COURES STRUCTURE & SYLLABUS

FOR

B. TECH. MECHANICAL

SEMESTER- V & VI

(CBCS 2023 COURSE AS PER NEP 2020 GUIDELINES)

Bharati Vidyapeeth

(Deemed to be a University)

College of Engineering, Pune

Department of Mechanical Engineering

Vision of the Bharati Vidyapeeth (Deemed to be University) College of Engineering is:

To be a Class Institute for Social Transformation through Dynamic Education

Missions of the Bharati Vidyapeeth (Deemed to be University) College of Engineering are:

- *To provide quality technical education with advanced equipment, qualified faculty members, and infrastructure to meet the needs of the profession & society.*
- *To provide an environment conducive to innovation, creativity, research, and entrepreneurial leadership.*
- *To practice and promote professional ethics, transparency, and accountability for the social community, economic & environmental conditions.*

Goals of the Bharati Vidyapeeth (Deemed to be University) College of Engineering are:

- *Recruiting experienced faculty.*
- *Organizing faculty development programs.*
- *Identifying socio-economically relevant areas & emerging technologies.*
- *Constant review & upgradation of curricula.*
- *Upgradation of laboratories, library & communication facilities.*
- *Collaboration with industry and research & development organizations.*
- *Sharing of knowledge, infrastructure, and resources.*
- *Training, extension, testing, and consultancy services.*
- *Promoting interdisciplinary research.*

The vision of the Mechanical Engineering Department is:

To develop high-quality Mechanical Engineers through dynamic education to meet social and global challenges.

Mission Statements of the Mechanical Engineering Department are:

- *To provide extensive theoretical and practical knowledge to the students with well-equipped laboratories and ICT tools through motivated faculty members.*
- *To inculcate aptitude for research, innovation, and entrepreneurial qualities in students.*
- *To acquaint students with ethical, social, and professional responsibilities to adapt to the demands of the working environment.*

Program Educational Objectives (PEOs) of the B. Tech. Mechanical are:

Graduates will be able,

- *To fulfill the needs of industry and society with theoretical and practical knowledge.*
- *To engage in research, innovation, lifelong learning, and continued professional development.*
- *To fulfill professional ethics and social responsibilities.*

Knowledge and Attitude Profile (WK)

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2: Conceptually based mathematics, numerical analysis, data analysis, statistics, and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, reuse of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6: Knowledge of engineering practice (technology) in the practice areas of the engineering discipline.

WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9: Ethics, inclusive behavior, and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability, etc., with mutual understanding and respect, and of inclusive attitudes.

PROGRAM OUTCOMES

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals, and an engineering specialization as specified in WK1 to WK4, respectively, to develop solutions to complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems, reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for public health and safety, whole-life cost, net zero carbon, culture, society, and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge, including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering & IT tools, including prediction and modelling, recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for their impact on sustainability with reference to economy, health, safety, legal framework, culture, and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity, and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, making effective presentations considering cultural, language, and learning differences

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for and have the preparation and ability for i) independent and life-long learning, ii) adaptability to new and emerging technologies, and iii) critical thinking in the broadest context of technological change. (WK8)

Statements of Program Specific Outcomes (PSOs)

PSO1: Use the knowledge of thermal, design, manufacturing engineering, and computational sciences to solve Mechanical Engineering problems.

PSO2: Use Mechanical Engineering principles for research, innovation, and develop entrepreneurial skills.

B. TECH. MECHANICAL: COURSE STRUCTURE: (CBCS 2023 Course) As per NEP 2020 Guidelines

B. Tech. Mechanical Sem.-V

S. No.	Category	Course Code	Course	Teaching Scheme			Examination Scheme-Marks					Credits				
				L	P	T	SEE	IA	TW	PR	OR	Total	Th	Pr/Or	Tut	Total
1.	MJ	MJ1111501	Heat Transfer-Principles & Applications	3	2	-	60	40	25	-	25	150	3	1	-	4
2.	MJ	MJ1111502	Turbo Machinery	3	2	-	60	40	25	-	25	150	3	1	-	4
3.	MJ	MJ1111503	Renewable Energy Technologies	3	-	-	60	40	-	-	-	100	3	-	-	3
4.	MJ	MJ1111504	Computer-Integrated Manufacturing	3	2	-	60	40	25	-	25	150	3	1	-	4
5.	MJ	MJ1111505	Machine Design & Analysis -II*	3	-	1	60	40	-	-	-	100	3	-	1	4
6.	SE	SE1111506	Skill-Based Course-V: Computer-Oriented Numerical Methods	-	2	-	-	-	25	-	25	50	-	1	-	1
7.	AC	AC1102507	Environmental Studies**	4	-	-	60	40	-	-	-	100	4	-	-	4
			Total	**19**	**8**	**1**	**360**	**240**	**100**	**-**	**100**	**800**	**19**	**04**	**1**	**24**

*Sem. End Examination of 4 Hrs; **Mandatory Audit Course.

B. Tech. Mechanical Sem.-VI

S. No.	Category	Course Code	Course	Teaching Scheme			Examination Scheme-Marks					Credits				
				L	P	T	SEE	IA	TW	PR	OR	Total	Th	Pr/Or	Tut	Total
1.	MJ	MJ1111601	Introduction to CFD & FEA	3	2	-	60	40	25	25	-	150	3	1	-	4
2.	MJ	MJ1111602	Industrial Automation	3	-	-	60	40	-	-	-	100	3	-	-	3
3.	MJ	MJ1111603	Refrigeration & Air Conditioning	3	2	-	60	40	25	-	-	125	3	1	-	4
4.	PE	PE1111604	Program Elective-I	3	0	-	60	40	-	-	-	100	3	-	-	3
5.	MJ	MJ1111605	Mechanical System Design*	3	2	-	60	40	25	-	25	150	3	1	-	4
6.	SE	SE1113606	Professional Skills	-	2	-	-	-	25	-	-	25	-	1	-	1
7.	SE	SE1111607	Skill-Based Course-VI: Introduction to Data Science	-	2	-	-	-	25	-	25	50	-	1	-	1
			Total	**15**	**10**	**-**	**300**	**200**	**125**	**25**	**50**	**700**	**15**	**5**	**-**	**20**
8.	VA	VA1111608	Value-added courses-II[#]	2	-	-	-	50	-	-	-	50	2	--	-	2
9.	AE	AE1111609	MOOC-II	2	-	-	-	--	-	-	-	--	-	-	-	2

[#]Value added Course-II: 1. Solar PV Installation; 2. Area Service Manager

Professional Elective-I: 1. Industrial Engineering & Management; 2. Engineering Economics; 3. Carbon Footprint and GHG Accounting; 4. Additive Manufacturing and Rapid Prototyping; 5. Reliability and Machine Condition Monitoring

Course Codes and Definitions

Course Code	Definitions
AC	Audit Course
AE	Ability Enhancement Course
BC	Basic Chemistry Course
BM	Basic Mathematics Course
BP	Basic Physics Course
CC	Co-curricular Courses
EC	Extra-Curricular Course
EE	Electrical Engineering
ES	Engineering Science Course
GE	General Elective Course
ID	Inter-disciplinary Course
L	Lecture
MD	Multidisciplinary Course
MI	Minor Course
MJ	Major (Core) Course
MO	Massive Open Online Course
O	Oral
OE	Open Elective Course
P	Practical
PC	Practical Courses
PE	Programme Elective Courses
RP	Research I Project Course
SE	Skill Enhancement Course
SEE	Semester End Examination
T	Tutorial
TW	Term Work
UH	Course Related to Universal Human Values
VA	Value Added Course
VE	Vocational Enhancement Course
VS	Vocational Skill Courses

Programme Code:

Commencement/ Revised Year	Faculty Code (Engg & Tech.)	Programme Type (UG)	Programme Number (Mech.)	Programme Code
23	11	2	11	2311211

Course Code:

Type of Course	Faculty Code	Programme Number	Sem/Year	Course Number	Course Code
MJ	11	11	3	01	MJ1111301

B. Tech. Mechanical
Sem.-V

HEAT TRANSFER PRINCIPLES AND APPLICATIONS

(**Course** Code: MJ1111501)

Designation of Course	**Heat Transfer Principles and Applications**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03 Hours/ Week Tutorial:- --Hours/ Week	Semester End Examination Internal Assessment	60 Marks 40 Marks	03
Practical:- 02 Hours/ Week	Term Work Oral/~~Practical~~	25 Marks 25 Marks	01
	Total	**150 Marks**	**04**

Course Prerequisites: -	The students should know 1. Fundamentals of Thermodynamics: Principles and Applications. 2. Fundamentals of Fluid Mechanics.
Course Objectives:-	1. To provide knowledge of basic principles and applications of heat transfer. 2. Analyze the performance of heat transfer equipment 3. Apply principles to heat transfer for different applications
Course Outcomes: -	The students should be able to– 1. Interpret basic concepts of heat transfer and apply them to solve engineering problems 2. Analyze problems based on one-dimensional steady-state heat conduction and its applications 3. Analyze problems based on extended surfaces and also on unsteady heat conduction and its applications 4. Analyze problems based on the concepts of heat transfer by forced and natural convection 5. Interpret concepts of heat transfer by thermal radiation and apply them to solve engineering problems 6. Analyze the performance of heat exchangers and interpret concepts of condensation & boiling.

Course Contents

Unit I	**Basic Concepts of Heat Transfer**	**(06 Hrs.)**
Overview of subject, Modes of heat transfer, Applications of heat transfer in different fields of engineering, Fourier's law of conduction, Newton's law of cooling, Stefan- Boltzmann's law of radiation, Isotropic and anisotropic materials, Three dimensional heat conduction equation in Cartesian coordinate for anisotropic material for steady state condition, and reduction to Fourier equation, Laplace equation and Poisson's equation, Three dimensional heat conduction equation in cylindrical and spherical coordinates (no derivation), Thermal diffusivity. Purpose of insulation, critical radius of Insulation, Economic thickness of Insulation, Thermal contact resistance, thermal conductivity, and its variation with temperature for metals, non-metallic solids, gases, and liquids, one-dimensional problems of variable thermal conductivity.		
Unit II	**One-dimensional steady-state heat conduction**	**(06 Hrs.)**
One-dimensional steady state heat conduction through a plane wall, cylindrical wall, and sphere. Analogy between heat flow and electricity, heat conduction through a composite slab, cylinder, and sphere, Overall heat transfer coefficient, Concept of thermal resistance and conductance. Symmetrical boundary condition in a plane wall, conduction in a solid, hollow cylinder, and sphere,		

and practical problems of heat generation.		
Unit III	**Extended Surfaces and Unsteady Heat Conduction**	**(06 Hrs.)**
Extended surfaces: Heat transfer through extended surfaces, Classification of fins, Derivation of differential equation for fins with constant cross-sectional area with insulated tip boundary conditions, Effectiveness and efficiency of a fin, design of thermo well. **Unsteady Heat Conduction**: System with negligible internal resistance, Biot & Fourier numbers, Criteria for neglecting internal temperature gradient, Concept of time constant		
Unit IV	**Convection**	**(06 Hrs.)**
Introduction to hydrodynamic**,** thermal boundary layer, Laminar & turbulent flow over & closed conductors, convection heat transfer coefficients & order of magnitude, Dimensional analysis of free & forced convection, physical significance of the dimensionless, parameters, Nusselt's number, Reynolds' number, Prandtl's number, Grashof's number, Stanton number, Rayleigh number. **Forced Convection:** Empirical correlations for heat transfer in laminar and turbulent flow over a flat plate and in a circular pipe, Concept of hydraulic diameter, reference temperature. **Natural Convection:** Flow patterns, Empirical correlations for free convection, heat transfer over horizontal, vertical plates.		
Unit V	**Thermal Radiation**	**(06 Hrs.)**
Fundamental principles - Gray, White, Opaque, Transparent, and Black bodies, Spectral emissive power, Wien's, Rayleigh-Jeans' and Planck's laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff's Laws, View factor, Net radiation exchange in a two-body enclosure, Typical examples for these enclosures, Radiation Shield.		
Unit VI	**Heat Exchangers**	**(06 Hrs.)**
Classification, Applications of heat exchangers, Heat exchanger analysis, Logarithmic Mean Temperature Difference for parallel and counter flow heat exchangers, LMTD correction factors, fouling factor. The effectiveness: NTU method for parallel and counter flow heat exchangers, design considerations for heat exchangers. Film and drop-wise condensation, heat transfer coefficient for laminar film condensation on vertical and inclined plate(descriptive treatment), Correlations for condensation on and inside tubes, modes of pool boiling, critical heat flux, pool boiling.		

Term Work

Any ten experiments from the following:

1. Determination of thermal conductivity of insulating powder.
2. Determination of thermal conductivity of a metal rod.
3. Determination of thermal conductivity of different materials in the composite wall.
4. Temperature distribution along the length of a fin and determination of fin effectiveness and fin efficiencies.
5. Determination of film heat transfer coefficient on a hollow vertical tube heated from inside.
6. Determination of film heat transfer coefficient for turbulent flow inside a pipe.
7. Determination of the emissivity of a non-black surface.
8. Determination of Stefan-Boltzmann constant.
9. Performance of a parallel flow and counter flow heat exchanger.
10. Calibration of the thermocouple.
11. Demonstration of a heat pipe.

Project-Based Learning

1. Demonstration of conduction heat transfer through a Plane Slab
2. Demonstration of conduction heat transfer through Composite Slab/ Sphere/ Cylinder.

3. Demonstration of different types of fins
4. Demonstration of Natural Convection mode heat transfer
5. Demonstration of forced Convection mode heat transfer
6. Demonstration of radiation mode heat transfer
7. Design of a heat exchanger for domestic application

Reference Books

1. Incropera F. P., Dewitt D. P., "Fundamentals of Heat and Mass Transfer", John Wiley.
2. Cengel Y. A. and Ghajar A. J., "Heat and Mass Transfer – Fundamentals and Applications", Tata McGraw-Hill Education Private Limited.
3. Holman J. P., "Fundamentals of Heat and Mass Transfer", McGraw–Hill publication.
4. Mills A. F., "Basic Heat and Mass Transfer", Pearson

Text Books

1. Sukhatme S. P., "A Textbook on Heat Transfer", Universities Press.
2. Nag P. K., "Heat & Mass Transfer", McGraw-Hill Education Private Limited.
3. Thirumaleshwar M., "Fundamentals of Heat and Mass Transfer", Pearson Education India.
4. Sachdeva R.C., "Fundamentals of Engineering Heat and Mass Transfer", New Age Science
5. S.C. Arora, S. Domkundwar," A Course in Heat and Mass Transfer," Dhanpat Rai & Co
6. Introduction to Heat Transfer - S. K. Som

Unit Test–

Unit Test-I	Unit I, II, III

TURBO MACHINERY

(Course Code: MJ1111502)

Designation of Course	**Turbo Machinery**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03 Hours/ Week	Semester End Examination	60 Marks	03
Tutorial:- --Hours/ Week	Internal Assessment	40 Marks	
Practical:- 02 Hours/ Week	Term Work	25 Marks	01
	Oral/~~Practical~~	25 Marks	
	Total	**150 Marks**	**04**

Course Prerequisites: -	The students should know of 1. Fundamentals of Thermodynamics: Principles and Applications. 2. Fundamentals of Fluid Mechanics.
Course Objectives:-	1. To provide the knowledge of basic principles and applications of turbo machinery. 2. Analyze the performance of turbo machines. 3. Apply thermodynamics and kinematics principles to turbo machines.
Course Outcomes: -	The students should be able to– 1. Analyze the impact of fluid jets using jet theory and interpret velocity triangles for various operating conditions. 2. Evaluate the performance characteristics and working principles of impulse water turbines. 3. Analyze the operation and efficiency of reaction water turbines under different flow conditions. 4. Examine the working principles and flow behavior of rotary and axial-flow compressors. 5. Analyze the performance and applications of centrifugal pumps, incorporating the interpretation of velocity triangles. 6. Investigate the working principles and performance parameters of reciprocating pumps.

Course Contents

Unit I	**Impact of Free Jets**	**(06 Hrs.)**
Impulse-momentum principle, fixed and moving flat plates, curved vanes, with jet striking at the center of the vane and jet striking tangentially onto the vane, Impact of jet on hinged plates, Impact of jets on a series of flat plates and vanes, water wheels, velocity tri-angles and their analysis, work done and efficiency calculations.		
Unit II	**Impulse Water Turbines**	**(06 Hrs.)**
Main components and constructional features of Pelton wheel, Concept of centrifugal head, general energy equation for turbine, Velocity diagrams and analysis, Important non-dimensional parameters such as speed ratio, jet ratio, flow ratio, Condition for maximum hydraulic efficiency, working Proportion of Pelton wheel, Design of Pelton turbine runner, Performance characteristics.		
Unit III	**Reaction Water Turbines**	**(06 Hrs.)**
Classifications, Construction and working of Francis, Propeller, Kaplan Turbines, construction features, velocity diagrams and analysis, working proportion of Francis, Propeller, Kaplan Turbines, Degree of reaction (DOR), draft tubes- types and analysis, cavitation causes and remedies, specific speed, performance characteristics and governing of reaction turbines, selection of turbines.		
Unit IV	**Centrifugal Pumps**	**(06 Hrs.)**

Centrifugal Pumps: Classification, components of centrifugal pump, various terms associated with centrifugal pump, various heads, velocity triangle and their analysis, effect of outlet blade angle, cavitation, NPSH, Thomas Cavitation factor, priming of pumps, installation, specific speed, Performance characteristics of centrifugal pump, Axial thrust, maintenance, trouble and remedies, series and parallel operation of pumps system, water hammer problem in pumping system, selection of pumps.

