CURRICULUM STRUCTURE AND DETAILED SYLLABI

FOR

MASTER OF TECHNOLOGY

IN

PRODUCTION ENGINEERING PROGRAMME

(Applicable from the academic year 2021-2022)

Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

Haringhata-741249, Nadia, West Bengal, India

Web: https://makautwb.ac.in

Maulana Abul Kalam Azad University of Technology, West Bengal
Master of Technology in Production Engineering Programme

Program Educational Objectives (PEOs)

PEO1: To practice Production engineering in manufacturing industry, public sector undertaking or as an entrepreneur for successful professional career.

PEO2: To pursue higher education for professional development.

PEO3: To exhibit leadership qualities with demonstrable attributes in lifelong learning to contribute to the societal needs.

Program Outcomes (POs)

Post-Graduates in Production Engineering will acquire:

PO1: An ability to independently carry out research/ investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/ document.

PO3: An ability to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery should be at a level higher than the requirements in the appropriate bachelor programme.

Program Specific Outcomes (PSOs)

Post-Graduates in Production Engineering will be able to:

PSO1: Understand, analyse and manage production processes and systems related to mechanical manufacturing.

PSO2: Disseminate fundamental as well as state-of-the-art knowledge in academic and/or industrial environment related to mechanical manufacturing.

PSO3: Carry out independent research efficiently and effectively in the areas of manufacturing technology and production engineering.

Maulana Abul Kalam Azad University of Technology, West Bengal
M. Tech in Production Engineering: 2021-2022
Curriculum Structure

Sl No.	Category	Subject Code	Subject Name	Total Number of contact hours			Credits
				L	T	P	
Semester-I							
Theory							
1	Program Core I	PC-PEM 101	Advances in Forming and Joining Processes	3	0	0	3
2	Program Core II	PC-PEM 102	Theory of Machining and Grinding	3	0	0	3
3	Program Elective-I	PE-PEM 103A/B	A. Advanced Engineering Mathematics B. Statistics and Probability with R	3	0	0	3
4	Program Elective-II	PE-PEM 104A/B/C/D/E/F/G/H	A. Planning and Control of Production Systems B. Project Engineering and Management C. Materials Management D. Industrial Ergonomics E. Introduction to Finite Element Methods in Engineering F. Environmental Degradation of Materials G. Production and Operation Management H. Fluid Power Control Systems: Design and Application	3	0	0	3
5	Mandatory Learning Course	MC-PEM 105	Research Methodology and IPR	2	0	0	2
6	Audit Course	AC-PEM 101A/B/C/D/E/F/G/H	Audit Course 1	2	0	0	0
	Total Theory			**16**	**0**	**0**	**14**
Practical							
1	Laboratory I	PC-PEM 191	Manufacturing Process Laboratory	0	0	4	2
2	Laboratory II	PC-PEM 192	Design Laboratory-I	0	0	4	2
	Total Practical			**0**	**0**	**8**	**4**
			Total of Semester-I	**16**	**0**	**8**	**18**
Semester-II							
Theory							
1	Program Core III	PC-PEM 201	Automation in Manufacturing	3	0	0	3
2	Program Core IV	PC-PEM 202	Modern Machining Processes	3	0	0	3
3	Program Elective-III	PE-PEM 203A/B/C/D	A. Machine Tools Engineering B. Micro and Precision Manufacturing C. Mechatronic Systems Design and Applications D. Safety and Occupational Health Management	3	0	0	3
4	Program Elective-IV	PE-PEM 204A/B/C/D/E/F	A. Quality Management B. CAD-CAM Systems C. Design of Experiments D. Advanced Welding Technology E. Product Design and Development F. Computational Fluid Dynamics	3	0	0	3
5	Audit Course	AC-PEM 201 A/B/C/D/E/F/G/H	Audit Course 2	2	0	0	0

Maulana Abul Kalam Azad University of Technology, West Bengal
M. Tech in Production Engineering: 2021-2022
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	Total Theory			**14**	**0**	**0**	**12**
Practical							
1	Laboratory III	PC-PEM 291	Manufacturing Process and Systems Laboratory	0	0	4	2
2	Laboratory IV	PC-PEM 292	Design Laboratory-II	0	0	4	2
	Total Practical			**0**	**0**	**8**	**4**
Sessional							
1	Mini Project	PW-PEM 281	Mini Project with Seminar	**2**	**0**	**0**	**2**
			Total of Semester-II	**16**	**0**	**8**	**18**
Semester-III							
Theory*							
1	Program Elective-V	PE-PEM 301A/B/C/D/E/F	A. Logistics and Supply Chain Management B. Introduction to Management Information Systems C. Robotics and Robot Applications D. Tribology and Terotechnology E. Design and Manufacture of Cutting Tool, Moulds and Dies F. Industrial Pollution and Waste Management	3	0	0	3
2	Open Elective-I	OE-PEM 302A/B/C/D/E/F/G	A. Business Analytics B. Applied Operations Research C. Cost Management of Engineering Projects D. Industrial Safety E. Composite Materials F. Waste to Energy G. Automation and Control in Industrial Application	3	0	0	3
	Total Theory			**6**	**0**	**0**	**6**
Sessional							
1	Major Project	PW-PEM 381	Dissertation-I (Progress)	0	0	20	10
			Total of Semester-III	**6**	**0**	**20**	**16**
Semester-IV							
Sessional							
1	Major Project	PW-PEM 481	Dissertation-II (Completion)	0	0	32	16
			Total of Semester-IV	**0**	**0**	**32**	**16**
Total Credits for the programme							**68**

List of Program Electives

- **Program Elective – I**

A. Advanced Engineering Mathematics (PE-PEM 103A)
B. Statistics and Probability with R (PE-PEM 103B)

- **Program Elective – II**

A. Planning and Control of Production Systems (PE-PEM 104A)
B. Project Engineering and Management (PE-PEM 104B)
C. Materials Management (PE-PEM 104C)
D. Industrial Ergonomics (PE-PEM 104D)
E. Introduction to Finite Element Methods in Engineering (PE-PEM 104E)
F. Environmental Degradation of Materials (PE-PEM 104F)
G. Production and Operation Management (PE-PEM 104G)
H. Fluid Power Control Systems: Design and Application (PE-PEM 104H)

- **Program Elective – III**

A. Machine Tools Engineering (PE-PEM 203A)
B. Micro and Precision Manufacturing (PE-PEM 203B)
C. Mechatronic Systems Design and Applications (PE-PEM 203C)
D. Safety and Occupational Health Management (PE-PEM 203D)

- **Program Elective – IV**

A. Quality Management (PE-PEM 204A)
B. CAD-CAM Systems (PE-PEM 204B)
C. Design of Experiments (PE-PEM 204C)
D. Advanced Welding Technology (PE-PEM D)
E. Product Design and Development (PE-PEM 204E)
F. Computational Fluid Dynamics (PE-PEM 204F)

- **Program Elective – V**

A. Logistics and Supply Chain Management (PE-PEM 301A)
B. Introduction to Management Information Systems (PE-PEM 301B)
C. Robotics and Robot Applications (PE-PEM 301C)
D. Tribology and Terotechnology (PE-PEM 301D)
E. Design and Manufacture of Cutting Tool, Moulds and Dies (PE-PEM 301E)
F. Industrial Pollution and Waste Management (PE-PEM 301F)

List of Open Electives

A. Business Analytics (OE-PEM 302A)
B. Applied Operations Research (OE-PEM 302B)
C. Cost Management of Engineering Projects (OE-PEM 302C)
D. Industrial Safety (OE-PEM 302D)
E. Composite Materials (OE-PEM 302E)
F. Waste to Energy (OE-PEM 302F)
G. Automation and Control in Industrial Application (OE-PEM 302G)

Audit course 1 & 2

A. English for Research Paper Writing (AC-PEM 101A/ AC-PEM 201A)
B. Pedagogy Studies (AC PEM 101B/ AC-PEM 201B)
C. Constitution of India (AC-PEM 101C/ AC-PEM 201C)
D. Disaster Management (AC-PEM 101D/ AC-PEM 201D)
E. Value Education (AC-PEM 101E/ AC-PEM 201E)
F. Stress Management by Yoga (AC-PEM 101F/ AC-PEM 201F)
G. Personality Development through Life Enlightenment Skills (AC-PEM 101G/ AC-PEM 201G)
H. Sanskrit for Technical Knowledge (AC-PEM 101H/ AC-PEM 201H)

Subject Code: PC-PEM 101	**Category:** Program Core
Subject Name: Advances in Forming and Joining Processes	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Knowledge of Solid Mechanics, Primary Manufacturing Processes	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Review basic governing equation of elasticity
CO2: Illustrate basic knowledge of plasticity and their associated mathematical treatment
CO3: Summarize knowledge of different categories of forming processes and associated mathematical treatment
CO4: Classify different types of advanced casting process
CO5: Demonstrate different types conventional and advanced types of welding processes
CO6: Illustrate welding of special materials like ceramics and plastics, etc., weldability and welding defects

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Review of Theory of Elasticity: Stress and Strain tensor, stress and strain transformation, differential equation of equilibrium, Mohr's circles (three dimensional stress situation), Plane stress and Plane strain.	8
2	Review of theory of Plasticity: Stress space, Yield criterion, Von-Mises, Tresca's yield criterion, Yield Surface, Slip Line Field theory, Stress-Strain relationships- treatment involving differential equation, Upper and Lower bound theorem.	8
3	Metal forming processes and analysis: Drawing and extrusion, rolling, forging, bending, High Energy density metal forming Processes, Powder metallurgical processes.	8
4	Advanced Casting Processes: Evaporation casting process, vacuum sealed process, shell mould casting, Rapid Prototyping and Tooling.	4
5	Review of Basic welding process and classification, power sources, arc and electrode characteristics, electrode selection, Critical and Precision welding processes like: PAW, LBW, EBW, USW, etc.	6
6	Welding of Ceramics, Plastics, Composites, Welding Metallurgy, HAZ, Weldability of Plain Carbon Steels, Stainless Steel, Cast Iron, Aluminium and its alloys, Residual stresses and distortion, testing of welding joints.	6
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Durelli, Phillip's and Tsao, Introduction to the Theory of Theoretical and Experimental Analysis of Stress and Strain, McGraw Hill Book Co.
2. Timoshenko and Goodier, Theory of Elasticity, McGraw Hill Book Co.
3. Johnson and Mellur, Engineering Plasticity, Van Nostrand-Reinhold Co.
4. Hoffman, O. and Sachs, G., Introduction to the Theory of Plasticity- Metal Forming Applications, McGraw Hill Book Co.
5. Mendelson, Introduction to Theory of Plasticity.
6. Heine, Loper and Rosenthal, Principles of Metal Casting, TMH Publication.
7. Jail, P.L., Principles of Foundry Technology, TMH Publications.
8. Udin, Funk and Wulf, Welding for Engineers, John Wiley and Sons.
9. Morris, J.L., Welding Process and Procedures.
10. Khanna, O.P., A Text Book of Welding Technology, Dhanpat Rai & Sons.
11. Parmar, R.S., Welding Engineering and Technology, Khanna Publishers, New Delhi, 2010.
11. Nadkarni, S.V., Modern Arc Welding Technology, Oxford & IBH Publishing Co. Pvt. Ltd./Advani-Oerlikon Ltd.
12. El Wakil, S.D., Processes and Design for Manufacturing, PWS Publishing.
13. Bolaji Adeyemi, Metal Forming, Khanna Book Publishing Company.

Subject Code: PC-PEM 102	**Category:** Program Core
Subject Name: Theory of Machining and Grinding	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Knowledge of Machining at the Under-Graduate Level	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Apply suitable cutting tool geometry and the method for sharpening a cutting tool.
CO2: Make use of the basics related to machining to apply them in practice
CO3: Design and construct a tool force measuring dynamometer
CO4: Utilize the understanding of tool wear phenomenon and chatter in practice field
CO5: Apply and select appropriate grinding process and process parameters in industry

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Machining, definition and objectives. Geometry of cutting tools; turning, milling and drilling - in different reference systems like machine reference system, tool reference system and work reference system. Sharpening and re-sharpening of cutting tools.	9
2	Mechanism of chip formation by single point tools, drills and milling cutters. Types of chips and their characteristics. Effective rake. Mechanics of machining, theoretical estimation and experimental determination of cutting forces and power consumption. Dynamometers; types, design, construction and use.	9
3	Thermodynamics of machining, sources of heat generation, cutting temperature modeling, measurement of cutting temperature. Cutting fluids; purpose, essential characteristics, selection and methods of application.	5
4	Cutting tools; methods of failure, mechanics of tool wear, essential properties, assessment of tool life and cutting tool materials. Causes of vibration and chatter in machining, and their remedy.	6
5	Economics of machining; principal objectives, main parameters and their role on cutting forces, cutting temperature, tool life and surface quality, selection of optimum combination of parameters.	4
6	Mechanics of grinding, characteristics, specification and selection of grinding wheels. Process and wheel parameters in grinding. Grinding forces, grinding fluid applications, grinding ratios and surface integrity. High speed grinding and modern grinding wheels.	7
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Bhattacharyya, A., Metal Cutting: Theory and Practice, Central Book Publishers, Kolkata.
2. Shaw, M.C., Metal Cutting Principles, Oxford University Press CBS.
3. Boothroyd, G., Fundamentals of Metal Machining & Machine Tools, McGraw Hill.
4. P.K. Lal , G.K., Introduction to Machining Science, New Age International Pub., New Delhi.
5. Chattopadhyay, A.B., Machining and Machine Tools, Wiley India, New Delhi.
6. Arshinov, V. and Alekseev, G., Metal Cutting Theory and Cutting Tool Design, Mir Publishers, Moscow.
7. Ghosh, A. and Mallik, A.K., Manufacturing Science, Affiliated East-West Press Pvt. Ltd., New Delhi.
8. Trent, E.M. and Wright, Metal Cutting, Butterworth Heinemam Publication.
9. Zorev, N.N., Metal Cutting Mechanics, Pergamon Press.
10. Malkin, S., Grindings Technology: Theory and Application of Machining with Abrasives, Ellis Harwood Publication, U.K.
10. Fujimasa, I., Micromachines, Oxford University Press.
11. Bolaji Adeyemi, Metal Forming, Khanna Book Publishing Company

Subject Code: PE-PEM 103A	**Category:** Program Elective-I
Subject Name: Advanced Engineering Mathematics	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basics of Engineering Mathematics	

Course Outcomes:

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

CO1: Understand the basic ideas of statistics with different characterization of a univariate and bivariate data set.

CO2: Apply statistical tools to analyze sample data set and predict characteristics of populations.

CO3: Utilize numerical methods to find eigen values and eigen vectors of a square matrix.

CO4: Apply the concept of Laplace and Fourier Transform to solve ordinary and partial differential equations.

