theory and Applications*, 4th Edition, Prentice Hall, 1997.

Reference Books

- Jagadeesha. T., *Pneumatics Concepts, Design and Applications*, Universities Press, 2015.
- Majumdar, S.R., *Oil Hydraulics Systems – Principles and Maintenance*, Tata McGraw Hill, 2001.
- Shanmugasundaram.K., *Hydraulic and Pneumatic Controls*. Chand & Co, 2006.
- Srinivasan.R., *Hydraulic and Pneumatic Controls*, Vijay Nicole Imprints, 3rd Edition, 2019.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

HARDWARES:

S. No.	NAME OF THE EQUIPMENT	Qty.
1	Electro Hydraulic Trainer Kit	1
2	Basic Pneumatic Trainer Kit	1
3	Electro Pneumatic Trainer Kit	1
4	PLC Pneumatic Trainer Kit	1
5	Personal Computers (Intel Core i3, 500 GB, 4 GB RAM)	30

SOFTWARES:

S. No.	NAME OF THE EQUIPMENT	Qty.
1	Automation Studio Software	10 Licenses

Course Code	Course Name	L	T	P	C
ME2303	METROLOGY AND MEASUREMENTS	2	0	2	3

Category: Professional Core (Theory cum Lab)

a. Preamble

This course introduces the basic measurement concepts and to learn the measurement of screw thread and gear parameters. It makes use measuring instruments and how it is been used in industry for quality and inspection.

b. Course Outcome (for Theory)

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Discuss the concepts of measurements to apply in various metrological instruments.	K2
CO2	Demonstrate the techniques of form measurement used for industrial components.	K2
CO3	Understand the tolerance symbols and tolerance analysis for industrial applications.	K2
CO4	Explain the GD&T principles and geometric derivations.	K2
CO5	Explain the procedure for conducting computer aided inspection.	K2

Course Outcome (for Laboratory)

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Apply the fundamental principles of measuring techniques for the measurement of various dimensional tolerances.	K3
CO2	Measure the various dimensions of linear and angular components using linear and angular measuring instruments.	K3

CO3	Find the parameters of thread and gear profile using Projection technique.	K3
CO4	Calculate shear force and moment induced in a cantilever beam by varying load conditions.	K3
CO5	Measure the temperature, Speed, vibration and dimensional parameters of a given component.	K3

c. Course Syllabus (for Theory)

Total : 30 Periods

BASICS OF METROLOGY

6

Introduction to Metrology – Need – generalized measurement system - Factors affecting measurement - SWIPE Characteristics of measuring instruments - Calibration of measuring instruments. Precision & Accuracy and their effect. Error – types of Errors in Measurements - Methods of Measurement and standards of measurement.

FORM MEASUREMENT

6

Measurement of Screw threads – Pitch Diameter and Lead. Measurement of Gears - Runout, Pitch variation, Tooth profile, Lead – Rolling gear test. Measurement of Surface finish – Functionality of surfaces, Parameters, Comparative, Filters, Introduction to 3D surface metrology- Parameters.

TOLERANCE AND FITS ANALYSIS

6

Tolerancing– Interchangeability, Selective assembly, Tolerance representation, Terminology, Limits and Fits, Problems (using tables IS919); Design of Limit gauges - Problems.

FUNDAMENTALS OF GD & T

6

Fundamentals of GD & T- Conventional vs Geometric tolerance, Datums, Inspection of geometric deviations like straightness, flatness, roundness deviations; Simple problems. Tolerance analysis in manufacturing, Process capability, tolerance stackup, tolerance charting.

ADVANCES IN METROLOGY

6

Basic concept of lasers - Advantages of lasers. Laser Interferometers – DC and AC Lasers interferometer, NPL flatness Interferometer, Michelson Interferometer – Applications.

Computer Aided Metrology - Basic concept of CMM, Types of CMM, Constructional features, Probes, Accessories, Software - Applications – Basic concepts of Machine Vision System and stages – Applications.

Course Syllabus (for laboratory)

Total : 30 Periods

LIST OF EXPERIMENTS

1. Measurement of various components by using – Vernier caliper, micrometer, Vernier height gauge and Vernier Depth Gauge.
2. Measurement of Bore diameter by using telescope gauge.
3. Checking the Limits of Dimensional Tolerances using Mechanical Comparator.
4. Measurement of angles using bevel protractor and sine bar.
5. Measurement of thread Parameters by using Floating Carriage Micrometer.
6. Measurement of Gear Parameters using Gear Tooth Vernier.
7. Measurement of features of a given component using Coordinate Measuring Machine (CMM).
8. Measurement of thread parameters using Toolmaker’s microscope / Profile projector.
9. Measurement of surface roughness using talysurf instrument.
10. Measurement of straightness using Auto Collimator.
11. Measurement of force, torque and temperature.
12. Measurement of speed and vibration.

d. Activities

Students shall be expected to draw the detailed drafting including GD&T symbols for a machined component using 3D Modelling software.

e. Learning Resources (for both Theory and Laboratory)

Text Books

1. Raghavendra, Krishnamurthy., *Engineering Metrology & Measurements*, Oxford Univ. Press, 2013.
2. Dotson Connie., *Dimensional Metrology*, Cengage Learning, First edition, 2012.

Reference Books

1. Gupta. I.C., *Engineering Metrology*, Dhanpatrai Publications, 2005.

2. Ammar Grous. J., *Applied Metrology for Manufacturing Engineering*, Wiley, 2011.
3. Galy er, J.F.W. Charles Reginald Shotbolt., *Metrology for Engineers*, Cengage Learning EMEA; 5th revised edition, 1990.
4. Mark Curtis, Francis T. Farago., *Handbook of Dimensional Measurement*, Industrial Press, Fifth edition, 2013.
5. Charles Reginald Shotbolt., *Metrology for Engineers*, 5th edition, Cengage Learning EMEA,1990.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Micrometer.	5
2.	Vernier Caliper.	5
3.	Vernier Height Gauge.	2
4.	Vernier Depth Gauge.	2
5.	Slip Gauge Set.	1
6.	Gear Tooth Vernier.	1
7.	Sine Bar / Bevel Protractor.	1
8.	Floating Carriage Micrometer.	1
9.	Profile Projector / Tool Makers Microscope.	1
10.	Mechanical Comparator.	1
11.	Autocollimator.	1
12.	Temperature Measuring Setup.	1
13.	Force Measuring Setup.	1
14.	Torque Measuring Setup.	1
15.	Coordinate measuring machine.	1
16.	Surface finish measuring equipment.	1
17.	Bore gauge.	1
18.	Telescope gauge.	1
19.	Speed and Vibration Measuring Setup.	1

Course Code	Course Name	L	T	P	C
ME2304	CAD AND 3D PRINTING LABORATORY	0	0	3	1

Category: Professional Core

a. Preamble

This course familiarizes students in various software tools for designing 3D geometric models of parts and assemblies, processes & techniques to create physical objects that satisfy product development / prototyping requirements using AM.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Model the 3D components using 3D modelling software.	K3
CO2	Assemble the components using 3D Modelling Software.	K3
CO3	Simulate the animation of CAD assembly model.	K3
CO4	Create a 3D printed model with the aid of supporting software.	K3
CO5	Evaluate the design project in engineering applications using CAD software.	K3

c. Course Syllabus

Total : 45 Periods

1. Introduction to 3D CAD Modelling Software.
2. Importance of Detailing in Engineering Drawing.
3. 3D Modelling of Machine Component using Extrude Feature.
4. 3D Modelling of Machine Component using Revolve Feature.
5. 3D Modelling of parts with Loft/Blend Feature.
6. 3D Modelling of parts with Sweep Feature.
7. 3D Modelling of parts with Helical Sweep.
8. Parametric Modelling of a Machine Components using 3D CAD Software.
9. Assembly Modelling of Piston of an I.C. engine using any 3D CAD Software.
10. Mechanism Simulation of an automotive assembly using CAD Software.
11. Introduction to 3D Printing and its process flow.

12. Introduction to Slicing Software and its functions.
13. Design a simple model and prepare a .STL file for 3D printing
14. Print a simple model by varying part orientation and support structures.
15. Design and Print objects containing moving parts without assembly.
16. Scan any complex object by 3D Scanner and then print it with 3D printer.
17. Design Project and Presentation.

d. Activities

Design Project can be done as a part of teams with the maximum of three members.

e. Learning Resources

Text Books

1. Gopalakrishna.K.R., *Machine Drawing*, 22nd Edition, Subhas Stores Books Corner, Bangalore, 2017.

References

1. <https://www.youtube.com/channel/UC38EzpQ0QpmsRg2g9HUGaGw>.
2. https://www.youtube.com/channel/UCjd_zIvYtQymk0dPx3vTJcA.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
1.	Computer Nodes (With 8GB Ram, 2 GB Graphics Card).	30
2.	Computer Server.	1
3.	Networking Laser Printer.	1
4.	3D Printer.	1
5.	3D Scanner.	1
6.	Any High-end CAD modelling software.	30 Licences
7.	Opensource 3D Printing Slicing Software.	30
8.	Licensed operating system.	30

Course Code	Course Name	L	T	P	C
ME2305	IC ENGINE AND STEAM LABORATORY	0	0	3	1

Category: Professional Core

a. Preamble

This course introduces the concepts of IC engines, boiler and steam turbine components. It includes the performance of IC engines, boiler, steam turbine and characteristics of fuels and lubricants used in automobiles and power generation.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Conduct tests to draw valve and port timing diagram of a model IC engine.	K3
CO2	Conduct tests to find out the performance of IC engines.	K3
CO3	Draw heat balance sheet of IC engines.	K3
CO4	Evaluate flash and fire point of given fuels/lubricants.	K3
CO5	Conduct tests to find out the performance of steam generator and steam turbine.	K3

c. Course Syllabus

Total: 45 Periods

I.C. ENGINE LAB

1. Valve Timing and Port Timing diagrams.
2. Actual p-v diagrams of IC engines.
3. Performance Test on 4 – stroke Diesel Engine.
4. Heat Balance Test on 4 – stroke Diesel Engine.
5. Morse Test on Multi-Cylinder Petrol Engine.
6. Retardation Test on a Diesel Engine.
7. Determination of Flash Point and Fire Point of various fuels / lubricants.

STEAM LAB

1. Study on Steam Generators and Turbines.

2. Performance and Energy Balance Test on a Steam Generator.
3. Performance and Energy Balance Test on Steam Turbine.

d. Activities

Students shall be exposed to the hands on experience on estimating the performance of IC engines, steam boiler and steam turbine.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S. No.	Description of Equipment	Quantity Required
1.	I.C Engine – 2 stroke and 4 stroke model.	1 set
2.	Apparatus for Flash and Fire Point.	1 No.
3.	4-stroke Diesel Engine with mechanical loading.	1 No
4.	4-stroke Diesel Engine with hydraulic loading.	1 No.
5.	4-stroke Diesel Engine with electrical loading.	1 No.
6.	Multi-cylinder Petrol Engine.	1 No.
7.	Single cylinder Petrol Engine.	1 No.
8.	Data Acquisition system with any one of the above engines.	1 No.

Course Code	Course Name	L	T	P	C
EM2301	INTERNSHIP	0	0	0	1

Category: Employability Enhancement Course

a. Preamble

To enable the students to

- Get connected with industry/ laboratory/research institute.
- Get practical knowledge on production process in the industry and develop skills to solve industry related problems.
- Develop skills to carry out research in the research institutes/laboratories.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Validate system-level processes, techniques, manufacturing and production processes in the industry/research facilities of the laboratory/research institute.	K5
CO2	Analyse the solutions of industry/research problems.	K4
CO3	Document system specifications, design methodologies, process parameters, testing parameters and results.	K2
CO4	Comprehend the process followed in the industry/research institute in the form of presentation .	K2
CO5	Demonstrate the technical knowledge observed in the industry/research institute with the courses studied.	K2

c. Course Instruction

The students individually undergo training in reputed industry/ research institutes / laboratories for the specified duration. After completion of the training, a detailed report should be submitted within ten days from the commencement of next semester. The evaluation will be done as per the Regulations. Credits shall be awarded to the students who satisfy the clauses for industrial training/ internship of the Regulation concerned.

Course Code	Course Name	L	T	P	C
EM2252	AN INTRODUCTION TO ADVANCED READING AND WRITING	0	0	2	1

Category: Employability Enhancement Course

a. Preamble

The Course will enable learners:

- To strengthen the reading skill of students of engineering.
- To enhance their writing skill with specific reference to technical writing
- To develop their critical thinking skill.

To provide more opportunities to develop their project and proposal writing skill.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Understand how the text positions the reader.	K3
CO2	Develop critical thinking while reading a text.	K3
CO3	Develop a descriptive paragraph.	K3
CO4	Make use of sentence structures effectively when creating an essay.	K3
CO5	Demonstrate proper usage of grammar in writing E-Mails, Job application and project proposals.	K3

c. Course Syllabus

Total : 30 Periods

EFFECTIVE READING

6

Reading – Strategies for effective reading – Use glosses and footnotes to aid reading comprehension – Read and recognize different text types – Predicting content using photos and title. Reading-Read for details – Use of graphic organizers to review and aid comprehension.

CRITICAL READING

6

Reading – Understanding pronoun reference and use of connectors in a passage – speed reading techniques. Reading – Genre and Organization of Ideas – Reading – Critical reading and thinking – understanding how the text positions the reader.

PARAGRAPH WRITING

6

Writing – Plan before writing – Develop a paragraph: topic sentence, supporting sentences, concluding sentence – Write a descriptive paragraph Writing – State reasons and examples to support ideas in writing – Write a paragraph with reasons and examples – Write an opinion paragraph.

ESSAY WRITING

6

Writing – Elements of good essay – Types of essays – descriptive-narrative – issue-based argumentative – analytical.

EFFECTIVE WRITING

6

Writing – letter of recommendation – Email writing – resumes – Job application – project writing-writing convincing proposals.

d. Activities

1. Reading comprehension exercises.
2. Critical reading and thinking.
3. Writing different types of paragraphs.
4. Writing different types of essays.
5. Writing job application and resume.

e. Learning Resources

Text Books

1. Gramer, F, Margot & Colin, S, Ward., *Reading and Writing (Level 3)*, Oxford University Press, Oxford, 2011.
2. Debra Daise, CharlNorloff, and Paul Carne., *Reading and Writing (Level 4)*, Oxford University Press: Oxford, 2011.

Reference Books

1. Davis, Jason & Rhonda LIss., *Effective Academic Writing (Level 3)*, Oxford University Press: Oxford, 2006.
2. E. Suresh Kumar and et al., *Enriching Speaking and Writing Skills*. Second Edition. Orient Black swan: Hyderabad ,2012.

3. Withrow, Jeans and et al., *Inspired to Write. Readings and Tasks to develop writing skills*, Cambridge University Press: Cambridge, 2004.
4. Goatly, Andrew., *Critical Reading and Writing*, Routledge: United States of America, 2000.
5. Petelin, Roslyn & Marsh Durham., *The Professional Writing Guide: Knowing Well and Knowing Why*, Business& Professional Publishing: Australia, 2004.

Course Code	Course Name	L	T	P	C
ME2351	HEAT AND MASS TRANSFER (Usage of standard HMT Tables is permitted)	3	0	0	3

Category: Professional Core

a. Preamble

This course introduces the basic concepts for designing and optimizing thermal systems as well as predicting and controlling the behavior of materials and fluids under different conditions. It is important for addressing societal challenges such as energy efficiency, climate change and sustainable development.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Apply the principle mechanism of conductive heat transfer under steady state and transient conditions.	K3
CO2	Apply the fundamental concepts and principles in convective heat transfer.	K3
CO3	Solve problems in phase change heat transfer and heat exchangers.	K3
CO4	Apply the fundamental concepts and principles in radiation heat transfer.	K3
CO5	Apply the basic principles in mass transfer.	K3

c. Course Syllabus

Total : 45 Periods

CONDUCTION

9

General Differential equation - Cartesian and Cylindrical Coordinates - One Dimensional Steady State Heat Conduction - plane and Composite Systems – Conduction with Internal Heat Generation – Extended Surfaces – Unsteady Heat Conduction – Lumped Analysis – Semi Infinite and Infinite Solids – Use of Heisler’s charts – Heat transfer in Electronics appliances (descriptive only).

CONVECTION **9**

Conservation Equations, Boundary Layer Concept – Forced Convection: External Flow – Flow over Plates, Cylinders Spheres and Bank of tubes. Internal Flow – Entrance effects. Free Convection – Flow over Vertical Plate, Horizontal Plate, Inclined Plate, Cylinders and Spheres.

PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGERS **9**

Nusselt's theory of condensation- Regimes of Pool boiling and Flow boiling, correlations in boiling and condensation (descriptive only). Heat Exchanger Types – Overall Heat Transfer Coefficient – Fouling Factors. LMTD and NTU methods.

RADIATION **9**

Radiation laws, Black Body and Gray body Radiation. Shape Factor. Electrical Analogy (descriptive only). Radiation Shields.

MASS TRANSFER **9**

Basic Concepts – Diffusion Mass Transfer – Fick's Law of Diffusion – Steady state Molecular Diffusion. Convective Mass Transfer – Momentum, Heat and Mass Transfer Analogy – Convective Mass Transfer Correlations.

d. Activities

Students are given problem sets that require them to apply the concepts learned in class to solve real time engineering problems. They perform laboratory experiments to measure thermal properties of materials, study heat transfer mechanisms and analyze the heat transfer phenomena.

e. Learning Resources

Text Books

1. Yunus A. Cengel., *Heat Transfer A Practical Approach*, Tata McGraw Hill Education Private Limited, 5th Edition, 2018.
2. R.C. Sachdeva., *Fundamentals of Engineering Heat and Mass transfer*, New Age International Publishers, 2018.

Reference Books

1. Frank P. Incropera and David P. Dewitt., *Fundamentals of Heat and Mass Transfer*, John Wiley & Sons, 7th Edition, 2019.

2. Holman, J.P., *Heat and Mass Transfer*, Tata McGraw Hill Education Private Limited, 2018.
3. Kothandaraman, C.P., *Fundamentals of Heat and Mass Transfer*, New Age International Publishers, 2019.
4. Ozisik, M.N., *Heat Transfer*, Tata McGraw Hill Education Private Limited, 2016.
5. S.P. Venkateshan., *Heat Transfer*, Ane Books Private Limited, New Delhi, 2018.

Course Code	Course Name	L	T	P	C
ME2352	HEAT TRANSFER AND REFRIGERATION AND AIR-CONDITIONING LABORATORY	0	0	3	1

Category: Professional Core

a. Preamble

This course provides hands on training to predict the thermal conductivity, heat transfer coefficient and emissivity of materials. It helps to measure the performance of heat exchangers, air compressor and refrigeration and air-conditioning systems.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Conduct tests on conductive heat transfer apparatus to measure thermal conductivity of materials.	K3
CO2	Conduct tests on convective and radiative heat transfer apparatus to measure thermal property of substances.	K3
CO3	Calculate the performance of parallel/counter flow heat exchanger apparatus.	K3
CO4	Evaluate the performance of reciprocating air compressor.	K3
CO5	Estimate COP of refrigeration and air conditioning test rigs.	K3

c. Course Syllabus

Total : 45 Periods

HEAT TRANSFER LAB:

1. Thermal conductivity measurement using guarded plate apparatus.
2. Thermal conductivity measurement of pipe insulation using lagged pipe apparatus.
3. Determination of heat transfer coefficient under natural convection from a vertical cylinder.
4. Determination of heat transfer coefficient under forced convection from a tube.
5. Determination of Thermal conductivity of composite wall.
6. Determination of Thermal conductivity of insulating powder.
7. Heat transfer from pin-fin apparatus (natural & forced convection modes).

8. Determination of Stefan – Boltzmann constant.
9. Determination of emissivity of a grey surface.
10. Effectiveness of Parallel / counter flow heat exchanger.

REFRIGERATION AND AIR CONDITIONING LAB:

1. Determination of COP of a refrigeration test rig.
2. Performance test on a reciprocating air compressor.
3. Determination of COP of a air-conditioning test rig.

d. Activities

Students shall be exposed to the hands on experience on heat transfer and Refrigeration and air-conditioning devices.

e. Learning Resources

Text Books

1. R.C. Sachdeva., *Fundamentals of Engineering Heat and Mass transfer*, New Age International Publishers, 2018.
2. Kothandaraman, C.P., *Fundamentals of Heat and Mass Transfer*, New Age International Publishers, 2019.