Unit V	**Reciprocating Pumps**	**(06Hrs.)**

Reciprocating Pumps: Classification, Main Components, Working of Single and double acting reciprocating pumps, discharge, work done, and Power required to drive the reciprocating pump, coefficient of discharge and slip of Reciprocating Pumps, Energy analysis, Performance characteristics.

Unit VI	**Rotary Air Compressor**	**(06 Hrs.)**

Centrifugal Compressor: Classification, Construction, flow process on T-S Diagram, velocity diagram, Euler's work, slip factor and its effect on work input, and actual work input.

Axial Flow Compressor: Construction, stage velocity triangles and their analysis, enthalpy-entropy diagram, Degree of reaction, flow through the blade rows, pressure rise across the stage, stage losses and efficiencies, performance characteristics

Term Work

Any ten experiments from the following:

1. Study and application of the impulse momentum principle.
2. Study and trial on a Pelton wheel and plotting of main/operating characteristics.
3. Study and trial on a Francis turbine and plotting of main/operating characteristics.
4. Study and trial on a Kaplan turbine and plotting of main/operating characteristics
5. Study and trial on a Centrifugal pump and plotting of operating / and variable speed characteristics.
6. Study and trial on the reciprocating Pump.
7. Study of axial flow compressors/ centrifugal air blower.
8. Assembly and disassembly of pumps.
9. Trial on centrifugal air compressor.
10. Design of a complete pumping system installation using standard tables, charts supplied by pump manufacturers.
11. Visit to Hydroelectric power stations and write a report based on the visit.
12. Visit to water pumping station and write a report based on the visit.

Reference Books

1. Maneesh Dubey, BVSSS Prasad, Archan Nema, “Turbomachinery”, Tata-McGraw Hill.
2. S.M. Yahya, “Turbines, Compressors & Fans”, Tata-McGraw Hill.
3. B. U. Pai, “Turbomachines”, Wiley India.
4. Dr. Onkar Singh, “Thermal Turbo machines”, Wiley India.

Text Books

1. P. N. Modi and Dr. S. M. Seth, “Hydraulics and Fluid Mechanics”, Standard Book House, New Delhi.
2. R. K. Rajput, “Hydraulic Machines”, S. Chand Publishers, New Delhi.
3. R. K. Bansal, “Fluid Mechanics and Hydraulic Machines”, Laxmi Publications (P) LTD.
4. S.C. Gupta, “Fluid Mechanics & Hydraulic Machines”, Pearson Education.

Project-based learning

Demonstration model of

1. water wheel with flat blades, water wheel with curved blades
2. Pelton wheel, Francis turbines, Propeller turbines, Kaplan Turbines, etc.
3. Rotary compressor, Preliminary design of Centrifugal pump- single stage/multistage.
4. Reciprocating pump

Unit Test–

Unit Test-I	Unit I, II, III

RENEWABLE ENERGY TECHNOLOGIES

(Course Code: MJ1111503)

Designation of Course	**Renewable Energy Technology**		
Teaching Scheme :	**Examination Scheme**		**Credits Allotted**
Theory: 03 Hours/ Week	Semester End Examination	60 Marks	03
Tutorial: - -- Hours/ Week	Internal Assessment	40 Marks	
Practical: - Hours/ Week	Term Work	-- Marks	-
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**03**

Course Prerequisites:	The students should know of 1. Mechanical Engineering System. 2. Thermodynamic principles 3. Thermodynamic Applications 4. Power Plant Technology
Course Objectives:	1. To explain the concepts of Non-renewable energy systems 2. To outline the utilization of renewable energy sources for both domestic and industrial applications 3. To analyze the environmental and cost economics of renewable energy sources in comparison with fossil fuels.
Course Outcomes:	On completion of the course, students will be able to– 1. Explain the fundamental principles of solar energy and its utilization. 2. Describe the construction and working of solar power systems and analyze their performance under different operating conditions. 3. Explain the principles of wind energy technology and evaluate the performance of wind energy systems. 4. Describe the fundamentals of biogas and biomass energy systems and analyze their operational performance. 5. Compare different renewable energy technologies and assess their performance and suitability for various applications. 6. Explain the construction and working of energy storage technologies and evaluate their applicability in renewable energy systems.

Course Contents

Unit I	**Fundamentals of Solar Energy**	**(06 Hrs.)**
Principle of conversion of solar radiation into heat, Applications of solar energy, Collectors used for solar thermal conversion: Flat plate collectors and Concentrating collectors, Solar Thermal Power Plant, Solar Pond, Solar cookers, Solar hot water systems, Solar dryers, Solar Distillation, Solar greenhouses.		
Unit II	**Solar Energy Technology**	**(06 Hrs.)**
Conversion of Solar energy into Electricity - Photovoltaic Effect, Solar photovoltaic cell and its working principle, Different types of Solar cells, Series and parallel connections, Photovoltaic applications: Battery chargers, domestic lighting, street lighting, and water pumping.		
Unit III	**Wind Energy Technology**	**(06 Hrs.)**
Power from wind, site selection, characteristics of the wind, wind energy conversion systems and their classification, construction and working of a typical wind mill, design considerations for wind mills, social and environmental considerations, and present status.		
Unit IV	**Bio-Energy Technology**	**(06 Hrs.)**

Importance of biogas technology, Different Types of Biogas Plants. Aerobic and anaerobic bioconversion processes, various substrates used to produce Biogas, Removal of CO_2 and H_2O, Application of Biogas in domestic, industrial, and vehicles.
Biomass Energy: Introduction, Photosynthesis Process, Biomass Resources, Biomass conversion technologies -fixed dome, Biomass gasification, Conversion of Biogas to Bio CNG

Unit V	**Other Renewable Technologies**	**(06 Hrs.)**

Ocean Thermal Energy Conversion: Introduction, Working principle, Resource and site requirements, Location of OTEC system, Electricity generation methods from OTEC, Advantages and disadvantages, Applications of OTEC.
Tidal Energy - Introduction, Origin and nature of tidal energy, Basic principle of tidal power generation, Components of tidal power plants, Tidal energy technology, Advantages and limitations.
Introduction to Hydroelectric Power Plant- Introduction, types, system components of Small Hydro Power Systems.

Unit VI	**Energy Storage Technologies**	**(06 Hrs.)**

Pumped Hydroelectric Storage, Compressed Air Energy Storage, Battery Technologies - Traditional and Advanced, Flywheels, Fuel cell: Principle of working, various types – construction and applications. Superconducting Magnetic Energy Storage, Super-capacitors/Ultra-capacitors.

Term Work

1. Study of the national and global renewable energy scenario.
2. To perform an analysis of the solar power system.
3. Case Studies on Solar Power Systems.
4. To perform an analysis of the Wind power system.
5. Determination of characteristics of a wind generator.
6. Measurement of I-V characteristics of a solar cell.
7. Study the effect of input light intensity on the performance of the solar cell.
8. Study of Energy Storage Technologies.
9. Study of Horizontal and Vertical-axis windmill.
10. Study of Biogas/ Biomass Plant.
11. Study of Tidal Power/ Ocean Power Plant.
12. Visit to Wind Power/ Solar Power Plant.
13. Visit to Biogas Plant

Project-Based Learning

Following is the list of Topics for project-based learning (Not Limited to) based on the syllabus Contents:

1. To prepare a demonstration model of a Solar Power System
2. To prepare a demonstration model of Small Hydro Power Systems
3. To prepare a demonstration model of a Wind power system
4. To prepare a demonstration model of the Biomass Energy system
5. To prepare a demonstration model of a Biogas system
6. To prepare a demonstration model of a Fuel cell system
7. To prepare a demonstration model of Energy Storage Technologies
8. Case study on Small Hydro Power Systems
9. Case study on Solar Power System
10. Case study on Wind power system
11. Case study on Biomass Energy
12. Case study on Biogas system
13. Case study on Fuel cell system
14. Case study on Ocean Thermal Energy
15. Case study on Tidal Energy

Text Books:

1. Felix A. Farret, M. Godoy Simoes, Integration of Alternative Sources of Energy, John Wiley and Sons, 2006.
2. Solanki: Renewable Energy Technologies: Practical Guide for Beginners, PHI Learning Pvt. Ltd., 2008.

Reference Books:

1. Solar Energy Principles, Thermal Collection & Storage, S. P. Sukhatme: Tata McGraw Hill Pub., New Delhi.
2. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw-Hill Pub., 2009.
3. Non-Conventional Energy Resources by Shobh Nath Singh, Pearson India, 2016.
4. Solar Cells: From Materials to Device Technology edited by S. K. Sharma, Khuram Ali, Springer (2020)
5. D. Mukherjee: Fundamentals of Renewable Energy Systems, New Age International Publishers, 2007.
6. Remus Teodorescu, Marco Liserre, Pedro Rodriguez: Grid Converters for Photovoltaic and Wind Power Systems, John Wiley and Sons, 2011.
7. Gilbert M. Masters: Renewable and Efficient Electric Power Systems, John Wiley and Sons, 2004.
8. Non-Conventional Energy Sources, G. D. Rai, New Delhi.
9. Renewable Energy, Power for a sustainable future, Godfrey Boyle,2004,
10. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw-Hill Pub.,2009.
11. Fundamentals of Renewable Energy Resources by G.N.Tiwari, M.K.Ghosal, Narosa Pub., 2007.
12. Rational Design of Solar Cells for Efficient Solar Energy Conversion edited by Alagarsa My Pandikumar, Ramasamy Ramaraj, Wiley (2018).
13. Energy fables, Edited by edited by Jenny Rinkinen, Elizabeth Shove, Jacopo Torriti, Routledge, a T&F group, (2019).

Unit Test–

Unit Test-I	Unit I, II, III

COMPUTER INTEGRATED MANUFACTURING

(Course Code: MJ1111504)

Designation of Course	**Computer-Integrated Manufacturing**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03 Hours/ Week	Semester End Examination	60 Marks	03
Tutorial:- --Hours/ Week	Internal Assessment	40 Marks	
Practical:- 02 Hours/ Week	Term Work	25 Marks	01
	Oral/~~Practical~~	25 Marks	
	Total	**150 Marks**	**04**

Course Prerequisites: -	The student should have basic knowledge of 1. Manufacturing Processes.
Course Objectives: -	1. To acquire the knowledge of Machining Processes and CNC technology. 2. To acquire the knowledge of Additive manufacturing processes and Computer integration for Manufacturing. 3. To acquire the knowledge of Flexible Manufacturing Systems and Computer-Aided Process Planning.
Course Outcomes: -	The students should be able to– 1. Explain various manufacturing processes and apply them to produce engineering components. 2. Develop CNC programs and implement them for the manufacturing of components. 3. Classify different Additive Manufacturing processes and utilize them to create prototype and functional parts. 4. Analyze the role of computer integration in manufacturing and apply these concepts to improve production systems. 5. Describe the components and working of Flexible Manufacturing Systems (FMS) and evaluate their applicability in modern manufacturing. 6. Explain the principles of Computer-Aided Process Planning (CAPP) and apply them to plan efficient manufacturing operations.

Course Contents

Unit I	**Machining Processes**	**(06 Hrs.)**
Mechanical Processes: Ultrasonic machining (USM), Abrasive Jet Machining (AJM), Water Jet machining (WJM), Abrasive water Jet Machining (AWJM) processes-Process principle and mechanism of material removal, Process Parameters; Applications; Operational characteristics; Limitations. **Electro Chemical Processes:** Electrochemical Machining Process (ECM) principle; Mechanism of material removal; Process Parameters; Process Capabilities; Applications, Tool Design, Electro Chemical Deburring (ECDE). **Thermal Processes:** Electro discharge Machine (EDM), Wire Electro Discharge Machining (WEDM), Laser Beam Machining (LBM),Electron Beam Machining (EBM), Plasma Arc machining (PAM) processes–Process principle and mechanism of material removal; Process parameters and characteristics; Surface finish and accuracy, Applications; Limitations.		
Unit II	**CNC Technology**	**(06 Hrs.)**

Evolution of CNC Technology, principles, features, advantages, applications, CNC and DNC concept, classification of CNC Machines – turning Centre, machining Centre, CNC controllers, characteristics, interpolators– Computer Aided Inspection, CNC Programming: Coordinate system, structure of a part program, G & M Codes, tool length compensation, cutter radius and tool nose radius compensation, do loops, subroutines, canned cycles, mirror image, parametric programming, machining cycles, programming for the machining Centre and the turning Centre for a well-known controllers such as Fanuc, Siemens. Introduction to CMM.

Unit III	**Additive Manufacturing**	**(06 Hrs.)**

Introduction to Additive Manufacturing (AM): Need for Additive Manufacturing, Generic AM process, Distinction between AM and CNC, Classification of AM Processes, Steps in AM process, Advantages of AM, Major Applications.

Vat Photo polymerization AM Processes: Stereo lithography (SL), Materials, SL resin curing process, Micro-stereo lithography, Process Benefits and Drawbacks, Applications of Photo polymerization Processes.

Extrusion-Based AM Processes: Fused Deposition Modelling (FDM), Principles, Materials, and Plotting and Path Control, Bio-Extrusion, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes.

Unit IV	**Computer-Integrated Manufacturing**	**(06 Hrs.)**

Manufacturing Systems: Concept Objectives, Types and Trends; Concepts of Mechanization, Automation and Integration. Concept of CAD/CAM and CIMS; Software Technology for CIM System: Business Database System: File processing, Data Processing and Database Design, File Organization and Relational Analysis; Decision Support System, Personal/Distributed Computing and Local Area Network.

Unit V	**Flexible Manufacturing Systems**	**(06 Hrs.)**

Fundamentals of Group Technology and Flexible Manufacturing Systems, types of FMS, FMS components, Material handling and storage system, applications, benefits, computer control systems, FMS planning and design issues, Automated Storage and Retrieval Systems, AS/RS, and Automatic parts identification systems and data capture.

Unit VI	**Computer-Aided Process Planning**	**(06 Hrs.)**

Process Planning and Production Planning, manual experience-based planning, Decision table and decision trees, Process capability analysis, Variant and Generative process planning approach, Process planning systems like CAM-I, CAPP, MIPLAN, APPAS, AUTOPLAN, and PRO, CPPP. Introduction to total integrated process planning systems.

Term Work

1. Study and demonstration of the EDM Machine.
2. Study and demonstration of the ECM Machine.
3. Manual part programming using G and M codes for turning, Step turning, Taper turning, and turning facing.
4. Manual part programming using G and M codes for Drilling.
5. Component to be manufactured on a CNC machine.
6. CNC Milling program involving linear motion and circular interpolation.
7. A study on the group technology method utilized in FMS
8. Measurements of geometric parameters of parts using a Coordinate Measuring Machine (CMM).
9. Manufacturing of Component using Additive Manufacturing Technique
10. Generating G and M code using Delcam and Mastercam

11. Simulation of Tool using Delcam and Mastercam.

Textbooks:

1. P. C. Sharma, Production Engineering, S. Chand Publications
2. R. K. Jain, Production Technology, Khanna Publishers

Reference Book

1. P. N. Rao, Manufacturing Technology- Vol 1, McGraw-Hill Education (India) Private Limited
2. P. N. Rao, Manufacturing Technology, Vol- II, McGraw-Hill Education (India) Private Limited
3. Tai ran Hsu, "MEMS & Microsystem: Design & Manufacture", Tata McGraw Hill Publisher, 2002.
4. B. S. Raghuwanshi, Workshop Technology, Vol-II, Dhanpat Rai & Co.
5. Julian W. Gardner & Vijay K. Varadan, "Microsensors, MEMS and smart Devices", John Wiley & Sons, 2001.
6. Roy A. Lindberg, Process & Materials of Manufacture, PHI
7. E. P. DeGrmo, J. T. Black, and A. Kosher, Material and processes in manufacturing, PHI
8. HMT Handbook, Production Technology, TMH
9. Ian Gibson, David W Rosen, Brent Stucker. "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer, 2015.
10. PatriK. Venuvinod and Weiyin Ma, "Rapid Prototyping: Laser-based and Other Technologies", Springer, 2004.
11. S. R. Deb. "Robotics", Tata McGraw-Hill Publishing Co. Ltd., ISBN 0-07-460090-
12. M. P. Grover, M. Weiss, R. N. Nagel, N. G. Odrey, "Industrial Robotics Technology", ISBN 0-07-100442-
13. Computer Integrated Manufacturing and Engineering- U.Rembold, Addison-Wesley Publishers, 1993 edition.
14. Quick Responsive Manufacturing – Rajan Suri, Productivity Press, 1998.
15. Principles of computer-integrated manufacturing- S Kant Vajpayee, PHI Learning Private Limited, New Delhi, 2012.

