DEPARTMENT OF MECHANICAL ENGINEERING

(Choice Based Credit System)

R18

POST GRADUATION PROGRAM

MASTER OF TECHNOLOGY

in

PRODUCTION ENGINEERING

Scheme of Instructions and Evaluation

*(With effect from the Academic Year **2016-17**)*

SRI VENKATESWARA UNIVERSITY

COLLEGE OF ENGINEERING: TIRUPATI -517502

(AUTONOMOUS)

VISION AND MISSION OF MECHANICAL ENGINEERING DEPARTMENT

VISION:

To be a globally renowned center for quality education and innovative research in Mechanical Engineering

MISSION:

M1	Prepare effective and responsible graduate engineers for global requirements.
M2	Continuously strive to improve pedagogical methods employed in delivering the academic programs.
M3	Respond dynamically to the changing requirements of the industry.
M4	Conduct basic and applied research to contribute to intellectual human capital.
M5	Inculcate the spirit of entrepreneurship and social responsibility.

PROGRAM OUTCOMES

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and

understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

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

MECHANICAL ENGINEERING

M.Tech (Mechanical Engineering) Specialization: Production Engineering

SEMESTER – I

Course Code	Course Title	Scheme of Instruction (Hours/Week)				No. of Credits	Scheme of Evaluation		
		Lecture	Tutorial	Practical	Total		Sessional Marks	Semester End Examination Marks	Total
PEPC 01	Advanced Manufacturing Processes	3	-	-	3	3	40	60	100
PEPC 02	Advanced material technology	3	-	-	3	3	40	60	100
Professional Elective- I Any One from the Following		3	-	-	3	3	40	60	100
PEPE 11	Applied Probability and Statistics								
PEPE 12	Operations Planning and Control								
PEPE 13	Advanced Casting Technology								
Professional Elective- II Any One from the Following		3	-	-	3	3	40	60	100
PEPE 21	Robotics								
PEPE 22	Design for Manufacturing								
PEPE 23	Metrology & Computer								
PECP 01	Production Engineering Lab – I	-	-	2	2	2	40	60	100
PECP 02	CAD Lab	-	-	2	2	2	40	60	100
PGMC 01	Research Methodology and IPR	2	-	-	-	2	40	60	100
PGPA 01	Audit Course-I								
	Total	16	-	8	20	15	280	420	700

SEMESTER – II

Course Code	Course Title	Scheme of Instruction (Hours/Week)				No. of Cred	Scheme of Evaluation		
		Lectu	Tutor	Practi	Tot		Sessio	Semester End	Tota

		re	ial	cal	al	its	nal Marks	Examination Marks	l
PEPC 03	Computer Integrated Manufacturing	3	-	-	3	3	40	60	100
PEPC 04	Metal Cutting Tool Design	3	-	-	3	3	40	60	100
Professional Elective- III Any One from the Following		3	-	-	3	3	40	60	100
PEPE 31	Automation Manufacturing								
PEPE 32	Metal Forming Technology								
PEPE 33	Additive Manufacturing								
Professional Elective- IV Any One from the Following		3	-	-	3	3	40	60	100
PEPE 41	Energy Management								
PEPE 42	Advanced Welding Processes								
PEPE 43	Oil Hydraulics and Pneumatics								
PECP 03	Production Engineering Lab-II	-	-	2	4	2	40	60	100
PECP 04	CAM Lab - II	-	-	2	4	2	40	60	100
PGPA 02	Audit Course-II	2	-	--	-	-	-	-	-
PEMP 01	Mini Project	-	--	4	4	2	100		100
	Total	14	-	8	20	18	340	360	700

SEMESTER – III

Course Code	Course Title	Scheme of Instruction (Hours/Week)	No. of Credits	Scheme of Evaluation

		Lecture	Tutorial	Practical	Total		Sessional Marks	Semester End Examination Marks	Total
Professional Elective- V Any One from the Following		3	-	-	3	3	40	60	100
PEPE 51	Finite Element Methods								
PEPE 52	Expert Systems in Manufacturing								
Open Elective- I Any One from the Following		3	-	-	3	3	40	60	100
PGOP 11	Business Analytics								
PGOP 12	Industrial Safety								
PGOP 13	Operation Research								
PGOP 14	Cost Management of Engineering Projects								
PGOP 15	Composite Materials								
PGOP 16	Waste to Energy								
PEPD 01	Major Project: Phase-I Dissertation	-	-	20	20	10	100	-	100
	Total	6	-	20	26	16	180	120	300

SEMESTER – IV

Course Code	Course Title	Scheme of Instruction (Hours/Week)				No. of Credits	Scheme of Evaluation		
		Lecture	Tutorial	Practical	Total		Sessional Marks	Semester End Examination Marks	Total
PSPD 01	Major Project: Phase-I Dissertation	-	-	32	32	16	40	60	100
Total		-	-	32	32	16	40	60	100

Audit Course 1 & 2

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

PEPC 01 ADVANCED MANUFACTURING PROCESSES
M.Tech I Semester
Production Engineering

Lectures / Week: 3 periods

Course Objectives:

1. To learn about various unconventional machining processes, the various process parameters and their influence on performance and their applications
2. Understand various surface processing operations.
3. Able to learn about the fiber reinforced composites, Elastomers, Reinforced plastics, MMC, CMC, Polymer matrix composites.