Reference Books

1. S.P. Venkateshan., *Heat Transfer*, Ane Books Private Limited, New Delhi, 2018.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

S.No.	Description of Equipment	Quantity Required
1.	Guarded plate apparatus.	1
2.	Lagged pipe apparatus.	1
3.	Natural convection-vertical cylinder apparatus.	1
4.	Forced convection inside tube apparatus.	1
5.	Pin-fin apparatus.	1
6.	Stefan-Boltzmann apparatus.	1
7.	Emissivity measurement apparatus.	1
8.	Parallel/counter flow heat exchanger apparatus.	1
9.	Single/two stage reciprocating air compressor.	1

S.No.	Description of Equipment	Quantity Required
10.	Refrigeration test.	1
11.	Air-conditioning test.	1

Course Code	Course Name	L	T	P	C
ME2353	SIMULATION AND ANALYSIS LABORATORY	0	0	3	1

Category: Professional Core

a. Preamble

This course provides indepth knowledge on analysis software - Femap Nastran for the students to get familiar in analysis and simulation of mechanical components.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Evaluate the stress analysis of one-dimensional structural problems using analysis software and compare it to an analytical solution.	K5
CO2	Analyze the stress and deformation of two-dimensional structural problems using analysis software.	K4
CO3	Resolve the heat transfer analysis for a given problem using analysis software.	K4
CO4	Execute the dynamic analysis for a given structural problem using analysis software.	K4
CO5	Simulate a mechanism using Multibody Dynamic Software.	K4

c. Course Syllabus

Total : 45 Periods

A. SIMULATION

1. MATLAB basics, Dealing with matrices, Graphing-Functions of one variable and two variables
2. Use of Matlab to solve simple problems in vibration
3. Mechanism Simulation using Multibody Dynamic software

B. ANALYSIS

a. Structural Analysis

1. Introduction to Finite Element Analysis
2. Force and Stress analysis using link elements in Trusses, cables etc.

3. Stress and deflection analysis in beams with different support conditions.
4. Stress analysis of flat plates and simple shells.
5. Stress analysis of axi – symmetric components.

b. Thermal Analysis

6. Thermal stress and heat transfer analysis of plates.
7. Thermal stress analysis of cylindrical shells.

c. Vibrational Analysis

8. Vibration analysis of spring-mass systems.
9. Model analysis of Beams.
10. Harmonic, transient and spectrum analysis of simple systems.

d. Activities

Students shall be exposed to model, analyse and simulate experiments to meet real world system and evaluate the performance.

e. Learning Resources

Reference Books

1. Averill M. Law., *Simulation Modeling and Analysis*, 4th Edition, McGraw Hill Education, 2017.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S.No.	Description of Equipment	Quantity Required
20.	Computer System	15
21.	Color Desk Jet Printer	01
22.	Multibody Dynamic Software Suitable for Mechanism simulation and analysis	15 licenses
23.	MATLAB	15 licenses

Course Code	Course Name	L	T	P	C
ME2354	DESIGN PROJECT AND PROTOTYPING	0	0	3	1

Category: Employability Enhancement Course

a. Preamble

The main objective is to give an opportunity to the student to get hands on training in the fabrication of one or more components of a complete working model, which is designed by them.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Identify, select the need based potential problem related to engineering.	K3
CO2	Develop the solution by applying the design principles.	K3
CO3	Create the design model and find solution.	K3
CO4	Develop the detailed design in manufacturing aspect by preparing the bill of materials and cost estimation.	K4
CO5	Fabrication of the model and implementation / Testing.	K4

c. Guideline For Review and Evaluation

Total : 45 Periods

The students may be grouped into 2 to 4 and work under a project supervisor. The device/system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible with an industry. A project report to be submitted by the group and the fabricated model, which will be reviewed and evaluated for internal assessment by a Committee constituted by the Head of the Department. At the end of the semester examination the project work is evaluated based on oral presentation and the project report submitted by students .

Course Code	Course Name	L	T	P	C
VME311	NEW PRODUCT DEVELOPMENT	3	0	0	3

Category: Professional Elective (Vertical -1)

a. Preamble

This course details the functional attributes of new product development like material specifications and processing, feasibility Studies, Market Survey. It describes the reverse engineering concepts and also converting cloud data to 3D model.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Discuss fundamental concepts and customer specific requirements of the New Product development.	K2
CO2	Discuss the Material specification standards, analysis and fabrication, manufacturing process.	K2
CO3	Develop Feasibility Studies & reporting of New Product development.	K2
CO4	Analyzing the New product qualification and Market Survey on similar products of new product development.	K3
CO5	Develop Reverse Engineering. Cloud points generation, converting cloud data to 3D model.	K3

c. Course Syllabus

Total : 45 Periods

FUNDAMENTALS OF NPD

9

Introduction – Reading of Drawing – Grid reading, Revisions, ECN (Engg. Change Note), Component material grade, Specifications, customer specific requirements – Basics of monitoring of NPD applying Gantt chart, Critical path analysis – Fundamentals of BOM (Bill of Materials), Engg. BOM & Manufacturing BOM. Basics of MIS software and their application in industries like SAP, MS Dynamics, Oracle ERP Cloud – QFD.

MATERIAL SPECIFICATIONS, ANALYSIS & PROCESS

9

Material specification standards – ISO, DIN, JIS, ASTM, EN, etc. – Awareness on various manufacturing process like Metal castings & Forming, Machining (Conventional, 3 Axis, 4 Axis, 5 Axis,), Fabrications, Welding process. Qualifications of parts mechanical, physical & Chemical properties and their test report preparation and submission. Fundamentals of DFMEA & PFMEA, Fundamentals of FEA, Bend Analysis, Hot Distortion, Metal and Material Flow, Fill and Solidification analysis.

ESSENTIALS OF NPD

9

RFQ (Request of Quotation) Processing – Feasibility Studies & reporting – CFT (Cross Function Team) discussion on new product and reporting – Concept design, Machine selection for tool making, Machining – Manufacturing Process selection, Machining Planning, cutting tool selection – Various Inspection methods – Manual measuring, CMM – GOM (Geometric Optical Measuring), Lay out marking and Cut section analysis. Tool Design and Detail drawings preparation, release of details to machine shop and CAM programming. Tool assembly and shop floor trials. Initial sample submission with PPAP documents.

CRITERIONS OF NPD

9

New product qualification for Dimensions, Mechanical & Physical Properties, Internal Soundness proving through X-Ray, Radiography, Ultrasonic Testing, MPT, etc. Agreement with customer for testing frequencies. Market Survey on similar products, Risk analysis, validating samples with simulation results, Lesson Learned & Horizontal deployment in NPD.

REPORTING & FORWARD-THINKING OF NPD

9

Detailed study on PPAP with 18 elements reporting, APQP and its 5 Sections, APQP vs PPAP, Importance of SOP (Standard Operating Procedure) – Purpose & documents, deployment in shop floor. Prototyping & RPT - Concepts, Application and its advantages, 3D Printing – resin models, Sand cores for foundries; Reverse Engineering. Cloud points generation, converting cloud data to 3D model – Advantages & Limitation of RE, CE (Concurrent Engineering) – Basics, Application and its advantages in NPD (to reduce development lead time, time to Market, Improve productivity and product cost.).

d. Activities

- Students able to generate the 3D models form cloud data.
- Students are exposed to understand the dimensioning, detailed Drawing preparation and mechanical, physical and soundness properties of new product.

e. Learning Resources

Text Books

1. Karl T. Ulrich, Maria C. Young, Steven D. Eppinger., *Product Design & Development*, 2020.
2. Sten Jonsson, *Product Development*.

Reference Books

1. Steven C Wheelwright & Kim B. Clar., *Revolutionizing Product Development*.
2. James Morgan & Jeffrey K. Liker., *Toyota Product Development System*.
3. Robert Brands., *Winning at New Products*, 3rd Edition.
4. Dr. M.A. Bulsara &Dr. H.R. Thakka., *Product Design & Value Engineering*.

Course Code	Course Name	L	T	P	C
VME312	REVERSE ENGINEERING	3	0	0	3

Category: Professional Elective (Vertical - 1)

a. Preamble

This course details the various aspects of how reverse engineering works in product design and development. It also describes the working of 3D scanning hardware & software operations and procedure to generate 3D model.

d. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Discuss the fundamental concepts and principles of reverse engineering in product design and development.	K2
CO2	Develop the concept and principles of data processing, part performance and system compatibility in reverse engineering.	K2
CO3	Understand the concepts of 3D scanning hardware & software operations and procedure to generate 3D model.	K2
CO4	Understand the various design rules for developing product through 3D printing.	K2
CO5	Apply the concept of reverse engineering in various industrial applications.	K3

c. Course Syllabus

Total : 45 Periods

INTRODUCTION & GEOMETRIC FORM 9

Introduction – Uses – The Generic Process – Phases – Computer Aided Reverse Engineering - Surface and Solid Model Reconstruction – Dimensional Measurement – Prototyping.

DATA PROCESSING 9

Statistical Analysis – Data Analysis – Reliability and the Theory of Interference – Weibull Analysis – Data Conformity and Acceptance – Data Report – Performance Criteria – Methodology of Performance Evaluation – System Compatibility.

3D SCANNING AND MODELLING

9

Introduction, working principle and operations of 3D scanners: Laser, White Light, Blue Light - Applications- Software for scanning and modelling: Types- Applications- Preparation techniques for Scanning objects- Scanning and Measuring strategies - Calibration of 3D Scanner- Step by step procedure: 3D scanning - Geometric modelling – 3D inspection- Case studies.

DESIGN FOR 3D PRINTING

9

General design considerations for 3D printing, 3D printed features – Design Rules for Material extrusion, Binder jetting, Material jetting, SLA, SLS.

INDUSTRIAL APPLICATIONS

9

Reverse Engineering in the Automotive Industry; Aerospace Industry; Medical Industry. Case studies and Solving Industrial projects in Reverse Engineering. Legality: Patent – Copyrights – Trade Secret – Third-Party Materials.

d. Activities

- Students able to scan the 3D physical models and convert it into CAD files.
- Students are exposed to various softwares related to reverse engineering, and also information related to calibration of 3D scanner.

e. Learning Resources

Text Books

1. Robert W. Messler, *Reverse Engineering: Mechanisms, Structures, Systems & Materials*, 1st Edition, McGraw-Hill Education, 2014.
2. Wego Wang, *Reverse Engineering Technology of Reinvention*, CRC Press, 2011.

Reference Books

1. Scott J. Lawrence., *Principles of Reverse Engineering*, Kindle Edition, 2022.
2. Kevin Otto and Kristin Wood., *Product Design: Techniques in Reverse Engineering and New Product Development*, Prentice Hall, 2001.
3. Kathryn, A. Ingle., *Reverse Engineering*, McGraw-Hill, 1994.
4. Linda Wills., *Reverse Engineering*, Kluwer Academic Publishers, 1996.

5. Vinesh Raj and Kiran Fernandes., *Reverse Engineering: An Industrial Perspective*, Springer- Verlag London Limited 2008.

Course Code	Course Name	L	T	P	C
VME313	PIPING DESIGN	3	0	0	3

Category: Professional Elective (Vertical - 1)

a. Preamble

This course explains the selection of appropriate piping materials, sizing and layout of piping systems, determination of pressure and temperature ratings, stress analysis, support design, and the use of relevant codes and standards.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the working of components of piping system and the various materials commonly used in piping system.	K2
CO2	Demonstrate the piping layout planning and design for successful implementation of piping system.	K2
CO3	Illustrate the stress developed in the piping system using software tools.	K2
CO4	Demonstrate the insulation and testing procedures associated with the piping system with its safety considerations.	K2
CO5	Interpret the piping maintenance strategies and the codes & standards of piping system.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION TO PIPING DESIGN

9

Introduction - Importance to piping design in industry - Need for piping design - Piping System Components - Types of Piping Systems - Piping Design Process - Piping Materials Selection - Pipe Manufacturing Processes - Piping Specifications and Standards.

PIPING LAYOUT AND DESIGN

9

Piping Layout Planning - Piping Layout Drawings - Piping Design Criteria - Pipe Sizing and Pressure Drop Calculation - Support and Restraint Design - Flexibility Analysis.

PIPING SUPPORTS AND STRESS ANALYSIS 9

Types of Supports and Hangers - Selection Criteria – Design and Installation - Stress Analysis Fundamentals - Types of Stress - Stress Analysis Methods - Software Tools for Stress Analysis.

PIPING INSULATION AND TESTING 9

Types and Selection of insulation and coating - Thickness Calculation – Installation - Piping Testing Procedures - Piping Commissioning Procedures - Safety Considerations in Piping Testing and Commissioning.

PIPING MAINTENANCE AND REPAIR 9

Piping Maintenance Strategies - Piping Repair Techniques - Piping Integrity Management - Piping Codes and Standards - ASME B31.1, B31.3, B31.4, B31.8, etc. - API 570, 574, 579, etc. - Other Relevant Codes and Standards.

d. Activities

- Students are able to design piping systems for various industrial applications.
- Students are exposed to various software tools for stress analysis in the piping systems.

e. Learning Resources

Text Books

1. Mohinder L. Nayyar., *Piping Handbook*, 7th Edition, McGraw-Hill Education.
2. Peter Smith., *Process Piping Design Handbook, Volume One: The Fundamentals of Piping Design*, Gulf Publishing Company, Texas.

Reference Books

1. Ed Bausbacher and Roger Hunt., *Process Plant Layout and Piping Design*, Prentice Hall, USA.
2. George A. Antaki., *Piping and Pipeline Engineering: Design, Construction, Maintenance, Integrity, and Repair*, CRC Press, 2003.
3. John J. McKetta Jr., *Piping Design Handbook*, CRC Press, 1992.
4. Brian Silowash., *Piping Systems Manual*, McGraw-Hill Education, 2009.

Course Code	Course Name	L	T	P	C
VME314	DRONE TECHNOLOGY	3	0	0	3

Category: Professional Elective (Vertical - 1)

a. Preamble

This course summarizes the fundamental of design, fabrication and programming of drone.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Know about a various type of drone technology, drone fabrication and programming.	K2
CO2	Execute the suitable operating procedures for functioning a drone.	K2
CO3	Select appropriate sensors and actuators for drones.	K3
CO4	Develop a drone mechanism for specific applications.	K3
CO5	Summarise the regulation and standardization of Drones.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Drone Concept - Vocabulary Terminology- History of drone - Types of current generation of drones based on their method of propulsion- Drone technology impact on the businesses- Drone business through entrepreneurship- Opportunities/applications for entrepreneurship and employability.

DRONE DESIGN, FABRICATION AND PROGRAMMING

9

Classifications of the UAV -Overview of the main drone parts- Technical characteristics of the parts -Function of the component parts -Assembling a drone- The energy sources- Level of autonomy- Drones configurations -The methods of programming drone- Download program - Install program on computer- Running Programs- Multi rotor stabilization- Flight modes -Wi-Fi connection.

DRONE FLYING AND OPERATION **9**

Concept of operation for drone -Flight modes- Operate a small drone in a controlled environment – Localization and Track optimization –management tool –Sensors-Onboard storage capacity - Removable storage devices- Linked mobile devices and applications.

DRONE COMMERCIAL APPLICATIONS **9**

Choosing a drone based on the application -Drones in the insurance sector- Drones in delivering mail, parcels and other cargo- Drones in agriculture- Drones in inspection of transmission lines and power distribution -Drones in filming and panoramic picturing.

FUTURE DRONES AND SAFETY **9**

The safety risks- Guidelines to fly safely -Specific aviation regulation and standardization- Drone license- Miniaturization of drones- Increasing autonomy of drones -The use of drones in swarms.

d. Activities

Students shall be exposed to various drone technology and its application.

e. Learning Resources

Text Books

1. Daniel Tal and John Altschuld., *Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation*, 2021 John Wiley & Sons, Inc.
2. Terry Kilby and Belinda Kilby., *Make:Getting Started with Drones*, Maker Media, Inc, 2016.

Reference Books

1. John Baichtal., *Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs*, Que Publishing, 2016.
2. Završnik., *Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance*, Springer, 2018.

Course Code	Course Name	L	T	P	C
VME315	DESIGN FOR X	3	0	0	3

Category: Professional Elective (Vertical - 1)

a. Preamble

This course is concerned with the imperative practice of product development to achieve simultaneous improvements in products and processes. With DFX, any product can improve quality, reducing costs, compressing cycle times, increasing flexibility, raising productivity & efficiency and improving the social image to turn out to be more competitive.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the various DFX tools and its needs, considerations and benefits.	K2
CO2	Elaborate different design principles of manufacturability.	K2
CO3	Analyze the methods and evaluation process of design for assembly.	K4
CO4	Describe the various DFX tools on lifecycle and competitiveness.	K2
CO5	Implement design for optimization and technical merit on industrial product.	K3

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Concurrent Engineering- Objectives, benefits – Support for Concurrent Engineering, Design for X (DFX): Need, Considerations, Various DFX tools, benefits, applications, Computation tools for DFX.

DESIGN FOR MANUFACTURABILITY (DFM)

9

Embodiment Design – Form Design - Economics of Process selection - General Design Principles for Manufacturability – General design rules –Raw materials Selection process –

Primary Process of Material Selection – Various other DFM Methods – Case Studies: DFM in automobile and electronics industry.

DESIGN FOR ASSEMBLY (DFA) 9

Aims – DFA Tools and techniques – General design guidelines - Evaluation process – DFA Analysis Methods – Assembly oriented design process- Application of the DFA Methodology - Case Study – DFA in industrial robots & electrical connections.

DESIGN FOR LIFECYCLE AND COMPETITIVENESS 9

Overview and short brief: Design for dimension control- Design for inspectability- Design for reliability- Design for serviceability – Design for recycling – Design for quality – Design for modularity- Design for environmental impact - Computer Applications for DFMA.

DESIGN FOR OPTIMIZATION AND TECHNICAL MERIT 9

Design optimization for product life cycle - Design optimization for performance and cost- Design optimization for customer/market needs – Design optimization for usage – Technical Merit: Concept & Definitions - Design for Technical Merit - Computer Aided applications on technical merit - Implementing DFX Tools.

d. Activities

Students shall be expected to deliver seminar presentation on various case studies in design for manufacture and assembly & other DFX applications in the industrial products.

e. Learning Resources

Text Books

1. Huang. G.Q., *Design for X (Concurrent engineering imperatives)*, Springer Science+ Business Media Dordrecht, 2012.

Reference Books

1. Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight., *Product Design for Manufacture and Assembly*, CRC Press, 2020.
2. Chanan S. Syan and UnnyMenon., *Concurrent Engineering (Concepts implementation and practice)*, Springer Science+ Business Media Dordrecht, 2010.
3. James G. Bralla., *Design for Manufacturability Handbook*, Tata McGraw-Hill, 1998.
4. Molloy.O, Warman.E.A, Tilley.S., *Design for Manufacturing and Assembly: Concepts, Architectures and Implementation*, Springer, 1998.

Course Code	Course Name	L	T	P	C
VME316	CAD /CAE	3	0	0	3

Category: Professional Elective (Vertical - 1)

a. Preamble

This course summarizes the fundamental of computer aided design and engineering analysis.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Apply the fundamental concepts of computer graphics and its tools in a generic framework.	K3
CO2	Create and manipulating geometric models using curves, surfaces and solids.	K3
CO3	Apply concept of 3D modeling, visual realism and CAD standard practices in engineering design.	K3
CO4	Develop the mathematical models for Boundary Value Problems and their numerical solution.	K3
CO5	Formulate the solution techniques to solve non-linear problems.	K3

c. Course Syllabus

Total :45 Periods

FUNDAMENTALS OF COMPUTER GRAPHICS

9

Design process - Computer Aided Design – Computer graphics – co-ordinate systems- 2D and 3D transformations - Graphic primitives (point, line, circle drawing algorithms) - Clipping- viewing transformation. Standards for computer graphics – Introduction to vector graphics

GEOMETRIC MODELING

9

Representation of curves - Hermite cubic spline curve, Bezier curve, B-spline curves, Surface Modeling – Surface Entities, Representation of Surface, Bezier Surface, B-Spline Surface and Coons Surface. Solid Modeling - Solid Entities, Solid Representation,

Boundary Representation (B-Rep), Sweeps Representation, Constructive Solid Geometry (CSG).