Project-Based Learning:

Following is the list of topics for project-based learning (Not Limited to) based on the syllabus contents:

1. Make a Working model of non-conventional machining processes
2. To show the use of the controller for CNC applications
3. Select an Industrial drawing, prepare a CNC program, and implement it on the CNC.
4. Make a Prototype Model for a Tool Changer for CNC.
5. Make a Prototype Model for Clamping and decamping of the job on the CNC
6. Make a model using additive Manufacturing
7. Prepare a process plan for the industrial component
8. Make a model for an automated storage and retrieval system
9. Prepare the system for automatic part identification and data capture
10. Prepare Process Plan for industrial components.

Unit Test–

Unit Test-I	Unit I, II, III

MACHINE DESIGN AND ANALYSIS-II

(**Course** Code: MJ1111505)

Designation of Course	**Machine Design and Analysis-II**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory:- 03 Hours/ Week	Semester End Examination	60 Marks	04
Tutorial:- 01 Hours/ Week	Internal Assessment	40 Marks	
Practical:- - Hours/ Week	Term Work	- Marks	-
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**04**

Course Prerequisites: -	The students should have knowledge of 1. Computer-Aided Drafting and Visualization 2. Computer-Aided Machine Drawing 3. Strength of Machine Components 4. Machine Design and Analysis-I
Course Objectives: -	1. To study basic concepts of the design of machine elements. 2. Impart design skills to the students to apply these skills to the problems in real-life industrial applications. 3. To enable students to attain the basic knowledge required to understand, analyze, design, and select the machine elements required in
Course Outcomes: -	The student should be able to – 1. Design spur gears by applying fundamental gear design principles to solve engineering problems. 2. Design helical gears for specified operating conditions using standard design procedures. 3. Analyze and design bevel gears and worm gear systems for practical engineering applications. 4. Evaluate rolling contact bearings and select appropriate bearings from manufacturers' catalogues based on load and life requirements. 5. Design sliding contact bearings for industrial applications, considering performance and operating constraints. 6. Design belt drive systems and select suitable belts, ropes, and chains for various power transmission applications.

Course Contents

Unit I	**Design of Spur Gears**	**(08 Hrs.)**
Introduction to gears: Gear Selection, material selection, Basic modes of tooth failure, Gear Lubrication Methods, Introduction to Gear design standards like AGMA, IS. **Spur Gears:** Number of teeth and face width, Force analysis, Beam strength (Lewis) equation, Velocity factor, Service factor, Load concentration factor, Effective load on gear, Wear strength (Buckingham's) equation, Estimation of module based on beam and wear strength, Estimation of dynamic tooth load by velocity factor and Buckingham's equation, Micro geometry and its impact		
Unit II	**Design of Helical Gears**	**(08 Hrs.)**
Transverse & normal module, virtual number of teeth, Force analysis, Beam & wear strength, Effective load on gear tooth, Estimation of dynamic load by velocity factor, Spott's equation, Buckingham's equation. (No numerical on force analysis of helical Gear)		
Unit III	**Design of Bevel Gears and Worm Gears**	**(08 Hrs.)**

Bevel Gears-Introduction, Terminology, Virtual number of teeth, and force analysis of Straight Bevel Gear. Design of Straight Bevel Gear based on Beam Strength, Wear Strength, and estimation of effective load based on Velocity factor (Barth factor) and Buckingham's equation. **Worm Gears**–Introduction, terminology and proportions of worm and worm gears, Force analysis of worm gear drives, Friction in Worm gears, efficiency of worm gears, Strength and wear ratings of worm gears gears (Bending stress factor, speed factor, surface stress factor, zone factor)		
Unit IV	**Rolling Contact Bearing**	**(08 Hrs.)**
Equivalent bearing load, Load life relationship, Selection of bearing life, Selection from manufacturer's catalogue, Design for cyclic load & speed, Bearing with probability of survival other than 90%, Lubrication & mounting, construction materials, Selection of oil seals & gaskets, Types of failure of bearings and their remedies. Taper roller bearing: Force analysis and selection criteria. (Theoretical Treatment only)		
Unit V	**Sliding Contact Bearing**	**(08 Hrs.)**
Basic modes for lubrication, Viscosity, Effect of temperature on viscosity, Viscosity index, Additives, Greases, and Selection of lubricants. Viscous flow through rectangular slot, Load carrying capacity & flow requirement of hydrostatic step bearing, Energy losses, Hydrodynamic lubrication, Reynolds equation, Summerfield number, Raimondi & Boyd's method, Parameters of bearing design, Length to diameter ratio, Unit bearing pressure, Radial clearance, Minimum oil film thickness, Constructional details of bearings, Bearing materials & their selection, Comparison of rolling& sliding contact bearing.		
Unit VI	**Belt, Rope, and Chain Drives**	**(08 Hrs.)**
Belt drive: Materials and construction of flat and V belts, geometric relationships for length of belt, power rating of belts, concept of slip & creep, initial tension, effect of centrifugal force, maximum power condition, Selection of Flat and V-belts from manufacturer's catalogue, belt tensioning methods, relative advantages and limitations of Flat and V- V-belts, **Wire Ropes** (Theoretical Treatment Only): Construction of wire ropes, lay of wire rope, stresses in wire rope, and selection of wire ropes. **Chain Drives** (Theoretical Treatment Only): Types of chains and their Geometry, selection criteria for chains drive, Polygon effect of chain, Modes of failure for chain, Lubrication of chains		

Term work

Term work shall consist of the following experiments. Hand calculations must be confirmed through a computer programme using any programming language.

1. Design Project on a single-stage Spur gearbox design
2. Design of a single-stage helical Gearbox
3. Calculation of the module for the bevel gear
4. Calculation of the module for the worm gear
5. Selection of Bearing by using the manufacturer's catalogue
6. Calculation of belt drive parameters

Assignment

Numerical and/or theory questions on the following topics from previous year question papers of GATE/ESE Mechanical Engg. Examinations.

1. Spur Gears, Helical Gears, Bevel and Worm Gears, Rolling Contact Bearing
2. Sliding Contact Bearing, Belt, Rope, and Chain Drive

Note: The Design Data Book should be used extensively.Project-Based Learning

Following is the list of topics for project-based learning (Not Limited to) based on the syllabus contents:

1. To develop an Industrial/real-life application demonstration model of different types of Gears.

2. To develop a demonstration model for any practical applications where spur gears are used.
3. To design the gearbox for wind windmill application.
4. To design the in-line gearbox for an Automobile application
5. To design the gearbox for building an Elevator.
6. To design the gearbox for building a Hoist.
7. To design the gearbox for the Worm gearbox for the Sugar Industry.
8. To develop a demonstration model for any one practical application where helical gears are used.
9. To develop a demonstration model for any one practical application where bevel gears are used.
10. To develop a demonstration model for any one practical application where worm and worm gears are used.
11. To observe the mechanical system where transmission of power or motions takes place through gears, like the Transmission of power from the motor to the pump/generator/lathe machine/drilling machine. By selecting suitable materials, design the gears. To prepare a design report and assembly drawing indicating overall dimensions, tolerances, and surface finish. Also, to prepare a bill of materials using any CAD software.
12. To develop demonstration models of different types of bearings.
13. Case study on Selection of Bearing from Manufacturer's Catalog.
14. Case study Mounting of machine elements on transmission shaft (like Bearings, gears, pulleys, sprockets, etc).
15. To observe the mechanical system where different types of bearings are used. By selecting suitable materials, design a sliding contact bearing. To prepare a design report and assembly drawing indicating overall dimensions, tolerances, and surface finish. Also, to prepare a bill of materials using any CAD software.

Textbooks

1. V. B. Bhandari, "Design of Machine Elements", Tata McGraw-Hill Publication Co. Ltd.
2. R. S. Khurmi And J.K. Gupta, "Machine Design", S Chand Publication.
3. Shigley J. E. and Mischke C. R., "Mechanical Engineering Design", McGraw-Hill Publication Co. Ltd.
4. Spotts M. F. and Shoup T.E., "Design of Machine Elements", Prentice Hall International.

Reference Books

1. Black, P.H. and O. Eugene Adams, "Machine Design", McGraw-Hill Book Co., Inc.
2. Willium C. Orthwein, "Machine Components Design", West Publishing Co. and Jaico Publications House.
3. Hall A. S., Holowenko A. R., and Laughlin H. G., "Theory and Problems of Machine Design", Schaum's Outline Series.
4. Sharma C. S. and Purohit Kamlesh, "Design of Machine Elements", PHI Learning Pvt. Ltd.
5. D. K. Aggarwal & Sharma P. C., "Machine Design", S.K. Kataria and Sons
6. Gope P. C., "Machine Design: Fundamentals and Applications", PHI Learning Pvt. Ltd.
7. "Design Data- P.S.G." College of Technology, Coimbatore.
8. V. B. Bhandari, "Design Data Book", Tata McGraw-Hill Publication Co. Ltd.

Unit Test–

Unit Test-I	Unit I, II, III

SBC-V: COMPUTER-ORIENTED NUMERICAL METHODS

(Course Code: MJ1111506)

Designation of Course	**Computer-Oriented Numerical Methods**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory:- -- Hours/ Week	Semester End Examination	-- Marks	--
Tutorial:- -- Hours/ Week	Internal Assessment	-- Marks	
Practical:- 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	25 Marks	
	Total	**50 Marks**	**01**

Course Prerequisites:-	The students should know of 1. Basic Mathematics 2. Programming Language
Course Objectives:-	1. The goal of the course is for students should develop techniques for problem-solving using a numerical method.
Course Outcomes:-	On completion of the course, students will be able to: 1. Determine the roots of single-variable nonlinear equations using appropriate numerical methods. 2. Solve systems of simultaneous linear equations using direct and iterative numerical techniques. 3. Apply curve-fitting methods to obtain empirical equations that best represent the given data. 4. Estimate unknown values of a function using interpolation techniques. 5. Evaluate definite and indefinite integrals of functions using numerical integration methods. 6. Compute approximate solutions to ordinary differential equations (ODEs) using suitable numerical approaches.

Course Contents

Experiment No I	**Roots of equations**	**(04 Hrs.)**
Bracketing methods-Bisection and False Position method		
Experiment No II	**Linear Algebraic Equation:**	**(04 Hrs.)**
Naive Gauss elimination, pitfalls of Gauss Elimination, techniques of improving solutions		
Experiment No III	**Curve Fitting:**	**(04 Hrs.)**
Least-Squares Regression-Linear regression		
Experiment No IV	**Interpolation**	**(04 Hrs.)**
Newton's Forward and Backward Interpolation		
Experiment No V	**Numerical Integration**	**(04 Hrs.)**
Trapezoidal rule, Simson's 1/3 and 3/8 rule		
Experiment No VI	**Ordinary Differential Equations**	**(04 Hrs.)**
Ordinary Differential Equations: Euler's method		

Term work shall consist of any eight programs described in the syllabus and listed below.

1. Program on Bisection Method
2. Program on False Position Method
3. Program on the Gaussian Method
4. Program on Curve fitting by the least square method
5. Program on Newton’s Forward Method
6. Program on Newton’s Backward Method

7. Program on Trapezoidal Rule
8. Program on Simpson's 1/3 rule
9. Program on Simpson's 3/8 rule
10. Program on Euler's Method.

Textbooks/ Reference Books

1. Numerical Methods for Engineers, Steven Chapra and Raymond Canale, McGraw-Hill
2. Ordinary Differential Equations**:** Euler's method, improvement of Euler's method, Runge-Kutta method, system of equations, B. S. Garewal, Khanna Publisher
3. Numerical Recipes: The art of scientific computing, William H Press, Cambridge University Press

ENVIRONMENTAL STUDIES (Course Code: AC1102507)					
TEACHING SCHEME		**EXAMINATION SCHEME**		**CREDITS SCHEME**	
Lectures :	4 Hours /Week	Semester End Examination	60 marks		
		Internal Assessment:	40 marks		
Total	4 Hours /Week	Total:	100 Marks	Total:	4

Course Prerequisites:

The students should have basic Knowledge of environmental studies.

Course Objectives:

Environmental studies are an interdisciplinary field that integrates physical, chemical, and biological sciences with the study of the environment. It provides an integrated, qualitative, and multidisciplinary approach for environmental systems & gives an insightful solution to ecological problems.

Course Outcomes:

1. Explain the historical evolution of human interactions with the environment and its impact on societal development.
2. Interpret the concept of natural resources and classify their types, distribution, and utilization with a special focus on India.
3. Analyze major environmental issues and demonstrate a critical understanding of their causes and consequences.
4. Explain the fundamental concepts of ecosystems and biodiversity and discuss various conservation strategies.
5. Identify different types of pollution, explain their sources, and evaluate their effects on the environment and human health.
6. Describe the science behind climate change and examine global and national response measures for mitigation and adaptation.
7. Explain the broad components of Environmental Management Systems (EMS) and illustrate their relevance in sustainable development.
8. Discuss major international environmental treaties and evaluate India's position and responses to these agreements.

UNIT-I **(4 Hours)**

Humans and the Environment: - The man-environment interaction: Humans as hunter-gatherers; Mastery of fire; Origin of agriculture; Emergence of city-states; Great ancient civilizations and the environment, Indic Knowledge and Culture of sustainability; Middle Ages and Renaissance; Industrial revolution and its impact on the environment; Population growth and natural resource exploitation; Global environmental change. Environmental Ethics and emergence of environmentalism: Anthropocentric and eco-centric perspectives (Major thinkers); The Club of

Rome- Limits to Growth; UN Conference on Human Environment 1972; World Commission on Environment and Development and the concept of sustainable development; Rio Summit and subsequent international efforts.

UNIT-II	**(4 Hours)**

Natural Resources and Sustainable Development: - Overview of natural resources: Definition of resource; Classification of natural resources- biotic and abiotic, renewable and non-renewable. Biotic resources: Major types of biotic resources- forests, grasslands, wetlands, wildlife, and aquatic (fresh water and marine); Microbes as a resource; Status and challenges. Water resources: Types of water resources- fresh water and marine resources; Availability and use of water resources; Environmental impact of over-exploitation, issues and challenges; Water scarcity and stress; Conflicts over water. Soil and mineral resources: Important minerals; Mineral exploitation; Environmental problems due to the extraction of minerals and their use; Soil as a resource and its degradation. Energy resources: Sources of energy and their classification, renewable and non-renewable sources of energy; Conventional energy sources- coal, oil, natural gas, nuclear energy; non-conventional energy sources- solar, wind, tidal, hydro, wave, ocean thermal, geothermal, biomass, hydrogen and fuel cells; Implications of energy use on the environment. Introduction to sustainable development: Sustainable Development Goals (SDGs)- targets and indicators, challenges and strategies for SDGs**.**

UNIT-III	**(4 Hours)**

Environmental Issues: Local, Regional and Global: - Environmental issues and scales: Concepts of micro, meso-, synoptic and planetary scales; Temporal and spatial extents of local, regional, and global phenomena. Pollution: Impact of sectoral processes on the Environment; Types of Pollution- air, noise, water, soil, thermal, radioactive; municipal solid waste, hazardous waste; transboundary air pollution; acid rain; smog. Land use and Land cover change: land degradation, deforestation, desertification, urbanization. Biodiversity loss: past and current trends, impact. Global change: Ozone layer depletion; Climate change. Disasters – Natural and Man-made (Anthropogenic).

UNIT-IV	**(4 Hours)**

Conservation of Biodiversity and Ecosystems: - Biodiversity and its distribution: Biodiversity as a natural resource; Levels and types of biodiversity; Biodiversity in India and the world; Biodiversity hotspots; Species and ecosystem threat categories. Ecosystems and ecosystem services: Major ecosystem types in India and their basic characteristics- forests, wetlands, grasslands, agriculture, coastal and marine; Ecosystem services- classification and their significance. Threats to biodiversity and ecosystems: Land use and land cover change; Commercial exploitation of species; Invasive species; Fire, disasters, and climate change. Major conservation policies: in-situ and ex-situ conservation approaches; Major protected areas; National and International Instruments for biodiversity conservation; the role of traditional knowledge, community-based conservation; Gender and conservation.

