CURRICULUM STRUCTURE

FOR

BACHELOR OF TECHNOLOGY
IN
MECHANICAL ENGINEERING

(Applicable from the academic session 2023-2024)

Haldia Institute of Technology

(An Autonomous Institution Under Maulana Abul Kalam Azad University Of Technology, West Bengal)

Haldia Institute of Technology

(An Autonomous Institution Under Maulana Abul Kalam Azad University Of Technology, West Bengal)

Department of Mechanical Engineering

VISION

To create a platform for quality teaching-learning process where, the students are not only taught various subjects as per framed syllabus, but also exposed to the topic beyond it with an emphasis on blending of knowledge and skill and relevance of a topic or subject with the real-life situation so that one can adapt to the industrial requirements.

MISSION

Contemporary Skills (M1): To create qualified and proficient technocrats having contemporary skills through outcome-based and self-learning strategies.

Higher Studies And Research (M2): To encourage innovation-oriented and problem-based research capabilities in the young engineers through higher studies to nurture the progress of the society.

Ethical And Human Values (M3): To instill strong ethical values and good professional behavior, so as to adapt and absorb emerging changes in the field of engineering profession.

Haldia Institute of Technology

(An Autonomous Institution Under Maulana Abul Kalam Azad University Of Technology, West Bengal)

Department of Mechanical Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

PEO 1: To educate and groom the students with strong understanding and knowledge of mathematics, basic science and engineering coupled with contemporary skills in the areas of Mechanical Engineering

PEO 2: To equip the students for successful professional careers in Mechanical Engineering domain of private and government enterprises, to prepare for PG studies in engineering, management and allied areas, and to prepare for entrepreneurship.

PEO 3: To make the students aware of the societal aspects of engineering profession, ethical practices in profession, and the importance of team work to function coherently and effectively in multi-disciplinary context.

Haldia Institute of Technology

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Department of Mechanical Engineering

PROGRAM OUTCOMES (POs):

PO 1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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Department of Mechanical Engineering

PROGRAM SPECIFIC OUTCOMES (PSOs):

PSO 1: Should be able to clearly understand, analyze and comprehend the different courses of Mechanical Engineering and other interdisciplinary courses and develop a holistic approach for implementation.

PSO 2: Should be able to apply the knowledge, techniques and skills acquired to provide solutions to the real world problems related to Mechanical Engineering.

PSO 3: Should have the capability to comprehend the advancements in the usage of modern design tools and latest techniques to analyze and design subsystems/processes for a variety of applications.

A. Definition of Credit

1 Hr. Lecture (L) per week	1 credit
1 Hr. Tutorial (T) per week	1 credit
1 Hr. Practical (P) per week	0.5 credits

B. Range of credits

All B.Tech. programs include a range of credits from 160 to 165.

C. Mandatory Additional Requirement (MAR) for earning B. Tech Degree

Every student, who is admitted to the 4 years B. Tech program from the academic year 2019-20 onwards, is required to earn *minimum 100* Activity Points, in addition to the required academic grades for getting B. Tech degree.

The MAR activities, (as per guideline of AICTE / affiliating University, MAKAUT) will provide necessary needs of modern industry and the society. Through this program, irrespective of one's technological field, each student develops the skill of active participation in the co-curricular and extra-curricular activities through SAWYAM based learning activities. Such activities enhance student's employability and global acceptances. Details are given in *Annexure-I*.

D. MOOCs for B. Tech Honours

A student will be eligible to get B.Tech Degree *with Honours*, if he/she completes an *additional 20 credits*, through Massive Open Online Courses (MOOCs). The complete description of the MOOCs relevant for the first year course is given in *Annexure-II.*

E. Guidelines regarding Mandatory Induction Program for the new students

The aim of the Induction Programme is to acclimatize the students to the environment of their engineering institution, give them a flavour of the exciting new world of education that they are entering, provide them with mentoring schemes, and make them aware of their neighbourhood, society and people. This will allow them to evolve as well rounded individuals. Details are given in *Annexure-III*.

F. Group division

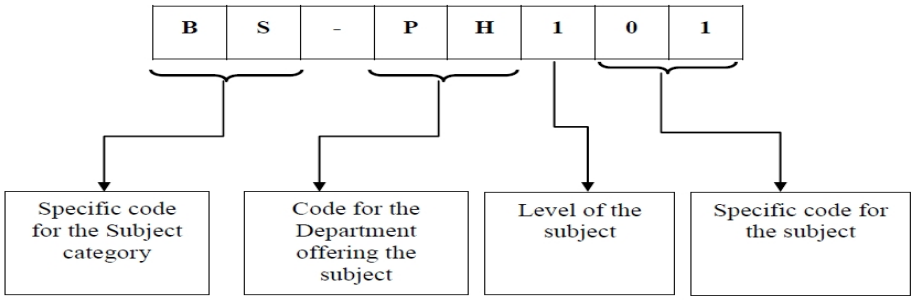
Group-A

All non-IT based programme like - Mechanical Engineering (ME), Chemical Engineering (CHE), Civil Engineering (CE), Electrical Engineering (EE), Applied Electronics & Instrumentation Engineering (AEIE), Biotechnology (BT), Food Technology (FT), Agriculture Engineering (AE), and Electronics & Communication Engineering (ECE).

Group-B

All IT-based programmes like – Computer Science & Engineering (CSE), Computer Science & Engineering (Cyber Security), Computer Science & Engineering (Data Science), Computer Science & Engineering (Artificial Intelligence & Machine Learning), Information Technology.

Subject Numbering Scheme:



List of Codes for Subject Category	
Code	**Category Name**
BS	Basic Science Courses
ES	Engineering Science Courses
HM	Humanities and Social Sciences including Management courses
PC	Professional core courses
PE	Professional Elective courses
OE	Open Elective courses
MC	Mandatory courses
PW	Project

Curriculum Structure

SEMESTER-I

Theory							
Sl No.	**Paper Name**	**Paper Code**	**Marks**	**L**	**T**	**P**	**Credit**
1	**Mathematics-I [Group-A & B]**	**BS-M 101**	**100**	**3**	**1**	**0**	**4**
2	**Physics-I [Group-A] /Chemistry-I [Group-B]**	**BS-PH 101/ BS-CH101**	**100**	**3**	**1**	**0**	**4**
3	**Basic Elec. & Electro. Engg. [Group-A] / Programming for problem solving [Group-B]**	**ES-EE 101/ ES-CS 101**	**100**	**3**	**1**	**0**	**4**
4	**English Language and Technical Communication. [Group-B]**	**HM-HU 101**	**100**	**2**	**0**	**0**	**2**
Total Marks: 300 Total Credit: 12.0 [Group-A] **Total Marks: 400 Total Credit: 14.0 [Group-B]**							
Practical							
5	**Physics-I Lab [Group-A]/ Chemistry-I Lab [Group-B]**	**BS-PH 191/ BS-CH 191**	**100**	**0**	**0**	**3**	**1.5**
6	**Basic Elec. & Electro. Engg. Lab[Group-A] / Programming Lab [Group-B]**	**ES-EE 191/ ES-CS 191**	**100**	**0**	**0**	**3**	**1.5**
7	**Workshop Practice [Group-A]/ Engg. Drawing [Group-B]**	**ES-ME 191/ ES-ME 192**	**100**	**1**	**0**	**3**	**2.5**
8	**Language Lab [Group-B]**	**HM-HU 191**	**100**	**0**	**0**	**2**	**1**
Extra Curricular Activity							
9	**NSS[Group-A]**						
Total Marks: 300 &Total Credit: 5.5 [Group-A] **Total Marks: 400 &Total Credit: 6.5 [Group-B]**							

SEMESTER-II

Sl No.	Paper Name	Paper Code	Marks	L	T	P	Credit
Theory							
1	Mathematics-II [Group-A & B]	BS-M 201	100	3	1	0	4
2	Chemistry-I [Group-A]/ Physics-I [Group-B]	BS-CH 201/ BS-PH 201	100	3	1	0	4
3	Programming for problem solving [Group-A]/ Basic Elec. & Electro. Engg. [Group-B]	ES-CS 201 / ES-EE 201	100	3	1	0	4
4	English Language and Technical Communication [Group-A]	HM-HU 201	100	2	0	0	2
Total Marks: 400 Total Credit: 14.0 [Group-A] **Total Marks: 300 Total Credit: 12.0 [Group-B]**							
Practical							
5	Chemistry-I Lab [Group-A]/ Physics-I Lab [Group-B]	BS-CH 291/ BS-PH 291	100	0	0	3	1.5
6	Programming Lab [Group-A]/ Basic Elec. & Electro. Engg. Lab[Group-B]	ES-CS 291/ ES-EE 291	100	0	0	3	1.5
7	Workshop Practice [Group-B]/ Engg. Drawing [Group-A]	ES-ME291 /ES-ME292	100	1	0	3	2.5
8	Language Lab[Group-A]	HM-HU 291	100	0	0	2	1
Extra Curricular Activity							
9	NSS [Group-B]						
Total Marks: 400 &Total Credit: 6.5 [Group-A] **Total Marks: 300 &Total Credit: 5.5[Group-B]**							

SEMESTER-III

Sl. No.	Course Code	Subject Name	Contact period per week			Total	Credit
			L	T	P		
THEORY							
1	HM-HU 301	Engg. Economics	2	0	0	2	2
2	BS-M 301	Mathematics-III	3	0	0	3	3
3	ES-ME 301	Engineering Mechanics	3	0	0	3	3
4	PC-ME 301	Thermodynamics	3	0	0	3	3
5	PC-ME 302	Fluid Mechanics	3	1	0	4	4
6	PC-ME 303	Material Science	3	0	0	3	3
		Total Theory				**18**	**18**
PRACTICAL							
1	PC-ME 391	Fluid Mechanics Lab	0	0	3	3	1.5
2	PC-ME 392	Material Testing Lab	0	0	3	3	1.5
3	PC-ME 393	Machine Drawing	0	0	3	3	1.5
		Total Practical				**9**	**4.5**
		Total of Semester				**27**	**22.5**

SEMESTER-IV

Sl. No.	Course Code	Subject Name	Contact period per week			Total	Credit
			L	T	P		
THEORY							
1	PC-ME 401	Strength of Materials	3	0	0	3	3
2	PC-ME 402	Applied Thermodynamics	3	0	0	3	3
3	PC-ME 403	Metrology & Measurement	3	0	0	3	3
4	PC-ME 404	Manufacturing Processes	3	0	0	3	3
5	PC-ME 405	Theory of Machines	3	1	0	4	4
		Total Theory				**16**	**16**
PRACTICAL							
1	PC-ME 491	Strength of Materials Lab	0	0	3	3	1.5
2	PC-ME 492	Theory of Machines Lab	0	0	3	3	1.5
3	PC-ME 493	Manufacturing Processes Lab	0	0	3	3	1.5
4	PC-ME 494	Metrology & Measurement Lab	0	0	3	3	1.5
		Total Practical				**12**	**6**
		Total of Semester				**28**	**22**

NOTE: Vocational Training/Internship to be conducted after fourth semester and to be evaluated in fifth semester.

SEMESTER-V

THEORY							
Sl. No.	**Course Code**	**Subject Name**	**Contact period per week**			**Total**	**Credit**
			L	**T**	**P**		
1	CS-ME 501	Numerical Methods & Computer Programming	2	0	0	2	2
2	PC-ME 501	Heat Transfer	3	0	0	3	3
3	PC-ME 502	Machining Principles & Machine Tools	3	0	0	3	3
4	PC-ME 503	Design of Machine Elements	3	0	0	3	3
5	PC-ME 504	IC Engines	3	0	0	3	3
6	MC 501	Essence of Indian Knowledge Tradition	0	2	0	2	0
					Total Theory	**16**	**14**
PRACTICAL/SESSIONAL							
1	CS-ME 591	Computer Programming Lab	0	0	3	3	1.5
2	PC-ME 591	Machine Tools Lab	0	0	3	3	1.5
3	PC-ME 592	Thermal Engineering Lab	0	0	3	3	1.5
4	PW-ME 581	Project -I (on Summer Internship/Vocational Training)	0	0	0	0	2
					Total Practical	**9**	**6.5**
					Total of Semester	**25**	**20.5**

SEMESTER-VI

THEORY							
Sl. No.	**Course Code**	**Subject Name**	**Contact period per week**			**Total**	**Credit**
			L	**T**	**P**		
1	PC-ME 601	Air-conditioning & Refrigeration	3	0	0	3	3
2	PC-ME 602	Modern Manufacturing Processes	3	0	0	3	3
3	PC-ME 603	Machine Design	3	0	0	3	3
4	PC-ME 604	Production & Operations Management	3	0	0	3	3
5	OE-ME 601	Open Elective-I	3	0	0	3	3
6	MC 601	Constitution of India	0	2	0	2	0
					Total Theory	**17**	**15**
PRACTICAL							
1	PC-ME 691	Air-conditioning & Refrigeration Lab	0	0	3	3	1.5
2	PC-ME 692	Modern Manufacturing Process Lab	0	0	3	3	1.5
3	PC-ME 693	Design Practice Lab	0	0	3	3	1.5
					Total Practical	**9**	**4.5**
					Total of Semester	**26**	**19.5**

Open Elective-I:
OE-ME 601A – Computer Integrated Manufacturing
OE-ME 601B - Mechatronics
OE-ME 601C – Artificial Intelligence

NOTE: Vocational Training/Internship to be conducted after sixth semester and to be evaluated in seventh semester.

SEMESTER-VII

THEORY							
Sl. No.	**Course Code**	**Subject Name**	**Contact period per week**			**Total**	**Credit**
			L	**T**	**P**		
1	PC-ME 701	Power Plant Engg.	3	0	0	3	3
2	PE-ME 701	Professional Elective-I	3	0	0	3	3
3	PE-ME 702	Professional Elective-II	3	0	0	3	3
4	OE-ME 701	Open Elective-II	3	0	0	3	3
5	MC 701	Environmental Science	0	2	0	2	0
					Total Theory	**14**	**12**
SESSIONAL							
1	PW-ME 781	Project – II	0	0	6	6	3
2	PW-ME 782	Project -III (on Summer Internship/Vocational Training)	0	0	4	4	2
3	PW-ME 783	Seminar	0	0	3	3	2
					Total Practical	**13**	**7**
					Total of Semester	27	**19**

Professional Elective-I:
PE-ME 701A –Automobile Engineering
PE-ME 701B – Computational Fluid Dynamics
PE-ME 701C – Alternative Fuels & Renewable Energy

Professional Elective-II:
PE-ME 702A– Industrial Engineering
PE-ME 702B– Operations Research
PE-ME 702C– Principles and Practices of Management

Open Elective-II:
OE-ME 701A – Enterprise Resource Planning (ERP)
OE-ME 701B – Marketing Management
OE-ME 701C – Internet of Things

SEMESTER-VIII

THEORY							
Sl. No.	**Course Code**	**Subject Name**	**Contact period per week**			**Total**	**Credit**
			L	**T**	**P**		
1	PE-ME 801	Professional Elective-III	3	0	0	3	3
2	PE-ME 802	Professional Elective-IV	3	0	0	3	3
3	PE-ME 803	Professional Elective-V	3	0	0	3	3
4	OE-ME 801	Open Elective-III	3	0	0	3	3
					Total Theory	**12**	**12**
SESSIONAL							
1	PW-ME 881	Project – IV	0	0	10	10	5
2	PW-ME 882	Comprehensive Viva Voce	0	0	0	0	2
					Total Practical	**10**	7
					Total of Semester	**22**	**19**
	Total Credit					**160.5**	

Professional Elective-III:
PE-ME 801A – Additive Manufacturing;
PE-ME 801B – Quantity Production Methods
PE-ME 801C – Engineering Tribology

Professional Elective-IV:
PE-ME 802A – Supply Chain Management
PE-ME 802B – Total Quality Management
PE-ME 802C – Management Information System
PE-ME 802D- Finite Element Analysis

Professional Elective-V:
PE-ME 803A – Industrial Automation & Instrumentation
PE-ME 803B – Industry 4.0
PE-ME 803C – Fluid Power Control
PE-ME 803D- Advanced Fluid Mechanics

Open Elective-III:
OE-ME 801A – Human Resource Management
OE-ME 801B – Entrepreneurship
OE-ME 801C – Industrial Safety

COURSE CURRICULA
B.TECH, 1ST YR-1ST SEMESTER

Sl No.	Paper Name	Paper Code	Marks	L	T	P	Credit
Theory							
1	Mathematics-I [Group-A & B]	BS-M 101	100	3	1	0	4
2	Physics-I [Group-A] /Chemistry-I [Group-B]	BS-PH 101/ BS-CH101	100	3	1	0	4
3	Basic Elec. & Electro. Engg. [Group-A] / Programming for problem solving [Group-B]	ES-EE 101/ ES-CS 101	100	3	1	0	4
4	English Language and Technical Communication. [Group-B]	HM-HU 101	100	2	0	0	2
Total Marks: 300 Total Credit: 12.0 [Group-A] Total Marks: 400 Total Credit: 14.0 [Group-B]							
Practical							
5	Physics-I Lab [Group-A]/ Chemistry-I Lab [Group-B]	BS-PH 191/ BS-CH 191	100	0	0	3	1.5
6	Basic Elec. & Electro. Engg. Lab[Group-A] / Programming Lab [Group-B]	ES-EE 191/ ES-CS 191	100	0	0	3	1.5
7	Workshop Practice [Group-A]/ Engg. Drawing [Group-B]	ES-ME 191/ ES-ME 192	100	1	0	3	2.5
8	Language Lab [Group-B]	HM-HU 191	100	0	0	2	1
Extra Curricular Activity							
9	NSS[Group-A]						
Total Marks: 300 &Total Credit: 5.5 [Group-A] Total Marks: 400 &Total Credit: 6.5 [Group-B]							

COURSE CURRICULA
B.TECH, 1ST YR-2ND SEMESTER

Sl No.	Paper Name	Paper Code	Marks	L	T	P	Credit
Theory							
1	Mathematics-II [Group-A & B]	BS-M 201	100	3	1	0	4
2	Chemistry-I [Group-A]/ Physics-I [Group-B]	BS-CH 201/ BS-PH 201	100	3	1	0	4
3	Programming for problem solving [Group-A]/ Basic Elec. & Electro. Engg. [Group-B]	ES-CS 201 / ES-EE 201	100	3	1	0	4
4	English Language and Technical Communication [Group-A]	HM-HU 201	100	2	0	0	2
Total Marks: 400 Total Credit: 14.0 [Group-A] Total Marks: 300 Total Credit: 12.0 [Group-B]							
Practical							
5	Chemistry-I Lab [Group-A]/ Physics-I Lab [Group-B]	BS-CH 291/ BS-PH 291	100	0	0	3	1.5
6	Programming Lab [Group-A]/ Basic Elec. & Electro. Engg. Lab[Group-B]	ES-CS 291/ ES-EE 291	100	0	0	3	1.5
7	Workshop Practice [Group-B] Engg. Drawing [Group-A] /	ES-ME291 /ES-ME292	100	1	0	3	2.5
8	Language Lab[Group-A]	HM-HU 291	100	0	0	2	1
Extra Curricular Activity							
9	NSS [Group-B]						
Total Marks: 400 &Total Credit: 6.5 [Group-A] Total Marks: 300 &Total Credit: 5.5[Group-B]							

Paper Name: Mathematics-I	**Category: Basic Science Course**
Paper Code: BS-M101	**Semester: First**
L-T-P: 3-1-0	**Credit: 4**

Total Lecture: 45L

Course Objectives

- Providing the core concepts of higher Engineering Mathematics and describing the techniques, this works as an essential tool to solve the problems in their field of applications.
- To provide an overview of Differential Equations, Laplace Transform and Complex Analysis to engineers.

Module-1[8L]
Matrix& Determinant:
Inverse and rank of a matrix; Elementary row and column operations over a matrix; System of linear equations and its consistency; Rank and nullity; Determinants; minors and cofactors; Eigen values and eigen vectors; Diagonalization of matrices; Cayley Hamilton theorem; Orthogonal transformation.

Module-2[9L]
Differential Calculus:
Successive derivative, Leibnitz's Theorem; Rolle's Theorem, Mean value theorem, Taylor's and Maclaurin's theorems with remainders;

Sequence and Series:
Basic concept of Convergence of sequence and series; Tests for convergence: Comparison test, Cauchy's Root test, D' Alembert's Ratio test(statements and related problems on these tests), Raabe's test; Alternating series; Leibnitz's Test (statement only); Absolute convergence and Conditional convergence.

Module-3[8L]
Integral calculus:
Improper integrals; Beta and Gamma functions and their properties;Convergence of improper integrals; Applications of definite integrals to evaluate surface areas and volumes of revolutions.Differentiation under integral sign.

Module-4[10L]
Calculus of function of several variables:
Introduction to functions of several variables;Limit and continuity, Partial derivatives, Homogeneous functions and Euler's theorem up to three variables, Chain rules, Differentiation of implicit functions, Total differentials and their applications, Jacobians up to three variables Maxima, minima;Saddle points of functions; Lagrange Multiplier method and their applications; Concept of line integrals, Double and triple integrals.

Module-5[10L]

Vector Calculus:

Scalar and vector triple products with related problems, Equation of straight line, plane and sphere. Vector function of a scalar variable, Differentiation of a vector function, Scalar and vector point functions, Gradient of a scalar point function, divergence and curl of a vector point function, Directional derivative. Related problems on these topics. Green's theorem, Gauss Divergence Theorem and Stoke's theorem (Applications only, proofs not required).

Course Outcomes (COs)

CO1. To provide students with skills in algebra and calculus which would enable them to devise engineering solutions for given situations they may encounter in their profession.

CO2. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice by enhancing the power of knowledge and imagination

CO3. Prepare students for realization of journal papers outcomes, and expose them to the world of research. Illustrate the current research works and publications of the subjects in different fields adopted by the students as per course curriculum in various journals and literature.

CO4. To explore and enhance research potential explain how the ideas those are adopted can be implemented through projects and demonstrate various models, recent project proposals executing the knowledge adopted from the course.

CO5. An ability to function on multi-disciplinary teams. Lighten on the latest and modern developments in the fields.

CO6. Explain about ethical awareness and impact in the field of environmental, social and safety of the finished products. Describe the pollution, legal aspects and impacts may arise in large scale production.

Learning Resources

1. Advanced Engineering Mathematics , by Erwin Kreyszig is published by Wiley India
2. Engineering Mathematics: B.S. Grewal (S. Chand & Co.)
3. Higher Engineering Mathematics: John Bird (4th Edition, 1st Indian Reprint 2006, Elsevier)
4. Engineering Mathematics: S. S. Sastry (PHI, 4PthP Edition, 2008)
5. Advanced Engineering Mathematics, 3E: M.C. Potter, J.L. Goldberg and E.F. Abonfadel (OUP),Indian Edition.

Paper Name: Mathematics-II	**Category: Basic Science Course**
Paper Code: BS-M201	**Semester: Second**
L-T-P: 3-1-0	**Credit: 4**

Total Lecture: 45L

Course Objectives

- Providing the core concepts of higher Engineering Mathematics and describing the Techniques, this works as an essential tool to solve the problems in their field of applications.
- To provide an overview of Differential Equations, Laplace Transform and Complex Analysis to engineers.

Module -1[10L]

Ordinary differential equation (ODE)- First order and first degree: Exact equations, Necessary and sufficient condition for exactness of a first order and first degree ODE (statement only), Rules for finding Integrating factors, Linear and non-linear differential equation, Bernoulli's equation. General solution of ODE of first order and higher degree (different forms with special reference to Clairaut's equation).

Second order and first degree: General linear ODE of order two with constant coefficients, C.F. & P.I., D-operator methods for finding P.I., Method of variation of parameters, Cauchy-Euler equations.

Module -2[5L]

Basics of Graph Theory: Graphs, Digraphs, Weighted graph, Connected and disconnected graphs, Complement of a graph, Regular graph, Complete graph, Subgraph,; Walks, Paths, Circuits, Euler Graph, Matrix representation of a graph, Adjacency and incidence matrices of a graph,Graph isomorphism, Bipartite graph.

Module -3[10L]

Laplace Transform: Introduction to integral transformation, functions of exponential order, Definition and existence of LT (initial and final value theorem with applications proofs not required), LT of elementary functions, Properties of Laplace Transformations , Evaluation of sine , cosine and exponential integrals using LT, LT of periodic and step functions.

Definition and properties of inverse LT Convolution Theorem (statement only) and its application to the evaluation of inverse LT, Solution of linear ODEs with constant coefficients (initial value problem) using LT.

Module -4[12L]

Complex Variable: Complex functions, Concept of Limit, Continuity and Differentiability. Analytic functions, Cauchy-Riemann Equations (statement only). Sufficient condition for a function to be analytic. Harmonic function and Conjugate Harmonic function, related problems. Construction of Analytic functions: Milne Thomson method, related problems. Conformal mappings, Bilinear transformation, Mobius transformations and their properties.

Complex Integration: Concept of simple curve, closed curve, smooth curve & contour. Some elementary properties of complex Integrals. Line integrals along a piecewise smooth curve. Cauchy's theorem (statement only). Cauchy-Goursat theorem (statement only). Cauchy's integral formula, Cauchy's integral formula for the derivative of an analytic function, Cauchy's integral formula for the successive derivatives of an analytic function.

Module -5[8L]

Zeros and Singularities of an Analytic Function & Residue Theorem.

Zero of an Analytic function, order of zero, Singularities of an analytic function. Isolated and non-isolated singularity, essential singularities. Poles: simple pole, pole of order m. Examples on determination of singularities and their nature. Taylor's series, Laurent's series.

Residue, Cauchy's Residue theorem (statement only), problems on finding the residue of a given function, evaluation of definite integrals: $\int_0^{\infty} \frac{\sin x}{x} dx$, $\int_0^{2\pi} \frac{d\theta}{a+b\cos\theta+c\sin\theta}$, $\oint_C \frac{P(z)}{Q(z)} dz$ (elementary cases, P(z) & Q(z) are polynomials of 2nd order or less). Evaluation of certain improper integrals using the Bromwich contour.

Course Outcomes(COs)

CO1. Recall the earlier mathematical thoughts, such as idea of derivative, integration, ordinary differential equations and complex algebra.

CO2. Exhibit the idea of ordinary differential equation of first and higher order. Recognize the concept of graph theory and Laplace transform and complex variable.

CO3. Apply the knowledge of Laplace transform to reduce the complexity of differential equation. Use different graphical algorithm to find optimal solutions.

CO4. Analyze the ideas of mentioned mathematical tools so that it can be implemented to real time engineering problems

CO5. Justify and make gradation of above mentioned mathematical tools and determine the right approach to solve multidisciplinary engineering problems.

CO6. Build up logical and analytical skills to create a new idea appreciated by academics, research & emerging trends in industry.

Learning Resources

1. Probability and Statistics for Engineers, Miller & Freund R.A.Johnson, Prentice Hall of India
2. Advanced Engineering Mathematics, Erwin Kreyszig, (Wiley Eastern)
3. Graph Theory: V. K. Balakrishnan, (Schaum's Outline, TMH)
4. Engineering Mathematics: B.S. Grewal (S. Chand & Co.)
5. Introductory Course in Differential Equations: Daniel A. Murray (Longmans & Green).
6. Graph Theory: N. Deo (Prentice-Hall of India)
7. Numerical Analysis and Computational Procedures, Sahajahan Ali Mollah, Books & Allied Ltd
8. Fundamentals of Mathematical Statistics, Gupta & Kapoor, (Sultan Chand & Sons).
9. Schaum's Outlines: Laplace Transforms ,Murray R. Spiegel,

Paper Name: Physics –I	**Category: Basic Science Course**
Paper Code: BS-PH 101 / BS-PH 201	**Semester: First / Second**
L-T-P: 3-1-0	**Credit: 4**

Total Lecture: 42L

Course Objectives

- To introduce the rudimental and relevant concepts of physics to different branches of Engineering and Technology.
- To compile all the knowledge acquired from the course and to apply in industry, academia, and research keeping in the mind about ethical awareness and impact in the field of environmental (pollution), social (legal) and safety.

Module-1 [10L]
Vector Calculus
Gradient of a Scalar function, Divergence and Curl of Vector field, Vector Integration –Line-, surface and volume integration - Divergence and Stoke's Theorem

Oscillations And Waves
Simple Harmonic Oscillation- Motion of simple and compound pendulum –Energy Considerations - Coupled oscillations, approximate solutions, linear and transverse oscillations.
Damped Oscillations – Over damped - critical damping –oscillatory damping – Relaxation time & log decrement. Forced oscillation – Electromechanical Analogy between Mechanical Oscillator with Electrical circuit – Mechanical Impedance - Transient and Steady state oscillations – Resonance - Power considerations - Low and high frequency responses – Bandwidth – Quality factor - Sharpness of Resonance

Module -2 [11L]
Interference – Division of wave front and division of amplitude - Two-and Multiple Beam Interference, Interference in parallel and wedge shaped films - Newton's rings - determination of wave length and thickness - Thin film Interference - Anti-reflection Coating – its application.

Diffraction – Fresnel and Fraunhofer diffraction - Single Slit, Double Slit and N-Slit Diffraction (Qualitative discussion only)

Polarization – Introductory discussion of Polarization – States of Polarization – Brewster's law –Malus Law – Phase Retardation Plate –Optical Activity

Lasers – Characteristics of Laser – Classification of Laser - construction and working - Einstein's coefficients – Example of Gas Laser, Solid state laser and semiconductor lasers - Applications of Laser

Module -3 [5L]
Statistical Mechanics
Phase Space (μ- and Γ- phase space) – Macro states and Microstates – Density of States - Statistical Ensemble and Thermodynamic Probability
Classical Statistical systems (Maxwell - Boltzman statistics) and quantum statistical systems (Fermi-Dirac and Bose-Einstein Statistics) and their applications

Module -4 [10L]
Quantum Mechanics
Blackbody Radiation – Stefan-Boltzmann law - Wein's displacement law - Wein's distribution law - Rayleigh-Jeans law - Ultraviolet catastrophe - Planck's Radiation law, Compton Effect, Dual Nature of Matter – De' Broglie hypothesis – Heisenberg's Uncertainty Principle – Group velocity and Phase velocity, Wave function – Postulates of Quantum Mechanics – Quantum Mechanical operator –Eigen function and Eigen value - Schrödinger's time dependent and time independent wave equation – Particle in 1D box –Particle in 3D box – Concept of degeneracy

Module -5[6L]
Dielectric Polarization
Fundamentals of Dielectric polarization – Macroscopic and microscopic field – Electronic, Ionic, Orientational and Space charge polarization (Qualitative overview) - dielectric loss- Loss tangent - Application of dielectric materials

Magnetic Properties
Fundamentals of magnetic properties – Classification (Dia, Para, Ferro, Anti-ferro, Ferri, Super-para) of magnetic materials – Curie temperature – Magnetic domain – Hysteresis – hard and soft magnetic materials –Applications of Magnetic materials

Course Outcomes(COs)
CO1. Describe how different electronic tools, various parameters & variables of fundamental physics related to the programme. To overcome & eliminate different constraints those may arises by solving the physical and numerical problems.
CO2. Overall enhancement of innovative problems solving ability by enhancing the power of knowledge and imagination.
CO3. Describe the current research works and publications of the subjects in different fields adopted by the students as per course curriculum in various journals and literature.
CO4. Describe how the ideas those are adopted can be implemented through projects and demonstrate various models, recent project proposals to execute the knowledge adopted from the course.
CO5. Define how the ideas can be share with the multi - disciplinary personals. Lighten on the latest and modern developments in the fields.
CO6. Explain about ethical awareness and impact in the field of environmental, social and safety of the finished products. Describe the pollution, legal aspects and impacts may arise in large scale production.

Learning Resources
1. Vector Analysis – M.R.Spiegel
2. Waves and Oscillation – N.k.Bajaj
3. Introduction to Classical Mechanics R Takwale, P Puranik, McGraw Hill Education
4. Principles of Physics, 10ed, David Halliday, Robert Resnick Jearl Walker , Wiley
5. Optics –A.K.Ghatak McGraw Hill Education India Private Limited
6. Modern Physics for Scientists and Engineers, J. R. Taylor, C.D. Zafiratos and M. A. Dubson, 2nd Ed., Pearson (2007)
7. Modern Quantum Mechanics, J. J. Sakurai, Cambridge University Press
8. Solid State Physics, S.O.Pillai

Paper Name: Chemistry-I	**Category: Basic Science Course**
Paper Code: BS-CH-101 / BS-CH-201	**Semester: First / Second**
L-T-P: 3-1-0	**Credit: 4**

Total Lecture: 42L

Course Objective

- To develop the interest among the students regarding chemistry and their applications in engineering
- To develop confidence among students about chemistry, how the knowledge of chemistry is applied in technological field.

Module I [11L]

Thermodynamics: (6L)

Preliminary information on First Law of Thermodynamics (Principle, Molar Heat Capacity; Relation of C_p and C_V (for Ideal and Real Gas); Joule's Experiment, Joule-Thompson Co-efficient, Throttling, Adiabatic Relationship); Second Law, Engine; Carnot's Cycle; Entropy, Entropy change; Entropy of system/surrounding/Universe; Free Energy, Free energy expression; Gibbs-Helmholtz equation; Clausius-Clapeyron equation; Maxwell relations.

Electrochemistry: (2L)

Cell construction; Primary and Secondary Cell; Nernst Equation; Relation with ΔG, ΔH and ΔS; pH of Cell; Batteries; Fuel Cell

Chemical Kinetics: *(*3L)

Rate equation; Collision and Activation Theory; Temperature dependency; Complex Reaction; Parallel reaction; Consecutive reaction; Chain Reaction; Homogeneous and Heterogeneous Catalyst; Acid base catalysis; Enzyme Catalysis; Michaelis Menten equation.

Module II [8L]

Atomic structure:*(*3L)

Preliminary Accounts on Bohr-Sommerfeld model of the atom (Electronic configuration and Quantum numbers; Shapes of *s, p, d, f* orbitals - Pauli's exclusion principle - Hund's Rule of maximum multiplicity – Aufbau principle). Emission and absorption spectra, line and band spectra; Hydrogen spectrum – Lyman, Balmer, Paschen, Brackett and Pfund series; de-Broglie's hypothesis; Heisenberg's uncertainty principle – wave nature of electron – Schrodinger wave equation (No derivation). Eigenfunctions and eigenvalues.

Chemical bonding and Coordination Chemistry: (5L)

Elementary information on Chemical bondingincluding VBT, Shapes of molecules with hybridization, Valency shell electron pair repulsion (VSEPR) theory. Molecular orbital of diatomic molecules (e.g. H_2, O_2, N_2, CO, HF, CN^-, NO^+). Pi-molecular orbital of butadiene and benzene. Crystal field theory of coordination compounds- magnetism, spin and orbital

contribution, quenching of magnetic moment: d-d transitions, color. Metallic bond – concept of conductor, semiconductor, insulator; photoelectric effect.

Module III [7L]

Organic Spectroscopy (7L)

UV-Visible Spectroscopy: Types of electronic transitions, chromophores and auxochromes; Bathochromic and Hypsochromic shifts; intensity of absorptions (Hyper-/Hypochromic effects); application of Woodward's Rules for calculation of λ_{max} for the following systems: conjugated dienes, relative positions of λ_{max} considering conjugative effect, steric effect, solvent effect.

IR Spectroscopy: Introduction; modes of molecular vibrations (fundamental and nonfundamental); IR active molecules**.**

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance; NMR active molecules; equivalent and non-equivalent protons with examples; chemical shift. Significance of the terms: up-/downfield, shielded and deshielded protons.

Fluorescence, phosphorescence and their application.

Mass Spectroscopy: Introduction; Principles, Ion sources**,** Fragmentation and analysis of mass spectra.

Module IV [6L]

Polymer (3L)

Molecular weight of Polymers (number average, weight average, viscosity average), Polymerization processes (addition and condensation), Mechanism of addition polymerization (free radical, cationic, anionic, coordination), Poly Dispersity Index (PDI), Degree of Polymerization, Stereo-regularity of polymers (crystallinity and amorphicity). Vulcanization. Conducting, semi-conducting polymers and doping.

Corrosion (3L)

Types of corrosion (dry, wet),Pitting corrosion, Crevice corrosion, Galvanic series, Stress corrosion cracking, Corrosion of polymers. Protection from Corrosion (Surface treatments, Reactive coatings, Anodization, Biofilm coatings) Sacrificial anode protection, Rust removal, Passivation, Water treatment (waste, surface), Alkalinity, Scale-sludge.

Module V [6L]

Stereochemistry *(*4L)

Different types of isomerism;concept of chirality and optical activity (upto two carbon atoms); elements of symmetry [plane (σ), center (i) and alternating axis (Sn) of symmetry]; interconversion of Fischer and Newman representations; threo and erythro, D and L, CIP Rules: R/S (upto 2 chiral carbon atoms),E/Z nomenclature. Conformational analysis of ethane, *n*-butane.

Structure and reactivity of Organic molecule (2L)

Molecular Effects: Inductive, resonance, hyperconjugation, steric effects. Oxidation and reduction reactions for organic compounds. Some name reactions: Aldol, Cannizzaro, Michael, Claisen-Schmidt, Wittig reactions.

Module VI [4L]

Elementary Chemical Biology:

Origin of Life and Chemical Elements; Role of concentration of ions/small molecules in the growth profile of cells; Trace and Ultratrace elements; Basic Biomolecules, Elementary reactions in the biological system and roles of metal ions. Function of Fe (with special reference to Hemoglobin and Myoglobine) and Cu (with special reference to Hemocyanin) in Biological system. Toxicity of Hg, As, Pb, F, P(V).Synthesis of some commonly used drug molecules (Aspirin, Paracetamol, Salbutamol and Ibuprofen). Synthesis of some commonly used Pesticides and Insecticides in Agriculture: DDT, Gammaxene/Lindane (organochlorine group), Parathion (organophosphate group) and Carbaryl (carbamate group).

Course Outcomes(COs)

CO1. To memorize the elementary topics of chemistry such as chemical thermodynamics, atomic structures, electromagnetic spectroscopy, corrosion chemistry, electrochemistry, organic reactions and synthesis of drug molecules.

CO2. To acquire knowledge on the fundamental concepts of chemical thermodynamics, atomic structures, electromagnetic spectroscopy, corrosion chemistry, electrochemistry, organic reactions, polymers and synthesis of drug molecules.

CO3. Making use of concepts of drug molecules, polymer chemistry, corrosion chemistry and battery technology to meet day to day necessities including application of the organic synthesis, Maxwell's equations, spontaneity and equilibrium reactions etc.

CO4. analyse versatileand novel problems and sorting them out,covering all the topics of the entire course.

CO5. rationalize, explain and corroborate several chemical problems, determine the most plausible approach of solving real life interdisciplinary chemical complications.

CO6. To construct apurposeful and efficient model through which learners can be able to develop and solve trivial as well as up to date problems recognized by academia, researchers and industries.

Learning Resources

1. P.C.Rakshit, , Physical Chemistry Sarat Book House
2. S. Pahari, , Physical Chemistry New Central Book Agency
3. P. W. Atkins, & Paula, J. de Atkins', Physical Chemistry, Oxford UniversityPress
4. J. D. Lee, Concise Inorganic Chemistry, 5th Ed., Wiley India Pvt. Ltd.
5. F.A. Cotton, G. Wilkinson, and P.L. Gaus, Basic Inorganic Chemistry 3rdEd.; Wiley India.
6. J. E. Huheey, E. A. Keiter, & R. L. Keiter, Inorganic Chemistry, Principles ofStructure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.

7. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, Second edition, Oxford University Press.
8. S. Sen Gupta, Reaction Mechanisms in Organic Chemistry, Oxford University Press
9. L. Finar, Organic Chemistry (Volume 1) Pearson Education.
10. R. N. Morrison, & R. N. Boyd, Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
11. D. Nasipuri, Stereochemistry of Organic Compounds, Wiley Eastern Limited.
12. E. L. Eliel, & S. H. Wilen, Stereochemistry of Organic Compounds, Wiley: London, 1994.
13. B. K. Sharma,Industrial Chemistry (including Chemical Engineering), GOEL Publishing House

Paper Name: **Programming for Problem Solving**	**Category: Engineering Science Course**
Paper Code: ES-CS-101/ES-CS -201	**Semester: First / Second**
L-T-P: 3-1-0	**Credit: 4**

Total Lecture: 40L

Course Objectives

- To introduce to students to the field of programming using language.
- To enhance their analyzing and problem solving skills **.**

Module 1 [12L]

Unit 1: Introduction to Programming (4 L)

Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.)

Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudocode with examples.

From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code

Unit 2: Arithmetic expressions and precedence (**2 L**)

Unit 3: Conditional Branching and Loops (**6 L**)

Writing and evaluation of conditionals and consequent branching
Iteration and loops

Module 2 [12L]

Unit 1: Arrays (**6 L**)

Arrays (1-D, 2-D), Character arrays and Strings

Unit 2: Basic Algorithms (**6 L**)

Searching, Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)

Module 3 [9L]

Unit 1: Function (**5 L**)

Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference

Unit 2: Recursion (**4 L**)

Recursion, as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.

Module 4 [7 L]

Unit 1: Structure (**4 L**)

Structures, Defining structures and Array of Structures

Unit 2: Pointers (**2 L**)

Idea of pointers, Defining pointers, Use of Pointers in self-referential structures, notion of linked list, dynamic memory allocation, Union (no implementation)

Unit 3: File handling (**1 L)**

Basic idea about read, write, append operation if time is available, otherwise should be done as part of the lab)

Course Outcomes (COs)

CO1. To formulate simple algorithms for arithmetic and logical problems.
CO2. To test and execute the programs and correct syntax and logical errors.
CO3. To implement conditional branching, iteration and recursion.
CO4. To decompose a problem into functions and synthesize a complete program using divide and conquer approach. To use arrays, pointers and structures to formulate algorithms and programs.
CO5. To apply programming to solve matrix addition and multiplication problems and searching and sorting problems.
CO6. To apply programming to solve simple numerical method problems, namely rot finding of function, differentiation of function and simple integration.

Learning Resources

1. R. S. Salaria, Computer Concepts and Programming in C, Khanna Publishers
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill
3. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill
4. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India

Paper Name: Basic Electrical and Electronics Engineering	**Category: Engineering Science Courses**
Paper Code: ES-EE101 / ES-EE201	**Semester: First / Second**
L-T-P: 3-1-0	**Credit: 4**

Total Lecture: 45L

Course Objectives

- To understand the impact of technology in a global and societal context.
- To Provide working knowledge for the analysis of basic DC and AC circuits used in electrical and electronic devices.

Module 1 [3L]

Electromagnetism:

Magnetic circuits, Analogous quantities in magnetic and electric circuits, Faradays' law, self and mutual inductance, Hysteretic and Eddy current losses, Self and Mutual inductance, B-H loop, Hysteresis and Eddy current loss

Module 2 [10L]

Circuits Analysis

DC Network Theorem: Definition of electric circuit, network, linear circuit, non-linear circuit, bi lateral circuit, unilateral circuit. Kirchhoff's law. nodal analysis, mesh analysis. Principle of superposition. Source equivalence and conversion, Thevenin's theorem, Norton Theorem,
AC fundamental: Production of alternating voltage, waveforms, average and RMS values, peak factor, form factor, phase and phase difference, phasor representation of alternating quantities, phasor diagram, behavior of AC series circuits, power factor, power in AC circuit.

Module 3 [6L]

Transformers

Single phase transformer: Core and shell type construction, ideal and practical transformer,
EMF equation, no load and on load, operation, phasor diagram and equivalent circuit, losses of a transformer, open and short circuit tests, regulation and efficiency calculation, Auto-transformer.

Module 4 [10L]

Electrical Machines

DC Machine :Construction, working, torque speed characteristic and speed control of separately excited dc motor.
AC Machine: Construction, Generation of rotating magnetic fields and working of a three-phase induction motor, Torque-slip characteristic, Brief idea about Single Phase Induction Motor and Synchronous generators

Module 6 [8L]

Transistors

Transistor Biasing and Bias stability: calculation of stability factor with variation of Ico Different operating modes; CE, CB, CC and their properties; small signal low frequency operation of transistors; equivalent circuits h parameters as a two port network. Transistors as amplifier:

expression of voltage gain, current gain, input impedance and output impedance, frequency response for CE amplifier with and without source impedance(qualitative)

Module 7 [5L]
Field Effect Transistor
Construction and characteristics of JFET (N channel only), Transfer characteristics; construction and characteristics of MOSFET (N channel only), depletion and enhancement type; CS, CG, CD configuration

Module 8 [3L]
Operational Amplifier
Concept of virtual earth, inverting and non-inverting mode of operation, voltage summing, difference, constant gain multiplier, voltage follower, comparator, integrator, differentiator.

Course Outcomes(COs)

CO1. To acquire knowledge of different theorems for electric and magnetic circuits analysis. Explain the working principle, construction, applications of Transformer, DC machines, AC machines. Concept of 3 phase power, JFET, MOSFET, OPAMP, sinusoidal voltages and currents in different machines and circuits. Explain fundamental laws and theorems governing the working different electrical machines and circuits. Able to identify the procedures for calculations of different circuit parameters.

CO2. Use the concepts of applying mathematics and science principles, trigonometry, complex algebra, phasor operations to provide solution of different simple problems; critical circuit problems related to electrical systems.

CO3. Analyze series circuits, flow of currents, algebraic sum of voltages (voltage drops) in any closed path in a circuit to examine the behavior of electric circuits and performance characteristics and efficiency of electrical machines.

CO4. Evaluate and judge whether the solutions obtained are correct and matches the required parameters and characteristics.

CO5. Use the knowledge acquired to investigate unknown problems and design and assemble to find a solution to the problem.

Learning Resources

1. Basic Electrical engineering, D.P Kothari & I.J Nagrath, TMH, Second Edition
2. Basic Electrical Engineering, V.N Mittle & Arvind Mittal, TMH, Second Edition
3. Basic Electrical Engineering, Nath & Chakraborti
4. Electrical Technology, Vol-I,Vol-II, Surinder Pal Bali, Pearson Publication
5. A Text Book of Electrical Technology, Vol. I & II, B.L. Theraja, A.K. Theraja, S.Chand &Company
6. Electrical Engineering Fundamentals, Vincent Del Toro, Prentice-Hall
7. Advance Electrical Technology, H.Cotton, Reem Publication
8. Basic Electrical Engineering, R.A. Natarajan, P.R. Babu, Sictech Publishers
9. Basic Electrical Engineering, N.K. Mondal, Dhanpat Rai

Paper Name: Basic Electrical and Electronics Engineering Laboratory	**Category: Engineering Science Courses**
Paper Code: ES-EE191 / ES-EE291*	**Semester: First / Second**
L-T-P :0-0-3	**Credit: 1.5**

Course Objectives:

CO 1:Analyse fundamental theoretical concept, laws and theorems of Basic Electrical Engineering-I through experimental set up.

CO 2:Identify and use of various electrical measuring devices.
CO 3:Practice different types of wiring and devices connections keeping in mind technical and economical safety issues.
CO 4:Evaluate and judge whether the solutions obtained are correct and matches therequired parameters and characteristics.
CO 5:Familiarize with different active and passive electronic and electrical components, Trainer Kit, Function Generator, CRO and different measuring equipments and apply network theorems on DC and AC networks and Choose the proper type and specification of measuring procedure and measuring instruments for different industrial/commercial/domestic applications.
CO 6:Examine various real life situations in domestic or industrial scenario where measurements of electronics and electrical quantities are essential without measuring equipments i.e. alternate process of identification and characterization of components and build up the ability to work in a team to complete the task within a fixed time limit and proper resource utilization taking different responsibility with fully cooperation with other team mates

Choose 10 experiments from the following:

1. First activity: Introduction to basic safety precautions .
   a) Introduction and uses of Voltmeter , ammeter , Wattmeter and Auto-transformer .
   b) Introduction and uses of components of LT switchgear (MCB and different types of fuses .
2. Introduction and uses of following instruments :
   a) Multimeter (b) Oscilloscope and c) Function Generator .Demonstration of real life resistors, capacitors, inductors with color code .
3. Calibration of ammeter and Wattmeter.
4. Observation of voltage phase differences of R-L and R-C seriescircuit whena pure sinusoidal supply is applied across it.
5. Open circuit and short circuit test of a single-phase transformer.
6. Connection and measurement of power consumption of a fluorescent lamp.
7. Voltage-current characteristic of incandescent lamps.
8. Measurement of power in a three phase unbalanced circuit by two wattmeter

method.

9. Determination of Torque –Speed characteristics of separately excited DC motor.

10. Determination of Torque speed characteristics and observation of direction reversal by change ofphase sequence of connection of Induction motor.

11. Verification of Thevenin's Theorem .

12. Verification of Norton's Theorem .

13. Verification of Superposition Theorem.

14. .Study of OPAMP circuits: Inverting and Non-inverting amplifiers, Integrators and Differentiators.

Text Books:

1. Basic Electrical engineering, D.P Kothari & I.J Nagrath, TMH, Second Edition

2. Basic Electrical Engineering, V.N Mittle& Arvind Mittal, TMH, Second Edition

3. Basic Electrical Engineering, Nath&Chakraborti

4. Electrical Technology, Vol-I,Vol-II,Surinder Pal Bali, Pearson Publication

5. A Text Book of Electrical Technology, Vol. I & II, B.L. Theraja, A.K.Theraja,S.Chand& Company

Reference Books:

1. Electrical Engineering Fundamentals, Vincent Del Toro, Prentice-Hall

2. Advance Electrical Technology, H.Cotton, Reem Publication

3. Basic Electrical Engineering, R.A. Natarajan, P.R. Babu, Sictech Publishers

4. Basic Electrical Engineering, N.K. Mondal, Dhanpat Rai

Paper Name: English Language and Technical Communication	**Category: Humanities and Social Sciences including Management course**
Paper Code: HM-HU 101/HM-HU201	**Semester: First / Second**
L-T-P: 2-0-0	**Credit: 2**

Total Lecture: 32L

Course Objectives

- To acquire language skills,
- to develop linguistic and communicative competencies for Engineering students.
- to study academic subjects more effectively using the theoretical and practical components of English syllabus, and hence will develop study skills and communication skills in formal and informal situations.

Module 1: Theories of Communication [6L]

Theories and Principles of Communication: Definition, Process, Model (Schematic diagram of Shannon and Weaver's Model of Communication), Types of Communication – Verbal and Non-verbal communication, Flows of communication

Barriers to communication

Workplace/ Business Communication which can have the following items:

a) Scope of Oral Communication

b) Oral Business Communication: Introducing oneself in a professional setup - brevity, context, understatement, body language –

Task: Introducing others - introducing a junior professional to a senior professional, introducing an employee to a customer, introducing a colleague from your firm to an employee of another firm.

c) Telephone (audio and video) communication: choice of words, body language, paralinguistic elements of speech, enunciation, brevity, clarification, effective closure

Module 2 : Applied Grammar [9L]

Common Errors in English

- Subject-verb agreement
- Tenses
- Noun-pronoun agreement
- Articles and Prepositions
- Misplaced or dangling modifiers
- Redundancies
- Cliché

Transformation of Sentences

- Active and Passive voice
- Direct and Indirect speech
- Degrees of Comparison

Use of phrases and clauses in sentences

Synthesis of Sentences: Simple, Complex and Compound

Module 3 Vocabulary Building [3L]

The concept of word formation: Compounding, Backformation, Clipping and Blending
Root words from foreign languages and their use in English
Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.
Synonym, antonym, phrasal verbs, one word substitution and standard abbreviation

Module 4 Basic Writing Skills [4L]

Documenting: definition, meaning, basic concept of documenting (print and online media), types of technical documents
Importance of proper punctuation
Creating coherence: Arranging paragraphs & Sentences in logical order
Creating Cohesion: Organizing principles of paragraphs in documents
Techniques for writing precisely

Module 5 Professional Writing Skills [10L]

Technical Report Writing: Types and formats
Comprehension, Précis and Expansion Writing, Essay Writing, Writing SOPs and Project Proposals.
Business Letters; Cover letter & CV
Office Correspondence:

- Notice
- Agenda
- Minutes
- Memo
- E-mail

Course Outcomes(COs)

CO1. Understanding the mechanism of interpretation through language learning by practicing reading, writing and comprehension skills.
CO2. Understanding complex engineering problems by a sound grammatically correct knowledge of the English Language & honing writing, and reading skills for software research, solutions, marketing etc.
CO3. Equipping learners to solve various problems related to aptitude test through the practice of various Verbal reasoning and grammar practice.
CO4. Development of analytical thinking through practice of analytical essays, business correspondence.
CO5. Learning effective communication strategies for handling criticism and adverse remarks and also knowing strategies of effective intervention, kinesics and courtesies and different components of soft skills.
CO6. Awareness about the society, public health and safety, growth and changes in society, culture and environment through comprehension, technical report writing practice.

Learning Resources

1. Connect: A Course in Communicative English by Debashis Bandyopadhyay and Malathy Krishnan. Cambridge University Press. 2018.
2. Communication Skills. Sanjay Kumar and Pushp Lata. Oxford University Press. 2015.
3. Communication Skills for Professionals. Nira Konar, Prentice Hall of India 2nd edition, New Delhi,2011
4. High School English Grammar by Wren and Martin
5. Common Errors in English by S.Prasad & K.P.Thakur,Bharti Bhhawan Publishers
6. Business Correspondence and Report Writing – R.C. Sharma and Krishna Mohon, Tata McGraw-Hill Publishing company Ltd., New Delhi
7. English Vocabulary in Use- McCarthy
8. Communicative English – E. Sureshkumar and P. Sreehari – Orient Blackswan , 2007
9. Speaking Effectively**,** Developing Speaking Skills for Business English, Jeremy Comfort-Cambridge University Press, 1994
10. Practical English Usage. Michael Swan. OUP. 1995.
11. Remedial English Grammar. F.T. Wood. Macmillan.2007
12. A Practical English Grammar – A.J. Thomson, A.V. Martinet – Oxford University Press
13. Guide to writing as an Engineer, John Willey - David F.Beer and David McMurrey,. New York, 2004

Paper Name: **Physics Labotary –I**	**Category: Basic Science Course**
Paper Code: (BS-PH-191 & BS-PH-291)	**Semester: First / Second**
L-T-P: 0-0-3	**Credit: 1.5**

Periods: 36P

Course Objectives

- To provide exposure to the students with hand on experience for data acquisition, precession, statistical data analysis, graph plotting calculation of fundamental quantities and error estimation of different fundamental physics experiments relevant to various engineering discipline.

All students have to perform total 9 experiments taking at least one from Optics,Electricity & Magnetism, Quantum Mechanics, Miscellaneous experiments and Innovative experiment sections. (One Innovative experiment is mandatory)

List of Experiments

Optics Experiments

1. Determination of dispersive power of the material of a prism
2. Determination of wavelength of a monochromatic light by Newton's ring
3. Determination of wavelength of a monochromatic light by Fresnel's bi-prism
4. Determination of wavelength of the given laser source by diffraction method
5. Determination of numerical aperture, angle of acceptance and bending energy losses of an optical fiber

Electricity & Magnetism Experiments

1. Determination of thermo electric power of a given thermocouple.
2. Determination of specific charge (e/m) of electron by J.J. Thompson's method.
3. Determination of dielectric constant of a given dielectric material.
4. Determination of Hall coefficient of a semiconductor by four probe method.
5. Determination of resistance of ballistic galvanometer by half deflection method and study of variationof logarithmic decrement with series resistance.
6. Determination of unknown resistance using Carey Foster's bridge
7. Study of Transient Response in LR, RC and LCR circuits using Exp EYES
8. Generating sound from electrical energy using Exp EYES

Quantum Physics Experiments

1. Determination of Stefan-Boltzmann constant.
2. Determination of Planck constant using photocell.
3. Determination of Lande-g factor using Electron spin resonance spectrometer.
4. Determination of Rydberg constant by studying Hydrogen spectrum.
5. Determination of Band gap of semiconductor.
6. To study current voltage characteristics, load response, areal characteristic and spectral response of a photovoltaic solar cell.

Miscellaneous Experiments

1. Determination of Young's modulus of elasticity of the material of a bar by the method of flexure
2. Determination of bending moment and shear force of a rectangular beam of uniform cross-section
3. Determination of modulus of rigidity of the material of a rod by static method
4. Determination of rigidity modulus of the material of a wire by dynamic method
5. To determine the moment of inertia of a body about an axis passing through its centre of gravity and to determine the modulus of rigidity of the material of the suspended wire
6. Determination of coefficient of viscosity by Poiseuille's capillary flow method
7. Measurement of wavelength and velocity of Ultrasonic wave by using Ultrasonic Interferometer.

Innovative Experiments

1. Studies on Bandgap measurement of thin film using UV-VIS spectrophotometer.
2. Basic UV-VIS absorbance study of organic dyes.
3. Basic UV-VIS study of nano-particles (NPs) and quantum dots (Q Dots).
4. Basic photoluminescence study of organic dyes.
5. Basic photoluminescence study of nano-particles (NPs) and quantum dots (Q Dots).
6. Studies on Basics of Vacuum system and Vacuum measurements.

Course Outcomes (COs)

CO1. Describe the various aspects, parameters, scales of experimental tools and design to conduct the experiments in the laboratory.
CO2. Analyze the methods of experiments and interpret the output results. Emphasis on the limitations of theoretical concepts, measuring instruments to perform the experiments and deviation of results from ideal one.
CO3. Describe the needs of publication of the outcome results and correlate the results with published papers in various journals and literature in the respective fields.
CO4. Describe how the ideas those are adopted can be implemented through projects and demonstrate various models, recent project proposals to execute the knowledge adopted from the course.
CO5. Define how the ideas can be share with the multi - disciplinary personals. Lighten on the latest and modern developments in the fields.
CO6. Explain about ethical awareness and impact in the field of environmental, social and safety of the finished products. Describe the pollution, legal aspects and impacts may arise in large scale production.

Learning Resources

1. B.Sc. Practical Physics – C.L.Arora
2. B.Sc. Practical Physics – Harnam Singh and Dr. P.S.Hemne – S.Chand

Paper Name: Chemistry Laboratory –I	**Category: Basic Science Course**
Paper Code: (BS-CH-191 & BS-CH-291)	**Semester: First / Second**
L-T-P: 0-0-3	**Credit: 1.5**

Periods: 36P

Course Objective

- To be able to design, carry out, record and analyze the results of chemical experiments.
- To demonstrate creative and independent thinking in both learning and work environments.
- To be able to use modern instrumentation and classical techniques, to design experiments and to properly record the results of their experiments.

Name of the Experiments

1. Preparation of Phenyl and Hand Sanitizer owing to its disinfectant and germicidal values.
2. Determination of the partition coefficient of a substance between two immiscible liquids.
3. Complexometric titration for determination of calcium and magnesium hardness of water.
4. Conductometric and pH- metric titration for determination of strength of a given HCl solution against a standard NaOH solution.
5. Determination of dissolved oxygen present in a given water sample.
6. Determination of chloride ion in a given water sample by Argentometric method (using chromate indicator solution)
7. Determination of percentage composition of sugar solution by viscosity measurement method.
8. Saponification/acid value of oil.
9. Preparation of some useful organic compounds: Pthalimide, Aspirin
10. Study on Thin layer chromatography
11. Preparation of some useful polymer: PF resin, MF resin.

Course Outcomes(COs)

CO1. To be able to design, carry out, record and analyze the results of chemical experiments. Students will demonstrate laboratory skills and show understanding in all major laboratory techniques and principles including instrumentation, synthesis, purification, analysis including green chemistry.

CO2. To be skilled in problem solving, critical thinking and analytical reasoning. To operate a range of chemical instrumentation with adequate hands-on experiences.

CO3. To be able to use modern instrumentation and classical techniques, to design experiments and to properly record the results of their experiments.

CO4. To be able to use appropriate literature research and go through journal articles for

useful information. Students will show proficiency at scientific communication including posters, presentations, laboratory reports and even journal articles.

CO5. To demonstrate creative and independent thinking in both learning and work environments. Work independently and collaborate effectively with other people in a team. Self-evaluate their own learning progress and develop motivation and learning skills for lifelong learning.

CO6. To learn the value of a professional work ethic including working as part of a diverse team. They will develop the ability to recognize ethical issues related to the impact of technological advances on society.

Learning Resources

1. A. I. Vogel, Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.
2. A. K. Nad, B. Mahapatra, A. Ghoshal, An Advanced Curse in Practical Chemistry, New Central Book Agency; 3rd edition.
2. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.
3. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. Practical Organic Chemistry, 5th Ed.,Pearson (2012).
4. H. T. Clarke, A Handbook of Organic Analysis (Qualitative and Quantitative), Fourth Edition, CBS Publishers and Distributors (2007).
5. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.

Paper Name: Programming for Problem Solving	**Category: Engineering Science Course**
Paper Code: ES-CS-191/ES-CS -291	**Semester: First / Second**
L-T-P: 0-0-3	**Credit:1.5**

Periods: 36P

Course Objectives

- To formulate and test simple algorithms for arithmetic and logical problems,execute the programs and correct syntax and logical errors for implementing conditional branching, iteration and recursion.

The laboratory should be preceded or followed by a tutorial to explain the approach or algorithm to be implemented for the problem given

Tutorial 1: Problem solving using computers:
Lab1: Familiarization with programming environment
Tutorial 2: Variable types and type conversions:
Lab 2: Simple computational problems using arithmetic expressions
Tutorial 3: Branching and logical expressions:
Lab 3: Problems involving if-then-else structures
Tutorial 4: Loops, while and for loops:
Lab 4: Iterative problems e.g., sum of series
Tutorial 5: 1D Arrays: searching, sorting:
Lab 5: 1D Array manipulation
Tutorial 6: 2D arrays and Strings
Lab 6: Matrix problems, String operations
Tutorial 7: Functions, call by value:
Lab 7: Simple functions
Tutorial 8 &9: Numerical methods (Root finding, numerical differentiation, numerical integration):
Lab 8 and 9: Programming for solving Numerical methods problems
Tutorial 10: Recursion, structure of recursive calls
Lab 10: Recursive functions
Tutorial 11: Pointers, structures and dynamic memory allocation
Lab 11: Pointers and structures
Tutorial 12: File handling:
Lab 12: File operations

Course Outcomes(COs)

CO1. To formulate simple algorithms for arithmetic and logical problems.
To translate the algorithms to programs (in C language).
CO2. To test and execute the programs and correct syntax and logical errors.
To implement conditional branching, iteration and recursion.
CO3. To decompose a problem into functions and synthesize a complete program using divide and conquer approach.

CO4. To use arrays, pointers and structures to formulate algorithms and programs.
CO5. To apply programming to solve matrix addition and multiplication problems and searching and sorting problems.
CO6. To apply programming to solve simple numerical method problems, namely rot finding of function, differentiation of function and simple integration.

Paper Name: Workshop Practice	**Category: Engineering Science Course**
Paper Code: ES-ME191 / ES-ME291	**Semester: First / Second**
L-T-P: 1-0-3	**Credit: 2.5**

Periods: 39P

Course Objectives

- To gives the basic working knowledge required in various engineering based constructions, function, use and application of different working tools, equipment, and machines as well as the technique of manufacturing a product from its raw material.

[Before practice, background lectures will be delivered on the topics. Tool specifications and their materials will be described. Brief reports on the work done will be submitted by the students and evaluation will be made on the basis of examination of the report and viva, conducted by the teachers.]

Theory

1. Carpentry (Wood Working)

Timber, Seasoning and Preservation, Plywood and Plyboards, Carpentry Tools, Engineering applications. Different Joints

2. Metal Joining

Definitions of welding, brazing and soldering processes, and their applications. Oxy-acetylene gas welding process, equipment and techniques. Types of flames and their applications. Manual metal arc welding technique and equipment. AC and DC welding, electrodes, constituents and functions of electrodes. Welding positions. Types of weld joint. Common welding defects such as cracks, slag inclusion and porosity.

3. Bench work and Fitting

Tools for laying out, chisels, files, hammers, hand hacksaw, their specifications and uses.

4. Metal Cutting

Introduction to machining and common machining operations. Cutting tool materials, geometry of cutting tool, cutting fluid. Definition of machine tools, specification and block diagram of lathe, shaper, milling, drilling machine and grinder. Common lathe operations such as turning, facing and chamfering and parting. Difference between drilling and boring. Use of measuring instruments like micrometer / verniercaliper.

5. Tin Smithy

Sheet metal introduction, tools and operations, Shearing and Bending of sheets, types of joints

Jobs to be made in the Workshop

Group A(6 P)

Carpentry Shop: T-Lap joints and Dovetail joint

Group B (6 P)

a. Gas Welding practice on mild steel flat/sheet (upto 3mm thick)

b. Lap joint by Gas Welding (upto 3mm thick)

c. Manual Metal Arc Welding practice (upto 5mm thick)

d. Square butt joint by MMA Welding

e. Lap joint by MMA Welding

Group C

Fittings work: Sawing and Finishing by Filing. (6 P)

Group D

a. Jobs on lathe with turning, facing, chamfering and parting operations (6 P)

b. Job on shaper and milling machine for finishing two sides of a job (6 P)

c. Drilling of holes of size 5 and 12 mm diameters on the jobs / External threads making by dies, Tap size drill hole/ hand tapping operations

Group E

Smithy - making simple products on sheet metal (6 P)

Course Outcomes (COs)

CO1. Define, describe and determine the types and nature of the physical parameters like cutting speed, feed, depth of cut etc applied on mechanical manufacturing systems.

CO2. Classify and explain the effects of the above physical parameters as applied on mechanical manufacturing systems for proper comprehension.

CO3. Train the students in metal joining process like welding, soldering, etc

CO4. Impart skill in fabricating simple components using sheet metal

CO5. Cultivate safety aspects in handling of tools and equipment

CO6. Develop the collective skill and potentiality and leadership quality to work in a group or team.

Learning Resources

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., “Elements of WorkshopTechnology”, Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2. Kalpakjian S. and Steven S. Schmid, “Manufacturing Engineering and Technology”, 4th edition,Pearson Education India Edition, 2002.

3. Gowri P. Hariharan and A. Suresh Babu,"Manufacturing Technology – I" Pearson Education, 2008.
4. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th edition, Prentice Hall India, 1998.
5. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGrawHill House, 2017.

Paper Name: Engineering Drawing	**Category: Engineering Science Course**
Paper Code: ES-ME192 / ES-ME292	**Semester: First / Second**
L-T-P: 1-0-3	**Credit: 1.5**

Periods: 42P

Course Objectives

- To teach students to communicate using **graphic** techniques.
- To accomplish the principles and standards of mechanical **drawing** and dimensioning.

[Sessional work should be completed in the class. Problems sheet will be provided. Students should attempt to solve the problems given in the Problem Sheet. Home assignments will be given. Evaluation will be made on the basis of seasonal work and viva-voce examination.]

Scales (3P)

Plain scales, Diagonal scales, Vernier scales

Geometrical Construction and Curves (3P)

Conic Section: Parabola, Hyparabola, Ellipse

Projection of Points, Lines, Surfaces (9P)

Orthographic Projection – First angle and third angle projection More no. of problems should be practiced in first angle projection. Projection of lines inclined to the planes Projection of surfaces Pentagon, Hexagon

Projection of Solids (12P)

Cube, Pyramid, Prism, Cylinder, Cone, Frustums

Isometric View And Isometric Projection (6 P)

(Prism, Pyramid, Cylinder, Cone and examples of simple solid objects / models).

Sectional Views of Solids, True Shape of a Section (6 P)

Development of Surfaces (3 P)

(Cube, Prism, Cylinder, Truncated Cone)

Course Outcomes (COs)

CO1. To represent pictorially different elements and components using basic engineering drawing guidelines.

CO2. To gain significance of scaling pertinent to engineering drawing problems. The incumbents should also have knowledge about analytical curves and their relevance to understand different higher level mechanical engineering problems.

CO3. To understand the concept of projections for 1D, 2D and 3D object representation.

CO4. To develop an idea and ability to view complex interior sections of a solid object, and they will also be able to analyze and explain how different surfaces are generated when a solid object is cut along a plane and its surfaces are stretched out.

CO5. To draw isometric to orthographic views and vice versa.

CO6. To apply the comprehensive knowledge by using a suitable computer aided drafting package.

Learning Resources

1. Pradeep Jain, AnkitaMaheswari, A.P. Gautam, Engineering Graphics & Design, Khanna PublishingHouse
2. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House
3. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication
4. Shah, M.B. &Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education
5. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers
6. Corresponding set of CAD Software Theory and User Manuals

Paper Name: Language Laboratory	**Category: Humanities and Social Sciences including Management**
Paper Code: HM-HU 191/ HM-HU291	**Semester: First / Second**
L-T-P: 0-0-2	**Credit: 1**

Periods: 22P

Course Objectives

- To provide advanced skills of Technical Communication in English through various activities performed in the Language Lab Practice Sessions to 1st Semester U.G. students of Engineering and Technology.
- To instil confidence in them so that they can competently communicate in English language in all spheres.
- To make them efficient enough to communicate about day-to day events and experiences of life, comprehend lectures delivered in English, read and understand relevant materials written in English and also to write grammatically correct English.
- To make them capable of shedding their fear of communication and public speaking.

List of Experiments

1. Developing active 'Listening Skill' and its sub skills through Language Lab Audio device; (Listening to conversations, passages, stories, news bulletin, speeches by famous personalities – Listening for general and specific information etc.,) (3P)

2. Developing 'Speaking Skill' and its sub skills; (Interpersonal Communication, Oral Presentations — Debate –Extempore – Speech Presentation– Conversational Practice – Face to Face / Telephonic Conversation) (5P)

3. Developing 'Reading Skills' and its sub skills through reading excerpts from plays, poetry, news and various technical/non technical passages using Visual / Graphics/Diagrams /Chart Display etc. and using Literary text(s):
   The Homecoming by Rabindranath Tagore
   We're Not Afraid to Die... if We're Together by Gordon Cook and Alan East(4P)

4. Developing 'Writing Skill' and its sub skills by using Language Lab Audio –Visual input; Practice Sessions (Analytical essay writing, dialogue writing, story writing, etc.) (3P)

5. Pronunciation: Basic Rules (with emphasis on Accent Neutralisation)
   Organs of Speech (2P)

6. Introducing 'Group Discussion' through audio –Visual input and acquainting them with key strategies for success; GD practice sessions (unstructured and structured) (4P)

7. SWOT analysis (1P)

Learning Resources

1. Nira Konar: English Language Laboratories, A Comprehensive Manual, PHI Learning Pvt. Ltd.
2. Dr. D. Sudharani: Manual for English Language Laboratory. Pearson Education (WB edition),2010
3. Board of Editors: Contemporary Communicative English for Technical Communication, Pearson Longman, 2010
4. A Textbook of English Phonetics for Indian Students, T. Balasubramanian, Macmillan India Ltd.
5. Communicative English – E. Sureshkumar and P. Sreehari – Orient Blackswan , 2007
6. Speaking Effectively**,** Developing Speaking Skills for Business English, Jeremy Comfort- Cambridge University Press , 1994
7. Pocket Style Manual - Diane Hacker, Bedford Publication, New York, 2003. (ISBN 0312406843)

Course Outcome (COs)

CO1. Improving comprehension ability in English & understanding the mechanism of interpretation though language learning.
CO2. Honing conversation skills by learning to substantiate conclusions in grammatically correct English
CO3. Honing 'Reading Skills' and its sub skills using Visual / Graphics/Diagrams /Chart Display/Technical/Non Technical Passages; Learning Global / Contextual / Inferential Comprehension for technical competence.
CO4. Learning effective, real life communication skills in English through several language lab activities pertaining to the four basic skills of LSRW
CO5. Learning basic soft skills and leadership qualities
CO6. Engaging the learner in a positive and imaginative environment to hone socio-cultural, ethical and moral skills.

Paper Name: NSS	**Category: Universal Human Value**
Paper Code: XC-181	**Semester: First / Second**
L-T-P: 0-0-2	**Credit: 0**

Periods: 24P

Course Objectives

- To create awareness for women's education, old age education saving of girl child. Medical issue-blood donation and Thalassemia test.
- To realize, synthesize, and evaluate their personal readiness for leadership by group work, communicating effectively and to overcome & eliminate different constraints those may arises in their academic and daily life.

1. Creating Awareness in Social Issues

Blood Donation Camp, Road Safety Awareness, Poster Competition (Saving of Girl child, saving of water and fuel for future, Pollution and control,Global warming,Equal education for girls),Thalassemia awareness Programme, Eye Check-Up Camp.

2. Participating in Mass-Education Programme

a. Poster Presentation on Education for All
b. Elocation competition, SA writing on education for all
c. National Education Day celebration (11^{th} Nov)

3. Proposal for Local Slum Area Development

a. Road and Costal Side Cleaning Programme
b. Local Hospital Area Cleaning Programme (with collaboration Haldia Minicipality)
c. Campus Cleaning Programme

4. Environmental Awareness Programme

a. Resource Conversation (By Poster Competition)
   i. Water
   ii. Energy
b. Poster Competition on Global warming
c. Plantation Programme (5^{th} September)
d. Fire Safety Awareness Programme (With Haldia Fire Station)

5. Relief and Rehabilitation work during Natural Calamities

Course Outcomes (COs)

CO1. To Create awareness for women's education, old age education saving of girl child. Medical issue-blood donation and Thalassemia test.

CO2. To Realize, synthesize, and evaluate their personal readiness for leadership by group work, communicating effectively and to overcome & eliminate different constraints those may arises in their academic and daily life.

CO3. To Define and correlate different kind of social, cultural and ethical issue in light of saving of girl child, women education, saving of fuel. Manifest an ethics and

service to the nation as a fundamental duty by organizing seminar symposia, work shop, essay writing, poster presentation etc.

CO4. To Apply problem solving skills by taking on volunteer and community service in their professional and social life and show interest to think about eco-friendly projects for the betterment of the society.

CO5. To Recognize the importance of civic engagement and community activism through volunteerism, community and campus service, team projects.

CO6. To Realizing his/her importance and duty, feel interest about ethical awareness and impact in the field of environmental, social and safety of the finished products.

Curriculum Structure

SEMESTER-III

THEORY							
Sl. No.	**Course Code**	**Subject Name**	**Contact period per week**			**Total**	**Credit**
			L	**T**	**P**		
1	HM-HU 301	Engg. Economics	2	0	0	2	2
2	BS-M 301	Mathematics-III	3	0	0	3	3
3	ES-ME 301	Engineering Mechanics	3	0	0	3	3
4	PC-ME 301	Thermodynamics	3	0	0	3	3
5	PC-ME 302	Fluid Mechanics	3	1	0	4	4
6	PC-ME 303	Material Science	3	0	0	3	3
	Total Theory					**18**	**18**
PRACTICAL							
1	PC-ME 391	Fluid Mechanics Lab	0	0	3	3	1.5
2	PC-ME 392	Material Testing Lab	0	0	3	3	1.5
3	PC-ME 393	Machine Drawing	0	0	3	3	1.5
	Total Practical					**9**	**4.5**
	Total of Semester					**27**	**22.5**

Subject Code : HM-HU 301	**Category :** Humanities and Social Sciences including Management Courses
Subject Name : Economics for Engineers	**Semester** : Third
L-T-P : **2-0-0**	**Credit : 2**
Pre-Requisites : Nil	

Course Objective:

1. To make general awareness among budding engineers regarding basic principles of economics and that needed to use in an industry.
2. To give basic understanding of engineering costs, estimation, depreciation analysis and basic accounting principles.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Economic Decisions Making- Overview, Problems, Role, Decision making process.	2
2	Engineering Costs & Estimation- Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring and Nonrecurring Costs, Incremental Costs, Cash Costs vs Book Costs, Life-Cycle Costs; Types of Estimate, Estimating Models - Per- Unit Model, Segmenting Model, Cost Indexes, Power- Sizing Model, Improvement & Learning Curve, Benefits.	4
3	Present Worth Analysis: End-of-Year Convention, Viewpoint of Economic Analysis Studies, Borrowed Money Viewpoint, Effect of Inflation & Deflation, Taxes, Economic Criteria, Applying Present Worth Techniques, Multiple Alternatives.	4
4	Cash Flow & Rate of Return Analysis- Calculations, Treatment of Salvage Value, Annual Cash Flow Analysis, Analysis Periods; Internal Rate of Return, Calculating Rate of Return, Incremental Analysis; Best Alternative Choosing an Analysis Method, Future Worth Analysis, Benefit-Cost Ratio Analysis, Sensitivity and Break Even Analysis. Economic Analysis in the Public Sector- Quantifying and Valuing Benefits & drawbacks.	4
5	Depreciation- Basic Aspects, Deterioration & Obsolescence, Depreciation and Expenses, Types of Property, Depreciation Calculation Fundamentals, Depreciation and Capital Allowance Methods, Straight Line Depreciation Declining Balance Depreciation, Common Elements of Tax Regulations For Depreciation and Capital Allowances.	4
6	Inflation and Price Change- Definition, Effects, Causes, Price Change With Indexes, Types of Index, Composite vs Commodity Indexes, Use of Price Indexes in Engineering Economic Analysis, Cash Flows that inflate at different Rates.	3
7	Accounting- Function, Balance Sheet, Income Statement, Financial Ratios Capital Transactions, Cost Accounting, Direct and Indirect Costs, Indirect Cost Allocation.	3
	Total	**24**

Course Outcomes:

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

HM-HU 301.1	Understand the basic concepts and terminology used in engineering economics.
HM-HU 301.2	Use the concepts of cash flows, time value of money in evaluation of investments and projects in real life.
HM-HU 301.3	Able to compare and evaluate alternatives based on present, annual, rate of return, and benefit over cost analyses
HM-HU 301.4	Identify and analyse the impact of depreciation, taxation and other economic factors on feasibility of real life projects.
HM-HU 301.5	Recognize the economic impact of engineering solutions and Conduct sensitivity analysis on key compounding parameters, so as make financially prudent decisions in everyday life.
HM-HU 301.6	Understand major principles of economic analysis for decision making among alternative courses of action in engineering.

Learning Resources:

1. Premvir Kapoor, Sociology & Economics for Engineers, Khanna Publishing House, Delhi.
2. J.L. Riggs, D.D. Bedworth and S.U. Randhawa, Engineering Economics, 4th Edition, McGraw Hill International Edition, 1996.
3. D. Newnan, T. Eschembach and J. Lavelle, Engineering Economics Analysis, Oxford University Press, 2019.
4. J.A. White, K.E. Case and D.B. Pratt, Principle of Engineering Economic Analysis, John Wiley, 2016.
5. W.G. Sullivan, E.M. Wicks and C.P. Koelling, Engineering Economy, 17th Edition, Pearson, 2018.
6. R. Panneerselvan, Engineering Economics, Prentice Hall of India, 1999.
7. M.R. Lindeburg, Engineering Economics Analysis: An Introduction, Professional Publication, 1993.