VISUAL REALISM and CAD STANDARDS 9

Need for hidden surface removal, The Depth - Buffer Algorithm, Properties that help in reducing efforts, Scan Line coherence algorithm, Span - Coherence algorithm, Area-Coherence Algorithms, Warnock's Algorithm, Priority Algorithms– shading – coloring – computer animation. Standards for computer graphics- Graphical Kernel System (GKS) - standards for exchange images Open Graphics Library (OpenGL) - Data exchange standards - IGES, STEP, CALS etc.

FINITE ELEMENT ANALYSIS 9

Historical Background – Weighted Residual Methods - Basic Concept of FEM – Variational Formulation of Boundary Value Problems – Ritz Method – Finite Element Modelling – Element Equations – Linear and Higher order Shape functions – Bar, Beam Elements –Applications to Heat Transfer problems.

NON-LINEAR ANALYSIS 9

Introduction to Non-linear problems - some solution techniques- computational procedure- material non-linearity-Plasticity and visco-plasticity, stress stiffening, contact interfaces- problems of gaps and contact - geometric non-linearity - modeling considerations - Free and Mapped meshing -Mesh quality- Error estimate- Introduction to Analysis Software.

d. Activities

- Students shall be exposed to apply their CAD knowledge while developing the products.

e. Learning Resources

Text Books

1. Ibrahim Zeid., *Mastering CAD/ CAM* , Tata McGraw Hill publishing Co. Ltd, New Delhi, 2007.
2. Seshu.P., *Textbook of Finite Element Analysis* , PHI Learning Pvt. Ltd., NewDelhi, 2012.

Reference Books

1. William M Neumann and Robert F.Sproul., *Principles of Computer Graphics* , McGraw Hill Book Co. Singapore, 1989.
2. Donald Hearn and M. Pauline Baker., *Computer Graphics*, Prentice Hall, Inc, 1992.
3. Rao, S.S., *The Finite Element Method in Engineering*, 6th Edition, Butterworth Heinemann, 2018.
4. Reddy J.N., *Introduction to the Finite Element Method*, 4th Edition, Tata McGrawHill, 2018.

Course Code	Course Name	L	T	P	C
VME317	PRODUCT LIFE CYCLE MANAGEMENT	3	0	0	3

Category: Professional Elective (Vertical - 1)

a. Preamble

This course summarizes the functions and features of PLM/PDM with legacy data bases, C&ERP systems.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Summarize the history, concepts and terminology of PLM.	K2
CO2	Develop the functions and features of PLM/PDM.	K3
CO3	Discuss different modules offered in commercial PLM/PDM tools.	K2
CO4	Interpret the implementation steps for PLM/PDM approaches in industrial applications.	K2
CO5	Integrate PLM/PDM with legacy data bases, CAX & ERP systems.	K2

c. Course Syllabus

Total : 45 Periods

HISTORY, CONCEPTS AND TERMINOLOGY OF PLM

9

Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDM), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM). PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications.

PLM/PDM FUNCTIONS AND FEATURES

9

User Functions – Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility

Functions – Communication and Notification, data transport, data translation, image services, system administration and application integration.

PLM SOFTWARE SOLUTIONS 9

Case studies based on top few commercial PLM/PDM tools – Teamcenter, Windchill, ENOVIA, Aras PLM, SAP PLM, Arena, Oracle Agile PLM and Autodesk Vault.-Architecture of PLM software- selection criterion of software for particular application - Brand name to be removed.

ROLE OF PLM IN INDUSTRIES 9

Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organization, users, product or service, process performance-process compliance and process automation.

BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE 9

PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP.

d. Activities

Students shall be demonstrated PLM/PDM approaches for industrial applications.

e. Learning Resources

Text Books

1. *Product Lifecycle Management for a Global Market.*, Springer edition (29 September 2016),ISBN-10 : 3662516330, 2014.
2. *Product Life Cycles and Product Management.*, Praeger Publishers Inc (27 March 1989)ISBN-10 : 0899303196.

Reference Books

1. AnttiSaaksvuori and AnselmiImmonen., *Product Lifecycle Management*, 3rd Edition, Springer Publisher, 2008.
2. IvicaCrnkovic, Ulf Asklund and AnnitaPerssonDahlqvist., *Implementing and Integrating Product Data Management and Software Configuration Management*, Artech House Publishers, 2003.

3. John Stark., *Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question*, Springer Publisher, 2007.
4. Michael Grieves., *Product Life Cycle Management*, Tata McGraw Hill, 2006.

Course Code	Course Name	L	T	P	C
VME321	MODERN ROBOTICS	3	0	0	3

Category: Professional Elective (Vertical - 2)

a. Preamble

This course helps the student to basic idea of Robots. Students are introduced to the basic design consideration of robots. Concepts like trajectory planning and obstacle avoidance and kinematics of robots are introduced. Discussion on various mobile robots and robotic applications of robotics in various domain are also included as part of the course to get an overall idea on robotics.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Discuss the definition, history of robotics and robot anatomy.	K2
CO2	Develop the simulation of robot kinematics.	K2
CO3	Describe the grasping and manipulation of robots.	K2
CO4	Explain about mobile robot and manipulation.	K2
CO5	Discuss the applications of industrial, service and domestic robots.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Robot: Definition, History of Robotics, Robot Anatomy, Co-ordinate systems, types and classification, Configuration space and degrees of freedom of rigid bodies and robots, Configuration space topology and representation; configuration and velocity constraints; task

space and workspace, Rigid-body motions, rotation matrices, angular velocities, and exponential coordinates of rotation, Homogeneous transformation matrices.

SIMULATION OF ROBOT KINEMATICS **9**

Robot kinematics, Forward and inverse kinematics (two three four degrees of freedom), Forward and inverse kinematics of velocity, Homogeneous transformation matrices, translation and rotation matrices Denavit and Hartenberg (D-H) transformation, Dynamics of Open Chains, Trajectory Generation, motion planning, robot control: First- and second-order linear error dynamics, stability of a feedback control system.

GRASPING AND MANIPULATION OF ROBOTS **9**

Kinematics of contact, contact types (rolling, sliding, and breaking), graphical methods for representing kinematic constraints in the plane, and form-closure grasping, Coulomb friction, friction cones, graphical methods for representing forces and torques in the plane, End effectors, grippers, types of gripper, gripper force analysis, and examples of manipulation and grasping.

MOBILE ROBOTS **9**

Mobile robot, Wheeled Mobile Robots: Kinematic models of omnidirectional and non-holonomic wheeled mobile robots, Controllability, motion planning, feedback control of non-holonomic wheeled mobile robots; odometry for wheeled mobile robots; and mobile manipulation. Reference Trajectory generation, feed forward control.

APPLICATIONS OF ROBOTS **9**

Application of robotic: industrial robots, Service robots, domestic and house hold robots, Medical robots, military robots, agricultural robots, space robots, Aerial robotics Role of robots in inspection, assembly, material handling, underwater, space and healthcare.

d. Activities

Students will do the 3D modeling and motion simulation of Cartesian, articulated, spherical and cylindrical robot.

e. Learning Resources

Text Books

1. Kevin M. Lynch , Frank C. Park., *Modern Robotics: Mechanics, Planning, and Control*, Cambridge University Press; 1st edition (25 May 2017), ISBN-10 : 110715.

2. Julian Evans., *Modern Robotics: Mechanics, Systems and Control*, Larsen and Keller Education (27 June 2019), ISBN-10 : 1641720751.

Reference Books

1. Jared Kroff., *Modern Robotics: Designs, Systems and Control*, Willford Press (18 June 2019), ISBN-10 : 1682856763.
2. ChenguangYang , Hongbin Ma , Mengyin Fu., *Advanced Technologies in Modern Robotic Applications*, Springer; Softcover reprint of the original 1st ed. 2016 edition (30 May 2018), ISBN- 10 : 981109263X.
3. Harry Henderson., *Modern Robotics: Building Versatile Machines*, Facts On File Inc; Illustrated edition (1 August 2006), ISBN-10 : 0816057451.
4. Francis X. Govers., *Artificial Intelligence for Robotics*, Packt Publishing Limited; Standard Edition (30 August 2018), ISBN-10 : 1788835441.
5. Lauren Barrett., *Modern Robotics Hardcover*, Murphy & Moore Publishing (1 March 2022), ISBN-10 : 1639873732.

Course Code	Course Name	L	T	P	C
VME322	AUTOMATION FOR MANUFACTURING	3	0	0	3

Category: Professional Elective (Vertical - 2)

a. Preamble

This course goes beyond a focus on robot controls and interfacing to address the interaction with objects in the surrounding world. It is also an excellent beginning for the student who intends to continue with advanced courses or with original research in robotics.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Explain the various concepts of Industrial Automation.	K2
CO2	Describe the basic concepts of Programmable logic controllers.	K2
CO3	Describe the distributed control system and its components with applications	K2
CO4	Discuss how to integrate SCADA with PLC Systems	K2
CO5	Comprehend the economical aspects of automation.	K2

c. Course Syllabus

Total : 45 Periods

INDUSTRIAL AUTOMATION

9

Concept of Mechanization and Automation - Elements of Automated System - Automation Functions - Levels of Automation - Types of Automation - Reasons for Automation.

Types of Production - Function in Manufacturing - Automation Principles & Strategies - Automated Flow Lines - Automated Assemble systems : Definition & types.

PROGRAMMABLE LOGIC CONTROLLERS (PLC)

9

Programmable controllers - Programmable logic controllers - PLC programming - Ladder diagram - PLC Communication and networking - PLC selection - PLC Installation - Advantage of using PLC for Industrial automation - Application of PLC to process control industries.

DISTRIBUTED CONTROL SYSTEM (DCS) 9

Overview of DCS - DCS software configuration - DCS communication - DCS Supervisory Computer Tasks - DCS integration with PLC and Computers - Features of DCS - Advantages and applications of DCS.

REAL TIME INTERFACING 9

Data acquisition systems - virtual instrumentation - interfacing of sensors/actuators with PC - condition monitoring - adaptive control - Introduction to SCADA - Comparison between SCADA and DCS - Human Machine Interface systems - Need for HMI systems - Types of HMI - Interfacing of SCADA with PLC.

AUTOMATION ECONOMY 9

Plant Economy - Effect of Automation on Economy - Feasibility of Automation on Economical sense - Feasibility of automation in Indian market - Scope of automation in Indian Industries - Break Even point analysis for automation.

d. Activities

Students shall present the seminar on various industrial automation case studies.

e. Learning Resources

Text Books

1. S.K.Singh, “ Industrial Instrumentation and Control”, Tata McGraw Hill Company, 2010.
2. Devdas Shetty and Richard A Kolk , "Mechatronics System Design", PWS Publishing Company, 2010.

Reference Books

1. Mikell P Groover , "Automation, Production Systems and Computer-Integrated Manufacturing", Pearson Education, 2016.
2. Johnson, C.D. "Process Control Instrumentation Technology." Prentice Hall of India, 2013.

3. Dunning, Delmar. "Programmable Logic Controller." Delmar Publishers, 2016.
4. Michael P. Lukas, "Distributed Control systems", "Van Nostrand Reinhold Company"1995 .

Course Code	Course Name	L	T	P	C
VME323	ROBOTS AND SYSTEMS IN SMART MANUFACTURING	3	0	0	3

Category: Professional Elective (Vertical - 2)

a. Preamble

This course is designed to provide the knowledge of working on Industrial robots and applications in material handling systems. It familiarizes applications of robot in welding and allied processes used in smart manufacturing.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Recognize various concepts of Industrial Robot.	K2
CO2	Select the appropriate manufacturing procedure for Robots.	K2
CO3	Apply various manufacturing process in Robot manufacturing.	K2
CO4	Summarise the Welding operation in Robotics and also related to Programming.	K2
CO5	Produce a manufacturing plan for developing a robot.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Types of industrial robots - Load handling capacity - general considerations in Robotic material handling-material transfer - machine loading and unloading - CNC machine tool loading – Robot centered cell.

SELECTION OF ROBOTS AND OTHER APPLICATIONS

9

Factors influencing the choice of a robot - robot performance testing - economics of robotization- impact of robot on industry and society. Application of Robots in continuous arc welding – Spot welding - Spray painting -assembly operation - cleaning - robot for underwater applications.

MATERIAL HANDLING 9

Concepts of material handling - principles and considerations in material handling systems design - conventional material handling systems - industrial trucks - monorails - rail guided vehicles -conveyor systems -cranes and hoists - advanced material handling systems - automated guided vehicle systems - automated storage and retrieval systems (ASRS) - bar code technology – radio frequency identification technology -Introduction to Automation Plant design software.

ROBOTIC WELDING 9

Robotic welding system, Programmable and flexible control facility –Introduction-Types- Flex Pendant-Lead through programming, Operating mode of robot, Jogging-Types, programming for robotic welding, Welding simulation, Welding sequences, Profile welding.

APPLICATIONS OF ROBOTS IN WELDING AND ALLIED PROCESSES 9

Application of robot in manufacturing: Exploration of practical application of robots in welding: Robots for car body’s welding, robots for box fabrication, robots for microelectronic welding and soldering – Applications in nuclear, aerospace and ship building, case studies for simple and complex applications.

d. Activities

Students shall be expected to deliver seminar presentation on various application of industrial robotics.

e. Learning Resources

Text Books

1. Richard D Klafter, Thomas Achmielewski, MickaelNegin , *Robotic Engineering – An integrated Approach*, Prentice Hall India, New Delhi, 2006.
2. Mikell P Groover , *Automation, Production Systems, and Computer Integrated Manufacturing*, Pearson Education, New York, 2019.
3. Pires J N, Loureiro A, Bolmsjo G, *Welding Robots: Technology, System Issues and Application*, Springer, London, 2010.

Reference Books

1. Parmar R S., *Welding Processes and Technology*, Khanna Publishers, New Delhi, 2nd Edition, 2013.
2. John A. piotrowski, William T. Randolph., *Robotic welding: A Guide to Selection and Application*, Welding Division, Robotics International of SME, Publications Development Dept., Marketing Division, 1987.
3. Mikell P Groover, Mitchel Weiss, Roger N Nagel, N.G.Odrey, Ashish Dutta ., *Industrial Robotics (SIE): Technology, Programming and Applications*, 2nd Edition, McGraw Hill Education India Pvt Ltd, 2012.
4. Yoram Koren., *Robotics for Engineers*, McGraw-Hill, 1987.

Course Code	Course Name	L	T	P	C
VME324	ADDITIVE MANUFACTURING	3	0	0	3

Category: Professional Elective (Vertical - 2)

a. Preamble

This course is designed to impart knowledge and skills related to 3D printing technologies. It introduces the development of Additive Manufacturing (AM), various business opportunities and applications. It familiarizes various software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using AM. It introduces about selecting the materials and equipments for various 3D printing products. It comprehensively details about developing a 3D printed product.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Classify the development of AM technology.	K2
CO2	Explain the principle, process, advantages and disadvantages of various Polymer-based AM techniques.	K2
CO3	Discuss the principle, process, advantages and disadvantages of various Metal AM techniques.	K2
CO4	Select particular AM materials for suitable applications.	K2
CO5	Discuss about Post processing of additively manufactured product and its various business developing opportunities.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Introduction, Process, Classification, Advantages, Additive vs Conventional Manufacturing processes. AM Process Chain- CAD Data formats, Data translation, Data loss, STL format.

Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defense, Automotive, Construction, Food Processing, Machine Tools.

ADDITIVE MANUFACTURING USING POLYMERS 9

Principle, Pre-Build Process and Part-Building - Advantages, Limitations and Applications for Stereo- Lithography, LOM, FDM, SLS, Binder Jet technology- Process, Process parameter, Process Selection for various applications- Defects and their causes.

METAL ADDITIVE MANUFACTURING 9

Principle, Pre-Build Process, Part-Building and Post Processing Requirement and Techniques, Advantages, Limitations and Applications for Selective Laser Melting (SLM), Laser Beam Melting (LBM), Laser Metal Fusion (LMF), Direct Metal Laser Sintering (DMLS), Electron Beam melting (EBM), Laser Cladding, Directed Energy Deposition and Laser Metal Deposition Process, Laser Engineered Net Shaping (LENS), Wire Arc AM, Friction Stir AM.

AM MATERIALS 9

Polymers, Metals, Non-Metals, Ceramics - Various forms of raw material- Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their Properties - Support Materials- FGM – Composite Materials in AM - Metallurgy and Properties of Materials for Metal AM.

POST PROCESSING AND INSPECTION TECHNIQUES 9

Post Processing Requirement and Types of Post Processing Techniques; Post processing Techniques for metal AM - Surface Treatments; Inspection techniques; Business Opportunities and Future Directions – Case studies: Automobile, Aerospace, Healthcare.

d. Activities

Students shall be exposed to acquire knowledge on process of transforming a concept into the final product in AM technology. Students will learn to evaluate the advantages, limitations, applications of AM processes.

e. Learning Resources

Text Books

1. Lan Gibson, David W. Rosen and Brent Stucker., *Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing*, Springer, 2010.

2. Soloman S, *3D Printing and Design*, Khanna Publishing House, Delhi, 2020.

Reference Books

1. Andreas Gebhardt., *Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing*, Hanser Publisher, 2011.
2. CK Chua, Kah Fai Leong., *3D Printing and Rapid Prototyping- Principles and Applications*, World Scientific, 2018.
3. J.D. Majumdar and I. Manna., *Laser-Assisted Fabrication of Materials*, Springer Series in Material Science, 2013.
4. L. Lu, J. Fuh and Y.S. Wong., *Laser-Induced Materials and Processes for Rapid Prototyping*, Kulwer Academic Press, 2001.
5. Zhiqiang Fan & Frank Liou., *Numerical Modelling of the Additive Manufacturing (AM) Processes of Titanium Alloy*, InTech, 2012.

Course Code	Course Name	L	T	P	C
VME325	DIGITAL MANUFACTURING AND IOT	3	0	0	3

Category: Professional Elective (Vertical - 2)

a. Preamble

This course introduces the basic concepts of digital Manufacturing, framework of digital manufacturing, Industrial IoT, Digital Product life cycle and its supply chain management, Digital twin and Digital Thread in Manufacturing.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Elucidate the concepts of Digital Manufacturing with its benefits and its future scope.	K2
CO2	Describe the digital life and supply chain management of product.	K2
CO3	Explain the basic concepts of smart factory, key principles, challenges and cyber security of smart factory.	K2
CO4	Define the basic concepts of IoT, basic framework, cloud computing and cyber physical systems of Industry 4.0.	K2
CO5	Explicate the concepts of Digital twin, digital thread, their challenges and future scope.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Introduction – Need – Overview of Digital Manufacturing and the Past – Aspects of Digital Manufacturing: Product life cycle, Smart factory, and value chain management – Practical Benefits of Digital Manufacturing – The Future of Digital Manufacturing.

DIGITAL LIFE CYCLE & SUPPLY CHAIN MANAGEMENT **9**

Collaborative Product Development, Mapping Requirements to specifications – Part Numbering, Engineering Vaulting, and Product reuse – Engineering Change Management, Bill of Material and Process Consistency – Digital Mock up and Prototype development – Virtual testing and collateral. Overview of Digital Supply Chain - Scope& Challenges in Digital SC - Effective Digital Transformation - Future Practices in SCM.

SMART FACTORY **9**

Smart Factory – Levels of Smart Factories – Benefits – Technologies used in Smart Factory – Smart Factory in IoT- Key Principles of a Smart Factory – Creating a Smart Factory – Smart Factories and Cyber security.

INDUSTRY 4.0 **9**

Introduction – Industry 4.0 –Internet of Things – Industrial Internet of Things – Framework: Connectivity devices and services – Intelligent networks of manufacturing – Cloud computing – Data analytics –Cyber physical systems –Machine to Machine communication – Case Studies.

DIGITAL TWIN **9**

Introduction to Plant simulation, Process simulation and Product simulation, Digital Twin: Basic Concepts – Features and Implementation –Digital Twin: Digital Thread and Digital Shadow- Building Blocks – Types – Characteristics of a Good Digital Twin Platform – Benefits, Impact & Challenges – Future of Digital Twins.

d. Activities

Students shall be given poster presentation to know how to apply the IoT concepts and industry 4.0 for the industry.

e. Learning Resources

Text Books

1. Zude Zhou, Shane (Shengquan) Xie and Dejun Chen., *Fundamentals of Digital Manufacturing Science*, Springer-Verlag London Limited, 2012.
2. Alasdair Gilchrist., *Industry 4.0: The Industrial Internet of Things*, A press, 2016.