UNIT-V	(4 Hours)
Environmental Pollution and Health: - Understanding pollution: Production processes and generation of wastes; Assimilative capacity of the environment; Definition of pollution; Point sources and non-point sources of pollution. Air pollution: Sources of air pollution; Primary and secondary pollutants; Criteria pollutants- carbon monoxide, lead, nitrogen oxides, ground-level ozone, particulate matter and sulphur dioxide; Other important air pollutants- Volatile Organic compounds (VOCs), Peroxyacetyl Nitrate (PAN), Polycyclic aromatic hydrocarbons (PAHs) and Persistent organic pollutants (POPs); Indoor air pollution; Adverse health impacts of air pollutants; National Ambient Air Quality Standards. Water pollution: Sources of water pollution; River, lake, and marine pollution, groundwater pollution; water quality, Water quality parameters and standards; adverse health impacts of water pollution on human and aquatic life. Soil pollution and solid waste: Soil pollutants and their sources; Solid and hazardous waste; Impact on human health. Noise pollution: Definition of noise; Unit of measurement of noise pollution; Sources of noise pollution; Noise standards; adverse impacts of noise on human health. Thermal and Radioactive pollution: Sources and impact on human health and ecosystems.	
UNIT-VI	**(4 Hours)**
Climate Change: Impacts, Adaptation and Mitigation:– Understanding climate change: Natural variations in climate; Structure of atmosphere; Anthropogenic climate change from greenhouse gas emissions– past, present and future; Projections of global climate change with special reference to temperature, rainfall, climate variability and extreme events; Importance of 1.5 °C and 2.0 °C limits to global warming; Climate change projections for the Indian sub-continent. Impacts, vulnerability and adaptation to climate change: Observed impacts of climate change on ocean and land systems; Sea level rise, changes in marine and coastal ecosystems; Impacts on forests and natural ecosystems; Impacts on animal species, agriculture, health, urban infrastructure; the concept of vulnerability and its assessment; Adaptation vs. resilience; Climate-resilient development; Indigenous knowledge for adaptation to climate change. Mitigation of climate change: Synergies between adaptation and mitigation measures; Green House Gas (GHG) reduction vs. sink enhancement; Concept of carbon intensity, energy intensity and carbon neutrality; National and international policy instruments for mitigation, decarbonizing pathways and net zero targets for the future; Energy efficiency measures; Renewable energy sources; Carbon capture and storage, National climate action plan and Intended Nationally Determined Contributions (INDCs); Climate justice.	
UNIT-VII	**(4 Hours)**
Environmental Management: - Introduction to environmental laws and regulations: Constitutional provisions- Article 48A, Article 51A (g), and other environmental rights derived; Introduction to environmental legislations on the forest, wildlife, and pollution control. Environmental management system: ISO 14001, Concept of Circular Economy, Life cycle analysis, Cost-benefit analysis, Environmental audit and impact assessment, Environmental risk assessment, Pollution control and management; Waste Management- Concept of 3R (Reduce, Recycle and Reuse) and sustainability; Ecolabeling /Ecomark scheme.	

UNIT-VIII	**(4 Hours)**
Environmental Treaties and Legislation :-An overview of instruments of international cooperation; bilateral and multilateral agreements; conventions and protocols; adoption, signature, ratification and entry into force; binding and non-binding measures; Conference of the Parties (COP) Major International Environmental Agreements: Convention on Biological Diversity (CBD); Cartagena Protocol on Biosafety; Nagoya Protocol on Access and Benefit-sharing; Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES); Ramsar Convention on Wetlands of International Importance; United Nations Convention to Combat Desertification (UNCCD); Vienna Convention for the Protection of the Ozone Layer; Montreal Protocol on Substances that Deplete the Ozone Layer and the Kigali Amendment; Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal; Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade; Stockholm Convention on Persistent Organic Pollutants; Minamata Convention on Mercury; United Nations Framework Convention on Climate Change (UNFCCC); Kyoto Protocol; Paris Agreement; India's status as a party to major conventions Major Indian Environmental Legislations: The Wild Life (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Forest (Conservation) Act, 1980; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; The Biological Diversity Act, 2002; The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006; Noise Pollution (Regulation and Control) Rules, 2000; Industry-specific environmental standards; Waste management rules; Ramsar sites; Biosphere reserves; Protected Areas; Ecologically Sensitive Areas; Coastal Regulation Zone; Status phase-out of production and consumption of Ozone Depleting Substances by India; National Green Tribunal; Some landmark Supreme Court judgements Major International organisations and initiatives: United Nations Environment Programme (UNEP), International Union for Conservation of Nature (IUCN),World Commission on Environment and Development (WCED), United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Panel on Climate Change (IPCC), and Man and the Biosphere (MAB) programme.	
UNIT- IX	**(4 Hours)**
Case Studies and Field Work: - The students are expected to be engaged in some of the following or similar identified activities: Discussion on one national and one international case study related to the environment and sustainable development. Field visits to identify local/regional environmental issues, make observations, including data collection and prepare a brief report. Participation in plantation drive and nature camps. Documentation of campus biodiversity. Campus environmental management activities such as solid waste disposal, water Management and sanitation.	
Textbooks	
1. Fisher, Michael H. (2018) An Environmental History of India- From Earliest Times to the Twenty-First Century, Cambridge University Press.	

2. Headrick, Daniel R. (2020). Humans versus Nature- A Global Environmental History, Oxford University Press.

3. John W. Twidell and Anthony D. (2015). Renewable Energy Sources, 3rd Edition, Weir Publisher (ELBS)

4. Harper, Charles L. (2017). Environment and Society, Human Perspectives on Environmental Issues, 6th Edition. Routledge

Reference Books

1 Bawa, K.S., Oomen, M.A. and Primack, R. (2011) Conservation Biology: A Primer for South Asia. Universities Press.

2 Varghese, Anita, Oommen, Meera Anna, Paul, Mridula Mary, Nath, Snehlata (Editors) (2022) Conservation through Sustainable Use: Lessons from India. Routledge.

3 Jackson, A. R., & Jackson, J. M. (2000). Environmental Science: The Natural Environment and Human Impact. Pearson Education.

4 Pittock, Barrie (2009) Climate Change: The Science, Impacts and Solutions. 2nd Edition. Routledge.

B. Tech. Mechanical
Sem.-VI

INTRODUCTION TO CFD AND FEA

(Course Code: MJ1111601)

Designation of Course	**Introduction To CFD And FEA**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03 Hours/ Week	Semester End Examination	60 Marks	03
Tutorial----- Hours/ Week	Internal Assessment	40 Marks	
Practical:- 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	25 Marks	
	Total	**150 Marks**	**04**

Course Prerequisites:-	The students should know of 1. Engineering Mathematics 2. Engineering Mechanics 3. Strength of Materials 4. Heat Transfer 5. Fluid Mechanics 6. Mechanical Vibration
Course Objectives:-	1. Analyze a physical problem 2. Develop finite element procedures for accurately investigating the problem, and effectively perform and document findings. 3. Solve 1D, 2D, and dynamic problems using the Finite Element Analysis approach 4. Impart knowledge to solve complex fluid flow problems using computational fluid dynamics. 5. Familiar with modern trends in computational fluid dynamics
Course Outcomes:-	The students should be able to– 1. Apply the governing equations of fluid flow by analyzing flow physics and the associated mathematical behavior. 2. Generate computational grids and enhance mesh quality using advanced meshing tools and optimization techniques. 3. Formulate appropriate turbulence models and evaluate different turbulence modeling approaches for engineering applications. 4. Apply the Rayleigh–Ritz, Galerkin, and Weighted Residual Methods to solve engineering problems and **justify** the role and significance of shape functions in finite element formulations. 5. Interpret the formulation of element stiffness matrices and load vectors using the potential energy approach for 1D and 2D finite element problems. 6. Derive shape functions for bar, rectangular, and higher-order elements and apply numerical methods for numerical integration and evaluation of eigenvalues and eigenvectors for stepped bar and beam systems.

Course Contents

Unit I	**Governing Equations & Numerical Methods in CFD**	**(06 Hrs.)**
Philosophy of CFD, Governing equations of fluid dynamics viz.Continuity, Momentum (Navier Stokes, Energy Equations.Physical meaning of governing equations, Simple CFD techniques Introduction to FVM and FDM. Higher order methods, Implicit and explicit methods, Steady and transient solutions.		

Unit II	**Meshing in CFD**	**(06 Hrs.)**
Types of Mesh elements, 2D and 3D meshing: Tet., pyramid, prism, and hex grids, using various elements in combination. Parameters affecting mesh quality, mesh smoothing algorithms, and grid clustering. Adaptive, Moving, and Hybrid Grids: Need for adaptive and moving grids. Mesh independency.		
Unit III	**Introduction to Turbulence Modeling**	**(06 Hrs.)**
Introduction and background of Turbulence Modeling, Algebraic models, One equation models, Two equation models, Near wall treatment, Reynolds stress models.		
Unit IV	**Introduction to FEA**	**(06 Hrs.)**
Introduction to FEM, Stress-strain relations, shape functions- linear and quadratic, Triangular, Quadrilateral, Higher order elements, Variational methods of approximation-Rayleigh Ritz Method, Methods of Weighted Residuals-Least Square Method, Subdomain Method, Collocation Method, Garlekin's method.		
Unit V	**One-Dimensional Problems**	**(06 Hrs.)**
Finite element modeling, Convergence of results, Potential energy approach, Global stiffness matrix, properties of stiffness matrix, load vector, Penalty approach, Elimination approach, Finite Element Analysis of 2-D truss structure and Constant strain triangle.		
Unit VI	**Isoparametric Elements**	**(06 Hrs.)**
Isoparametric formulation – Natural Co-ordinate system, Lagrangian interpolation polynomials, Isoperimetric element, Numerical Integration Newton Cotes formula, Gauss Quadrature formula in two and three dimensions, triangular elements, rectangular elements. Dynamic Analysis, Formulation of Dynamic problems, Consistent and Lumped Mass Matrices. Solution of Eigenvalue Problems. Transformation Method, Jacobi Method, Vector Iteration Method, Subspace Iteration Method.		

Term Work

The term work shall consist of

1. Four computer program assignments to be developed for FEA. (Using any programming language.)
2. Two assignments on structural and modal analysis using FEA Software
3. Two assignments on fluid flow analysis using CFD software.
4. Two assignments on solid thermal analysis using CFD software.
5. Two assignments on structural plus thermal analysis using CFD software.

Text Books/ Reference Books

1. K. J. Bathe, “Finite Element Procedures”, PHI
2. R. D. Cook, D. S. Malus, M. E. Plesha, “Concepts and Applications of Finite Element Method Analysis”, John Wiley
3. J. N. Reddy, “An Introduction to Finite Element Method Analysis”, MGH

4. Desai & Abel, “Introduction to Finite Element Methods”
5. D. L. Logan, “A course in the Finite Element Method”, Third Edition, Thomson Learning
6. T. R. Chandrupatia, A. D. Belegundu, “Introduction to Finite Elements in Engineering”, Third Edition, PHI
7. John D. Anderson, “Computational Fluid Dynamics: The Basics with Applications”, McGraw-Hill, 1995
8. V. V. Ranade, “Computational Flow Modeling for Chemical Reactor Engineering”, Process Engineering Science, Volume 5, 2001
9. Patrick Knupp and Stanly Steinberg, “Fundamentals of Grid Generation”, CRC Press, 1994
10. D. C. Wilcox, “Turbulence Modelling for CFD”, 1993
11. Pieter Wesseling, “An Introduction to Multigrid Methods”, John Wiley & Sons, 1992
12. J. F. Thompson, Z. U., A. Warsi and C. W. Mastin, “Numerical Grid Generation: Foundations and Applications”, North Holland, 1985
13. S. V. Patankar, “Numerical Heat Transfer and Fluid Flow”, McGraw-Hill,1981
14. Thomas B. Gatski, M. Yousuff Hussaini, John L. Lumley, “Simulation and Modelling of Turbulent Flows”, Eds., Oxford University Press, 1996
15. Laney, C. B., “Computational Gas Dynamics”, Cambridge Uni. Press, 1998

Project-Based Learning

Following is the list of topics for project-based learning (Not Limited to) based on the syllabus contents:

1. Structural analysis of any mechanical component.
2. Thermal analysis of any mechanical component.
3. Modal analysis of any mechanical component.
4. Heat transfer & fluid flow analysis using various models

Unit Test–

Unit Test-I	Unit I, II, III

INDUSTRIAL AUTOMATION

(Course Code: MJ1111602)

Designation of Course	**Industrial Automation**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03 Hours/ Week	Semester End Examination	60 Marks	03
Tutorial:- --Hours/ Week	Internal Assessment	40 Marks	
Practical:- --Hours/ Week	Term Work	-- Marks	-
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**03**

Course Prerequisites:-	The students should have knowledge of 1. Knowledge of Mathematics, Mechanical Engineering Systems 2. Knowledge of Properties of Fluid 3. Knowledge of Basic Electrical and Electronics
Course Objectives:-	To impart knowledge on 1. Interpret automation technologies and identify advantages, limitations, and applications of the same. 2. Develop the ability to recognize, articulate, and solve industrial problems using automation technologies. 3. To provide students with knowledge of the applications of fluid power systems in process, construction, robotics, and manufacturing industries, and enable them to design and implement automated systems using pneumatics. 4. To make the students acquainted with the conceptual as well as practical knowledge of the PLC programming & latest technologies being used to achieve PLC Industrial Automation.
Course Outcomes:-	The students should be able to– 1. Explain and apply the fundamental principles of industrial automation in basic automation tasks. 2. Analyze the concepts of control systems and apply them to industrial automation applications. 3. Describe the working principles of fluid power systems, power units, and their accessories, and select suitable components for automation needs. 4. Explain the control of fluid power systems and control valves and evaluate their suitability for specific applications. 5. Interpret and apply the concepts of hydraulic and pneumatic actuators and circuits for practical industrial operations. 6. Explain the architecture and functions of PLC, SCADA, HMI, and DCS, and develop ladder logic programs for industrial automation applications.

Course Contents

UNIT I	**Introduction to Industrial Automation and Robotics**	**(06 Hrs.)**
Introduction of Automation and Robotics, Historical Development, three laws of robotics by Isaac Asimov, Broad classes of industrial automation-Fixed, flexible, and programmable, and their comparative study, Automation Principles and Strategies, USA Principle, Ten Strategies for Automation and production systems, Automation Migration Strategy-Manual Production, Automated Production, Automated integrated production.		
UNIT II	**Automatic Control Systems and Control Actions**	**(06 Hrs.)**
Introduction to control systems: mechatronics system & its examples, mechatronics system components. Open loop and closed loop systems, effects of feedback, basic characteristics of feedback control systems, and classification of control systems.		

Introduction to Controllers: Control System Parameters, Controller Modes, Control Actions, Types of Controllers-ON-OFF Controller, Proportional Controller (P-Controller), Proportional + Integral Controller (P-I Controller), Proportional + Derivative Controller (P-D Controller), Proportional + Integral + Derivative Controller (P-I-D Controller), Effect of Proportional, Integral, and derivative control on the Time Response of the System

Control System Components: Elements of a Data Acquisition and Control System, Overview of The Input/Output Process, Data Acquisition Case Studies. Variable Frequency Drive, Servomotor, switches, Relays, and Contactors.

Unit III	**Fundamentals of Industrial Fluid Power Systems**	**(06 Hrs.)**

Fluid Power System: Components of the fluid power system, advantages, and limitations. Difference between electrical, pneumatic, and fluid power systems. Seals, sealing materials. Types of pipes, hoses, and materials. Fluid conditioning through filters, strainers, sources of contamination, and contamination control.

Power units and accessories: Types of power units, reservoir assembly, sizing of reservoirs, constructional details, pressure switches, temperature switches. Accumulators: Types, selection procedure, and applications of accumulators. ISO symbols for hydraulic and pneumatic Components

Unit IV	**Fluid Power Control**	**(06 Hrs.)**

Necessity of fluid control through pressure control, directional control, and flow control valves. Control valves: i) Principle of pressure control valves, direct operated and pilot operated pressure relief valves, pressure reducing valve, sequence valve. ii) Principle of flow control valves, pressure-compensated and non-compensated flow control valves. iii) Principle of directional control valves, types of directional control valves, two-way, three-way, four-way valves, check valve and shuttle valve, Proportional DCV, Servo Valve. Open centre, close centre, tandem centre valves. Actuating devices- manually operated, mechanically operated, solenoid operated, pilot operated, lever operated.

UNIT V	**Hydraulic & Pneumatic Circuits**	**(06 Hrs.)**

Linear and rotary actuators: Types, construction, and characteristics. Cylinder mountings, cushioning of cylinders.

Hydraulic & Pneumatic circuits: Simple reciprocating, regenerative, speed control (meter in, meter out and bleed off), sequencing, synchronization, traverse and feed, automatic reciprocating, fail-safe circuit, counterbalance circuit, actuator locking, unloading circuit, motor breaking circuit, etc. Types of filters, pressure regulators, lubricators, mufflers, dryers, direction control valves, pneumatic actuators, shuttle valve, two-pressure valve, quick exhaust valve, and time delay valves. Speed regulating methods, pneumatic circuits, reciprocating, cascading time delay, etc. Application of pneumatics in low-cost automation and in industrial automation. Case studies on electro-hydraulic circuits and electro-pneumatic circuits.