Subject Code: BS-M 301	**Category :** Basic Science course
Subject Name: Mathematics-III	**Semester :** Third
L-T-P : 3-0-0	**Credit :** 3
Pre-Requisites : No prerequisites	

Objectives:

1. To introduce the solution methodologies for second order Partial Differential Equations with applications in engineering
2. To provide an overview of probability and statistics to engineers

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Definition of Partial Differential Equations, First order partial differential equations, solutions of first order linear PDEs; Solution to homogenous and non-homogenous linear partial differential equations of second order by complimentary function and particular integral method. Second-order linear equations and their classification, Initial and boundary conditions, D' Alembert's solution of the wave equation; Duhamel's principle for one dimensional wave equation. Heat diffusion and vibration problems, Separation of variables method to simple problems in Cartesian coordinates. The Laplacian in plane, cylindrical and spherical polar coordinates, solutions with Bessel functions and Legendre functions. One dimensional diffusion equation and its solution by separation of variable.	14
2	Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality. Continuous random varibales and their properties, distribution functions and densities, normal, exponential and gamma densities. Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.	12
3	Basic Statistics, Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation. Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, Tests for single mean, difference of means, and difference of standard deviations. Test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.	10
	Total	**36**

Course Outcomes:

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

BS-M 301.1	Solve field problems in engineering involving PDEs.
BS-M 301.2	Formulate the solved problems involving random variables and apply statistical methods for analysing experimental data.
BS-M 301.3	Analyze and solve engineering problems using Laplace Series.
BS-M 301.4	Solve engineering problems using Complex Integration.
BS-M 301.5	Know the basic properties of the Fourier transform, and how to use it to solve linear constant coefficient PDE's.
BS-M 301.6	Utilize technology tools to find geometric, graphical and (optionally) numeric techniques for the analysis of solutions in engineering problems

Textbooks/References:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. Chandrika Prasad & Reena Garg, Advanced Engineering Mathematics, Khanna PublishingHouse, 2019.
3. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
4. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.

Subject Code : ES-ME 301	**Category:** Engineering Science Courses
Subject Name : Engineering Mechanics	**Semester** : Third
L-T-P : **3-0-0**	**Credit: 3**
Pre-Requisites: Class XI physics	

Course objective:

1. To provide an introductory treatment of Engineering Mechanics to all the students of engineering, with a view to prepare a good foundation for taking up advanced courses in the area in the subsequent semesters.
2. To provide knowledge of statics with emphasis on force equilibrium and free body diagrams for understanding the kinds of stress and deformation.
3. To determine the kinds of stress and deformation in a wide range of simple, practical structural problems, and an understanding of the mechanical behavior of materials under various load conditions.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Module 1***: Introduction to Engineering Mechanics:* Fundamentals of Vector Algebra, Force Systems: Basic concepts, Particle equilibrium in 2-D & 3-D; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Lame's Theorem, Components in Space – Resultant- Moment of Forces and its Application; Principle of Moments- Varignon's Theorem, Couple/Moment of a couple, and Resultant of Force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium of Coplanar Systems and Spatial Systems; Beams & types of beams; Statically Indeterminate Systems.	3
2	**Module 2***: Friction:* Types of friction, Limiting friction, Laws of Friction, Angle of Repose, Angle of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack & differential screw jack.	4
3	**Module 3***: Truss:* Element of a Truss; Assumptions for Truss Analysis; Determinacy and Stability; Method of Sections; Method of Joints; Simple Trusses; Zero force members.	4
4	**Module 4***: Centroid and Centre of Gravity covering,* Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its applications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone, Sphere, Hook.	5
5	**Module 5***: Virtual Work and Energy Method:* Virtual displacements, principle of virtual work for particle and ideal system of rigid bodies, degrees of freedom. Active force diagram, systems with friction, mechanical efficiency. Conservative forces and potential energy (elastic and gravitational), energy equation for equilibrium. Applications of energy method for equilibrium. Stability of equilibrium.	5
6	**Module 6***: Review of particle dynamics:* Rectilinear motion; Circular Motion; Plane curvilinear motion (rectangular, path, and polar coordinates). 3-D curvilinear motion; Relative and constrained motion; Newton's 2nd law (rectangular, path, and polar coordinates). Work-kinetic energy, Torque; Power, potential energy. Impulse-momentum (linear, angular); Impact (Direct and oblique).	5
7	**Module 7:***Introduction to Kinetics of Rigid Bodies:* Basic terms, general principles in dynamics; Types of motion, Instantaneous centre of rotation in plane motion and simple problems; D'Alembert's principle and its applications in plane motion and connected bodies; Work energy principle and its application in plane motion of connected bodies; Kinetics of rigid body rotation.	5
8	**Module 8:** *Vibrations:* Basic terminology, free and forced vibrations, resonance and its effects; Degree of freedom; Derivation for frequency and amplitude of free vibrations without damping and single degree of freedom system, simple problems, types of pendulum, use of simple, compound and torsion pendulums.	5
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

ES-ME 301.1	Define fundamental concepts in engineering mechanics, such as forces, moments, and equilibrium and formulate the key equations related to static equilibrium and basic mechanical principles.
ES-ME 301.2	Explain the principles of statics and dynamics and their applications in engineering and analyze the forces using free body diagrams and governing equations.
ES-ME 301.3	Apply principles of mechanics to solve engineering problems related to forces, moments, and equilibrium and utilize mathematical tools to solve engineering mechanics problems.
ES-ME 301.4	Analyze complex structures and systems under various loading conditions using principles of engineering mechanics and break down real-world engineering problems into components for analysis and solution.
ES-ME 301.5	Evaluate the stability and safety of structures under different loading scenarios and critically assess the appropriateness of different engineering solutions to specific problems.
ES-ME 301.6	Design and create engineering solutions for practical problems using principles of mechanics and develop new applications or modifications based on engineering mechanics principles.

Text /Reference Books:

1. M.P. Poonia & D.S. Bedi, Engineering Mechanics, Khanna Publishing House, 2019
2. Irving H. Shames (2006), Engineering Mechanics, 4th Edition, Prentice Hall
3. R.S. Khurmi, Engineering Mechanics, S.Chand Publications, Delhi
4. Andy Ruina and Rudra Pratap (2011), Introduction to Statics and Dynamics, OxfordUniversity Press
5. Shanes and Rao (2006), Engineering Mechanics, Pearson Education,
6. Hibler and Gupta (2010),Engineering Mechanics (Statics, Dynamics) by Pearson Education
7. Reddy Vijaykumar K. and K. Suresh Kumar(2010), Singer's Engineering Mechanics
8. Bansal R.K.(2010), A Text Book of Engineering Mechanics, Laxmi Publications
9. Tayal A.K. (2010), Engineering Mechanics, Umesh Publications
10. Engineering Mechanics by Timoshenko & Young – McGraw Hill
11. Engineering Mechanics by Meriam & Kraige – Statics (Vol I) and Dynamics (Vol II) – John Wiley
12. Vector Mechanics for Engineers by Beer & Johnston – McGraw Hill

Subject Code : PC-ME 301	**Category:** Professional Core courses
Subject Name : Thermodynamics	**Semester** : Third
L-T-P : **3-0-0**	**Credit:3**
Pre-Requisites: Class XI physics	

Course Objective:

1. To learn about work and heat interactions, and balance of energy between system and its surroundings
2. To learn about application of I law to various energy conversion devices
3. To evaluate the changes in properties of substances in various processes
4. To understand the difference between high grade and low grade energies and II lawlimitations on energy conversion.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Concept of System & Control volume; Property, State & Process;Exact & Inexact differentials; Work-Thermodynamic definition of work; examples; Displacement work; Path dependence of displacement work and illustrations for simple processes; electrical, magnetic, gravitational, spring and shaft work.	5
2	Temperature, Definition of thermal equilibrium and Zeroth law; Temperature scales; Various Thermometers- Definition of heat; examples of heat/work interaction in systems- First Law for Cyclic & Non-cyclic processes; Concept of total energy E ; Demonstration that E is a property; Various modes of energy, Internal energy and Enthalpy. Conservation of mass principle, flow work and energy of a flowing fluid. Perpetual motion machine of second law of thermodynamics.	5
3	Definition of Pure substance, Ideal Gases and ideal gas mixtures, Real gases and real gas mixtures, Compressibility charts- Properties of two phase systems - Const. temperature and Const. pressure heating of water; Definitions of saturated states; P-v-T surface; Use of steam tables and R134a tables; Saturation tables; Superheated tables; Identification of states & determination of properties, Mollier's chart.	7
4	First Law for Flow Processes - Derivation of general energy equation for a control volume; Steady state steady flow processes including throttling; Examples of steady flow devices; Unsteady processes; examples of steady and unsteady I law applications for system and control volume.	4
5	Second law - Definitions of direct and reverse heat engines; Definitions of thermal efficiency and COP; Kelvin-Planck and Clausius statements; Definition of reversible process; Internal and external irreversibility; Carnot cycle; Absolute temperature scale. Carnot theorem, Carnot heat engine, Carnot refrigerator and heat pump. Perpetual motion machine of second law of thermodynamics.	5
6	Clausius inequality; Definition of entropy S ; Demonstration that entropy S is a property; Evaluation of S for solids, liquids, ideal gases and ideal gas mixtures undergoing various processes; Determination of s from steam tables- Principle of increase of entropy; Illustration of processes in Ts coordinates; Definition of Isentropic efficiency for compressors, turbines and nozzles.	6
7	Thermodynamic cycles - Basic Rankine cycle; Basic Brayton cycle; Brayton cycle regeneration, intercooling, reheating, Basic vapor compression cycle and comparison with Carnot cycle.	4
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 301.1	Recall and define the basic laws of thermodynamics, including the zeroth, first, and second laws, as well as key thermodynamic concepts such as entropy and enthalpy.
PC-ME 301.2	Explain the principles of energy conservation and transfer in thermodynamic systems, demonstrating an understanding of how heat and work interact within different processes.
PC-ME 301.3	Solve practical problems involving thermodynamic processes, applying the laws of thermodynamics to analyze and predict changes in temperature, pressure, and other thermodynamic properties.
PC-ME 301.4	Evaluate the efficiency of various heat engines and refrigeration cycles, breaking down complex thermodynamic systems into components to assess the impact of individual factors on overall performance.
PC-ME 301.5	Design a new thermodynamic system or modify an existing one, considering factors such as efficiency, sustainability, and economic feasibility.
PC-ME 301.6	Critically assess and compare different approaches to solving thermodynamic problems, demonstrating the ability to evaluate the effectiveness of various methods and propose improvements or alternative solutions based on scientific reasoning.

Learning Resources:

1. Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J., 2003, 6th Edition, *Fundamentals of Thermodynamics*, John Wiley and Sons.
2. Jones, J. B. and Duggan, R. E., 1996, *Engineering Thermodynamics*, Prentice-Hall of India
3. Moran, M. J. and Shapiro, H. N., 1999, *Fundamentals of Engineering Thermodynamics*, John Wiley and Sons.
4. Nag, P.K, 1995, *Engineering Thermodynamics*, Tata McGraw-Hill Publishing Co. Ltd.
5. M.P. Poonia & S.C. Sharma, Basics of Mechanical Engineering, Khanna Publishing House, N. Delhi.

Subject Code : PC-ME 302	**Category:** Professional Core courses
Subject Name : Fluid Mechanics	**Semester** : Third
L-T-P : **3-1-0**	**Credit:4**
Pre-Requisites: Class XI physics	

Course Objective:

1. To learn about the application of mass and momentum conservation laws for fluid flows
2. To understand the importance of dimensional analysis
3. To obtain the velocity and pressure variations in various types of simple flows
4. To analyze the flow in water pumps and turbines.

Course Content:

Module No.	Description of Topic	Contact Hrs.
Fluid Mechanics		
1	Review of fluid properties and fluid statics: Newton's Law of Viscosity, Surface Tension, Pascal's Law, Centre of pressure. Hydraulic forces on submerged surfaces; forces on vertical, horizontal, inclined and curved surfaces. Buoyancy and Floatation.	7
	Kinematics of fluid flow: Types of fluid flow. Continuity equation in 1D & 3D. Velocity and acceleration; Vortex Flow, Potential flow & Stream function; types of flow lines.	4
2	Dynamics of fluid: equations of motion; Euler's equation; Bernoulli's equation; Applications of Bernoulli's equation: Venturimeter, orificemeter, pitot-tube, Hagen Poiseuille Formula, Flow of viscous fluid between two parallel plates, Momentum Analysis of flow systems; the linear momentum equation for steady flow, differential approach.	5
		3
3	Flow through pipes; Flow through pipe in series and parallel connection, Darcy – Weisbach equation of friction loss; hydraulic grade line and total energy line. Velocity and Momentum Correction Factor. Different types of losses. Viscous flow.	4
4	Basic principle for flow through orifices & mouth pieces, notches, weirs. Flow through open channels; use of Chezy's formula.	4
5	Dimensional Analysis & Model investigation applied to flow systems – Buckingham Pi theorem. Dimensionless numbers in fluid flow. Flow of fluid around submerged bodies; basic concepts of drag and lift. Boundary layer Theory; Displacement thickness, Momentum thickness and Energy Thickness Boundary layer separation – basic concept.	6
Fluid Machines		
6	Hydraulic Turbines; Principles and Classifications; Design & working principle of a Pelton Wheel, efficiency and performance curves. Francis Turbine, Kaplan Turbine. Function of Draft Tube. Cavitation in Turbines.	5
7	Reciprocating Pumps: Components & Principles, Classification, discharge, work done, power requirement.	5
8	Centrifugal pumps: Components, working principle, head & efficiency. Multistage Centrifugal pumps. Pump characteristics, NPSH & Cavitation.	5
	Total	**48**

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 302.1	Understand the basic concepts of fluid flow and the properties of fluids.
PC-ME 302.2	Understand and apply the principles of fluid statics, kinematics, and
PC-ME 302.3	Analyze fluid flow problems with the application of the momentum and energy equations.
PC-ME 302.4	Understand and analyze the concept of viscosity in real flows.
PC-ME 302.5	Execute dimensional analysis and understand the concept of boundary layer formation for problems in fluid mechanics.
PC-ME 302.6	Understand the principles of fluid machineries like Pumps and Turbines and solve practical problems.

Learning Resources:

1. Fluid Mechanics & Hydraulic Machines, S.S. Rattan, Khanna Book Publishing Co., 2018
2. Fluid Mechanics and Machinery, R.K.Bansal, Laxmi Publication.
3. Introduction to Fluid Mechanics & Fluid Machines, Som and Biswas, TMH.
4. A Textbook on Fluid Mechanics and Machines, S.Pati, McGrawHill.
5. Fluid Mechanics and Machinery, C.S.P.Ojha, R. Berndtsson and P. N. Chadramouli, Oxford University Press, 2010.
6. Hydraulics and Fluid Mechanics, P M Modi and S M Seth, Standard Book House.

Subject Code : PC-ME 303	**Category:** Professional Core courses
Subject Name : Material Science	**Semester** : Third
L-T-P : **3-0-0**	**Credit:3**
Pre-Requisites: No prerequisite	

Course Objective:

1. Understanding of the correlation between the internal structure of materials, their mechanical properties and various methods to quantify their mechanical integrity and failure criteria.
2. To provide a detailed interpretation of equilibrium phase diagrams
3. Learning about different phases and heat treatment methods to tailor the properties of Fe-C alloys.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Electronic structure and atomic bonding. Crystal Structure: Unit cells, Metallic crystal structures, Diffraction of X-Rays and Bragg's law, Ceramics. Imperfection in solids: Point, line, interfacial and volume defects; dislocation strengthening mechanisms and slip systems, critically resolvedshear stress.	5
2	Mechanical Property measurement: Tensile, compression and torsion tests; Young's modulus, relations between true and engineering stress- strain curves, generalized Hooke's law, yielding and yield strength, ductility, resilience, toughness and elastic recovery; Strain hardening, precipitation hardening Hardness: Rockwell, Brinell and Vickers and their relation to strength.	5
3	Static failure theories: Ductile and brittle failure mechanisms, Tresca, Von- mises, Maximum normal stress, Mohr's Circle, Mohr-Coulomb and Modified Mohr-Coulomb; Fracture mechanics: Introduction to Stress-intensity factor approach and Griffith criterion. Fatigue failure: High cycle fatigue, Stress-life approach, SN curve, endurance and fatigue limits, effects of mean stress using the Modified Goodman diagram; Fracture with fatigue, Creep & Creep curves Introduction to nondestructive testing (NDT)	5
4	Alloys, substitutional and interstitial solid solutions- Phase diagrams: Interpretation of binaryphase diagrams and microstructure development; eutectic, peritectic, peritectoid and monotectic reactions. Iron Iron-carbide phase diagram and microstrctural aspects of ledeburite, austenite, ferrite and cementite, cast iron.	5
5	Heat treatment of Steel: Annealing, tempering, normalising and spheroidising, isothermal transformation diagrams for Fe-C alloys and microstructure development. Continuous cooling curves and interpretation of final microstructures and properties- austempering, martempering, case hardening, carburizing, nitriding, cyaniding, carbo- nitriding, flame and induction hardening, vacuum and plasma hardening.	5
6	Alloying of steel, properties of stainless steel and tool steels, maraging steels- cast irons; grey, white, malleable and spheroidal cast irons- copper and copper alloys; brass, bronze and cupro-nickel; Aluminium and Al-Cu – Mg alloys- Nickel based superalloys and Titanium alloys.	5
7	Powder Metallurgy: Basics steps of powder metallurgy: Powder production, atomization, mixing and blending, compacting (CIP & HIP), sintering, impregnation. Testing and inspection. Properties of powder particles. Advantages and disadvantages of Powder Metallurgy.	3
8	Ceramics : Types and applications, Shape Memory Alloys, Composites and its classifications, Processing of Fibre Reinforced Plastics, Glasses, Nanomaterials	3
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 303.1	Identify crystal structures for various materials and understand the defects in such structures.
PC-ME 303.2	Understand the effect of external mechanical loads on material and understand and analyze the failure mechanism of materials
PC-ME 303.3	Identify the properties of metals with respect to crystal structure and grain size.
PC-ME 303.4	Interpret the phase diagrams of materials.
PC-ME 303.5	Classify and Distinguish different types of cast irons, steels and non-ferrous alloys
PC-ME 303.6	Describe the concept of heat treatment of steels & strengthening mechanisms

Learning Resources:

1. W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India.
2. Kenneth G. Budinski and Michael K. Budinski, "Engineering Materials", Prentice Hall of IndiaPrivate Limited, 4th Indian Reprint, 2002.
3. V. Raghavan, "Material Science and Engineering', Prentice Hall of India Private Limited, 1999.
4. U. C. Jindal, "Engineering Materials and Metallurgy", Pearson, 2011

Subject Code : PC-ME 391	**Category:** Professional Core courses
Subject Name : Fluid Mechanics Lab	**Semester** : Third
L-T-P : **0-0-3**	**Credit:1.5**
Pre-Requisites: Fluid Mechanics (PC-ME 302)	

Course Objective:

1. To Enrich the concept of fluid mechanics and hydraulic machines.
2. To Demonstrate the classical experiments in fluid mechanics and hydraulic machinery.
3. To Correlate various flow measuring devices such as Venturimeter, orifice meter and notches etc.
4. To Discuss the performance characteristics of turbines and pumps.

Course Content:

Fluid flow measurements: Determining coefficient of discharge for venture meter, orifice meter, weirs; Experiment to verify Bernouli's theorem;
Flow through pipes: Reynold's experiments; Pipe friction in laminar and turbulent flow regimes; Pitot tube experiments on viscous flow and boundary layer theory; Determination of metacentric height of a floating vessel;
Experiments on Fluid Machinery: Pumps, jet pumps, Blowers, Compressors; Experiments on Hydro-Turbines: Francis and Pelton turbines.

(At least six experiments must be conducted)

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 391.1	Understand of basic physics of fluids.
PC-ME 391.2	Apply knowledge to calculate and design engineering applications involving fluid.
PC-ME 391.3	Understand the flow systems in terms of mass, momentum, and energy balance.
PC-ME 391.4	Acquire knowledge about the natural phenomenon of fluid mechanics.
PC-ME 391.5	Understand to analyse practical problems in power plants and chemical industries
PC-ME 391.6	Conduct experiments (in teams) in pipe flows and open-channel flows and interpreting data from model studies to prototype cases, as well as documenting them in engineering reports.

Subject Code : PC-ME 392	**Category:** Professional Core courses
Subject Name : Material Testing Lab	**Semester** : Third
L-T-P: **0-0-3**	**Credit:1.5**
Pre-Requisites: Material Science **(**PC-ME 303)	

Course Objective:

1. To test several properties of material like ductility, surface roughness, malleability, hardenability etc.
2. To function on multi-disciplinary teams in the area of materials testing.
3. To use the techniques, skills and modern engineering tools necessary for engineering.
4. To Understand the professional and ethical responsibility in the areas of material testing.

Course Content:

- Impact tests: Charpy and Izod tests.
- Test for drawability of sheet metals through cupping test.
- Fatigue test of a typical sample.
- Sample preparation and etching of ferrous and non-ferrous metals and alloys for metallographic observation.
- Experiments on heat treatment of carbon steels under different rates of cooling including quenching, and testing for the change in hardness and observing its microstructural changes through metallographic studies.
- Observation of presence of surface/ sub-surface cracks using different non-destructive techniques, such as dye penetration (DP) test, magnaflux test, ultrasonic or eddy current test.

(At least six experiments must be conducted)

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 392.1	Determine toughness value of industrial specimens.
PC-ME 392.2	Analyze various heat treatment methods for a given specimen to observe mechanical properties and grain size.
PC-ME 392.3	Find surface or subsurface defects relevant to almost all manufacturing industries.
PC-ME 392.4	Evaluate the mechanical properties like drawability, endurance limit of a steel specimen necessary for material selection in design and development.
PC-ME 392.5	Apply knowledge of mathematics and engineering in calculating the mechanical properties of structural materials.
PC-ME 392.6	Communicate effectively the mechanical properties of materials.

Subject Code : PC-ME 393	**Category:** Professional Core courses
Subject Name : Machine Drawing	**Semester** : Third
L-T-P: **0-0-3**	**Credit:1.5**
Pre-Requisites: Engineering Drawing (ES-ME 292)	

Course Objective:

1. Provide the fundamental concepts of machine drawing elaborating on how to concretize the idea of new structure such as a machine element.
2. Study the conventions and rules to be followed by engineers for making accurate drawings.
3. Understand the basic dimensioning practices that have to be followed in the preparation of drawings.
4. Help the student in the visualization of assembly and sub assembly of various machine elements.
5. Train the students in the preparation of assembly drawings

Course Content:

Schematic product symbols for standard components in mechanical, electrical and electronic systems, welding symbols and pipe joints; Orthographic projections of machine elements, different sectional views-full, auxiliary sections; Isometric projection of components; Assembly and detailed drawings of a mechanical assembly, such as a plummer block, tool head of a shaping machine, tailstock of a lathe, simple gear box, flange coupling, welded bracket joined by stud bolt on to a structure, welded pipe joints indicating work parts before welding, etc.

Practicing AutoCAD or similar graphics softwares and making orthographic and isometric projections of different components.

(At least six assignments must be completed)

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 393.1	Gain knowledge about the various practices with regard to the dimensioning, sectioning and development of views.
PC-ME 393.2	Understand product symbols for standard components in mechanical, electrical and electronic systems and joints.
PC-ME 393.3	Understand the sectional views of machine parts and the assembly drawing of mechanical components.
PC-ME 393.4	Prepare of the part or assembly drawings as per the conventions.
PC-ME 393.5	Interpret machine drawings that in turn help the students in the preparation of the production drawings
PC-ME 393.6	Understand and practice the Auto-CAD software for drawing orthographic and isometric projections.

Curriculum Structure

SEMESTER-IV

THEORY							
Sl. No.	**Course Code**	**Subject Name**	**Contact period per week**			**Total**	**Credit**
			L	**T**	**P**		
1	PC-ME 401	Strength of Materials	3	0	0	3	3
2	PC-ME 402	Applied Thermodynamics	3	0	0	3	3
3	PC-ME 403	Metrology & Measurement	3	0	0	3	3
4	PC-ME 404	Manufacturing Processes	3	0	0	3	3
5	PC-ME 405	Theory of Machines	3	1	0	4	4
	Total Theory					**16**	**16**
PRACTICAL							
1	PC-ME 491	Strength of Materials Lab	0	0	3	3	1.5
2	PC-ME 492	Theory of Machines Lab	0	0	3	3	1.5
3	PC-ME 493	Manufacturing Processes Lab	0	0	3	3	1.5
4	PC-ME 494	Metrology & Measurement Lab	0	0	3	3	1.5
	Total Practical					**12**	**6**
	Total of Semester					**28**	**22**

NOTE: Vocational Training/Internship to be conducted after fourth semester and to be evaluated in fifth semester.

Subject Code : PC-ME 401	**Category**: Professional Core courses
Subject Name : Strength of Materials	**Semester** : Fourth
L-T-P : 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Engineering Mechanics (ES-ME 301)	

Course Objective:

1. To understand the concept of stress and strain.
2. To evaluate the nature of stress developed in various geometries such as bars, cantilevers, beams, shafts, cylinders, spheres under various types of simple load.
3. To facilitate the concept of bending and its theoretical analysis
4. To calculate elastic deformation occurring in various simple geometries for different types of loading.
5. To understand the concept of column and critical load in different boundary conditions.
6. To calculate the stresses in pressure vessels.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	Concept of mechanics of deformable solids, concept of stress developed against external force; brief review of normal and shearing stress and strain, Volumetric strain, Factor of Safety, statically determinate and indeterminate problems, Deformations in solids- Hooke's law, Relation between shear modulus and Young's modulus, deformations of simple bar, stepped bar, taper bars, superposition cases under external loads, deformation due to self weight, thermal stresses. Compound Stress/Strain. Strain energy in tension and compression, Shear strain and shear strain energy, 3-D Stresses.	8
2	2-D Stress/Strain (Unidirectional, Bi-directional, Bi-directional with shear stresses) and related problems. Principal Stress and Principal Strain, Mohr's Circle, Stresses in thin walled pressure vessels- axial and Hoop stress.	7
3	Types of beams, Shear force and bending moment diagram of cantilever, Simply Supported and overhung beams under different types of loading. Simple bending of beams, Assumptions, bending stress distribution, problems on simple bending.	8
4	Torsion of a circular shaft, Shear stress distribution and deformation in solid and hollow shafts, shear energy in torsion, Shaft in series and parallel, Concept of closed and open coiled helical springs, Stresses and deflection of helical springs under axial pull.	4
5	Theory of columns; eccentric loading of short column, column buckling: Euler load for different column, effective length of column, limitations of Euler's formula, empirical column formulae – (i) straight line, (ii) parabolic and (iii) Rankine Gordon	3
6	Deflection and slopes of statically determinate and indeterminate beams due to bending moment, deflection of beams using double integration method, Area-moment method, Strain energy method- Catigliano's theorem, superposition method etc.	6
Total		**36**

Course Outcomes:

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

PC-ME 401.1	Understand the concept of stress and strain.
PC-ME 401.2	Evaluate the nature of stress developed in various geometries such as bars, cantilevers, beams, shafts, cylinders, spheres under various types of simple load.
PC-ME 401.3	Understand the concept of bending and its theoretical analysis
PC-ME 401.4	Analyze the elastic deformation occurring in various simple geometries for different types of loading.
PC-ME 402.2	Understand the concept of column and critical load in different boundary conditions.
PC-ME 402.1	Evaluate the stresses in pressure vessels.

Learning Resources:

1. Elements of Strength of Materials by Timoshenko & Young, East west press.
2. Introduction to Solid Mechanicsby Shames & Pitarresi, Prentice Hall India.
3. Mechanics of Materialsby Beer & Johnston, TMH
4. Engineering Mechanics of Solidsby E.P. Popov, Prentice Hall India
5. Fundamentals of Strength of Materialsby Nag & Chanda, Wiley India
6. Strength of Materialsby R.Subramanian, Oxford Univ. Press
7. Strength of Materials by Ryder, Mcmillan press
8. Strength of Materials by S S Rattan, McGraw Hill Education India
9. Strength of Materials by S S Bhavikatti, Vikas Publishing House Pvt Ltd.

Subject Code : PC-ME 402	**Category**: Professional Core courses
Subject Name : Applied Thermodynamics	**Semester** : Fourth
L-T-P : 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Thermodynamics (PC-ME 301)	

Course Objective:

1. To learn about exergy and quality of energy.
2. To learn about reciprocating air compressors and its modifications.
3. To learn about gas and vapour power cycles and their modifications.
4. To learn about refrigeration cycles and thermodynamic relations.
5. To learn about the properties of atmospheric air and the principles of psychrometry.
6. To learn about gas dynamics of compressible flow.

Course Content:

Module No.	Description of the Topic	Contact Hrs.
1	Exergy analysis, Maximum Work in a Reversible Process, Irreversibility and Gouy-Stodola Theorem, Exergy change of a system, 2nd Law efficiency.	5
2	Reciprocating Air Compressors, Staging of Reciprocating Compressors, Volumetric Efficiency, Optimal Stage Pressure Ratio, Effect of Intercooling, Minimum Work For Multistage Reciprocating Compressors.	5
3	Thermodynamic Relations, Maxwell's Equations, TdS Equations, Difference in Heat Capacities, Ratio of Heat Capacities, Joule-Kelvin Effect, Clausius-Clapeyron Equation, Gibbs Phase Rule.	4
4	Vapour Power Cycles & Its Modifications, Binary Vapour Power Cycle, Thermodynamics of Coupled Cycles, Cogeneration.	6
5	Vapour Compression Refrigeration Cycle, Comparison with Carnot Cycle, Vapour Absorption Refrigeration Cycle, Gas Cycle Refrigeration, Heat Pump System.	5
6	Air Standard Otto Cycle, Diesel Cycle, Dual Combustion Cycle, Comparison of Otto, Diesel, and Dual Cycles, Brayton Cycle & Its Modifications, Brayton-Rankine Combined Cycle.	7
7	Properties of Atmospheric Air, Use of Psychometric Charts, Psychrometric Processes.	4
Total		**36**

Course Outcomes:

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

PC-ME 402.1	Demonstrate a mastery of the fundamental laws of thermodynamics and their application to real-world engineering problems.
PC-ME 402.2	Develop the ability to analyze and evaluate energy systems, including heat engines, refrigeration cycles, and power plants, using thermodynamic principles.
PC-ME 402.3	Apply thermodynamic concepts to design and optimize thermal systems, considering factors such as efficiency, energy transfer, and environmental impact.
PC-ME 402.4	Gain proficiency in analyzing and designing gas and vapor cycles, such as Brayton and Rankine cycles, and their applications in power generation and propulsion.
PC-ME 402.5	Apply knowledge of heat transfer mechanisms to solve practical problems, including the design of heat exchangers and thermal systems with a focus on efficiency and sustainability.
PC-ME 402.6	Develop problem-solving skills and the ability to think critically in the application of thermodynamic principles to solve complex engineering challenges, fostering a practical and analytical mindset.

Learning Resources:

1. Engineering Thermodynamics, PK Nag (Author), Publisher: McGraw Hill Education.
2. Thermodynamics: An Engineering Approach, Yunus A Cengel (Author); Michael A Boles (Author), Publisher: McGraw Hill Education.
3. Fundamentals of Thermodynamics, Richard E. Sonntag (Author), Claus Borgnakke (Author), Gordon J. Van Wylen (Author), Publisher: John Wiley & Sons.
4. Fundamentals of Engineering Thermodynamics, Michael J. Moran (Author), Howard N. Shapiro (Author), Daisie D. Boettner (Author), Margaret B. Bailey (Author), Publisher: Wiley.

Subject Code : PC-ME 403	**Category**: Professional Core courses
Subject Name : Metrology & Measurement	**Semester** : Fourth
L-T-P : 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: No-prerequisite	

Course Objectives:

1. To understand the working of linear and an gular measuring instruments.
2. To familiarize with the working of optical measuring instruments and fundamentals of limits and limit gauges.
3. To give basic idea about various methods for measurement of screw thread and surface finish parameters.
4. To give an exposure to advanced measuring devices and machine tool metrology.
5. To provide students an overview of mechanical measurement systems and principle of instruments for motion and dimension measurement.
6. To provide basic idea about working principle and applications of devices for measurement of force and torque; strain and stress and temperature.

Course Content:

Module No.	Description of the Topic	Contact Hrs.
1	**Introduction:** Measurement fundamentals: Methods of measurements, Units of measurement, Errors in measurement, Measurement uncertainty - Introduction, Standard deviation as a measure, statistical concepts- Sampling, least squares model, covariance and correlation. Calculation of uncertainties- Law of propagation, correlated inputs, probability densities, sampling distributions, case studies and problems.	5
2	**Linear and Angular Measurements**: Length Measuring Instruments: Vernier, Micrometer, Slip Gauges; Angle measuring instruments: Protractor, Sine bar, Angle Gauges, Spirit Level, Optical Instruments for Angular Measurement. **Optical Measurement and Interferrometry:** Optical Measurement Techniques: Tool Maker's Microscope, Profile Projector, Optical Squares; Optical Interference; Interferometers: NPL AND Laser Interferometers. **Comparators:** Functional Requirements; Classification of Comparators, Comparators: Electrical, Optical, Mechanical and Pneumatic.	8
3	**Metrology of Gears and Screw Threads**: Gear measurement: Introduction and Classification of gears; Forms of gear teeth; Gear tooth terminology; Methods of measuring tooth thickness, tooth profile & pitch, Gear Errors; Screw Thread Measurement: Terminology, Forms of thread, Errors in threads, Measurement of major, minor and effective diameters (2-wire and 3-wire methods)	3
4	**Limits, Fits and Tolerances:** Principle of Interchangeability; Tolerances; Max and min metal conditions; Fits; Basic-Hole System; Basic-Shaft System; Allowance; System of Limits and Fits; Tolerance grades; Design of limit gauges	5
5	**Metrology of Surface Finish:** Surface Metrology Concepts; Analysis of Surface Traces; Specification of Surface Texture Characteristics; Methods of Measuring Surface Finish; Stylus Probe Instruments; Other Methods for Measuring Surface Roughness	3
6	**Principle of operation of a few measuring instruments:** Displacement by LVDT; force by strain – gauge load cell and piezoelectric load cell; pressure by Bourdon–tube gauge; temperature by liquid-in-glass thermometer, thermocouples, optical pyrometer; liquid velocity by pitot tube; water flow by orifice meter.	6
7	**Inspection and Quality Control:** Inspection; Selection of Gauging Equipment; Quality Control and Quality Assurance; Statistical Quality Control; Total Quality Management; Six Sigma; Quality Standards	3
8	**Recent Advancement And Development Metrology:** Coordinate Measuring Machine – constructional features – types – Applications of CMM, Importance of Nanometrology,Vision Based Metrology	3
Total		**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 403.1	Understand the working of Linear and Angular measuring instruments
PC-ME 403.2	Familiarize with the working of optical measuring instruments and fundamentals of limits and limit gauges
PC-ME 403.3	Understand various methods for measurement of screw thread and surface finish parameters
PC-ME 403.4	Apply the fundamental concepts of advanced measuring devices and machine tool metrology
PC-ME 403.5	Analyze the mechanical measurement systems and principles of instruments for motion and dimension measurement
PC-ME 403.6	Apply the working principles of devices for measurement of force, torque, stress, strain, and temperature.

Learning Resources:

1. Engineering Metrology by R.K.Jain, Khanna publishers.
2. A text book of Engineering Metrology by I.C.Gupta, Dhanpat Rai publications.
3. A text book of Measurement and Metrology by A.K. Sawhney, and M. Mahajan Dhanpat Rai & Co.
4. Principles of Engineering Metrology by R. Rajendra, Jaico Pub. House.
5. Mechanical Measurements by Beckwith, Lienhard and Marangoni, 6th ed. Pearson.
6. Measurement systems – Application and Design by E.O. Doebelin and D.N. Manik, 5th ed., Tata McGraw Hill.

Subject Code : PC-ME 404	**Category**: Professional Core courses
Subject Name : Manufacturing Process	**Semester** : Fourth
L-T-P : 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Engineering Drawing (ES-ME 292), Material Science (PC-ME 303)	

Course Objectives:

1. The student will be able to know the capability of selecting suitable manufacturing processes to manufacture the products optimally.
2. The student will be able to recommend the appropriate design of gating systems, forming processes, welding process and NDT technique.
3. The student will be able to develop simplified manufacturing processes with the aim of reduction of cost and manpower.
4. The student will be able to identify/control the appropriate process parameters, and possible defects of manufacturing processes so as to remove them.

Course Contents:

Module No	Description of the topic	Contact Hrs
1	**Introduction:** Manufacturing; Definitions and broad grouping.	1
2	**Casting:** Introduction, History, Definition, Major Classification, Casting Materials.	1
3	**Sand mould casting:** **Moulding sands:** composition, properties & testing. Design of gating system: sprue, runner, in gate & riser. Estimation of pouring time, Aspiration effect, Estimation of mould filling up time. Foundry equipments, Furnaces Melting, pouring and solidification, Estimation of Total Solidification Time (TST) using Chvorinov's rule, Type of patterning, use of a core, Different type of sand mould casting Floor mould casting Centrifugal casting Shell mould & CO_2 casting Investment casting.	12
4	Permanent mould casting Die casting, types, methods, advantages & applications Slush casting, principle & use. Casting defects, types, causes & remedy.	2
5	**Welding:** Introduction to metallic parts Major grouping of joining processes, welding, brazing and soldering Broad classification of welding processes, types and principles. Fusion welding, types, principles, equipments, characteristics & applications, Open Circuit Voltage and Open Circuit Current, Current and voltage for maximum power, Sources of heat-chemical action, heat affected zone, Gas welding & Thermit welding Sources of heat-electrical energy, Arc welding Submerged arc welding TIG & MIG; Plasma arc welding Resistance welding; Spot & butt welding.	7
6	Solid state welding Principles, advantages & applications of: Hot forge welding, Friction welding Pressure & percussion welding. **Precision welding processes:** Ultrasonic welding Laser beam welding Electron beam welding.	3

7	**Forming Processes:** Flow stress, Hollomon's equation, and average flow stress, strain hardening. Hot working, warm working, isothermal forming & Cold working, re-crystallization temperature. Forging Introduction, definition, classification, hot forging & cold forging, characteristics & applications Forging material operations, equipments & tools: Smith forging Drop forging Pressing or press forging Forging dies, materials & design. Rolling: Introduction, basic principles, analysis of rolling process: true strain, draft, angle of bite, rolling force and power, hot rolling & cold rolling, characteristics & applications Rolling processes & applications, operations, equipments & roll stands. Drawing & extrusions: Basic principles & requirements, analysis of drawing and extrusions, Classification, methods & applications.	7
8	Press tool works Basic principles, systems, operations & applications Shearing, parting, blanking, piercing & notching Cupping(drawing), Spinning & deep drawing, Coining & embossing.	3
Total		**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 404.1	Select appropriate Manufacturing Processing to manufacture any component.
PC-ME 404.2	Interpret foundry practices like pattern making, mold making, Core making and Inspection of defects.
PC-ME 404.3	Differentiate various metal forming processes such as Hot and Cold Working; Distinguish and analyze Rolling, Forging, Extrusion and Drawing Processes.
PC-ME 404.4	Design different sheet metal working processes
PC-ME 404.5	Select appropriate Joining Processes to join Work piece.
PC-ME 404.6	Implement the acquired knowledge in industrial applications.

Learning Resources:

1. Manufacturing technology, Foundry, Forming & Welding-P.N Rao.
2. Manufacturing Science-A Ghosh & A Mullick.
3. Manufacturing Engineering & Technology-S Kalpakjian; Pub:Addison Wesley.
4. Principles of manufacturing materials & processes-James & Campbell.
5. Manufacturing engineering & technology-K Jain.
6. Materials & processes in manufacturing-E.P Degarmo, Black & Kohser, Pub: Wiley (10^{th} ed.)
7. Processes & materials of manufacturing-R.A Lindberg.
8. Introduction to manufacturing technology-PP Date, Pub: Jaico.
9. Manufacturing processes-S.K Sharma & S Sharma, Pub: I.K International.

Subject Code : PC-ME 405	**Category**: Professional Core courses
Subject Name : Theory of Machines	**Semester** : Fourth
L-T-P : 3-1-0	**Credit**:4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Engineering Mechanics (ES-ME 301)	

Course Objectives:

1. To understand the kinematics and rigid- body dynamics of kinematically driven machine Components.
2. To understand the motion of linked mechanisms in terms of the displacement, velocity and acceleration at any point in a rigid link.
3. To be able to design some linkage mechanisms and cam systems to generate specified output motion.
4. To understand the kinematics of gear trains.