Reference Books

1. Lihui Wang and Andrew YehChing Nee., *Collaborative Design and Planning for Digital Manufacturing*, Springer-Verlag London Limited, 2009.
2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang., *Digital Twin Driven Smart Manufacturing*, Elsevier Science., United States, 2019.
3. Alp Ustundag and Emre Cevikcan., *Industry 4.0: Managing The Digital Transformation*, Springer Series in Advanced Manufacturing., Switzerland, 2017.
4. Ronald R. Yager and Jordan Pascual Espada., *New Advances in the Internet of Things*, Springer., Switzerland, 2018.

Course Code	Course Name	L	T	P	C
VME326	ADVANCED MANUFACTURING SYSTEMS	3	0	0	3

Category: Professional Elective (Vertical - 2)

a. Preamble

This course introduces the basic concepts of various manufacturing systems such as lean, Agile, Sustainable, Intelligent and Smart manufacturing.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Demonstrate on basic lean manufacturing.	K2
CO2	Integrate the knowledge on agile manufacturing.	K2
CO3	Formulate strategy in sustainable manufacturing.	K2
CO4	Comprehend the intelligence manufacturing and its various techniques.	K2
CO5	Understand the smart manufacturing and its various techniques.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION TO LEAN MANUFACTURING 9

Objectives of lean manufacturing-key principles and implications of lean manufacturing - traditional Vs lean manufacturing- flow-continuous improvement/Kaizen –worker involvement- 5S principles elements of JIT - uniform production rate - Kanban system – Lean implementation, Reconciling lean with other systems - lean six sigma- lean and ERP - lean with ISO 9001:2000.

AGILE MANUFACTURING 9

Agile Manufacturing Vs Mass Manufacturing - Agile practice for product development - Manufacturing agile practices - Implementing new technology - A checklist, technology

applications that enhance agility - agile technology make or buy decisions. - Costing for Agile Manufacturing practices.

SUSTAINABLE MANUFACTURING 9

Concepts of competitive strategy and manufacturing strategies and development of a strategic improvement programme - Manufacturing strategy in business success strategy formation and formulation - Structured strategy formulation - Sustainable manufacturing system design options - Approaches to strategy formulation - Realization of new strategies/system designs.

INTELLIGENT MANUFACTURING 9

Components of knowledge based systems – basic components of knowledge based systems, knowledge representation, comparison of knowledge representation schemes, interference engine, knowledge acquisition.

Machine learning – concept of artificial intelligence, conceptual learning, artificial neural networks-biological neuron, artificial neuron, types of neural networks, Fuzzy logic, applications in manufacturing.

SMART MANUFACTURING 9

Introduction to various Smart Manufacturing Techniques-Supply chain management-Block chain of inventory management - Plant digitization-Predictive maintenance-Supply chain visibility Warehouse - Cost reduction-Waste management-Automated systems - Applications.

d. Activities

Students will give seminar presentation on implementation and case studies of manufacturing systems.

e. Learning Resources

Text Books

1. Lonnie Wilson., *How to Implement Lean manufacturing*, McGraw-Hill Professional; 2nd edition, 2015.
2. Ibrahim Garbie., *Sustainability in Manufacturing Enterprises Concepts, Analyses and Assessments for Industry 4.0*, Springer International Publishing., United States, 2016, ISBN-13: 978-3319293042.
3. Kusiak, Andrew., *Intelligent Manufacturing Systems*, Prentice Hall, 1st edition, 1990.

Reference Books

1. Black.J.T. and Kohser R.A, DeGarmo's., *Materials and Processes in Manufacturing*, Published by Wiley, 11th edition, 2011.
2. Christian N. Madu., *Handbook of environmentally conscious manufacturing*, Springer US Publishers, 1st edition, 2001.
3. John Schey., *Introduction to Manufacturing Processes*, Tata McGraw-Hill Education ,3rd edition,1999.
4. Seliger G., *Sustainable Manufacturing: Shaping Global Value Creation*, Springer, United States, 2012, ISBN 978-3-642-27289-9.
5. 5. Rao R. V., *Advanced Modeling and Optimization of Manufacturing Processes*, 2nd edition, 2006.
6. 6. Ronald G. Askin and Jeffrey B. Goldberg., *Design and Analysis of Lean Production Systems*, John Wiley and Sons, 2003.
7. 7. Kutz M., *Environmentally Conscious Mechanical Design*, John Wiley & Sons., United States, 2007, ISBN: 978-0-471-72636-4.
8. Yagna Narayana., *Artificial Neural Networks*, PHI, 2009.

Course Code	Course Name	L	T	P	C
VME327	PROCESSING AND CHARACTERIZATION OF COMPOSITE MATERIALS	3	0	0	3

Category: Professional Elective (Vertical - 2)

a. Preamble

The knowledge gained from this course will aid in the design and development of composite materials for various fields. This course covers the fundamental principles of composite manufacturing, including different types of reinforcements, matrices, and processing methods. Additionally, the paper discusses the various characterization techniques used to evaluate the mechanical, thermal, and structural properties of composite materials.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the fundamentals of composite materials and properties of polymer composites.	K2
CO2	Comprehend the various manufacturing methods of metal matrix and ceramic matrix composites.	K2
CO3	Explain the various mechanical properties of composite materials.	K2
CO4	Demonstrate the different characterization techniques related to micro and crystal structure of materials.	K2
CO5	Describe the different characterization techniques related to morphology and thermal properties.	K2

Total : 45 Periods

c. Course Syllabus

INTRODUCTION TO COMPOSITES AND POLYMER MATRIX COMPOSITES

9

Definitions- Composites-Reinforcements and matrices-Types of reinforcements-Types of matrices- Properties of composites in comparison with standard materials. Classifications of polymer composites, Thermosets and Thermoplastics - properties, and uses- Fabrications of polymer composites – Hand lay-up method, compression and transfer moulding, pressure and vacuum bag process, filament winding, protrusion, Injection moulding.

METAL MATRIX AND CERAMIC MATRIX COMPOSITES 9

Metal Matrix Composites (MMCs) – Properties, Manufacturing -Powder metallurgy- Pressing; hot isostatic and cold isostatic-Sintering- Vacuum; spark plasma, microwave- stir casting, infiltration processing- Applications, Ceramic Matrix Composites (CMCs) –Properties- Manufacturing hot pressing-reaction bonding process-infiltration technique, direct oxidation- interfaces- Applications.

MECHANICAL TESTING OF COMPOSITES 9

Hardness – Brinell, Vickers, Rockwell and Micro Hardness Test – Tensile Test – Stress – Strain plot– Torsion Test - Ductility Measurement – Impact Test – Charpy & Izod –Fracture Toughness Test, Codes and standards for testing metallic and composite materials- Fatigue –Rotating Beam & Plate Bending HCF tests – S-N curve – Low Cycle Fatigue tests – Creep Tests.

MICRO AND CRYSTAL STRUCTURE ANALYSIS 9

Principles of Optical Microscopy – Specimen Preparation Techniques – Polishing and Etching – Polarization Techniques – Quantitative Metallography. Microstructure of Engineering Materials - Elements of Crystallography – X- ray Diffraction – Bragg’s law – Techniques of X- ray Crystallography – Debye – Scherer camera – Geiger Diffractometer – analysis of Diffraction patterns -Fourier Transform Infra Red Spectroscopy (FTIR)-Raman spectroscopy- Nuclear magnetic resonance spectroscopy (NMR).

ELECTRON MICROSCOPY, CHEMICAL AND THERMAL ANALYSIS 9

Scanning Electron Microscopy – Construction & working of SEM- Transmission Electron Microscopy – Construction & working of SEM - Atomic Force Microscopy- Construction & working of AFM –Basic Principles, Practice and Applications of X-Ray Spectrometry, Differential Thermal Analysis, Differential Scanning Calorimetry (DSC) And Thermo gravimetric Analysis (TGA).

d. Activities

Students shall be expected to fabricate and characterizing the different composite materials.

e. Learning Resources

Reference Books

1. Mallick, P.K. and Newman, S., (edition), *Composite Materials Technology: Processes and Properties*, Hansen Publisher, Munish, 1990.
2. Mallick, P.K., *Fiber Reinforced Composites: Materials, Manufacturing and Design*, Manel Dekker Inc, 1993.
3. Goldsten,I.J., Dale.E., Echin.N.P.& Joy D.C., *Scanning Electron Microscopy & X ray-Micro Analysis*, (2nd Edition), ISBN – 0306441756, Plenum Publishing Corp., 2000.
4. Grundy P.J. and Jones G.A., *Electron Microscopy in the Study of Materials*, Edward Arnold Limited, 1976.
5. Morita.S, Wiesendanger.R, and Meyer.E, *Non-contact Atomic Force Microscopy*, Springer, 2002.
6. *ASM Hand book-Materials characterization*, Vol – 10, 2004.

Course Code	Course Name	L	T	P	C
VME331	CONVENTIONAL AND ELECTRIC VEHICLES	3	0	0	3

Category: Professional Elective (Vertical - 3)

a. Preamble

This course describes vehicle construction, power transmission, steering, braking and suspension systems of automobiles. It explains about electric vehicles and its conversion, electric vehicle operation control, and vehicle management systems.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Classify the automobiles and its types.	K2
CO2	Infer the transmission parts along with the steering column and braking.	K2
CO3	Outline the basic knowledge of Electric vehicles.	K2
CO4	Acquire the understanding about the electric vehicle operation control elements and its respective working procedures.	K2
CO5	Familiarize about the recent vehicle management control systems.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Types of Automobiles - Vehicle construction and different layouts, Chassis, frame, and Vehicle body aerodynamics - Resistances and moments - IC engines –components- Functions and materials – MPFI – Turbocharging – Supercharging - Emission norms and standards.

POWER TRANSMISSION, STEERING AND BRAKING SYSTEMS

9

Clutch-types and construction, Gear boxes- Manual and automatic, Gear shift mechanisms, Propeller shaft, slip joints, universal joints, Differential and rear axle, Hotchkiss Drive and

Torque Tube Drive. Steering geometry and steering gear box, Pneumatic and Hydraulic Braking Systems, Suspension systems.

ELECTRIC VEHICLES AND CONVERSION 9

History of electrical vehicles, Electric and hybrid vehicles, flexible fuel vehicles (FFV), solar powered vehicles, fuel cells vehicles. fuel cells, flexible fuel systems. Series and parallel hybrid vehicles. High energy and power density batteries. Conversion of conventional vehicles as hybrid vehicles – Conversion kit and economics of conversion.

ELECTRIC VEHICLE OPERATION CONTROL 9

Dynamics and architecture of hybrid and electrical vehicles, DC-DC converters, DC- AC converters, AC electrical machines and permanent magnet for hybrid and electrical vehicles, Control system for electrical and hybrid electric vehicles – Energy management strategies and its general architecture, Rule, and optimization-based energy management strategies (EMS), EMS based on deterministic rule.

VEHICLE MANAGEMENT SYSTEMS 9

Regenerative braking, layout – Working and electronic control of suspension – Damping control, Electric power steering, Cruise control. Vehicle security systems- alarms, vehicle tracking system. On board diagnostics. Collision avoidance Radar warning system – E-charging solutions.

d. Activities

- Students shall be given mini project for electric vehicle conversion from conventional vehicle
- Students will be gaining the hands-on experience on conventional automobile engine and other components through hands-on-training.

e. Learning Resources

Text Books

1. Kirpal Singh., *Automobile Engineering – Vol. 1 & 2*, Standard Publishers, New Delhi, 2022.
2. Bosch Hand Book, SAE Publication, 2000.
3. Eric Chowanietz., *Automobile Electronics*, SAE Publications, Latest Edition, 2020.

Reference Books

1. Advance hybrid vehicle power transmission, SAE.
2. Ron Hodgkinson and John Fenton., *Light weight electric for hybrid vehicle design*, Elsevier, 2018.
3. Heinz., *Modern Vehicle Technology* Second Edition, Butter worth- Heinemann, Elsevier.

Course Code	Course Name	L	T	P	C
VME332	ELECTRIC VEHICLE DESIGN	3	0	0	3

Category: Professional Elective (Vertical - 3)

a. Preamble

This course provides comprehensive coverage of electric vehicle modeling, design, operation, and related environmental considerations.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the basics and parameters of electric vehicle modelling.	K2
CO2	Describe the considerations to optimize the electric vehicle design	K2
CO3	Explain the design and operation patterns of series hybrid electric drive train.	K2
CO4	Explain the design and operation patterns of parallel hybrid electric drive train.	K2
CO5	Identify the ancillary system and its environmental impact of electric vehicles.	K2

c. Course Syllabus

Total : 45 Periods

ELECTRIC VEHICLE MODELLING 9

Introduction to aerodynamics: Tractive Effort - Rolling resistance force - Aerodynamic drag - Hill climbing force - Acceleration force - Modelling Vehicle Acceleration – Acceleration performance parameters - Modelling the acceleration of a small car - Modelling Electric Vehicle Range - Driving cycles - Range modelling of battery electric vehicles - Constant velocity range modelling - Range modelling of fuel cell vehicles - Range modelling of hybrid electric vehicles.

ELECTRIC VEHICLE DESIGN CONSIDERATIONS 9

Transmission Efficiency - Consideration of Vehicle Mass - Electric Vehicle Chassis and Body Design - Body/chassis requirements - Body/chassis layout - Body/chassis strength, rigidity, and

crash resistance - Designing for stability - Suspension for electric vehicles - Chassis used in modern fuel cell electric vehicles.

SERIES HYBRID ELECTRIC DRIVE TRAIN DESIGN **9**

Operation Patterns - Control Strategies - maximum state-of-charge of peaking power source (PPS) - Thermostat Control Strategy (Engine-On–Off) - Sizing of the Major Components - Power Rating Design of the Traction Motor - Power Rating Design of the Engine/Generator - Design of PPS - Power Capacity of PPS - Energy Capacity of PPS.

PARALLEL HYBRID ELECTRIC DRIVE TRAIN DESIGN **9**

Control Strategies of Parallel Hybrid Drive Train - Maximum State-of-Charge of Peaking Power Source (Max. SOC-of- PPS) Control Strategy - Engine Turn-On and Turn-Off (Engine-On–Off) Control Strategy Design of Drive Train Parameters - Design of Engine Power Capacity - Design of Electric Motor Drive Power Capacity - Transmission Design - Energy Storage Design.

ANCILLARY SYSTEMS AND THE ENVIRONMENT **9**

Heating and Cooling Systems - Design of the Controls – stick controller - Power Steering - Choice of Tyres - Electric Vehicle Recharging and Refueling Systems - Vehicle Pollution in context with conventional vehicles - Quantitative Analysis - Alternative and Sustainable Energy.

d. Activities

Students shall be given seminars, case studies and NPTEL lecture tutorials to understand the concept of electric vehicle design.

e. Learning Resources

Text Books

1. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, John Wiley & Sons, 2022.
2. Mehrdad Ehsani, Yimin Gao, Stefano Longo Kambiz M. Ebrahimi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRS Press, 2018.

Reference Books

1. Iqbal Hussein., *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press.
2. Seref Soylu., *Electric Vehicles - The Benefits and Barriers*, InTech Publishers, Croatia, 2018.
3. Amir Khajepour, M. Saber Fallah, Avesta Goodarzi., *Electric and hybrid vehicles*

technologies, modeling and control: a mechatronic approach, John Wiley & Sons Ltd
2014.

Course Code	Course Name	L	T	P	C
VME333	BATTERY MANAGEMENT SYSTEM FOR ELECTRIC VEHICLES	3	0	0	3

Category: Professional Elective (Vertical - 3)

a. Preamble

This course focuses on various aspects of battery technology, including energy storage, management systems, thermal control, testing, recycling, and charging infrastructure.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the types of battery and its comparison	K2
CO2	Explain about battery electric management system.	K2
CO3	Describe the battery thermal management systems of electric vehicle.	K2
CO4	Describe the possible ways for testing and disposal of Battery.	K2
CO5	Illustrate the legal issues and the barriers on electric Vehicle charging systems	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Batteries: Fundamental principles - Technical Description- Types - Electrical Performance - Environmental safety of Lead Acid Battery- Nickel based batteries- Sodium based batteries- Lithium based batteries - Li-ion & Li-poly- Metal Air Battery; other forms of Energy - Comparison - Battery parameters.

BATTERY MANAGEMENT SYSTEM

9

High voltage Battery systems - Components of HV battery packs - Requirements of HV battery packs - Cell balancing, Types, causes, and effects of imbalances in battery cells- Balancing methods- battery state Estimation, and safety aspects of battery management systems for electric vehicles.

BATTERY THERMAL MANAGEMENT **9**

Introduction - Motivation for battery thermal management - Heat sources, sinks, and thermal balance - Design aspects of thermal management systems - Exemplary design calculations - Technologies in comparison - Operational aspects - Future trends.

BATTERY TESTING AND RECYCLING **9**

Standards applicable to EVs - Testing procedures for EV batteries- Testing for battery life- Testing for battery safety - Future trends in battery testing- Battery recycling - General operational loop for EV battery saving - Recycling technologies - Lithium- Ion Battery Recycling Process- Sorting- Dismantling and separation Acid leaching - Recent developments.

CHARGING INFRASTRUCTURE AND REGULATIONS **9**

Mobility behaviour and charging infrastructure- Driving behaviour - Pause times - Parking Location - Classification of battery charging systems and infrastructure - Plug Types - Safety considerations during charging - Standards and regulations - Licensing regulations for electric vehicles: legal requirements regarding rechargeable energy storage systems - E Waste Management Rule in the present year.

d. Activities

- Students shall be undergone hands on training on batteries and its management systems in electric vehicles.

e. Learning Resources

Text Books

1. Scrosati, Bruno, Jurgen Garche, and Werner Tillmetz, eds. *Advances in battery technologies for electric vehicles*, Wood head Publishing, 2022.

Reference Books

1. Larminie, James, and John Lowry., *Electric vehicle technology explained*. John Wiley & Sons, 2018.
2. Link, Albert N., Alan C. O'Connor, and Troy J. Scott, *Battery Technology for electric vehicles: Public science and private innovation*. Routledge, 2015.
3. Iqbal Hussein., *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2011.

4. Seref Soylu., *Electric Vehicles - The Benefits and Barriers*, InTech Publishers, Croatia, 2011.

Course Code	Course Name	L	T	P	C
VME334	THERMAL MANAGEMENT OF BATTERIES AND FUEL CELLS	3	0	0	3

Category: Professional Elective (Vertical - 3)

a. Preamble

This syllabus covers advanced batteries and thermal management in batteries and fuel cells, including topics such as Li-ion batteries, battery management systems, super capacitors, thermal management systems and methods, PCM cooling, case studies on battery and fuel cell thermal management systems, and fuel cell technologies and applications.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Discuss various advanced batteries with its operational characteristics.	K2
CO2	Describe the thermal management systems of a battery Pack with appropriate PCM.	K2
CO3	Demonstrate the case studies of battery thermal management systems.	K2
CO4	Describe the thermal management systems of fuel cells.	K2
CO5	Demonstrate the case studies of fuel cell thermal management systems.	K2

c. Course Syllabus

Total : 45 Periods

BATTERY TECHNOLOGY

9

Li-ion Batteries- chemistry, different formats, operating areas, efficiency, aging. Battery Management System- Configuration, Characteristics. Tesla Model S- 18650 Cell specifications, P85 Battery Pack mechanical structure, Texas Instruments BMS. Super capacitors Vs batteries. Diamond battery concepts.

THERMAL MANAGEMENT IN BATTERIES

9

Thermal Management Systems- impact, Types- Air, Liquid, Direct refrigerant, Heat pipe, Thermo Electric, Phase Change Material Cooling methods. Solid-liquid PCM Types- Organic, Inorganic, Eutectics. PCM Thermal properties and applications. Tesla Model-S Battery Module-bonding techniques, thermal management.

BATTERY THERMAL MANAGEMENT CASE STUDIES

9

EV Battery Cooling- challenges and solutions. Heat Exchanger Design and Optimization Model for EV Batteries using PCMs- system set up, selection of PCMs. Chevrolet Volt Model Battery Thermal Management System- Case study. Modelling Liquid Cooling of a Li-Ion Battery Pack.