UNIT VI	**Programmable Logic Controller, SCADA and HMI**	**(06 Hrs.)**

Introduction to PLCs, Basic Structure of a PLC, Principles of Operation, PLC Programming Languages, Ladder diagram, Latching and internal relays, Timers and Counters, Selection of a PLCs and its applications, Architecture of SCADA and its Applications, Need for HMI systems, types of HMI, Distributed Control Systems (DCS), Comparison between SCADA and DCS.

t Books:-

1. Automation, Production Systems and Computer Integrated Manufacturing M.P.Groover, Pearson Education.5th edition, 2009.
2. Majumdar S.R, Pneumatics Systems Principles and Maintenance ,Tata McGraw Hill.
3. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw Hill Publishing Company Ltd., New Delhi.
4. Majumdar S.R, Oil Hydraulic system- Principle and maintenance ,Tata McGraw Hill.
5. Esposito Anthony, Fluid Power with application, Prentice Hall.
6. Stewart H. L, Hydraulics and Pneumatics , Taraporewala Publication.
7. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, "Industrial Robotics:

Technology, Programming and Applications", McGraw Hill Book Company.
8. Pipenger J.J, Industrial Hydraulics, McGraw Hill.

Reference Books:-

1. Automation, Production Systems and Computer Integrated Manufacturing M.P.Groover, Pearson Education.5th edition, 2009.
2. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw Hill Publishing Company Ltd., New Delhi.
3. Stuart A Boyer: SCADA supervisory control and data acquisition, International Society of Automation, 2010.

Project Based Learning

Students have to prepare and submit a demonstration models/charts based on above syllabus

1. The following are the list of project-based learning (Not limited to)
2. To prepare a demonstration model of PID Controller with any application.
3. To prepare a demonstration model of control system applications.
4. To prepare a demonstration model of applications of Fluid power systems.
5. To prepare a demonstration model of applications of electro-hydraulic and electro- pneumatic systems.
6. To prepare a demonstration model of pick and place robot with any application.
7. To prepare a demonstration model of any industrial automation system with PLC programming.

Unit Test–

Unit Test-I	Unit-I, II,III

REFRIGERATION AND AIR CONDITIONING

(Course Code: MJ1111603)

Designation of Course	**Refrigeration and Air Conditioning**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03 Hours/ Week	Semester End Examination	60 Marks	03
Tutorial:- 00Hours/ Week	Internal Assessment	40 Marks	
Practical:- 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	0 Marks	
	Total	**125 Marks**	**04**

Course Prerequisites:-	The students should have knowledge of 1. Fundamentals of Thermodynamics Principles and applications. 2. Fundamentals of Heat Transfer.
Course Objectives	1. To provide the knowledge of basic principles and applications of RAC **2.** Analyze the performance of Refrigeration and A/C systems.
Course Outcomes:-	The students should be able to– 1. Explain the working principles and operating methods of refrigeration systems. 2. Analyze the performance and thermodynamic behavior of a simple vapour compression refrigeration system. 3. Evaluate the operation and efficiency of multi-pressure refrigeration systems used for advanced cooling applications. 4. Analyze various psychrometric processes involved in air-conditioning systems, using psychrometric charts and equations. 5. Identify and describe the key components of refrigeration and air-conditioning systems and their functional roles. 6. Analyze different air distribution systems and assess their suitability for specific air-conditioning applications.

Course Contents

Unit I	**Methods of Refrigeration**	**(06 Hrs.)**
Ice refrigeration, evaporative refrigeration, refrigeration by expansion of air, refrigeration by throttling of gas, vapour refrigeration system, steam jet refrigeration system, refrigeration by using liquid gases, Thermoelectric and ultrasound refrigeration. **Air refrigeration system:** Definition, refrigeration load, unit of refrigeration, Introduction to heat pump, Reverse Carnot cycle, Bell Coleman cycle, Methods of air refrigeration systems, simple air-cooling system, boot strap system, reduced ambient system, regenerative system.		
Unit II	**Simple Vapour Compression Systems**	**(06 Hrs.)**
Limitations of air refrigeration system, development of vapour compressor cycle, effect of operating parameters on VCC, use of P-H charts, actual vapour compression cycle. **Refrigerants** Desirable properties of refrigerants, classification of refrigerants, secondary refrigerants, alternative refrigerants for CFC's, HCFC'S, ozone depletion potential (ODP), Global warming Potential (GWP).		
Unit III	**Multi pressure Vapour compression system, Vapour absorption systems**	**(06 Hrs.)**

Multi Pressure Systems Introduction to multistage compression, two stage compression with flash gas removal, with liquid intercooler, Cascade systems.

Vapour absorption systems Introduction, Simple Vapour absorption system, practical vapour absorption system, COP of an ideal vapour absorption system, Water ammonia system, Electrolux refrigerator, Lithium-Bromide absorption System, Comparison between VCC and VAC (no mathematical treatment).

Unit IV	**Psychrometry and Human comfort**	**(06 Hrs.)**

Introduction, Psychrometric terms, Use of Psychrometric charts, Psychrometric processes, adiabatic saturation temperature, evaporative cooling, by pass factor of coil, efficiency of coil, adiabatic mixing of two air streams, Air washers, Thermodynamics of human body with environment effective temperature, comfort chart, factors influencing human comfort, Different techniques used for improvement of air quality.

Unit V	**Air Conditioning Systems and Components**	**(06 Hrs.)**

Definition, factors, equipment used, classification, all air system, all water system, air water system, unitary and central air conditioning, in filtration and ventilation loads, concepts of SHF, RSHF, ERSHF, ADP.

Compressors, condensers, evaporators, expansion devices such as capillary tubes, automatic expansion valves, thermostatic expansion valves and controls such as thermostats, humidistat, Solenoid, Installation, charging, testing and maintenance, study of modern trends in RAC, Use of IOT in RAC

Unit VI	**Air distribution system**	**(06 Hrs.)**

Introduction, classification of ducts, duct material, pressure in ducts, flow through duct, pressure losses in duct, friction losses, dynamic losses, air flow through simple duct system, equivalent diameter, for determination of duct size

Food Preservation: Cold storage, control and modified atmosphere (CAMA) storages, mobile refrigeration and air conditioning, refrigerant piping selection, pressure drop, valves, fitting, insulating materials.

Term Work

Any ten experiments from the following:

1. Test on Computerized vapour compression test rig
2. Test on Computerized air conditioning test rig
3. Test on Computerized ice plant test rig.
4. Study of non-conventional refrigeration system.
5. Determination of cooling load of air conditioning system (case study).
6. Determination of refrigeration load in cold storage (case study / visit).
7. Study of installation /operation/maintenance practices for refrigeration system.
8. Visit to any refrigeration or air conditioning plant.
9. Trial on Computerized heat pump test rig
10. Test on vapour absorption test rig.
11. Market survey of various components of refrigerating& air conditioning systems.
12. Determination of energy efficiency of refrigeration or air conditioning system.

Reference Books

1. Dossat Ray I, “Principal of Refrigeration”, Wiley Eastern Limited
2. Stocker W. F. and Jones J. W., “Refrigeration and Air Conditioning”, McGraw Hill

Text Books

1. Arora C. P., “Refrigeration and Air Conditioning”, Tata McGraw Hill

2. Arora S. C., Domkundwar S., “Refrigeration and Air Conditioning”, Dhanpat Rai and Company
3. Khurmi R. S. and Gupta J. K., “Refrigeration and Air Conditioning”, S Chand Publication

Project Based Learning

1. Demonstration models of non-convection refrigeration systems
2. Demonstration models of conventional system for domestic application
3. Demonstration models of vapor absorption systems
4. Finding applications of RAC
5. Demonstration models of air conditioning systems
6. Load calculations for any application
7. Design of duct and calculation of losses in ducts
8. study of modern trends in RAC
9. Assembly and disassembly of RAC components.
10. Preliminary design of refrigeration system for real life problem.
11. Preliminary design of air conditioning system for real life problem.

Unit Test–

Unit Test-I	Unit-I, II,III

Program Elective-I: Industrial Engineering & Management
(Course Code: PE1111604.1)

Designation of Course	**Industrial Engineering & Management**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03 Hours/ Week	Semester End Examination	60 Marks	03
Tutorial:- --Hours/ Week	Internal Assessment	40 Marks	
Practical:- -- Hours/ Week	Term Work	-- Marks	--
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**03**

Course Prerequisites:-	The student should have basic knowledge of 1. Basic concept of Management 2. Basic information of Industrial engineering 3. Man machine interaction.
Course Objectives	1. The student should understand the scope, objective and application of industrial engineering tools and management practices in industries
Course Outcomes:-	The students should be able to– 1. Explain the definitions, principles, and functions of management and apply them effectively in organizational settings. 2. Compare different organizational structures and types of business organizations and select appropriate structures for a given situation. 3. Describe the functioning of Production, Personnel, Marketing & Sales, and Finance departments and analyze their roles in overall business operations. 4. Use appropriate study tools to analyze work processes and standardize the methods. 5. Apply suitable work measurement techniques to determine and standardize the time required for industrial tasks. 6. Interpret key ergonomic principles, safety practices, and industrial laws and integrate them into manufacturing operations.

Course Contents

Unit I	**Introduction to Industrial Management**	**(06 Hrs.)**
Management- Meaning and Definitions, Management, Administration, and Organization concepts, Management as an Art and Science and a profession, contribution of various thinkers to management thought, Types and Functions of Management. Different approaches to management – Scientific, operational, human and system approach.		
Unit II	**Industrial Organization**	**(06 Hrs.)**
Different forms of business Organization –Individual proprietorship, Partnership, Joint stock company, Co-Operative enterprise, Public Sector, Undertakings, organizational structures in Industries, Line, Functional ,Line and functional , Project, Matrix Organization and Committees		
Unit III	**Departments of Industrial Management**	**(06 Hrs.)**

Production Management: Production/Operations Management, Materials / SCM & Logistics Management, Maintenance & Plant Engg., Planning, R & D ,Quality Management
Personnel Management-Definitions Recruitment, Selection and training of the employees, Job valuation and Merit rating, wage administration different methods of wage payments, incentives.

Marketing Management-Definitions, Marketing and Selling concept, market segmentation, distribution channels, Market Research, Advertising and sales promotion and Sales forecasting.
Financial Management-Capital structure, Fixed capital, working capital, sources of finance, cost analysis, Break even analysis, Depreciation and Financial statement

Unit IV	**Method Study**	**(06 Hrs.)**

Steps in method study, tools and techniques used, process chart symbols, flow diagrams, two handed chart, multiple activity chart, use of motion pictures and its analysis. SIMO charts, chorno & cycle graph, developing, presentation, installation and maintenance of improved methods, Bottle necking Layouts Planning, Workflow Planning, Work Balancing for multi person assembly/production lines, work cell design

Unit V	**Work Measurement**	**(06 Hrs.)**

Time Study: Aim and objectives , terminology and tools, use of stop watch procedure in making a time study, elements, selection of operations time study forms, handling of foreign elements. Performance rating. Allowances: Personal, Fatigue and other allowances. Analysis and calculation of Standard Time. Determination of number of cycles time study for indirect functions such as Maintenance, Marketing etc., Most Technique. Works Sampling: Definition, Objectives, theory of Work Sampling. Other applications of work sampling, errors in work sampling study.
Synthetic and Standard data Methods: Concepts, introduction to PMTS, MTM-1, WF, Basic motion time, MTM-2, and other second – generation methods timing of group operations.

Unit VI	**Industrial Engineering Tools**	**(06 Hrs.)**

Ergonomics: Definitions, importance in industry, basic anatomy of human body, anthropometrics, bio mechanical factors environment effects.
Industrial Safety: Importance of safety, planning, training, safety precautions, safety equipment's, Government regulations on safety.
Industrial Acts: Factory Act, AIR Act, Boiler Act, Workers Compensation Act.
Kaizen, Kanban, 5S, Poke-Yoke, Cross-functional team, The 5 M's of Lean, TQM

Textbooks

1. O. P. Khanna, Industrial Engineering & Management, Dhanapat Rai & Sons.
2. M. C. Shukla, Business Organization and Management, S. Chand & Co. Ltd, New Delhi.
3. Harold Koontz & Heinz Enrich, Essentials of Management, McGraw Hill International.
4. M. N. Mishra, Organizational Behavior, Vikas publishing New Delhi.
5. Dale Yoder, Personnel Management.
6. Work Study, ILO.
7. S. S. Patil, Industrial Engineering & Management, Electro tech Publication.
8. Mansoor Ali &Dalela, Industrial Engineering & Management System, Standard Publisher distributions.
9. R. M. Currie, Work Study, ELBS.
10. Management by James A. F. Stoner, R. Edward Freeman, PHI

Unit Test–

Unit Test-I	Unit-I, II,III

Program Elective-I: Engineering Economics

(Course Code: PE1111604.2)

Designation of Course	**Engineering Economics (Elective-I)**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:-03 Hours/Week	Semester End Examination	60 Marks	03
Tutorial:---Hours/Week	Internal Assessment	40 Marks	
Practical:---Hours/Week	Term Work	-- Marks	00
	Oral/Practical	-- Marks	
	Total	**100 Marks**	**03**

Course Prerequisites:-	The students should know Basics of Mathematics
Course Objectives:-	Students will be able to understand the economics behind running a successful engineering project
Course Outcomes:-	Student should be able to 1. Explain fundamental concepts of engineering economics and apply them in project selection and planning. 2. Analyze the time value of money and compute monetary values at different points in a project lifecycle. 3. Apply standard engineering economic analysis methodologies to evaluate and select viable project alternatives. 4. Compare multiple project options using appropriate economic evaluation methods to determine their feasibility and viability. 5. Perform replacement analysis to support effective planning and resource optimization in engineering projects. 6. Prepare depreciation schedules and apply corporate income tax considerations in economic decision-making for projects.

Course Contents

Unit 1	**Introduction to Economics**	**(06 Hrs.)**
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–V ratio, Elementary economic Analysis–Materials election for product Design selection for a product, Process planning.		
Unit 2	**Interest and Time Value of Money**	**(06 Hrs.)**
Introduction to Time Value of Money; Simple Interest; Compound Interest; Nominal Interest rate;EffectiveInterestrate;ContinuousCompounding;EconomicEquivalence;DevelopmentofInterest Formulas; The Five Types of Cash flows; Single Cash flow Formulas; Uneven Payment Series;EqualPaymentSeries;LinearGradientSeries;GeometricGradientSeries.		
Unit 3	**Basic Methodologies of Engineering Economic Analysis**	**(06 Hrs.)**

Minimum Attractive (Acceptable) Rate of Return (MARR); Payback Period Method; Equivalent Worth Methods: Present Worth Method, Future Worth Method, Annual Worth Method; Rate of Return Methods: Internal Rate of Return Method; External/Modified Rate of Return Method; Public Sector Economic Analysis (Benefit Cost Ratio Method); Introduction to Lifecycle Costing; Introduction to Financial and Economic Analysis

Unit 4	**Comparative Analysis of Alternatives**	**(06 Hrs.)**

Comparing Mutually Exclusive Alternatives having Same useful life by

1. Payback Period Method and Equivalent Worth Method
2. Rate of Return Methods and Benefit Cost Ratio Method

Comparing Mutually Exclusive Alternatives having different useful lives by

1.Repeatability Assumption 2.Co-terminated Assumption 3.Capitalized Worth Method

Comparing Mutually Exclusive, Contingent and Independent Projects in Combination.

Unit 5	**Replacement Analysis**	**(06 Hrs.)**

Fundamentals of Replacement Analysis: Basic Concepts and Terminology; Approaches for Comparing Defender and Challenger; Economic Service Life of Challenger and Defender Replacement Analysis When Required Service Life is Long: Required Assumptions and Decision Framework; Replacement Analysis under the Infinite Planning Horizon; Replacement Analysis under the Finite Planning Horizon

Unit6	**Depreciation and Corporate Income Taxes**	**(06 Hrs.)**

Concept and Terminology of Depreciation; Basic Methods of Depreciation: Straight line method, Declining Balance Method, Sinking Fund Method, Sum of the Year Digit Method, Modified Accelerated Cost Recovery System (MACRS); Introduction to Corporate Income Tax; After Tax Cash-flow Estimate; General Procedure for Making After Tax Economic Analysis.

Project Based Learning

1. Case study on break even analysis of a company, time value of money
2. Case study on feasibility of a project by economic analysis
3. Case study on Comparing Mutually Exclusive Alternatives having Same useful life by Payback Period Method and Equivalent Worth Method
4. Case study on Comparing Mutually Exclusive Alternatives having Same useful life by Payback Rate of Return Methods and Benefit Cost Ratio Method
5. Case study on Comparing Mutually Exclusive Alternatives having different useful lives
6. Case study on Replacement analysis of a machine, Calculation of depreciation of a machine
7. Case study on Calculation of corporate taxes.

Textbooks

1. R. Paneerselvem, Engineering Economics, Prentice Hall India.
2. M. P. Groover, "Automation, Production Systems & Computer Integrated Manufacturing", PHI, 3rd Edition, 2012.