CO5: Apply numerical methods on various mathematical operations and tasks such as interpolation, integration, solution of algebraic and transcendental equations, solutions of simultaneous linear equations and differential equations.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Statistics: Elements of statistics; frequency distribution, concept of mean, median, mode and different types of distribution; Standard deviation and Variance; Curve fitting by least square method; Correlation and Regression; Testing of hypothesis; Basic types of factorial design and analysis of variance (ANOVA).	12
2	Matrix Operation: Matrix operations; Eigen value and Eigen vector by iterative methods; Diagonalisation of a square matrix.	6
3	Laplace Transform, Fourier Transform; Fourier Integral and their applications.	8
4	Numerical methods: Interpolation by polynomials; Error analysis; Solution of system of linear equation by Gauss-Seidel iterative method; Newton-Raphson method; Numerical integration by Gauss-quadrature; solution of ordinary differential equation by Rayleigh-Ritz method.	14
	Total number of contacts (Hr.)	40

Learning Resources:

1. Reena Garg, Advanced Engineering Mathematics, Khanna Book Publishing (AICTE Recommended)
2. Sastry, S.S., Introductory Methods of Numerical Analysis, PHI.
3. Jain, M.K., Iyengar, S.R.K. and Jain, R.K., Numerical Methods for Scientific and Engineering Computation, New Age International Pub.
4. Goon, A.M., Gupta, M.K. and Dasgupta, B., An Outline of Statistical Theory, Volume I and

II, The World Press Private Ltd.
4. Adler, Yu.P., Markova, E.V. and Granovsky, Ylu.V., The Design of Experiments to Find Optimal Conditions, MIR Publication, Moscow, 1975.
5. Kreyszig, E., Advanced Engineering Mathematics, John Wiley & Sons.
6. Grossman, S. and Derrick, W.R., Advanced Engineering Mathematics, Harper & Row Publishers.
7. Cochran, W.C. and Cox, G.M., Experimental Designs, John Wiley & Sons, New York.
8. Montgomary, D.C., Design and Analysis of Experiments, Wiley-India Edition.
9. Roy, R.K., Design of Experiments Using the Taguchi Approach, Wiley-India Edition, New York, 2001.

Subject Code: PE-PEM 103B	**Category:** Program Elective-I
Subject Name: Statistics and Probability with R	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basics of Engineering Mathematics and Statistics	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Demonstrate the language and core concepts of probability theory.
CO2: Apply basic principles of statistical inference.
CO3: Make use of programming language R to do statistics.
CO4: Apply, examine, and conclude statistical information.
CO5: Develop skills for further coursework or on-the-job study.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Basic Statistical Concepts: Populations and Samples; Some Sampling Concepts; Random Variables and Statistical Populations; Basic Graphics for Data Visualization; Proportions, Averages, and Variances; Medians, Percentiles, and Boxplots; Comparative Studies; The Role of Probability; and Approaches to Statistical Inference	5
2	Introduction to Probability: Sample Spaces, Events, and Set Operations; Experiments with Equally Likely Outcomes; Axioms and Properties of Probabilities; Conditional Probability; and Independent Events Random Variables and Their Distributions: Describing a Probability Distribution, Parameters of Probability Distributions, Models for Discrete Random Variables, and Models for Continuous Random Variables Jointly Distributed Random Variables: Describing Joint Probability Distributions, Conditional Distributions, Mean Value of Functions of Random Variables, Quantifying Dependence, and Models for Joint Distributions	9
3	Some Approximation Results: The LLN and the Consistency of Averages, Convolutions, and The Central Limit Theorem Fitting Models to Data: Some Estimation Concepts, Methods for Fitting Models to Data, and Comparing Estimators: The MSE Criterion Confidence and Prediction Intervals: Introduction to Confidence Intervals, CI Semantics: The Meaning of "Confidence", Types of Confidence Intervals, The Issue of Precision, and Prediction Intervals.	7

4	Testing of Hypotheses: Setting Up a Test Procedure, Types of Tests, and Precision in Hypothesis Testing Comparing Two Populations: Two-Sample Tests and CIs for Means, The Rank-Sum Test Procedure, Comparing Two Variances, and Paired Data Comparing k>2 Populations: Types of k-Sample Tests, Simultaneous CIs and Multiple Comparisons, and Randomized Block Designs	7
5	Multifactor Experiments: Two-Factor Designs, Three-Factor Designs, and 2^r Factorial Experiments	5
6	Polynomial and Multiple Regression: The Multiple Linear Regression Model, Estimation, Testing, and Prediction, and Additional Topics	4
7	Statistical Process Control: The $\bar{X}$ Chart, The S and R Charts, The p and c Charts, and CUSUM and EWMA Charts	3
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Michael, A., Probability & Statistics with R for Engineers and Scientists, Pearson, 2015.
2. Amit Gupta, The Practice of Business Statistics, Khanna Book Publishing House
3. Gupta, B.C., Guttman, I. and Jayalath, K.P., Statistics and Probability with Applications for Engineers and Scientists Using MINITAB, R and JMP, Wiley.
4. Jeeva Jose, Beginner's Guide for Data Analysis using R Programming, Khanna Book Publishing Company.

Subject Code: PE-PEM 104A	**Category:** Program Elective-II
Subject Name: Planning and Control of Production Systems	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic concepts of Production Systems	

Course Outcomes:

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

CO1: Evaluate the design of tangible and intangible products efficiently and choose the optimum production process.

CO2: Apply the concept of forecasting as an interface of marketing and materials handling tool.

CO3: Apply the concepts of Engineering Economic Analysis like creation of business strategies so that the production house can achieve Break-Even analysis earlier. Modify/ appraise the Learning curve to understand Life Cycle analysis and Capacity Requirement Planning.

CO4: Evaluate facility planning. Create effective Plant layout to support retrofit and to select equipments and maintenance process.

CO5: Appraise Materials management to control Inventories, MRP & MRP-II, Smoothing of production process through Assembly Line Balancing and leveling of Human resources as major parameters of production system.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Analysis of different types of Organizational Structure to choose the effective structure to optimize production processes for designing and development of tangible and intangible products.	5
2	Different forecast techniques as interfaces of marketing and materials requirements for an uninterrupted production process.	7
3	Engineering Economic Analysis to sort out the problems related to capital investments, risk analysis, break-even analysis, product and process life cycle analysis and capacity requirement planning.	7
4	Selection of Location and Designing of Plant Layout effectively to ease the process of retrofit and optimization of production process.	7
5	Materials management to control Inventories, MRP & MRP-II, and Smoothing of production process through Assembly Line Balancing and leveling of human resources.	7
6	Knowledge of Six-Sigma, Acceptance sampling for Production monitoring, control and performance appraisal. Evaluation of Planning and Control of Production Systems through case study.	7
	Total number of Contacts (Hr.)	**40**

Learning Resources:

1. Buffa, E.S. and Sarin, R.K., Modern Production/Operations Management, John Wiley & Sons, 8th edition, 1994.
2. Bedi, K., Production and Operations Management, Oxford University Press, 3rd edition, 2013.
3. Adam, J.E. and Ebert, R.J., Production and Operations Management: Concepts, Models, and Behavior, PHI Learning Private Limited, 5th edition, 2010.
4. Riggs, J.L., Production Systems: Planning, analysis and Control, John Wiley & Sons, 4th edition, 1987.
5. Chary, S.N., Production and Operations Management, Tata McGraw-Hill Publishing Co. Ltd., 4th edition, 2009.

Subject Code: PE-PEM 104B	**Category:** Program Elective-II
Subject Name: Project Engineering & Management	**Semester**: **First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic idea in Engineering Economics and Operations Research	

Course Outcomes:

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

CO1: Classify different types of industrial projects, different steps of project formulation and roles of different parties involved in a project

CO2: Explain the procedure of market appraisal, demand analysis and measure elasticity of demand

CO3: Illustrate the procedure of technical appraisal, technology acquisition, layout design and project scheduling

CO4: Appraise a project proposal using different financial evaluation methods and conclude on financial status of a company from the annual report

CO5: Assess the economic contribution of a project through social cost-benefit analysis

CO6: Determine project duration by applying different networking techniques, eg., PERT and CPM

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Definition and classification of projects, Objectives and importance, role of entrepreneur, consultant and vendor, Types of contract, Steps of project formulation, Feasibility Report, Design Basis Report, Detailed Project Report, Approval from various statutory bodies and govt. departments.	6
2	Market Appraisal, Market and demand analysis, Elasticity of demand.	6
3	Technical analysis, Technology acquisition, Requirement of machinery, utilities, land, building etc., Plant layout, Project scheduling.	8
4	Financial Analysis: Cost of project, cost of capital, means of finance, norms and policies of financial Institutions, Government incentives; Estimate of sales, cost of production, working capital requirement and financing; Profitability, projection and statements, treatment of depreciation and taxes, pre-operative expenses, projected cash flows, projected balance sheet, financial appraisal criteria, viz. NPV, IRR, payback period, BCR, BEP and key financial ratios. Sensitivity and risk analysis. Application for financial assistance and incentives.	8
5	Social cost benefit analysis, environmental perspective, selection of site and factors involved.	6

6	Project Implementation: Pre-requisites of successful project implementation, Network techniques for project planning and control- PERT and CPM.	6
	Total number of contacts (Hr.)	40

Learning Resources:

1. Chandra, P., Projects- Planning, Analysis, Selection, Implementation & Review, McGraw-Hill, New Delhi.
2. Wiest, J.D. and Levy, F.K., A Management Guide to PERT/CPM, 2nd Ed., Prentice Hall of India, New Delhi.
3. van Horne, J.C., Financial Management Policy, 12th Ed. (Low Priced Edition), Pearson Education Asia, Singapore.
4. ICFAI, Institute of Chartered Financial Analysis of India, Hyderabad.
5. Punmia, B.C. and Khandelwal, K.K., Project Planning and Control with PERT and CPM, 4th Edition, Laxmi Publications Private Limited, 2016.
6. Singh, K. and Kansal, M.L., Project Planning and Management with CPM and PERT, HP Hamilton Limited, 2021.
7. Maylor, Project Management, Pearson Education, 3rd Ed., 2004.

Subject Code: PE-PEM 104C	**Category:** Program Elective-II
Subject Name: Materials Management	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic knowledge of Production Management, Inventory Management	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Apply forecasting, vendor rating, material inspection and acceptance sampling in industrial situation
CO2: Classify inventory items using ABC, VED and FSN analyses
CO3: Apply control theory in materials management
CO4: Determine the material management strategy to apply considering legalities

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Integrated material management; The material cycle, forecasting material need, procurement and storage; Vendor rating, incoming material inspection and acceptance sampling.	10
2	Classification of Inventory; ABC, VED and FSN analysis: Case Study.	8
3	Standardization, codification and variety reduction, control of level of inventory and frequency of purchase, Assessment of risk of inventory through Beta analysis in uncertain conditions of demand, Kanban inventory, TOC, SCM, MRP and JIT. Optimal Control theory in materials management.	12
4	Material management and Legal Environment; Value Analysis, Price Negotiation Strategies, Information System for Effective materials management, Application of Soft Computing in materials management.	10
	Total number of contacts (Hr.)	40

Learning Resources:

1. Vollmann, Bery and Whybarn, Manufacturing Planning and Control Systems, McGraw Hill Publication, New Delhi.
2. Gopalakrishnan, P. and Sundaresan, M., Materials Management: An Integrated Approach, PHI, New Delhi, 2011.
3. Tony Arnold, J. R. and Chapman, S.N., Introduction to Materials Management, Prentice Hall, 2001.

Subject Code: PE-PEM 104D	**Category:** Program Elective-II
Subject Name: Industrial Ergonomics	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic knowledge of Industrial Management	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Apply appropriate human factors to improve performance in a production system
CO2: Determine bio-engineering aspects of human motor activity to apply to raise productivity
CO3: Design workplace and work-components considering characteristics of individuals
CO4: Apply work design, method study and work measurement techniques in industry

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Defining human factors in a production system; Characteristic features of man-machine system; Human Performance and Reliability; Human sensory motor system, Stimulus Dimensions, Human information processing, noise and the theory of signal detection (TSD), quantitative and qualitative visual displays, Human factors associated with speech communication.	12
2	Introduction to Kinosiology; Bio-mechanics and bio-engineering aspects of human motor activity; Performance analysis of limbs in making specific types of movements; Energy expenditure in physical activities, Spatial movements and conceptual relationships of stimuli and responses; Continuous control systems, types of control functions, tools and related control device.	10
3	Design of workplace and work-components; Applied anthropometry, activity analysis, Work arrangement by simulation, Design of individual workplace, Human performance under heat, cold, illumination, vibration, noise, pollution, static and dynamic conditions.	12
4	Work design, method study and work measurement techniques.	6
	Total number of contacts (Hr.)	40

Learning Resources:

1. McCormick, E.J., Human Factors in Engineering and Design, McGraw Hill Publication.
2. Niebel, B. and Freivalds, A., Methods, Standards and Work Design, McGraw Hill Publication.
3. Nag, P.K., Ergonomics and Work Design, New Age International Publication.
4. S.C. Sharma, Industrial Engineering & Management, Khanna Book Publishing Company.

Subject Code: PE-PEM 104E	**Category:** Program Elective-II
Subject Name: Introduction to Finite Element Methods in Engineering	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basics of Mathematics of Under-Graduate Level	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Summarize the basic mathematical tool required for this course
CO2: Compare the different approaches in Finite Element Methods
CO3: Construct the Finite Element Models for one dimensional problem in detail.
CO4: Apply knowledge the Knowledge of one dimensional problem to Machine Frames.
CO5: Analyze Different Types of two Dimensional Problems in Finite Element Methods
CO6: Construct the Finite Element Models for Beams and Frames in detail.
CO7: Build and solve Scalar Field Problems with the use of Finite Element Methods.
CO8: Apply the Knowledge to Commercial Software and Programming.