THERMAL MANAGEMENT IN FUEL CELLS

9

Fuel Cells- operating principle, hydrogen-air fuel cell system characteristics, other fuel cell technologies, polarization curves, applications. Fuel cell thermal management- basic model, energy balance, governing equations, characteristic curve, sizing, cooling methods, advantages, restrictions.

FUEL CELL THERMAL MANAGEMENT CASE STUDIES

9

Fuel cell system- balance of plant- components required. Fuel cell power plant sizing problems- Fuel Cell Electric Vehicle Fuel economy calculations-Battery EVs Vs Fuel Cell EVs. Toyota Mirai FCV- Operating principle, High pressure hydrogen tank, Boost convertor, NiMH Battery, Internal circulation system, Hydrogen refueling- Case studies.

d. Activities

Students shall be given seminars, case studies and NPTEL lecture tutorials to understand the concept of battery and fuel cell thermal management system.

e. Learning Resources

Text Books

1. Ibrahim Dincer, Halil S. Hamut, and Nader Javani., *Thermal Management of Electric Vehicle Battery Systems*, Wiley, 2022.
2. Jiuchun Jiang and Caiping Zhang., *Fundamentals and applications of Lithium-Ion batteries in Electric Drive Vehicles*, Wiley, 2015.

3. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi., *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles-Fundamentals, Theory, and Design*, CRC Press, 2005.
4. John G. Hayes and G. Abas Goodarzi., *Electric Powertrai*, Wiley, 2018.
5. Davide Andrea., *Battery Management Systems for Large Lithium-Ion Battery Packs*, ARTECH House, 2010.

Reference Books

1. Nag.P.K., *Engineering Thermodynamics*, 5th Edition, Tata McGraw Hill Education, New Delhi, 2018.
2. *Vehicle thermal Management Systems Conference Proceedings*, 1st Edition; Coventry Techno centre, UK, 2019.
3. Younes Shabany., *Heat Transfer: Thermal Management of Electronics Hardcover*, CRC Press, 2019.
4. T. Yomi Obidi., *Thermal Management in Automotive applications*, SAE International, 2019.
5. Jerry Sergent, Al Krum., *Thermal Management Handbook: For Electronic Assemblies Hardcover*, Tata Mc Graw- Hill.

Course Code	Course Name	L	T	P	C
VME335	VEHICLE HEALTH MONITORING, MAINTENANCE AND SAFETY	3	0	0	3

Category: Professional Elective (Vertical - 3)

a. Preamble

This course covers maintenance and safety concepts for vehicles, including powertrain maintenance, vehicle system maintenance and simulation of safety concepts.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the principles, functions and practices adopted in maintenance activities of vehicles.	K2
CO2	Elucidate power train maintenance, fault diagnosis, maintenance of Batteries of vehicles.	K2
CO3	Define the maintenance and service systems of vehicles.	K2
CO4	Describe the awareness of vehicle safety.	K2
CO5	Enlighten the simulation of safety concepts.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Need for Maintenance – importance, classification of maintenance work-basic problem diagnosis. Maintenance of vehicle systems – power pack, tyres, safety systems. Scheduled maintenance services – service intervals – On-board diagnostics (OBD), Computerized engine analyzer study and practice- scan tools.

POWERTRAIN MAINTENANCE

9

Exhaust emission test of petrol and diesel engine; - Electronic fuel injection and engine management service - fault diagnosis- OBD-III and scan tool, identifying Direct torque control (DTC) and servicing emission controls, Maintenance of Batteries, Starting System, Charging System and Body Electrical -Fault Diagnosis Using Scan Tools.

VEHICLE SYSTEM MAINTENANCE 9

Clutch- adjustment and service, Maintenance and Service of Hydraulic brake, Bleeding of brakes, Checking ABS and components. Maintenance and Service of McPherson strut, coil spring. tyre wear, measurement of tread depth and tyre rotation, Computerized wheel balancing & wheel alignment, Maintenance and Service of steering linkage, steering column, Rack and pinion steering.

VEHICLE SAFETY 9

Concepts of vehicle safety -Seat belt, regulations, automatic seat belt tightener system, collapsible steering column, air bags, electronic system for activating air bags, bumper design for safety, Active Safety – Antilock braking system (ABS), Electronic brake distribution (EBD), Corner stability control (CSC), Traction control system, Modern electronic features in vehicles like tyre pressure monitoring, Automatic headlamp ON, Rain sensing wipers.

SIMULATION OF SAFETY CONCEPTS 9

Safety: Active safety - passive safety - Deformation behavior of vehicle body, speed and acceleration characteristics of passenger compartment on impact. Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system Interactions.

d. Activities

Students shall be given seminars and NPTEL lecture tutorials to understand the concept of vehicle system maintenance and safety.

e. Learning Resources

Text Books

1. Tom Denton., *Advanced Automotive Fault Diagnosis Automotive Technology: Vehicle Maintenance and Repair* , 2018.
2. S. V. Paul., *Safety Management System and Documentation Training Programme Handbook*, by ISBN: 9788123923444.

Reference Books

1. Ed May., *Automotive Mechanics Volume One and Two*, Mc Graw Hill Publications, Tenth edition, 2018.

2. Bosch Automotive Handbook, Tenth Edition, 2018.
3. Jack Erjavek, *A systems approach to Automotive Technology*, Cengage Learning, 5th Edition, 2012.
4. William H. Crouse and Donald L. Anglin., *Automotive Mechanics*, Tata McGraw Hill, 10th Edition, 2004.
5. Vehicle Service Manuals of Reputed Indian Manufacturers.

Course Code	Course Name	L	T	P	C
VME336	BIO ENERGY CONVERSION TECHNOLOGIES	3	0	0	3

Category: Professional Elective (Vertical - 3)

a. Preamble

This course is concerned with the bio mass types available in India and how they can be combusted, how bio mass energy can be used for economic and domestic purposes.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Estimate the surplus biomass availability of any given area.	K2
CO2	Understand biogas plants for a variety of biofuels.	K2
CO3	Determine the cost of steam generation from biofuels with that of coal and petroleum fuels.	K2
CO4	Demonstrate the influence of process governing parameters in thermochemical conversion of biomass.	K2
CO5	Interpret the synthesise of liquid biofuels for power generation from biomass.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Biomass: types – advantages and drawbacks – Typical characteristics – Proximate & ultimate analysis – comparison with coal - Indian scenario - Carbon neutrality – Biomass assessment studies – Typical conversion mechanisms - Densification technologies.

BIOMETHANATION

9

Biomethanation process – Influencing parameters – Typical feed stocks – Biogas plants: types and design, Biogas appliances – Burner, luminaries and power generation systems – Industrial effluent based biogas plants.

COMBUSTION **9**

Perfect, complete and incomplete combustion – Stoichiometric air requirement for biofuels - Equivalence ratio – fixed Bed and fluid Bed combustion.

GASIFICATION, PYROLYSIS AND CARBONISATION **9**

Chemistry of gasification - Types – Comparison – Typical application – Performance evaluation – economics. Pyrolysis - Classification - Process governing parameters – Typical yield rates. Carbonization – merits of carbonized fuels – Techniques adopted for carbonisation .

LIQUIFIED BIOFUELS **9**

Straight Vegetable Oil (SVO) as fuel - Biodiesel production from oil seeds, waste oils and algae - Process and chemistry - Biodiesel Vs. Diesel – Comparison on emission and performance fronts. Production of alcoholic fuels (methanol and ethanol) from biomass – Engine modifications.

d. Activities

Students shall be given seminars and case studies to understand the concept of Bio mass energy conversion and about the bio waste available to convert it to energy.

e. Learning Resources

Text Books

1. Nidhi Adlakha, Rakesh Bhatnagar , Syed Shams Yazdani ,*Biomass for Bioenergy and Biomaterials*, by, CRC Press; 1st edition (22 October 2021), ISBN-10 : 0367745550 .

Reference Books

1. Iyer PVR et al., *Thermochemical Characterization of Biomass*, M N E S.
2. Khandelwal KC, Mahdi SS., *Biogas Technology – A Practical Handbook*, Tata McGraw Hill, 1986.
3. Mahaeswari, R.C., *Bio Energy for Rural Energisation*, Concepts Publication, 1997.
4. Tom B Reed., *Biomass Gasification – Principles and Technology*, Noyce Data Corporation, 1981.

Course Code	Course Name	L	T	P	C
VME337	ENERGY AUDIT AND MANAGEMENT	3	0	0	3

Category: Professional Elective (Vertical - 3)

a. Preamble

This course concerned with the current energy scenario, audit and management. This course gives a systematic knowledge and skill about assessing the energy efficiency, energy auditing and energy management.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the basic energy scenario of the world and India and the need for energy conservation.	K2
CO2	Explain the various energy audit types and its needs, instruments used and role of energy managers.	K2
CO3	Explain the energy conservation and audit in boilers and industrial furnaces.	K2
CO4	Demonstrate the energy management in fans, blowers and cooling towers.	K2
CO5	Understand the energy management in pumping systems, refrigeration and air conditioning.	K2

c. Course Syllabus

Total : 45 Periods

ENERGY SCENARIO

9

Energy - Power – Past & Present scenario of World; National Energy consumption Data – Environmental aspects associated with energy utilization – Energy Conservation and its importance, Energy conservation Act., Thermal Energy basics - ISO 50001 Energy management systems.

ENERGY AUDIT

9

Definition, need, and types of energy audit; Energy management (audit) approach: Understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements; Fuel & energy substitution; Energy audit instruments; Energy Conservation Act; Duties and responsibilities of energy managers and auditors.

ENERGY MANAGEMENT IN BOILERS AND INDUSTRIAL FURNACES

9

Boilers- Classification, Efficiency, Energy conservation, Waste heat recovery, Performance. Industrial furnaces classifications, Efficiency, Energy conservation measures. Electrical, Induction furnaces- Energy saving measures. Compressed air network – Types of compressor, Selection of compressor, Performance monitoring and compressed air-distribution system.

ENERGY MANAGEMENT IN FANS, BLOWERS AND COOLING TOWERS

9

Fans- Classification, Selection of fans, Flow control methods, Performance curves, Efficiency. Cooling tower – Classification, Selection and Usage, Performance evaluation at site, Factors affecting cooling tower performance and Energy saving opportunities.

ENERGY MANAGEMENT IN PUMPING SYSTEMS, REFRIGERATION

9

AND AIR CONDITIONING

Pumps and Pumping systems - Classification, Performance, Factors affecting pump performance, characteristic, Efficiency and Flow control strategies. Refrigeration and Air Conditioning – Vapour compression system, Vapour absorption system, Measurement and field testing, Performance evaluation, Air washer and Energy conservation methods.

d. Activities

Students shall be given seminars and case studies to understand the concept of energy conservation and auditing in mechanical systems.

e. Learning Resources

Text Books

1. Abbi Y. P. and Shashank Jain., *Handbook on energy audit and environment management*. The Energy and Resources Institute (TERI), 2009.

Reference Books

1. Albert Thumann and Paul Mehta D., *Handbook of Energy Engineering*, 7th Edition, The Fairmont Press, 2013.
2. K. NagabhushanRaju., *Industrial Energy Conservation Techniques: (concepts, Applications and Case Studies)*, Atlantic Publishers & Dist, 2007.
3. Rao. P. SasiBhushana and PM Rao PSB Rao., *Environment Management and Audit*, Deep and Deep Publications, 2000.
4. Steve Doty, Wayne Turner C., *Energy Management Handbook*, 7th Edition, The Fairmont Press, 2009.

Course Code	Course Name	L	T	P	C
VME341	FUNDAMENTALS OF INDUSTRY 4.0	3	0	0	3

Category: Professional Elective (Vertical - 4)

a. Preamble

This course introduces the basic concepts of industry 4.0, the fundamental concepts and preparedness for implementing industry 4.0 in industry, the technology transformation required, concepts of Internet of Things, Cyber physical system and application of industry 4.0 in manufacturing industry.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the concepts of Industry 4.0 and challenges in preparedness and implementations.	K2
CO2	Explain the concepts and framework of Industry 4.0, supportive technologies and business models.	K2
CO3	Illustrate the technology contributing Industry 4.0 for digital transformations.	K2
CO4	Comprehend the concepts of industry 4.0 in IOT and cyber physical systems.	K2
CO5	Apply the concept of industry 4.0 in manufacturing sectors with its methodologies and implementations.	K3

c. Course Syllabus

Total: 45 Periods

INTRODUCTION TO INDUSTRY 4.0

9

Introduction to Industry 4.0 - The Various Industrial Revolutions - Digitalization and the Networked Economy - Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0 - Comparison of Industry 4.0 Factory and Today's Factory - Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation- Introduction to Industry 4.0 to Industry 5.0 Advances.

UNDERSTANDING INDUSTRY 4.0

9

Concepts & Components of Industry 4.0, Conceptual Framework for Industry 4.0, Smart and Connected Product Business Models, Lean Production Systems for Industry 4.0, Maturity and Readiness Model for Industry 4.0 Strategy - Proposed Framework for Technology Roadmap – Impacts of Industry 4.0.

CONTRIBUTING TECHNOLOGIES

9

Contributing technologies to Industry 4.0: Additive manufacturing, Robotics, Digital twin, Internet of things, Smart sensors, Augmented Reality and Virtual Reality, Artificial intelligence, Cloud computing, Fog Computing - Block chain, Big Data and Analytics, Cyber Security Systems – Green Technology.

IOT AND CYBER PHYSICAL SYSTEMS

9

Introduction – IoT, Industrial Internet Systems – Industrial Processes - Features of IIoT - Future Industrial Plant - Viewpoint of industrial processes – Cyber physical Systems, Support System for Industry 4.0, Cyber Security, Collaborative Platform and Product Lifecycle Management - Introduction to cloud computing and manufacturing.

APPLICATIONS AND CASE STUDIES

9

Inventory Management and Quality Control – Plant security and safety – Facility management – oil, chemical and Pharmaceutical Industry – Milk processing and packaging industries – Case Studies: Manufacturing Industry, Automotive Industry, Mining Industry, Electronics Industry.

d. Activity

Students shall be given poster presentation to know the basic concepts of industry 4.0, its implementation with applications.

e. Learning Resources

Text Books

1. Sudip Misra, Chandana Roy, Anandarup Mukherjee., *Introduction to Industrial Internet of Things and Industry 4.0*, CRC Press, 2021.
2. Alp Ustundag and Emre Cevikcan., *Industry 4.0: Managing the Digital Transformation*, Springer, Switzerland, 2018.

Reference Books

1. Klaus Schwab., *Fourth Industrial Revolution*, Random House USA Inc, New York, USA, 2017.
2. Carlos Toro, Wei Wang, Humza Akhtar., *Implementing Industry 4.0*, Intelligent Systems Reference Library, Springer, Singapore, 2018.
3. Mahmood. Z, and Puttini. R., *Cloud Computing: Concepts, Technology & Architecture*, Prentice Hall, 2013.

Course Code	Course Name	L	T	P	C
VME342	IOT IN INDUSTRIAL AUTOMATED SYSTEMS	3	0	0	3

Category: Professional Elective (Vertical - 4)

a. Preamble

The Internet of Things (IoT) is transforming the way we live and work, revolutionizing industries ranging from manufacturing to healthcare. This course provides an exploration of the basic concepts, principles and technologies of IOT in various industrial automated systems.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the basic architecture, fundamental concepts, evolution of IOT, current issues and implementations.	K2
CO2	Describe the concepts of business models, layers, sensors, networking and architecture of industrial IOT.	K2
CO3	Summarize the applications of IOT in automobile especially fault detections, vehicle communication and in food industry.	K2
CO4	Summarize the application of IOT in predictive maintenance, product development and renewable energy sectors.	K2
CO5	Apply the concepts of IOT in automation for the development of smart city, health care systems and agriculture field.	K3

c. Course Syllabus

Total: 45 Periods

INTRODUCTION TO IOT

9

Introduction - IoT Revolution - Fundamental Technologies - IoT Architecture - Cloud Computing (CC) and IoT - Edge Computing (EC) and IoT - Applications of IoT - Industry 4.0 Integrated with IoT Architecture - IoT for Design and Manufacturing System - IoT for Advanced manufacturing technologies - Current Issues and Challenges in IoT.

INDUSTRIAL IOT

9

IIoT-Introduction, Industrial IoT: Business Model and Reference Architecture: IIoT-Business

Models, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking - Interaction of Sensors during Machining Operation - IoT Technologies in Manufacturing Process.

APPLICATIONS OF IOT **9**

Industrial Applications - IoT in automobile – Need, Fault Diagnosis – Vehicle Communications - Vehicle connectivity Technologies - IoT in the Food Industry – Influences, Challenges and roles – IoT for Digitized Food Waste System.

ROLE OF IOT IN MECHANICAL ENGINEERING **9**

Role of IoT in Predictive Maintenance: Introduction, IPDM technologies, Methodologies, Framework, Implementations - Role of IoT in Product Development: Product Architecture, Product Development Process, Impacts and Future Perspectives – Role of IoT in Renewable Energy Sector: Introduction, Roles and insights, Data Analytics – Case Studies.

IOT IN AUTOMATED SYSTEMS **9**

Automated Systems – Benefits of Automation – Smart city Automation – Smart Home Automation – Automation in Manufacturing – Healthcare Automation – Industrial Automation – Air Pollution Monitoring – Irrigation Automation – Case Studies.

d. Activities

Students are encouraged to do on mini IoT based projects like smart parking system, home automation, security systems etc.

e. Learning Resources

Text Books

1. Rajasekar. R, Moganapriya. C, Sathish Kumar.P., *Integration of Mechanical and Manufacturing Engineering with IoT*, John Wiley & Sons, 2023.
2. Alasdair Gilchrist., *Industry 4.0: The Industrial Internet of Things*, Apress, 2016.

Reference Books

1. Sabina Jeschke., *Industrial Internet of Things: Cyber manufacturing Systems*, Springer, 2018.

Course Code	Course Name	L	T	P	C
VME343	ARTIFICIAL INTELLIGENCE IN MANUFACTURING	3	0	0	3

Category: Professional Elective (Vertical - 4)

a. Preamble

This course explores the intersection of AI and manufacturing, and how AI is transforming the way products are designed, produced, and delivered. We will delve into the fundamentals of AI, including machine learning, deep learning, and natural language processing, and their applications in various manufacturing processes.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Select the constraints on the availability of resources, develop a model and render an optimal solution during the given circumstances.	K2
CO2	Solve the dual problems, appraise the challenges in the transportation and production problems and furnish a rational solution to maximize the benefits	K3
CO3	Analyze different types of optimum Inventory levels for practical problems.	K2
CO4	Apply various queue disciplines according to respective environments.	K2
CO5	Determine appropriate network models for practical applications.	K3

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Introduction–Definition – Future of Artificial Intelligence – Characteristics of Intelligent Agents–Typical Intelligent Agents – Problem Solving Approach to Typical AI problems.

PROBLEM SOLVING METHODS **9**

Problem solving Methods – Search Strategies- Uninformed – Informed – Heuristics – Local Search Algorithms and Optimization Problems -Searching with Partial Observations – Constraint Satisfaction Problems – Constraint Propagation – Backtracking Search – Game Playing – Optimal Decisions in Games – Alpha – Beta Pruning – Stochastic Games.

KNOWLEDGE REPRESENTATION **9**

First Order Predicate Logic – Prolog Programming – Unification – Forward Chaining Backward Chaining – Resolution – Knowledge Representation – Ontological Engineering-Categories and Objects – Events – Mental Events and Mental Objects – Reasoning Systems for Categories - Reasoning with Default Information.

PLANNING AND MACHINE LEARNING **9**

Basic plan generation systems – Strips -Advanced plan generation systems – K strips -Strategic explanations - Why, why not and how explanations. Learning- Machine learning, adaptive Learning.

APPLICATIONS OF ARTIFICIAL INTELLIGENCE **9**

Applications of AI in Inventory management, Supply chain management, risk management, predictions on sales volume, Price and Demand forecasts - Case studies. Automobile Industries - Vehicle Maintenance Recommendations – Driver behavior Analytics/ self-driving cars – Analyzing Road conditions – Smart battery management system.

d. Activities

Students shall be exposed to present various case studies and applications of AI as a poster presentation to know the advancements in relevant fields.

e. Learning Resources

Text Books

1. Stuart Russell and Peter Norvig., *Artificial Intelligence – A Modern Approach*, Pearson Education, 2021.
2. Elaine Rich and Kevin Knight., *Artificial Intelligence*, Tata McGraw-Hill, 2008.