Reference Books

1. Chan S. Park, Contemporary Engineering Economics, Prentice Hall, Inc.
2. E. Paul DeGarmo, William G. Sullivan and James A. Bontadelli, Engineering Economy, MC-Milan Publishing Company.
3. James L. Riggs, David D. Bedworth and Sabah U. Randhawa, Engineering Economics, Tata MC-Graw Hill Education Private Limited.

Unit Test–

Unit Test-I	Unit-I, II,III

Program Elective-I: Carbon Footprint and GHG Accounting

(Course Code: PE1111604.3)

Designation of Course	**Carbon Footprint and GHG Accounting**		
Teaching Scheme	**Examination Scheme**		**Credits Allotted**
Theory:- 03 Hours/ Week	Semester End Examination	60 Marks	03
Practical:- 00 Hours/ Week	Internal Assessment	40 Marks	
	Term Work	-- Marks	--
	Oral	-- Marks	
	Total	100 Marks	03

Course Prerequisites:	1. Mechanical Engineering System. 2. Thermodynamic principals
Course Objectives:	To provide knowledge about 1. Interpret the concepts of carbon footprint and greenhouse gas (GHG) emissions. 2. Learn methods for measuring and calculating carbon footprints at various scales. 3. Explore international GHG accounting standards and regulatory frameworks. 4. Develop skills in carbon footprint reduction and mitigation strategies. 5. Analyze case studies from industries and organizations.
Course Outcomes:	On completion of the course, students will be able to - 1. Explain the principles and methodologies of GHG accounting and carbon footprint assessment. 2. Interpret and compare major GHG accounting frameworks and standards applicable across industries. 3. Apply appropriate carbon footprint measurement tools to quantify emissions for given scenarios. 4. Analyze real-world case studies and recommend suitable emission reduction strategies. 5. Evaluate the applications and implications of carbon footprint assessment across different sectors. 6. Assess various policy measures and industry best practices aimed at achieving carbon neutrality.

Course Contents

Unit 1	**Introduction to Carbon Footprint and GHG Emissions**	(6 Hrs.)
Definition and importance of carbon footprint, Overview of global warming and climate change, Greenhouse gases (GHGs) and their sources (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6), Carbon cycle and anthropogenic influences, Key metrics: CO_2-equivalent (CO_2e), Global Warming Potential (GWP)		
Unit 2	**GHG Accounting Frameworks and Standards**	(6 Hrs.)
The Kyoto Protocol and Paris Agreement, Corporate GHG accounting frameworks, **GHG Protocol:** Corporate Standard, Scope 1, 2, and 3 emissions, **ISO 14064**: Standard for GHG inventories, **Intergovernmental Panel on Climate Change (IPCC) Guidelines,** National and international GHG reporting requirements		
Unit 3	**Carbon Footprint Measurement and Calculation**	(6 Hrs.)
Life Cycle Assessment (LCA) and Carbon Footprint Assessment, Direct and indirect emission sources, Tools and software for carbon footprint calculation, GHG Protocol tools, SIMAP, SimaPro, OpenLCA, and other relevant software, Case studies on carbon footprint estimation (individual, product, corporate level)		
Unit 4	**Carbon Footprint Reduction and Mitigation Strategies**	(6 Hrs.)

Energy efficiency and renewable energy transition, Carbon capture, utilization, and storage (CCUS), Sustainable transportation and supply chain decarburization, Carbon offsets and carbon trading mechanisms, Role of circular economy in emission reduction		
Unit 5	**Industry Applications and Case Studies**	(6 Hrs.)
Carbon footprint in different sectors: Manufacturing & heavy industries, Agriculture and food production, Transportation and logistics, IT and service sectors, Carbon disclosure and corporate sustainability reporting, Case studies of carbon footprint reduction strategies in organizations		
Unit 6	**Policy, Regulations, and Future Trends**	(6 Hrs.)
National and regional climate policies (EU ETS, India's PAT scheme, US EPA regulations), Role of governments and businesses in carbon neutrality, Carbon taxes, cap-and-trade, and emission trading schemes (ETS), Innovations in GHG accounting and reporting, Future outlook: Net-zero strategies and climate action commitments		

Textbooks & References:

1. **Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard**, World Resources Institute (WRI) & World Business Council for Sustainable Development (WBCSD).
2. **ISO 14064: International Standard for GHG Accounting and Verification**.
3. **Carbon Footprint Analysis: Concepts, Methods, and Case Studies** by Matthew John Franchetti & Alok Bhandari.
4. **Life Cycle Assessment: Theory and Practice** by Michael Z. Hauschild, Ralph K. Rosenbaum, and Stig Irving Olsen.
5. **IPCC Guidelines for National Greenhouse Gas Inventories**.

Unit Test–

Unit Test-I	Unit-I, II,III

Program Elective-I: Additive Manufacturing and Rapid Prototyping (Course Code: PE1111604.4)

Designation of Course	**Additive Manufacturing and rapid Prototyping**	
TEACHING SCHEME:	EXAMINATION SCHEME:	CREDITS: 03
Theory: 03 Hours/ Week	University Examination Marks: 60 marks	Theory:03
Practical: --Hours/ Week	Internal AssessmentMarks:40	
	Term Work Marks:--	Practical: --
	Oral/ Practical Examination Marks:100	
	Total Credits	03

Course Prerequisites:-	Students should know about Solid Modelling, Auto CAD Manufacturing Technology Design & Analysis of Machine Components
Course Objectives:-	1. To understand the fundamental concepts of Additive Manufacturing (i.e. Rapid Prototyping) and 3-D printing, its advantages and limitations. 2. To classify various types of Additive Manufacturing Processes and know their working principle, advantages, limitations etc. 3. To have a holistic view of various applications of these technologies in relevant fields such as mechanical, Bio-medical, Aerospace, electronics etc.
Course Outcomes:-	The students will be able to 1. Explain the importance of additive manufacturing (AM) processes and outline the complete AM process chain. 2. Describe and apply liquid-based and solid-based additive manufacturing processes for part fabrication. 3. Explain and apply powder-based additive manufacturing processes for producing complex geometries. 4. Analyze and apply various metal additive manufacturing processes for manufacturing different engineering components. 5. Apply appropriate AM data formatting and data processing techniques for preparing digital models of different products. 6. Select suitable materials for AM processes and evaluate potential applications of AM components in domains such as automotive, aerospace, biomedical, and allied fields.

Course Contents

Unit-I	**Introduction to Rapid Prototyping**	**(06 Hrs.)**
Introduction: Prototyping fundamentals, Historical development, Fundamentals of Rapid Prototyping, Advantages and Limitations of Rapid Prototyping, Commonly used Terms, Classification of RP process, AM process chain: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing.		
Unit-II	**Liquid-based and Solid Based Rapid Prototyping**	**(06 Hrs.)**

Liquid-based Rapid Prototyping Systems:
Stereo lithography Apparatus (SLA): Models and specifications, Process, working principle, photopolymers, photo polymerization, Layering technology, laser and laser scanning, Applications, Advantages and Disadvantages, Case studies. Solid ground curing (SGC): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies

Solid-based Rapid Prototyping Systems:
Laminated Object Manufacturing (LOM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies. Fused Deposition Modeling (FDM): Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies.

Unit-III	Powder-Based Rapid Prototyping	(06 Hrs.)

Powder Bed Fusion AM Processes: Selective laser Sintering (SLS), Materials**,** Indirect and direct SLS, Powder fusion mechanism and powder handling, Process Modelling, SLS Metal and ceramic part creation, post processing, post curing, surface deviation and accuracy, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes, Post processing of AM parts
Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies.

Unit-IV	Design for Additive Manufacturing	(06Hrs.)

Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers etc.
Guidelines for process selection: Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control

Unit-V	AM Data Formatting and Data Processing	(06 Hrs.)

Rapid Prototyping Data Formats: STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Other Translators, Newly Proposed Formats. Rapid Prototyping Software's: Features of various RP software's like Magics, Mimics, Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D doctor.
AM Data Processing: Part Orientation and Support Structure Generation, Model Slicing and Contour Data Organization, Direct and Adaptive Slicing, Hatching Strategies and Tool Path Generation.

Unit-VI	AM Materials and Applications	(06 Hrs.)

3D Printing Materials: properties, characteristics and application of all types (ABS, PLA, PVA, HDPE, PET, PETG etc) Types of Composites Materials, properties, characteristics and application of all types.(N6,N12,ABS Carban Fiber, etc.)
RP Applications: Material Relationship, Application in Design, Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Jewellery Industry, Coin Industry, GIS application, Arts and Architecture.
RP Medical and Bioengineering Applications: Planning and simulation of complex surgery, Customized Implants & Prosthesis, Design and Production of Medical Devices, Forensic Science and Anthropology, Visualization of Bio molecules.

Internal assessment:
Unit Test I (Unit-I, II, III) & Unit Test II (Unit-IV, V, VI): 20 Marks each
Project-Based Learning: 20 Marks

Textbooks:

1. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
2. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
3. Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory and Practice", Springer, 2006.
4. David F. Rogers, J. A. Adams, "Mathematical Elements for Computer Graphics", TMH, 2008.
5. Kevin N. Otto, Kristin L. Wood, "Product Design", Pearson Education, 2004.
6. Patri K. Venuvinod and Weiyin Ma, "Rapid Prototyping: Laser-based and Other Technologies", Springer, 2004.
7. L. Lu, J. Y. H. Fuh and Y.S. Wong, "Laser-Induced Materials and Processes for Rapid Prototyping", Springer, 2001.
8. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4th Edition, World Scientific, 2015.
9. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.

Reference Books:

1. Anupam Saxena, Birendra Sahay, "Computer Aided Engineering Design", Springer, 2005.
2. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles and Applications", World scientific, 2003.
3. Khanna Editorial, "3D Printing and Design", Khanna Publishing House, Delhi.
4. Michael E. Mortenson, "Geometric Modeling", Wiley, NY, 1997

Unit Test–

Unit Test-I	Unit-I, II,III

Program Elective- I:- Reliability and Machine Condition Monitoring (Course Code: PE1111604.5)

Designation of Course	**Reliability and Machine Condition Monitoring**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03Hours/ Week	Semester End Examination	60 Marks	03
Practical:- 00Hours/ Week	Internal Assessment	40Marks	
Tutorial;- 00 Hours/Week	Term Work	-- Marks	00
	Oral	-- Marks	00
	Total	**100 Marks**	**03**

Course Prerequisites: -	Student should have knowledge of Engineering Mathematics, Probability, Statistics and Mechanical Vibration
Course Objectives:-	1. Understanding of basic principles of reliability for ensuring sustainable product design. 2. Application to system requirements, design, manufacturing and testing, with real world examples 3. Understand in detail Asset Management, Maintenance, Quality and Productiveness
Course Outcomes: -	Student should be able to 1. Interpret and compute key reliability measures such as MTTF, MTBF, failure rate, and hazard rate for engineering systems. 2. Apply fundamental probability concepts and analyze failure data for assessing system reliability. 3. Evaluate the reliability of different engineering systems using appropriate qualitative and quantitative methods. 4. Explain and apply the principles of design for reliability and maintainability in engineering applications. 5. Analyze concepts of data acquisition, signal processing, and their applications, and represent the acquired data effectively. 6. Diagnose machinery faults using vibration analysis, oil analysis, and particle analysis techniques.

Course Contents

Unit I	Fundamental Concepts of Reliability and Reliability Measures	**(06 Hrs.)**
Brief history, concepts, terms and definitions, applications, the life cycle of a system, concept of failure, typical engineering failures and their causes **Reliability Measures:** Reliability function–R(t), cumulative distribution function (CDF)– F(t), probability density function (PDF) – f(t), hazard rate function-λ(t), Mean time to failure (MTTF) and Mean time between failures (MTBF), typical forms of hazard rate function, bathtub curve		
Unit II	Probability Concepts and Failure Data Analysis	**(06 Hrs.)**
Theory of probability, rules of probability, Introduction to independence, mutually exclusive, conditional probability random variables, discrete and continuous probability distributions. Binomial, normal Comparison of probability distributions - , lognormal, Weibull, exponential, Standard deviation, variance, mean, mode and Central Limit Theorem. **Failure Data Analysis** Data collection and empirical methods, estimation of performance measures for ungrouped complete data, grouped complete data, analysis of censored data, fitting probability distributions graphically (Exponential and Weibull) and estimation of distribution parameters		
Unit III	Reliability Evaluation of Systems	**(06 Hrs.)**

Reliability Improvement Redundancy, element redundancy, unit redundancy, standby redundancy - types of stand by redundancy, parallel components single redundancy, multiple redundancies, cut and tie set approach for reliability evaluation. Star and delta method, matrix method (Numerical). Introduction to Reliability allocation or apportionment, reliability apportionment techniques- equal apportionment, AGREE, ARINC, Minimum effort method (Numerical)

Unit IV	Design for Reliability and Maintainability	**(06 Hrs.)**
Reliability design process and design methods, reliability allocation, failure modes, effects and criticality analysis (FMECA), fault tree and success tree methods, symbols used, maintainability design process, quantifiable measures of maintainability, repair versus replacement		
Unit V	Data Acquisition, Signal Processing, Applications and Representation:	**(06 Hrs.)**
Introduction, Collection of vibration signal – vibration transducers, characteristics and mountings, Conversion of vibrations to electrical signal. The fast Fourier transform (FFT) analysis, Time waveform analysis, Phase signal analysis, Spectral signal processes.		
Unit VI	Machinery Fault Diagnosis Using Vibration Analysis and Oil and Particle Analysis Oil Fundamentals	**(06 Hrs.)**
Commonly witnessed machinery faults diagnosed by vibration analysis, correcting faults that cause vibration; Balancing, Alignment, Resonance vibration control with dynamic absorbers. Condition-based maintenance and oil analysis, Setting up an oil analysis program, Oil analysis – sampling methods, Oil analysis – lubricant properties, Oil analysis – contaminants in lubricants, Particle analysis techniques, Alarm limits for various machines.		

Project Based Learning

1. Exemplar/ Case Studies
2. Data acquisition using a velocity pickup.
3. Data acquisition using an accelerometer.
4. Data acquisition of sound signals.
5. Spectral analysis of velocity, acceleration noise signals.
6. Experiment demonstrating balancing of rotating shaft shaft.

Reference Books:

1. Patrick D. T. Newton O'Conner, D., Bromley R., 2002, "Practical Reliability Engineering", John Wiley and Sons.
2. Rao S. S., 1992, "Reliability Based Design. McGraw-Hill
3. Andrew Kennedy, Skilling Jardine, Albert H. C. Tsang, 2006, "Maintenance, Replacement and Reliability: Theory and Applications", CRC/Taylor and Francis.
4. Nachlas Joel A., 2005, "Reliability Engineering: Probabilistic Models and Maintenance Methods" Taylor and Francis.
5. Cyril M. Harris, Allan G. Piersol, "Shock and Vibration Handbook", McGraw-Hill Publishing Co.
6. C. Scheffer, Paresh Girdhar, "Practical Machinery Vibration Analysis and Predictive Maintenance", Newnes an imprint of Elsevier

Text Books:

1. Ebling C. E., 2004, "An Introduction to Reliability and Maintainability Engineering", Tata McGraw Hill Education Private Limited, New Delhi.
2. Srinath L. S., 1991, "Reliability Engineering", East West Press, New Delhi.
3. Birolini A., 2010, "Reliability Engineering: Theory and Practice", Springer.
4. Parkhi R. M., "Market Leadership by Quality and Reliability", Vidyanand Publications 2012.
5. Roy B. and Allan R. N., 1992, "Reliability evaluation of engineering systems: concepts and techniques", Springer.
6. Thomson, W. T., "Theory of Vibration with Applications", CBS Publishers and Distributors, New Delhi, 1990
7. Gupta K., "Introductory Course on Theory and Practice of Mechanical Vibrations", New Age

International Ltd., 1984
8. J. S. Rao., “Vibratory Condition Monitoring of Machines”, Narosa publishing house, New Delhi

Unit Test–

Unit Test-I	Unit-I, II,III

MECHANICAL SYSTEM DESIGN

(Course Code: MJ1111605)

Designation of Course	**Mechanical System Design**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 03 Hours/ Week	Semester End Examination	60 Marks	03
Tutorial:- -- Hours/ Week	Internal Assessment	40 Marks	
Practical:- 02 Hours/ Week	Term Work	25 Marks	01
	Oral/Practical	25 Marks	
	Total	**150 Marks**	**04**

Course Prerequisites:-	The students should have knowledge of 1. Statics and dynamics 2. Computer Aided Machine Drawing 3. Machine design & Analysis I & II 4. Theory of machine
Course Objectives:-	To provide the knowledge of 1. To study basic concepts of vibration analysis 2. To acquaint with the principles of vibration measuring instruments 3. To develop competency for system visualization and design. 4. To enable student to design pressure vessels and to use IS code. 5. To introduce student to optimum design and use optimization methods to design mechanical components.
Course Outcomes:-	The students should be able to– 1. Analyze the behavior of free, undamped single-degree-of-freedom (SDOF) systems and determine key vibration parameters. 2. Analyze forced vibration of SDOF systems and evaluate transmissibility and the critical speed of rotating shafts. 3. Examine free, undamped multi-degree-of-freedom systems and compute their principal vibration parameters. 4. Evaluate the stresses in various pressure-vessel components and design different types of pressure vessels based on applicable design criteria. 5. Explain the design considerations of machine-tool gearboxes and determine the spindle speeds at each stage using ray diagrams. 6. Explain the principles of optimum design and apply optimization methods to the design of machine components.