Course Contents:

Module No	Description of the topic	Contact Hrs
1	**Introduction**: Kinematics, concept of machine and mechanism, inversion of mechanism, degrees of freedom, Grubler & Kutzbach criterion for plane mechanism, Grashof's law, four bar chain, slider crank chain and its inversion. **Kinematics of linkages**:- Velocity analysis by graphical method (relative velocity and instantaneous centre method), Kennedy's theorem, acceleration analysis by graphical method, Klein's construction, Acceleration of slider crank mechanism-Coriolis component of acceleration. **Synthesis of linkages**:- Types of dimensional synthesis, approximate and exact synthesis, Chebyshev's spacing of accuracy points, Analytical method – four bar function generator with 3 accuracy points – Freudenstein's Equation	15
2	**Cams and followers**:- Classification of cams and followers, terms used in radial cams, motion of followers, displacement, velocity and acceleration diagram with different kinds of follower motions – inline and offset, construction of cam profiles.	5
3	**Drive Systems** : Types of gear, Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing. Belt and Rope drives.	3
4	**Governors:-** Use and classification, Study and analysis of Porter, Proell,Hartnell and Wilson Hartnell governors, Sensitiveness, Stability, Isochronism, Hunting, Effort and power of governors	3
5	**Gyroscope:-**Gyroscopic couple, effect of gyroscopic couple on aeroplane and naval ship, stability of two wheel and four wheel drive while taking a turn.	2
6	**Turning moment diagram and flywheel**:-Velocity, acceleration and force on reciprocating parts of engine, correction couple, interia force and intertia torque of reciprocating engine, turning moment diagram of single and multicylinder engines, fluctuation of energy, flywheel, coefficient of fluctuation of speed, energy stored in flywheel	5
7	**Balancing of rotating and reciprocating masses:**- Static and dynamic balancing, balancing of single and multiple rotating mass in same and different planes, primary and secondary unbalanced forces of reciprocating masses, partial balancing of unbalanced primary force, variation of tractive forces, swaying couple and hammer blow	7
8	**Vibrations**:- Terms used, types of vibrating motions, types of free vibrations, natural frequency of longitudinal, transverse and torsional vibrations, effect of inertia, critical speed of shaft, frequency of viscous damping and under-damped forced vibrations, resonance, vibration isolation and transmissibility.	8
Total		**48**

Course Outcomes

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

PC-ME 405.1	Define different terminologies of linkages, kinematic pairs, kinematic chains and mechanisms and power transmission systems, describe the working mechanism of different linkages, kinematic pairskinematic chains and mechanisms and determine the velocity, acceleration, force, power required etc. for different linkages, joints, mechanisms and power transmitting devices.
PC-ME 405.2	Classify and explain different types of linkages, kinematic pairs, kinematic chains, mechanisms and power transmission systems.
PC-ME 405.3	Establish a proper understanding of kinematics and kinetics of different linkages, kinematic pairs, kinematic chains, mechanisms and power transmission systems
PC-ME 405.4	Solve complex engineering problems addressing velocity, acceleration, force and power transmitted for different linkages, kinematic chains, mechanisms and power transmission systems
PC-ME 405.5	Demonstrate the working mechanisms of different linkages, kinematic pairs, kinematic chains, mechanisms and power transmission systems and analyze their performances by developing mathematical models.
PC-ME 405.6	Draw schematic diagrams, velocity diagrams and acceleration diagrams of different linkages, kinematic pairs, kinematic chains, mechanisms and power transmission systems and perform dimensional synthesis of the above systems.

Learning Resources:

1. Elements of Mechanism – Daughty and James, McGraw Hill
2. Theory of Machines – S S Rattan, Tata McGraw Hill
3. Theory of Mechanisms & Machines – A.Ghosh & A.K.Mallik, AEWP
4. Design of Machinery – R.L.Norton, Tata McGraw Hill
5. Mechanism & Machine Theory – Rao, R.V. Dukkipati, Wiley
6. Theory of Machines, V.P.Singh, Dhanpat Rai & Co
7. W.T. Thomson, Theory of vibration with Applications, McGraw Hill.
8. Uicker, Pennock & Shigley, Theory of Machines and Mechanisms, Oxford University Press.
9. Rao & Dukkipati, Mechanism and Machine Theory, New Age Int. Pub.
10. J.S. Rao, The Theory of Machines Through Solved Problems, New Age Int. Pub.

Subject Code : PC-ME 491	**Category**: Professional Core courses
Subject Name : Strength of Materials Lab	**Semester** : Fourth
L-T-P : 0-0-3	**Credit**:1.5
Contact Per Week- 3P	**Contact Week / Semester=**12 minimum
Pre-Requisites: Strength of Materials (PC-ME 401)	

Course Objectives:

1. To demonstrate the basic principles in the area of strength and mechanics of materials.
2. To measure the properties of the materials such as impact strength, tensile strength, compressive strength, hardness, ductility etc.
3. To understand the deformation behavior of materials

Course Contents:

1. Verification of Varignon's theorem
2. Experiments on friction: determination of coefficient of friction
3. Tension Test and Compression Test of ductile and brittle materials: stress-strain diagram, determination of yield strength, ultimate strength, modulus of elasticity, percentage elongation and percentage reduction in areas, observation of fractured surfaces.
4. Determining spring stiffness under tension and compressive loads.
5. Strain gauge-based strain/ deflection/ force measurement of a cantilever beam.
6. Bend and re-bend test of flat test pieces, determination of bending stresses.
7. Torsion Test on a mild steel rod.
8. Hardness Tests: Brinel / Vickers and Rockwell tests.

(At least 6 (six) experiments must be conducted)

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 491.1	Design and conduct experiments, acquire data, analyze and interpret data.
PC-ME 491.2	Understand the behavior of structural elements such as bars, beams, and columns subjected to tension, compression, shear, bending, and torsion by means of experiments.
PC-ME 491.3	Comprehend physical insights into the behavior of materials and structural elements including distribution of stress and strain, deformation, and failure modes.
PC-ME 491.4	Evaluate spring stiffness, deformation etc. and able to design spring as per required strength.
PC-ME 491.5	Compute and analyze hardness values of different materials from various hardness measuring instruments.
PC-ME 491.6	Write individual and group reports on present objectives, describe test procedures and results, synthesize and discuss the test results, present conclusions.

Subject Code : PC-ME 492	**Category**: Professional Core courses
Subject Name : Theory of Machines Lab	**Semester** : Fourth
L-T-P : 0-0-3	**Credit**:1.5
Contact Per Week- 3P	**Contact Week / Semester=**12 minimum
Pre-Requisites: Theory of Machines (PC-ME 405)	

Course Objectives:

1. To determine the balancing of masses of rotating and reciprocating machine elements.
2. To understand the principles of gyroscope and governors.
3. To study working of brakes and dynamometer.
4. To determine the moment of inertia of various mechanical systems.
5. To understand the vibrational behavior of systems.

Course Contents:

1. To study the compound pendulum and to determine the radius of gyration of the same
2. Determination of radius of gyration of a bar using bi-fillar suspension.
3. Study of equivalent spring mass system and determination of the natural frequency of undamped free vibration of equivalent spring mass system.
4. Determination of the natural frequency of undamped torsional vibration of single rotor shaft system.
5. Determination of the natural frequency of undamped torsional vibration of double rotor shaft system.
6. Study of the rule of gyroscopic behaviour and verification of the relation of the gyroscopic couple using motorized gyroscope.
7. To study the operational features and be familiar with different characteristics curves of Porter Governor.
8. To study the operational features and be familiar with different characteristics curves of Proell Governor.
9. To study the behaviour of cam follower mechanism and to draw cam profiles from displacement of the follower.

(At least 6 (six) experiments must be conducted)

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 492.1	Identify the subsystems and components of different machines and mechanisms.
PC-ME 492.2	Explain the operating principles of different machines and mechanisms and sketch the schematic diagram of those machines and mechanisms.
PC-ME 492.3	Derive the relation between the operating parameters of the machines and the outputs from the machines.
PC-ME 492.4	Perform experimental studies on different mechanisms and machines.
PC-ME 492.5	Analyze and interpret the experimental results.
PC-ME 492.6	Write a laboratory report and work in a team.

Subject Code : PC-ME 493	**Category**: Professional Core courses
Subject Name : Manufacturing Processes Lab	**Semester** : Fourth
L-T-P : 0-0-3	**Credit**:1.5
Contact Per Week- 3P	**Contact Week / Semester=**12 minimum
Pre-Requisites: Material Science (PC-ME 303), Manufacturing Processes (PC-ME 404)	

Course Objectives:

1. The student will be having the capability of selecting suitable manufacturing processes to manufacture the products optimally.
2. The student will be able to recommend the appropriate design of gating systems, forming processes, welding process.
3. The student will be able to develop simplified manufacturing processes with the aim of reduction of cost and manpower.
4. The student will be able to identify/control the appropriate process parameters, and possible defects of manufacturing processes so as to remove them.

Course Contents:

1. Sand preparation and testing: specimen preparation for testing permeability, clay content, grain fineness number, moisture content, green compression strength, green shear strength, splitting strength, hardness, etc.;
2. Preparation of foundry sand and moulds,
3. Casting of metals after preparation of suitable moulds;
4. Experiments on properties of post casting, fettling, cleaning, deburring, and polishing operations;
5. Practicing smithy or forging of carbon steels and testing for its property changes;
6. Laboratory experiments in Fabrication processes to observe effects of varying process parameters in GMAW and SMAW and GTAW.
7. Testing for Joint defects.

(At least 6 (six) experiments must be conducted)

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 493.1	Build practical knowledge about Pattern Making; pattern material, pattern allowances and types of patterns casting processes.
PC-ME 493.2	Apply practical understanding for use of moulding tools: green sand moulding, gating system, risering system, core making.
PC-ME 493.3	Plan and create jobs using forging processes.
PC-ME 493.4	Apply advanced skills in fabrication processes and parameter control
PC-ME 493.5	Analyze joint testing and defect analysis
PC-ME 493.6	Relate the job manufactured from practical relevance point of view

Subject Code : PC-ME 494	**Category**: Professional Core courses
Subject Name : Metrology and Measurement lab	**Semester** : Fourth
L-T-P : 0-0-3	**Credit**:1.5
Contact Per Week- 3P	**Contact Week / Semester=**12 minimum
Pre-Requisites: Metrology & Measurement (PC-ME 403)	

Course Objectives:

1. To learn the main principle on which different instruments operate and provide hands on experience on them.
2. To generate knowledge and skill in use of precision instruments.
3. To learn a basic understanding of various instruments used in linear and angular

Course Contents:

1. Study of Micrometer and Measurement of dimension of combined slip gauges.
2. Measurement of external taper angle of a taper object.
3. Measurement of internal taper angle of a taper object.
4. Measurement of bore diameter using micrometer and gauges.
5. Linear Measurement using Vernier height gauge and micrometer (internal and external depth).
6. Measurement of threads parameter using tool makers microscope and optical profile projector.
7. Measurement of taper angle of a given work piece by bevel protector and sine bar(using balls and rollers).
8. Measurement of thread parameters – Screw thread Micrometers and Three wire method (floating carriage micrometer).
9. Measurements of surface roughness using Tally Surf/Mechanical Comparator.
10. Taking measurements using following instruments: (i) Vernier height & depth gauge, (ii) Dial micrometer, (iii) Thread gauge, (iv) Radius gauge, (v) Filler gauge, (vi) Slip gauge.
11. Checking / measuring parallelism, cylindricity and concentricity of components using dial indicator.
12. Measuring flatness with light band readings by using monochromatic light source.
13. Measurement of angle of a component using: (i) Vernier bevel protractor, (ii) angle gauges, (iii) Sine-bar and slip gauges.

(At least 6 (six) experiments must be conducted)

Course Outcomes:

Upon successful completion of the course, student will be able to

PC-ME 494.1	Demonstrate the knowledge/skill on standards, calibration process and analyze the characteristics of instruments keeping in mind technical, economical, safety issues.
PC-ME 494.2	Demonstrate the knowledge/skill on measurement of length, angle and form surface measurement
PC-ME 494.3	Develop testing method and select proper instruments to evaluate performance characteristics
PC-ME 494.4	Evaluate possible causes of discrepancy in practical experimental observations in comparison to theory
PC-ME 494.5	Demonstrate work in quality control departments of industries and to ensure quality of products.
PC-ME 494.6	Develop an ability of problem solving and decision making by identifying and analyzing the cause for variation and recommend suitable corrective actions for quality measurements.

Curriculum Structure

SEMESTER-V

THEORY							
Sl. No.	**Course Code**	**Subject Name**	**Contact period per week**			**Total**	**Credit**
			L	**T**	**P**		
1	CS-ME 501	Numerical Methods & Computer Programming	2	0	0	2	2
2	PC-ME 501	Heat Transfer	3	0	0	3	3
3	PC-ME 502	Machining Principles & Machine Tools	3	0	0	3	3
4	PC-ME 503	Design of Machine Elements	3	0	0	3	3
5	PC-ME 504	IC Engines	3	0	0	3	3
6	MC 501	Essence of Indian Knowledge Tradition	0	2	0	2	0
	Total Theory					**16**	**14**
PRACTICAL/SESSIONAL							
1	CS-ME 591	Computer Programming Lab	0	0	3	3	1.5
2	PC-ME 591	Machine Tools Lab	0	0	3	3	1.5
3	PC-ME 592	Thermal Engineering Lab	0	0	3	3	1.5
4	PW-ME 581	Project -I (on Summer Internship/Vocational Training)	0	0	0	0	2
	Total Practical					**9**	**6.5**
	Total of Semester					**25**	**20.5**

Subject Code : CS-ME 501	**Category**: Professional Core courses
Subject Name : Numerical Methods & Computer Programming	**Semester** : Fifth
L-T-P : 2-0-0	**Credit**: 2
Contact Per Week- 2L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Mathematics-I (BS-M 201) and Mathematics-II (BS-M 201)	

Course Objective:

1. To provide a basic understanding of the derivation, analysis, and use of these numerical methods.
2. To understand finite precision arithmetic and the conditioning and stability of the various problems and methods.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	**Errors:** Approximation in numerical computation: Truncation and rounding errors, Propagation of errors, Different types of Operators.	3
2	**Interpolation:** Newton forward and Backward interpolation, Lagrange's Interpolation.	3
3	**Numerical integration:** Trapezoidal rule, Simpson's 1/3 rule, Expressions for corresponding error terms.	3
4	**Numerical solution of Algebraic equation:** Bisection method, Regular-Falsi method, Newton-Raphson method.	3
5	**Numerical solution of a system of linear equations:** Gauss elimination method, Matrix inversion, Gauss-Seidel iterative method.	4
6	**Numerical solution of ordinary differential equation:** Euler's method, Euler's modified method, Runge-Kutta methods, Finite-difference methods.	4
7	**Programming Concepts:** Concept of conditional statement (if-else), For- loop and Nested For- loop, Do while, One and Two-dimension Array, Function Declaration.	4
Total		**24**

Course Outcomes:

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

CS ME 501.1	Understand the use of numerical methods in scientific computing.
CS ME 501.2	Calculate and interpret the errors in numerical methods.
CS ME 501.3	Apply the concept of numerical interpolation and approximation of functions.
CS ME 501.4	Solve numerical integration and differentiation.
CS ME 501.5	Solve numerical solution of ordinary differential equations.
CS ME 501.6	Formulate algorithms and programming.

Learning Resources:

1. C.Xavier: C Language and Numerical Methods.
2. Dutta & Jana: Introductory Numerical Analysis.
3. J.B.Scarborough: Numerical Mathematical Analysis.
4. Jain, Iyengar , & Jain: Numerical Methods (Problems and Solution).
5. Balagurusamy: Numerical Methods, Scitech.
6. Baburam: Numerical Methods, Pearson Education.
7. N. Dutta: Computer Programming & Numerical Analysis, Universities Press.
8. Soumen Guha & Rajesh Srivastava: Numerical Methods, OUP.
9. Srimanta Pal: Numerical Methods, OUP

Subject Code : PC-ME 501	**Category**: Professional Core courses
Subject Name : Heat Transfer	**Semester** : Fifth
L-T-P : 3-0-0	**Credit**: 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Thermodynamics (PC-ME 301)	

Course Objective:

1. To build a solid foundation in heat transfer exposing students to the three basic modes namely conduction, convection and radiation.
2. Rigorous treatment of governing equations and solution procedures for the three modes will be provided, along with solution of practical problems using empirical correlations.
3. The course will also briefly cover boiling and condensation heat transfer, and the analysis and design of heat exchangers.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	Introduction of the heat transfer and three modes of heat transfer, Basic laws of heat transfer, General discussion about applications of heat transfer, One Dimensional Steady State Conduction Heat Transfer: Homogeneous slabs, hollow cylinders, and spheres- Composite systems- overall heat transfer coefficient – Electrical analogy, Conduction Heat Transfer: Fourier rate equation – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates, concept of conduction and film resistances, Critical radius of insulation, Heat transfer through fins and applications, lumped system approximation and Biot number, heat transfer through pin fins- Two-dimensional conduction solutions for both steady and unsteady heat transfer-approximate solution to unsteady conduction heat transfer by the use of Heissler charts.	12
2	Heat convection, basic equations, boundary layers- Forced convection, external and internal flows- Natural convective heat transfer- Dimensionless parameters for forced and free convection heat transfer-Correlations for forced and free convection-Approximate solutions to laminar boundary layer equations (Momentum and energy) for both internal and external flow-Estimating heat transfer rates in laminar and turbulent flow situations using appropriate correlations for free and forced convection.	9
3	Introduction, Thermal radiation, Stefan Boltzmann's law radiation laws, Emission characteristics and laws of black-body radiation – total and monochromatic quantities – laws of Planck, Wien, Kirchoff, Lambert, The view factor, Radiation heat transfer from black surfaces, gray surfaces, diffuse surfaces, Radiosity, Irradiation, Radiation shields and the radiation effect.	9
4	Heat Exchangers: Classification of heat exchangers – overall heat transfer Coefficient and fouling factor – Concepts of LMTD and NTU methods – Problems using LMTD and NTU methods.	6
Total		**36**

Course Outcomes:

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

PC ME 501.1	Explain the laws of heat transfer and deduce the general heat conduction equation and to explain it for 1-D steady state heat transfer in regular shape bodies, Interpret the extended surfaces.
PC ME 501.2	Describe the critical radius of insulation, overall heat transfer coefficient, thermal conductivity and lumped heat transfer.
PC ME 501.3	Illustrate the boundary layer concept, dimensional analysis, forced and free convection under different conditions
PC ME 501.4	Explain the thermal radiation black body, emissivity and reflectivity and evaluation of view factor and radiation shields
PC ME 501.5	Evaluate the heat exchanger and examine the LMTD and NTU methods applied to engineering problems.
PC ME 501.6	Describe the Boiling heat transfer, mass transfer.

Learning Resources:

1. Y. A. Congel, Heat Transfer – A Practical Approach, Tata McGraw Hill Publications ,3rd edition, 2006.
2. J. P. Holman, Heat Transfer, Tata McGraw Hill Publications, 9th edition, 2004.
3. Essential Heat Transfer – Christopher A Long / Pearson.
4. Heat and Mass Transfer- PK Nag, Tata McGraw Hill Publications.

Subject Code : PC-ME 502	**Category**: Professional Core courses
Subject Name : Machining Principles & Machine Tools	**Semester** : Fifth
L-T-P : 3-0-0	**Credit**: 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Manufacturing Processes (PC-ME 404)	

Course Objective:

1. The course provides students with fundamental knowledge and principles in material removal processes.
2. In this course, the students apply the fundamentals and principles of metal cutting to practical applications through multiple labs using lathes, milling machines, grinding machines, and drill presses etc.
3. To demonstrate the fundamentals of machining processes and machine tools.
4. To develop knowledge and importance of metal cutting parameters.
5. To develop fundamental knowledge on tool materials, cutting fluids and tool wear mechanisms.
6. To apply knowledge of basic mathematics to calculate the machining parameters for different machining processes.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	**Introduction:** Machining: Basic principle, purpose, definition and requirements, M-W-T-F system, Representation by closed loop control system, Metal cutting process parameters: Speed, feed, depth of cut, Concept of material removal rate.	2
2	**Geometry of cutting tools:** 1. Geometry of single point turning (shaping, planning and boring) tools in ASA, ORS and NRS systems. 2. Conversion of tool angles from one system to another by graphical and vector methods. 3. Geometry of drills and milling cutters.	3
3	**Mechanism of machining:** 1. Chip formation mechanism, yielding and brittle fracture, chip reduction coefficient, cutting ratio, shear angle and cutting strain, velocity triangle, shear strain rate, Effect of friction on chip reduction coefficient. 2. Built-up edge formation, cause, type and effects, orthogonal cutting and oblique cutting. 3. Machining chips: types and conditions. **Mechanics of machining:** 1. Purposes of determination of cutting forces and basic two approaches, cutting force components in ORS and Merchant's circle diagram. 2. Determination of cutting forces, analytical methods, measurement. 3. Dynamometers, construction and working principles of strain gauge type and piezoelectric crystals type dynamometers for turning, drilling, milling. 4. Determination of shear stress and coefficient of friction in metal cutting. 5. Merchant 1st model; angle relationship, Merchant and Ernst 2nd model; machining constant. 6. Lee and Shaffer theory (Slip line model), upper and lower bound solution.	6
4	**Cutting temperature & Surface roughness:** 1. Heat generators and cutting zone temperature, sources, courses and effects on job and cutting tools, role of variation of the machining parameters on cutting temperature. 2. Determination of temperature rise in shear zone, thermal number. 3. Determination of cutting temperature by analytical and experimental methods 4. Control of cutting temperature and application of cutting fluids(purpose, essential properties, selection and methods of application) 5. Surface roughness in metal cutting, Determination of CLA values using sharp tool and nose tool; effect of process parameters on surface finish.	3
5	**Cutting tools:-failure, life, materials & Machinability, Economics of machining** 1. Methods of failure of cutting tools; types of tool wear, mechanisms of tool wear, geometry and assessment of tool wear. 2. Tool life, definition, assessment and measurement, Taylor's tool life equation and it's use, modified Taylor's tool life equation	4

	3. Cutting tool materials, essential properties, characteristics and applications of HSS, carbide(uncoated/coated), ceramic, diamond and CBN tools 4. Machinability: definition & assessment, Machinability rating 5. Optimization of process parameters in metal cutting	
6	**Abrasive machining process** 1. Introduction to abrasive machining, mechanics of chip formation, characteristics. 2. Types of grinding: Surface grinding, cylindrical grinding, center less grinding, and plunge grinding. 3. Specification of grinding wheel, selection of grinding wheel for specific applications, wheel loading and glazing, grinding ratio, self-sharpening feature of grinding wheel 4. Determination of chip thickness in surface and cylindrical grinding, Computation of MRR and machining time in different types of grinding. 5. Determination of grinding forces, torque, and power in grinding. 6. Other finishing operations: honing, lapping, super finishing.	5
7	**Machine tools – Introduction :** 1. Purpose of use , definition and general features of machine tools 2. Generatrix and Directrix and tool – work motions in different operations of conventional machine **General constructions function of machine tools :** 1. Major components and their functions in lathes; shaping, planning and slotting machines, drilling, machines and melting machines. 2. Machining operations including thread cutting and indexing, application of the common machine tools and their way of specification. **Automation and classification :** 1. Purposes, degree, type and economy of machine tool automation; broad classification of machine tools.	5
8	**Kinematic structure of machine tools :** 1. Kinematic structure of centre lathe ,shaping, planning and slotting machine 2. Kinematic structure of drilling (column /radial) and milling machines, capstan and turret lathes. 3. Kinematic structure of single spindle automatic lathe, hydraulically driven machine tools. **Control of speed and feed machine tools :** 1. Need of wide ranges of speeds and feeds , and machine tool drive 2. Design of speed gear box, speed layout, gear layout, ray diagrams , gears and spindle, 3. Control (selection and change) of feed in centre lathes and by hydraulically driven machine tools. **Machining time:** Estimation of time required for various operations like turning, drilling, shaping, and milling.	8
Total		**36**

Course Outcomes:

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

PC ME 502.1	Understand the M-W-T-F system and its components, role of significant process parameters, and geometry of cutting tool in various systems for their contribution in metal cutting KPIs.
PC ME 502.2	Determine various force components (by analytical and graphical using MCD), and Power consumed in cutting for performance analysis of the metal cutting systems and compare between angle relationships obtained through different models.
PC ME 502.3	Predict the temperature rise and tool wear in metal cutting and recommend the best combinations of process variables to control these during machining.
PC ME 502.4	Understand salient properties of different cutting tool materials and select and recommend the most appropriate one for specific applications
PC ME 502.5	Suggest and recommend different abrasive and finishing processes along with the tools (e.g. grinding wheel, honing stone, lapping tool etc.) for specific applications.
PC ME 502.6	Compute machining time for various processes, develop a knowledge base of the kinematics of different machine tools for automation, and recommend different accessories for varieties of operations in machine shops .

Learning Resources:

1. Principles of Metal Cutting/Principles of Machine Tools by G.C.Sen and A.Bhattacharya, New Central Book Agency, Kolkata.
2. Fundamentals of Metal Cutting Machine Tools by G.Boothroyd, TMH.
3. Production Technology, HMT Publication, TMH.
4. Production Engineering Sciences by P.C.Pandey and C.K.Singh, Standard Publishers Ltd.
5. Manufacturing Science by A.Ghosh and A.K.Mallik, Wiley Eastern.
6. Manufacturing Process by Danilovsky and Maslov et. Al, Mir Publication.
7. Metal working and Metrology,Narayana,Scitech
8. Machining and Machine Tools, A.B. Chattopadhyay, Wiley India (P) Ltd., New Delhi
9. A. Bhattacharyya, Metal Cutting Theory and Practice, New Central Book Agency, Kolkata

Subject Code : PC-ME 503	**Category**: Professional Core courses
Subject Name : Design of Machine Elements	**Semester** : Fifth
L-T-P : 3-0-0	**Credit**: 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Strength of Materials (PC-ME 401), Theory of Machines (PC-ME 405)	

Course Objective:

1. To make a strong background in mechanics of materials based failure criteria under pinning the safety critical design of machine components.
2. To understand the origins, nature and applicability of empirical design principles, based on safety considerations.
3. To make an overview of codes, standards and design guidelines for different elements.
4. To impart fundamental concepts in design procedure and to prepare them to apply this knowledge for common production requirements.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	Objective and scope of Mechanical Engineering Design; Design considerations; Review and selection of materials and manufacturing processes; codes and standards;	3
2	Modes of failure; Design/allowable stress; Factor of safety (FoS); Theories of failure – maximum normal stress theory, maximum shear stress theory, Distortion energy theory. Choice of Failure criteria; Design for stability : buckling analysis – Johnson and Euler columns	5
3	Fatigue in metals; S-N curve; Endurance limit and fatigue strength; Stress concentration factors – effect of discontinuity, fillets and notches; Effect of size, surface finish, stress concentration and degree of reliability on endurance limit; Design for finite and infinite life; Goodman, modified Goodman and Soderberg diagrams with respect to fatigue failure under variable stresses; Cumulative fatigue damage – Miner's equation.	5
4	Design of (i) Cotter joint; (ii) Knuckle joint and (iii) Fillet Welded joint of brackets under different types of loading.	4
5	Bolted joints : Metric thread, standard sizes, use of lock nuts and washers; Applications in structures including brackets, turn buckle; Pre-stressed bolts; Riveted joints : Unwin's formula; Brief discussion on single, double and triple row lap joints, butt joints with single or double strap / cover plate; simple strength design; joint efficiencies.	6
6	Design of : (i) Solid and hollow shafts, strength design of shafts, design based on torsional rigidity; (ii) Shaft coupling-rigid, pin-bush and geared flexible type, alignment of coupling; (iii) Belt drives-geometrical relations, Tension in flat belt and V-belts, derivation of torque and power transmission by flat and V-belt drives, selection of belt from manufacturers' catalogues, pulley	6
7	Design of: (i) Transmission screw, Screw jack, (ii) Helical compression spring - stress and deflection equations, stiffness, curvature effect : Wahl's factor, springs in parallel and series; (iii) Multi-leaf springs : load-stress and load-deflection equations, Nipping	7
Total		**36**

Course Outcomes:

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

PC ME 503.1	Develop ability to utilizing knowledge of mathematics, science and engineering outcomes.
PC ME 503.2	Explain the fundamentals of stress analysis, theories of failure and material science in the design of machine components.
PC ME 503.3	Make proper assumptions with respect to materials, factor of safety, static and dynamic loads for various machine components.
PC ME 503.4	Develop an ability to design a system, component or process to meet desired needs within realistic constraints.
PC ME 503.5	Use various techniques, skills and modern engineering tools necessary for engineering practices.
PC ME 503.6	Develop an ability to identify, formulate and solve engineering problems.

Learning Resources:

1. V. B. Bhandari, Design of Machine Elements, TMH.
2. Shigley and Mischke, Mechanical Engineering Design, TMH.
3. Hall, Holowenko and Laughlin, Theory and Problems of Machine Design, TMH.
4. P.C. Gope, Fundamentals of Machine Design, PHI.
5. M.F. Spotts, Design of Machine Elements, Prentice Hall.
6. P. Kannaiah, Machine Design, Scitech Publications.

Subject Code : PC-ME 504	**Category**: Professional Core courses
Subject Name : IC Engines	**Semester** : Fifth
L-T-P : 3-0-0	**Credit**: 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Thermodynamics (PC-ME 301), Applied Thermodynamics (PC-ME 402)	

Course Objective:

1. To acquire knowledge about the IC engine cycles, classification, working principles and to measure performance parameters along with heat balance sheet.
2. To explain different alternate fuels, gas turbines and about jet propulsion

Course Content:

Module No	Description of Topic	Contact Hrs.
1	**Introduction:** Basic Engine components and Nomenclature, Classification of Engines, The working principle of Engines, Comparison of 2-Strokeand 4-Stroke Engines; CI, and SI Engines, Ideal and Actual Working Cycles and their analysis, Valve timing Diagram. **Cycles:** Analysis of air standard cycles (Otto, Diesel, Dual)	4
2	**Fuels:** Fossil fuels, Chemical structure of Petroleum, Properties of SI and CI Engine Fuels, Fuel Ratings; Octane Number, Cetane Number. **Alternate Fuels For IC Engines:** Need for use of alternate fuels. Use of alcohol fuels. Biodiesel. Biogas and Hydrogen in engines.	4
3	**Carburetors & Fuel Injection:** Air Fuel Mixture Requirements, Construction and Working of Simple Carburetor, Calculation of Air-Fuel Ratio, Parts of Carburetor. Requirement of Injection Systems, Classification of Injection Systems, Fuel Feed pump, Injection Pumps, Working principles of Governors, Nozzles and Fuel Injector, Injection in SI and CI Engines.	4
4	**Combustion and Ignition Systems in SI and CI Engines:** Normal and Abnormal Combustion in SI and CI Engines, Stages of Combustion, Detonation and Knocking. Analysis of combustion products, HHV and LHV of fuels.	3
5	**Performance parameters for ICEngines:** Engine Power, Engine Efficiencies, Performance Characteristics, Variables Effecting Performance Characteristics, Methods of Improving Engine Performance, Heat Balance.	3
6	**Modern Automotive Engines:** Changes in Fuel injection Methods in S.I and C.I engines, Common Rail Direct Injection System, Gasoline Direct Injection, Variable Valve Technology, A brief review of Design changes to achieve high efficiency.	4
7	**Lubrication:** Principle of lubrication, properties of lubricating oil, lubrication systems. **Cooling:** Principle of cooling, air & water cooling systems.	3
8	**Gas Turbine:** Introduction to Gas Turbines, Development, Classification and Application of Gas Turbines, Ideal and Actual Cycles; Effect of Inter cooling, Reheating, Regeneration, Combined cycle and Cogeneration.	5
9	**Gas Turbine Cycles for Air craft Propulsion:** Criteria of performance, Intake, and propelling nozzle efficiencies, Simple Turbo jet Cycle, The turboprop engine, Thrust augmentation, Gas turbine combustion systems, Combustion chamber designs, Gas Turbine Emissions.	6
Total		**36**

Course Outcomes:

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

PC ME 504.1	Explain basic concepts of actual cycles with analysis and to describe the fundamental concepts of IC engines along with its working principles.
PC ME 504.2	Interpret different alternative fuels and its emissions, then the method to control these emissions.
PC ME 504.3	Analyse different electronic fuel injection system, supercharging and its effect on performance of SI and CI engine.
PC ME 504.4	Explain performance parameters and characteristics; and calculation of performance parameters.
PC ME 504.5	Explain Brayton cycle and Classify the essential components of gas turbine along with its performance improving methods
PC ME 504.6	Illustrate the working principle of different types of Jet propulsive engines and Rockets.

Learning Resources:

1. V.Ganesan,I.C.Engines,McGrawHill,2017.
2. V.Ganesan,GasTurbines,McGrawHill,2004.
3. C.R.FergusonandA.T.Kirkpatrick,InternalCombustionEngines,Wiley,2015.
4. H.N.Gupta,FundamentalsofInternalCombustionEngines,PHI,2012.
5. H.Cohen,H.I.H.Saravanamuttoo,G.F.C.Rogers,P.StraznickyandA.C.Nix,GasTurbineTheory, Pearson, 2019.
6. J.B.Heywood,InternalCombustionEngineFundamentals,McGrawHillCo.,1988.
7. W.W.Pulkrabek,EngineeringFundamentalsofICEngine,PHIPvt.Ltd.,2002.

Subject Code : MC 501	**Category**: Mandatory courses
Subject Name : Essence of Indian Knowledge Tradition	**Semester** : Fifth
L-T-P : 0-2-0	**Credit**: 0
Contact Per Week- 2L	**Contact Week / Semester=**12 minimum
Pre-Requisites: No-prerequisite	

Course Objective:

1. To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.
2. To make the students understand the traditional knowledge and analyse it and apply it to their day to day life.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	**Introduction to traditional knowledge:** Define traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, Indigenous Knowledge (IK), characteristics, traditional knowledge vis-a-vis indigenous knowledge, traditional knowledge Vs western knowledge traditional knowledge	5
2	**Protection of traditional knowledge:** The need for protecting traditional knowledge Significance of TK Protection, value of TK in global economy, Role of Government to harness TK.	4
3	**Legal framework and TK:** The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, Plant Varieties Protection and Farmer's Rights Act, 2001 (PPVFR Act); The Biological Diversity Act 2002 and Rules 2004, the protection of traditional knowledge bill, 2016.	5
4	**Traditional knowledge and intellectual property:** Systems of traditional knowledge protection, Legal concepts for the protection of traditional knowledge, Patents and traditional knowledge, Strategies to increase protection of traditional knowledge	5
5	**Traditional Knowledge in Different Sectors:** Traditional knowledge and engineering, Traditional medicine system, TK in agriculture, Traditional societies depend on it for their food and healthcare needs, Importance of conservation and sustainable development of environment, Management of biodiversity, Food security of the country and protection of TK	5
Total		**24**

Course Outcomes:

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

MC 501.1	Understand the concept of Traditional knowledge and its importance
MC 501.2	Know the need and importance of protecting traditional knowledge
MC 501.3	Know the various enactments related to the protection of traditional knowledge
MC 501.4	Understand the concepts of Intellectual property to protect the traditional knowledge
MC 501.5	Understand the traditional knowledge in different sectors
MC 501.6	Explain the importance of Traditional knowledge in Agriculture, Medicine and Indian Philosophy

Learning Resources:

1. Traditional Knowledge System in India, by Amit Jha, 2009.
2. Traditional Knowledge System in India by Amit Jha Atlantic publishers, 2002.
3. "Knowledge Traditions and Practices of India" Kapil Kapoor1, Michel Danino.

Subject Code : CS-ME 591	**Category**: Professional Core courses
Subject Name : Computer Programming Lab	**Semester** : Fifth
L-T-P : 0-0-3	**Credit**: 1.5
Contact Per Week- 3P	**Contact Week / Semester=**12 minimum
Pre-Requisites: Numerical Methods & Computer Programming (CS-ME 501)	

Course Objective:

To explore complex systems, physicists, engineers, financiers and mathematicians require computational methods since mathematical models are only rarely solvable algebraically. Numerical methods, based upon sound computational mathematics, are the basic algorithms underpinning computer predictions in modern systems science. The course will cover the classical fundamental topics in numerical methods such as, approximation, numerical integration, numerical linear algebra, solution of nonlinear algebraic systems and solution of ordinary differential equations.

Course Content:

1. **Interpolation:** Problems on Newton forward and Backward interpolation, Lagrange's Interpolation.

2. **Numerical integration:** Problems on Trapezoidal rule, Simpson's 1/3 rule, Weddle's rule.

3. **Numerical solution of Algebraic equation:** Problems on Bisection method, Regula-Falsi method, Newton-Raphson method

4. **Numerical solution of a system of linear equations:** Problems on Gauss elimination method, Gauss-Seidel iterative method.

5. **Numerical solution of ordinary differential equation:** Problems on Euler's method, Runge-Kutta methods

Course Outcomes:

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

CS ME 591.1	Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.
CS ME 591.2	Apply numerical methods to obtain approximate solutions to mathematical problems.
CS ME 591.3	Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.
CS ME 591.4	Analyse and evaluate the accuracy of common numerical methods.
CS ME 591.5	Implement numerical methods in Matlab.
CS ME 591.6	Write efficient, well-documented Matlab code and present numerical results in an informative way.

Subject Code : PC-ME 591	**Category**: Professional Core courses
Subject Name : Machine Tools Lab	**Semester** : Fifth
L-T-P : 0-0-3	**Credit**: 1.5
Contact Per Week- 3P	**Contact Week / Semester=**12 minimum
Pre-Requisites: Machining Principles & Machine Tools (PC-ME 502)	

Course Objective:

1. The course provides students with fundamental knowledge and principles in material removal processes.
2. In this course, the students apply the fundamentals and principles of metal cutting to practical applications through multiple labs using lathes, milling machines, grinding machines, and drill presses, Computer Numerical Control etc.
3. To demonstrate the fundamentals of machining processes and machine tools.
4. To develop knowledge and importance of metal cutting parameters.
5. To develop fundamental knowledge on tool materials, cutting fluids and tool wear mechanisms.
6. To apply knowledge of basic mathematics to calculate the machining parameters for different machining processes.

Course Content:

1. Measurement of cutting forces (Pz and Px or Py) in straight turning at different feeds and velocities.
2. Measurement of average cutting temperature in turning under different speed – feed combinations.
3. Measurement of surface roughness in turning under different conditions.
4. Study of chip formation (type, color & thickness) in turning mild steel and evaluation of role of variation of cutting velocity and feed on chip reduction coefficient /cutting ratio and shear angle.
5. Measurement of tool – wear and evaluation of tool life in turning mild steel by HSS or carbide tool. Geometrical and kinematic test of a centre lathe or a drilling machine.
6. Producing a cast iron vee – block by machining.
7. Production of a straight toothed spur gear from a cast or forged disc.

(At least six experiments must be conducted)

Course Outcomes:

Upon successful completion of the course, the students will be able

PC ME 591.1	Understand the fundamentals of process parameters and performance characteristics for different machine tools
PC ME 591.2	Apply the principles of metal cutting to various machining operations using lathe machine, drilling machine, milling machine, shaper, etc.
PC ME 591.3	Demonstrate and understand the practical application of different machine tools and develop the idea miniaturisation of those machines
PC ME 591.4	Interpret the performance results obtained through experimental analysis of machining processes
PC ME 591.5	Explain the fundamental knowledge of metal removal, tool wear, tool materials, cutting fluids, cutting force, coolant and machine tools
PC ME 591.6	Evaluate and analyse the numerical results of performance measures, obtained through different parametric combination of feed, depth of cut, RPM, etc.

Subject Code : PC-ME 592	**Category**: Professional Core courses
Subject Name : Thermal Engineering Lab	**Semester** : Fourth
L-T-P : 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Heat Transfer (PC-ME 501), IC Engines (PC-ME 504)	

Course Objective:
At the end of the course, student will be able to know different thermal properties and will understand principles and performance of various thermal devices.