Reference Books

1. Dan W. Patterson., *Introduction to Artificial Intelligence and Expert Systems*, Pearson Education,2007.
2. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar., *Foundations of Machine Learning* , MIT Press, 2012.
3. Ethem Alpaydin., *Introduction to Machine Learning*, MIT Press, Fourth Edition, 2020.
4. Mary Kathryn Allen, *The Development of an Artificial Intelligence System for Inventory Management* , Council of Logistics Management, 2012.

Course Code	Course Name	L	T	P	C
VME344	EMBEDDED SYSTEM DESIGN FOR INDUSTRIAL AUTOMATION	3	0	0	3

Category: Professional Elective (Vertical - 4)

a. Preamble

This course is designed to provide an introduction to the world of industrial automation and control systems using two popular microcontroller platforms named Arduino and Raspberry Pi. It will explore the fundamental concepts of industrial automation and how embedded systems can be used to control and automate various industrial processes.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the fundamentals of embedded systems and Arduino device.	K2
CO2	Illustrate the internal Architecture of various Arduino boards.	K2
CO3	Outline the basic programming essentials for Arduino.	K2
CO4	Explain the basic features of Raspberry Pi and its applications.	K2
CO5	Implement the Arduino/ Raspberry Pi programming for the industrial applications.	K3

c. Course Syllabus

Total : 45 Periods

EMBEDDED COMPUTING PLATFORM

9

Introduction to Embedded System – History of Embedded Systems, Classification – Purpose of Embedded Systems – Application Areas – Core of Embedded System – Memory – Sensors and Actuators – Arduino Family - Types of Arduino Devices – Arduino-Compatible Devices – Arduino Application Areas.

ARDUINO HARDWARE

9

AVR Microcontroller – Internal Architecture – Peripheral Functions – Analog Comparator – Analog-to-Digital Converter – Serial I/O – Watchdog Timer – Interrupts – Overview of

ATmega168/328 – ATmega1280/ATmega2560 – ATmega32U4 - Pin configuration and architecture.

PROGRAMMING BASICS FOR ARDUINO

Introduction to Embedded C - Arduino, data types, Variables and constants, Operators Control Statements, Arrays Functions - Loop functions- Arduino I/O Functions: Pins Configured as INPUT, Pull-up Resistors, Pins Configured as OUTPUT, pin Mode (), digital Write (), analog Read() function, Arduino Interrupts- Arduino Time functions: Arduino time delay (), delay Microseconds(), Millis(), micros() - Overview of Arduino IDE – Building an Arduino Sketch.

RASPBERRY PI

Introduction to Raspberry Pi: Overview, features, capabilities - Raspberry Pi Components - Setting up Raspberry Pi – Benefits & Limitations – Applications - Introduction to Python programming on Raspberry Pi - basic syntax and simple examples - General Purpose Input/Output (GPIO) programming - Connecting sensors and devices – Simple examples.

APPLICATIONS IN INDUSTRIAL AUTOMATION

9

Arduino and Raspberry Pi applications: Process Control, Robotics, Data Acquisition and Analysis, SCADA Systems, Human Machine Interface (HMI) interactions, Monitoring and Control, 3D printing, Smart homes, Material Handling and Packaging - Communication protocols: Modbus, Ethernet/IP, and Profibus - Safety – Industrial Automation using IoT.

d. Activities

Students shall be expected to design and develop small project with Arduino or Raspberry Pi which is implemented via Arduino interfacing & coding using respective hardware. Some of the Arduino projects are

1. Designing of Intelligent Home Locking System.
2. Designing of Car parking system.
3. Designing of Home Automation Using RFID.
4. Designing of Real Time Clock-Based Home Automation.
5. Designing of Intelligent Water Level Management System
6. Designing of Smart Weather Station.

e. Learning Resources

Text Books

1. Michael McRoberts., *Beginning Arduino*, Apress, 2010.
2. Shibu K.V., *Introduction to Embedded Systems*, McGraw Hill Education Private Limited, India, 2009.
3. John Snowden., *Raspberry Pi: Learn Fundamentals and Unlock Powerful Hacks of Using Raspberry Pi* , 2020.

Reference Books

1. Alan G. Smith., *Introduction to Arduino*, Independent Publishing Platform, 2011.
2. Simon Monk., *Programming Arduino: Getting Started with Sketches*, Tata McGraw Hill, 2022.
3. Frank Lamb., *Industrial Automation*, Tata McGraw Hill, 2013.
4. Massimo Banzi., *Getting Started with Arduino*, O'Reilly, 2009.

Course Code	Course Name	L	T	P	C
VME345	PROGRAMMING FOR ROBOTICS AND CNC MACHINES	3	0	0	3

Category: Professional Elective (Vertical - 4)

a. Preamble

This course focuses on the development of programming skills required for the operation of robots and CNC machines.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the basic concept of cutting tools, clamping methods and selection of CNC machining processes.	K2
CO2	Develop CNC programming for the operation of CNC turning centers.	K3
CO3	Prepare CNC programming for the operation of CNC milling centers.	K3
CO4	Explain the architecture of robot programming using ROS.	K2
CO5	Develop the robot programming using ROS and Gazebo workspace.	K3

c. Course Syllabus

Total: 45 Periods

INTRODUCTION TO CNC AND CNC PROGRAMMING 9

Objectives - Safety - Maintenance - Tool Clamping Methods - Cutting Tool Selection - Tool Compensation Factors - Tool Changing - Metal Cutting Factors - Process Planning for CNC - CNC Programming - Coordinate Systems - Points of Reference - Program Format.

PROGRAMMING CNC TURNING CENTERS 9

Objectives - G Codes - M Codes - Tool Function - Feed Function - Spindle Function - Coordinate System for programming of CNC Turning Centers - Program Structure - Preparatory Function - Multiple Repetitive Cycles – Examples.

PROGRAMMING CNC MACHINING CENTERS **9**

Objectives - Tool Function - Tool Changes - Feed Function - Spindle Speed Function - G Codes - M Codes - Programming of CNC Machining Centers - Program Structure - Preparatory Function - Canned Cycle Functions - Boring Cycle – Examples.

KICK-STARTING ROBOT PROGRAMMING USING ROS **9**

Robot Programming - The ROS Equation - Robot Programming Before and After ROS Installing ROS - Robots and Sensors Supporting ROS – Popular ROS Computing Platforms – ROS Architecture and Concepts.

PROGRAMMING WITH ROS AND GAZEBO **9**

Programming Using ROS – Creating a ROS Workspace and Package - Using ROS Client Libraries – Programming Embedded Boards - Programming Using Gazebo - Creating models and worlds - Controlling robots in simulation - Testing and debugging - Integrating with other software.

d. Activities

Students shall be exposed to create digital models of parts and assemblies that will be used for programming CNC machines.

e. Learning Resources

Text Books

1. Ken Evans., *Programming of CNC Machines*, Industrial Press Inc, 2016.
2. Lentin Joseph., *Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy*, Apress, 2018.

Reference Books

1. Aaron Martinez, Enrique Fernández., *Learning ROS for Robotics Programming*, Packt Publishing Ltd, 2013.
2. Anis Koubaa., *Robot Operating System (ROS): The Complete Reference*, Volume 3, Springer, 2018.
3. Morgan Quigley., *Programming Robots with Ros: A Practical Introduction To The Robot Operating System*, Shroff Publishers & Distributors Pvt Ltd, 2016.

Course Code	Course Name	L	T	P	C
VME346	DATA ANALYTICS IN MANUFACTURING	3	0	0	3

Category: Professional Elective (Vertical - 4)

a. Preamble

This course explores the opportunity for the students to study the basic concepts and terminologies used in data analytics and regression. It also explores the basic concepts of principal component analysis and latent variable models. An overview of data analytic tools such as R, Python, RapidMiner, HADOOP, Tableau are also discussed briefly with examples in this course.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the basic concepts and terminology used in data analytics.	K2
CO2	Explain the basic concepts of regression analysis.	K2
CO3	Describe latent variables and their role in statistical modeling.	K2
CO4	Demonstrate the key concepts of Principal Component Analysis including its purpose, assumptions, and limitations.	K2
CO5	Summarize various data analytics tools and its application in manufacturing sector.	K2

c. Course Syllabus

Total: 45 Periods

INTRODUCTION

9

Introduction to Multivariate Statistics - Degree of Relationship among Variables - Review of Univariate and Bivariate Statistics-Screening Data Prior to Analysis - Missing Data, Outliers, Normality, Linearity, and Homoscedasticity - Various Data Analytics Tools.

REGRESSION MODELLING

9

Multiple Regression - Linear and Nonlinear techniques- Backward-Forward-Stepwise Hierarchical Regression-Testing interactions (2way interaction) - Analysis of Variance and

Covariance (ANOVA & ANCOVA) - Multivariate Analysis of Variance and Covariance (MANOVA & MANCOVA) - Logistic Regression - Regression with binary dependent variable.

LATENT VARIABLE MODELS **9**

Latent Variable Models an Introduction to Factor, Path, and Structural Equation Analysis Time series data analysis (ARIMA model) - Decision tree analysis (CHAID, CART).

PRINCIPAL COMPONENT ANALYSIS **9**

Principal Component Analysis - Factor Analysis- Orthogonal and Oblique Rotation-Factor Score Estimation-Multidimensional Scaling - Perceptual Map - Cluster Analysis (Hierarchical Vs Nonhierarchical Clustering).

APPLICATIONS **9**

Introduction to Big Data: Characteristics, Benefits, Drivers - Big Data Analytics – Various Techniques - Self Service Analytics - Embedded Analytics - Manufacturing Analytics - Application of Data Analytics in Manufacturing Industry: Production Planning and Control, Maintenance, Product R&D.

d. Activities

Students shall explore trends, patterns, and anomalies in the data and make recommendations for process improvement using excel or Python.

e. Learning Resources

Text Books

1. Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L., *“Multivariate data analysis*, Pearson India, 2015.
2. Fenio Annansingh and Joseph Bon Sesay., *Data Analytics for Business: Foundations and Industry Applications*, Routledge, 2022.

Reference Books

1. Tabachnick, B. G., & Fidell, L. S., *Using multivariate statistics*, Pearson Prentice Hall, 2001.
2. Cohen, J., Cohen, P., West, S. G., & Aiken, L. S., *Applied multiple regression/correlation analysis for the behavioral sciences*, Routledge, 2013.

Course Code	Course Name	L	T	P	C
VME347	SCIENTIFIC COMPUTATIONS USING SOFTWARE TOOLS	2	0	2	3

Category: Professional Elective (Vertical – 4 ,Theory cum Laboratory)

a. Preamble

This course will introduce students to the use of software tools for scientific computations with both open source and commercial software tools. Numerical computations are a crucial aspect of many scientific and engineering disciplines. They are used to solve complex mathematical problems, simulate physical phenomena and analyze experimental data. The course will include a combination of lectures and laboratory exercises to gain the skills required to tackle complex numerical and engineering problems using MATLAB and Python.

b. Course Outcome (for Theory)

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the fundamentals of numerical and scientific computations and programming.	K2
CO2	Summarize various computational tools for engineering analysis and the fundamentals of Python language.	K2
CO3	Solve simple numerical computational problems using Python.	K3
CO4	Formulate simple numerical computational problems using MATLAB.	K3
CO5	Resolve simple engineering problems using Python and MATLAB.	K3

Course Outcome (for Laboratory)

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Develop simple python program for numerical computational analysis problems.	K3
CO2	Develop simple python program for engineering analysis problems.	K3
CO3	Develop simple python program using python scripts to integrate in design software.	K3
CO4	Develop simple MATLAB program for numerical computational analysis problems.	K3
CO5	Develop simple MATLAB program for engineering analysis problems.	K3

c. Course Syllabus (for Theory)

Total: 30 Periods

INTRODUCTION

6

Numerical computations - Scientific Computations - Types of numerical errors, Error analysis, numerical stability, and convergence - Iterative Numerical Methods: Gauss-Seidel method, Newton-Raphson method - Mathematical Foundations of Programming - Digital Computers.

COMPUTATIONAL TOOLS AND PYTHON FUNDAMENTALS

6

Overview and Applications of Core Languages: Python, C, C++, R Programme, Julia, FeniCS, PyTorch - Commercial Computational Tools: MATLAB, Maple, Mathematica - Python Fundamentals: Interpreter, Data Types, Variables and Value Assignments, Control Structures, Collection Types and Functions.

PYTHON IN SCIENTIFIC COMPUTATIONS

6

NumPy: Arrays, Vectors, Matrices, Advanced Construction Methods - Conjugate Gradient Method - SciPy - Linear Algebra - Graphics with Matplotlib - Nonlinear Equations, Optimization - Numerical Integration - Ordinary Differential Equations - Partial Differential Equations.

COMMERCIAL COMPUTING ENVIRONMENTS

6

MATLAB: Basics - Vectors & Matrices - Control Structures: Branching, Loops - Functions - M Files - Linear Algebra - Ordinary Differential Equations - Partial Differential Equations - Introduction to Maple & Mathematica (Features, Limitations and Applications only).

ENGINEERING COMPUTATIONS

6

Simple problem solving in Python: Projectile Motion, Von Misses Failure Theory Plots, Analysis of Beams - Shear force and Bending Moment Diagrams - Problem solving using any commercial package: Engineering Mechanics, Kinematics and Kinetics of particle – Free and Forced Vibration problems.

Course Syllabus (for laboratory)

Total: 30 Periods

LIST OF EXPERIMENTS

Note: The examples suggested in each experiment are only indicative. The lab instructor is expected to design other problems on similar lines. The Examination shall not be restricted to the sample experiments listed here.

1. Develop a simple python program using logical statements.
2. Develop a simple Python code to find the root(s) of a given function using the Newton-Raphson method. Test the code with different functions, such as a quadratic or a trigonometric function.
3. Develop a python program to solve a system of linear equations that models the stress distribution in a mechanical structure using NumPy.
4. Develop a python program to fit a curve to experimental data from sensors that measure the behavior of a mechanical system, such as acceleration, strain, or temperature using NumPy and SciPy. Use Matplotlib to process and visualize the data.
5. Write a Python program to calculate the deflection and stress of a simply supported beam based on user input for beam geometry and loading conditions. Use Matplotlib to visualize the beam deflection and stress distribution.
6. Write a Python program to calculate gear ratios, gear module, gear pitch diameter, and gear face width based on user input for desired speed and torque requirements. Visualize the gear design using Matplotlib to show the tooth profile and pitch circle.

7. Solve a simple engineering mechanics problem to determine the force, velocity acceleration using MATLAB.
8. Plot the stress-strain diagram for a material using MATLAB. You can also calculate the modulus of elasticity, yield strength, and ultimate tensile strength. using MATLAB.
9. Plot the trajectory of a projectile motion using MATLAB. You can also calculate the maximum height, time of flight, and range of the projectile. using MATLAB.
10. Solve a simple problem to plot the shear force and bending moment diagram of beams using MATLAB.

d. Activities

Students shall be given mini project in Python Programming for Mechanical Engineering applications in MATLAB.

e. Learning Resources (for both Theory and Laboratory)

Text Books

1. Einar Smith., *Introduction to the Tools of Scientific Computing*, Springer, 2020.
2. Svein Linge, Hans Petter Langtangen., *Programming for Computations – Python*, Springer Open, 2016.
3. Sergey E. Lyshevski., *Engineering and Scientific Computations Using MATLAB*, John Wiley & Sons, 2003.

Reference Books

1. Robert Johansson., *Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib*, Apress , 2019.
2. William J. Palm, *Introduction to MATLAB for Engineers*, 3rd Edition, McGraw Hill Publications, 2012.
3. Eli Bressert., *SciPy and NumPy: Optimizing & Boosting your Python Programming*, O'Reilly Media, 2016.
4. Kishore Kumar. M.R, *Learn Python: A Beginner's Guide to Python, Numpy,Pandas and Scipy*, 2021.
5. Sinan Kalkan, Onur Tolga Sehitoglu, Gokturk Ucoluk., *Programming with Python for Engineers*, Github, 2020.

6. Dukkipati, Rao V., *MATLAB: An introduction with applications*, New Age International, 2008.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

S.No.	Description of Equipment	Quantity Required
1.	Computer Nodes (With 8GB RAM, 2 GB Graphics Card) .	30
2.	Python software (Open Source Licenses– Any versions) .	30 no of users
3.	MATLAB Software.	15 no.of users
4.	Licensed operating system .	30
5.	Laser Printer.	01

Course Code	Course Name	L	T	P	C
OME781	INDUSTRIAL SAFETY	3	0	0	3

Category: Open Elective

a. Preamble

This course impart knowledge on safety engineering fundamentals and safety management practices. This course imparts knowledge about various hazard identification and risk assessment techniques. It also enables the students to identify the causes of accidents and its preventions.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the evolution of modern safety concepts, functions and activities of safety engineering department.	K2
CO2	Conduct hazard analysis for a given activity or task and suggest suitable suggestions for hazard prevention and control.	K2
CO3	Summarize the different safety management training activities involved in industry.	K2
CO4	Understand the safety performance of an organization from accident records.	K2
CO5	Explain the requirements mentioned in various acts and rules for the prevention of accidents.	K2

c. Course Syllabus

Total : 45 Periods

CONCEPTS OF SAFETY MANAGEMENT AND HAZARD IDENTIFICATION 9

Evolution of modern safety concepts - safety management functions - safety organization, safety department - safety committee - line and staff functions for safety - budgeting for safety - safety audit. Hazard - classification - chemical, physical, mechanical, ergonomic, biological hazards - Identification and Control measures - Electrical hazards - Shock Protection methods.

HAZARD ANALYSIS, RISK ASSESSMENT AND CONTROL 9

Fire hazards of flammable and explosive materials - Fire prevention and control – hazard evaluation techniques - job safety analysis, safety inspection, safety sampling - Fault Tree Analysis (FTA), Failure Modes and Effects Analysis (FMEA), HAZOP analysis and Risk Assessment – Personal Protective equipment.

SAFETY EDUCATION AND TRAINING 9

Importance of training - identification of training needs-training methods - programme, seminars, conferences, competitions - method of promoting safe practice - motivation - communication - role of government agencies and private consulting agencies in safety training – creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign - Domestic Safety and Training.

SAFETY PERFORMANCE MONITORING AND ACCIDENT PREVENTION 9

Reactive and proactive monitoring techniques - Permanent total disabilities, permanent partial disabilities, temporary total disabilities -Calculation of accident indices, frequency rate, severity rate, frequency severity incidence, incident rate, accident rate, safety “t” score, safety activity rate – Total Injury illness incidence rate, Lost work day cases Incidence rate (LWDI), Number of lost work days rate.

SAFETY REGULATIONS 9

Factories act 1948 with special reference to safety, Health and welfare provisions - Indian boiler act - SMPV rules - The environmental protection act - Electricity act - Explosive act - Health and Safety at work act (HASAWA) UK, - Occupational Safety health act (OSHA).

d. Activities

- Students shall be exposed to identify and prevent chemical, environmental mechanical, fire hazard through analysis and apply proper safety techniques on safety engineering and management.

e. Learning Resources

Text Books

1. John V.Grimaldi and Rollin H.Simonds., *Safety Management*, Richard D. Irwin publisher, 1994.
2. John V.Grimaldi., *Safety Management*, AITB S Publishers, 2003.

Reference Books

1. C.Ray Asfahl, David W. Rieske., *Industrial Safety and Health Management*, Prentice Hall, 7th Edition, 2018.
2. David L.Goetsch., *Occupational Safety and Health for Technologists*, 5th Edition, Engineers and Managers, Pearson Education Ltd., 2005.
3. R.K. Mishra., *Safety Management*, AITBS publishers, 2016.
4. Charles D. Reese., *Occupational Health and Safety Management: A Practical Approach*, 3rd Edition CRC press 2015.
5. Mark A. Friend, James P. Kohn., *Fundamentals of Occupational Safety and Health*, 6th Edition Bernan press, 2014.
6. Krishnan N.V., *Safety Management in Industry*, Jaico Publishing House, Bombay 2015.