Course Contents

Unit I	**Free Undamped Single Degree of Freedom Vibration System**	**(06 Hrs.)**
Vibration classification, Steps involved in vibration analysis Longitudinal, transverse, torsion vibration system, Methods for formulation of differential equations by Newton, Energy, and Rayleigh's Method.		
Unit II	**Forced Single Degree of Freedom Vibratory System**	**(06 Hrs.)**
Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper) Vibration Isolation and Transmissibility Force Transmissibility, Motion Transmissibility Typical isolators& Mounts Rotor Dynamics: Critical speed of single rotor, undamped and damped.		
Unit III	**Free Undamped and Damped Vibration System**	**(06 Hrs.)**

Viscous damped system – under damped, critically damped, over damped; Logarithmic decrement; Coulomb's damping; Combined viscous and coulomb's damping. Two rotors, Three rotors and geared system; Dunkerley's and Rayleigh's method for transverse vibratory system. Vibration Measurement: Vibration measuring devices: Accelerometers, Vibration exciters, FFT analyzer Introduction to signal analysis: Time domain & Frequency domain analysis of signals. Noise measurement		
Unit IV	**Pressure Vessels**	**(06 Hrs.)**
Introduction, Classification of Pressure Vessels, Stresses in a Thin Cylindrical Shell due to an Internal Pressure, Circumferential or Hoop Stress, Longitudinal Stress, Thin Spherical Shells Subjected to an Internal, Thick Cylindrical Shell Subjected to an Internal Pressure, Compound Cylindrical Shells, Stresses in Compound Cylindrical Shells, Cylinder Heads and Cover Plates, Auto-frettage.		
Unit V	**Design of Machine Tool Gearbox**	**(06 Hrs.)**
Introduction to machine tool gear boxes, design and its applications, basic considerations in design of drives, determination of variable speed range, graphical representation of speed and structure diagram, ray diagram, selection of optimum ray diagram, deviation diagram, difference between numbers of teeth of successive gears in a change gear box.		
Unit VI	**Optimum Design**	**(06 Hrs.)**
Objectives of optimum design, adequate and optimum design, Johnson's Method of optimum design, primary design equations, subsidiary design equations and limit equations Frequency Distribution-Histogram and frequency polygon, normal distribution-units of central tendency and dispersion – standard deviation- population combinations , statistical analysis of tolerances, mechanical reliability and factor of safety.		

Term Work

Part A (Any 4)

1. To determine the natural frequency of damped vibration of single degree freedom system and to find it's damping coefficient.
2. To obtain frequency response curves of single degree freedom system of vibration for different amount of damping
3. Free vibration of simply supported beam
4. Free Vibration of a Two-DOF System
5. Forced vibration of SDOF system
6. To determine natural frequency of vibration of beam using vibration analyzer.
7. Noise measurement and analysis using vibration Analyzer

Part B

1. One design project: The design project shall consist of two imperial size sheets (Preferably drawn with 3D/2D CAD software)-one involving assembly drawing with a part list and overall dimensions and the other sheet involving drawings of individual components, manufacturing tolerances, surface finish symbols and geometric tolerances must be specified so as to make it working drawing. A design report giving all necessary calculations of the design of components and assembly should be submitted. Projects shall be in the form of design of mechanical systems like multispeed gear box.

Project Based Learning

Following is the list of topics for project based learning (Not Limited to) based on the syllabus contents:

1. Case study on : Free Undamped Single Degree of Freedom Vibration System
2. Case study on : Forced Single Degree of Freedom Vibratory System
3. Case study on : Free Undamped and Damped Vibration System
4. Case study on : Measurement of natural frequency of vibration of beam using FFT vibration analyzer
5. Case study on : Noise measurement using FFT vibration Analyzer.

Text Books/ Reference Books

1. Mechanical Vibrations - G. K. Grover Nem Chand & BrosJames Gere, Mechanics of
2. Mechanical Vibrations 4th edition- S. S. Rao - Pearson Education
3. Vibration Analysis - P. Srineevasan - Tata McGraw Hill
4. Bhandari V.B.— Design of Machine Elements, Tata McGraw Hill Pub. Co. Ltd
5. S. K. Basu and D. K. Pal,—Design of Machine Tools Oxford and IBH Pub Co
6. Design Data—,P.S.G.College of Technology, Coimbatore
7. Singiresu S. Rao, Engineering Optimization: Theory and Practice, ,John Wiley & Sons
8. I.S. 2825: Code for unfired pressure vessels

Unit Test–

Unit Test-I	Unit-I, II,III

PROFESSIONAL SKILLS (**Course** Code: SE1113606)		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS:**
Practical: - 2 Hours/ Week	Semester End Examination: Term work: 25 Marks	Credits:1

Course Pre-requisites: The students should know	
1	Basic mathematical concepts, reasoning skills, and comprehension abilities.
2	Fundamentals of communication processes and soft skills.
3	Basic understanding of leadership qualities, ethics, etiquettes, and values.
Course Objective:	
	This course is structured to provide students with a well-rounded foundation in quantitative aptitude, logical and verbal reasoning, professional communication, employment skills, leadership development, and business ethics. By integrating these components, students will be better equipped to excel in recruitment processes and succeed in their professional careers.

Course Outcomes: The student will be able to

1. Apply shortcut techniques to solve quantitative aptitude problems efficiently for recruitment and competitive examinations.
2. Use logical reasoning strategies and employ mnemonics to enhance analytical and problem-solving abilities in placement assessments.
3. Enhance verbal communication skills by building vocabulary, constructing effective sentence structures, and interpreting reading comprehension passages for professional interactions.
4. Prepare well-structured job applications and résumés, and demonstrate effective interview skills to improve employability.
5. Interpret and apply soft skills, leadership traits, and professional ethics for effective workplace conduct.
6. Demonstrate appropriate corporate etiquette, business ethics, and professional values in organizational settings.

Course Content:

Unit-I	• **QUANTITATIVE APTITUDE**: • Number System, Percentage, Profit and Loss, Simple & Compound Interest • Ratio, Proportion, and Average • Mixture and Allegation • Time, Speed & Distance, Time & Work • Permutation & Combination, Probability • Pipes and Cisterns	**(4 Hrs.)**
Unit-II	**LOGICAL REASONING:** • Coding-Decoding, Number Series, Blood Relation, Directions • Cubes & Dices, Data Interpretation, Data Sufficiency • Set Theory & Syllogisms, Matching, Selection & Arrangement • Clocks & Calendars, Visual Reasoning • Input-Output & Flow Charts	**(4 Hrs.)**
Unit-III	**VERBAL REASONING:** • Sentence Patterns, Sentence Correction, Spotting Errors • Vocabulary, Antonyms & Synonyms, Analogy • Phrasal Verbs, Idiomatic Expressions • Reading Comprehension, Cloze Test • Sentence Rearrangement and Theme Detection	**(4 Hrs.)**

Unit-IV	**HONING EMPLOYBILITY AND PRESENTATION SKILLS:** • Job Application Letters: Layout, Structure, Covering Letter • Resume & CV Building: Structure, Effective Writing Tips • Group Discussion: Skills, Strategies, and Evaluation • Interview Skills: Telephonic & Face-to-Face Interviews • Body Language, Grooming & Etiquette for GD & PI • Extempore Speaking Techniques • Presentation Skills: Structure, Layout, Flow, and PPT Creation	**(4 Hrs.)**
Unit-V	**SOFT SKILLS AND LEADERSHIP DEVELOPMENT:** • Soft Skills: Definition, Importance, and Differences from Hard Skills • Life Skills & Personal Development • Team Building & Conflict Resolution • Problem-Solving, Time & Stress Management • Pareto Principle (80/20 Rule), Time Management Matrix • Leadership Skills: Importance, Types, Attributes of a Good Leader • Motivational Theories and Emotional Intelligence in Professional Life	**(4 Hrs.)**
Unit-VI	**BUSINESS ETHICS, ETIQUETTES AND VALUES:** • Ethics & Values in the Business World • Respect for Individuality and Workplace Diversity • Key Features of Corporate Etiquette • Corporate Grooming & Dressing • Social & Office Etiquette • Importance of Professional Behavior in the Workplace • Corporate Social Responsibility (CSR): Need and Importance.	**(4 Hrs.)**
Reference Books:		

1	Quantitative Aptitude by R. S. Agarwal published by S. Chand
2	The Book of Numbers by Shakuntala Devi
3	A Modern Approach To Logical Reasoning by R. S. Agarwal published by S. Chand
4	A New Approach to Reasoning Verbal & Non-Verbal by Indu Sijwali
5	Business Communication by Meenakshi Raman, Prakash Singh published by Oxford University press, second edition
6	Communication Skills by Sanjay Kumar, Pushp Lata, published by Oxford University press, second edition
7	Technical Communication by Meenakshi Raman, Sangeeta Sharma published by Oxford University press
8	Developing Communication Skills by Krishna Mohan, Meera Banerji published by Macmillan India Pvt Ltd
9	Soft Skills by Meenkashi Raman, published by Cengage publishers
10	Soft Skills by Dr. K Alex published by Oxford University press
11	Soft skills for Managers by Dr. T. Kalyana Chakravarthi and Dr. T. Latha Chakravarthi published by biztantra

Term Work

Unit I: Quantitative Aptitude

1. Solve 20 practice problems on Number System, Percentage, and Profit & Loss.
2. Create a comparative analysis of Simple Interest vs. Compound Interest with real-world examples.

Unit II: Logical Reasoning

1. Solve a set of logical reasoning problems covering Coding-Decoding, Blood Relations, and Directions.
2. Prepare a case study on how logical reasoning skills are used in competitive exams and corporate assessments.

Unit III: Verbal Reasoning

1. Identify and correct errors in 10 sentences focusing on sentence structure and grammatical mistakes.
2. Develop a vocabulary list with antonyms, synonyms, and phrasal verbs commonly used in professional settings.

Unit IV: Honing Employability and Presentation Skills

1. Draft a job application letter along with a structured resume tailored for a technical position.
2. Participate in a mock group discussion and receive peer and instructor feedback.
3. Conduct a mock interview (telephonic & face-to-face) and submit an evaluation report

Unit V: Soft Skills and Leadership Development (Term Work Assignments)

1. Conduct a self-assessment on personal soft skills and identify areas for improvement.
2. Develop a time management plan using the Pareto Principle (80/20 Rule) and Time Management Matrix.
3. Prepare a report on different leadership styles and their impact on the corporate world.

Unit VI: Business Ethics, Etiquettes, and Values

1. Write a report on corporate ethics and how companies implement ethical policies.
2. Conduct a role-play activity demonstrating appropriate corporate etiquette in business interactions.
3. Prepare a presentation on the significance of Corporate Social Responsibility (CSR).

INTRODUCTION TO DATA SCIENCE
(Course Code: SE1111607)

Designation of Course	**Introduction to Data Science**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- -- Hours/ Week	Semester End Examination	-- Marks	--
Tutorial:- -- Hours/ Week	Internal Assessment	-- Marks	
Practical:- 02 Hours/ Week	Term Work	25 Marks	01
	Oral/~~Practical~~	25 Marks	
	Total	**50 Marks**	**01**

Course Prerequisites:-	The students should know Linear Algebra, Probability, Statistics, Logical Reasoning
Course Objectives	To explore the fundamental concepts of data analytics. 1. To Interpret the various search methods and visualization techniques. 2. To apply various machine learning techniques for data analysis.
Course Outcomes:-	The students should be able to– 1. Explain the fundamental concepts of data analytics using principles of statistics and probability. 2. Describe the basic methods of data mining, integrating concepts from statistics and probability. 3. Apply appropriate inferential statistical techniques to analyze data sets and draw meaningful conclusions from acquired data. 4. Explore and utilize various data analytics tools and techniques for effective data interpretation. 5. Apply data science concepts and methodologies to solve real-world problems across different domains. 6. Employ advanced analytical techniques to conduct comprehensive and insightful analyses and interpret the results effectively.

Course Content

Unit I	**Introduction to Data Science**	**(04 Hrs.)**
Predictive Analytics involves the use of mathematical methods and tools such as statistical analysis, and predictive models.		
Unit II	**Data mining**	**(04 Hrs.)**
Data mining is to identify anomalies in the process, which help in preventive maintenance. Estimate the demand for product, raw material etc. based on historical data and current scenario. Forecast possible outcomes based on data obtained from the process.		
Unit III	**Prescriptive Analytics**	**(04 Hrs.)**
Prescriptive Analytics is used identify ways in which an industrial process can be improved like action need to take to avoid the failure, plan the maintenance schedule, review your supplier, etc		
Unit IV	**Descriptive Analytics**	**(04 Hrs.)**
Descriptive Analytics, describe the problem by diagnosing the symptoms, analytics method to discover the trends and patterns based on historical data, charts, and graphs.		
Unit V	**Data visualization**	**(04 Hrs.)**
Data visualization tools, problems in the manufacturing process, descriptive analytics in the form of charts and graphs.		
Unit VI	**Diagnostic Analytics**	**(04 Hrs.)**

Root cause analysis, data discover, correlation, and down and drill.

Term work

Any 8 experiments on the following topics (not limited to this)

1. Fundamental Operations: Creating and Inspecting Pandas Data Structures
2. Accessing and Filtering Data: Pandas Indexing Methods
3. Data Transformation: Aggregation and Grouping with Pandas
4. Understanding Data: Descriptive Statistics, Probability, and Confidence Intervals
5. Statistical Decision Making: Null and Alternative Hypothesis Testing
6. Building and Evaluating Linear Regression Models
7. Exploring Feature Selection Methods for Improved Model Performance
8. Improving Model Performance with Effective Feature Engineering

Note: Students need to apply computational algorithms using suitable software/programming language.

Text Book

1. Brunton, S. L., & Kutz, J. N. (2022). Data-driven science and engineering: Machine learning, dynamical systems, and control. Cambridge University Press.
2. Dunn, P. F., & Davis, M. P. (2017). Measurement and data analysis for engineering and science. CRC press.
3. Roy, S. S., Samui, P., Deo, R., & Ntalampiras, S. (Eds.). (2018). Big data in engineering applications (Vol. 44). Berlin/Heidelberg, Germany: Springer.
4. Middleton, J. A. (2021). Experimental Statistics and Data Analysis for Mechanical and Aerospace Engineers. Chapman and Hall/CRC.

References Books:

1. Zsolt Nagy, “Artificial Intelligence and Machine Learning Fundamentals”, Packt Publishing, 2018, ISBN: 978-1-78980-165-1
2. Hastie, Trevor, Robert Tibshirani, Jerome H. Friedman, and Jerome H. Friedman. The elements of statistical learning: data mining, inference, and prediction. Vol. 2. New York: springer, 2009.
3. Zaki, Mohammed J., Wagner Meira Jr, and Wagner Meira. Data mining and analysis: fundamental concepts and algorithms. Cambridge University Press, 2014.
4. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.

Value Added Course-II Solar PV Installation (NSDC Course Code: SGJ/Q0102)

(Course Code: VA1111608.1)

Designation of Course	**Solar PV Installation**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 02 Hours/ Week	Semester End Examination	Marks	02
Practical : Hours/ Week	Internal Evaluation	50 Marks	
	Term Work:	Marks	00
	Total	**50 Marks**	**02**

Course Prerequisites:-	
Course Objectives:-	To study 1. The basics of solar energy, photovoltaic technology, and electrical concepts. 2. Describe different types of Solar PV systems (on-grid, off-grid, and hybrid) and their applications. 3. How to assess site feasibility using sun path diagrams and shading analysis tools. 4. Evaluating roof condition, soil type, load requirements, and customer needs. 5. Introduce different tools such as multimeters, crimping tools, torque wrenches, and insulation testers. 6. Wiring configurations, connection standards, and layout diagrams for Solar PV systems.
Course Outcomes:-	Students should be able to 1. Explain the fundamentals of electricity, solar radiation parameters such as DNI, GHI, and diffuse irradiance, and perform basic electrical and solar energy calculations relevant to solar PV performance. 2. Identify, interpret, and select appropriate solar PV system components by analyzing their types, specifications, and manufacturer data sheets. 3. Identify and demonstrate the proper use of various installation tools and tackles required for solar PV system deployment. 4. Conduct a site survey by analyzing sun-path and shading, evaluate installation conditions, prepare load profiles, and estimate system size based on customer requirements and site constraints. 5. Interpret system drawings, install electrical components and wiring as per standards, and apply correct procedures for material handling, cabling, earthing, and safety compliance. 6. Conduct testing and commissioning of solar PV systems by performing continuity, polarity, and fault-finding checks, and explain relevant interconnection regulations and standards.