Module No.	Description of Topic	Contact Hrs.
1	Matrix Algebra and Gaussian Elimination: Matrix algebra, Gaussian elimination, conjugate gradient method for equation solving.	4
2	Fundamental Concepts: Outline of presentation, stress and equilibrium, boundary conditions, strain-displacement relations, stress-strain relations, temperature effect, potential energy and equilibrium, the Rayleigh-Ritz Method, Galerkin's method, saint Venant's principle, von Misses stress, computer programming, historical references.	5
3	One Dimensional Problems: Introduction, finite element modeling, coordinates and shape functions, the potential energy approach, the Galerkin approach, assembly of the global stiffness matrix and load factor, properties of stiffness matrix [K], finite element equations, treatment of boundary conditions, quadratic shape functions, temperature effects.	6
4	Machine Frames: Introduction, plane trusses, assembly of global stiffness matrix for the banded and skyline solutions.	3
5	Two-Dimensional Problems Using Constant Strain Triangles: Introduction, finite element modeling, constant strain triangle (CST), problem modeling and boundary conditions, orthotropic materials. Axi-Symmetric Solids Subjected to Axi-Symmetric Loading: Introduction, Axi-symmetric formulation, finite element modeling, triangular element, problem modeling and boundary conditions.	6
6	Two Dimensional Iso-Parametric Elements and Numerical Integration: Introduction, four-node quadrilateral, numerical	4

	integration, higher-order elements.	
7	Beams and Frames: Introduction, finite element formulation, load vector, boundary considerations, shear force and bending moment, plane frames.	4
8	Scaler Field Problems: Introduction, steady-state heat transfer, torsion, potential flow, seepage, fluid flow in ducts, unsteady 1-D and 2-D heat conduction problems.	6
9	Pre-Processing and Post-processing: Introduction, mesh generation, post-processes.	2
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Chandrupatla, T.R. and Belegundu, A.D., Introduction to Finite Elements in Engineering, 2nd Edition, Prentice Hall of India Publication.
2. Seshu, P., Textbook of Finite Element Analysis, PHI Learning Pvt. Ltd.
3. Reddy, J.N., An Introduction to the Finite Element Method, McGraw-Hill, New York.
4. Bhavikatti, S.S., Finite Element Analysis, New Age International.
5. Hutton, D.V., Fundamentals of Finite Element Analysis, McGraw-Hill, New York.
6. Segerlind, L.J., Applied Finite Element Analysis, 2nd Edition, Wiley & Sons Publication.

Subject Code: PE-PEM 104F	**Category:** Program Elective-II
Subject Name: Environmental Degradation of Materials	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basics knowledge in Chemistry and Materials Science and Metallurgy	

Course Outcomes:

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

CO1: Determine types of corrosion by obtaining the basic knowledge about types of corrosion, thermodynamics and kinetics of corrosion

CO2: Apply different corrosion control strategies by analyzing the characteristics of corroded components

CO3: Select materials and suitable strategy to combat corrosion in practical situation

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction: Definitions, Different forms of Environmental degradation, Cost of Corrosion, Electrochemical Nature, Aim.	4
2	Thermodynamics: Process at Interface, Free Energy and Electrochemical Potential, EMF Series, Nernst Relationship, Important Reactions, Cell Potential, Reference Electrodes, Advanced Thermodynamics (E-pH Diagrams).	4
3	Kinetics: Current Density and Corrosion Rate, Exchange Current Density, Polarization, Experimental Techniques. Mixed Potential Theory: Postulates, Applications to Active Metals.	5
4	Passivation: Historical Interest, Polarization Behaviour, Application of Mixed Potential Theory.	4
5	Forms of Corrosion: Uniform, Galvanic, Intergranular, Crevice, Pitting, De-alloying, Erosion, Stress related corrosion, Different Factors- Metal Purity, Crystal Defects, Grain Structure, Concentration cells, Velocity, Temperature, Humidity, Stress, Microbial effect, Liquid metal effect. High Temperature Oxidation: Reactions, Thermodynamics, Oxide Structure, Oxide Growth, Hot Corrosion.	8
6	Corrosion Measurement and Failure Analysis: Philosophy, Laboratory Tests, Electronic Probes.	3
7	Corrosion Control: Philosophy, Materials Selection- Stainless Steels, Nickel and Nickel Alloys, Other Metal Alloys, Plastics, Nonmetallics, Protective Coatings/ Claddings- Metallic Coatings, Conversion Coatings, Organic Coatings, Ceramic Coatings, Cladding, Inhibitors- Passivators, Barrier Inhibitors, Poisons, Scavengers, Neutralizers, Mixed Potential Theory Approach, Electrical Methods- Sacrifical Anode Cathothic Protection, Impressed Current Cathodic Protection, Anodic Protection, Mixed Potential Theory Analysis, Corrosion	6

	Control by Design- Establishing Uniform Corrosion, Minimization of Moisture Condensation, Prevention of Galvanic Cells, Prevention of Environment Cells, Prevention of Corrosion-Mechanical Interactions, Design for Inspection and Maintenance.	
8	Degradation of Polymeric Materials: Swelling and Dissolution, Bond Rupture, Weathering, Other Processes, Polymer Cycling and Degradation. Corrosion of Composite Materials: Galvanic Effects, Matrix Nature, Reinforcement Nature, Prevention. Future Outlook: Corrosion and Society, Research, Industry.	6
	Total number of contacts (Hr.)	40

Learning Resources:

1. Uhlig, H.H. and Revie, R.W., Corrosion and Corrosion Control, Wiley, New York, 1985.
2. Fontana M.G., Corrosion Engineering, McGraw Hill.
3. M.P. Poonia, S.C. Sharma & Santosh Kumar, Environmental Studies, Khanna Book Publishing House, 2021.
4. M.P. Poonia, S.C. Sharma & Santosh Kumar, Environmental Engineering, Khanna Book Publishing Company, 2021.
5. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Book Publishing House, 2018 (AICTE Recommended Textbook)
6. Shreir, L.L., Corrosion, Vol I and II, Butterworths, Kent, 1976.
7. Pourbaix, M., Atlas of Electrochemical Equilibria in Aqueous Solutions, NACE, Houston, 1974.
8. Bockris, J.O.M. and Reddy, A.K.N., Modern Electrochemistry, Vol. I and II, Plenur Press, New York, 1970.
9. Staehle, R.W., Fundamental Aspects of Corrosion of Metals in Aqueous Environments, Special Lecture Series on the fundamentals of corrosion, Univ. of Minnesota, USA, 1968.
10. NPTEL, Course on Advances in Corrosion Engineering, http://www.iitm.ac.in.

Subject Code: PE-PEM 104G	**Category:** Program Elective-II
Subject Name: Production and Operations Management	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic concept of Production and Manufacturing processes	

Course Outcomes:

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

CO1: Understand Product Life Cycle and apply Production and Operations Management in highly competitive corporate.

CO2: Apply scheduling of operations as per forecast and maintain Statistical Quality Control.

CO3: Apply Facility Layout, MRP & MRP-II. Apply optimization through Facility Layout, Assembly Line Balancing and Line of Balance (LOB).

CO4: Apply modern and sophisticated techniques of Supply Chain Management (SCM) and apply Soft-Computing to Production Management.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Improvement of Organizational Effectiveness through Production and Operations Management, Determination of Product and Process Life Cycle of the corporate world.	8
2	Applying Scheduling and Inventory Control and developing an overall idea of MRP on the basis of Forecasting. Knowledge of maintaining Statistical Quality Control in the production house.	8
3	Choosing the criteria of capital investment for minimizing risk so as to adopt suitable technique for designing of product and process properly. Developing MRP and MRP-II. Apply optimization through Facility Layout, Assembly Line Balancing and Line of Balance (LOB).	8
4	Impact of improved productivity to improve organizational efficiency in strategy making for further implementation.	8
5	Apply modern and sophisticated customer-centric techniques of Supply Chain Management (SCM) and apply Soft-Computing to Production Management.	8
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Adam, E.E., Jr. and Ebert, R.J., Production and Operations Management, Prentice Hall Publication.
2. Shore, B., Operations Management, EMH Publishing Co. Ltd., India.
3. George, G.S., Management for Business and Industry, PHI Publication.

4. Buffa, E.S., Production/ Operations Management, PHI Publication.
5. Adam and Ebert, Production and Operations Management- Concepts Mode1s and Behaviour, 5th Ed., PHI Publication.
6. Okino, C.H., Advances in Production Management Systems, Narosa Book Distributors Pvt. Ltd.
7. Bennett, J.W., The Management of Engineering, Narosa Book Distributors Pvt. Ltd.
8. Muthelemann, A.W., Production and Operations Management, Narosa Book Distributors Pvt. Ltd.
9. Bolton, W., Production and Operations Management, Orient Longman Pub.
10. Tenner, A. and Detoro, I.J., Total Quality Management, Addison Wesley Publication.
11. Wagner, H.M., Principles of Operations Research, Prentice Hall of India, 2010.

Subject Code: PE-PEM 104H	**Category: Program Elective-II**
Subject Name: Fluid Power Control Systems: Design and Application	**Semester: First**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic concepts of Fluid Mechanics and Fluid Machinery	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Utilize the understanding of the fluid power control systems and their applications
CO2: Adapt the working principles of different components of pneumatic and hydraulic system
CO3: Develop fluid power control circuits to suit an application
CO4: Make use of hydraulic actuators, hydraulic valves
CO5: Illustrate the electrical devices for controlling fluid power control systems

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Hydraulics and Pneumatics Power Control Systems:** Components of a hydraulic and pneumatic system, Applications, Desired properties of a hydraulic fluid.	6
2	**Hydraulic Actuators:** Features of single acting and double acting hydraulic cylinders; mounting of cylinders, cushioning of cylinder; force, velocity and power from a cylinder.	6
3	**Hydraulic Valves:** Different types of valves and their applications; Operation and graphical symbol of 3 way and 4 way Direction Control Valve; different modes of activation of valves; Operation of check valves, pressure relief Valve, pressure reducing valve, unloading valve and flow control valve.	8
4	**Analysis of different hydraulic circuits:** Single and double acting cylinder control, regenerative circuit, pump unloading circuit, double pump hydraulic system, cylinder synchronization circuit, to lift and hold heavy load, automatic sequencing of two cylinders.	8
5	**Pneumatic power control system:** Working principle and use of filter, pressure regulator, lubricator; Compressed air distribution system in a plant; Drawing pneumatic circuits for different operations.	6
6	**Electrical devices for controlling fluid power control circuits: E**lectrical devices like push-button switches, limit switches, pressure switches, solenoids, relays and timers and their symbols.	6
	Total number of contacts (Hr.)	40

Learning Resources:

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

Subject Name: Research Methodology and IPR	**Category:** Mandatory Learning Course
Subject Code: MC-PEM 105	**Semester: First**
L-T-P: 2-0-0	**Credit: 2**
Prerequisite: Basic knowledge in English	

Course Outcomes:

On completion of this course the students will be able to:

CO1: Develop an understanding on different types of research problems, different steps of formulation of research problems according to their roles in real life.

CO2: Generate research questions associated with research problems.

CO3: List various sources of information for literature review and data collection

CO4: Apply different research techniques and methodologies for implementation so that research problem can be solved.

CO5: Develop an understanding on the role of Intellectual Property Rights (IPR) and its laws which can protect the researchers for promoting new and better products and in turn brings about socio-economic benefits.

Course contents:

Module No.	Description of Topic	Contact Hour
1	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.	6
2	Effective Literature Review: Approaches, Analysis Plagiarism, Research ethics.	3
3	Effective Technical Writing: How to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	4
4	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	6
5	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	3
6	New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	4
	Total number of contacts (Hr.)	**26**

Learning Resources:

1. Melville, S. and Goddard, W., Research Methodology: An Introduction for Science and Engineering Students, Kenwyn, Juta & Co. Ltd., 1996.
2. Goddard, W. and Melville, S., Research Methodology: An Introduction, Juta Academic, 2nd Ed., 2014.
3. Alley, M., The Craft of Scientific Writing, Springer, 4th Ed., 2018.
4. Kumar, R., Research Methodology: A step-by-step guide for beginners, SAGE, 5th Ed., 2018.
5. Kothari, C.R. and Garg, G., Research Methodology: Methods and Techniques, New Age International Publishers, 4th Ed., 2019.

Subject Code: PC-PEM 191	**Category:** Program Core Practical
Subject Name: Manufacturing Process Laboratory	**Semester:** First
L-T-P: 0-0-4	**Credit: 2**
Pre-Requisites: Basic Knowledge of Manufacturing Processes at the Under-Graduate Level	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Identify the quality of green sand mould to obtain sound casting
CO2: Demonstrate metallographic sample preparation to observe and interpret microstructures
CO3: Evaluate soundness of welding and determine influence of welding process parameter on weld quality
CO4: Examine the change in surface grinding performance with number of passes
CO5: Construct a cutting tool with given tool geometry
CO6: Experiment with machining process by varying parameters to achieve required machinability
CO7: Make use of metal forming and other manufacturing process to characterize them

Course contents:

Laboratory Modules are to be on the following areas:
1) Testing of moulding sand, and Casting of non-ferrous metals / alloys
2) Heat Treatment and Metallographic studies
3) Characterization and Testing of Fabrication processes: GMAW, GTAW, etc.
4) Surface Grinding operation and its parametric dependence
5) Grinding of Cutting Tools with a given tool signature
6) Chip formation in machining processes under different process parameters
7) Metal forming, etc.

Subject Code: PC-PEM 192	**Category:** Program Core Practical
Subject Name: Design Laboratory-I	**Semester:** First
L-T-P: 0-0-4	**Credit: 2**
Pre-Requisites: Basic Knowledge of Computer Aided Drafting	

Course Outcomes:

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

CO1: Obtain a working knowledge of component drafting and drawing using AutoCAD or equivalent software.

CO2: Able to perform stress analysis using standard tools like ANSYS, etc.

CO3: Get experience with CAD/CAM tools such as Solid Edge, ProEngineer, and others to accomplish component manufacturing as well as learning how to use Project Engineering software for making an object using CAM.

Course contents:

Laboratory Modules on the following areas:

1) Component drafting and drawing through AutoCAD or similar software
2) Stress analysis using standard software such as ANSYS, etc.
3) Use of CAD/CAM software like Solid Edge, ProEngineer, etc. for component manufacture
4) Use of a Project Engineering Software, etc.

Subject Code: PC-PEM 201	**Category:** Program Core
Subject Name: Automation in Manufacturing	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Knowledge of Manufacturing Processes and Machining at the Under-Graduate Level	

Course Outcomes:

On completion of this course the students will be able to:

CO1: Develop an understanding on different types of hard automation and flexible automation machines and systems and their applications.

CO2: Apply the programming expertise for making a component in a CNC machine after making process plan and selection of tools

CO3: Apply the knowledge of robotics to select a robot for a specific application

CO4: Develop an understanding on the application of group technology, process monitoring, product development and inspection system using CMM in automated industry

Course contents:

Module No.	Description of Topic	Contact Hour
1	Review of basic principles of automation, type and degree of automation, hard automation and flexible automation, working of stand alone semi-automatic machine tools- turret and capstan lathes, stand alone automatic machine tools, multi-spindle machine tools, transfer machines.	6
2	Introduction to computer aided manufacturing (CAM) systems, basic building blocks of computer integrated manufacturing (CIM).	4
3	Numerical Control Machines and Systems- CNC, DNC (Direct and Distributed), FMC, FMM, FMS, Machining Centres, CAPP, Part Programming on CNC machines for machining, EDMing, forming, etc. using G and M codes, APT, etc., toolings of CNC machines; Adaptive Control systems, tool and work handling systems involving robot, AGV, AS/RS, ATC, APC, etc.	12
4	Robotics; types, anatomy, drives, kinematics, controls, and applications of the robot.	12
5	Computer aided production planning and control, CAD-CAM interface, Manufacturing from product design- concept of group technology (GT), Control systems, Process monitoring, Automatic inspection systems, use of CMM.	6
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Groover, M.P., Automation, Production Systems and Computer-Integrated Manufacturing,

Prentice Hall of India.
2. Zeid, I., CAD/CAM- Theory and Practice, McGraw-Hill Publishing Co. Ltd., New Delhi.
3. Groover, M.P. and Zimmers, E.W. Jr., CAD/CAM, Prentice Hall of India.
4. Radhakrishnan, P., Subramanyan, S. and Raju, V., CAD/CAM/CIM, New Age International Publishers.
5. Rao, P.N., Tewari, N.K. and Kundra, T.K., Computer Aided Manufacturing, McGraw-Hill Publication.
6. Deb, S.R., Robotics Technology and Flexible Automation, McGraw-Hill Publication.
7. Kumar, S., Industrial Robots and Computer Integrated Manufacturing, Oxford & IBH Publishing Co. Ltd.
8. Mahapatra, P.B., Computer-Aided Production Management, Prentice Hall of India.