Course Code	Course Name	L	T	P	C
OME782	WORLD CLASS MANUFACTURING	3	0	0	3

Category: Open Elective

a.Preamble

The course helps to understand of the concept and importance of strategy planning for manufacturing industries. It describes the techniques to apply principles in the identifiable formulation and implementation of manufacturing strategy for competitive in global context.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Demonstrate the industrial scenario in world wise.	K2
CO2	Describe the concepts to build strength through customer focused principles.	K2
CO3	Explain the human resource department practices in WCM.	K2
CO4	Outline the concepts of making stability and strategic linkages.	K2
CO5	Summarise about impediments for continuous improvement.	K2

c. Course Syllabus

Total : 45 Periods

INDUSTRIAL SCENARIO 9

Global Competitiveness and Manufacturing Excellence - Japan decade - American decade - Manufacturing Challenges, Problems in Manufacturing Industry.

WCM AND CUSTOMER FOCUSED PRINCIPLES 9

WCM - evolution, principles - Infinite loop process - Pillars of WCM - Customer - Focused principles - General principles - Design - Operations - Human resources - Quality and Process improvement - Promotion and Marketing.

LABOUR AND HRD PRACTICES IN WCM 9

Human Resource Dimensions in WCM - Morale and Teamwork - High Employee Involvement - Cross Functional Teams - Work Study Methods - Human Integration Management.

STABILITY AND STRATEGIC LINKAGES **9**

Employee stability - Team stability and cohesiveness - Project cohesiveness and stability - Product decisions and customer service - Multi-company planning - Smoothing the demand turbulence.

IMPEDIMENTS **9**

Bad plant layout design in production lines, assembly lines - Whole Plant Associates - Facilitators - Teams manship - Motivation and reward in the age of continuous.

d. Activities

The students shall be given real time case studies through cross functional teams to realize the principles and techniques of world class manufacturing.

e. Learning Resources

Text Books

1. Richard J. Schonberger., *World Class Manufacturing: The next decade: Buliding power, strength and value*, The Free Press, Newyork, 2018.
2. Sahay B. S., Saxena K. B. C., Ashish Kumar., *World Class Manufacturing*, MacMillan Publishers, 2018.

Reference Books

1. V. K. Narayanan., *Managing Technology & Innovation for Competitive Advantage*, Prentice Hall.
2. Richard J Schonberger., *World Class Manufacturing - The Lesson of Simplicity*, Free Press - A Division of Simon and Schuster.

Course Code	Course Name	L	T	P	C
MME101	INTRODUCTION TO PRODUCT DESIGN	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course introduces the basic concepts of new product design and development. It explains the problem solving design tools, environmental, legal and ethical aspects of product design.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe problem solving tools in the process of design.	K2
CO2	Judiciously make correct decision while designing products.	K2
CO3	Adopt modularity in Product architecture.	K2
CO4	Interpret the Environmental issues in design.	K2
CO5	Understand the legal and ethical aspects in design.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION AND PROBLEM DEFINITION 9

Design as a Discipline-Cost reduction & Higher Sophistication-The Morphology of Design (seven phases) - Product Life Cycle. Problem Definition & Need Identification-Identifying customer needs-Establishing the engineering characteristicsQuality Function Deployment-Product Design Specifications - Case studies.

INNOVATION 9

Time management - Problem Solving tools: Pareto charts, Cause and effect diagrams, Force field analysis - Planning and Scheduling - Tools for Planning and Scheduling: Gantt charts, critical path method. Case Studies. Criticality of data in design - Data sources: Library sources, Government sources, Internet sources, Information from Intellectual property rights - Company centered information.

DECISION MAKING

9

Creative thinking methods - Generating design concepts - Functional decomposition and synthesis – Inventive problem solving - Axiomatic design. Concept Evaluation: Pugh Concept Selection Method-Measurement Scales, Weighted Decision Matrix, Analytic Hierarchy Process – Concept Selection.

EMBODIMENT DESIGN

9

Product Architecture – configuration design and best practices - Parametric design – Design for Assembly - Failure Mode Effect Analysis. Design for Environment - DFE Scoring Methods- Role of Prototyping in design - Concept of Rapid Prototyping - Detail design – Design communication-Bill of Materials-Common challenges in Technical Writing.

ECONOMIC DESIGN

9

Cost evaluation – Methods of developing cost estimates - Make or Buy decision – Design to Cost: Order of magnitude estimates, Costing in Conceptual Design. Legal and ethical issues in design - Tort Law - Product liability - Protecting intellectual property - Solving Ethical conflicts - Economic decision making: benefit cost analysis.

d. Activities

Students shall be exposed to understanding the of product life cycle and also be familiar with the basic concepts of Engineering Design.

e. Learning Resources

Text Books

1. George E. Dieter & Linda C. Schmidt., *Engineering Design*, 4th edition, McGraw-Hill, 2009.

Reference Books

1. Nigel Cross., *Engineering Design Methods – Strategies for Product Design*, Wiley, 2005
2. Philip Kosky, George Wise& Robert Balmer., *Exploring Engineering An Introduction to Engineering and Design*, Academic Press, 2009.
3. Ernst Eder, Stanislav Hosnedl., *Introduction to Design Engineering: Systematic creativity and management*, CRC Press, 2010.

4. Prasant Kumar., *Product Design-Creativity, Concepts and Usability*, PHI Learning Pvt. Ltd., New Delhi, 2012.

Course Code	Course Name	L	T	P	C
MME102	3D PRINTING AND DESIGN	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course is designed to impart knowledge and skills related to 3D printing technologies. It familiarizes various software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using 3D printing. It introduces about selecting the materials and equipments for various 3D printed products.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Explain how to select a 3D printing process for an application.	K2
CO2	Explain the principle, process, advantages and disadvantages of various Polymer-based AM techniques.	K2
CO3	Discuss the principle, process, advantages and disadvantages of various Metal AM techniques.	K2
CO4	Select particular AM materials for suitable applications.	K2
CO5	Design a 3D printer with suitable mechanism.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION

9

Introduction, Process, Classification, Advantages, Additive vs Conventional Manufacturing processes. CAD Data formats, Data translation, Data loss, STL format. Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defense, Automotive, Construction, Food Processing, Machine Tools.

ADDITIVE MANUFACTURING USING POLYMERS

9

Principle, Pre-Build Process, Part - Building and Post Processing Requirement and Techniques, Advantages, Limitations and Applications for Stereo - Lithography, LOM, FDM, SLS, Binder Jet technology - Process, Process parameter, Process Selection for various applications- Defects and their causes - Inspection and Testing of polymer-based AM.

METAL ADDITIVE MANUFACTURING 9

Principle, Pre - Build Process, Part-Building and Post Processing Requirement and Techniques, Advantages, Limitations and Applications for Selective Laser Melting (SLM), Laser Beam Melting (LBM), Laser Metal Fusion (LMF), Direct Metal Laser Sintering (DMLS), Electron Beam melting (EBM), Laser Cladding, Directed Energy Deposition and Laser Metal Deposition Process, Laser Engineered Net Shaping (LENS), Wire Arc AM, Friction Stir AM - Inspection and Testing metal AM.

AM MATERIALS 9

Polymers, Metals, Non - Metals, Ceramics - Various forms of raw material - Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their Properties - Support Materials- FGM - Composite Materials in AM - Metallurgy and Properties of Materials for Metal AM.

DESIGN OF 3D PRINTING EQUIPMENT 9

Process Equipment- Design and Process Parameters – Design Requirements & Limitations of 3D Printing - Governing Bonding Mechanism - Components and Block Diagram - Design of Low-Cost 3D printers - Components and Block diagram - Electronics Design & Circuit Diagram - Firmware - Common faults and Troubleshooting.

d. Activities

Students shall be exposed to acquire knowledge on process of transforming a concept into the final product in 3D printing technology. Students will learn comprehensively about developing a 3D printed product. Students will learn to evaluate the advantages, limitations and applications of AM processes.

e. Learning Resources

Text Books

1. Lan Gibson, David W. Rosen and Brent Stucker., *Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing* , Springer, 2010.
2. Soloman S., *3D Printing and Design* , Khanna Publishing House, Delhi, 2020.

Reference Books

1. Andreas Gebhardt., *Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing*, Hanser Publisher, 2011.

2. CK Chua, Kah Fai Leong., *3D Printing and Rapid Prototyping- Principles and Applications*, World Scientific, 2018.
3. J.D. Majumdar and I. Manna., *Laser-Assisted Fabrication of Materials*, Springer Series in Material Science, 2013.
4. L. Lu, J. Fuh and Y.S. Wong., *Laser-Induced Materials and Processes for Rapid Prototyping*, Kulwer Academic Press, 2001.
5. Zhiqiang Fan & Frank Liou., *Numerical Modelling of the Additive Manufacturing (AM) Processes of Titanium Alloy*, InTech, 2012.

Course Code	Course Name	L	T	P	C
MME103	DESIGN FOR ADDITIVE MANUFACTURING	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course provides a thorough overview of design for additive manufacturing (DFAM) fundamentals. Students can understand the unique characteristics and limitations of the different 3D printing technologies, materials, and post-processing techniques through this course. Students are expected to optimize the design for the specific 3D printing technology and material being used to ensure the best possible outcome.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the needs and various DFAM tools used in AM.	K2
CO2	Apply the design rules and guidelines of part consolidation.	K3
CO3	Describe the design considerations for metal AM.	K2
CO4	Elaborate the design guidelines and rules for polymer based AM process.	K2
CO5	Describe the various post processing steps used in AM and the future goals for AM.	K2

c. Course Syllabus

Total : 45 Periods

STRATEGIC DESIGN IN ADDITIVE MANUFACTURING

9

Design for additive manufacturing (DFAM) – Value addition with AM – General Guidelines for Designing AM parts - Design to Avoid Anisotropy – Design to Minimize Print Time - Design to Minimize Post - processing - Topology Optimization. Design Analysis for AM – Considerations for Analysis of AM Parts - Role of mesh, topology and size optimization – Build process simulation.

PART CONSOLIDATION AND TOOLING DESIGN 9

Part Consolidation – Design for Function – Material Considerations – Number of Fasteners - Conventional DFM/DFA principles to DFAM – Assembly Considerations – Design of Moving Parts AM Tooling Design – Mounting Fixtures and Guides – Conformal Cooling – Coolant Flow Strategies – Coolant Channel Shape and Spacing – Steps to minimize Print Time in Tooling.

DESIGN CONSIDERATIONS FOR METAL AM 9

Designing for Metal Powder Bed Fusion – Metal Powder Production – Powder Morphology – Powder Size Distribution – Other Powder Considerations – Potential Defects in AM Materials – Topology Optimization – Lattice Structures – Overhangs and Support Material Designing to Reduce Residual stress and Stress Concentrations – General Part Positioning Guidelines - Design for Laser Powder Bed Fusion, Electron Beam Melting and Metal Binder Jetting.

DESIGN FOR POLYMER AM PROCESS AND OTHER AM CONSIDERATIONS 9

Design considerations due to Anisotropy, Wall Thickness, Overhangs and Support Material, Holes, Ribs, fonts and intricate details – Design guidelines for Material Extrusion, Vat Photo polymerisation and Polymer Powder Bed Fusion. Designer Machine Operator Cooperation – Health and Safety – prevention of explosion – AM Part Certification.

POST PROCESSING AND FUTURE OF AM 9

Post Processing: Support Material Removal - Polymer Surface Treatments - Metal Surface Treatments - Gluing and Welding AM Parts - Heat Treatment and Aging Future of AM: Functionally Graded Materials – Bio printing - Printed Electronics - Nano Printing - Food Printers.

d. Activities

Students shall be expected to design and print 3D printing component which included all DFAM guidelines and rules.

e. Learning Resources

Text Books

1. Olaf Diegel., *A Practical Guide to Design for Additive Manufacturing*, Springer, 2019.
2. Martin Leary., *Design for Additive Manufacturing*, Elsevier, 2019.

Reference Books

1. Ben Redwood., *The 3D Printing Handbook: Technologies, Design and Applications*, 3D Hubs, 2017.

Course Code	Course Name	L	T	P	C
MME104	REVERSE ENGINEERING	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course details the various aspects of how reverse engineering works in product design and development. It also describes the working of 3D scanning hardware & software operations and procedure to generate 3D model.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Discuss the fundamental concepts and principles of reverse engineering in product design and development.	K2
CO2	Discuss the concept and principles of material identification and process verification in reverse engineering.	K2
CO3	Interpret the concept and principles of data processing, part performance and system compatibility in reverse engineering.	K2
CO4	Understand the concepts of 3D scanning hardware & software operations and procedure to generate 3D model.	K2
CO5	Apply the concept of reverse engineering in various industrial applications.	K3

c. Course Syllabus

Total : 45 Periods

INTRODUCTION & GEOMETRIC FORM 9

Introduction – Uses – The Generic Process – Phases – Computer Aided Reverse Engineering - Surface and Solid Model Reconstruction – Dimensional Measurement – Prototyping.

MATERIAL CHARACTERISTICS AND PROCESS IDENTIFICATION 9

Alloy Structure Equivalency – Phase Formation and Identification – Mechanical Strength – Hardness –Part Failure Analysis – Fatigue – Creep and Stress Rupture – Environmentally Induced Failure Material Specification - Composition Determination - Microstructure Analysis – Manufacturing Process Verification.

DATA PROCESSING **9**

Statistical Analysis – Data Analysis – Reliability and the Theory of Interference – Weibull Analysis – Data Conformity and Acceptance – Data Report – Performance Criteria – Methodology of Performance Evaluation – System Compatibility.

3D SCANNING AND MODELLING **9**

Introduction, working principle and operations of 3D scanners: Laser, White Light, Blue Light - Applications- Software for scanning and modelling: Types- Applications- Preparation techniques for Scanning objects- Scanning and Measuring strategies - Calibration of 3D Scanner- Step by step procedure: 3D scanning - Geometric modelling – 3D inspection- Case studies.

INDUSTRIAL APPLICATIONS **9**

Reverse Engineering in the Automotive Industry; Aerospace Industry; Medical Device Industry. Case studies and Solving Industrial projects in Reverse Engineering. Legality: Patent – Copyrights – Trade Secret – Third-Party Materials.

d. Activities

- Students able to scan the 3D physical models and convert it into CAD files.
- Students are exposed to various softwares related to reverse engineering, and also information related to calibration of 3D scanner.

e. Learning Resources

Text Books

1. Robert W. Messler., *Reverse Engineering: Mechanisms, Structures, Systems & Materials*, 1st Edition, McGraw-Hill Education, 2014.
2. Wego Wang., *Reverse Engineering Technology of Reinvention*, CRC Press, 2011.

Reference Books

1. Scott J. Lawrence., *Principles of Reverse Engineering*, Kindle Edition, 2022.
2. Kevin Otto and Kristin Wood., *Product Design: Techniques in Reverse Engineering and New Product Development*, Prentice Hall, 2001.
3. Kathryn, A. Ingle., *Reverse Engineering*, McGraw-Hill, 1994.
4. Linda Wills., *Reverse Engineering*, Kluwer Academic Publishers, 1996.

5. Vinesh Raj and Kiran Fernandes., *Reverse Engineering: An Industrial Perspective*, Springer- Verlag London Limited 2008.

Course Code	Course Name	L	T	P	C
MME105	BUSINESS VALUE ENHANCEMENT WITH ADDITIVE MANUFACTURING	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course aims to explore the potential of Additive Manufacturing (AM) in enhancing business value by discussing various aspects of AM technology, including its principles, processes, and applications. Through this course, we will delve into the different ways in which AM can create value for businesses, such as reducing lead times, lowering costs, increasing efficiency, and improving product quality. We will also examine how businesses can leverage AM to innovate and create new revenue streams.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the need for sustainable manufacturing and realize how AM helps in that direction.	K2
CO2	Explain Business value improvement with additive manufacturing.	K2
CO3	Describe the value addition due to reduced operations.	K2
CO4	Expound strategic alignment of additive manufacturing.	K2
CO5	Summarise the applications of AM for value addition in key application areas.	K2

c. Course Syllabus

Total: 45 Periods

SUSTAINABILITY WITH ADDITIVE MANUFACTURING

9

Sustainable manufacturing – Economic Sustainability with AM – Environmental Sustainability – Impacts on Energy Consumption resources and pollution – Societal Sustainability with AM – Destructive implications and counter measures.

BUSINESS VALUE 9

AM as a Driver for Business Competitiveness, new services, creativity, and Innovation – Impact on Manufacturing Paradigms, Product Lifecycle and Operational Costs and Supply Chain Management – Mass customization – Strategic Challenges and Barriers Ahead of AM.

OPERATIONS VALUE 9

Impact of AM on the Product Development Process – Evolution in Design Methodologies – Design Freedom – Impact on Production Process, Product Quality, Manufacturing Costs and Material Waste – Impact on Inventory Turnover, Spare Part Supply Chain and 3DP Online Platforms Supply Chain.

STRATEGIC ALIGNMENT OF ADDITIVE MANUFACTURING 9

Framework for Strategic Alignment – Contingency Factors Driving AM Performance – Organizational Factors, Operational Factors and Product Characteristics – Economic Analysis – Technology Analysis – Selecting AM Technology – Organizational, Operational and Supply Chain Changes for implementation of AM.

BUSINESS VALUE IN KEY APPLICATION AREAS 9

The Role of Additive Manufacturing and business value in Industry of the Future – Industrial Diffusion – Business value addition in Healthcare, Automotive, Aerospace, Consumer Goods, Architecture, Food Industry and Research and Education industries – Case Studies.

d. Activities

Students shall be exposed to read and analyze case studies on how businesses have successfully integrated AM into their operations to create value.

e. Learning Resources

Text Books

1. Mojtaba Khorram Niaki, Fabio Nonino., *The Management of Additive Manufacturing: Enhancing Business Value*, (Springer Series in Advanced Manufacturing), Springer, 2018.
2. David M. Dietrich, Michael Kenworthy, Elizabeth Cudney., *Additive Manufacturing Change Management: Best Practices*, CRC Press, 2019.

Reference Books

1. Subramanian Senthilkannan., *Handbook of Sustainability in Additive Manufacturing*, Springer, 2016.
2. Olaf Diegel, Axel Nordin, Damien Motte., *A Practical Guide to Design for Additive Manufacturing*, Springer, 2019.

Course Code	Course Name	L	T	P	C
MME106	STANDARDS AND QUALITY ATTRIBUTES OF 3D-PRINTING	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

By setting clear standards and implementing rigorous quality control and inspection measures, organizations can minimize the risk of defects, errors, and accidents, while maximizing the value and effectiveness of their products and services.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Dicuss the various additive manufacturing standards.	K2
CO2	Select suitable additive manufacturing standards for a given application.	K3
CO3	Describe the material characterization and its types for additive manufacturing systems.	K2
CO4	Select a suitable process control for additive manufacturing systems.	K3
CO5	Comprehend the quality management frame work in additive manufacturing.	K2

c. Course Syllabus

Total : 45 Periods

ADDITIVE MANUFACTURING STANDARDS 9

Introduction to standards for Additive Manufacturing - Importance of standards -Importance of Quality Management – Standards - Quality Control - And measurement Sciences - History of formation of committee for - standards. Work plan and roadmap of Joint Committee between ASTM - ISO - Priority areas on Additive Manufacturing Standards - Lists of different types of Standards for Additive manufacturing (ASTM AM Standards).

MEASUREMENT SCIENCE AND DATA FORMAT FOR ADDITIVE MANUFACTURING 9

Introduction to measurement science – challenges - Additive Manufacturing Materials – processes - parts and Uncertainties - Additive Manufacturing Modelling and Simulation - Potentials of Measurement science - typical applications - Data format in Additive Manufacturing - New Developments - Scanning Technology - Contact scanners and Non-contact scanners.

MATERIAL CHARACTERIZATION FOR ADDITIVE MANUFACTURING 9

Introduction to Material Characterization - Types - Liquid Materials Characterization Techniques - rheology and wetting behaviour - curing characteristics - liquid density - Solid materials characterization techniques - Filament Diameter Consistency – density – porosity - Moisture content - thermal properties - Micro structure of filament - Powder material characterization Techniques - powder size measurements - chemical composition, Flow characteristics.

PROCESS CONTROL AND MODELING 9

Introduction to qualification - Definition and Terms - equipment qualification and general test - Four stages for qualification - Motivation for process control - Monitoring sensors - visual imaging - Thermal sensing - Displacement sensing - Measurand of In-Process Control Research-SLM, EBM, DED, Wire Fed DED - Commercial solutions on process modelling, simufact additive, ESI-Additive Manufacturing - Netfabb Simulation.