Course Contents

Unit 1	**Introduction to Solar PV Installer, Basics of Solar energy and Electrical concepts**	**(4 Hrs)**
Understand Ohm's Law; Understand the basics of electricity and electrical concepts; Perform simple calculations to derive power and energy, Explain and understand DNI, GHI and Diffused Irradiance & Irradiation; Understand the movement of the sun and its effect on the performance of the plant; Understand Terminology used in the Solar Industry;		
Unit 2	**Basics of Solar Photovoltaic systems and its components**	**(4 Hrs)**

Identify the different components of a Solar PV system and its basic operation; Identify and understand the working of different types of Solar PV systems, Understand and acquire know-how of different Types, sizes and specifications of , Modules, Solar Inverters, Charge Controllers, Cables, Conduits, Junction Boxes, Solar Batteries and allied accessories. Read and Interpret the manufacturing data specification sheets of different Types, sizes and specifications of ,Modules, Solar Inverters, Charge Controllers, Cables, Conduits, Junction Boxes, Solar Batteries and allied accessories. Understand and acquire know-how of different Types, sizes and specifications of foundations/footings; Select the right footing/foundation as per site location including suitability of roof condition or suitability of soil.

Unit 3	**Identification and Use of different tools and tackles used for installation of solar PV system**	**(4 Hrs)**
Identify and acquire the know-how of the different tools & tackles used for specific purpose in an installation of Solar PV system.		
Unit 4	**Site Survey for Installation of Solar PV System**	**(4 Hrs)**
Understand how to observe Sun path diagram and shading analysis; Understand and assess the site conditions for safe installation of Solar PV system; Identify the load to be connected to the Solar PV system; Prepare load profile Engage with customers for any specific requirement and budget constraints; Calculate size of the system with basic mathematical tools;		
Unit 5	**Installation of Electrical Components of Solar PV Systems.**	**(4 Hrs)**
Read and Interpret the Single Line Diagram, Layout Diagrams. Understand the DO's and Don'ts of material handling; Read and interpret the Bill of Material to verify with the delivery of components on-site. Understand and acquire know-how of installing the electrical components including inverter, batteries, junction boxes, energy meters and other electrical components, Identify and acquire know- how of installation of cables and conduits; Understand Do's and Don'ts of DC wiring; Identify and understand use of Tools & tackles used for cable and conduit installation. Understand Different types of Earthing and its installation; Understand and identify significance and types of earth faults as per standards.		
Unit 6	**Test and Commission Solar PV system**	**(4 Hrs)**
Describe and conduct the testing of all the solar components of the Solar PV system including fault finding and analysis including continuity checks, polarity check and other commissioning activities; Understand Regulations & Standards for interconnection; Describe the Commissioning process for the Solar PV System.		

Project-Based Learning:

Term Work:

1. Demonstrate the use of a pyranometer to measure DNI (Direct Normal Irradiance), GHI (Global Horizontal Irradiance), and Diffused Irradiance.

2. Demonstrate different mounting structures, roof conditions, and soil testing methods for selecting the right foundation.

3. Demonstrate the use of:

Crimping tools (for connectors and lugs) Torque wrench (for bolt tightening) Multimeter & clamp meter (for electrical measurements) Drilling machine & concrete anchors (for mounting structures) Cable cutters & insulation testers.

4. Calculate panel wattage, battery bank capacity, and inverter size for a given load.

5. Demonstrate the correct procedure for mounting and wiring these components.

6. Interconnection Standards & Grid Compliance: Understand how to connect an on-grid system with a net meter.

7. Conduct a full test of the system before handing it over to the customer, ensuring compliance with safety and performance standards.

Text Books/ Reference Books:

1. Solar Photovoltaics: Fundamentals, Technologies, and Applications

   Author: Chetan Singh Solanki Publisher: PHI Learning Pvt. Ltd.

2. Photovoltaic Systems

Author: James P. Dunlop, Jim Dunlop Publisher: American Technical Publishers

3. Solar Energy: Principles of Thermal Collection and Storage
   Author: S.P. Sukhatme, J.K. Nayak Publisher: McGraw Hill Education
4. The Solar PV Installer's Guide
   Author: SEI (Solar Energy International)

Value Added Course-II: Area Service Manager

(NSDC Course Code: ASC/Q0603) (Course Code: VA1111608.2)

Designation of Course	**Area Service Manager**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- 02 Hours/ Week	Semester End Examination	-- Marks	02
Practical : 00 Hours/ Week	Internal Evaluation	50 Marks	
	Term Work:	-- Marks	00
	Total	**50 Marks**	**02**

Course Prerequisites:-	
Course Objectives:-	To study 1. The fundamentals of managing service networks across multiple locations. 2. Learning strategies for customer engagement, retention, and satisfaction. 3. Developing skills for managing service partnerships effectively 4. Financial management for service operations 5. And Understanding laws, compliance, and ethical responsibilities in automotive service operations. 6. Ensuring workplace safety and regulatory compliance in service centers
Course Outcomes:-	Students should be able to 1. Manage multiple service centers effectively and ensure consistency in service quality across all locations. 2. Handle customer grievances and complaints efficiently by applying appropriate communication and problem-solving strategies. 3. Evaluate and coordinate dealership and workshop partnerships to enhance service performance and customer satisfaction. 4. Apply principles of budgeting and financial planning to monitor and optimize service operations. 5. Ensure compliance with automotive service laws, safety standards, and regulatory requirements through systematic monitoring and documentation. 6. Lead and motivate service teams across multiple locations to achieve organizational objectives and improve overall service productivity.

Course Contents

Unit 1	**Service Network Management**	**(4 Hrs)**
Introduction to Service Network Management, Service Operations Oversight: Supervising service operations across locations. Ensuring adherence to company policies and standards. Standard Operating Procedures (SOPs): Importance of SOPs in service operations. Developing, implementing, and monitoring SOPs. Performance Metrics & KPIs:		
Unit 2	**Customer Relationship Management (CRM)**	**(4 Hrs)**
Introduction to Customer Relationship Management (CRM), Customer Engagement & Experience Management: Enhancing customer interactions, Managing service expectations. Feedback Mechanisms & Complaint Handling: Establishing feedback channels, Resolving customer complaints effectively. Service Customization & Personalization:		
Unit 3	**Channel Partner Management**	**(4 Hrs)**

Role of Channel Partners in Service Operations, Partner Selection & On boarding: Criteria for selecting service partners. Setting service quality expectations. Training & Development of Channel Partners: Providing continuous skill development, Ensuring alignment with brand standards. Performance Evaluation & Monitoring: KPIs for assessing partner performance		
Unit 4	**Financial Acumen in Service Operations**	**(4Hrs)**
Fundamentals of Financial Management in Automotive Services. Budget Management & Cost Control: Developing and managing service budgets, Identifying cost-saving opportunities. Revenue Enhancement Strategies: Up selling, cross-selling, and service value addition, Maximizing profitability in service departments		
Unit 5	**Legal & Ethical Practices in Service Management**	**(4 Hrs)**
Legal Framework in the Automotive Service Industry: Overview of automotive service laws and policies, Understanding compliance requirements. Ethical Standards in Service Management: Maintaining transparency in service transactions Ethical customer interactions and fair pricing. Regulatory Compliance & Documentation: Maintaining service records and warranty claims, Ensuring audit readiness.		
Unit 6	**Health & Safety Compliance in Service Operations**	**(4 Hrs)**
Introduction to Health, Safety & Environmental (HSE) Standards, Implementing Safety Protocols in Service Workshops: Ensuring safety measures for employees and customers, Workplace hazard identification and prevention. Training & Development for Safety Compliance: Conducting regular safety training sessions, Emergency response and first-aid training.		

Text Books/ Reference Books:

1. Automotive Service Manager and Service Advisor Manual. Author:- Mr. Surinder K. Ahluwalia
2. Automotive After Sales Management: A Practical Guide to Success. Author:- Mohamad Idrakisyah.
3. Building a Gold Standard Service Advisor: The Evolution of Customer Service. Author :- Joseph Michelli
4. The Book That Shook the Industry. Author:- Chris Collins
5. Automotive Service; Author:- Tim Gilles

Massive Open Online Courses (MOOC)-II

(Course Code: AE1111609)

Designation of Course	**Massive Open Online Courses (MOOC)-II**		
Teaching Scheme:	**Examination Scheme:**		**Credits Allotted**
Theory:- -- Hours/ Week	Semester End Examination	-- Marks	--
Practical: -- Hours/ Week	Internal Evaluation	-- Marks	
	Term Work:	-- Marks	--
	Total	**-- Marks**	**02**

The students shall be encouraged to complete two MOOCs during their B. Tech. Mechanical programme. Students shall register to MOOCs which are offered by any one the following agencies:

(i) SWAYAM: www.swayam.gov.in

(ii) NPTEL: www.onlinecourse.nptel.ac.in

(iii) Course Era: www.coursera.org

(iv) edX online learning: www.edx.org

(v) MIT Open Course ware: www.ocw.mit.edu

(vi) Udemy: www.udemy.com

(vii) IIT Bombay Spoken Tutorial: www.spoken-tutorial.org

(viii) Artificial Intelligence-CDAC Pune: https://futureskillsprime.in/

(ix) AR- VR - CDAC Pune: https://futureskillsprime.in/https://tinyurl.com/jx93jwft

Student shall take a prior approval from the department before registering for a given MOOCs. Students shall complete MOOCs during their tenure of a given B. Tech. programme. Students shall submit a passing certificate of MOOCs to obtain two credits per MOOC. The credits obtained for MOOC will be reflected in the mark sheet of Semester VIII.

B. Tech. – (All branches)

Rules and Regulations

(I) Theory

(A) Theory Examination

Theory examination consists of: (i) Semester End examination (ESE), and (ii) Internal assessment (IA).

(i) ESE is of 60 marks for theory courses.

(ii) The existing internal assessment system, totaling 40 marks, currently utilizes two components: a Unit Test and Project-Based Learning (PBL), each allocated 20 marks. To further enhance the teaching-learning experience, the following additional innovative assessment tools will be incorporated into the current framework. These additions are intended to improve the assessment of student learning outcomes and ensure thorough syllabus coverage through engaging and effective methods.

a) Poster presentation

b) Quiz

c) Case study

d) Presentation/Seminar

e) Open book test

f) Assignment

g) MCQ

h) Modelling

i) Group discussion

j) Role play

k) Term paper/Review paper

Note

1. Each semester shall include two Internal Assessments: Internal Assessment–I and Internal Assessment–II.
2. Internal Assessment–I will be based on Units I, II, and III, while Internal Assessment–II will cover Units IV, V, and VI.
3. It is mandatory to categorize the courses within each discipline into appropriate groups based on their nature. For each group, a set of 2 to 4 suitable assessment tools shall be identified and used for evaluation.
4. The Course Coordinator shall prepare a unit-wise plan for conducting the Internal Assessments using the selected tools and submit it to the Head of the Department before the commencement of the academic term. A maximum of 2–3 tools may be selected for each course.
5. The Course Coordinator is also responsible for maintaining proper documentation of the Internal Assessments and shall submit the same to the Head of the Department at the end of the semester, if

required.

6. All Internal Assessments must be designed, conducted, and evaluated in alignment with the appropriate levels of Bloom's Taxonomy.

(B) Standard of Passing

(i) There is a separate passing of 40% of 60 marks, i.e. 24 marks, for ESE for a given course.

(ii) There is a separate passing of 40% of 40 marks, i.e. 16, for IA for a given course.

(iii) A candidate who fails at ESE in a given course has to reappear only at ESE as a backlog candidate and clear the head of passing. Similarly, a candidate who fails at IA in a given course has to reappear only at IA as a backlog candidate and clear the head of passing

(II) Practical

(A) Practical Examination

Practical examination consists of: (i) Term work, and (ii) Practical/Oral examination for a given course.

(i) Term work (TW): TW marks are as mentioned in the curriculum structure.

(ii) Practical/Oral (PR/OR): PR/OR marks are as mentioned in the curriculum structure.

(B) Conduction of practical/oral examination

(i) A candidate will be permitted to appear for practical/oral examination only if he/she submits term work of a given course.

(ii) Practical/oral examination shall be conducted in the presence of internal and external examiners appointed by university.

(C) Standard of Passing

(i) A candidate shall pass both heads TW and PR/OR separately with minimum 40% of total marks of respective head.

(III) MOOC and Social Activity Course

(i) If a student completes one MOOC during a programme, he/ she will earn additional TWO credits, subjected to submission of the certificate of completion of the respective course. It is mandatory for a student to complete atleast two MOOC to obtain degree in a given discipline. Students shall register to MOOCs which are offered by any one the following agencies:

(a) SWAYAM : www.swayam.gov.in

(b) NPTEL : www.onlinecourse.nptel.ac.in

(c) Course Era : www.coursera.org

(d) edX online learning : www.edx.org

(e) MIT Open Course ware : www.ocw.mit.edu

(f) Udemy : www.udemy.com

(g) Spoken tutorial : www.spoken-tutorial.org

(ii) If a student completes social activity, he/she will earn additional TWO credits, subjected to submission of the certificate of completion of the respective course/ activity from the relevant authorities. It is mandatory for a student to complete atleast one social activities to obtain degree in a given discipline.

(iii) The additional credits for MOOC and Social Activity will be given only after verification of the authentic document by the Head of the Department and a separate mark-sheet will be submitted by the Head of the Department along with the course examiner.

(IV) Value Added Course (VAC) and Indian Knowledge System (IKS) Course

(i) The VAC and IKS courses are mandatory and must be passed by students during the designated semester to earn two credits.

(ii) These courses have an internal assessment worth 100 marks, which are distributed as follows: (a) three assignments, each worth 20 marks, and (b) two case studies, presentations, or quizzes, each worth 20 marks. Faculty members have the flexibility to choose between conducting two case studies, two presentations, two quizzes, or any combination thereof.

(V) Minor Programme

(i) A students shall receive a MINOR degree when he/she acquires additional 20 credits in a given specialization defined by the UG programmes offered at the institute.

(ii) The theory and practical/oral components for a given course are mentioned in curriculum structure. The theory and examination for a given course are mentioned in Section I and II.

(iii) The grade point, grade letter and equivalent marks system for MINOR programme is mentioned in Section V.

(iv) The MINOR DEGREE programme is OPTIONAL. The interested students may opt MINOR programme.

(v) A student shall complete the MINOR program prior to his/her graduation.

(VI) A. T. K. T

(i) A student who is granted term for B. Tech. Semester-I, III, V, VII will be allowed to keep term for his/her B. Tech. Semester-II, IV, VI, VIII examination, respectively even if he/she appears and fails or does not appear at B. Tech. Semester-I,III, V, VII examination respectively.

(ii) A student shall be allowed to keep term for the B. Tech. Semester-III course if he/she has a

backlog of any number of Heads of passing at B. Tech. Semester-I & II taken together.

(iii) A student shall be allowed to keep term for the B. Tech. Semester-V of respective course if he/she has no backlog of B. Tech. Semester-I & II and he/she has a backlog of any number of Heads of passing at B. Tech. Semester-III & IV taken together.

(iv) A student shall be allowed to keep term for the B. Tech. Semester- VII of respective course if he/she has no backlog of B. Tech. Semester-I, II, III, IV and he/she has a backlog of any number of Heads of passing at B. Tech. Semester-V & VI taken together.

(VII) Grade Point, Grade Letter and Equivalent Marks

The student must obtain a minimum Grade Point of 5.0 (40% marks) in ESE and also in combined ESE + IA. A student who fails in ESE of a course has to reappear only to ESE as a backlog student and clear that head of passing.

Award of the Class for the Degree considering CGPA: A student who has completed the minimum credits specified for the programme shall be declared to be passed in the programme. The CGPA will be computed every year of all the courses of that year. The grade will be awarded according to the CGPA of every year.

Range of CGPA	**Final Grade**	**Performance Descriptor**	**Equivalent range of Marks (%)**
9.50 ≤ CGPA ≤10.00	O	Outstanding	80 ≤ Marks ≤ 100
9.00 ≤ CGPA ≤ 9.49	A+	Excellent	70 < Marks <80
8.00 ≤ CGPA ≤ 8.99	A	Very Good	60 < Marks < 70
7.00 ≤ CGPA ≤ 7.99	B+	Good	55 < Marks < 60
6.00 ≤ CGPA ≤ 6.99	B	Average	50 < Marks < 55
5.00 ≤ CGPA ≤ 5.99	C	Satisfactory	40 ≤ Marks < 50
CGPA below 5.00	F	Fail	Marks Below 40

NOTE:

Amendment in Internal assessment tools:

From the A.Y. 2025-26, the Internal Assessment for B. Tech. Sem. I onward will be as per the above guidelines.