Subject Code: PC-PEM 202	**Category:** Program Core
Subject Name: Modern Machining Processes	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic concept in Non-Conventional Machining	

Course Outcomes:

On completion of this course the students will be able to:

CO1: Categorize by understanding the various unconventional manufacturing processes based on energy sources and mechanism employed

CO2: Analyze the process and evaluate the role of each process parameter during machining of advanced materials.

CO3: Model the material removal in various modern manufacturing processes

CO4: Select the best suitable advanced manufacturing process for processing of unconventional materials employed in modern manufacturing industries

CO5: Develop an understanding on the concept of hybrid machining and high-speed machining

Course contents:

Module No.	Description of Topic	Contact Hour
1	Modern Machining Processes; Non-traditional machining: Introduction, Specific applications and advantages over Traditional Machining Processes; Need of High production rate machining.	4
2	Mechanical Non-Traditional Machining Processes; Ultrasonic Machining, Abrasive Jet Machining, Water Jet Machining, and Abrasive Water Jet Machining; Process details, parametric effects, recent advancements and modelling.	10
3	Thermal Non-Traditional Machining Processes; Electro discharge Machining, Plasma Arc Machining, Electron Beam Machining, and Laser Beam Machining; process, parameters, recent advances and modelling.	10
4	Chemical and Electrochemical processes; Chemical Machining, Electro Chemical Machining and Electrochemical grinding. Hybrid-type systems; Electro Chemical Discharge Machining, Ultrasonic-assisted Electro Discharge Machining, ELID during grinding and other types.	8
5	High Production Rate Machining and Grinding; Designing suitable tooling, cutting fluid application; alternative processes- hot machining, stretch machining, etc.; obstacles faced and possible remedies. Micro and Nano machining, Environment friendly machining. Intelligent Manufacturing Systems: Fuzzy, Neural Networks, Genetic Algorithms to be applied in smart/ digital manufacturing. Indusrty 4.0: Cyber Physical Manufacturing System.	8
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Pandey, P.C. and Shan, H.S., Modern Machining Processes, Tata McGraw-Hill Publication.
2. Mishra, P.K., Non-Conventional Machining, Narosa Publishers.
3. El-Hofy, H.A.G., Advanced Machining Processes- Nontraditional and Hybrid Machining Processes, McGraw-Hill.
4. Ghosh, A. and Mallik, A.K., Manufacturing Science, East-West Publications.
5. Kalpakjian, S., Manufacturing Engineering and Technology, Addison Wesley.
6. DeGarmo, E.P., Black, J.T. and Kohser, R.A., Materials and Processes in Manufacturing, Prentice Hall of India.
8. Khanna, O.P. and Lal, M., A Text Book of Production Technology, Dhanpat Rai and Sons.
9. Ghosh, A., Rapid Prototyping: A Brief Introduction, East West Publication.
10. Amstead, Ostwald and Begeman, Manufacturing Processes, John Wiley and Sons.
11. Fujimasa, I., Micromachines, Oxford University Press.
12. Murty, R.L., Precision Engineering in Manufacturing, New Age International Publishers.
13. Rykalin, N., Uglov, A. and Kokora, A., Laser Machining and Welding, Mir Publishers, Moscow.

Subject Code: PE-PEM 203A	**Category:** Program Elective-III
Subject Name: Machine Tools Engineering	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basics of Machine Tools at Under-Graduate Level	

Course Outcomes:

On completion of this course the students will be able to:

CO1: Categorize Chronological developments of machine tools and selection of machine tool and its drive system for different purposes.
CO2: Design of machine elements for strength, rigidity and life.
CO3: Illustrate the design of speed and feed in stepped and non-stepped regulation.
CO4: Summarize Mechatronic elements of a CNC machine and machine tool error analysis.
CO5: Analyze machine tool vibration and its associated effects.
CO6: Apply acceptance tests of machine tools
CO7: Summarize advanced machine tool systems like Agile manufacturing and Reconfigurable machining system and ergonomics.

Course contents:

Module No.	Description of Topic	Contact Hour
1	Chronological developments of machine tools, design principles of metal cutting machine tools, machine kinematics, criterion for selection of operating capacity and design parameters, analysis of formative motions and preparation of layouts, concept of standardization.	5
2	Design of elements for strength, rigidity and life.	3
3	Design of Speed and Feed box, stepless regulations of speed and feed, machine tool structure, design of bed, headstock, guide ways, slide ways, structure analysis, use of finite element method	6
4	Concepts of oil hydraulics and pneumatics, electro hydraulics servo mechanisms, basic configuration of hydraulic power supplies, bypass regulated and stroke regulated hydraulic power supplies, heat generation and dissipation in hydraulic systems, hydraulic control elements- DCV, PCV, FCV, valve configuration and analysis.	10
5	Mechatronic elements of a CNC machine, machine tool error analysis, sources of error, error compensation strategies, use of neural networks.	4
6	Machine tool dynamics, free and forced vibrations, review of multiple degree of freedom systems, response to excitations, models of vibrations, self excited vibrations, random vibrations and stability analysis	6
7	Acceptance tests of machine tools.	3
8	Agile manufacturing, Reconfigurable machining systems, Application of ergonomics in machine tool design.	3
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Sen, G.C. and Bhattacharya A., Principles of Machine Tools, Central Book Publishers, Kolkata.
2. Acherkan, J.N., Machine Tool Design, Vol. 1 to 4, MIR Publishers, Moscow.
3. Mehta, N.K., Machine Tool Design, Tata McGraw Hill Publications.
4. Blackburn, J.F., Reetholf, G. and Shearer, J.L., Fluid Power Control, Technology Press of MIT and Wiley, New York.
5. Ernst, W., Oil Hydraulic Power and Its Industrial Applications, 2nd Ed., New York, McGraw Hill.
6. Merrit, H.E., Hydraulic Control Systems.
7. Shleisinger, G., Testing of Machine Tools, Pergamon Press.
8. Meirovitch, L., Elements of Vibration Analysis, McGraw Hill Co.
9. Bolton, W., Mechatronics, Addition Wesley Longman, Singapore.
10. HMT Limited, Mechatronics, Tata McGraw Hill.
11. Murty, R.L., Precision Engineering in Manufacturing, New Age International Publishers.
12. Nag, P.K., Ergonomics and Work Design, New Age Int. Publishers.
13. Groover, M.P., Mechanical Vibration, PHI Publication.

Subject Code: PE-PEM 203B	**Category:** Program Elective-III
Subject Name: Micro and Precision Manufacturing Systems	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Knowledge of Manufacturing at the Under-Graduate Level	

Course Outcomes:

On completion of this course the students will be able to:

CO1: Develop an understanding on micromachining, milimachining and nanotechnology to make miniaturized components

CO2: Build the concept of mesoscopic domain of micromachines and its future scope

CO3: Select the suitable precision manufacturing and microfinishing process for manufacture of a micro component

CO4: Choose appropriate measuring system to test accuracy of a micro component

Course contents:

Module No.	Description of Topic	Contact Hour
1	Introduction to micromachining, milimachining and nanotechnology, different fabrication and other processes involved and related process parameters, application of miniaturized components.	12
2	Mesoscopic domain of micromachines- Introduction, biological systems, cells as machines, role of proteins, physics of micromechanism, future prospects.	10
3	Precision manufacturing- Introduction, concept of accuracy, tolerance and fits, influence of different factors on the maintainability of accuracy of the machine tools and the product, compensation of thermal errors and location errors, effects of vibration and tool wear, dimensioning and dimensional chains, microfinishing processes.	12
4	Different Measuring Systems: Different Optical/ Acoustic/ Magnetic, etc. equipment to be used in post treatment and measurements.	6
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Murty, R.L., Precision Engineering in Manufacturing, New Age International Publishers.
2. Fujimasa, I., Micromachines: A New Era in Mechanical Engineering, Oxford Science Publications.
3. Kalpakjian, S., Manufacturing Engineering and Technology, Addison Wesley Publication.
4. Pandey, P.C. and Shan, H.S., Modern Machining Processes, Tata McGraw Hill Publication.
5. El-Hofy, H.A.G., Advanced Machining Processes – Nontraditional and Hybrid Machining Processes, McGraw-Hill.

Subject Code: PEM 203C	**Category:** Program Elective-III
Subject Name: Mechatronic Systems Design and Applications	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic concepts of Mechatronics	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Apply the Transfer Function in dynamic equations
CO2: Utilize the understanding of Time and Frequency domain analysis in control systems
CO3: Design and construct the PID and PLC in Mechatronic applications
CO4: Model nonlinear control systems and develop nonlinear controller
CO5: Develop state space model applied in Mechatronic systems analysis
CO6: Build optimal and adaptive control in Mechatronic systems

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Concepts of mechatronics:** Basic concept of mechatronics, components of a mechatronic system. **Motion conversion techniques**- Different linear, rotary and complex motions, its mechanisms and transmission; mechanical load analysis for actuator selection. **Electro-mechanical energy conversion** - transducers, stepper motors- principles of operation, types, construction, basics of stepper motor drives; brushless motor (BLM) control, analog-digital conversion, speed control of induction motor, vector control, servo control- principles, operations of a servo motor.	6
2	**Control Systems:** Open loop and closed loop control, transfer functions, Laplace transforms, Poles and Zeros of Transfer Function. **PID controllers:** Operation or Control Philosophy of PID Controller, Mathematical form of PID Controller, The transfer function of the PID Controller, Functionality of each term in PID Controller. **PLC controller**: Automatic process control, Basic purpose of Automation in Manufacturing industry, Classification of industrial and laboratory automation, How PLC works, PLC architecture, Key features of PLCs, Advanced PLC Features.	6
3	**Time and frequency domains analysis:** Analysis of the response of a dynamic system in time and frequency domain, Specifications of time and frequency domain analysis. **Transient response of first and second order systems:** Common Ways of analysing the response of systems, Natural and Forced Responses, Transient Responses of first and second order system.	6

4	**Introduction to nonlinear control:** Definition of nonlinear controller, introduction to nonlinear control, Example of Nonlinear Algebraic Equation, Properties of Nonlinear System, Analysis and Control of Nonlinear System, Examples of essentially nonlinear phenomena, Definition of Different Types of Stable Systems.	4
5	**State space analysis:** Definition of state-space representation; state variables; State-Space Representation of Linear System, Most general State-Space Representation of Linear System, State-space model representation for different types of linear system, Example of continuous-time LTI case, Controllability of continuous-time LTI, Observability of continuous-time LTI, Transfer function of continuous-time LTI.	6
6	**Optimal and adaptive control:** Definition of Optimal and Adaptive control, Application of Optimal and adaptive Control Theory, General Method for describing an optimal control and adaptive control theory, Difference between adaptive and robust control.	6
7	**Electro-pneumatic and electro-hydraulic control:** Solenoid control valves, PLC control, microprocessors and control using it, computer interface. **Applications of mechatronic systems**- Robots, position and level control systems, etc.	6
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Bolton, W., Mechatronics, Addison Wesley Longman, Singapore.
2. Histand, M.B. and Alciatore, D.G., Introduction to Mechatronics and Measurement Systems, McGraw Hill Co.
3. Kamm, L.J., Understanding Electro-Mechanical Engineering: An Introduction to Mechatronics, Prentice Hall of India.
4. Mahalik, N.P., Mechatronics, Tata McGraw-Hill.
5. HMT Limited., Mechatronics,Tata McGraw-Hill.
6. Stadler, W., Analytical Robotics and Mechatronics, McGraw-Hill Book Co.
7. Kurtz, G.W., Schueller, J.K. and Claar, P.W., Machine design for mobile and industrial applications, SAE.
8. Parr, A., Hydraulics and Pneumatics, Butterworth/ Jaico Publishing House.
9. TurnerI, C., Engineering Applications of Pneumatics and Hydraulics, Arnold.
10. Majumdar, S.R., Pneumatic Systems-Principles and Maintenance, Tata McGraw-Hill Pub.
11. Esposito, A., Fluid Power with Applications, Prentice Hall International.
12. Shetty, D. and Kolk, R.A., Mechatronic Systems Design, Brooks/Cole, Thompson Learning/ Vikas Publishing House.
13. Raven, F.H., Automatic Control Engineering, 5th ed., McGraw-Hill International.
14. Ogata, K., Modern Control Engineering, 3rd ed., Prentice Hall.
15. Kuo, B.C., Automatic Control Systems, 6th ed., Prentice Hall.
16. Ambikapathy, A., Control Systems, Khanna Book Publishing House.