Course Content:
1. Determination of thermal conductivity of a metal rod.
2. Determination of thermal conductivity of an insulating powder/or an insulating plate.
3. Determination of emissivity of a plate.
4. Study of a shell and tube heat exchanger and determination of LMTD.
5. Study and performance test of a single acting reciprocating air compressor.
6. Determination of the calorific value of a given fuel and its flash & fire points.
7. Flue gas analysis by ORSAT apparatus.
8. Study of valve timing diagram of diesel engine.
9. Performance test of a muti-cylinder petrol engine by Morse method.
10. Performance test of a 4-stroke I.C. Engine.
11. Study of cut models- Lanchashire Boiler, Babcock & Willcox Boiler.

(<u>At least six experiments must be conducted</u>)

Course Outcomes:

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

PC ME 592.1	Apply the knowledge of mathematics, science and engineering fundamentals to model the energy conversion.
PC ME 592.2	Evaluate by experiment the water equivalent of a bomb calorimeter and thereby calculate the calorific value of any unknown fuel.
PC ME 592.3	Evaluate the exhaust smoke and exhaust emission by ORSAT Apparatus and understand the preventive measures.
PC ME 592.4	Perform test in a single cylinder diesel engine and determine the performance parameters like fuel consumption, BP, Fuel efficiency, air consumption.
PC ME 592.5	Determine the performance parameters of a multi cylinder petrol engine and also perform the morse test to evaluate the power of an individual cylinder.
PC ME 592.6	Understand the different parts and working of different types boiler.

Subject Code : PW-ME 581	**Category**: Project/ Internship
Subject Name : Project -I (on Summer Internship/Vocational Training)	**Semester** : Fifth
L-T-P : 0-0-0	**Credit**: 2
Contact Per Week-	**Contact Week / Semester:** One month or 04 Weeks
Pre-Requisites: Basic knowledge of Mechanical Engineering	

Course Objective:
This course aims to provide real-world, industry-relevant experience, enhancing students' practical skills and theoretical knowledge. Interns will engage in project-based learning, network with professionals, and develop soft skills crucial for career advancement. By its conclusion, interns should have a tangible project or accomplishment, reflecting their learning and contributions.

Course Outcomes:

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

PC ME 581.1	Recall and summarize the fundamental theories, concepts, and techniques learned in the academic curriculum of mechanical engineering applicable to the specific industry or domain of the internship.
PC ME 581.2	Interpret and comprehend the practical application of theoretical knowledge in the workplace, linking academic concepts to real-world engineering practices encountered during the internship.
PC ME 581.3	Apply acquired knowledge and skills to contribute effectively to engineering tasks or projects within the internship setting, demonstrating the ability to solve problems and execute assigned responsibilities.
PC ME 581.4	Analyse and assess engineering processes, equipment, or systems encountered during the internship, identifying inefficiencies, potential improvements, or areas for optimization.
PC ME 581.5	Evaluate the effectiveness and efficiency of engineering solutions or strategies implemented during the internship, offering constructive critiques and suggesting improvements based on learned principles and industry best practices.
PC ME 581.6	Develop innovative solutions, recommendations, or reports based on the internship experience, synthesizing knowledge and practical insights gained to propose novel ideas or improvements in mechanical engineering applications within the specific industry or context.

Curriculum Structure

SEMESTER-VI

THEORY							
Sl. No.	**Course Code**	**Subject Name**	**Contact period per week**			**Total**	**Credit**
			L	**T**	**P**		
1	PC-ME 601	Air-conditioning & Refrigeration	3	0	0	3	3
2	PC-ME 602	Modern Manufacturing Processes	3	0	0	3	3
3	PC-ME 603	Machine Design	3	0	0	3	3
4	PC-ME 604	Production & Operations Management	3	0	0	3	3
5	OE-ME 601	Open Elective-I	3	0	0	3	3
6	MC 601	Constitution of India	0	2	0	2	0
	Total Theory					**17**	**15**
PRACTICAL							
1	PC-ME 691	Air-conditioning & Refrigeration Lab	0	0	3	3	1.5
2	PC-ME 692	Modern Manufacturing Process Lab	0	0	3	3	1.5
3	PC-ME 693	Design Practice Lab	0	0	3	3	1.5
	Total Practical					**9**	**4.5**
	Total of Semester					**26**	**19.5**

Open Elective-I:
OE-ME 601A – Computer Integrated Manufacturing
OE-ME 601B - Mechatronics
OE-ME 601C – Artificial Intelligence

NOTE: Vocational Training/Internship to be conducted after sixth semester and to be evaluated in seventh semester.

Subject Code: PC-ME 601	**Category**: Professional Core courses
Subject Name: Air-conditioning & Refrigeration	**Semester**: Sixth
L-T-P: 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Thermodynamics (PC-ME 301), Applied Thermodynamics (PC-ME 402), Heat Transfer (PC-ME 501)	

Course Objective:

1. To know about the basics of refrigeration and air-conditioning system.
2. To learn about different types of Refrigeration, Air-Conditioning and ventilation systems.
3. To know about designing a Refrigeration and Air-Conditioning system.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	Introduction: Concepts of Refrigeration and Air-conditioning. Unit of refrigeration, Refrigerants–Desirable Properties, Nomenclature.	2
2	Simple Vapour Compression Refrigeration System (Simple VCRS): Vapour compression cycle on p-hand T-S diagrams. Cycles with subcooling and superheating, their effects; Effect of changes in evaporator pressure and condenser pressure on the performance of a simple VCRS; dry compression and wet compression of refrigerant; actual Vapour Compression Cycle.	5
3	Air Refrigeration System (ARS): Bell-Coleman refrigerator. COP determination, actual air refrigeration cycle.	3
4	Vapor Absorption Refrigeration System (VARS): Advantages of VARS over VCRS. Working principle of simple VARS, practical VARS. Limitations of VARS, maximum COP of a VARS, Lithium bromide-water System; Aqua-ammonia systems	4
5	Equipment and Control: Major Refrigeration Equipment - Compressors: Types; reciprocating, rotary& centrifugal, volumetric efficiency, Condensers: types used in refrigeration systems; Evaporators: expansion devices: capillary tubes and thermostatic expansion valves.	5
6	Basic definitions and principles related to Psychometry; Psychometric Charts & Their Uses; Heating, Cooling, Heating &Humidification & Cooling & Dehumidification processes. Adiabatic Saturation, Cooling Coils, By-pass Factor, Sensible Heat Factors. Heat Load estimation: Simple cases of Cooling and Dehumidification.	9
7	Ventilation – Definition & Requirement, Natural & Mechanical Ventilation, Ventilation Load Calculation, Duct Sizing & Design	4
8	Air-conditioning equipment: Air handling units, Cooling Towers.	4
Total		**36**

Course Outcomes:

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

PC ME 601.1	Understand various refrigeration cycles and evaluate performance using Mollier charts and/ or refrigerant property tables.
PC ME 601.2	Illustrate the fundamental principles and applications of refrigeration and air conditioning system.
PC ME 601.3	Conduct test on vapour compression refrigeration systems to obtain cooling capacity and coefficient of performance.
PC ME 601.4	Estimate the condition of steam and performance of vapour power cycle and vapour compression cycle.
PC ME 601.5	Determine cooling load for air conditioning systems used for various applications
PC ME 601.6	Apply the concept of psychometric charts and estimate various essential properties related to Psychrometry and processes.

Learning Resources:

1. W.F. Stocker and J.W. Jones, Refrigeration and Air Conditioning, McGraw Hill, 2014.
2. C.P. Arora, Refrigeration and Air Conditioning, McGraw Hill India, 2017.

3. P.L. Ballaney, Refrigeration and Air Conditioning, Khanna Publication, New Delhi, 1972.
4. R.C. Arora, Refrigeration and Air Conditioning, PHI, 2010.
5. S.C. Arora and S. Domkundwar, Refrigeration and Air Conditioning, Dhanpat Rai Publication, 2018.

Subject Code: PC-ME 602	**Category**: Professional Core courses
Subject Name: Modern Manufacturing Processes	**Semester**: Sixth
L-T-P: 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Manufacturing Processes (PC-ME404)	

Course Objective:

1. To introduce principles of material removal mechanism of advanced machining processes such as mechanical, electro-chemical and thermal.
2. To give basic understanding of the machining capabilities, limitations, and productivity of advanced manufacturing technologies.
3. Outline the basic principles of operation of different NTM processes and RP techniques and develop mathematical relationship for the different responses with respect to the control parameters of the NTM process.
4. To design the experimental plan for different processes while computing the responses and analyze the results of the process outcomes and optimize the process responses using several criteria.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	Introduction to and scope of the subject of Modern Manufacturing Processes. Concept and need of automation; Difference between mechanization and automation; degree and levels of automation; potential benefits of automation; Types of automation: Hard, programmable, and flexible automation. Hard automation in machine tools: Chronological development of machine tools to realize higher degree of automation: Capstan & Turret lathe, single spindle automatics, Multi-spindle automatics, and Transfer line (rotary and in-line); Limitations of hard automation and emergence of flexible and programmable automation.	6
2	Need and classification of non-traditional machining processes – Material removal in traditional and non-traditional machining processes - considerations in process selection. Advantages over traditional, classification, characteristics of all processes.	2
3	Abrasive Jet Machining (AJM): Working principle with help of layout, Applications, Effect of pressure, strand-off distance, grain size, abrasive flow rate on material removal rate (MRR) Mechanism of material removal. Advantages and limitations Water Jet Machining: Introduction, Machining System, Basic principle, Process parameters, Applications, Advantages and Disadvantages.	4
4	Ultrasonic Machining (USM): Schematic Diagram of USM- Working principle, Functions of each equipment used in the set up, Material removal process. Influence of Process parameters on (i) machining rate (ii) Surface finish and accuracy and repeatability, Applications.	3
5	Electro-Chemical Machining: Principle of ECM process, chemistry of the ECM processes, Parameters of the process, determination of the metal removal rate, dynamics of ECM process, polarization, tool design, advantages and disadvantages, application, electrochemical grinding, electrochemical honing, electrochemical deburring, Application of ECM for deep hole drilling – electro stream drilling and shaped tube electrolytic machining. Chemical machining - Fundamental principle, types of chemical machining, maskants, etchants, advantages, disadvantages, applications	4
6	Electric Discharge Machining: Working principle of EDM, Power circuits for EDM - RC pulse generator and controlled pulse generator– Analysis of R-C Circuits – Mechanics of metal removal in EDM, Process parameters, selection of tool electrode and dielectric fluids, surface finish and machining accuracy, characteristics of spark eroded surface and recent development in EDM. Wire EDM – Working principle, process variables, process characteristics and applications. Electric discharge grinding and electric discharge diamond grinding - working principle, process capabilities and applications.	3

7	Laser Beam Machining (LBM): General working principle of laser beam machining – Generation of Laser, types of Lasers, Basic mechanism of Ruby laser, Energy level diagram of Ruby laser. Carbon Dioxide laser, Energy level diagram process characteristics and applications. Electron Beam Machining - Equipment for production of Electron Beam, theory of EBM, thermal and non-thermal type, process characteristics and applications. Ion Beam Machining - Mechanism of metal removal and associated equipment, process characteristics and applications. Plasma Arc Machining: Basic principle, Metal removal mechanism, process parameters, process characteristics, types of torches, applications. Applications.	7
8	Hybrid Machining- Introduction, Methodology for Hybrid machining, thermal interaction, chemical and electrochemical interaction, mechanical interaction, Electromechanical Discharge Machining (ECDM/ECAM), Electrical Discharge Machining with Ultrasonic Assistance (EDMUS). Micro-Machining: Need- evolution- fundamentals and trends in micro technologies Consequences of the technology and society- challenges to manufacturing technology- evolution of precision in manufacturing, tooling and current scenario, requirements and applications Theory of micromachining- Chip formation- Size effect in micromachining- micro turning- micro drilling.	7
Total		**36**

Course Outcomes:

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

PC ME 602.1	Identify the background behind the development of unconventional machining processes and to understand the basic principles, equipment, merits, demerits and applications of various non-traditional machining processes.
PC ME 602.2	Understand various material processing techniques for critical components.
PC ME 602.3	Analyse the influence of process parameters in various non-traditional machining processes.
PC ME 602.4	Understand various micro machining processes.
PC ME 602.5	Understand and select various measurement techniques in micro machining processes.
PC ME 602.6	Capture the international market with latest mechanical industry needs with the knowledge and support of advanced manufacturing techniques, so student with this judgment will be absorbed in any mechanical industry.

Learning Resources:

1. Non-Conventional Machining by P. K. Mishra, Narosa Publishers.
2. Manufacturing Engineering & Technology, K. Jain, Pearson Education]
3. Modern machining process, Pandey and Shah, Tata McGraw Hill 2000
4. Manufacturing Science by A.Ghosh, East-West Publications.
5. Non-Traditional Manufacturing by Benidict.
6. Automation, Production Systems and Computer Integrated Manufacturing by Groover, Prentice Hall.
7. Non-Traditional and Advanced Machining Technologies: Machine Tools and Operations, Hassan El-Hofy, McGraw Hill Co.
8. Advanced Machining Processes: Non traditional and Hybrid Processes, Hassan El-Hofy, McGraw Hill Co.

Subject Code: PC-ME 603	**Category**: Professional Core courses
Subject Name: Machine Design	**Semester**: Sixth
L-T-P : 3-0-0	**Credit**: 3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Strength of Materials (PC-ME 401), Theory of Machines (PC-ME 405)	

Course Objective:

1. Enable students to attain the basic knowledge required to understand, analyze, design and select machine elements required in transmission systems.
2. Reinforce the philosophy that real engineering design problems are open-ended and challenging.
3. Impart design skills to the students to apply these skills for the problems in real life industrial applications.
4. Inculcate an attitude of team work, critical thinking, communication, planning and scheduling through design projects.
5. Create awareness amongst students about safety, ethical, legal, and other societal constraints in execution of their design projects.
6. Develop an holistic design approach to find out pragmatic solutions to realistic domestic and industrial problems.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	**Clutches:** Function, types; Friction clutches – torque capacity based on uniform pressure and uniform wear theory for disc and cone clutch; Centrifugal clutch; Friction materials; Considerations for heat dissipation.	4
2	**Brakes:** Function, types; pivoted block brake (single and double block brakes), internal expanding shoe brake, self-energizing and self-locking; Pivoted block brake; Band brake-simple and differential; Energy equation for braking time calculation; Magnetic and hydraulic thruster operated fail-safe brakes; Brake lining materials; Thermal considerations during braking.	4
3	**Gears:** Design objectives, types, terminologies, conjugate action and involute tooth profile, tooth systems, standard modules; Gear materials. Gear trains – simple, compound, epicyclic gear train; Speed-torque analysis of gear trains. **Spur Gear**: Strength design, static and dynamic considerations in strength design, Lewis formula, Lewis form factor, beam strength, Buckingham equation for dynamic tooth load; Endurance strength and wear strength; Designing a pinion based on above considerations; **Helical Gear**: Helix angle, minimum face width, virtual number of teeth; Strength design, Buckingham formulae for checking dynamic load and wear load. **Bevel Gear:** Terminologies, formative number of teeth; Lewis equation, dynamic load, endurance strength and wear strength checking. **Worm- worm wheel:** Terminologies and their inter-relation; Preferred combination of various parameters; Efficiency; Materials.	10
4	**Pressure vessels**–thick cylinder, Lame's equation, Clavarino's equation, Birnie's equation, Autofrettage– compound cylinders, End Covers, opening in pressure vessel – area compensation method, Fired and unfired vessels – category, Thermal stresses in pressure vessels, Industrial Code.	6
5	**Flywheel** design for application to: (i) Punching press; (ii) 2-stroke engine; (iii) 4-stroke engine, Torque analysis, Solid disc and rimmed flywheel	4
6	**Sliding contact bearings:** Bearing types and materials; Stribeck Curve, Petroff equation, Hydrodynamic lubrication theory - pressure development; Tower experiment, Reynolds equation, Finite bearings – Raimondi- Boyd charts, Design factors/variables, Heat generation & dissipation; Hydrostatic bearing; Plummer block.	4
7	**Rolling contact bearings:** Bearing types, nature of load; Static and dynamic load capacity, Stribeck equation, Load - Life relation; Bearing selection from manufacturers' catalogues; Methods of lubrication; Bearing mounting on journal and bearing block.	4
Total		**36**

Course Outcomes:

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

PC ME 603.1	Understand the basic concepts of the design process.
PC ME 603.2	Comprehend the standard codes, critical design parameters, and practices to select materials and geometric parameters.
PC ME 603.3	Apply empirical data to the design of various automobile components.
PC ME 603.4	Evaluate and analyze the design processes of the spur, helical, bevel gear, and worm gear systems.
PC ME 603.5	Analyze the design considerations of pressure vessels and the applications of industrial codes.
PC ME 603.6	Develop expertise in the design of rolling contact and sliding contact bearings for industrial applications.

Learning Resources:

1. V. B. Bhandari, Design of Machine Elements, TMH.
2. Shigley and Mischke, Mechanical Engineering Design, TMH.
3. Hall, Holowenko and Laughlin, Theory and Problems of Machine Design, TMH.
4. P.C. Gope, Fundamentals of Machine Design, PHI.
5. M.F. Spotts, Design of Machine Elements, Prentice Hall.
6. P. Kannaiah, Machine Design, Scitech Publications.

Subject Code: PC-ME 604	**Category**: Professional Core courses
Subject Name: Production & Operations Management	**Semester**: Sixth
L-T-P: 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: No-prerequisite	

Course Objective:

1. To develop an understanding of how the operations, have strategic importance and can provide a competitive advantage in the workplace.
2. To understand the relationship between operations and other business functions.
3. To understand techniques of location and facility planning; line balancing; job designing; and capacity planning in operations management.
4. To understand the Materials Management function starting from Demand Management through Inventory Management.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	Introduction: System concept of production; Product life cycle; Types and characteristics of different production system: Mass, Batch, Job; Productivity, Strategies to connect Sales with Production: MTS, ATO, MTO, ETO; Primary, Secondary, tertiary production systems; Process and product focused organization structures; Management decisions – strategic, tactical and operational.	3
2	Forecasting: Patterns of a time series – trend, cyclical, seasonal and irregular; Forecasting techniques: Time series: moving average, weighted moving average, simple exponential smoothing, adjusted exponential smoothing; Causal: linear regression; Forecasting a time series with trend and seasonal component; Accuracy of forecasting: MAD, MAPE, MSE, MFE; BIAS.	5
3	Materials Management and Inventory Control: Components of materials management; Inventory control: Taxonomy of inventory control, EOQ model, Economic (production) lot size model, Inventory model with planned shortages, Quantity discounts for EOQ model; Q-system and P-system of inventory control; Selective inventory: ABC analysis, FSN, VED etc; Determination of re-order point, safety stock, service level. Just-in-time inventory management, Kaizen, Kanban.	5
4	Materials Requirement Planning: MRP concept – bill of materials (BOM), master production schedule; capacity requirements planning, MRP calculations, MRP – II.	3
5	Machine Scheduling: Concept of Scheduling and process planning, Taxonomy of Scheduling and Scheduling attributes; Forward scheduling vs. backward scheduling, Gantt Chart; Single machine scheduling problem: Different priority rules: shortest processing time (SPT) rule to minimize mean flow time, Earliest due date (EDD) rule to minimize maximum lateness, Total tardiness minimizing model; Minimizing make span with identical parallel machines; Johnson's rule for 2 and 3 machines scheduling; Problems of 2 jobs – m machines. Limitations of static scheduling and emergence of dynamic scheduling, Types of dynamic scheduling: (i) pure reactive scheduling, (ii) Predictive-reactive scheduling, (iii) Robust pro-active scheduling; Concept of distributed scheduling.	7
6	Assembly Line Balancing: Line balancing problem, Taxonomy of line balancing: Cycle time, task time, minimum number of stations required; Performance Measures of Line Balancing: Idle time, line efficiency, balance delay, smoothness index; Line balancing procedures: Precedence diagram, Rank positional weight method.	3
7	Project Scheduling: Activity analysis; Network construction; critical path method (CPM); Crashing of project network.	4
8	Quality Control & Assurance : Meaning of Quality; Quality assurance system; choice of process and quality; Inspection and control of quality; Maintenance function & quality; Process control charts : x-chart and R-chart, p-chart and c-chart; Acceptance sampling : Operating characteristic (O.C) curve, Single sampling plan, Double sampling plan, Acceptance sampling by variables and Six Sigma.; Concept and principles of TQM: Quality policy, quality plan, role of customer and people in TQM, total quality maintenance, benefits.	6
Total		**36**

Course Outcomes:

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

PC ME 604.1	Define and distinguish the different types of production & Operations system in manufacturing and service sector, and will be able to plan and implement production and service related decisions.
PC ME 604.2	Predict (Forecast) the market and production demands by using different mathematical and statistical techniques and judge the accuracy of forecasting.
PC ME 604.3	Plan production schedules and resources (material and machine) required for production system.
PC ME 604.4	Apply the concepts of purchase, stores and inventory management, analyse and evaluate material requirement decisions.
PC ME 604.5	Optimize maintenance schedules in manufacturing and service units in industry.
PC ME 604.6	Design the algorithms that are appropriate for production and operations related problems and measure performance related to productivity and quality management.

Learning Resources:

1. Buffa and Sarin, Modern Production and Operations Management, Wiley, 2016.
2. R. Panneerselvam, Production and Operations Management, PHI Learning 2012.
3. C.J. O'Donnel and H. Koontz, Principles of Management, McGraw Hill, 1995.
4. S.N. Chary, Production and Operations Management, McGraw Hill.
5. J.A.F. Stoner, R. Freeman and D.R. Gilbert. Jr., Management, Prentice Hall of India, 1985.
6. H. Koontz and H. Weihrich, Essentials of Management, McGrew Hill, 2007.

Subject Code: OE-ME 601A	**Category**: Open Elective Courses
Subject Name: Computer Integrated Manufacturing	**Semester**: Sixth
L-T-P: 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester** = 12 minimum
Pre-Requisites: Machining Principles & Machine Tools (PC-ME 502)	

Course Objective:

1. To understand the different aspects of CAD/CAE/CAM and apply various techniques in the relevant areas of design and manufacturing
2. To learn and develop Flexible Manufacturing Systems
3. To understand the philosophy of CIM and apply the same for the development and implementation of CIM systems.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	Computer Aided Design (CAD): CAD hardware and software; product modelling, automatic drafting; engineering analysis, FEM design review and evaluation.	4
2	Fundamentals of NC and CNC: NC and CNC system as per EIA; Concept of retrofitting; purpose, principle, advantages, limitations and application in machine tools; advantages of CNC over NC, Hardware based NC vs. software-based CNC. Axis nomenclature of NC/CNC machine tools, Classifications of NC/CNC machine tools w. r. to: (a) Positioning system (b) Absolute and incremental programming (c) Open loop and closed loop (servo system), Fundamental unit of NC/CNC: Concept of BLU.	4
3	Precision in NC/CNC: Resolution, Accuracy, Repeatability, Elements of NC/CNC machine tools: (a) Machine Control Unit: DPU and CLU (b) Drive systems: Spindle and feed drives (considering recirculating ball screw) (c) Feedback devices, Design analysis of open and closed loop systems: Determination of resolution, pulse count, pulse frequency, and encoder gain (Numerical problems to be solved). Interpolation: Linear and Circular; Derivation of summation formulae. Concept and features of Turning Centres, Machining Centres, Hybrid and Multi-tasking machines	5
4	Part programming for NC/ CNC Systems, Manual part programming: (i) Concept of Word, Block; Word Address Format; Various G Codes and M codes ; Modal and Non-modal codes; (ii) Process planning for programming (iii) Concept of Reference points in NC/CNC: Machine zero, Home position, Program zero, Job zero; Concept of tool offset. (iv) Part programming for Turning Centres: Complete program writing considering dedicated cycles e. g. box turning cycles, peck drilling cycle, peck grooving cycle, multiple thread cutting cycle, (v) Part programming for Machining Centres: Canned cycles for drilling, Concept of cutter radius compensation in milling, Complete program for drilling and profile milling.	6
5	Computer aided part programming (i) Limitations of manual programming and need for computer assisted part programming: Block diagram, Pre-processor and post processor, programming languages (ii) statements in APT: Geometry, Tool path, and auxiliary functions (iii) examples of Computer aided part programming in APT (iv) CAD-CAM based part programming.	2
6	Networking of NC/CNC machine tools: Direct and Distributed Numerical Control (DNC): Scheme, networking, NC data management systems, potential benefits. Optimization in CNC: (i) Adaptive control: Definition and Types: ACC, ACO, and GAC. Scheme, objectives, and benefits. (ii) Concept of Performance Indexes (PI), Optimization of machining attributes: Cost, time, productivity etc. (iii) On-line vs. Off-line adaptive control, Economics of NC/CNC systems.	5
7	Group Technology: Concept of GT and part families, design similarity and manufacturing similarity, Production Flow Analysis, Rank Order Clustering Technique, Part coding and classification systems: OPITZ and MICLASS system, advantages of group technology. Computer aided process planning (CAPP): Retrieval type and Generative Type.	4
8	Computer aided material requirements planning (MRP); computer aided production scheduling; computer aided inspection planning; computer aided inventory planning; Flexible manufacturing system (FMS): Concept of flexible manufacturing;	6

	Components of FMS and types of flexibilities, Advantages. Concept of Computer Integrated Manufacturing (CIM): CIM wheel; Concurrent Engineering; Basic components of CIM; Distributed database system; distributed communication system, computer networks for manufacturing; future automated factory; social and economic factors. CIM implementations, Barriers to CIM.	
Total		**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

OE ME 601A.1	Establish the need of automation and its benefits, define, characterize and distinguish the different types of automation and automated manufacturing systems cater to different types of production strategy.
OE ME 601A.2	Outline the principles of operation of NC & CNC machine tools, their constructions, control systems used, the features of Turning centers, machining centers, and hybrid (multi-tasking) machines and select a particular type for specific application(s).
OE ME 601A.3	Design and analyse the open and closed loop control systems of NC/CNC machine tools, develop the DDA interpolation expressions (Summation formulae) for linear and circular trajectory, and analyse the DNC and adaptive control systems.
OE ME 601A.4	Create process plan for Turning centers and Machining centers and write (Code generation) the manual part program and for complex mechanical components.
OE ME 601A.5	Apply data management and its importance for decision making in CIMS environment.
OE ME 601A.6	Design Flexible manufacturing cell after carrying out Group technology study and finally creating FMS.

Reference Books:

1. Computer Control of Manufacturing Systems by ***Y. Koren;*** McGraw Hill
2. Numerical Control & Computer aided Manufacturing by ***Pressman & Williams***; John Wiley
3. Automation, Production Systems & CIM by ***M. P. Groover***, PHI
4. CAD/CAM/CIM by ***Radhakrishnan, Subhramanyan, & Raju*****;** New Age International
5. Computer Integrated Manufacturing by ***Henry W. Kraebber and James A Rehg;*** Pearson Prentice Hall.

Subject Code: OE-ME 601B	**Category**: Open Elective Courses
Subject Name: Mechatronics	**Semester**: Sixth
L-T-P: 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Fluid Mechanics (PC-ME 302), Theory of Machines (PC-ME 4050, Basic Elec. & Electro. Engg. (ES-EE 101)	

Course Objective:

1. Understand key elements of Mechatronics system, representation into block diagram.
2. Understand concept of transfer function, reduction and analysis.
3. Understand principles of sensors, its characteristics, interfacing with DAQ microcontroller.
4. Understand the concept of PLC system and its ladder programming, and significance of PLC systems in industrial application.
5. Understand the system modelling and analysis in time domain and frequency domain.
6. Understand control actions such as Proportional, derivative and integral and study its significance in industrial applications.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	Introduction to Mechatronics: Definition, Mechatronics in manufacturing, products and design. Comparison, between Traditional and Mechatronics approach.	2
2	Electronics: Review of fundamentals of electronics, logic gates and their operations.	2
3	Data conversion devices, sensors, microsensors, transducers, electrical contacts, actuators, and switches, contactless input devices, signal processing devices; relays, output devices.	3
4	Drives: Electrical: Stepper motors, servo drives; Mechanical: Ball screws, linear motion bearings, transfer systems, Hydraulics: Hydraulic elements, actuators and various other elements. Design of hydraulic circuit.	9
5	Control Systems: Open loop and closed loop control, block diagrams, transfer functions, Laplace transformation, Mathematical model of physical system; PI and PID controllers, 8085 microprocessors.	6
6	PLC controller and Ladder diagrams hydraulic and pneumatic controllers.	3
7	Time domain analysis, transient response of first and second order systems. Introduction to nonlinear control; State space analysis, optimal and adaptive control. Introduction to discrete-time systems and Z-transform.	8
8	Design and fabrication of Mechatronics systems.	3
Total		**36**

Course Outcomes:

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

OE ME 601B.1	Recall the definition of mechatronics and differentiate between traditional approaches and mechatronics approaches in manufacturing, products, and design.
OE ME 601B.2	Explain the fundamentals of electronics including logic gates and their operations, as well as the function and operation of data conversion devices, sensors, microsensors, transducers, and actuators.
OE ME 601B.3	Apply knowledge of drives including stepper motors, servo drives, ball screws, and linear motion bearings to design and analyze mechanical systems.
OE ME 601B.4	Analyze control systems concepts such as open-loop and closed-loop control, block diagrams, transfer functions, and Laplace transformation to understand the mathematical models of physical systems and the behavior of PI and PID controllers.
OE ME 601B.5	Evaluate the effectiveness of PLC controllers and ladder diagrams in controlling hydraulic and pneumatic systems, considering factors such as reliability, efficiency, and ease of programming.
OE ME 601B.6	Design and fabricate a mechatronics system incorporating elements such as sensors, actuators, controllers, and drives, while considering factors such as system requirements, constraints, and optimization techniques.

Learning Resources:

1. Automatic Control Engineering by F.H.Raven, 5th ed., McGrawHill International.
2. Modern Control Engineering by K.Ogata, 3rd ed., Prentice Hall.
3. Mechatronics, Bolton, Pearson Education
4. Automatic Control Systems by B.C.Kuo, 6th ed., Prentice Hall.
5. Mechatronics, HMT Ltd., TMH.
6. Machine design for mobile and industrial applications by G.W.Kurtz, J.K.Schueller, P.W.Claar, SAE.
7. Mechatronics, Mohali, TMH.

Subject Code: OE-ME 601C	**Category**: Open Elective Courses
Subject Name: Artificial Intelligence	**Semester**: Sixth
L-T-P: 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Mathematics-III (BS-M 301)	

Course Objective:

1. To provide a strong foundation of fundamental concepts in Artificial Intelligence.
2. To provide a basic exposition to the goals and methods of Artificial Intelligence.
3. To learn fuzzy logic and neural networks.
4. To enable the student to apply these techniques in applications which involve perception,creasoning and learning.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	Introduction: Meaning and definition of artificial intelligence, Physical Symbol System Hypothesis, production systems, Characteristics of production systems; Breadth first search and depth first search techniques. Heuristic search Techniques: Hill Climbing, Iterative deepening DFS, bidirectional search. Analysis of search methods. A* algorithm, and their analysis. Introduction to Genetic Algorithms.	6
2	Knowledge Representation, Problems in representing knowledge, knowledge representation using propositional and predicate logic, logical consequences, syntax and semantics of an expression, semantic Tableau. Forward and backward reasoning. Proof methods, substitution and unification, conversion to clausal form, normal forms, resolution, refutation, deduction, theorem proving, inferencing, monotonic and non-monotonic reasoning. Introduction to prologue.	6
3	Network-based representation and reasoning, Semantic networks, Conceptual Graphs, frames. Description logic (DL), concept language, reasoning using DL. Conceptual dependencies (CD), scripts, reasoning using CD. Introduction to natural language processing.	8
4	Network-based representation and reasoning, Semantic networks, Conceptual Graphs, frames. Description logic (DL), concept language, reasoning using DL. Conceptual dependencies (CD), scripts, reasoning using CD. Introduction to natural language processing.	8
5	Reasoning in uncertain environments, Fuzzy logic, fuzzy composition relation, operations on fuzzy sets. Probabilistic reasoning, Bayes theorem, construction of Bayesian networks, belief propagation. Markov processes and Hidden Markov models	8
Total		**36**

Course Outcomes:

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

OE ME 601C.1	Understand the various searching techniques, constraint satisfaction problem and example problems- game playing techniques.
OE ME 601C.2	Apply these techniques in applications which involve perception, reasoning and learning.
OE ME 601C.3	Explain the role of agents and how it is related to environment and the way of evaluating it and how agents can act by establishing goals.
OE ME 601C.4	Acquire the knowledge of real-world Knowledge representation.
OE ME 601C.5	Analyse and design a real-world problem for implementation and understand the dynamic behaviour of a system.
OE ME 601C.6	Use different machine learning techniques to design AI machine and enveloping applications for real world problems.

Learning Resources:

1. Artificial Intelligence: Elaine Rich, Kevin Knight, Mc-GrawHill.
2. Introduction to AI & Expert System: Dan W.Patterson, PHI.
3. Artificial Intelligence by Luger (Pearson Education)
4. Russel&Norvig, Artificial Intelligence: A Modern Approach, Pearson Education.

Subject Code: MC 601	**Category**: Mandatory courses
Subject Name: Constitution of India	**Semester**: Sixth
L-T-P: 0-2-0	**Credit**:0
Contact Per Week- 2L	**Contact Week / Semester=**12 minimum
Pre-Requisites: No-prerequisite	

Course Objective:
To develop a sound understanding of the importance of our constitution in transforming our nation to a holistic developed country in the world.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	**Unit - I- Introduction** 1. Meaning and importance of Constitution 2. Making of Indian Constitution 3. Salient features and the Preamble	6
2	**Unit - II- Important features** 1. Fundamental rights 2. Fundamental duties 3. Directive Principles	3
3	**Unit - III- Union Government** 1. Lok Sabha & Rajya Sabha (Composition, Powers &Functions) 2. President & Prime Minister (Powers, Functions, position) 3. Supreme Court-Composition, Powers & Functions	6
4	**Unit - IV- State Governments** 1. Bidhan Sabha (Composition, Powers &Functions) 2. Governor & Chief Minister (Powers, Functions, position) 3. High Court-Composition, Powers & Functions	5
5	**Unit - V- Major Functionaries** 1. Union Public Service Commission 2. Election Commission 3. Planning Commission (NITI)	4
Total		**24**

Course Outcomes:
Upon successful completion of the course, students will be able to

MC 601.1	Describe historical background of the constitution making and its importance for building a democratic India.
MC 601.2	Explain the functioning of three wings of the government i.e., executive, legislative and judiciary.
MC 601.3	Explain the value of the fundamental rights and duties for becoming good citizen of India.
MC 601.4	Analyse the decentralisation of power between central, state and local self-government
MC 601.5	Apply the knowledge in strengthening of the constitutional institutions like CAG, Election Commission and UPSC for sustaining democracy.
MC 601.6	Apply the knowledge to analyse and evaluate the existing systems

Learning Resources:

1. Indian Constitution by Durga Das Basu;
2. Indian Constitution by Vidhya Bhushan and Vishnu Bhagawan;
3. India's Constitution by Faida;
4. Indian Government and Politics by J.C. Johri.

Subject Code: PC-ME 691	**Category**: Professional Core courses
Subject Name: Air-conditioning & Refrigeration Lab	**Semester**: Sixth
L-T-P: 0-0-3	**Credit**: 1.5
Contact Per Week- 3P	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Air-conditioning & Refrigeration (PC-ME 601)	

Course Objective:

1. To understand the working of a vapour compression refrigeration system.
2. To understand and perform the experimentation on vapour compression refrigeration test rig.
3. To carry out the experimentation on air conditioning test rig.
4. To understand and perform the experimentation on ice plant apparatus.

Course Content:

1. Study on different component of a vapour compression refrigeration system and its working cycle.
2. Experiment on vapour compression refrigeration test rig.
3. Experiment on vapour compression refrigeration test rig with continuous flow of water.
4. Experiment on air conditioning test rig.
5. Experiment on air conditioning test rig psychrometric properties and - coil bypass factor.
6. Experiment on ice plant apparatus.

Course Outcomes:

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

PC ME 691.1	Understand the different components of vapour compression refrigeration system and its working cycle
PC ME 691.2	Illustrate the fundamental principles and applications of refrigeration and air conditioning system
PC ME 691.3	Present the properties, applications and environmental issues of different refrigerants
PC ME 691.4	Obtain coefficient of performance by conducting test on vapour compression refrigeration systems test rig.
PC ME 691.5	Calculate of cycle COP for all the experiments
PC ME 691.6	Operate and analyze all the experiments

Subject Code: PC-ME 692	**Category**: Professional Core courses
Subject Name: Modern Manufacturing Process Lab	**Semester**: Sixth
L-T-P: 0-0-3	**Credit**:1.5
Contact Per Week- 3P	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Modern Manufacturing Process (PC-ME 602)	

Course Objective:

1. To make acquainted the various unconventional manufacturing processes.
2. To know about the applications of advanced manufacturing processes (which are exceptional).
3. To encourage the students for developing the models (experimental/theoretical) of Advanced Manufacturing Processes.

Course Content:

1. Parametric Study of Electric-Discharge Machining Process
2. Study of Micro Electric-Discharge Machining Process
3. Study of Electro Chemical Machining Process
4. Study of CO2 Laser Cutting Process
5. Study of Abrasive Jet Machining
6. Study of Ultrasonic Machining

Course Outcomes:

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

PC ME 692.1	Understand and recognize constructional features and modes of operations of CNC.
PC ME 692.2	Identify different axes, machine zero, home position, systems and controls of CNC machines.
PC ME 692.3	Create and simulate CNC turning part program and to identify errors and to make components on CNC turning centre.
PC ME 692.4	Develop and simulate CNC milling part program and identify errors and to manufacture components on CNC milling machine.
PC ME 692.5	Study geometry of robot manipulator, actuators and grippers.
PC ME 692.6	Study the various process parameters and their effect on the component machined on ECM & EDM.

Subject Code: PC-ME 693	**Category**: Professional Core courses
Subject Name: Design Practice Lab	**Semester**: Sixth
L-T-P: 0-0-3	**Credit**: 1.5
Contact Per Week- 3P	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Machine Drawing (PC-ME 393), Machine Design (PC-ME 603)	

Course Objective:

1. To understand use of different types mechanical components and determine the safe design under given conditions.
2. To make the students familiar with different design softwares.
3. Understand the design optimization and various methods of optimization.

Course Content:

Design of mechanical components based on Advanced Design Software:

1. At least **two assignments** on 2-D and 3-D modelling of mechanical components and systems using software packages like AUTOCAD, CATIA, PRO E or similar software.
2. At least **two assignment** on design analysis of mechanical components using software packages like CATIA, PRO E or similar software.
3. At least **one assignment** on Design Practice using IS codes, e.g., Pressure vessel codes, Gear design codes etc.
4. At least **one assignment** on analysis of stress strain and deformation of any mechanical components.

Course Outcomes:

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

PC ME 693.1	Remember the fundamental principles of machine design, standard design equations and formulas and Identify key components and terminology used in machine design.
PC ME 693.2	Explain the principles of statics and dynamics, engineering drawings and specifications and describe the importance of material properties in machine components.
PC ME 693.3	Apply design principles to solve manually real-world machine design problems and then use design software tools for drafting and analysis. Demonstrate also the use of material selection criteria in design decisions.
PC ME 693.4	Investigate failure modes, conduct failure analysis and analyse the forces and stresses in machine components.
PC ME 693.5	Critique and compare alternative design solutions, assess the reliability and safety aspects of machine designs and evaluate the alternatives.
PC ME 693.6	Design machine components and systems to meet specified requirements and propose improvements to existing machine designs.