QUALITY MANAGEMENT FRAME WORK IN ADDITIVE MANUFACTURING 9

Need for Quality management frame work, Leadership and commitment - planning - Additive Manufacturing support - Additive manufacturing operation - performance Evaluation - PDCA Frame work cycle - Roles of regulatory and certification bodies - Proposed Framework For Additive Manufacturing Implementation - User inputs, product knowledge - Equipment qualification - process knowledge - continuous process verification.

d. Activities

They involve the implementation of procedures and processes to ensure that products and services meet predetermined standards and specifications, and that they are subject to

appropriate quality control and inspection measures to identify and correct defects and non-conformities.

e. Learning Resources

Text Books

1. Chee Kai Chua , Chee How Wong and Wai Yee Yeong, *Standards, Quality Control, and Measurement Sciences in 3D Printing and Additive Manufacturing*, Singapore Centre for 3D Printing, Academic press, Singapore, 1st Edition, 2017.

Reference Books

1. Ben Redwood, Filemon Schöffner, Brian Garret., *The 3D Printing Handbook: Technologies, Design and Applications*, 3D Hubs, 2017.
2. Chee Kai Chua., *3D Printing and Additive Manufacturing: Principles and Applications*, World Scientific, 5th edition, 2017.

Course Code	Course Name	L	T	P	C
MEN001	FOUNDATIONS OF ENTREPRENERUSHIP	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course is designed to introduce you to the fundamental concepts and practices of entrepreneurship.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the basics of entrepreneurship.	K2
CO2	Interpret the business ownership patterns and environment.	K2
CO3	Understand the Job opportunities in Industries relating to Technopreneurship.	K2
CO4	Learn about applications of technopreneurship and successful technopreneurs.	K2
CO5	Explain the recent and emerging trends in entrepreneurship.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION TO ENTREPRENEURSHIP

9

Entrepreneurship- Definition, Need, Scope - Entrepreneurial Skill & Traits - Entrepreneur vs. Intrapreneur; Classification of entrepreneurs, Types of entrepreneurs -Factors affecting entrepreneurial development – Achievement Motivation – Contributions of Entrepreneurship to Economic Development.

BUSINESS OWNERSHIP & ENVRIONMENT

9

Types of Business Ownership – Business Environmental Factors – Political-Economic-Sociological- Technological-Environmental-Legal aspects – Human Resources Mobilization-Basics of Managing Finance- Essentials of Marketing Management - Production and Operations Planning – Systems Management and Administration.

FUNDAMENTALS OF TECHNOPRENEURSHIP 9

Introduction to Technopreneurship - Definition, Need, Scope- Emerging Concepts- Principles - Characteristics of a technopreneur - Impacts of Technopreneurship on Society – Economy- Job Opportunities in Technopreneurship - Recent trends.

APPLICATIONS OF TECHNOPRENEURSHIP 9

Technology Entrepreneurship - Local, National and Global practices - Intrapreneurship and Technology interactions, Networking of entrepreneurial activities – Launching - Managing Technology based Product / Service entrepreneurship – Success Stories of Technopreneurs - Case Studies.

EMERGING TRENDS IN ENTREPRENEURSHIP 9

Effective Business Management Strategies for Franchising - Sub-Contracting- Leasing- Technopreneurs – Agripreneurs - Netpreneurs- Portfolio entrepreneurship - NGO Entrepreneurship – Recent Entrepreneurial Developments - Local – National – Global perspectives.

d. Activities

Students shall be exposed to the different types of entrepreneurships, the challenges, and opportunities of starting a business, and the key traits and skills that are essential for successful.

e. Learning Resources

Text Books

1. S.S.Khanka, *Entrepreneurial Development*, S. Chand & Company Ltd., 2021.
2. Donald F. Kuratko, *Entrepreneurship: Theory, Process, Practice*, Cengage Learning, 2019.

Reference Books

1. Daniel Mankani., *Technopreneurship: The Successful Entrepreneur in the New Economy*, Prentice Hall, 2003.
2. Jack Lang., *The High-Tech Entrepreneur's Handbook: How to start and run a high-tech company*, ft com, 2001.

Course Code	Course Name	L	T	P	C
MEN002	TEAM BUILDING & LEADERSHIP MANAGEMENT FOR BUSINESS	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course is designed to provide with the knowledge and skills necessary to effectively lead and manage teams in a business setting.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the basics of managing teams for business.	K2
CO2	Discuss to develop effective teams for business management.	K2
CO3	Understand the fundamentals of leadership for running a business.	K2
CO4	Learn about the importance of leadership for business development.	K2
CO5	Explain the emerging trends in leadership effectiveness for entrepreneurs.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION TO MANAGING TEAMS

9

Introduction to Team - Team Dynamics - Team Formation – Stages of Team Development - Enhancing teamwork within a group - Team Coaching - Team Decision Making - Virtual Teams - Self Directed Work Teams (SDWTs) - Multicultural Teams.

MANAGING AND DEVELOPING EFFECTIVE TEAMS

9

Team-based Organizations - Leadership roles in team-based organizations - Offsite training and team development - Experiential Learning - Coaching and Mentoring in team building - Building High-Performance Teams - Building Credibility and Trust - Skills for Developing Others - Team Building at the Top - Leadership in Teamwork Effectiveness.

INTRODUCTION TO LEADERSHIP

9

Introduction to Leadership - Leadership Myths – Characteristics of Leader, Follower and Situation - Leadership Attributes - Personality Traits and Leadership- Intelligence Types and Leadership - Power and Leadership - Delegation and Empowerment.

LEADERSHIP IN ORGANISATIONS

9

Leadership Styles – LMX Theory - Leadership Theory and Normative Decision Model - Situational Leadership Model - Contingency Model and Path Goal Theory – Transactional and Transformational Leadership - Charismatic Leadership - Role of Ethics and Values in Organizational Leadership.

LEADERSHIP EFFECTIVENESS

9

Leadership Behavior - Assessment of Leadership Behaviors - Destructive Leadership - Motivation and Leadership - Managerial Incompetence and Derailment Conflict Management - Negotiation and Leadership - Culture and Leadership - Global Leadership – Recent Trends in Leadership.

d. Activities

Students shall be exposed to know the importance of effective leadership and teamwork in achieving business goals, and will gain an understanding of the different leadership styles and approaches.

e. Learning Resources

Text Books

1. Richard Hughes, Robert Ginnett, Gordon Curphy., *Leadership: Enhancing the Lessons of Experience*, McGraw-Hill Education, 2018.
2. Jon R. Katzenbach, Douglas K. Smith., *The Wisdom of Teams: Creating the High-Performance Organization*, Harvard Business Review Press, 2015.

Reference Books

1. Uday Kumar Haldar., *Leadership and Team Building*, Oxford University Press, 2010.
2. Daft, R.L., *The Leadership Experience*, Cengage, 2015.
3. Daniel Levi., *Group Dynamics for Teams*, Sage Publications, 2014.
4. W. Gibb Dyer Jr., Jeffrey H. Dyer, William G. Dyer., *Team building: Proven strategies for improving team performance*, Jossey-Bass, 2013.

Course Code	Course Name	L	T	P	C
MEN003	ENGINEERING ECONOMICS AND COST ANALYSIS	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course is designed to provide with a comprehensive understanding of the principles of engineering economics and cost analysis. The students will need to be able to make informed financial decisions in order to optimize projects and maximize profitability.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Understand the basic terminologies and laws in Engineering Economics.	K2
CO2	Use different interest formulae to solve real-world engineering problems.	K3
CO3	Analyze financial alternatives using various techniques, including present worth analysis, future worth analysis, annual equivalent analysis, and rate of return analysis.	K3
CO4	Describe the concepts of replacement and maintenance analysis and their importance in the management of engineering assets.	K2
CO5	Compute cost analysis for capital subjecting based on depreciation and money available.	K3

c. Course Syllabus

Total: 45 Periods

INTRODUCTION TO ECONOMICS

9

Introduction to Economics - Flow in an economy, Law of supply and demand, Concept of Engineering Economics – Engineering efficiency, Economic efficiency, Scope of engineering economics- Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis- P/V ratio, Elementary economic Analysis – Material selection for product Design selection for a product, Process planning.

VALUE ENGINEERING

9

Make or buy decision, Value engineering – Function, aims, Value engineering procedure. Interest formulae and their applications –Time value of money, Single payment compound amount factor, Single payment present worth factor, Equal payment series sinking fund factor, Equal payment series payment Present worth factor- equal payment series capital recovery factor-Uniform gradient series annual equivalent factor, Effective interest rate.

CASH FLOW

9

Methods of comparison of alternatives – present worth method, Future worth method, Annual equivalent method, rate of return method.

REPLACEMENT AND MAINTENANCE ANALYSIS

9

Replacement and Maintenance analysis – Types of maintenance, types of replacement problem, determination of economic life of an asset, Replacement of an asset with a new asset – capital recovery with return and concept of challenger and defender, Simple probabilistic model for items which fail completely.

DEPRECIATION

9

Depreciation - Introduction, Straight line method of depreciation, declining balance method of depreciation - Sum of the year's digits method of depreciation, sinking fund method of depreciation/ Annuity method of depreciation, service output method of depreciation - Evaluation of public alternatives - introduction, Examples, Inflation adjusted decisions – procedure to adjust inflation, Examples on comparison of alternatives and determination of economic life of asset.

d. Activities

Students shall be exposed to the different types of costs, the time value of money and the concept of economic efficiency. They will also learn about the role of engineering economics in decision making.

e. Learning Resources

Text Books

1. Panneer Selvam R., *Engineering Economics*, Prentice Hall of India Ltd, 2013.
2. Chan S.Park., *Contemporary Engineering Economics*, Prentice Hall of India, 2017.

Reference Books

1. Donald.G. Newman, Jerome.P.Lavelle., *Engineering Economics and analysis* Engg. Press, Texas, 2017.

Course Code	Course Name	L	T	P	C
MEN004	CREATIVITY & INNOVATION IN ENTREPRENEURSHIP	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course is designed to explore the vital role of creativity and innovation in entrepreneurship. In this course, students will learn about the essential skills and techniques that are needed to develop and implement innovative business ideas.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the basics of creativity for developing Entrepreneurship.	K2
CO2	Understand the importance of creative intelligence for business growth.	K2
CO3	Demonstrate the advances through Innovation in Industries.	K2
CO4	Summarise the applications of innovation in building successful ventures.	K2
CO5	Explain the developing innovative business models to run the business efficiently and effectively.	K2

c. Course Syllabus

Total : 45 Periods

CREATIVITY 9

Creativity: Definition- Forms of Creativity-Essence, Elaborative and Expressive Creativities- Quality of Creativity-Existential, Entrepreneurial and Empowerment Creativities – Creative Environment- Creative Technology- - Creative Personality and Motivation.

CREATIVE INTELLIGENCE 9

Creative Intelligence: Convergent thinking ability – Traits Congenial to creativity – Creativity Training-- Criteria for evaluating Creativity-Credible Evaluation- Improving the quality of our

creativity – Creative Tools and Techniques - Blocks to creativity- fears and Disabilities- Strategies for Unblocking- Designing Creativity Enabling Environment.

INNOVATION 9

Innovation: Definition- Levels of Innovation- Incremental Vs Radical Innovation-Product Innovation and Process- Technological, Organizational Innovation – Indicators- Characteristics of Innovation in Different Sectors. Theories in Innovation and Creativity- Design Thinking and Innovation- Innovation as Collective Change-Innovation as a system.

INNOVATION AND ENTREPRENEURSHIP 9

Innovation and Entrepreneurship: Entrepreneurial Mindset, Motivations and Behaviors- Opportunity Analysis and Decision Making- Industry Understanding - Entrepreneurial Opportunities- Entrepreneurial Strategies – Technology Pull/Market Push – Product -Market fit.

INNOVATIVE BUSINESS MODELS 9

Innovative Business Models: Customer Discovery-Customer Segments-Prospect Theory and Developing Value Propositions- Developing Business Models: Elements of Business Models – Innovative Business Models: Elements, Designing Innovative Business Models- Responsible Innovation and Creativity.

d. Activities

Students shall be exposed to the difference between creativity and innovation, and how they are essential to the success of any business venture. They will also explore the various sources of innovation and the role of creativity in problem-solving.

e. Learning Resources

Text Books

1. S.S.Khanka, *Creativity and Innovation in Entrepreneurship*, Sultan Chand & Sons, 2020.
2. Pradip N Khandwalla, *Lifelong Creativity: An Unending Quest*, Tata Mc Graw Hill, 2004.

Reference Books

1. Paul Trott, *Innovation Management and New Product Development*, Pearson, 2018.
2. Vinnie Jauhari, Sudanshu Bhushan, *Innovation Management*, Oxford Higher Education, 2014.

3. C.S.G. Krishnamacharyulu, R. Lalitha, *Innovation Management*, Himalaya Publishing House, 2010.
4. Dale Timpe, *Creativity*, Jaico Publishing House, 2003.

Course Code	Course Name	L	T	P	C
MEN005	PRINCIPLES OF MARKETING MANAGEMENT FOR BUSINESS	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course is designed to provide a foundational understanding of the principles of marketing management. As a business professional, it is important to have a comprehensive understanding of marketing concepts and strategies to promote the business and achieve the goals. This course will equip the knowledge and skills necessary to develop and implement effective marketing campaigns.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Comprehend the awareness of marketing management process.	K2
CO2	Understand the marketing environment.	K2
CO3	Acquaint about product and pricing strategies.	K2
CO4	Acquire the knowledge of promotion and distribution in marketing management.	K2
CO5	Know the contemporary marketing scenarios and offer solutions to marketing issues.	K2

c. Course Syllabus

Total : 45 Periods

INTRODUCTION TO MARKETING MANAGEMENT 9

Introduction - Market and Marketing – Concepts- Functions of Marketing - Importance of Marketing - Marketing Orientations - Marketing Mix-The Traditional 4Ps - The Modern Components of the Mix - The Additional 3Ps - Developing an Effective Marketing Mix.

MARKETING ENVIRONMENT 9

Introduction - Environmental Scanning - Analyzing the Organization’s Micro Environment and Macro Environment - Differences between Micro and Macro Environment – Techniques of

Environment Scanning - Marketing organization - Marketing Research and the Marketing Information System, Types and Components.

PRODUCT AND PRICING MANAGEMENT 9

Product- Meaning, Classification, Levels of Products – Product Life Cycle (PLC) - Product Strategies - Product Mix - Packaging and Labelling - New Product Development - Brand and Branding - Advantages and disadvantages of branding Pricing - Factors Affecting Price Decisions - Cost Based Pricing - Value Based and Competition Based Pricing - Pricing Strategies - National and Global Pricing.

PROMOTION AND DISTRIBUTION MANAGEMENT 9

Introduction to Promotion – Marketing Channels- Integrated Marketing Communications (IMC) - Introduction to Advertising and Sales Promotion – Basics of Public Relations and Publicity - Personal Selling - Process - Direct Marketing - Segmentation, Targeting and Positioning (STP)- Logistics Management- Introduction to Retailing and Wholesaling.

CONTEMPORARY ISSUES IN MARKETING MANAGEMENT 9

Introduction - Relationship Marketing Vs. Relationship Management - Customer Relationship Management (CRM) - Forms of Relationship Management - CRM practices - Managing Customer Loyalty and Development – Buyer-Seller Relationships- Buying Situations in Industrial / Business Market - Buying Roles in Industrial Marketing - Factors that Influence Business - Services Marketing - E-Marketing or Online Marketing.

d. Activities

Students shall be exposed to learn about the key components of the marketing mix, including product, price, promotion, and place. They will also learn about the role of marketing in creating customer value and developing a competitive advantage.

e. Learning Resources

Text Books

1. Sherlekar S.A, *Marketing Management*, Himalaya Publishing House, 2016.
2. Philip Kotler and Kevin Lane Keller, *Marketing Management*, PHI, 2015.

Reference Books

1. Vijay Prakash Anand, *Marketing Management- An Indian perspective*, Biztantra, 2016.
2. V.S.Ramaswamy &S.Namakumari, *Marketing Management Global Perspective, Indian Context*, Macmillan Publishers India, 2015.
3. S.H.H. Kazmi, *Marketing Management*, Excel Books India, 2013.
4. Dr. C.B.Gupta & Dr. N.Rajan Nair, *Marketing Management- text and Cases*, Sultan Chand and Sons, 2016.

Course Code	Course Name	L	T	P	C
MEN006	FINANCIAL MARKETS AND SERVICES	3	0	0	3

Category: Open Elective (Minor Degree)

a. Preamble

This course Financial Markets and Services is designed to provide students with an in-depth understanding of the financial markets, financial services, and the various financial instruments used in these markets. The course will cover topics such as the functions of the financial system, financial intermediaries, financial assets, and the importance of capital markets.

b. Course Outcome

After successful completion of the course, the students will be able to

CO. No.	Course Outcome	Knowledge Level
CO1	Describe the functioning of the financial system and its importance in economic development.	K2
CO2	Summarise the basics of stock exchanges, their functions, and services.	K2
CO3	Explain the role of the Securities and Exchange Board of India (SEBI) in regulating securities markets and its functions.	K2
CO4	Interpret the new financial products and services, including innovative financial instruments, available in the market.	K2
CO5	Understand the organization and operation of mutual funds and the facilities available to investors.	K2

c. Course Syllabus

Total : 45 Periods

THE FINANCIAL SYSTEM IN INDIA

9

Functions of the Financial System – Financial Concepts – Financial Assets – Financial Intermediaries – Financial Markets – Importance of Capital Market – Money Market – Foreign Exchange Market – Financial Rates of Return – Financial Instruments – Development of Financial System in India – Financial Markets Regulation Department (FMRD) — Financial System and Economic Development – Weaknesses of Indian Financial System.

STOCK EXCHANGE

9

Introduction – Functions/Services of Stock Exchanges – Recognition of Stock Exchanges – Procedure – Organization of Stock Exchanges in India – Listing of Securities – Listing Procedure – Registration of Stock Brokers – Functions of Brokers – Registration of Sub-brokers – Kinds of Brokers and their Assistants – Methods of Trading in a Stock Exchange – Current Settlement Procedure of Trading Transactions – Online Trading – BSE-BOLT System – Mobile Trading – Algo Trading– Merits of Online Trading – Types of Stock Market Orders (NSE-NEAT System) – Carry Over or Badla Transactions – Genuine Trading vs. Speculative Trading – Kinds of Speculators – Speculative Transactions – Stock Indices – Indices of NSE – Defects of Indian Stock/Capital Market – Recent Developments – Securities Lending (SLB) – Recent Reforms – Major Reforms in the Secondary Market.

SECURITIES AND EXCHANGE BOARD OF INDIA

9

Controller of Capital Issues (CCI) – Securities Contracts (Regulations) Act – Malpractices in Securities Market – Deficiencies in the Market – Securities and Exchange Board of India (SEBI) – SEBI Guidelines – Prohibition of Unfair Trade Practices – Recent Guidelines.

FINANCIAL SERVICES

9

Meaning, Scope, and Innovations – Meaning of Financial Services – Features of Financial Services – Importance of Financial Services – Classification of Financial Service Industry – Scope of Financial Services – Causes for Financial Innovation – Financial Services and Promotion of Industries – New Financial Products and Services – Innovative Financial Instruments – Classification of Equity Shares – Challenges Facing the Financial Service Sector – Present Scenario.

MUTUAL FUND

9

Introduction – Scope of Mutual Fund – Definition – Origin of the Fund – Types of Funds/Classification of Funds – Importance of Mutual Funds – Risks – Organization of the Fund – Operation of the Fund – Facilities Available to Investors – Net Asset Value – Performance Evaluation of Mutual Funds – Sharpe's Model for Evaluation – Treynor's Model for Evaluation – Jensen Model – Other Parameters of Performance – Investor's Rights – General Guidelines – Selection of a Fund – Commercial Banks and Mutual Funds – Mutual Funds Abroad – Mutual

Funds in India – Reasons for Slow Growth – Future of Mutual Fund – Block chain and digital assets.

d. Activities

The students shall be exposed to practical understanding of the stock market and its operation.

e. Learning Resources

Text Books

1. K.Natrajan E.Gordon, *Financial Markets and Services*, Himalaya Publishing House 2016.
2. Fabozzi, F. J. Modigliani, F., Jones F.j and Feri MG, *Foundation of Financial Markets & Institutions*, Pearson, 2009.

Reference Books

1. Bhole, L. M. : *Financial Markets and Institutions*, Tata McGraw Hill, 2020.