Subject Code: PE-PEM 203D	**Category:** Program Elective-III
Subject Name: Safety and Occupational Health Management	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Engineering Knowledge	

Course Outcomes:

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

CO1: Have an overall idea about safety and occupational health
CO2: Explain various safety issues and its socio-economic aspects
CO3: Have an overall idea about accident and hazards with a knowledge on prevention and mitigation
CO4: Have sound knowledge in safety legislation, guidelines and various acts
CO5: Industry-ready to implement safety management at their workplace

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to occupational health and safety, fundamental objectives and principles of occupational health and safety, workplace and health, occupational health and safety in developing countries, occupational hazards and hygiene, ergonomics for prevention of injuries and health hazards in industry.	9
2	Sector specific occupational health and safety issues; socio-economic aspects – women's occupational health issues, child labour issues, health issues in unorganised sectors.	7
3	Accidents and hazards- accident analysis, monitoring of hazards, reporting and investigation of accidents. Types of fire, Fire Hazards, Fire Explosion, fire prevention, Means of Escape. Occupational diseases in various sectors. Occupational health and safety standards – basics of ISO 45001: 2018.	9
4	Duties of employer and employees, Safety Legislation, Safety Guidelines, emergency actions, related acts (related to chemical processes, mines, workshop practices, construction work, electrical installations), Brief introduction to and overview of 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, Factory Act, 1948, Role of National Safety Council, International labour organization (ILO).	9
5	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	6

	Management and Loss Control.	
	Total number of contacts (Hr.)	**40**

Learning Resources:

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

Subject Code: PEM 204A	**Category:** Program Elective-IV
Subject Name: Quality Management	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic idea in Statistical Quality Control and Total Quality Management	

Course Outcomes:

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

CO1: Define what is meant by statistical process control and draw control charts for variables and attributes

CO2: Define product control, explain acceptance sampling with single and double sampling plan and determine reliability of a system

CO3: Define total quality management, rules, tools and techniques

CO4: Explain Just-in-time approach, its logic, impact, advantages and implementation

CO5: Illustrate cost of quality, quality loss, waste elimination and quality consideration in design

CO6: Outline significance of ISO certification, its implementation and registration

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Basic concepts, definitions and history of quality control, Process control: Upper and Lower Specification Limits, Accuracy and Precision. Process Capability, Potential Capability and Actual Capability. Use of control charts and process engineering techniques for implementing the quality plan.	8
2	Acceptance sampling: Rejection and Rectification plan, Single and Double sampling plan, Operation Characteristic curve- producer's risk and consumer's risk.	8
3	Reliability: Definitions, Applications, Exponential life distribution, Series and Parallel operations.	6
4	Total Quality Control and Management: Definition, vision and philosophy, Concepts of TQM, Concepts of customer-centred environment, Golden Rules of TQM, PDCA Cycle, Tools and Techniques, Implementation of TQM, 5S Campaign, Flow Chart, Pareto Analysis, Cause and Effect Diagram, Brain Storming, Quality Circle, Quality Function Deployment, Benchmarking, BPR, Kaizen, JIT and Kanban.	8
5	Quality Cost Matrix, Evaluation of Quality Costs. Taguchi's Quality Loss Function, Waste Elimination.	6
6	ISO 9000 Standard, Implementation and Registration, ISO vis-à-vis TQM.	4
	Total number of contacts (Hr.)	40

Learning Resources:

1. M.P. Poonia, S.C. Sharma, Total Quality Management, Khanna Book Publishing Company (AICTE Recommended Textbook).
2. Juran, J., Quality Control Handbook, McGraw-Hill Book Company.
3. Juran, M. and Gryana, F.M., Quality Planning and Analysis, 3rd Ed., Tata McGraw Hill.
4. Mahajan, M., Statistical Quality Control, Dhanpat Rai Publication.
5. Mohanty, R.P. and Lakhe, R.R., Handbook of Total Quality Management, Jaico Publishing House.
6. Besterfield, D.H., Besterfield-Michna, C., Besterfield, G. and Besterfield-Sacre, M., Total Quality Management, Pearson Education, Asia.
7. Duncan, A.J., Quality Control and Industrial Statistics, Richard D. Irwin Inc., USA.

Subject Code: PE-PEM 204B	**Category:** Program Elective-IV
Subject Name: CAD-CAM Systems	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic knowledge about Computer Aided Drafting and Manufacturing in Uder-Graduate Level	

Course Outcomes:

On completion of this course the students will be able to:
CO1: Develop an understanding on designing a product and design srages in CAD
CO2: Apply interactive computer graphics for making a CAD graphic model using a software
CO3: Apply engineering analysis, design reviews and evaluation technique on a new design
CO4: Apply the knowledge of CAD-CAM integration to transfer CAD data to CAM system for making a specified product along with testing for its acceptance

Course contents:

Module No.	Description of Topic	Contact Hour
1	Basic concepts of product design. Different phases of computer aided design (CAD), integration of CAD-CAM, system software, benefits of CAD.	4
2	Elements of interactive computer graphics (ICG); introduction, point and line plotting and display techniques, 2D and 3D transformation, concatenation, clipping, segmentation, 2D and 3D graphics, input and output devices, raster scan graphics systems.	6
3	Geometric modeling; wire-frame, surface and solid modeling techniques.	6
4	Computer-aided drafting; drafting packages, dimensions, text, shading, hatching, etc. of mechanical components.	6
5	Engineering analysis; design reviews and evaluation.	9
6	Element of CAM/CIM systems; CNC Machines, DNC, FMS, Machining Centres, A.C. Systems, different handling and robotic configurations employed; Computer Integrated Production Planning and Control; MRP, MRP-II, CAPP, CAI and CAQC, Application of softwares. Interfacing of CAD with CAM; manufacturing data generated from CAD data.	9
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Zeid, I., CAD/CAM- Theory and Practice, McGraw-Hill Publishing Co. Ltd., New Delhi.
2. Groover, M.P. and Zimmers, E.W. Jr., CAD/CAM, Prentice Hall of India.
3. Groover, M.P., Automation, Production Systems and Computer-Integrated Manufacturing, Prentice Hall of India.

4. Ramamurti, V., Computer Aided Mechanical Design and Analysis, 3rd Edition, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.
5. Rogers, D.F. and Adams, J.A., Mathematical Elements for Computer Graphics, McGraw-Hill Publishing Co., Singapore, 2nd Edition.
6. Newman, W.M. and Sproull, R.F., Principles of Interactive Computer Graphics, 2nd Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
7. Xiang, Z. and Plastock, R., Schaum's Outlines of Theory and Problems of Computer Graphics, 2nd Edition, McGraw Hill, Singapore.
8. Radhakrishnan, P., Subramanyan, S. and Raju, V., CAD/CAM/CIM, New Age International Publishers.
9. Rao, P.N., Tewari, N.K. and Kundra, T.K., Computer Aided Manufacturing, McGraw-Hill Publication.
10. Deb, S.R., Robotics Technology and Flexible Automation, McGraw-Hill Publication.
11. Kumar, S., Industrial Robots and Computer Integrated Manufacturing, Oxford & IBH Publishing Co. Ltd.
12. Mahapatra, P.B., Computer-Aided Production Management, Prentice Hall of India.
13. A.P. Gautam & Pradeep Jain, Engineering AutoCAD, Khanna Book Publishing Company.

Subject Code: PE-PEM 204C	**Category:** Program Elective-IV
Subject Name: Design of Experiments	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basics of Engineering Mathematics and Statistics	

Course Outcomes:

On completion of this course the students will be able to:
CO1: Select the suitable technique of design of experiments before an experimental work
CO2: Apply design of experiments to determine experimental runs and process parameters
CO3: Apply DoE and do analysis to find relation between the response and process variables

Course contents:

Module No.	Description of Topic	Contact Hour
1	Introduction to design of experiments (DoE)- Its utility, Historical background, Basic statistical concepts, Analysis of Variance (ANOVA), Distribution of function of variables, Sampling, Estimation and Test of Hypothesis, Power of tests, Non-Parametric Tests.	12
2	Types of design of experiments- Factorial design, Latin Square, Response Surface Methodology, Randomised design strategy, Taguchi method for optimizing the number of experiments, etc. Analysis of the result- Chi-Square Test, 't' test, ANOVA, etc.	16
3	Application examples of different designs of experiments.	12
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Mukhopadhyay, P., Applied Statistics, Books and Allied (P) Ltd.
2. Goon, A.M., Gupta, M.K. and Dasgupta, B., An Outline of Statistical Theory, Volume I and II, The World Press Private Ltd.
3. Jash, B., Elements of Probability & Statistics, Tata McGraw Hill.
4. De, S.K. and Sen, S., Mathematical Statistics, U.N. Dhur & Sons Private Ltd.
5. Adler, Yu.P., Markova, E.V. and Granovsky, Ylu.V., The Design of Experiments to find Optimal Conditions, MIR Publication, Moscow, 1975.
6. Petersen, R.G., Design and analysis of Experiments, Marcel Dekkar Inc., New York.
7. Cochran, W.C. and Cox, G.M., Experimental Designs, John Wiley & Sons, Inc., New York.
8. Montgomary, D.C., Design and Analysis of Experiments, Wiley-India Edition.
9. Gupta, R., Design of Experiments (DOE) Using the Taguchi Approach, John Wiley & Sons.
10. Barker, T.B., Engineering Quality by Design: Interpreting the Taguchi Approach, Marcel Dekker, Inc., New York.

Subject Code: PE-PEM 204D	**Category:** Program Elective-IV
Subject Name: Advanced Welding Technology	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic knowledge on Welding Processes, Materials Science and Engineering Metallurgy	

Course Outcomes:

On completion of this course the students will be able to:
CO1: Select suitable welding technique for joining a material
CO2: Apply appropriate process parameters during a welding process
CO3: Carry out different destructive and non-destructive tests to judge weld quality
CO4: Interpret microstructure of weldment and determine weld characteristics

Course contents:

Module No.	Description of Topic	Contact Hour
1	Review of Welding Processes: Fusion and Solid State Welding.	2
2	Process Descriptions: Solid State Welding processes, and Fusion Welding processes- Arc welding- SMAW, Stud arc welding, GMAW, GTAW and FCAW; Gas welding; Resistance welding processes.	6
3	Equipment of Arc Welding: Different types, Power sources, Arc characteristics, Welding Consumables: Electrode and Filler selection with different types of flux. Precision Welding Processes: PAW, LBW, EBW, USW, Friction stir welding.	6
4	Joining of Non-Metals: Ceramics, Plastics, and Composites.	3
5	Welding Metallurgy: HAZ, Effects of different process parameters on weldment.	6
6	Weldability of Work Materials: Plain carbon steel, Stainless steel, Cast iron, Aluminium & Copper and its alloys, Welding of Dissimilar Materials.	8
7	Applications of Welding Techniques Other than Joining: Hard facing, Cladding, Repair welding.	3
8	Inspection and Testing of Weld Defects and their Remedies: Welding Defects, Inspection and Testing of Welding Joints, Residual stresses and Distortion, Remedial Measures.	6
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Khanna, O.P., A Text Book of Welding Technology, Dhanpat Rai & Sons.

2. Parmar, R.S., Welding Engineering and Technology, Khanna Publishers.
3. Bhattacharyya, M., Weldment Design, The Association of Engineers, India Publication, Kolkata.
4. Lippold, J.C. and Kotecki, D.J., Welding Metallurgy and Weldability of Stainless Steels, Wiley-India (P) Ltd., New Delhi.
5. Nadkarni, S.V., Modern Arc Welding Technology, Oxford & IBH Publishing Co. Pvt. Ltd./ Advani-Oerlikon Ltd.

Subject Code: PE-PEM 204E	**Category:** Program Elective-IV
Subject Name: Product Design and Development	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Elements of Machine Design, Basics of Management Principles	

Course Outcomes:

On completion of this course the students will be able to:
CO1: Apply the concept of product design following sequential engineering design method
CO2: Apply Product Planning and Project Selection steps to manufacture a new product
CO3: Carry out market survey to identify the need for new product development
CO4: Interpret customer's response on a new product and to improve it keeping in view environmental aspect

Course contents:

Module No.	Description of Topic	Contact Hour
1	Introduction to Product Design, Design and Development Process, Sequential Engineering Design Method, Product Planning and Project Selection.	8
2	Identifying Customer Needs- Interpreting Raw Data; Product Specifications- Establishing Target Specifications, Setting Final Specifications.	8
3	Concept Generation- Activities of Concept Generation, Clarifying Problem, Exploring the Output; Concept Selection- Concept Screening and Concept Scoring, Methods of Selection.	10
4	General Theory of Innovation and TRIZ (Theory of Inventive Problem Solving), Applications in Product Design and Development.	6
5	Concept Testing- Qualitative and Quantitative Methods Including Survey, Measurement and Customer's Response; Design for Environment- Basic Concepts.	8
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Ulrich, K.T. and Eppinger, S.D., Product Design and Development, Tata McGraw Hill.
2. Orloff, M.A., Inventive Thinking through TRIZ: A Practical Guide, Springer.
3. Gupta, A.K., Concepts in Engineering Design, Dhanpat Rai Publications.

Subject Code: PE-PEM 204F	**Category:** Program Elective-IV
Subject Name: Computational Fluid Dynamics	**Semester: Second**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic knowledge in Finite Volume Method and Finite Element Method (FEM)	

Course Outcomes:

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

CO1: Gain a working knowledge of the major ideas, methods, and methodologies used in CFD.

CO2: Develop abilities in the real implementation of CFD methodologies (eg. boundary conditions, different numerical schemes, etc.)

CO3: Solve flow and heat transfer issues using various discretization methods, solution procedures and turbulence modelling.

CO4: Gain experience using CFD method to examine actual engineering designs.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	A Brief Overview of the Basic Conservation Equations for Fluid Flow And Heat Transfer, Classification of Partial Differential Equations and Pertinent Physical Behaviour, Parabolic, Elliptic and Hyperbolic Equations, Role of Characteristics. Common Methods of Discretization: An Overview of Finite Difference, Finite Element and Finite Volume Methods.	6
2	Numerical Solution of Parabolic Partial Differential Equations Using Finite-Difference and Finite-Volume Methods: Explicit and Implicit Schemes, Consistency, Stability and Convergence.	3
3	Numerical Solution of Systems of Linear Algebraic Equations: General Concepts of Elimination and Iterative Methods, Gaussian Elimination, LU Decomposition, Tridiagonal Matrix Algorithm, Jacobi and Gauss-Seidel Iterations, Necessary and Sufficient Conditions for Convergence of Iterative Schemes, Gradient Search Methods, Steepest Descent and Conjugate Gradient Methods.	7
4	The Finite Volume Method of Discretization for Diffusion Problems: One-Dimensional Steady Diffusion Problems, Specification of Interface Diffusivity, Source-Term Linearization. Discretization of Transient One-Dimensional.	6
5	Diffusion Problems, Discretization for Multi-Dimensional Diffusion Problems. Solution of Discretized Equations Using Point and Line Iterations, Strongly Implicit Methods and Pre-Conditioned Conjugate Gradient Methods.	6

6	Convection-Diffusion Problems: Central Difference, Upwind, Exponential, Hybrid and Power-Law Schemes, Concept of False Diffusion, QUICK Scheme.	4
7	Numerical Solution of the Navier-Stokes System for Incompressible Flows: Stream-Function. Vorticity and Artificial Compressibility Methods, Requirement of a Staggered Grid. MAC, SIMPLE, SIMPLEC and SIMPLER Algorithms.	4
8	An Introduction to Unstructured Grid Finite Volume Methods. Special Topics: Turbulence and Its Modelling, Phase-Change Problems, Interface/ Free-Surface Tracking Methods	4
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Anderson, J.D., Computational Fluid Dynamics: The Basics with Applications. Science/ Engineering/ Math, McGraw-Hill Science.
2. Patankar, S., Numerical Heat Transfer and Fluid Flow. Hemisphere Series on Computational Methods in Mechanics and Thermal Science, Taylor & Francis.
3. Hirsch, C., Numerical Computation of Internal and External Flows, (Vol. 1&2), John Wiley & Sons.
4. Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems.