Curriculum Structure

SEMESTER-VII

THEORY							
Sl. No.	**Course Code**	**Subject Name**	**Contact period per week**			**Total**	**Credit**
			L	**T**	**P**		
1	PC-ME 701	Power Plant Engg.	3	0	0	3	3
2	PE-ME 701	Professional Elective-I	3	0	0	3	3
3	PE-ME 702	Professional Elective-II	3	0	0	3	3
4	OE-ME 701	Open Elective-II	3	0	0	3	3
5	MC 701	Environmental Science	0	2	0	2	0
	Total Theory					**14**	**12**
SESSIONAL							
1	PW-ME 781	Project – II	0	0	6	6	3
2	PW-ME 782	Project -III (on Summer Internship/Vocational Training)	0	0	4	4	2
3	PW-ME 783	Seminar	0	0	3	3	2
	Total Practical					**13**	**7**
	Total of Semester					27	**19**

Professional Elective-I:
PE-ME 701A –Automobile Engineering
PE-ME 701B – Computational Fluid Dynamics
PE-ME 701C – Alternative Fuels & Renewable Energy

Professional Elective-II:
PE-ME 702A– Industrial Engineering
PE-ME 702B– Operations Research
PE-ME 702C– Principles and Practices of Management

Open Elective-II:
OE-ME 701A – Enterprise Resource Planning (ERP)
OE-ME 701B – Marketing Management
OE-ME 701C – Internet of Things

Subject Code: PC-ME 701	**Category:** Professional Core courses
Subject Name: Power Plant Engineering	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:3**
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Applied Thermodynamics (PC-ME 402)	

Course Objective:

1. To understand the functions of various components and economics of power plant.
2. To understand the functions of various boilers, performance of boilers, mountings and accessories.
3. To understand the fuel properties and combustion mechanism.
4. To understand the working principle of combustion equipment and different firing methods.
5. To understand the details of steam turbine components and performance of nozzle.
6. To understand the details of staging and governing of turbine.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Power plant economics: load curve and various factors, cost of power generation. Introduction to hydel, nuclear and renewable power plants.	4
2	Steam generators: definition, classification. Performance of boiler: boilers efficiency, equivalent evaporation, losses in boilers. Mountings and accessories: super heater, economizer, air-pre heater, handling of coal and ash, electrostatic precipitator, deaeration. Power station boilers: Benson, Lamont. Supercritical boiler.	6
3	Fuels and combustion: types of fuel, properties of coal, coal analysis, combustion reactions, heat of combustion, heating values, draught system, fans.	5
4	Combustion equipment and firing methods: combustion equipment for burning coal, fuel bed combustion, pulverized coal firing system, fluidized bed combustion. Introduction to boiling and circulation in boilers.	4
5	Steam turbine: parts and classification, nozzles types, flow through nozzles and nozzle efficiency. Impulse turbine: velocity diagram, work done and blade efficiency.	6
6	Pressure compounding and velocity compounding of steam turbine, impulse reaction turbine: velocity diagram, degree of reaction and parson's turbine.	7
7	Governing in steam turbine. Condenser, feed water and circulating water systems: direct contact condenser, surface condensers, effect of various parameters on condenser performance, feed water heaters, circulating water system, cooling towers and cooling ponds.	4
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PC-ME 701.1	Understand the correlation between economic factors, load curves, and power generation costs.
PC-ME 701.2	Apply the principles of steam generator classification to enhance boiler efficiency.
PC-ME 701.3	Analyze fuel properties and combustion reactions to optimize power plant operation.
PC-ME 701.4	Evaluate the efficiency and effectiveness of combustion equipment and firing methods.
PC-ME 701.5	Understand steam turbine parts, classifications, and operational principles.
PC-ME 701.6	Apply knowledge of steam turbine governing mechanisms and condenser systems to improve overall power plant performance.

Learning Resources:

1. Power plant Engineering, P.K. Nag (Author), Publisher: Tata McGraw- Hill.
2. A course in Power Plant Engineering, Arora and Domkundwar (Author), Publisher: Dhanpat Rai & Sons.
3. Power Plant Technology, M.M.EI- Wakil (Author), Publisher: Tata McGraw - Hill.

Difference with MAKAUT syllabus:

Following topics are included in this syllabus-

1. Study of electrostatic precipitator, deaeration is included.
2. Detail study of fuels is included.
3. Detail study of condenser, feedwater heaters, circulating water system, cooling towers and cooling ponds are included.

Subject Code: PE-ME 701A	**Category**: Professional Elective Courses
Subject Name: Automobile Engineering	**Semester**: Seventh
L-T-P: 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester** =12 minimum
Pre-Requisites: IC Engine (PC-ME 504), Theory of Machines (PC-ME 405)	

Course Objective:

1. Student should able to understand basics of automobile history and it's development.
2. Student should able to understand Role of the automobile industry in national growth.
3. Student should able to understand various Automotive system.
4. Student should able to understand basics of drive train of automobiles

Course Content:

Module No	Description of Topic	Contact Hrs.
1	**Introduction**: History and development of Automobile, various sub system of Automobile.	1
2	**Prime Mover**: Engine for 2-wheeler and 3-wheeler vehicles, Engine for passenger cars, commercial and other vehicles, fuel system for carburetted engine, MPFI engine and Diesel engine, Lubrication and cooling system.	5
3	**Auto Electrical**: Electric Motor as prime mover, Battery, Generator, ignition system, Starting system, lightning and signalling	6
4	**Steering system**: Davis steering and Ackerman steering system, Rack and Pinion, cam and Lever, worm and sector system.	3
5	**Transmission system**: Flywheel and clutch, Gearbox, sliding and constant mesh type, Automatic Transmission, Universal joint, propeller shaft. **Differential and Axle**: Construction and function of differential, different types of front and rear axles.	9
6	**Suspension system**: Conventional and independent suspension systems, application **Brake System**: Disc and drum brake, Hydraulic brake, parking brake, stopping distance.	6
7	**Power requirement**: Various resistances such as air resistance, gradient resistance, rolling resistance, Tractive effort, Torque-Speed curve, Horse power calculation.	4
8	Maintenance of Vehicles.	2
	Total	**36**

Course Outcomes:

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

PE-ME 701A.1	Identify and recall fundamental concepts of automobile engineering. Define key terminologies related to automotive engineering.
PE-ME 701A.2	Understand the function of different automotive systems. Explain the working principle of the various automotive system.
PE-ME 701A.3	Apply mathematical and scientific principles to solve problems related to automotive engineering, such as calculating engine performance parameters, vehicle dynamics, and fuel efficiency.
PE-ME 701A.4	Analyse the performance characteristics of different types of engines (e.g., petrol, diesel, electric) and compare their advantages and limitations.
PE-ME 701A.5	Evaluate the design and performance of existing automotive technologies and design various improvements of the components.
PE-ME 701A.6	Create innovative solutions to complex automotive engineering challenges, such as enhancing fuel efficiency, reducing emissions, or improving vehicle safety.

Learning Resources:

1. Motor Vehicle by Newton, Steed and Garrette, 2nd ed., Butterworth.
2. Automobile Engineering Vols - I & II by Kirpal Singh, Standard Publishers Distributers.
3. Automotive Mechanics by Heitner Joseph, East west Press.
4. Automotive Mechanics by Crouse, McGrawhill.
5. Automobile Mechanics by N.K.Giri, 7th ed., Khanna Publishers.

Subject Code: PE-ME 701B	**Category:** Professional Elective Courses
Subject Name: Computational Fluid Dynamics	**Semester**: Seventh
L-T-P: 3-0-0	**Credit: 3**
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Fluid Mechanics (PC-ME 302), Mathematics –III (BS-M 301)	

Course Objectives:
The objective of the course is to impart knowledge on numerical modeling and its role for the solution of complex engineering problems in the field of heat transfer and fluid dynamics.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods	2
2	**Governing equations of fluid dynamics:** Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.	4
3	**Mathematical behavior of partial differential equations:** Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.	2
4	**Basic aspects of discretization:** Introduction to finite differences, Finite difference equations usingTaylorseriesexpansionandpolynomials,Explicitandimplicitapproaches,- Discretization of First and Second Derivatives by Forward, Backward and Central Differencing. Truncation and Order of Error Uniform and unequally spaced grid points. **Grids with appropriate transformation:** General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fittedcoordinatesystems,Algebraicandellipticgridgenerationtechniques,Adaptivegrids, staggered grid and collocated grid	7
5	**Parabolic partial differential equations:** Finite difference formulations, Explicit methods - FTCS, Richardson and Du Fort-Frankel methods, Implicit methods-Lasonen, Crank-Nicolson	7

	and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis ,Linearization. **Stability analysis:** Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion, Courant–Friedrichs–Lewy or CFL condition is a condition for the stability.	
6	**Scalar representation of Navier-Stokes equations:** Equations of fluid motion, numerical algorithms: FTCS explicit, FTBCS explicit, Dufort-Frankel explicit, McCormack explicit and implicit, BTCS and BTBC Simplicit algorithms, applications.	4
7	**Grid generation:** Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation **Finite volume method for unstructured grids:** Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetrahedral Elements,2-D Heat conduction with Triangular Elements.	6
8	**CFD Solution Procedure:** Problem setup–creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization. **Case Studies:** Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem.	4
Total		**36**

Course Outcomes:

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

PE-ME 701B.1	Understand the differential equations for flow phenomena and numerical methods for their solution.
PE-ME 701B.2	Analyse different mathematical models and computational methods for fluid flow and heat transfer simulations.
PE-ME 701B.3	Formulate computational problems related to fluid flows and heat transfer.
PE-ME 701B.4	Estimate the accuracy of a numerical solution by comparison to known solutions of simple test problems and by mesh refinement studies.
PE-ME 701B.5	Evaluate forces in both internal and external flows.
PE-ME 701B.6	Explain different CFD Solution Procedures using softwares.

Learning Resources:

1. P.S.Ghosdastidar, Computer Simulation of Flow and Heat Transfer, McGraw-Hill,1998.
2. K. Muralidhar and T.Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House,1995.
3. J.D. Anderson Jr., Computational Fluid Dynamics, McGraw-Hill Book Company,1995.
4. P. Niyogi, S.K. Chakrabarty and M.K. Laha, Introduction to Computational Fluid Dynamics, Pearson Education, 2006.
5. V. S. V. Patankar, Numerical heat transfer and fluid flow, McGraw Hill Book Company, New York 1980.

Subject Code: PE-ME 701C	**Category**: Professional Elective Courses
Subject Name: Alternative Fuel and Renewable Energy	**Semester**: Seventh
L-T-P : 3-0-0	**Credit**:3
Contact Per Week- 3L	**Contact Week / Semester** = 12 minimum
Pre-Requisites: IC Engines (PC-ME 504), Fluid Mechanics (PC-ME 302)	

Course Objectives

1. To Create awareness about sources of energy and able to estimate how long the available conventional fuel reserves will last.
2. To Learn the fundamental concepts about solar energy systems and devices.
3. To Design wind turbine blades and know about applications of wind energy for water pumping and electricity generation.
4. To Understand the working of OTEC system and different possible ways of extracting energy from ocean, know about Biomass energy, mini-micro hydro systems and geothermal energy system.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	**INTRODUCTION TO ENERGY STUDIES** Introduction, Energy science and Technology, Forms of Energy, Importance of Energy Consumption as Measure of Prosperity, Per Capita Energy Consumption, Roles and responsibility of Ministry of New and Renewable Energy Sources, Needs of renewable energy, Classification of Energy Resources, Conventional Energy Resources , Non-Conventional Energy Resources, World Energy Scenario, Indian Energy Scenario.	4
2	**SOLAR ENERGY** Introduction, Solar Radiation, Sun path diagram, Basic Sun-Earth Angles, Solar Radiation Geometry and its relation, Measurement of Solar Radiation on horizontal and tilted surfaces, Principle of Conversion of Solar Radiation into Heat, Collectors, Collector efficiency, Selective surfaces, Solar Water Heating system , Solar Cookers , Solar driers, Solar Still, Solar Furnaces, Solar Greenhouse. Solar Photovoltaic, Solar Cell fundamentals, Characteristics, Classification, Construction of module, panel and array. Solar PV Systems (stand-alone and grid connected), Solar PV Applications. Government schemes and policies. Relevance of solar thermal power generation; Components of solar thermal power plant, Design and performance, characteristics of different solar concentrator types suitable for thermal power generation.	6
3	**WIND ENERGY** Introduction, History of Wind Energy, Wind Energy Scenario of World and India. Basic principles of Wind Energy Conversion Systems (WECS), Types and Classification of WECS, Parts of WECS, Power, torque and speed characteristics, Electrical Power Output and Capacity Factor of WECS, Stand alone, grid connected and hybrid applications of WECS, Economics of wind energy utilization, Site selection criteria, Wind farm, Wind rose diagram.	4
4	**BIOMASS ENERGY** Introduction, Biomass energy, Photosynthesis process, Biomass fuels, Biomass energy conversion technologies and applications, Urban waste to Energy Conversion, Biomass Gasification, Types and application of gasifier, Biomass to Ethanol Production, Biogas production from waste biomass, Types of biogas plants, Factors affecting biogas generation, Energy plantation, Environmental impacts and benefits, Future role of biomass , Biomass programs in India.	6

5	**HYDRO POWER AND OTHER RENEWABLE ENERGY SOURCES** Hydropower: Introduction, Capacity and Potential, Small hydro, Environmental and social impacts. Tidal Energy: Introduction, Capacity and Potential, Principle of Tidal Power, Components of Tidal Power Plant, Classification of Tidal Power Plants. Ocean Thermal Energy: Introduction, Ocean Thermal Energy Conversion (OTEC), Principle of OTEC system, Methods of OTEC power generation. Geothermal Energy: Introduction, Capacity and Potential, Resources of geothermal energy.	4
6	**FUEL CELL TECHNOLOGY** Different fuel energy resources, it's Indian and global perspective, Classification of Solid, liquid and gaseous fuels, Combustion appliances for solid, liquid and gaseous fuels. Different theories on coal formation, Coal as a source of energy and chemicals in India, Coal preparation, Carbonization, Gasification and liquefaction of coal and lignite, Fundamentals of coal combustion, combustion stoichiometry, Flue gas composition, Fundamentals of coal gasification, producer gas, water gas. Petroleum and its derived products, Petroleum refining processes, Inter conversion of fuels, Liquid fuel resources, world and Indian statistics, methods for characterization of crude oil and its products, refinery operations, testing of liquid fuels Natural gases and its derivatives, sources, potential, Gas hydrates Different types of gaseous fuels and its resources and their characteristics, principles of manufacturing of gaseous fuels from coal and oil, kinetics and mechanism of gasification, production of industrial fuel gases, rich gases such as SNG, purification, storage and transportation of gaseous fuels. Nuclear fuels: Oxide fuel, Metal fuel, Ceramic fuel, liquid fuel, Refused-derived fuel, Bio-fuels: Biomass, Algae, biodiesel, Alcohol Fuels: Methanol, Ethanol, Butanol, Propane, etc.	8
7	**ELECTRIC ENERGY CONVERSION SYSTEM** Generation of electricity using different sources, Transmission and distribution losses, AC to DC and DC to AC conversions, Electric motors: Types, losses, efficiency, Lightning systems, Diesel generating systems.	4
Total		**36**

Course Outcomes

After the end of the course, a student should be able to:

PE-ME 701C.1	Understand of renewable and non-renewable sources of energy
PE-ME 701C.2	Gain knowledge about working principle of various solar energy systems
PE-ME 701C.3	Understand the application of wind energy and wind energy conversion system.
PE-ME 701C.4	Develop capability to do basic design of bio gas plant.
PE-ME 701C.5	Understand the applications of different renewable energy sources like ocean thermal, hydro, Geo-thermal energy etc.
PE-ME 701C.6	Explain electric energy conversion system.

Learning Resources:

1. Sukhatme. S.P., Solar Energy, Tata McGraw Hill Publishing Company Ltd., New Delhi,1997.
2. B. H. Khan, Non-Conventional Energy Resources, , The McGrawHill
3. Twidell, J.W. & Weir, A. Renewable Energy Sources, EFN Spon Ltd., UK,2006.
4. S. P. Sukhatme and J.K. Nayak, Solar Energy – Principles of Thermal Collection and Storage,
5. Tata McGraw-Hill, NewDelhi.
6. Garg, Prakash, Solar Energy, Fundamentals and Applications, Tata McGrawHill.
7. G.D. Rai, Non-Conventional Energy Sources, Khanna Publications, New Delhi,2011.
8. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press,

U.K.,1996.

9. Khandelwal, K.C., Mahdi, S.S., Biogas Technology – A Practical Handbook, Tata McGraw-Hill,1986.
10. Tiwari. G.N., Solar Energy – "Fundamentals Design, Modeling & Applications", Narosa Publishing House, New Delhi,2002.
11. Freris. L.L., "Wind Energy Conversion Systems", Prentice Hall, UK,1990.
12. Frank Krieth& John F Kreider ,Principles of Solar Energy, John Wiley, NewYork
13. Ke Liu, C. Song and V. Subramani, Hydrogen and Syngas Production and Purification Technologies, John Wiley & Sons,2010

Subject Code: PE-ME 702A	**Category:** Professional Elective Courses
Subject Name: Industrial Engineering	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Production and Operations Management (PC-ME 604)	

Course Objectives:

1. To provide introductory knowledge on Industrial Engineering, concept of productivity.
2. To make familiar about facility location, facility layout and planning, material handling, systems of production planning and control, forecasting techniques
3. To understand the technics of inventory management, organizational structure, break even analysis and various wage incentive plans.

Module No.	Description of Topic	Lectures Hours
1	**Introduction to Industrial Engineering and Productivity:** Definition and Functions of Industrial Engineering, Origin and development of factory system, Contribution of Taylor and Gilbreth Productivity: Definition of productivity, Factors Influencing Productivity, Causes of Low Productivity, Productivity Measurement Models, Productivity Improvement Techniques.	4
2	**Plant/Facility Location:** Factors affecting Plant Location, Subjective, Quantitative and Semi-Quantitative techniques. **Plant Layout and Planning:** Nature, Significance and Scope of Facility layout and design; Steps in facility layout planning, Assembly Line Balancing. **Material Handling:** Definition, Objective and Principles of Material Handling, Classification of Material Handling Devices.	6
3	**Production Planning and Control:** Introduction to Production Systems, Types of production systems (Job, batch& Mass Production), Need and functions of PPC. **Constituents of PPC:** Production planning, Routing, Scheduling, Dispatching & Follow up **Forecasting:** Definition and Functions of Forecasting, forecasting techniques (linear regression, moving average, exponential smoothing), Analysis of forecast error. Aggregate production planning, Capacity Planning, ERP, Master Production Schedule. Basic sequencing and scheduling techniques.	9
4	**Work Study**: Basic Concept, Steps Involved in Work Study, Techniques of Work Study, Human Factors in the Application of Work Study. **Method Study:** Basic Concept, Steps Involved in Method Study, Recording Techniques, Operation Process Charts, Flow Process Charts, Two-Handed-Process Charts, Multiple Activity Charts, Flow Diagrams. String Diagrams, Principles of Motion Economy, Micro-Motion Study, Therbligs, SIMO Charts. **Work Measurement:** Basic Concept, Techniques of Work Measurement, **Time Study:** Steps Involved in Time Study, Time Study Equipment, Performance Rating, Basic concept and Procedure of Work Sampling Study. **Motion Study:** Meaning, Objectives procedures of motion study	7
5	**Inventory Management**: Importance and areas of materials management, Definition of Inventory, Need for inventory, Types of inventory, Inventory costs; Structure of inventory models, **Deterministic models:** Order Quantity, Reorder Point, Lead time, safety stock, EOQ, inventory control systems; Selective inventory management. MRP and JIT-based production systems, Concept of zero inventory, Fundamental concepts of purchasing, storing, distribution, and value analysis & engineering.	7
6	**Organizational Structure:** Line, Functional, Line & Stuff and Complex (Line, functional and staff) organization. **Break-Even Analysis (BEP):** Introduction, Functions, Algebraic determination of BEP, Break-Even charts, numerical problems. **Wages & Incentives:** Types of Wages, Wage Incentive Plans; Individual & Group Incentive Plans.	3
	Total	**36**

Course Outcomes:

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

PE-ME 702A.1	Understand the concepts of Industrial Engineering.
PE-ME 702A.2	Explain production systems and their characteristics.
PE-ME 702A.3	Describe different aspects of work system design and facilities design pertinent to manufacturing industries.
PE-ME 702A.4	Apply forecasting and scheduling techniques, time study and work measurement techniques and inventory management tools to the various production systems.
PE-ME 702A.5	Analyze and Evaluate complex Industrial problems.
PE-ME 702A.6	Create a new facility layout and material handling technique in order to increase productivity.

Learning Resources:

1. S. C. Sharma, Industrial Engineering and Management, Khanna Book Publication, 2016.
2. O. P. Khanna, Industrial Engineering and Management, Dhanpat Rai Publication, 1980.
3. M. T. Telsang, Industrial Engineering and Production Management, S. Chan d Publishing, 2018.
4. K. B. Zandin and H. B. Maynard, Maynard's Industrial Engineering Hand Book, McGraw Hill Education, 2001.
5. ILO, Introduction to Work Study, Oxford and IBH Publishing, 1992.
6. B. Mahadevan, Operations Management: Theory and Practice, Pearson, 2010.
7. S. N. Chary, Production and Operations Management, McGraw-Hill Education, 2019.
8. K. Bedi, Production and Operations Management, Oxford University Press, 2004.
9. A.Tompkins, J. A.White, Y. A. Bozer, and J.M. A.Tanchoco, Facilities Planning,Wiley, 2005.

Subject Code: PE-ME 702B	**Category:** Professional Elective Courses
Subject Name: Operations Research	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Production and Operations Management (PC-ME 604)	

Course Objectives:

1. To study the various Operations Research tools,
2. To study the application of an appropriate model in the given situation.
3. To formulate the Industrial problems.
4. To solve and analyse the Industrial problems on using Operations Research tools.

Module No.	Description of Topic	Lectures Hours
1	**Introduction:** Brief history of development of OR; Introduction to different OR problems/ techniques: Decision theory, Linear programming, Transportation and Assignment problems, Network analysis, Sequencing, Project scheduling, Integer programming, Non-linear programming, Inventory control, Queuing or Waiting line problems, Metaheuristics.	2
2	**Decision Theory:** Structure of the problem (decision table); Decision making under uncertainty with optimistic, pessimistic and average outcome criteria; Decision under uncertainty: Laplace criterion, Maxi Min criterion, Mini Maxcriterion, savage Mini Max regret criterion, Hurwitz criterion, Decision tree **Replacement Models:** Introduction, Replacements of Items that Deteriorate with time, Optimal Replacement Policy, Replacements of Equipment that Fails suddenly.	5
3	**Linear Programming (LP):** Nature of LP problems through examples; Formulation of LP Problems; Graphical solutions of two decision variable problems; Properties of a solution to LP problems: convex solution space and extreme point solution; General form of LP model; Simplex method and its meaning; Steps of simplex method in tabular form; Solving LP problems by Simplex Method; Sensitivity analysis.	7
4	**Transportation Problem:** Introduction, Formulation of Transportation Problem (TP), Transportation Algorithm (MODI Method), the Initial Basic Feasible Solution, Moving Towards Optimality. **Assignment Problem:** Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Travelling Salesman Problem **Job Sequencing:** Introduction to sequencing and scheduling models: n job two machinesproblem, n job 3 machines problem	8
5	**Project Management Using CPM-PERT:** Project Scheduling and PERT-CPM: Introduction, Basic Difference between PERT and CPM, PERT/CPM Network Components and precedence Relationship, Project Management – PERT, Float calculation and its importance. Cost reduction by Crashing of activity	4
6	**Inventory Management**: Importance and areas of materials management, Definition of Inventory, Need for inventory, Types of inventory, Inventory costs; Structure of inventory models, **Deterministic models:** Order Quantity, Reorder Point, Lead time, safety stock, EOQ, inventory control systems; Selective inventory management. MRP and JIT-based production systems, Concept of zero inventory, Fundamental concepts of purchasing, storing, distribution, and value analysis & engineering.	4
7	**Queuing Theory:** Structure of a waiting line System: Single-channel waiting line, process of arrivals, distribution of service times, queue discipline, steady stage operation; Single	3

	channel model with Poisson arrivals and exponential service time; Multiple channel model with Poisson arrival and exponential service times; Single channel model with Poisson arrivals and arbitrary service time (M/G/1); Economic analysis of waiting lines.	
8	**Non-Linear Programming:** Graphical illustration of a non-linear programming problem; Unconstrained optimization by (i) direct search method, (ii) steepest decent method; Constrained optimization by Lagrange multipliers; Integer linear programming by branch & bound technique; Dynamic programming problems and their characteristics; Bellman's principle of optimality; solving (i) Stagecoach problem, (ii) Knapsack problem.	3
	Total	**36**

Course Outcomes:

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

PE-ME 702B.1	Understand the concepts of Operation Research.
PE-ME 702B.2	Explain objectives of various operations research tools.
PE-ME 702B.3	Formulate different industrial problems with respect to the different Operations Research tools.
PE-ME 702B.4	Apply different operations research tools to solve those industrial problems.
PE-ME 702B.5	Analyse and evaluate after solution of those Industrial problems.
PE-ME 702B.6	Create new decision-making tools, optimization tool, scheduling techniques etc. for solving industrial problems.

Learning Resources:

1. Kanti Swarup, P.K. Gupta and Man Mohan, Operations Research, Sultan Chand & Sons, New Delhi.
2. H.A. Taha, Operations Research: An Introduction, Pearson Publication
3. C.K. Musatfi, Operations Research, New Age International Publishers
4. R. Panneerselvam, Operations Research, Prentice Hall of India
5. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, The McGraw Hill Companies.
6. Operations Research - An Introduction by H. A. Taha, Prentice Hall of India.
7. Operations Research by J. K. Sharma, Macmillan.
8. A Textbook of Operations Research: By Jana & Roy, Chhaya Prakashani.
9. J.K. Sharma, Operation Research: Theory and Applications, 5th Edition, Macmillan Pub.,2013.
10. K.V. Mittal and C. Mohan, Optimization Methods in Operations Research and Systems Analysis, New Age, 2003.

Subject Code: PE-ME 702C	**Category:** Professional Elective Courses
Subject Name: Principles and Practices of Management	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Production and Operations Management (PC-ME 604)	

Course Objectives:

1. To provide an understanding of basic concepts, principles and practices of management.
2. To emphasize on the conceptual development in the area of planning, organizing, leading and controlling managerial functions.
3. To emphasis on conceptual and technical frameworks of leadership and the role of managers and change agent.

Module No.	Description of Topic	Lectures Hours
1	**Management:** Definition, nature, importance, evolution of management thoughts– pre & post scientific era, contributions made by Taylor, Fayol, Gilbreth, Elton Mayo, McGregor, Maslow– Covering Time & Motion Study, Hawthorne Experiments; Is management a science or art? Functions of manager, ethics in managing and social responsibility of managers.	5
2	**Planning & Control:** Why Management process starts with planning, steps in planning, planning premises, types of planning, barriers to effective planning, operational plan, strategic planning, McKinney's 7's Approach, SWOT analysis, Controlling- concept, Planning- control relationship, process of control, human response to control, dimensions of control, MBO.	5
3	**Decision Making & Organizing:** Nature, process of decision making, decision making under Certainty and Uncertainty, decision-tree, group-aided decision, brain-storming; Organizing – concept, nature and process of organizing, authority and responsibility, delegation and empowerment, centralization and decentralization, concept of departmentation.	6
4	**Organizational Change:** Introduction, Resistance to Change, Behavioral Reactions to Change, Approaches Or Models to Managing Organizational Change	4
5	**Staffing & Motivation:** Concept, Manpower planning, Job design, recruitment & selection, training and development, performance appraisal, motivation, motivators and satisfaction, motivating towards organizing objectives, morale building.	4
6	**Leadership & Communication:** Defining leadership and its role, should managers lead, leadership style, leadership development, Leadership behavior. Communication-Process, Bridging gap-using tools of communication, electronic media in Communication.	4
7	**Financial Management:** Financial functions of management, Financial Planning, Management of Working Capital, Sources of Finance.	4
8	**Marketing Management:** Functions of Marketing, Product Planning & Development, Marketing Organization, Sales Organization, Sales Promotion, Consumer Behavior, Marketing Research and Information.	4
	Total	**36**

Course Outcomes:

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

PE-ME 702C.1	Understand the role and importance of management, Various managerial functions and skills, ethics to be followed in an organization, and analyze and compare the significant contributions made by various management and quality Gurus.
PE-ME 702C.2	Identify different aspects of Planning and decision-making and control and apply varieties of techniques in decision making and compare the results.
PE-ME 702C.3	Develop the Organization structure, assign the responsibilities to the various positions, and suggests the ways for coordination.
PE-ME 702C.4	Learn and imbibe leadership qualities, acquire and follow different motivational techniques and adapt effective means of communications.
PE-ME 702C.5	Learn and understand the role and importance of different aspects of Financial management and determine/analyze/compare various attributes of the same in their work.
PE-ME 702C.6	Develop a clear concept of Sales and marketing and distinguish between them and explore different approaches for the growth of the organizations.

Learning Resources:

1. S. Robbins and M. Culter, Management, Pearson, 2016.
2. J.R. Schermerhorn, Introduction to Management, Wiley India Edition, 2011.
3. C.J. O'Donnel and H. Koontz, Principles of Management, McGrew Hill, 1995.
4. R.L. Daft, New Era of Management, Cengage Learning, 2008.
5. J.A.F. Stoner, R. Freeman and D.R. Gilbert. Jr., Management, Prentice Hall of India, 1985.
6. H. Koontz and H. Weihrich, Essentials of Management, McGrew Hill, 2007.
7. D.C. Bose, Principles of Management and Administration, Prentice Hall of India, 2012.
8. K. Nerkar, V. Chopde and Kogent Learning Solutions Inc, Principles and Practices of Management, Dreamtech Press, 2011.
9. P. Diwan, Management Principles and Practices, Excel Books, New Delhi, 2002.
10. R.L. Daft, Principles of Management, Cengage Learning, 2012.
11. Premvir Kapoor, Principles of Management, Khanna Publishing House, 2019.

Subject Code: OE-ME 701A	**Category:** Open Elective Courses
Subject Name: Enterprise Resource Planning	**Semester:** Seventh
L-T-P: 3-0-0	**Credit**: 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Production and Operations Management (PC-ME 604)	

Course Objectives:

1. To provide a contemporary and forward-looking on the theory and practice of Enterprise Resource Planning Technology.
2. To focus on a strong emphasis upon practice of theory in Applications and Practical oriented approach.
3. To train the students to develop the basic understanding of how ERP enriches the business organizations in achieving a multidimensional growth.
4. To aim at preparing the students technological competitive and make them ready to self-upgrade with the higher technical skills.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	ERP Introduction, Benefits, Origin, Evolution and Structure: Conceptual Model of ERP, the Evolution of ERP, the Structure of ERP.	6
2	Business Process Reengineering, Data ware Housing, Data Mining, Online Analytic Processing (OLAP), Product Life Cycle Management (PLM), LAP, Supply chain Management.	6
3	ERP Marketplace and Marketplace Dynamics: Market Overview, Marketplace Dynamics, the Changing ERP Market. ERP- Functional Modules: Introduction, Functional Modules of ERP Software, Integration of ERP, Supply chain and Customer Relationship Applications.	6
4	ERP Implementation Basics, ERP Implementation Life Cycle, Role of SDLC/SSAD, Object Oriented Architecture, Consultants, Vendors and Employees.	6
5	ERP & E-Commerce, Future Directives- in ERP, ERP and Internet, Critical success and failure factors, Integrating ERP into organizational culture.	6
6	Using ERP tool: either SAP or ORACLE format to case study.	6
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

OE-ME 701A.1	Develop model for ERP for large projects
OE-ME 701A.2	Develop model for E-commerce architecture for any application
OE-ME 701A.3	Describe the advantages, strategic value, and organizational impact of utilizing an ERP system for the management of information across the functional areas of a business: sales and marketing, accounting and finance, human resource management, and supply chain.
OE-ME 701A.4	Demonstrate a working knowledge of how data and transactions are integrated in an ERP system to manage the sales order process, production process, and procurement process.
OE-ME 701A.5	Evaluate organizational opportunities and challenges in the design system within a business scenario.
OE-ME 701A.6	Develop model for ERP for large projects

Learning Resources:

1. Vinod Kumar Garg and Venkitakrishnan N K, "Enterprise Resource Planning Concepts and Practice", PHI.
2. Joseph A Brady, Ellen F Monk, Bret Wagner, "Concepts in Enterprise Resource Planning", Thompson Course Technology.
3. Alexis Leon, "ERP Demystified", Tata McGraw Hill
4. Rahul V. Altekar "Enterprise Resource Planning", Tata McGraw Hill,
5. Vinod Kumar Garg and Venkitakrishnan N K, "Enterprise Resource Planning – A Concepts and Practice", PHI
6. Mary Summer, "Enterprise Resource Planning"- Pearson Education

Subject Code: OE-ME 701B	**Category:** Open Elective Courses
Subject Name: Marketing Management	**Semester:** Seventh
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Production and Operations Management (PC-ME 604)	

Course Objectives:

1. To provide the students exposure to modern marketing concepts, tools, and techniques,
2. To help them develop abilities and skills required for the performance of marketing functions.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Marketing Concepts: Customer Value and Satisfaction, Customers Delight, Conceptualizing Tasks and Philosophies of Marketing Management, Value chain, scanning the Marketing Environment.	5
2	Market Segmentation, Targeting, Positioning: Market segmentations, levels of market segmentations, patterns, procedures, requirement for effective segmentation, evaluating the market segments, selecting the market segments, tool for competitive differentiation, developing a positioning strategy.	6
3	Product Decision: Objectives, Product classification, Product-Mix, Product life cycle strategies, equity, challenges, repositioning branding, introduction and factors contributing the growth of packaging, introduction of labelling.	5
4	Pricing Decision: Factors affecting price, pricing methods and strategies.	5
5	Distribution Decisions: Importance and Functions of Distribution Channel, Considerations in Distribution Channel Decisions, Distribution Channel Members	5
6	Promotion Decisions: A view of Communication Process, developing effective communication, Promotion-Mix elements.	5
7	Emerging Trends in Marketing: An introduction to Internet Marketing, Multi-level Marketing, and Introduction of CRM & EVENT marketing.	5
Total		**36**

Course Outcomes

Upon successful completion of the course, student will be able to

OE-ME 701B.1	Identify the scope and significance of Marketing in Domain Industry.
OE-ME 701B.2	Examine marketing concepts and phenomenon to current business events In the Industry.
OE-ME 701B.3	Coordinate the various marketing environment variables and interpret them for designing marketing strategy for business firms
OE-ME 701B.4	Relate Marketing Mix as a framework for Marketing Decision making.
OE-ME 701B.5	Illustrate market research skills for designing innovative marketing strategies for business firms
OE-ME 701B.6	Practice marketing communication skills relevant to the corporate world.

Learning Resources:

1. Marketing Management - A South Asian Perspective, New Delhi Philip Kotler, Kevin Lane Keller, Abraham Koshy, Mithileshwar Jha (2009: Pearson Education India, Thirteenth Edition.
2. Fundamentals of Marketing Management, Willam J. Stanton, Michael J. Etzel and Bruce J. Welker (1995). New York: Mc Graw Hill, 10th Edition.
3. Marketing Management, Planning Analysis and Control Philip Kotler (1998). New Delhi, Prentice Hall of India, 9th Edition.
4. Marketing Concepts and Strategies, William L. Pride and O.C. Ferrell (1993). Boston: Houghton Mifflin Co., 8th Edition.

Subject Code: OE-ME 701C	**Category**: Open Elective Courses
Subject Name: Internet of Things	**Semester**: Seventh
L-T-P: 3-0-0	**Credit**: 3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: No prerequisite	

Course Objective:

The overall goal of this course is to enable you to build an IoT system from the ground up. Note, this is an IoT system; as you'll learn, there's extensive variety insofar as what an IoT system can be. That said, during this course, you'll learn the various kinds of IoT systems that you'll encounter and build one using representative technologies.

Course Content:

Module No	Description of Topic	Contact Hrs.
1	**Unit 1**: Environmental Parameters Measurement and Monitoring: Why measurement and monitoring are important, effects of adverse parameters for the living being for IOT.	6
2	**Unit 2:** Sensors: Working Principles: Different types; Selection of Sensors for Practical Applications. Introduction of Different Types of Sensors such as Capacitive, Resistive, Surface Acoustic Wave for Temperature, Pressure, Humidity, Toxic Gas etc.	8
3	**Unit 3:** Important Characteristics of Sensors: Determination of the Characteristics. Fractional order element: Constant Phase Impedance for sensing applications such as humidity, water quality, milk quality Impedance Spectroscopy: Equivalent circuit of Sensors and Modelling of Sensors. Importance and Adoption of Smart Sensors.	10
4	**Unit 4:** Architecture of Smart Sensors: Important components, their features Fabrication of Sensor and Smart Sensor: Electrode fabrication: Screen printing, Photolithography, Electroplating Sensing film deposition: Physical and chemical Vapor, Anodization, Sol-gel	9
5	**Unit 5:** Interface Electronic Circuit for Smart Sensors and Challenges for Interfacing the Smart Sensor.	3
Total		**36**

Course Outcomes:

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

OE-ME 701C.1	Describe what IoT is and how it works today
OE-ME 701C.2	Recognise the factors that contributed to the emergence of IoT
OE-ME 701C.3	Design and program IoT devices
OE-ME 701C.4	Use real IoT protocols for communication
OE-ME 701C.5	Secure the elements of an IoT device
OE-ME 701C.6	Design an IoT device to work with a Cloud Computing infrastructure

Learning Resources:

1. Adrian McEwen, "Designing the Internet of Things", Wiley Publishers, 2013, ISBN: 978-1-118-43062-0
2. Daniel Kellmereit, "The Silent Intelligence: The Internet of Things". 2013, ISBN 0989973700

Subject Code: MC 701	**Category**: Mandatory courses
Subject Name: Environmental Science	**Semester**: Seventh
L-T-P: 0-2-0	**Credit**: 0
Contact Per Week- 2	**Contact Week / Semester** = 12 minimum
Pre-Requisites: No prerequisite	

Course Objectives:

1. To provide students with a broad interdisciplinary liberal arts framework for understanding the relationship between humans and their environment.
2. To provide students with informed perspectives on biological and physical processes relevant to environmental problems, to help students understand responsible environmental policy and practice, and to engage students in ethical reflection regarding environmental problems in local, regional, national, and global communities.
3. To prepare students for careers, citizenship and environmental stewardship through experiential curricular and co-curricular opportunities.
4. To equip students with the knowledge and skills necessary to pursue professional careers and advanced study related to the multi-faceted nature of environmental studies.
5. To serve as an environmental resource, through service, outreach and engagement, to the Chicago metropolitan region.