Subject Code: PC-PEM 291	**Category:** Program Core Practical
Subject Name: Manufacturing System and Process Laboratory	**Semester: Second**
L-T-P: 0-0-4	**Credit: 2**
Pre-Requisites: Basic idea in Manufacturing and Automation	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Identify the quality of green sand mould to obtain sound casting
CO2: Demonstrate metallographic sample preparation to observe and interpret microstructures
CO3: Evaluate soundness of welding and determine influence of welding process parameter on weld quality
CO4: Examine the change in surface grinding performance with number of passes
CO5: Construct a cutting tool with given tool geometry
CO6: Experiment with machining process by varying parameters to achieve required machinability
CO7: Make use of metal forming and other manufacturing process to characterize them

Course contents:

Experiments on modern, computer aided manufacturing and allied systems, such as;

- Part programming on a CNC lathe
- Part programming on a CNC milling / machining centre
- Using MasterCAM, etc. for making a job from AutoCAD drafting
- Computer Aided Process Planning
- Robotic Programming
- Electric Discharge Machining
- Testing for alignment/ error in machine tools
- Finding out speed ratios and constructing ray diagrams of machine tools.
- Machine Tool Vibration
- Pneumatic, Hydraulic and Mechatronic elements in machine tools

Subject Code: PC-PEM 292	**Category:** Program Core Practical
Subject Name: Design Laboratory-II	**Semester: Second**
L-T-P: 0-0-4	**Credit: 2**
Pre-Requisites: Basic idea in Computer Aided Drafting and Design	

Course Outcomes:

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

CO1: Select components of machine tools with appropriate metal working processes to model in a suitable CAD package

CO2: Select cutting tools with appropriate metal working processes to model in a suitable CAD package

CO3: Analyse stress of components of machine tools under different loading conditions in a standard simulation software

CO4: Analyse stress of cutting tools under different loading conditions in a standard simulation software.

CO5: Develop design of new products

Course contents:

Tasks on computer aided designing and analysis of components and systems, such as;

- Design of components of machine tools, cutting tool, other toolings, metal working processes, etc.
- Stress analysis of components of machine tools, cutting tool, other toolings, metal working processes, etc. under different types of loading conditions using standard software such as ANSYS, etc.
- Designing for New Product Development.

Subject Code: PW-PEM 281	**Category:** Program Core Project
Subject Name: Mini Project with Seminar	**Semester: Second**
L-T-P: 2-0-0	**Credit: 2**
Pre-Requisites: Basic knowledge about the topic of the project to choose	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Identify the topic of project work
CO2: Elaborate a write up by demonstrating the literature review, identifying the research gap and selecting the plan for work
CO3: Experiment with, or Solve, an identified task independently

Course Contents:

Mini Project would be to do some preliminary works that would lead to the detailed project work spanning over Semester III and IV. Related to the same, the Seminar would be based on literature review on some emerging areas related to this course and the preliminary works done on the mini project.

Seminar presentation would be made by an individual student, and a report would have to be submitted by each student separately.

Subject Code: AC-PEM 101A/ AC-PEM 201A	**Category:** Audit course
Subject Name: English for Research Paper Writing	**Semester**: **First/ Second**
L-T-P: 2-0-0	**Credit: 0**
Pre-Requisites: No prerequisite	

Course Objectives:

On successful completion of the course, students will be able to:
CO1: Understand that how to improve your writing skills and level of readability
CO2: Learn about what to write in each section
CO3: Understand the skills needed when writing a Title
CO4: Construct the good quality of paper at very first-time submission

Course Contents:

Module No.	Description of Topic	Contact Hour
1	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.	4
2	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction.	4
3	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	6
4	Key skills needed when writing a Title; key skills needed when writing an Abstract, key skills needed when writing an Introduction, skills needed when writing a Review of the Literature.	5
5	Skills needed when writing the Methods, skills needed when writing the Results, skills needed when writing the Discussion, skills needed when writing the Conclusions.	5
6	Useful phrases, how to ensure paper to be good for it to be possibly the first-time submission.	4
	Total number of contacts (Hr.)	**28**

Learning Resources:

1. Goldbort, R., Writing for Science, Yale University Press (available on Google Books), 2006.
2. Day, R., How to Write and Publish a Scientific Paper, Cambridge University Press, 2006.
3. Highman, N., Handbook of Writing for the Mathematical Sciences, SIAM, 1998.
4. Wallwork, A., English for Writing Research Papers, Springer, New York, 2011.

Subject Code: AC-PEM 101B/ AC-PEM 201B	**Category:** Audit Courses
Subject Name: Disaster Management	**Semester**: **First/ Second**
L-T-P: 2-0-0	**Credit: 0**
Pre-Requisites: No prerequisite	

Course Outcome:

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

CO1: Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO2: Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO3: Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

CO4: Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

Course Contents:

Module No.	Description of Topic	Contact Hour
1	**Introduction** Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.	4
2	**Repercussions of Disasters and Hazards**: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.	5
3	**Disaster Prone Areas in India** Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics.	4
4	**Disaster Preparedness and Management** Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data From Meteorological and other Agencies, Media Reports: Governmental and Community Preparedness.	6
5	**Risk Assessment** Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global	5

	Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.	
6	**Disaster Mitigation** Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.	4
	Total number of contacts (Hr.)	**28**

Learning Resources:

1. Sharma, S.C., Disaster Management, Khanna Book Publishing Company, Delhi.
2. Nishith, R., Singh, A.K., Disaster Management in India: Perspectives, Issues and Strategies, New Royal book Company.
3. Sahni, Pardeep Et. Al. (Eds.), Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi.
4. Goel, S.L., Disaster Administration and Management Text and Case Studies, Deep & Deep Publication Pvt. Ltd., New Delhi.

Subject Code: AC-PEM 101C/ AC-PEM 201C	**Category:** Audit Courses
Subject Name: Sanskrit for Technical Knowledge	**Semester: First/ Second**
L-T-P: 2-0-0	**Credit: 0**
Pre-Requisites: No prerequisite	

Course Outcome:

On successful completion of the course, students will be able to:
CO1: Understanding basic Sanskrit language
CO2: Ancient Sanskrit literature about science & technology can be understood
CO3: Being a logical language will help to develop logic in students

Course Contents:

Module No.	Description of Topic	Contact Hour
1	• Alphabets in Sanskrit, • Past/ Present/ Future Tense, • Simple Sentences	10
2	• Order • Introduction of roots • Technical information about Sanskrit Literature	10
3	• Technical concepts of Engineering- Electrical, Mechanical, Architecture, Mathematics	8
	Total number of contacts (Hr.)	**28**

Learning Resources:

1. Vishwas, Abhyaspustakam, Samskrita-Bharti Publication, New Delhi.
2. Vempati K., Teach Yourself Sanskrit, Prathama Deeksha- Rashtriya Sanskrit Sansthanam, New Delhi Publication.
3. Soni, S., India's Glorious Scientific Tradition, Ocean books (P) Ltd., New Delhi.

Subject Code: AC-PEM 101D/ AC-PEM 201D	**Category:** Audit Courses
Subject Name: Value Education	**Semester**: **First/ Second**
L-T-P: 2-0-0	**Credit: 0**
Pre-Requisites: No prerequisite	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Have knowledge of self-development.
CO2: Learn the importance of Human values.
CO3: Develop the overall personality.

Course Contents:

Module No.	Description of Topic	Contact Hour
1	• Values and self-development- Social values and individual attitudes. • Work ethics, Indian vision of humanism. • Moral and non- moral valuation. Standards and principles. • Value judgments	4
2	• Importance of cultivation of values. • Sense of duty, Devotion, Self-reliance. Confidence, Concentration, Truthfulness, Cleanliness. • Honesty, Humanity. Power of faith, National Unity. • Patriotism. Love for nature, Discipline	8
3	• Personality and Behaviour Development- Soul and Scientific attitude. Positive Thinking. Integrity and discipline. • Punctuality, Love and Kindness. • Avoid fault Thinking. • Free from anger, Dignity of labour. • Universal brotherhood and religious tolerance. • True friendship. • Happiness Vs suffering, love for truth. • Aware of self-destructive habits. • Association and Cooperation. • Doing best for saving nature	8

4	• Character and Competence- Holy books vs. Blind faith. • Self-management and Good health. • Science of reincarnation. • Equality, Non violence, Humility, Role of Women. • All religions and same message. • Mind your Mind, Self-control. • Honesty, Studying effectively	8
	Total number of contacts (Hr.)	**28**

Learning Resources:

1. Chakroborty, S.K., Values and Ethics for Organizations Theory and Practice, Oxford University Press, New Delhi.
2. Premvir Kapoor, Professional Ethics & Human Values, Khanna Book Publishing Company, Delhi.

Subject Code: AC-PEM 101E/ AC-PEM 201E	**Category:** Audit Courses
Subject Name: Constitution of India	**Semester**: **First/ Second**
L-T-P: 2-0-0	**Credit: 0**
Pre-Requisites: No prerequisite	

Course Outcome:

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

CO1: Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
CO2: Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
CO3: Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
CO4: Discuss the passage of the Hindu Code Bill of 1956.

Course Contents:

Module No.	Description of Topic	Contact Hour
1	❖ **History of Making of the Indian Constitution:** • History • Drafting Committee, (Composition& Working)	4
2	❖ **Philosophy of the Indian Constitution:** • Preamble • Salient Features	4
3	❖ **Contours of Constitutional Rights & Duties:** • Fundamental Rights • Right to Equality • Right to Freedom • Right against Exploitation • Right to Freedom of Religion • Cultural and Educational Rights • Right to Constitutional Remedies • Directive Principles of State Policy • Fundamental Duties.	6
4	❖ **Organs of Governance:** • Parliament • Composition • Qualifications and Disqualifications • Powers and Functions	4

	• Executive • President • Governor • Council of Ministers • Judiciary, Appointment and Transfer of Judges, Qualifications • Powers and Functions	
5	❖ **Local Administration:** • District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. • Pachayati raj: Introduction, PRI: Zila Pachayat. • Elected officials and their roles, CEO Zila Pachayat: Position and role. • Block level: Organizational Hierarchy (Different departments), • Village level: Role of Elected and Appointed officials, • Importance of grass root democracy	6
6	❖ **Election Commission:** • Election Commission: Role and Functioning. • Chief Election Commissioner and Election Commissioners. • State Election Commission: Role and Functioning. • Institute and Bodies for the welfare of SC/ST/OBC and women	4
	Total number of contacts (Hr.)	**28**

Learning Resources:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Busi, S.N., B.R. Ambedkar Framing of Indian Constitution, 1st Edition, 2015.
3. Jain, M.P., Indian Constitution Law, 7th Edition, Lexis Nexis, 2014.
4. Basu, D.D., Introduction to the Constitution of India, Lexis Nexis, 2015.

Subject Code: AC-PEM 101F/ AC-PEM 201F	**Category:** Audit Courses
Subject Name: Pedagogy Studies	**Semester**: **First/ Second**
L-T-P: 2-0-0	**Credit: 0**
Pre-Requisites: No prerequisite	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: To explain overall concept of Pedagogy
CO2: To explain learning theories
CO3: To analyze different components of curriculum and their implementation
CO4: To explain Outcome Based Education and it implementation
CO5: To explain role of Technology in Pedagogy and it implementation
CO6: To explain importance of Research in relation to Pedagogy

Course Contents:

Module No.	Description of Topic	Contact Hour
1	**Introduction and Methodology:** • Aims and rationale, Policy background, Conceptual framework and terminology • Theories of learning, Curriculum, Teacher education. • Conceptual framework, Research questions. • Overview of methodology and Searching	6
2	• Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. • Curriculum, Teacher education	4
3	• Evidence on the effectiveness of pedagogical practices • Methodology for the in depth stage: quality assessment of included studies. • How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? • Theory of change. • Strength and nature of the body of evidence for effective pedagogical practices. • Pedagogic theory and pedagogical approaches. • Teachers' attitudes and beliefs and Pedagogic strategies.	6
4	• Professional development: alignment with classroom practices and follow-up support • Peer support • Support from the head teacher and the community. • Curriculum and assessment • Barriers to learning: limited resources and large class sizes	6

5	• Research gaps and future directions • Research design • Contexts • Pedagogy • Teacher education • Curriculum and assessment • Dissemination and research impact	6
	Total number of contacts (Hr.)	**28**

Learning Resources:

1. Ackers, J., Hardman, F., Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261, 2001.
2. Agrawal, M., Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379, 2004.
3. Akyeampong, K., Teacher training in Ghana- does it count? Multi-site teacher education research project (MUSTER) country report 1, DFID, London, 2003.
4. Akyeampong, K., Lussier, K., Pryor, J., Westbrook, J., Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282, 2013.
5. Alexander, R.J., Culture and pedagogy: International comparisons in primary education, Blackwell, Oxford and Boston, 2001.
6. Chavan, M., Read India: A mass scale, rapid, 'learning to read' campaign, 2003.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Subject Code: AC-PEM 101G/ AC-PEM 201G	**Category:** Audit Courses
Subject Name: Stress Management by Yoga	**Semester: First/ Second**
L-T-P: 2-0-0	**Credit: 0**
Pre-Requisites: No prerequisite	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Develop healthy mind in a healthy body thus improving social health also
CO2: Improve efficiency

Course Contents:

Module No.	Description of Topic	Contact Hour
1	• **Definitions of Eight parts of yog. (Ashtanga)**	8
2	• **Yam and Niyam:** Do's and Don'ts in life. i. Ahinsa, satya, astheya, bramhacharya and aparigraha ii. Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	10
3	• **Asan and Pranayam:** i. Various yog poses and their benefits for mind & body ii. Regularization of breathing techniques and its effects- Types of pranayam.	10
	Total number of contacts (Hr.)	**28**

Learning Resources:

1. Yogic Asanas for Group Training- Part-I, Janardan Swami Yogabhyasi Mandal, Nagpur.
2. Vivekananda, S., Rajayoga or Conquering the Internal Nature, Advaita Ashrama (Publication Department), Kolkata.

Subject Code: AC-PEM 101H/ AC-PEM 201H	**Category:** Audit Courses
Subject Name: Personality Development through life Enlightenment skills	**Semester: First/ Second**
L-T-P: 2-0-0	**Credit: 0**
Pre-Requisites: No prerequisite	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: develop his personality and achieve the highest goal in life
CO2: lead the nation and mankind to peace and prosperity
CO3: help in developing versatile personality of students

Course Contents:

Module No.	Description of Topic	Contact Hour
1	**Neetisatakam-Holistic development of personality:** • Verses- 19,20,21,22 (wisdom) • Verses- 29,31,32 (pride & heroism) • Verses- 26,28,63,65 (virtue) • Verses- 52,53,59 (don'ts) • Verses- 71,73,75,78 (do's)	9
2	• Approach to day to day work and duties. • Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48, • Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17,23, 35, • Chapter 18-Verses 45, 46, 48.	9
3	• Statements of basic knowledge. • Shrimad Bhagwad Geeta : Chapter2-Verses 56, 62, 68 • Chapter 12 -Verses 13, 14, 15, 16,17, 18 • Personality of Role model. Shrimad Bhagwad Geeta : • Chapter2-Verses 17,Chapter 3-Verses 36,37,42, • Chapter 4-Verses 18, 38,39 • Chapter18 – Verses 37,38,63	10
	Total number of contacts (Hr.)	**28**

Learning Resources:

1. Srimad Bhagavad Gita, Swami Swarupananda Advaita Ashram (Publication Department), Kolkata.
2. Gopinath, P., Bhartrihari's Three Satakam (Niti-sringar-vairagya), Rashtriya Sanskrit Sansthanam, New Delhi.

Subject Code: PE-PEM 301A	**Category:** Program Elective-V
Subject Name: Logistics and Supply Chain Management	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Knowledge of Inventory Management	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Build clear understanding about different supply chain management concepts
CO2: Develop logistics and supply chain management in an organization
CO3: apply appropriate supply chain for the benefit of an organization keeping environmental aspects in mind

Course Contents:

Module No.	**Description of Topic**	**Contact Hour**
1	Introduction: Understanding logistics and supply chain management (SCM); wholistic approach to physical flow; customer focus in SCM: efficient customer response (ECR), quick response (QR), accurate response (AR), corporate goal through competitive advantage, push and pull type system.	6
2	Inbound and Outbound Logistic: SCM integration considering material flow, information flow and cash flow; Bullwhip effect, transportation and warehousing.	5
3	Cost Analysis: Historical costing, standard costing and estimated costs, marginal costs, concept of cost drivers; activity based costing (ABC), through put accounting.	7
4	Benchmarking for SCM: Techniques of performance measurement and its barriers and evaluation of SCM. Transportation and Warehousing Location: Multi-model transport operation, routing, scheduling, fleet size insurances, sales tax, outsourcing, 3rd and 4th party logistics.	8
5	IT and Its Applications in SCM: MRP, ERP, distribution resource planning (DRP/DRPB) and designing SCM.	6
6	Supply chain management in service sector, global market and global sourcing, supplier alliance, supplier quality control, supplier chain re-engineering. Green supply chain management.	8
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Christopher, M., Logistics and Supply Chain Management, Pearson Education Limited, UK.

2. Hugos, M., Essentials of Supply Chain Management, Wiley Publication.
3. Chopra, S., Supply Chain Management: Strategy, Planning, and Operation, Pearson Education Limited, UK.
4. Bedi, K., Production and Operations Management, Oxford University Press.
5. Laudon, K.C. and Laudon, J.P., Management Information Systems- Managing the Digital Firm, Pearson Education.

Subject Code: PE-PEM 301B	**Category:** Program Elective-V
Subject Name: Introduction to Management Information Systems	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic knowledge about a Computer and its Operations	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Build clear understanding about Management Information Systems
CO2: Develop data management system to apply automation in an organization
CO3: Identify data source and apply appropriate Data Management towards implementation of Quality assurance

Course Contents:

Module No.	Description of Topic	Contact Hour
1	An Overview of Management Information Systems, Structure of a Management Information System, Need of MIS.	3
2	Hardware, Software and Communication Technology for Information Systems. Storage and Retrieval of Data, Transaction Processing, Office Automation and Information Processing.	6
3	Data processing Systems, The Decision Making Process, Concepts of Information, Human as Information Processors, System concepts, Concepts of Planning and Control, Real Time Systems, Organizational Structure and Management Concepts. Case Studies	8
4	Supports Systems for Planning Control and Decision Making, Support Systems for Management of Knowledge Work.	5
5	Data Communication hardware, Computer Networks, Developing a Long Range Information system Plan, Strategies for the Determination of Information Requirements, Database Requirements, User Interface Requirements.	8
6	Data sources and Data Management, Hierarchy of data organisation, Design & development of Application Systems, Quality assurance and Evaluation of Information Systems, Organization and Management of the Information Resources function, Future Developments and Their Organizational and Social Implications. Elements of software Engineering-models design issue.	10
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Dads, G.B. and Olson, M.H., Management Information System: Conceptual Foundations, Structure and Development, McGraw-Hill Book Company.

2. Long, L., Management Information Systems, Prentice Hall, New Jersey.
3. Scott, G.M., Principles of MIS, McGraw-Hill Publishing Company.
4. Chakraborty, S.K., Theory & Problems on Quantitative Techniques: Management Information System & Data Processing, New Central Book Agency.
5. Hughes, B. and Cotterell, M., Software Project Management, 2nd Ed.
6. Laudon, K.C. and Laudon, J.P., Management Information Systems- Managing the Digital Firm, Pearson Education.
7. Bhat, A. and Kumar, A., Management- Principles, Processes and Practices, Oxford University Press.

Subject Code : PEM 301C	**Category:** Program Elective-V
Subject Name : Robotics and Robot Application	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic concepts of Robotic System	

Course Outcomes:

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

CO1: Utilize the understanding of the robotic system and applying in automated manufacturing, production, material handling

CO2: Model the kinematics and dynamics equations of robotics

CO3: Make use of robot actuators, end effectors and sensors

CO4: Develop robot language and its programming

CO5: Demonstrate the economic performances and evaluation strategies of robotic systems

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	**Robotic systems:** Robot definition, Its role in automated manufacturing; robot anatomy; robot classifications and specifications.	6
2	**Robot kinematics:** Forward and reverse transformations, homogeneous transformation.	6
3	**Robot Dynamics:** Introduction to Force Analysis, Trajectory generation.	6
4	**Robot actuators and control:** Pneumatic, hydraulic and electrical drives and controls used in robots. **Robot end-effectors**: Mechanical, magnetic and vacuum grippers, gripping forces, RCC and design features of grippers.	6
5	**Robot sensors:** Contact and non-contact sensors, Robot vision and their interfaces.	5
6	**Robot languages:** Robotic language and programming techniques.	5
7	**Applications of robots:** In materials handling, machine loading/unloading, inspection, welding, spray painting and finish coating, and assembly, etc. **Economic performance and evaluation strategies:** Robot installation and planning. Safety features.	6
	Total number of contacts (Hr.)	40

Learning Resources:

1. Craig, J.J., Introduction to Robotics, Addison-Wesley.
2. Schilling, R.J., Fundamentals of Robotics Analysis and Control, Prentice Hall of India.
3. Deb, S.R., Robotics Technology and Flexible Automation, Tata McGraw-Hill Publication.
4. Yoshikawa, T., Foundations of Robotics Analysis and Control, Prentice Hall of India.
5. Santosh Mukherjee, Robotics & Process Automation, Khanna Book Publishing Company.

5. Koren, Y., Robotics for Engineers, McGraw-Hill Book Company, New York.
6. Kumar, S., Industrial Robots and Computer Integrated Manufacturing, Oxford & IBH Publishing Co. Ltd.
7. Groover, M.P., Automation, Production Systems, and Computer-Integrated Manufacturing, Prentice Hall of India.
8. Rao, P.N., Tewari, N.K. and Kundra, T.K., Computer Aided Manufacturing, Tata McGraw-Hill Publication.
9. Fu, K.S., Gonzales R.C. and LeeC.S.G., Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1997.
10. Stadler, W., Analytical Robotics and Mechatronics, McGraw Hill Book Co.

Subject Code: PE-PEM 301D	**Category:** Program Elective
Subject Name: Tribology and Terotechnology	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Knowledge of Physics, Solid Mechanics, Fluid Mechanics, Design and Materials Science at the Under-Graduate Level	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Make understanding of the tribological systems and the flow behaviour of lubricants
CO2: Apply appropriate bearings in a situation
CO3: Develop model of interfacial contacts and wear phenomenon
CO4: Utilize the knowledge in analyzing System Reliability considering economy

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to tribological systems, economic aspects, lubrication of bearings, friction control and wear prevention, properties and testing of lubricants, mechanisms of fluid flow- Reynold's equation and its limitations.	6
2	Idealized hydrodynamic bearing, plane slider bearings, journal bearings- finite and infinite, finite bearing, numerical solution, bearing design, fluid inertia and turbulence, hydrodynamic instability.	6
3	Squeeze film bearing, thrust and journal bearing, gas lubricated bearing, hydrodynamic bearings, hydrostatic bearings, porous bearings, elasto-hydrodynamic lubrication, solid lubricants.	6
4	Physico-mechanical interactions at interfacial contact, surfaces; Analysis and assessment of topography; tribo-models for asperity contact, frictional resistance and wear; Frictional instability and stick-slip phenomenon; Models of adhesion- diffusion wear process; Kinetics of solid state interfacial interactions.	6
5	Reliability, Maintainability and Availability Analysis: Failure Data Analysis, Hazard Models, System Reliability, Optimization in Reliability System, Reliability Economics and Life Cycle Analysis.	5
	Total number of contacts (Hr.)	40

Learning Resources:

1. Gunther, R.C., Lubrication, Baily Brothers and Swinfen Limited.
2. Halling, J. (Editor), Principles of Tribology, Macmillan, London.
3. Bhooshan, B. and Gupta, B.K., Handbook of Tribology: Materials, Coatings and Surface Treatments, McGraw Hill, New York.

4. Neale, M.J., Tribology Handbook- Butterworth Publication.
5. Cameron, A.t., Basic Lubrication Theory, Wiley Eastern Limited.
6. Majumdar, B.C., Introduction to Tribology of Bearings, A.H. Wheeler and Co. Pvt. Ltd., Allahabad.
7. Hutchings, L.M., Tribology: Friction and Wear of Engineering Materials, Edward Arnold, London.
8. Williams, A.H., Engineering Tribology, Oxford University Press.
9. Fuller, D.D., Theory and Practice of Lubrication for Engineers, John Wiley and Sons.
10. Moore, D.F., Principles and Applications of Tribology, Pergamon Press.
11. Rabinowicz, E., Friction and Wear of Metals, John Wiley and Sons.
12. Wilcock, D.F. and Booser, E.R., Bearing Design and Application, McGraw-Hill.
13. Hamrock, B.J., Fundamentals of Fluid Film Lubrication, McGraw-Hill.
14. Kragelsky L.V. and Alisin, V.B., Friction Wear Lubrication- Tribology Handbook, Vol- I, II, III, Mir Publication, Moscow.

Subject Code: PE-PEM 301E	**Category:** Program Elective-V
Subject Name: Design and Manufacture of Cutting Tools, Mould and Dies	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Knowledge of Manufacturing Processes and Machining at the Under-Graduate Level	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Select and design suitable cutting tool for machining a material
CO2: Apply a manufacturing method to make the tooling
CO3: Design a mould to facilitate casting of different types
CO4: Make an innovative tooling using RP system
CO5: Design tooling systems to make components using shearing, rolling, extrusion, etc.

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Design of cutting tools- designing for single and multi-point tools, form tool design, drill, milling cutter, gear cutting hob, broach; designing for product quality requirement. Design of high-production cutting tools- features, typical tools available.	6
2	Economics of tooling- analyses for optimum machining conditions, comparison between inserted and brazed tools.	4
3	Process steps for tool manufacture- moulding, die making, powder forming, machining, grinding, brazing, surface coating, etc., special purpose and unconventional machine tools and equipment for tool making, related heat treatment processes and furnaces, finishing techniques.	6
4	Mould construction- injection mould, compression mould, transfer mould; feed system, ejection system, cooling system, heating system; selection of parting surfaces, mould with external and internal undercuts, mould for threaded components, under feed moulds. Defects in moulding and its remedies. Design features of mould, methodical approach for design of mould, moulding machines.	7
5	Rapid prototyping; utility, integration of CAD data with the rapid prototyping machine.	3
6	Punch and die design for shearing operations; blank layouts; die sets, split dies, strippers, stops, pilots and punch mounting methods; progressive, compound and combination dies; fine blanking; bending tools; drawing and deep drawing tools; miscellaneous tools like embossing, coining, standard die set, etc.	7

7	Design of rolling and extruding dies, plastic processing, multiple extrusion dies. Flow analysis in forming; theory of spring back. Selection of press; feeding devices; Press working lubricant. Material selection and heat treatment.	7
	Total number of contacts (Hr.)	40

Learning Resources:

1. Bhattacharyya, A. and Ham, I., Design of Cutting Tools: Use of Metal Cutting Theory, ASTME, Michigan, 1969.
2. Bhattacharyya, A., Metal Cutting: Theory and Practice, Central Book Publishers, Kolkata.
3. Arshinov, V. and Alekseev, G., Metal Cutting Theory and Cutting Tool Design, Mir Publishers, Moscow.
4. Ghosh, A. and Mallik, A.K., Manufacturing Science, Affiliated East-West Press Pvt. Ltd., New Delhi.
5. Shaw, M.C., Metal Cutting Principles, Oxford University Press CBS.
6. Boothroyd, G., Fundamentals of Metal Machining & Machine Tools, McGraw Hill.
7. Trent, E.M. and Wright, P.K., Metal Cutting, Butterworth Heinemam Publication.
8. Joshi, P.H., Cutting Tools, Wheeler Publication.
9. Malkin, S., Grindings Technology: Theory and Application of Machining with abrasives, Ellis Harwood Publication, U.K., 1990.
10. Pye, R.J.W., Injection Mould Design, Longman Scientific Technical.
11. Paquin, J.R., Die Design Fundamentals, Industrial Press Inc.
12. Wright, R.E., Injection/ Transfer Moulding of Thermosetting Plastics, Hanser Pub Inc, 1995.
13. Nagpal, Metal Forming Prolesses, Khanna Pub.
14. Chitale, A.K., Gupta, R.C., Product Design & Manufacturing, 5th edition, Prentice Hall India Learning Private Limited, 2011.
15. Campbel, J.S., Principles of Manufacturing Materials & Processing.

Subject Code: OE-PEM 302A **Subject Code:** PE-PEM 301F	**Category:** Open Elective-I **Category:** Program Elective-V
Subject Name: Industrial Pollution and Waste Management	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Chemistry, Thermodynamics, Fluid Mechanics	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Have an overall idea about the various sources of industrial pollution
CO2: Tackle waste management techniques for pollution prevention
CO3: Explain various sources of air pollution and methods to control them
CO4: Have in-depth knowledge about industrial wastewater pollution and management techniques
CO5: Prevent and manage noise pollution in industries

Course Content:

Module No.	Description of Topic	Contact Hrs.
1	Introduction; classification of pollution; effects of pollution on human beings, plants and animals.	6
2	Basics of Waste Management- segregation, land application (composting), landfill, and recycling of waste. Prevention of pollution through waste management in industries.	7
3	Air pollution: physical effects; atmospheric dispersion and diffusion; method of sampling and analysis; modelling technique; practical control of air pollution and abatement.	7
4	Industrial wastewater pollution: analytical methods for industrial wastewater, industrial wastewater management, biological treatment of industrial waste.	6
5	Treatment of wastewater of food processing industries, distilleries, diaries, rice mills, textile and tanneries. Treatment of medical and pharmaceutical waste, Handling and disposal of radioactive wastes.	7
6	Noise pollution: physics of sound generation and transmission; physical characters of noise; physiological effects of noise; measuring instruments and technique; assessment of noise; noise control principle, rules and regulations.	7
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Rajni Kant, Air Pollution Control, Khanna Book Publishing Company. (AICTE Textbook)
2. Chermisinoff, P.N., Air Pollution Control and Design for Industry, Taylor & Francis.
3. Sell, N.J., Industrial Pollution Control: Issues and Techniques, Wiley-Blackwell.
4. Lohchab, R.K. and Saini, J.K., Industrial Pollution Control, IAHRW Publications.
5. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House.