Course Content

Module No.	Description of Topic	Contact Hrs.
1	Basic ideas of environment, basic concepts, man, society & environment, their interrelationship. Mathematics of population growth and associated problems, Importance of population study in environmental engineering, definition of resource, types of resource, renewable, non-renewable, potentially renewable, effect of excessive use vis-à-vis population growth, Sustainable Development. Materials balance: Steady state conservation system, steady state system with non-conservative pollutants, step function. Environmental degradation: Natural environmental Hazards like Flood, earthquake, Landslide-causes, effects and control/management. Anthropogenic degradation like Acid rain-cause, effects and control. Nature and scope of Environmental Science and Engineering.	3
2	**Ecology** Elements of ecology: System, open system, closed system, definition of ecology, species, population, community, definition of eco system components types and function. Structure and function of the following ecosystem: Forest ecosystem, Grassland ecosystem, Desert ecosystem, Aquatic ecosystems, Mangrove ecosystem (special reference to Sundar ban); Food chain [definition and one example of each food chain], Food web. Biogeochemical Cycle- definition, significance, flow chart of different cycles with only elementary reaction [Oxygen, carbon, Nitrogen, Phosphate, Sulphur]. Bio-diversity- types, importance, Endemic species, Biodiversity Hot-spot, Threats to biodiversity, Conservation of biodiversity.	4
3	**Air pollution and control** Atmospheric Composition: Troposphere, Stratosphere, Mesosphere, Thermosphere, Tropopause and Mesopause. Energy balance: Conductive and Convective heat transfer, radiation heat transfer, simple global temperature model [Earth as a black body, earth as albedo], Problems.	6

	Green house effects: Definition, impact of greenhouse gases on the global climate and consequently on sea water level, agriculture and marine food. Global warming and its consequence, Control of Global warming. Earth's heat budget. Lapse rate: Ambient lapse rate Adiabatic lapse rate, atmospheric stability, temperature inversion (radiation inversion). Atmospheric dispersion: Maximum mixing depth, ventilation coefficient, effective stack height, smokestack plumes and Gaussian plume model. Definition of pollutants and contaminants, Primary and secondary pollutants: emission standard, criteria pollutant. Sources and effect of different air pollutants- Suspended particulate matter, oxides of carbon, oxides of nitrogen, oxides of sulphur, particulate, PAN. Smog, Photochemical smog and London smog. Depletion Ozone layer: CFC, destruction of ozone layer by CFC, impact of other greenhouse gases, effect of ozone modification. Standards and control measures: Industrial, commercial and residential air quality standard, control measure (ESP. cyclone separator, bag house, catalytic converter, scrubber (ventury), Statement with brief reference).	
4	**Water Pollution and Control** Hydrosphere, Hydrological cycle and Natural water. Pollutants of water, their origin and effects: Oxygen demanding wastes, pathogens, nutrients, Salts, thermal application, heavy metals, pesticides, volatile organic compounds. River/Lake/ground water pollution: River: DO, 5 day BOD test, Seeded BOD test, BOD reaction rate constants, Effect of oxygen demanding wastes on river[deoxygenation, reaeration], COD, Oil, Greases, pH. Lake: Eutrophication [Definition, source and effect]. Ground water: Aquifers, hydraulic gradient, ground water flow (Definition only) Standard and control: Waste water standard [BOD, COD, Oil, Grease], Water Treatment system [coagulation and flocculation, sedimentation and filtration, disinfection, hardness and alkalinity, softening] Waste water treatment system, primary and secondary treatments [Trickling filters, rotating biological contractor, Activated sludge, sludge treatment, oxidation ponds] tertiary treatment definition. Water pollution due to the toxic elements and their biochemical effects: Lead, Mercury, Cadmium, and Arsenic.	5
5	**Land Pollution** Lithosphere; Internal structure of earth, rock and soil. Solid Waste: Municipal, industrial, commercial, agricultural, domestic, pathological and hazardous solid wastes; Recovery and disposal method- Open dumping, Land filling, incineration, composting, recycling. Solid waste management and control (hazardous and biomedical waste). **Noise Pollution** Definition of noise, effect of noise pollution, noise classification [Transport noise, occupational noise, neighbourhood noise] Definition of noise frequency, noise pressure, noise intensity, noise threshold limit value, equivalent noise level, $L10$ (18hr Index) , $n\ Ld$. Noise pollution control.	4
6	**Environmental Management:** Environmental impact assessment, Environmental Audit, Environmental laws and protection act of India, Different international environmental treaty/ agreement/ protocol.	2
Total		**24**

Course Outcomes:
Upon successful completion of the course, students will be able to

MC 701.1	Articulate the interconnected and interdisciplinary nature of environmental studies.
MC 701.2	Demonstrate an integrative approach to environmental issues with a focus on sustainability.
MC 701.3	Use critical thinking, problem-solving, and the methodological approaches of the social sciences, natural sciences, and humanities in environmental problem solving.
MC 701.4	Communicate complex environmental information to both technical and non-technical audiences;
MC 701.5	Understand and evaluate the global scale of environmental problems.
MC 701.6	Reflect critically on their roles, responsibilities, and identities as citizens, consumers and environmental actors in a complex, interconnected world.

Learning Resources:

1. Masters, G. M., "Introduction to Environmental Engineering and Science", Prentice-Hall of India Pvt. Ltd., 1991.
2. De, A. K., "Environmental Chemistry", New Age International.

Subject Code: PW-ME 781	**Category:** Project
Subject Name: Project – II	**Semester:** Seventh
L-T-P: 0-0-6	**Credit:** 3
Contact Per Week-6	**Contact Week / Semester=**12 minimum
Pre-Requisites: All the theory and practical aspects of Engineering	

Course Objectives:
This course aims to cultivate advanced technical and research skills through hands-on project work. Students will engage in the comprehensive design, development, and analysis of mechanical systems, applying theoretical knowledge to real-world problems. This course emphasizes innovation, requiring students to explore emerging technologies and industry trends. Additionally, it aims to develop soft skills such as teamwork, project management, and effective communication, preparing students for successful careers in the mechanical engineering field.

Course Outcomes:

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

PW-ME 781.1	Recall and apply foundational principles of mechanical engineering to identify and describe the key components and requirements of the chosen project.
PW-ME 781.2	Interpret and explain the theoretical frameworks and methodologies relevant to the project's objectives, demonstrating comprehension of various mechanical concepts and their practical applications.
PW-ME 781.3	Utilize acquired knowledge to design and execute innovative solutions within the project, applying mechanical engineering principles to address real-world challenges effectively.
PW-ME 781.4	Break down complex mechanical problems, evaluate different design approaches, and analyze the project's constraints to make informed decisions and optimize the project's design and functionality.
PW-ME 781.5	Critically assess the effectiveness and efficiency of the project's implementation, comparing and contrasting various design choices and justifying the selected methodologies based on performance, feasibility, and impact.
PW-ME 781.6	Develop and construct a prototype or model, demonstrating originality and innovation in integrating various mechanical components, processes, or systems to achieve the project's objectives.

Subject Code : PW-ME 782	**Category**: Project/ Internship
Subject Name : Project -III (on Summer Internship/Vocational Training)	**Semester** : Seventh
L-T-P : 0-0-0	**Credit**: 2
Contact Per Week-	**Contact Week / Semester:** One month or 04 Weeks
Pre-Requisites: Basic knowledge of Mechanical Engineering	

Course Objective:
This course aims to provide real-world, industry-relevant experience, enhancing students' practical skills and theoretical knowledge. Interns will engage in project-based learning, network with professionals, and develop soft skills crucial for career advancement. By its conclusion, interns should have a tangible project or accomplishment, reflecting their learning and contributions.

Course Outcomes:

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

PW-ME 782.1	Recall and list fundamental theories, principles, and methodologies studied in mechanical engineering coursework relevant to the industry or domain of the internship.
PW-ME 782.2	Interpret and explain how theoretical knowledge translates into practical applications within the specific field of the internship, demonstrating comprehension of engineering concepts in real-world contexts.
PW-ME 782.3	Apply acquired knowledge and skills to perform assigned tasks or projects within the internship, demonstrating the ability to use theoretical understanding to solve practical engineering problems.
PW-ME 782.4	Analyze and assess the functioning of mechanical systems, processes, or equipment encountered during the internship, identifying key components, performance factors, and areas for potential improvement.
PW-ME 782.5	Evaluate the effectiveness and efficiency of engineering solutions or methodologies applied during the internship, providing reasoned judgments on their applicability and suggesting enhancements or modifications.
PW-ME 782.6	Develop reports, proposals, or innovative solutions based on the internship experience, synthesizing knowledge, practical insights, and industry best practices to propose novel ideas or improvements in mechanical engineering applications specific to the internship context.

Subject Code : PW-ME 783	**Category**: Project
Subject Name : Seminar	**Semester** : Seventh
L-T-P : 0-0-0	**Credit**: 2
Contact Per Week-	**Contact Week / Semester:**
Pre-Requisites: Basic knowledge of Mechanical Engineering	

Course Objective:

This course is designed to culminate students' learning and technical expertise. Objectives include: developing the ability to effectively research, analyze, and present advanced mechanical engineering topics, demonstrating mastery in integrating theoretical and practical aspects of mechanical engineering. Students will refine their communication skills, both orally and in writing, tailored to technical and non-technical audiences. Additionally, the seminar aims to foster critical thinking and problem-solving skills through in-depth discussions and peer reviews, preparing students for professional engineering roles and further academic pursuits.

Course Outcomes:

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

PW-ME 783.1	Analyze and interpret complex engineering problems, demonstrating a deep understanding of underlying principles and methodologies.
PW-ME 783.2	Apply critical thinking and innovative approaches to design and implement effective engineering solutions.
PW-ME 783.3	Collaborate effectively in multidisciplinary teams, enhancing team dynamics and project outcomes.
PW-ME 783.4	Communicate technical concepts and solutions clearly and persuasively to both technical and non-technical audiences.
PW-ME 783.5	Evaluate the ethical, environmental, and societal implications of engineering decisions, fostering responsible professional practices.
PW-ME 783.6	Continuously acquire and integrate new knowledge, staying abreast of emerging technologies and trends in the engineering field.

Curriculum Structure

SEMESTER-VIII

THEORY							
Sl. No.	**Course Code**	**Subject Name**	**Contact period per week**			**Total**	**Credit**
			L	**T**	**P**		
1	PE-ME 801	Professional Elective-III	3	0	0	3	3
2	PE-ME 802	Professional Elective-IV	3	0	0	3	3
3	PE-ME 803	Professional Elective-V	3	0	0	3	3
4	OE-ME 801	Open Elective-III	3	0	0	3	3
					Total Theory	**12**	**12**
SESSIONAL							
1	PW-ME 881	Project – IV	0	0	10	10	5
2	PW-ME 882	Comprehensive Viva Voce	0	0	0	0	2
					Total Practical	**10**	**7**
					Total of Semester	**22**	**19**
	Total Credit					**160.5**	

Professional Elective-III:
PE-ME 801A – Additive Manufacturing;
PE-ME 801B – Quantity Production Methods
PE-ME 801C – Engineering Tribology

Professional Elective-IV:
PE-ME 802A – Supply Chain Management
PE-ME 802B – Total Quality Management
PE-ME 802C – Management Information System
PE-ME 802D –Finite Element Analysis

Professional Elective-V:
PE-ME 803A – Industrial Automation & Instrumentation
PE-ME 803B – Industry 4.0
PE-ME 803C – Fluid Power Control
PE-ME 803D-Advanced Fluid Mechanics

Open Elective-III:
OE-ME 801A – Human Resource Management
OE-ME 801B – Entrepreneurship
OE-ME 801C – Industrial Safety

Subject Code: PE-ME 801A	**Category:** Professional Elective Courses
Subject Name: Additive Manufacturing	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester**=12 minimum
Pre-Requisites: Manufacturing Processes (PC-ME 404), Modern Manufacturing Processes (PC-ME 602)	

Course Objectives:

1. To introduce students the basics of additive manufacturing/rapid prototyping and its applications in various fields, reverse engineering techniques.
2. To familiarize students with different processes in rapid prototyping systems.
3. To teach students about mechanical properties and geometric issues relating to specific rapid prototyping applications.
4. To develop CAD models for 3D printing, import and export CAD data to generate .stl file.
5. To select a specific material for the given application.
6. To select 3D printing process for an application and produce a product using 3D Printing or Additive Manufacturing.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Rapid Prototyping- Overview of Rapid Prototyping, Product development process, Design for Modularity (Manufacturing), Subtractive versus Rapid Manufacturing. Materials in Rapid Manufacturing, Post-processing concerns, Product costing for Rapid Manufacturing, Rapid Product Development, CAE and CIM	11
2	Reverse Engineering: Use of CMM and 3-D Camera for making virtual model.	2
3	Powder based processes, Extrusion based processes, Sheet Stacking processes, Beam Deposition processes.	4
4	3D printing processes: Basic Process- CAD Model Creation, Conversion to STL format, Slicing the STL File, Layer by layer construction, Clean and finish.	4
5	Stereo lithography (SLG): Principles, systems, relative advantages and applications, Selective laser sintering (SLS): Principles, systems, relative advantages and applications. Fused deposition modelling (FDM): Principles, systems, relative advantages and applications. Laminated objects manufacturing (LOM): Principles, systems, relative advantages and applications.	12
6	3-D Inkjet Printing: Principles, systems, relative advantages and applications,	3
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PE-ME 801A.1	Recall and describe the foundational concepts, principles, and terminology associated with additive manufacturing processes and technologies.
PE-ME 801A.2	Explain the underlying principles and mechanisms behind various additive manufacturing techniques, demonstrating comprehension of their applications and limitations.
PE-ME 801A.3	Apply knowledge of additive manufacturing processes to select appropriate techniques, materials, and parameters for specific engineering applications or designs.
PE-ME 801A.4	Analyze and evaluate the feasibility and efficiency of additive manufacturing methods in comparison to traditional manufacturing processes, identifying advantages and limitations.
PE-ME 801A.5	Assess and critique the quality, accuracy, and reliability of additive manufacturing-produced components or structures, justifying assessments based on industry standards and requirements.
PE-ME 801A.6	Develop and propose innovative design solutions or applications utilizing additive manufacturing, showcasing originality and creativity in integrating this technology into engineering projects or product development.

Learning Resources:

1. Automation, Production Systems and Computer Integrated Manufacturing by Groover, Prentice Hall.
2. CAD/CAM by M. P. Groover and E. W. Zimmers, Prentice Hall of India.

3. Manufacturing Technology, Radhakrishnan, Scitech
4. Ian Gibson, David W. Rosen, Brent Stucker , "Additive Manufacturing Technologies", Springer,2009
5. Chua C. K., Leong K. F., and Lim C. S., "Rapid Prototyping: Principles and Applications", Second Edition, World Scientific Publishers (2003),.
6. Patri K. Venuvinod, Weiyin Ma "Rapid Prototyping: Laser-Based and Other Technologies" Springer , 2004
7. Peter D. Hilton, Hilton/Jacobs, Paul F. Jacobs, "Rapid Tooling: Technologies and Industrial Applications", CRC Press, 2000.
8. Burns. M, "Automated fabrication", Prentice-Hall, 1993.

Subject Code: PE-ME 801B	**Category:** Professional Elective Courses
Subject Name: Quantity Production Method	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester**=12 minimum
Pre-Requisites: Manufacturing Processes (PC-ME 404), Machining Principles & Machine Tools (PC-ME 502)	

Course Objectives:

1. To provide knowledge on different types of quantity production methods practised in industry.
2. To make students familiar with planning and scheduling for having high productivity and quality enhancement in industry

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**INTRODUCTION:** Engineering Production: aim and objectives history of progress, definition and requirements Levels of production: piece, batch, lot, mass and quantity production Mechanization and need, degree and types of automation Role of automation in industrial production, advantages.	4
2	Extending the capabilities of conventional machines through improved devices; Capstan and Turret Lathe, Automatic machines; Hydro copying lathe; copy milling; single spindle Auto screw machine; Swiss type Automats, Transfer line.	6
3	**Quantity production methods – Concept:** Broad classification of engineering production methods Major sequential steps in industrial production, preforming, semi finishing, heat treatment, finishing, assembly and inspection Quantity production (methods) of common items: (i) shafts and spindles (ii) automobile parts: engine block, piston, connecting rods and crank shaft (iii) metallic wires, rods, tubes, bars, plates and sheets (iv) various types of gears and bearings Methods of quantity production of cutting tools, tool inserts and tool holders, Coating of inserts: CVD and PVD Small size products: pins, clips, needles, metallic caps, washers, utensils, chains springs, paste tubes and coins Large scale production of bolts and nuts Quantity production by spinning, bulging, magneto forming, hydro forming and explosive forming Production by powder metallurgical process.	16
4	**Planning and scheduling:** Process planning and scheduling for quantity production using (i) semi-automatic and automatic lathes (ii) transfer machines (iii) CNC machining systems (including machining centers, FMS)	3
5	Design and use of jigs and fixtures for batch production in machine shops	3
6	**Productivity and quality enhancement in Quantity production:** Group technology: concept and application in large scale production	4
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PE-ME 801B.1	**Establish** the need of automation and **justify** the benefits of automation to realize bulk quantity production for reduction of cost.
PE-ME 801B.2	**Apply** the principles of different manufacturing processes for bulk quantity production of industrial items such as bearing components, nuts, bolts, washers, shafts, spindles, gears (forming and generating), rods, tubes, structural shapes, industrial wires etc.
PE-ME 801B.3	**Apply** the powder metallurgy process for manufacturing of cutting tools, inserts, and ceramic products and different coating methods (CVD and PVD) for carbide inserts.
PE-ME 801B.4	**Understand** the sequence of operations required to manufacture different automotive

	components like piston, connecting rod, crank shaft and cylinder and **develop** the process plan (sequence) of these items.
PE-ME 801B.5	**Develop** productivity and quality enhancement aspects in Quantity production along with associated Jigs and Fixture requirements
PE-ME 801B.6	**Establish** the need of non-conventional manufacturing in quantity production and **apply** these for the same

Learning Resources:

1. M. P. Groover, Fundamentals of Modern Manufacturing, Wiley Pub, 2009.
2. S. Kalpakjian, Manufacturing Engineering and Technology, Pearson, 2002.
3. S. D. El Wakil, Processes and Design for Manufacturing, CRC Press, 2019.
4. R. A. Lindberg, Process and Materials of Manufacture, Pearson, 2015.
5. E. P. DeGarmo, J.T. Black and R.A. Kosher, Materials and Processes in Manufacturing, Prentice Hall, 1997.
6. C. Donaldson, Tool Design, 4th Edition, McGraw Hill Publication, 2012.
7. G. C. Sen and A. Bhattacharyya, Principles of Machine Tools, New Central Agency Publication, Kolkata, 2015.

Subject Code: PE-ME 801C	**Category:** Professional Elective Courses
Subject Name: Engineering Tribology	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Fluid Mechanics (PC-ME 302), Machine Design (PC-ME 603)	

Course Objectives

1. To become familiar with adhesion theories and the effect of adhesion on friction and wear.
2. To gain knowledge on the friction/lubrication mechanisms and know how to apply them to the practical engineering problem.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to tribology**: History of tribology; Interdisciplinary Approach; Economic Benefits; Tribology in design	2
2	**Engineering Surfaces**: Properties and Measurement; Typical surface layers, Measurement Methods (Surface Profilometry, Optical Microscopy, Electron Microscopy). **Contact of engineering surfaces**: Hertzian and non-hertzian contact, Contact pressure and deformation in non-conformal contacts.	4
3	**Friction**: Causes of Friction; Measurement Methods; Friction Theories (Adhesion Theory, Abrasive Theory, Junction Growth Theory); Stick-slip; Rolling Friction; Friction of Metals; Friction of Non-Metallic Material **Wear**: Wear Mechanisms; Types of Wear (Adhesive Wear, Abrasive Wear, Erosive Wear, Corrosive/Oxidative Wear, Fatigue Wear); Wear in Metals; Wear in Ceramics; Wear in Polymers; Wear test methods (Tribometer); Wear controlling methods.	12
4	**Lubrication**: Importance of Lubrication; Lubricants and their types; Physical properties of Liquid Lubricants; Types of additives; Testing of Lubricants (Viscometer, Four Ball Tester).	2
5	**Hydrodynamic lubrication**: Theory of hydrodynamic lubrication; pressure development mechanism in oil film; two-dimensional Reynold's equation, infinitely long journal bearing, infinitely short journal bearing, and finite bearing. Hydrodynamic thrust bearing: Introduction; flat plate thrust bearing; pressure equation; load; centre of pressure.	4
6	**Hydrostatic Lubrication**: Basic concept; advantages and limitations; viscous flow through rectangular slot; load carrying capacity and flow requirement of hydrostatic step bearing; energy losses; optimum design of step bearing.	4
7	**Elasto-hydrodynamic Lubrication**: Introduction; Contact stresses (Simplifying assumptions to Hertz's theory); Contact between two elastic spherical or spheroidal bodies; Elasto hydrodynamic lubricating films; Micro-elastohydrodynamic lubrication and mixed or partial EHL.	4
8	**Surface Engineering:** Introduction to surface engineering; concept and scope of surface engineering; **Coating:** Electro and electroless plating; metal spraying; cladded coating; selection of coating for wear and corrosion resistance; potential properties and parameters of coating.	4
	Total	**36**

Course Outcomes:
Upon successful completion of this course, students will be able to

PE-ME 801C.1	Develop knowledge on surface topography
PE-ME 801C.2	Know how to model a rough engineering surface
PE-ME 801C.3	Understand the fundamental principles in the field of tribology.
PE-ME 801C.4	Analyze the mechanisms of friction and wear in mechanical system.
PE-ME 801C.5	Establish the concepts on the design of lubrication system.
PE-ME 801C.6	Apply the concept of surface engineering in industrial applications.

Learning Resources:

1. Gwidon W. Stachowiak. and Andrew W. Batchelor.Engineering tribology. Butterworth-heinemann, 2013.
2. B. Bhushan and B.K. Gupta, Handbook of Tribology: Materials, Coatings and Surface Treatments, McGraw-Hill, 1991
3. J. Halling, Principles of Tribology, McMillan Press Ltd., 1978
4. S. Wen and P. Huang, Principles of Tribology, 2nd Edition, Wiley, 2012

A. Cameron, Basic Lubrication Theory, Wiley Eastern Ltd., 1976

5. D.D. Fuller, Theory and Practice of Lubrication for Engineers, John Wiley and Sons, 1984
6. J. Davis, Surface Engineering for Corrosion and Wear Resistance, Woodhead Publishing, 2001

Subject Code: PE-ME 802A	**Category:** Professional Elective Courses
Subject Name: Supply Chain Management	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Production and Operations Management (PC-ME 604), Operations Research (PE-ME 702B), Principles and Practices of Management (PE-ME 702C)	

Course Objective:

To develop a sound understanding of the important role of supply chain management in today's business environment. Become familiar with current supply chain management trends, understand and apply the current supply chain theories, practices and concepts utilizing case problems and problem-based learning situations.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction, Historical evolution and basic concept of a Supply Chain, Supply chain defined, basic framework of a supply chain:** A typical Supply chain; Objective of a supply chain; Classification of supply chain; Different supply chain decisions and their importance; process views of a supply chain. Examples of real life industrial supply chains.	5
2	**Supply chain Performance: Attainment of strategic fit and scope**: a supply chain strategy; Competitive strategies; attainment of strategic fit; scope of the supply chain strategic fit.	3
3	**Supply Chain Drivers and Metrics**: Drivers of Supply Chain Performance; Facilities, Inventory, Transportation, Information, sourcing and Pricing. Framework for Structuring Drivers	4
4	**Designing the Supply Chain Network:** Designing distribution networks and applications to online sales; Network design in the supply chain; Designing global supply chain networks.	6
5	**Planning and Coordinating Demand and Supply in a Supply Chain:** Demand Forecasting in a supply; Aggregate planning in a supply chain; Planning supply and demand in a supply chain; Coordination in a supply chain.	4
6	**Planning and Managing inventories in a Supply chain**: Managing economies of scale in a supply chain: cycle inventory; Managing uncertainty in a supply chain: safety inventory; Determining the optimal level of product availability.	4
7	**Designing and Planning Transportation Networks:** The role of transportation in a supply chain; Modes of Transportation and Their Performance characteristics; The Role of IT in Transportation; Risk Management in Transportation	4
8	**Managing Cross-Functional Drivers in a Supply Chain:** Sourcing decisions in a supply chain; Pricing and revenue management in a supply chain; Information technology in a supply chain; Sustainability and the supply chain.	6
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PE-ME 802A.1	Develop a sound understanding of the important role of supply chain management in today's business environment.
PE-ME 802A.2	Understand and apply current supply chain theories, practices, and concepts utilizing case problems and problem-based learning situations.
PE-ME 802A.3	Use and apply computer-based supply chain optimization tools including the use of selected state of the art supply chain software suites currently used in business.
PE-ME 802A.4	Design, develop and utilize critical management skills such as negotiating, working effectively within a diverse business environment, ethical decision making and use of information technology.
PE-ME 802A.5	Apply the knowledge of supply chain design and analyze the related problems.
PE-ME 802A.6	Apply critical thinking skills in complex industrial problems.

Learning Resources:

1. Supply Chain Management: Strategy, Planning and Operation by Sunil Chopra and Peter Meindl.
2. Essentials of Supply Chain Management by Michael H Hugos.
   Logistics and Supply Chain Management by Martin Christopher
3. The Supply Chain Revolution by Suman Sarkar.

Subject Code: PE-ME 802 B	**Category:** Professional Elective Courses
Subject Name: Total Quality Management	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester**=12 minimum
Pre-Requisites: Production and Operations Management (PC-ME 604), Operations Research (PE-ME 702B), Principles and Practices of Management (PE-ME 702C)	

Course Objective:

1. Understanding basic knowledge of quality
2. Evolution of quality improvement and management towards Total Quality Management (TQM) plan for the organization
3. Understanding TQM Principles
4. Quality Tools and Techniques
5. Quality Standards and Systems
6. Quality Culture and Leadership
7. Quality Improvement Strategies
8. TQM in the Service Sectors

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction, Basic concepts of Quality, Total Quality, Total Quality control : Quality function and concept of quality circle, Quality policy and objectives:** Quality- A Look at History; Quality- The changing Business condition - "Quality" Defined; The Quality Function; Managing for Quality; Quality policy; Quality circle; Perspective on Quality—Internal versus External. Transformational route to Total Quality Management (TQM); Various TQM Gurus.	4
2	**Frameworks of TQM:** Elements of TQM; Characteristics of TQM and its enablers; Barriers to TQM; 4Cs of TQM; Different TQM models.	4
3	**Economics of quality and measurement of the cost of quality. Quality considerations in design:** Cost of poor Quality; Categories of Quality Cost; Analysis of Quality costs; Economic models of Quality of conformance; Quality measurement in design.	5
4	**Process control, Machine and process capability analysis Use of control charts and process engineering techniques for Use of control charts and process engineering techniques for implementing the quality plan:** Definition and Importance of statistical process control; Statistical Control charts; Steps in setting up a control chart; Control chart for variables data; Process Capability; Estimating Inherent or potential Capability from a Control –chart analysis; Measuring process performance; Attribute Control Charts**.**	6
5	**Acceptance sampling: single, double and multiple sampling, lot quality protection, Features and types of acceptance tables, Acceptance sampling of variables and statistical tolerance analysis:** The concept of Acceptance Sampling; Economies of Inspection; Sampling Risk: The Operating Characteristic curve; Analysis of some Rule-of –Thumb Sampling; Quality Indices for Acceptance Plan; Types of Sampling Plan; Single Sampling, Double Sampling and Multiple Sampling; Characteristic of a good Sampling Plan; Dodge-Roming Sampling Tables; Acceptance Sampling by Variables.	4
6	**Quality education, principles of participation and participative approaches to quality improvement:** Quality Planning & Quality Control; Quality Improvement; Theories of motivation; Create and maintain awareness of Quality; Provide Participation as a Means of Inspiring Action. **Six Sigma:** The Concept of Six Sigma, Objectives of Six Sigma, The Frame-Work of Six Sigma Programme, Six Sigma Organization: Roles and Responsibilities, Six Sigma Problem Solving Approach, The DMAIC Model, Six Sigma Metrics: Cost of Poor Quality, Defects Per Million Opportunities and First Pass Yield, Benefits and Costs of Six Sigma.	5
7	TQM in the Service Sectors: Implementation of TQM in Service Organization: Framework for Improving Service Quality, Model to Measure Service Quality Programs, TQM in Health - Care Services, Hotels and Financial Services - Banks, Investment Company and Mutual Funds.	4
8	**Emerging concepts of quality management:** Traditional versus modern quality management; Taguchi's concept of off-line quality control; Strength and Weakness of Taguchi's ideas Deming's philosophy; The Juran Philosophy; Just In Time (JIT); benchmarking; Business Process Re-engineering (BPR), Supply Chain Management (SCM).	4

	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PE-ME 802 B.1	Define key terms and concepts related to Total Quality Management. Recall the principles and components of TQM
PE-ME 802 B.2	Explain the principles and philosophy of Total Quality Management. Understand the role of leadership in fostering a culture of quality.
PE-ME 802 B.3	Apply TQM tools and techniques to identify and solve quality-related issues in an organization. Implement statistical methods for quality improvement.
PE-ME 802 B.4	Analyze processes and systems to identify areas for improvement in quality and efficiency. Assess the impact of quality initiatives on organizational performance.
PE-ME 802 B.5	Evaluate the effectiveness of TQM strategies in enhancing customer satisfaction. Critically assess the success of quality improvement initiatives within an organization.
PE-ME 802 B.6	Design a comprehensive Total Quality Management plan for an organization. Propose innovative strategies for continuous improvement in quality processes.

Learning Resources:

1. Quality Planning and Analysis by JM Juran and Gryna,
2. Total Quality Management by K. Shridhara Bhat.
3. Total Quality Management – An Introductory Text by Paul James, Prentice Hall.
4. Industrial Engineering Management by O. P. Khanna.

Subject Code: PE-ME 802C	**Category:** Professional Elective Courses
Subject Name: Management Information System	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:**3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Production and Operations Management(PC-ME 604), Numerical Methods & Computer Programming (CS-ME 501)	

Course Objectives:

1. To describe the role of information technology and decision support systems in business
2. To introduce the fundamental principles of computer-based information systems analysis and design and develop an understanding of the principles and techniques used.
3. To provide various knowledge representation methods and different expert system structures as strategic weapons to counter the threats to business and make business more competitive.
4. To use information to assess the impact of the Internet and Internet technology on electronic commerce and electronic business and understand the specific threats and vulnerabilities of computer systems.
5. To provide the theoretical models used in database management systems to answer business questions

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to MIS:** MIS concept, Role of the MIS, Impact of the MIS, Development process of the MIS system, data and information,	3
2	**Introduction to Information Technology:** Database management system (DBMS), networking, systems and application software	3
3	**Decision Making & Types of Information system:** Management information systems, transactions processing systems, decision support systems, expert systems, office automation systems and knowledge-based systems, structured decision making, unstructured decision making, and semi-structured decision making.	6
4	**Information system analysis and design:** Need for system analysis, System analysis of the existing system, System analysis of a new requirements, System Development Model, Structured System Analysis and Design, Object Oriented Analysis. Resource utilization, implementation, audit, operation, maintenance and modification	6
5	**Technology of information system:** Data process- Transaction and application process, Information system process; Unified communication and network, Security challenges in E-enterprises, Security threats and vulnerability: Controlling security threat and vulnerability.	6
6	**Data base management system:** Objectives of data base approach, Characters of database Management systems, Data processing system- Components of DBMS packages, Data base administration, Data models, Data warehouse.	6
7	**Functional Information Systems:** Marketing, Finance, HR, Production/Operations information systems.	3
8	**Enterprise Resource Planning:** Process mapping, implementation management, ERP system	3
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to :

PE-ME 802C.1	Understand the technologies used in the field of management information systems;
PE-ME 802C.2	Understand the development and implementation process of information systems.
PE-ME 802C.3	Understand the role of the ethical, social, and security issues of information systems.
PE-ME 802C.4	Explain the role of information systems in organizations, the strategic management processes, with the implications for the management.
PE-ME 802C.5	Apply the understanding of how various information systems like DBMS work together to accomplish the information objectives of an organization.
PE-ME 802C.6	Apply critical-thinking skills in identifying information systems problems and investigate existing literature about hardware and software solutions to problems.

Learning Resources:

1. Jawadekar, W.S., “Management Information Systems”, Tata McGraw Hill Private Limited, New Delhi, 2009.

2. Kenneth C. Laudon and Jane P. Laudon: "Management Information Systems" 9/e, Pearson Education, New Delhi.
3. Alex Leon and Mathew Leon: "Data Base Management Systems", Vikas Publishing House, New Delhi.
4. Goyal, D.P.: "Management Information System", MACMILLAN India Limited, New Delhi, 2008.
5. Mahadeo Jaiswal, Monika Mital: "Management Information System", Oxford University Press, New Delhi, 2008.
6. Murthy C.S.V.: "Management Information System", Himalaya Publications, New Delhi, 2008.
7. Panneerselvam R.: "Database Management System", PHI Private Limited, New Delhi, 2008.
8. Philip J, Pratt, Joseph J. Adamski: "Database Management Systems", Cengage Learning, New Delhi, 2009.
9. Richard T. Watson: "Data Management ", WILEY INDIA Limited, New Delhi, 2008.
10. Rob and Cornell: "Data Base Management Systems" Cengage Learning, New Delhi.

Subject Code: PE-ME 802D	**Category:** Professional Elective Courses
Subject Name: Finite Element Analysis	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:**3
Contact Per Week- 3L	**Contact Week / Semester**=12 minimum
Pre-Requisites: Engineering Mechanics (ESME-301), Strength of Materials (PCME 401), Mathematics (BS-M-301)	

Course Objectives:

To apprise the students about the basics of the Finite Element analysis technique, a numerical tool for the solution of different classes of problems in solid mechanics, thermal engineering, and fluid mechanics

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Historical background, Relevance of FEA/FEM to design problems, Application to the continuum– Discretization, Matrix approach, Matrix algebra– Gaussian elimination, Governing equations for continuum, Classical Techniques in FEM, Weighted residual method, Ritz method, Galerkin method	6
2	**One dimensional problems:** Finite element modeling– Coordinates and shape functions, Potential energy approach– Element matrices and vectors, Assembly for global equations, Boundary conditions, Higher order elements- Shapes functions, Applications to axial loadings of rods– Extension to plane trusses, Bending of beams– Finite element formulation of stiffness matrix and load vectors, Assembly to Global equations, boundary conditions, Solutions and Post processing, Example Problems.	6
3	**Two dimensional problems– scalar variable problems:** Finite element modeling– CST element, Element equations, Load vectors and boundary conditions, Assembly, Application to heattransfer, Examples	3
4	**Two dimensional problems– vector variable problems**: Vector Variable problems, Elasticity equations–Plane Stress, Plane Strain and Axisymmetric problems, Formulation, element matrices, Assembly, boundary conditions and solutions Examples	7
5	**Isoparametric elements for two dimensional problems:** Natural coordinates, Isoparametric elements, Four node quadrilateral element, Shape functions, Element stiffness matrix and force vector, Numerical integration, Stiffness integration, Displacement and Stress calculations, Examples.	6
6	**Numerical Integration and 2-D problems of Elasticity:** Introduction to numerical integration, two dimensional integrals, plane stress, plane strain, axisymmetric, plate bending problems. Thermal Applications: Two- dimensional heat conduction analysis, formulation of functional, element matrices and case studies. Fluid Mechanics Applications: Stream function formulation, velocity potential formulation and torsional analysis of a prismatic bar. Computer implementation: Pre-processor, Processor, Post- processor. Discussion about finite element packages.	**8**
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to :

PE-ME 802D.1	Analyze and interpret complex engineering problems using finite element methods, demonstrating application-level understanding.
PE-ME 802D.2	Design and execute finite element models for various engineering applications, showcasing synthesis and creativity in problem-solving.
PE-ME 802D.3	Evaluate the accuracy and validity of finite element analysis results, applying critical judgment and analysis.

PE-ME 802D.4	Integrate advanced finite element techniques into multidisciplinary projects, showing adeptness in knowledge transfer and practical application.
PE-ME 802D.5	Critically assess and optimize finite element models for efficiency and effectiveness, demonstrating high-level evaluative skills.
PE-ME 802D.6	Create comprehensive reports and presentations on finite element analysis projects, exhibiting mastery in communication and knowledge dissemination.

Learning Resources:

1. P. Seshu, Textbook of Finite Element Analysis, Prentice Hall of India, 2009.
2. J. N. Reddy, Finite Element Method in Engineering, McGraw Hill, 2009.
3. O.C. Zienkiewicz, R.L. Taylor and J.Z. Zhu, The Finite Element Method for Solid and Structural Mechanics, 4th Edition, Elsevier 2007.
4. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and Applications of Finite Element Analysis, Wiley, 2001.
5. T.R. Chandrupatla and A.D. Belegundu, Introduction to Finite Elements in Engineering, Pearson, 2012.
6. C.S. Krishnamoorthy, Finite Element Analysis, McGraw Hill, 1994.
7. K.J. Bathe, Finite Element Procedures, Prentice Hall of India, 1982.

Subject Code: PE-ME 803A	**Category**: Professional Elective Courses
Subject Name: Industrial Automation and Instrumentation	**Semester:** Eighth
L-T-P: 3-0-0	**Credit**: 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: Metrology & Measurement (PC-ME 403), Fluid Mechanics (PC-ME 302)	

Course Objectives:

1. To introduce the importance of automation techniques manufacturing and process industries.
2. To impart the role of PLC in industry automation.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**DISPLACEMENT** - LVDT, capacitive type transducers- Theory, applications.	2
2	**PRESSURE:** Absolute, gauge and vacuum pressures, Manometer **Elastic transducers:** Elastic diaphragm, Corrugated diaphragm, capsule type - relative merits and demerits, pressure ranges. Bourdon type pressure gauge- Theory, construction, installation, Pressure range, materials **Vacuum gauges:** Mcleod gauge, thermal conductivity gauge,	7
3	**TEMPERATURE:** **Non- Electrical gauges:** Liquid in glass thermometer, pressure thermometer. **Electrical gauges**- resistance temperature detector- 2, 3 and 4-wire configurations thermocouples and thermopiles, CJC, Compensating wires, thermistor- theory, applications, relative merits and demerits, operating range. **Non-contact type temperature gauges** - total radiation pyrometer, optical pyrometer, temperature measuring problem in flowing fluid. Thermo well.	8
4	**FLOW:** **Variable head type flow meters**: orifice plate, Venturi tube, Flow nozzle: Theory, Pitot tube construction, installation, tapping, selection methods. **Variable Area flow meter**: Theory, construction and installation **Positive displacement type flow meters**: Nutating disc, reciprocating piston, oval gear and helix type-Theory, construction and installation **Open channel flow measurements**: Different shapes of weirs and corresponding flow relations. **Electrical type flow meters:** Theory, installation details of electromagnetic flow meter, ultrasonic flow meter	10
5	**LEVEL:** **Non-Electrical gauges:** Sight glass type, Float type, displacer type, Air purge system- Theory, arrangements, relative merits and demerits **Electrical level gauge:** capacitive types- Theory, arrangement, limitations **ultrasonic type** **Differential pressure type level measurement:** open and closed tanks	6
6	**DATA Acquisition, Transmission and Recording:** Cable transmission of analog voltage and current signals; cable transmission of digital data; Electromechanical XT and XY recorders; Transmitter	3
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PE-ME 803A.1	Illustrate with various automation technologies in manufacturing and process industries.
PE-ME 803A.2	Understand various automation tools and methods in manufacturing industry.
PE-ME 803A.3	Explain various control and automation method in process industries.
PE-ME 803A.4	Define with various communication technologies in manufacturing and process industries.
PE-ME 803A.5	Expose to various control techniques employed in process automation.
PE-ME 803A.6	Develop automation system for manufacturing and process industries

Learning Resources:

1. R K Jain, “Mechanical and Industrial Measurements”, Khanna Publishers Co Ltd., New Delhi.
2. S.K.Singh, “Industrial instrumentation”, TMH

3. RK Rajput, “Mechanical Measurements and Instrumentation”, SK Kataria and Sons, New Delhi.
4. Donald P. Eckman, " Industrial Instrumentation”, Wiley
5. E O Doeblin, Measurement Systems- Application and Design, McGraw Hill
6. T G Beckwith and N L Buck, “Mechanical Measurements”, Addition Wesley Publishing Company Limited.
7. J P Holman, “Experimental Methods for Engineers”, McGraw Hill
8. Alan S Morris, “Measurement and Instrumentation Principles”, Butterworth.