Subject Name: Business Analytics	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Knowledge of Machining at the Under-Graduate Level	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Demonstrate knowledge of data analytics
CO2: Demonstrate the ability of think critically in making decisions based on data and deep analytics
CO3: Demonstrate the ability to use technical skills in predicative and prescriptive modelling to support business decision-making
CO4: Demonstrate the ability to translate data into clear, actionable insights

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics. Process and organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modeling, sampling and estimation methods overview.	8
2	Trendiness and Regression Analysis: Modeling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.	6
3	Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modeling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modeling, nonlinear Optimization.	8
4	Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, News vendor Model, Overbooking Model, Cash Budget Model.	8

5	Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.	7
6	Recent Trends in: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.	3
	Total number of contacts (Hr.)	40

Learning Resources:

1. Schniederjans, M.J., Schniederjans, D.G. and Starkey, C.M., Business analytics Principles, Concepts, and Applications, Pearson FT Press.
2. Vivek Bhambri, Business Analytics, Khanna Book Publishing Company.
3. Evans, J., Business Analytics, Pearson Education.

Subject Code: OE-PEM 302B	**Category:** Open Elective-I
Subject Name: Applied Operations Research	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic concepts of Operations Research	

Course Outcomes:

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

CO1: Apply Operations Research as a quantitative method of decision making.

CO2: Apply Operations Research as an optimization technique for linear as well as non-linear problems.

CO3: Apply dynamic programming to solve discrete as well as continuous variables.

CO4: Apply graph theory and optimize problems through network diagrams for non-linear programming problems.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Formulation of a model of real-life problem and overall optimization techniques like simplex method, finding out its sensitivity analysis and an overall idea of inventory control.	8
2	Formulation of LPPs of real-life problems and solving them through Graphical and Simplex method, solving duality and dual simplex method and parametric programming.	8
3	Introduction of non-linear programming, Kuhn-Tucker conditions and solutions through CPM/PERT.	8
4	Scheduling and sequencing of single server and multiple server models. Deterministic and probabilistic inventory control models.	8
5	Dynamic Programming, Elementary Graph Theory, Game Theory and Simulation	8
	Total number of Contacts (Hr.)	**40**

Learning Resources:

1. Sharma, J.K., Operations Research, Theory and Application, Macmillan, 2009.
2. Hillier, Lieberman, Nag, Basu, Introduction to Operations Research, McGraw Hill, 2017.
3. Panneerselvam, R., Operations Research, PHI, 2010.
4. Pant, J.C., Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.
5. Wagner, H.M., Principles of Operations Research, Prentice Hall of India, 2010.
6. Taha, H.A. Operations Research- An Introduction, PHI, 2008.

Subject Code: OE-PEM 302C	**Category:** Open Elective-I
Subject Name: Cost Management of Engineering Projects	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Knowledge of Industrial Management and Economics	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Apply cost concepts in decision-making of a project
CO2: Apply cost behaviour and profit planning related to a project
CO3: Apply pricing strategies in an industrial situation
CO4: Apply quantitative techniques for cost management in executing a project

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction and Overview of the Strategic Cost Management Process.	4
2	Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.	7
3	Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process	8
4	Cost Behaviour and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.	6
5	Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. easurement of Divisional profitability pricing decisions including transfer pricing.	8

6	Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.	7
	Total number of Contacts (Hr.)	**40**

Learning Resources:

1. Premvir Kapoor, Sociology & Economics for Engineers, Khanna Book Publishing Company.
2. Cost Accounting- A Managerial Emphasis, Prentice Hall of India, New Delhi.
3. Horngren, C.T. and Foster, G., Advanced Management Accounting.
4. Amit Gupta, The Practice of Business Statistics, Khanna Book Publishing Comapny.
5. Kaplan, R.S. and Alkinson, A.A., Management & Cost Accounting.
6. Bhattacharya, A.K., Principles & Practices of Cost Accounting, A.H. Wheeler publisher.
7. Vohra, N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.
8. Jeeva Jose, Beginner's Guide to Data Analysis using R Programming, Khanna Book Publishing Company.
9. V.K. Jain, Data Sciences, Khanna Book Publishing Company.

Subject Code: OE-PEM 302D	**Category:** Open Elective-I
Subject Name: Industrial Safety	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic concepts in Engineering	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Apply various preventive measures to avoid accidents
CO2: Apply maintenance engineering strategies in various equipment and machineries
CO3: Identify the wearing and corrosion phenomenon and its causes to take wear control strategy
CO4: Evaluate type of faults in machine tools, plants, etc. and determine their general causes

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety colour codes. Fire prevention and fire fighting, equipment and methods.	7
2	Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.	7
3	Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.	8
4	Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.	8
5	Periodic and preventive maintenance: Periodic inspection-concept and	10

	need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.	
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Poonia, M.P. & Sharma, S.C., Industrial Safety & Management, Khanna Book Publishing Company.
2. SHiggins and Morrow, Maintenance Engineering Handbook, Da Information Services.
3. Garg, H.P., Maintenance Engineering, S. Chand and Company.
4. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication.
5. Winterkorn and Hans, Foundation Engineering Handbook, Chapman & Hall London

Subject Code: OE-PEM 302E	**Category:** Open Elective-I
Subject Name: Composite Materials	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Knowledge of Materials Science	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Classify composite materials to find their applications
CO2: Learn about different reinforcements in composites
CO3: Know about manufacturing methods of composites to apply them suitable
CO4: Apply suitable technique to develop composites having desirable properties

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Definition– Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.	8
2	**Reinforcements:** Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.	8
3	**Manufacturing of Metal Matrix Composites:** Casting– Solid State diffusion technique, Cladding– Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration– Liquid phase sintering. Manufacturing of Carbon– Carbon composites: Knitting, Braiding, Weaving. Properties and applications.	8
4	**Manufacturing of Polymer Matrix Composites:** Preparation of Moulding compounds and prepregs– hand layup method– Autoclave method– Filament winding method– Compression moulding– Reaction injection moulding. Properties and applications.	8
5	**Strength:** Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.	8
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Cahn, R.W., Material Science and Technology– Composites, Vol 13, VCH, West Germany.
2. Callister, W.D.Jr., Adapted by Balasubramaniam, R., Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian Edition, 2007.
3. Lubin (Ed.), Hand Book of Composite Materials.
4. Chawla, K.K., Composite Materials.
5. Chung, D.D.L., Composite Materials Science and Applications .
6. Gay, D., Hoa, S.V. and Tasi, S.W., Composite Materials Design and Applications.
7. Gupta, O.P., Energy Technology, Khanna Book Publishing Company.

Subject Code: OE-PEM 302F	**Category:** Open Elective-I
Subject Name: Waste to Energy	**Semester: Third**
L-T-P: 3-0-0	**Credit: 3**
Pre-Requisites: Basic Chemistry, Thermodynamics, Fluid Mechanics	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Know about the various types of bio-wastes
CO2: Learn about biomass pyrolysis
CO3: Know about biomass gasification and gasifiers
CO4: Know about biomass combustion and combustors
CO5: Learn about biogas plants and production

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction to Energy from Waste: Classification of waste as fuel– Agro based, Forest residue, Industrial waste- MSW– Conversion devices– Incinerators, gasifiers, digestors.	6
2	Biomass Pyrolysis: Pyrolysis– Types, slow fast– Manufacture of charcoal– Methods– Yields and application– Manufacture of pyrolytic oils and gases, yields and applications.	6
3	Biomass Gasification: Gasifiers– Fixed bed system– Downdraft and updraft gasifiers– Fluidized bed gasifiers– Design, construction and operation– Gasifier burner arrangement for thermal heating– Gasifier engine arrangement and electrical power– Equilibrium and kinetic consideration in gasifier operation.	10
4	Biomass Combustion: Biomass stoves– Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation- Operation of all the above biomass combustors.	8
5	Biogas: Properties of biogas (Calorific value and composition)- Biogas plant technology and status– Bio energy system- Design and constructional features- Biomass resources and their classification– Biomass conversion processes- Thermo chemical conversion- Direct combustion- biomass gasification- pyrolysis and liquefaction- biochemical conversion- anaerobic digestion– Types of biogas Plants– Applications- Alcohol production from biomass- Bio diesel production- Urban waste to energy conversion- Biomass energy programme in India.	10
	Total number of contacts (Hr.)	**40**

Learning Resources:

1. Gupta, O.P., Energy Technology, Khanna Book Publishing Company.
2. Ashok, V., Non Conventional Energy, Desai, Wiley Eastern Ltd., 1990.
3. Khandelwal, K. C. and Mahdi, S. S., Biogas Technology- A Practical Hand Book, Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
4. Challal, D.S., Food, Feed and Fuel from Biomass, IBH Publishing Co. Pvt. Ltd., 1991.
5. Chandra & Chandra, Non Conventional Energy Resources, Khanna Book Publishing Company.
6. WereKo-Brobby, C.Y. and Hagan, E.B., Biomass Conversion and Technology, John Wiley & Sons, 1996

Subject Code : OE-PEM 302G	**Category:** Open Elective-I
Subject Name : Automation and Control in Industrial Application	**Semester: Third**
L-T-P: 3-0-0	**Credit:** 3
Pre-Requisites: Basic concepts of Fluid Power Control system	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Utilize the understanding of the control systems
CO2: Make use of transfer function in different dynamic equations
CO3: Analyze the time and frequency domain systems and their applications
CO4: Model of PID and PLC in industrial applications
CO5: Measure the performance of the control systems

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Control system:** Objectives of control system, Types of control systems, Concept of feedback and Automatic control, Effects of feedback, **Linear and nonlinear control systems:** Properties of Nonlinear System, Analysis and Control of Nonlinear System, Examples of essentially nonlinear phenomena, **Transfer function concept in control system:** Laplace transforms, Poles and Zeros of Transfer Function	6
2	**Dynamic Systems and their Mathematical modelling:** Translational systems, Rotational systems, Mechanical coupling, Liquid level systems, Electrical analogy of Spring–Mass-Dashpot system. Block diagram representation of control systems. Block diagram algebra. Signal flow graph. Mason's gain formula.	4
3	**Time domain analysis:** Analysis response of a dynamic system in time domain, Specifications of time domain analysis- overshoot, undershoot, rise time and settling time. Time domain analysis of a standard second order closed loop system. Concept of undamped natural frequency, damping. **First and second order systems**- Step and Impulse response. Effects of Pole and Zeros on transient response. Stability by pole location. Routh-Hurwitz criteria and applications. **Stability Analysis using root locus:** Construction of Root Loci for simple systems. Effects of gain on the movement of Pole and Zeros	9

4	**State space analysis:** Definition of state-space representation; state variables; State-Space Representation of Linear System, Most general State-Space Representation of Linear System, State-space model representation for different types of linear system, Example of continuous-time LTI case, Controllability of continuous-time LTI, Observability of continuous-time LTI, Transfer function of continuous-time LTI.	6
5	**Frequency domain analysis of linear system:** Bode plots, Polar plots, Nichols chart, Nyquist criteria, measure of relative stability, phase and gain margin. Determination of margins in Bode plot. Nichols chart. M circle and M-Contours in Nichols chart.	6
6	**PID controllers:** Operation or Control Philosophy of PID Controller, Mathematical form of PID Controller, The transfer function of the PID Controller, Functionality of each term in PID Controller. **PLC controller** : Automatic process control, Basic purpose of AUTOMATION in Manufacturing industry, Classification of industrial and laboratory automation, How PLC works, PLC architecture, Key features of PLCs, Advanced PLC Features.	5
7	**Control System performance measure:** Improvement of system performance through compensation. Lead, Lag and Lead- lag compensation, PI, PD and PID control. **Control system components:** Potentiometer, Synchros, Resolvers, Position encoders.	4
	Total number of contacts (Hr.)	40

Learning Resources:

1. Ogata, K., Modern Control Engineering, 4th Edition, Pearson Education.
2. Nagrath, I.J. and Gopal, M., Control System Engineering, New Age International.
3. Kuo, B.C. and Golnaraghi, F., Automatic Control Systems, 8th Edition, PHI.
4. Bandyopadhyay, M.N., Control Engineering Theory & Practice, PHI.
5. Varmah, K.R., Control Systems, Mc Graw Hill.
6. Nise, N., Control System Engineering, 5th Edition, John Wiley & Sons.
7. Dorf, R.C. and Bishop, R.H., Modern Control System, 11th Edition, Pearson Education.
8. Graham, C.G., Graebe, F., Stefan, F. and Mario, S.E., Control System Design, PHI.
9. Macia, N.F. and Thaler, G.J., Modeling & Control of Dynamic System, Thompson.
10. Kilian, C.T., Modern Control Technology Components & Systems, 3rd Edition, Cengage Learning.
11. Singh, Y. and Janardhanan, S., Modern Control Engineering, Cengage Learning.
12. Anandanatarajan, R. and Ramesh Babu R., Control System Engineering, Scitech.
13. Ambikapathy, A., Automatic Control Systems, Khanna Book Publishing Company, Delhi.
14. Wolovich, W.A., Automatic Control system, Oxford University Press.

Subject Code: PW-PEM 381	**Category:** Program Core Project
Subject Name: Dissertation-I (Progress)	**Semester: Third**
L-T-P: 0-0-20	**Credit: 10**
Pre-Requisites: Knowledge about the topic to choose	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Identify the scope for taking further steps to complete the project work
CO2: Analyze the observations made in the chosen area of work
CO3: Experiment with, or Solve, a task confidently and independently

Course Contents:

A Project Dissertation would be of two-semester duration and one project would be allotted to one student. The Progress of project dissertation up to the end of the Third Semester would be evaluated by the concerned supervisor and a panel of examiners through a seminar presentation on the progress of dissertation followed by viva voce. The Progress of project dissertation up to the end of the Third Semester would be presented by the student concerned and viva voce will be conducted by a panel of examiners.

Subject Code: PW-PEM 481	**Category:** Program Core Project
Subject Name: Dissertation-II (Completion)	**Semester: Fourth**
L-T-P: 0-0-32	**Credit: 16**
Pre-Requisites: Knowledge about the topic chosen	

Course Outcomes:

On successful completion of the course, students will be able to:
CO1: Identify the scope for future research work in the chosen area
CO2: Analyze and interpret the observed results utilizing reasoning ability
CO3: Organize detail of a project plan by exploring the research gap

Course Contents:

Total output of the project work would have to be submitted in form of a bound thesis containing literature review, objective, details of work done, conclusion, reference, etc. The evaluation of the thesis will be done by a panel of examiners.

Final presentation and viva voce of the project will be based on the project thesis submitted to be conducted by a panel of examiners.

---------- XXXX ----------