Subject Code: PE-ME 803B	**Category**: Professional Elective Courses
Subject Name: Industry 4.0	**Semester**: Eighth
L-T-P: 3-0-0	**Credit**: 3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-requisites: Computer Integrated Manufacturing (OE-ME 601A)	

Course Objectives:

1. To provide the students with the idea of Fourth Industrial Revolution: roots, expectations, technology, and challenges
2. Knowledge for the design and analysis of Industry 4.0 Systems for manufacturing industries

Course Contents:

Module No	Description of the topic	Contact Hrs.
1	**Introduction to Industry 4.0:** History of Industrial Revolution: Duration, motivation, major theme. Definition of Industry 4.0: What is it all about and why it is necessary? The motivation: German Federal Govt. initiative, Developments in USA, Europe, China and other countries Comparison of Industry 4.0 Factory and today's Factory, the 10 most important things that will change with Industry 4.0, Difference between conventional automation and Industry 4.0.	3
2	**Basic principles and technologies of a Smart Factory:** 9 pillars of Industry 4.0, Concept of smart factory: Conceptual framework, scenarios, and future perspectives; Smart design, smart manufacturing, smart scheduling, smart monitoring and control, smart decision-making. Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Big data, Cyber-Physical Systems (CPS), Cyber-Physical Production Systems (CPPS), Value chains in manufacturing companies, Customization of products, Digital Twins, Cloud Computing / Cloud Manufacturing, Security issues within Industry 4.0 networks.	3
3	**Cyber-Physical Systems (CPS) and Cyber-Physical Production Systems (CPPS):** What are cyber-physical systems? (Definitions, demarcation to embedded systems, ubiquitous computing, etc.), Core elements of Cyber-Physical Systems and Cyber-Physical Production Systems, 5C architecture of CPPS, Schematic representation of CPPS, Control theory and real-time requirements, Communication in cyber-physical systems, Interplay between CS, ICT and manufacturing. Design Methods for Cyber-physical Systems (Modelling, Programming, Model-Integrated Development), Applications for cyber-physical systems (examples of existing or future applications in the field of manufacturing, traffic, medical technology, etc.)	3
4	**The smart work piece:** The intelligent work piece as basic functionality in implementing Industry 4.0; What is an intelligent work piece? How to make a work piece intelligent? Work piece tagging, QR codes and RFID, Communication between work piece and environment, Multi-agent systems in production: Definition of an agent and agent-based systems, properties of MAS, advantages. Applications for smart work pieces (examples of existing or future applications in the field of manufacturing. **Digital Twins in Production:** Basic concepts of Digital Twins: Benefits, impact and challenges; Features and Implementation of Digital Twins, Types of Digital Twins, Digital Twin use cases, Applications for digital twins in production (examples of existing or future applications in the field of manufacturing), Cyber-physical modules for machine tools, Machine tool 4.0 (CPMT): Concept, features, implementations, advantages, and challenges.	7
5	**The six main use-cases for Augmented Reality in Manufacturing:** AR-devices an Overview (different versions, Videos) • Use case 1: Integrating Design and Manufacturing • Use case 2: Training Shop floor Workers • Use case 3: Supporting complex Assembly Operations • Use case 4: Service and Maintenance • Use case 5: Supporting complex Sales solutions • Use case 6: Executive Oversight and Data Visualization • Applications with Augmented Reality (examples of existing or future applications in the field of manufacturing)	4

6	**Interoperability: Communication systems and standards for Industry 4.0 and cloud applications:** Industrial communication, Industrial Internet of Things (IIOT), The Industry 4.0 Reference Architecture Model RAMI4.0, Basics on Service oriented Architecture, OPC-UA as future standard in Industry 4.0, Machine to machine interaction in practice (examples of existing or future applications in the field of manufacturing). **OPC-UA in Detail:** Introduction to OPC, Classic OPC vs. OPC-UA, Information Modelling, Standard Information Model, OPC Services, System Architecture, Profiles OPC-UA and the Cloud. OPC-UA in practice (examples of existing or future applications in the field of manufacturing). **Cloud Manufacturing and the connected factory:** Virtualization, Cloud Platforms, Big data in production, Cloud-based ERP and MES solutions, Connected factory applications, IT security for cloud applications.	8
7	**Artificial Intelligence in Production: Machine Learning Application:** Basics of Machine Learning, The Machine Learning Process, Into Machine Learning working cycle, Preparing Data, Running Experiments, Finding the Model, Training the Model, Deploying and using a Model Machine Learning in practice (examples of existing or future applications in the field of manufacturing).	5
8	**Safety and Security in networked Production Environments** What means Safety with Industry 4.0, Safety for connected Machines and Systems, Safety in Human Robot cooperation, How Industry 4.0 can optimize Safety, Security & Security Risks with Industry 4.0, Security and privacy risks in AI, Approach to Cyber-Physical Security in Industry 4.0, Practical Security Aspects with Industry 4.0 (examples of existing or future applications in the field of manufacturing).	3
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

PE-ME 803B.1	Develop knowledge of basics, drivers and enablers of Industry 4.0
PE-ME 803B.2	Gain knowledge of modern methods and techniques of planning, dimensioning, design and optimization of Industry 4.0 production systems
PE-ME 803B.3	Develop knowledge and understanding of value chains in Industry
PE-ME 803B.4	Formulate methods and techniques of production system planning and optimization through the application of theoretical learning content in the context of case studies
PE-ME 803B.5	Structure and documentation of innovative problem solutions using modern technologies for information acquisition and processing through DT.
PE-ME 803B.6	Apply the knowledge to design and develop CPPS considering machine tool 4.0

Learning Resources:

1. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist
2. Sustainability in Manufacturing Enterprises: Concepts, Analyses and Assessments for Industry 4.0 by Ibrahim Garbie

Subject Code: PE-ME 803C	**Category:** Professional Elective Courses
Subject Name: Fluid Power Control	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:**3
Contact Per Week- 3L	**Contact Week / Semester =** 12 minimum
Pre-Requisites: Fluid Mechanics (PC-ME 302)	

Course Objectives:

1. To learn about different hydraulic and pneumatic fluid power systems.
2. To learn about different components of fluid power systems.
3. To understand the design procedure for hydraulic and pneumatic fluid power systems.
4. To grasp the fluid mechanical principles that govern the operation of the fluid power systems.
5. To know about the controls and accessories of fluid power systems.

Course Contents:

Module No.	Description of Topic	Lectures Hours
1	**Introduction to fluid power systems:** applications, advantages and limitations. Components of a hydraulic and pneumatic system. Properties of fluids: pressure, head, force, density, specific gravity, kinematic and absolute viscosity, compressibility and incompressibility. Desired properties of a hydraulic fluids. Classification of hydraulic fluids. Fluid mechanical principles and their applications: Pascal's law; analysis of simple hydraulic jack, mechanical advantage; Conservation of mass: continuity equation. Conservation of energy. hydraulic power of a cylinder, hydraulic siphon. Losses in pipe flow.	4
2	**Hydraulic pumps:** Classification of hydraulic pumps. Construction, working principle, efficiency analysis, advantages, limitations and application of different types of pumps: positive displacement pump, gear pump, vane pump, lobe pump, screw pump, piston pump. Pump performance analysis. Factors for pump selection.	6
3	**Hydraulic actuators:** Classification of hydraulic actuators: linear, rotary, semi-rotary. Symbolic representation of hydraulic actuators. **Linear actuators:** Constructions of hydraulic cylinders. Mounting of arrangements of cylinders, cushioning of cylinder; Cylinder force, velocity and power. Performance analysis of hydraulic actuators. Applications of hydraulic actuators through mechanical linkages. **Rotary and semi-rotary actuators:** Classification of hydraulic motors. Theoretical torque, power and flow rate in a hydraulic motor. Hydraulic motor performance. Construction and working principle: gear, vane, piston motors. Semi-rotary actuators: classification and working principle.	6
4	**Hydraulic Valves:** Direction control valves: Classification, operation and graphical symbols. Different modes of activation of valves. **Pressure control valves:** Classification, construction and working principle. **Flow control valves:** Classification, construction and working principle.	4
5	**Hydraulic circuit design and analysis:** Representation of hydraulic components through ANSI symbols. Analysis of different hydraulic circuits, speed control of a hydraulic motor, circuit to lift and hold heavy load, automatic sequencing of two cylinders. Servo valves: classifications, operating principles and performance analysis. Accumulators: classifications, working principles, application. Fluid power systems accessories: seals, reservoirs, filters and strainers. Maintenance of fluid power systems.	6
6	**Pneumatic systems:** Advantages and disadvantages of pneumatic system compared to hydraulic system. Properties of air. Basic components of pneumatic systems. Air compressors: classification, construction and operating principles. Air preparation. Cooling and drying of compressed air. Storage of compressed air. Conditioning and distribution of compressed air: air filters, pressure regulator, lubricator and silencer; symbols of different	6

	pneumatic components; compressed air distribution system in a plant; drawing pneumatic circuits for different operations. Pneumatic actuators. Pneumatic control valves.	
7	**Electro-pneumatic control:** Use of electrical devices for controlling fluid circuits; function of electrical devices like push-button switches, limit switches, pressure switches, solenoids, electronic sensors, relays and timers and their symbols; concept of ladder diagram; study of circuits using electrical control devices such as control of a solenoid actuated cylinder using one limit switch, reciprocation of a cylinder using pressure or limit switches, and two cylinder sequencing circuit using two limit switches.	4
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to :

PE-ME 803C.1	Illustrate different types of fluid power control systems and their applications.
PE-ME 803C.2	Understand and analyse working principles of different components of a hydraulic pump and actuators.
PE-ME 803C.3	Analyse about various hydraulic valves with their designs.
PE-ME 803C.4	Discuss about working and applications of different components of pneumatic systems.
PE-ME 803C.5	Understand and analyse working principles Electro-pneumatic control systems.
PE-ME 803C.6	Explain the design of various fluid power systems for specific applications.

Learning Resources:

1. S. Ilango and V. Soundararajan, Introduction to Hydraulics and Pneumatics, PHI, 2011.
2. A. Esposito, Fluid Power with Applications, Pearson, 2003.
3. S.R. Majumdar, Pneumatic Systems: Principles and Maintenance, McGraw Hill, 1999.
4. E.C. Fitch Jr., Fluid Power and Control Systems, McGraw Hill, New York,1966.
5. D.S. Banks and D.D. Banks, Industrial Hydraulics, Prentice Hall, 1988.

Subject Code: PE-ME 803D	**Category:** Professional Elective Courses
Subject Name: Advanced Fluid Mechanics	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:**3
Contact Per Week- 3L	**Contact Week / Semester** = 12 minimum
Pre-Requisites: Fluid Mechanics (PC-ME 302)	

Course Objective:

1. To know about compressible fluid flow.
2. To learn about ideal fluid flow.
3. To know about free surface flow.
4. To know about unsteady flow.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Compressible Flow: review of thermodynamic principles for perfect gases, adiabatic and isentropic relations; steady flow energy equation; speed of propagation of a small disturbance through a compressible fluid, sonic velocity, Mach number, mach cone and Mach wave; isentropic flow, stagnation properties of a compressible flow, isentropic pressure, temperature and density ratios; compressibility correction factor in the measurement of air speed; area– velocity relationship for compressible flow through a variable area duct, mass flow rate through a duct, critical condition and choking; flow through convergent-divergent nozzle, over expansion and under expansion, performance of propulsive nozzles; normal shock, normal shock relations, wave drag.	12
2	Ideal Fluid Flow: rotation of a fluid particle, vorticity, rotational and irrotational motion; velocity potential function, circulation, stream function, flownet; governing equation for two dimensional irrotational motion, simple two dimensional irrotational flows like uniform flow, plane source, plane sink etc; superimposition of simple irrotational flows, combination of a source and a sink, combination of uniform flow and a source (Rankine half body), combination of a uniform flow and a source-sink pair (Rankine oval), doublet and its strength, superimposition of an uniform flow and a doublet (flow past a stationary cylinder); vortex motion– free and forced vortex, strength of a vortex; combination of a uniform flow, a doublet and a free vortex (flow over a rotating cylinder), Magnus effect, Kutta- Joukowski's theorem.	12
3	Free Surface Flow: flow in open channel, Chezy's equation, Manning's equation, economical cross section, specific energy, hydraulic jump.	8
4	Unsteady flow– water hammer.	4
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to:

PE-ME 803D.1	Analyze and apply thermodynamic principles to compressible flow, including adiabatic and isentropic relations, to solve problems involving sonic velocity and Mach numbers.
PE-ME 803D.2	Evaluate the dynamics of isentropic flow in compressible fluids, including stagnation properties and the impact of compressibility on airspeed measurement.
PE-ME 803D.3	Determine mass flow rates and critical conditions in variable area ducts, using area-velocity relationships, and analyze the performance of convergent-divergent nozzles in various expansion scenarios.
PE-ME 803D.4	Investigate and solve problems related to ideal fluid flow, including the use of potential functions, circulation, and stream functions in two-dimensional irrotational motion.
PE-ME 803D.5	Apply principles of free and forced vortex motion, including the Magnus effect and Kutta-Joukowski's theorem, to analyze the interaction of uniform flow with doublets and vortexes.
PE-ME 803D.6	Understand and model unsteady and free surface flows, including open channel flow dynamics, using Chezy's and Manning's equations, and analyze phenomena like hydraulic

	jumps and water hammer.

Learning Resources:

1. Sadhu Singh, Fluid Mechanics and Hydraulic Machines, Khanna Book Publishing, New Delhi, 2018.
2. R.K. Bansal, A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publication, New Delhi, 2010.
3. S.K. Som, G. Biswas and S. Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, McGraw-Hill, 2012.

Subject Code: OE -ME 801A	**Category:** Open Elective Courses
Subject Name: Human Resource Management	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: No- Prerequisites	

Course Objectives:

1. To enable the students to understand the HR Management and system at various levels in general and in certain specific industries or organizations.
2. 2. To help the students focus on and analyse the issues and strategies required to select and develop manpower resources
3. To develop relevant skills necessary for application in HR related issues
4. To Enable the students to integrate the understanding of various HR concepts along with the domain concept in order to take correct business decisions.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Human Resource Management:** Meaning, Scope, objectives, and functions of HRM, HR as a Factor of Competitive Advantage, Structure of HR Department, Line and staff responsibility of HR Managers, Environmental factors influencing HRM	2
2	**Human Resource Planning:** definition, objective, process of HRP. Supply and Demand Forecasting techniques, Manpower Inventory, Career Planning& Development, Succession Planning, Rightsizing, Restructuring. Human Resource Information System (HRIS	6
3	**Recruitment and Selection:** Process, Sources, Methods of selection, Interviewing Methods, Skills and Errors.	4
4	**Human Resource Development:** Definition, objective, process of HRD, Assessment of HRD Needs, HRD Methods: Training and Non-Training, Training Process; Designing, Implementation and Evaluation of Training Programmes, Induction Training. Developing Managerial Skills for: team management, collaboration, interaction across business functions, presentation, Negotiation, and Networking	4
5	**Performance Appraisal Systems:** Purpose, Methods, Appraisal instruments, 360-degree Appraisal, HR Score Card, Errors in appraisal, Potential Appraisal, Appraisal Interview	4
6	**Compensation Management:** Concepts, Components; System of Wage Payment, job evaluation, wage/ salary fixation, incentives, bonus, ESOPs, Fringe Benefits, Retirement Benefits. Compensation Plans	4
7	**Industrial Relations in India:** Parties; Management and Trade Unions, Industrial Disputes: Trends, Collective Bargaining, Settlement Machineries, Role of Government, Labour Policy in India. **Workers' Participation in Management:** Concept, Practices and Prospects in India, Quality Circles and other Small Group Activities.	6
8	**Strategic HRM:** Meaning, Strategic HRM vs Traditional HRM, SHRM Process, barriers to SHRM. Nature of e-HRM, e-Recruitment & Selection, e-Performance Management, e-Learning	6
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

OE -ME 801A.1	Develop the understanding of the concept of human resource management and to understand its relevance in organizations.
OE -ME 801A.2	Explain the Human Resource Planning.
OE -ME 801A.3	Develop necessary skill set for application of various HR issues like Recruitment and Selection, Human Resource Development etc.
OE -ME 801A.4	Define the Industrial Relations in India, Workers' Participation in Management, Discipline Management.
OE -ME 801A.5	Analyse the strategic issues and strategies required to select and develop manpower resources.

OE -ME 801A.6	Integrate the knowledge of HR concepts to take correct business decisions.

Learning Resources:

1. Agarwala T. - Strategic Human Resource Management, OUP
2. Aswathappa, K. - Human Resource Management, Tata McGraw Hill
3. Jyothi P. & Venkatesh, D.N. - Human Resource Management, OUP
4. Ramaswamy, E.A. - Managing Human Resources, OUP
5. Saiyadain, M.S - Human Resource Management : Tata McGraw Hill
6. Mondal Sabari & Goswami Amal - Human Resource Management: Vrinda Publications

Subject Code: OE -ME 801B	**Category:** Open Elective Courses
Subject Name: Entrepreneurship	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:** 3
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: No- Prerequisites	

Course Objectives:

1. Will be able to develop knowledge on how to assess business opportunities and an in-depth understanding of what typically characterize successes and failures
2. Will be able to develop about key processes necessary to bring new products and services to market and key challenges facing the entrepreneur at different stages of the entrepreneurial voyage
3. Will be able to develop an understanding of scientific research methods and theories relevant for the field
4. Will be able to to assess the commercial viability of new technologies, business opportunities and existing companies
5. Will be able to able to plan, organize, and execute a project or new venture with the goal of bringing new products and service to the market

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Concept of Entrepreneurship - need and scope for entrepreneurship - Entrepreneur and society- qualities of entrepreneur Risks, relevance and benefits of small-scale Industry - definition of tiny, small ancillary industry - prevailing industrial policy of SSI - incentives and benefits of SSI units.	6
2	Motivation theories - Maslow, McCllend - Motivation model - need, want, motive and behaviour – attitude towards work - self assessment and goal setting - Achievement, motivation and behaviour measurement, SWOT analysis, TA analysis - Stress and conflict management; coping with uncertainty; creativity and innovation.	6
3	**Project identification and formulation:** Sources of information - opportunity guidance - choice of technology and its evaluation; consumer behaviour; market survey and research; demand and resource based industry- servicing industry - import substitution- Techno economic feasibility assessment – short listing, preliminary project report, detailed project report, assessing viability and feasibility of a report.	6
4	**Forms of business organizations/ownership** - formation of a Company - procedures and formalities for setting up of new industry-sources of information to contact for what and where - subsidies and concessions for SSI - role of State and Central Government Agencies in promotion of Small Scale Industry. Sickness and nursing of sickness in SSI.	6
5	**Labour Laws** - The Factories Act 1948, Minimum Wages Act - Payment of Wages 1936, Workmen Compensation Act, 1923.	1
6	Taxation - State and Central - Concessions.	2
7	**Introduction to e-business;** EDI and e-commerce; EDI standard, implementation and Tools; e-commerce imperatives,	3
8	**e-commerce applications:** I - Markets, Customer care, Vendor Management and Extended supply chain management; security aspects - cryptography, digital signature, digital watermarking, secured socket layers, understanding threats to security, securing internet connections, Firewall techniques, electronic payment systems - ATM model, Payment Models, credit card based payment system, 1st virtual banking, e-cash, smart cards; Electronic Data interchange EDI) - Value added networks.	6
	Total	36

Course Outcomes:

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

OE -ME 801B.1	Understand the nature of entrepreneurship
OE -ME 801B.2	Understand the function of the entrepreneur in the successful, commercial application of innovations
OE -ME 801B.3	Confirm an entrepreneurial business idea
OE -ME 801B.4	Identify personal attributes that enable best use of entrepreneurial opportunities
OE -ME 801B.5	Explore entrepreneurial leadership and management style.
OE -ME 801B.6	Define various e-commerce applications

Learning Resources:

1. Handbook for New Enterpreneurs, EDII, Ahmedabad.

2. Entrepreneurial Development by P.Saravanavel.

Subject Code: OE -ME 801C	**Category:** Open Elective Courses
Subject Name: Industrial Safety	**Semester:** Eighth
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: No- Prerequisites	

Course Objectives:

1. To know the safety rules and regulations, standards and codes applicable for engineering industry.
2. To study various mechanical machines and their safety importance.
3. To understand the principles of machine guarding and operation of protective devices.
4. To know the working principle of mechanical engineering processes such as metal forming and joining process and their safety risks.
5. Developing the knowledge related to health and welfare measures in engineering industry.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Development of industrial safety:** Developments in Occupational Health, Occupational Safety and Health in India	2
2	**Accidents and their prevention:** Theory of accident, Anatomy of an accident, How Accidents are Caused? Cost of Accidents, Principles of Accident Prevention, Techniques of Accident Prevention, Safe Work Environment, Housekeeping, Job Safety Analysis, Investigation of Accidents, Ergonomics, Personal Protective Equipment, Promotion of Health and Safety, Basic Safety Programming.	6
3	**Fire hazard:** Types of fire, Fire Hazards, Fire Explosion, fire prevention, Means of Escape in Case of Fire Inspection Safety Supervision Safety, Responsibility Safety Inspection, Fire prevention authorities, Rules Safety Training Safety Appraisal Safety Communication Safety Audit.	6
4	**Occupational health and safety:** Occupational Health, Occupational Health Services in Places of Employment, Occupational Physician, Occupational Health in Developing Countries, Occupational Safety, Occupational Safety in Developing Countries, Promoting Occupational Health and Safety, Work Related Diseases, Occupational Health Hazards Recognition of Hazards, Industrial Hygiene, Occupational Diseases, basics of OHSAS 18001	6
5	**Health and safety at workplaces:** Health and Safety hazards, Occupational Health Requirements, Occupational Safety Requirements, Occupational Welfare Requirements, Abstracts and Notices, Obligations of a Worker, Obligations of Occupier, Personal protective equipment, Causes of Accidents, Prevention of Accidents, Safety Legislation, Safety Guidelines, emergency actions, related acts ***(related to chemical processes, mines, workshop practices, construction work, electrical installations)***	6
6	**Health and safety management:** Basics of Safety management, Role of safety supervisor, planning for safety, Safety Policies, Safety Promotion, Safety Committee, safety education & training, Health and Safety Process, Measuring Safety, Risk Management and Loss Control,	4
7	**Accident compensation:** Brief introduction to different acts - The Dangerous Machines (Regulations) Act, 1983, The Employers' Liability Act, 1938 The (Indian), Fatal Accidents Act, 1855 The Public Liability Insurance Act, 1991, The Workmen's Compensation Act, 1923, The Employees' State Insurance Act, 1948, Role of National Safety Council, International labour office.	6
	Total	**36**

Course Outcomes:
Upon successful completion of the course, students will be able to

OE -ME 801C.1	Analyze the effect of release of toxic substances
OE -ME 801C.2	Understand the industrial laws, regulations and source models.
OE -ME 801C.3	Apply the methods of prevention of fire and explosions.
OE -ME 801C.4	Understand the relief and its sizing methods.
OE -ME 801C.5	Understand the methods of hazard identification and preventive measures.
OE -ME 801C.6	Explain Accident compensation considering various laws.

Learning Resources:

1. Safety management Systems, A. Waring, (Chapman & Hall, 1996)
2. Environmental Health & Safety Management – A Guide to Compliance, N. P. Cheremisinoff, M. L. Graffia, (Noyes Publin. 2003)
3. Safety at Work, J. Ridley & J. Channing (5th. Edn.), (Butterworth & Heinemann, 2001)
4. Occupational Health & Hygiene, J.Stranks, (Pitman Publn., 1995)
5. Safety management: Strategy & Practice, R. Pybuss, (Butterworth & Heinemann, 1997)
6. Essentials of Safety management, H. L. Kalia, A. Singh, S. Ravishankar & S. V. Kamat, (Himalaya Publishing House, 2002)
7. Industrial Health & Safety Management, A.M.Sarma, (Himalaya Publishing House, 2002)
8. Encyclopaedia of Occupational Health & Safety (4th Ed.), Vol –I-IV, Ed. J. M. Stellman – International Labour Office, Geneva.
9. Safety Management System – Alan Waring, Chapman & Hill, London
10. Practical Health & Safety Management for small business- Jacqneline Jaynes, 2000, Butterworth Heinemann,
11. Industrial Safety and Human Behaviour, H. L. Kalia, AITBS Publishes, India.

Subject Code: PW-ME 881	**Category:** Project
Subject Name: Project – IV	**Semester:** Eighth
L-T-P: 0-0-10	**Credit:** 5
Contact Per Week- 3L	**Contact Week / Semester=**12 minimum
Pre-Requisites: All the theory and practical aspects of Engineering	

Course Objectives:
This course aims to cultivate advanced technical and research skills through hands-on project work. Students will engage in the comprehensive design, development, and analysis of mechanical systems, applying theoretical knowledge to real-world problems. This course emphasizes innovation, requiring students to explore emerging technologies and industry trends. Additionally, it aims to develop soft skills such as teamwork, project management, and effective communication, preparing students for successful careers in the mechanical engineering field.

Course Outcomes:

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

PW-ME 881.1	Recall and apply foundational principles of mechanical engineering to identify and describe the key components and requirements of the chosen project.
PW-ME 881.2	Interpret and explain the theoretical frameworks and methodologies relevant to the project's objectives, demonstrating comprehension of various mechanical concepts and their practical applications.
PW-ME 881.3	Utilize acquired knowledge to design and execute innovative solutions within the project, applying mechanical engineering principles to address real-world challenges effectively.
PW-ME 881.4	Break down complex mechanical problems, evaluate different design approaches, and analyze the project's constraints to make informed decisions and optimize the project's design and functionality.
PW-ME 881.5	Critically assess the effectiveness and efficiency of the project's implementation, comparing and contrasting various design choices and justifying the selected methodologies based on performance, feasibility, and impact.
PW-ME 881.6	Develop and construct a prototype or model, demonstrating originality and innovation in integrating various mechanical components, processes, or systems to achieve the project's objectives.

Subject Code: PW-ME 882	**Category:** Project
Subject Name: Comprehensive Viva Voce	**Semester:** Eighth
L-T-P: 0-0-0	**Credit:** 2
Contact Per Week-	**Contact Week / Semester=**
Pre-Requisites: All the theory and practical aspects of Mechanical Engineering	

Course Objectives:

This course aims to rigorously assess a student's holistic understanding of the field. Objectives include evaluating the depth and breadth of knowledge in core mechanical engineering concepts, analyzing the ability to integrate and apply theoretical principles to practical scenarios, and examining problem-solving skills across a wide range of topics. Additionally, this viva seeks to gauge the student's critical thinking, communication skills, and readiness for professional challenges in the mechanical engineering sector. Emphasis is also placed on understanding recent technological advancements and their applications in mechanical engineering.

Course Outcomes:

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

PW-ME 882.1	Recall and articulate fundamental theories, principles, and methodologies encompassing various disciplines within mechanical engineering, demonstrating a comprehensive grasp of foundational knowledge.
PW-ME 882.2	Interpret and explain complex mechanical engineering concepts, theories, and their practical applications, showcasing a deep comprehension of the interrelationships between different areas of study.
PW-ME 882.3	Apply acquired knowledge to analyze and solve intricate engineering problems presented during the viva voce, demonstrating the ability to transfer theoretical understanding into practical problem-solving scenarios.
PW-ME 882.4	Break down and analyze complex engineering issues presented during the viva voce, showcasing the capability to dissect multifaceted problems into their constituent elements and assess their interactions.
PW-ME 882.5	Critically evaluate and assess various engineering approaches and methodologies discussed during the viva voce, justifying the selection of specific solutions or methodologies based on their effectiveness, feasibility, and appropriateness.
PW-ME 882.6	Synthesize and integrate diverse engineering principles and knowledge to propose innovative strategies or recommendations for addressing real-world challenges or interdisciplinary problems within the field of mechanical engineering.

Annexture-I

Mandatory Additional Requirement (MAR) for earning B. Tech Degree

The additional requirement of MAR points applies to - every student, who is admitted to the 4 years B.Tech program under Autonomy, as per following:

Level of Entry in B.Tech Course	Total duration for earning Points	Minimum Points
1st Year from the academic year 2020-21 onwards	1st to 4th Year	100
2nd Year from the academic year 2020-21 onwards (Lateral Entry)	2nd to 4th Year	75

These points must be earned on the basis of active participation in co-curricular and extracurricular activities spanning through all the semesters of study. Every student may choose, as per his/her liking, activities in order to achieve the mandatory points (as per Table- I, depending on his/her entry level), before becoming eligible for award of the Degree. These activities can be spread over the years, as per convenience of the student.

Notes:

- Every student shall participate in the co-curricular and extra-curricular activities and produce documentary proof to the designated Faculty Members appointed by the Head of Department / Principal / Director in the respective college. Thereby the student should earn the required Points before *her* she appears for his/ her Final Examinations.
- A student's result of his/her Final Examinations will be withheld until he/she completes the minimum Activity Points by the end of his/her B.Tech Program.
- In every semester, every student is required to prepare a file containing documentary
- proofs of activities, done by him / her. This file will be duly verified and Activity Points will be assigned by the teachers as appointed above, at the end of every semester.
- The college will form a 3 members committee and finalize the Activity Points for each
- student before entering them into the Online Point Entry System of the Institute
- Every student has to earn at least 100 / 75 (for lateral) activity points. The points students has earned will be reflected in the student's mark sheet.
- Activity points earned by Lateral Entry students will be multiplied by 1.33.

Table I provides a List of Activity Heads and Sub-Activity Heads along with their capping of the Activity Points that can be earned by the students during the entire B.Tech duration.

Table- I

Sl. No.	Name of the Activity	Points	Maximum Points Allowed
1	MOOCS (SWAYAM/NPTEL/Spoken Tutorial) (per course)	20	40
2	Tech Fest/Teachers Day/Fresher's Welcome		
	Organizer	5	10
	Participants	3	6
5	Rural Reporting	5	10
6	Tree Plantation (per tree)	1	10
7	Participation in Relief Camps	20	40
8	Participation in Debate/Group Discussion/ Tech quiz	10	20
9	Publication of Wall magazine in institutional level (magazine/article/internet)	10	20
10	Publication in News Paper, Magazine & Blogs	10	20
11	Research Publication (per publication)	15	30
12	Innovative Projects (other than course curriculum)	30	60
13	Blood donation	8	16
	Blood donation camp Organization	10	20
15	Participation in Sports/Games		
	College level	5	10
	University Level	10	20
	District Level	12	24
	State Level	15	30
	National/International Level	20	20
21	Cultural Programme (Dance, Drama, Elocution, Music etc.)	10	20
22	Member of Professional Society	10	20
23	Student Chapter	10	20
24	Relevant Industry Visit & Report	10	20
25	Photography activities in different Club(Photography club, Cine Club, Gitisansad)	5	10
26	Participation in Yoga Camp (Certificate to be submitted)	5	10
27	Self-Entrepreneurship Programme	20	20
28	Adventure Sports with Certification	10	20
29	Training to under privileged/Physically challenged	15	30
30	Community Service & Allied Activities	10	20

Annexture- II

MOOCS list for B.Tech (Hons) 1st Yr

(Credit based courses are only opt by students from this bucket, which may change time to time as on the basis of availability of online courses)

Module	Course	Provider	Duration (Weeks)	Credits
Ethics	Ethics in Engineering Practice	NPTEL	8	2
	Ethics and Law in Data and Analytics	edX	6	1
	A Life of Happiness and Fulfilment	Coursera	6	1
	Introduction to Philosophy	Coursera	5	1
	Ethical Leadership Through Giving Voice	Coursera	4	1
Soft Skills	Enhancing Soft Skills and Personality	NPTEL	8	2
	Soft Skill Development	NPTEL	8	2
	Psychology at Work	Coursera	6	2
	Communication in the 21st Century Workplace	Coursera	4	1
	Successful Career Development	Coursera	7	2
	Working in Teams: A Practical Guide	edX	4	1
	Communication theory: bridging academia and practice	Coursera	9	3
	Write Professional Emails in English	Coursera	5	2
	Effective Writing	NPTEL	4	1
	Technical Writing	Coursera	5	2
	Interpersonal Communication for Engineering Leaders	Coursera	4	1
	Enhancing Soft Skill and Personality	NPTEL	8	2
	Employment Communication A Lab based course	NPTEL	8	2
	Speaking Effectively	NPTEL	8	2
	English Language for Competitive Exams	NPTEL	12	3
	Listening Skills - The Ultimate Workplace Soft Skills	Udemy	29hrs	2
	Soft Skills: The 11 Essential Career Soft Skills	Udemy	31.5hrs	3
Programming Skills	Introduction to Programming with MATLAB	Coursera	9	3
	Introduction to Computer Science and Programming Using Python	edX	9	3
	Introduction to R for Data Science	edX	4	1
	Java Programming: Solving Problems with Software	Coursera	4	1
	Responsive Website Basics: Code with HTML, CSS, and JavaScript	Coursera	4	1
	Joy of computing using Python	NPTEL	12	3
	Programming, Data Structures and Algorithm Using Python	NPTEL	8	2
	Web Design for Everybody (Basics of Web Development and Coding) Specialization	Coursera	15	4
	An Introduction to Programming Through C++	NPTEL	12	3
	Data Science with Python Course	Simplilearn	12	3
	Python Training	Simplilearn	12	3
	Data Science with R Programming	Simplilearn	12	3
	Complete Python Boot camp From Zero to Hero in Python	Udemy	22hrs	2
	Learn Python Programming Master class	Udemy	64.5hrs	4

MOOCS list for B.Tech (Hons), 2nd to 4th Year
(Credit based courses are only opt by students from this bucket, which may change time to time as on the basis of availability of online courses)

No	Course name	Name of the Moocs Provider/ Platform	Duration (weeks)	Credits
1	Business Analytics & Text Mining Modeling Using R	Swayam	12	3
2	Drones and Autonomous Systems I: Fundamentals	Edx	6	2
3	Entrepreneurship	Swayam	15	4
4	Data Science: Productivity Tools	Edx	8	2
5	Product Design: The Delft Design Approach	Edx	7	2
6	Lean Production	Edx	6	2
7	Data Science for Engineers	Swayam	8	2
8	Introduction to Machine Learning (IITM)	Swayam	12	3
9	Python for Data Science	Swayam	4	1
10	Introduction to Internet of Things	Swayam	12	3
11	Artificial Intelligence (AI)	Edx	12	3
12	Principles of Machine Learning: Python Edition	Edx	6	2
13	Machine Learning Fundamentals	Edx	10	3
14	Introduction to the Internet of Things (IoT)	Edx	6	2
15	Artificial Intelligence : Knowledge Representation And Reasoning	Swayam	12	3
16	IBM DATA SCIENCE	Coursera	12	3
17	Data Analysis and Presentation Skills: the PwC Approach Specialization	Coursera	12	3
18	Machine Learning with Python	Coursera	12	3
19	Data Processing Using Python	Coursera	12	3
20	Advanced Data Science with IBM Specialization	Coursera	8	2
21	Data Science: Foundations using R Specialization	Coursera	12	3
22	Python for Data Science and AI	Coursera	8	2
23	Data Science: Statistics and Machine Learning Specialization	Coursera	12	3
24	Python and Statistics for Financial Analysis	Coursera	4	2
25	Applied Machine Learning in Python	Coursera	12	3
26	Machine Learning, ML	Coursera	12	3
27	Inspection and Quality Control in Manufacturing	NPTEL	4	1
28	Machining Science	NPTEL	4	1
29	Failure Analysis and Prevention	NPTEL	8	2
30	Introduction to Soft Matter	NPTEL	8	2
31	Kinematics of Mechanisms and Machines	NPTEL	8	2
32	Modeling and Simulation of Dynamic Systems	NPTEL	8	2
33	Product Design and Manufacturing	NPTEL	12	3
34	Industrial Automation and Control	NPTEL	12	3
35	Applied Ergonomics	NPTEL	12	3
36	Fuzzy Sets, Logic and System Application	NPTEL	12	3
37	Data Analytics with Python	NPTEL	12	3
38	Machine Learning	NPTEL	8	2
39	Introduction to Machine Learning	NPTEL	12	3
40	An Introduction to Artificial Intelligence	NPTEL	12	3
41	Artificial Intelligence: Knowledge Representation and Reasoning	NPTEL	12	3
42	Deep Learning	NPTEL	12	3
43	Data Science for Engineers	NPTEL	8	2
44	Introduction to Internet of Things	NPTEL	12	3
45	Introduction to Industry 4.o and Industrial Internet of Things	NPTEL	12	3
46	Introduction to Algorithms and Analysis	NPTEL	12	3

Annexture-III

Guidelines regarding Mandatory Induction Program for the new students

Engineering education has evolved globally in a continuous manner to address the twin needs of industry and society. It is now an accepted fact that the institutions imparting technical education should aspire to create manpower who will possess strong technical knowledge and skill, have leadership qualities and be a team player, capable of coming up with innovative solutions and be alive to societal and community concerns. The aim of the Induction Programme is to acclimatize the students to the environment of their engineering institution, give them a flavour of the exciting new world of education that they are entering, provide them with mentoring schemes, and make them aware of their neighbourhood, society and people. This will allow them to evolve as well rounded individuals.

The following schedule is laid down by the Institute to implement the three week long Induction Programme:

Week 1	1st Half	Day 1	Overall introduction of the new students to the Institution, its different Departments & Faculty Members
	2nd Half	Day 1	a) Assignment of faculty mentors to the new students b) Assessment and allotment for mentoring by senior students preferably from the second year
	2 hrs	Day 2, 3, 4, 5	Lectures by eminent personalities on different areas such as a) Introduction to Engineering b) Various topics of science and technology c) Innovation and entrepreneurship d) Creative and performing arts (e) Social issues
	2 hrs	Day 2, 3, 4, 5	Participation in Games, Yoga, Meditation etc.
	2 hrs	Day 2, 3, 4, 5	Visit to the different Departments of the Institute
Week 2 (AllDays)	2hrs		Scheduled class lectures as per time table.
	2hrs		Students to be conducted through proficiency modules to be prepared by respective Colleges for ascertaining English skills & Computer knowledge of the students and to prepare a report on the same
	2hrs		Participation in Games, Sports, Yoga, Creative arts etc.
Week 3	2hrs		Scheduled class lectures as per time table
		Day 1	Visits to neighborhood locations
		Day 2	Visits to natural spots in adjoining areas to understand the effect of nature on society
		Day 3	Visits to Science Museum / laboratories
		Day 4 Day 5	Visits to NGOs

Department of Mechanical Engineering

Haldia Institute of Technology, Haldia

The minutes of the meeting of the BOS, ME Department at Haldia Institute of Technology, held on 30/03/2023.

The agendas of the meeting are as follows:

Agenda 1: Reforming the syllabus of 3rd and 4th year students of B. Tech (Mechanical Engineering).

The BOS will execute this activity in timely manner

Agenda 2: There should be provision of Internship/Project work in 3rd and 4th year. A good number of Professional Electives (PE) and Open Electives (OE) would be offered considering Multidisciplinary/interdisciplinary courses.

A healthy numbers of PE and OE are considered for inclusion.

Agenda 3: It is proposed that mechanical subjects like Theory of Machine I and II would be considered. Mechanical Vibration and other topics like CAM follower, Governor, Fly wheel would be included in the Theory of Machine II.

Agenda 4: The BOS members proposed, inclusion of Finite Element Analysis and Advanced Fluid Mechanics in the Final year professional Electives.

Agenda 5: Two open electives such as AI & ML and Object Oriented Programming were initially considered. However experts suggested to eliminate ML portion and Object Oriented Programming and to retain AI only.

Agenda 6: More Electives would be offered for M. Tech (Mechanical Engineering); particularly those, which are multidisciplinary in nature.

Two new Electives; namely

(i) Industrial and Systems Engineering, and

(ii) Cyber Physical Production Systems are considered.

Additionally, one existing elective: Holonic Manufacturing Systems is completely overhauled under new title: Agent based Holonic Manufacturing Systems.

Prof. (Dr.) Souren Mitra	Prof.(Dr.) Sudip Ghosh	Prof.(Dr.) Subasis Bhowmik	Prof.(Dr.)T. K. Jana	Prof.(Dr.) G. K. Bose
30/03/23	30/03/23	30/03/23	30/3/23	30/03/23

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