Course Content:

UNIT-I

Abrasive jet machining: Elements of the process, mechanics of metal removal process parameters, economic considerations, applications and limitations, recent developments.

Ultrasonic machining: Elements of the process, machining parameters, effect of parameters on surface finish and metal removal rate, mechanics of metal removal process parameters, economic considerations, applications and limitations.

UNIT-II

Electro-Chemical Processes: Fundamentals of electro chemical machining, metal removal rate in ECM, Tool design, Surface finish and accuracy economics aspects of ECM.

Wire EDM Process: General Principle and applications of Wire EDM, Mechanics of metal removal, Process parameters, and selection of tool electrode and dielectric fluids, methods surface finish and machining accuracy.

UNIT-III

Electron Beam Machining: Generation and control of electron beam for machining, theory of electron beam machining, principle, advantages, and limitations, comparison of thermal and non-thermal processes.

Plasma Arc Machining: Principle, machining parameters, effect of machining parameters on surface finish and metal removal rate, applications, limitations

UNIT-IV

Laser Beam Machining: Principle, effect of machining parameters on surface finish, applications, and limitations.

Surface Processing Operations: Plating and Related Processes, Conversion Coatings, Physical Vapor Deposition, Chemical Vapor Deposition, Organic Coatings, Porcelain Enameling and other Ceramic coatings, Thermal and Mechanical Coating Processes.

UNIT-V

Processing of Ceramics: Applications, characteristics, classification .Processing of particulate ceramics, Powder preparations, consolidation, Drying, sintering, Hot compaction, Area of application, finishing of ceramics. Processing of Composites: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, MMC, CMC, Polymer matrix composites.

REFERENCES:

1. Fundamentals of Modern Manufacturing- Mikell P. Groover, John Wiley & Sons Publishers
2. Modern Machining Process - P.C Pandey and H.S Shan, Tata McGraw - Hill Education (1980)
3. Manufacturing Engineering and technology – Serope Kalpakjian & Stephen Schmid
4. Advanced Machining Processes / V.K.Jain / Allied Publications.
5. Introduction to Manufacturing Processes / John A Schey / Mc Graw Hill.
6. Process and Materials of Manufacturing / R. A. Lindburg / 1th edition, PHI 1990.

Course Outcomes:

1. Students can able to demonstrate different unconventional machining processes
2. Able to test the influence of different process parameters on the performance and their applications
3. Able to select the different types of composites for different applications.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2				2							
CO2	2		2		3							
CO3	2				2							

PEPC 02 ADVANCED MATERIAL TECHNOLOGY
M.Tech I Semester
Production Engineering

Lectures / Week: 3 periods

Course Objectives:

1. Able to understand the concept of materials i.e., conventional materials such as metallic and non metallic materials with their structures and applications.
2. Able to know the need for newer materials by comparing the limitations of conventional materials along with their properties and applications.
3. Able to compile about the properties, structure of ceramic materials and their need for newer applications and processing techniques.

Course Content:

UNIT-I

Introduction to composite materials

Definition, Classification, Types of matrices & reinforcements, characteristics & selection, Fiber composites, laminated composites, particulate composites, prepregs, sandwich construction.

UNIT-II

Micro mechanical analysis of a lamina

Introduction, Evaluation of the four elastic moduli – Rule of mixture, ultimate strengths of unidirectional lamina.

UNIT-III

Macro mechanics of a lamina:

Hooke's law for different types of materials, number of elastic constants, Two – dimensional relationship of compliance & stiffness matrix. Hooke's law for two dimensional angle lamina, engineering constants – angle lamina, Invariants, Theories of failure.

UNIT-IV

Macro Mechanical analysis of laminate:

Introduction, code, Kirchoff hypothesis – CLT, A, B, & D matrices, Engineering constants, Special cases of laminates, Failure criterion.

UNIT-V

Nuclear Materials

Introduction to nuclear materials. Materials for nuclear fuel in fission and fusion reactors, Fissile and fertile materials. Control & Construction Materials for Nuclear reactors, Moderators, Heat Exchangers. Radiation proof materials. Brief discussion of safety and radioactive waste disposal.

REFERENCES:

1. Composite Materials handbook - Mein Schwartz - Mc Graw Hill Book Company - 1984.
2. Mechanics of composite materials - Autar K. - Kaw CRC Press New York. – 1st edition, 1997.
3. Mechanics of composite materials - Rober M. Joness - McGraw Hill Kogakusha Ltd. – 2008.
4. Introduction to Nuclear Engineering, by J.R Lamarsh.
5. W.D. Callister, Jr, - Material Science & Engineering Addition-Wesly Publishing Co.

Course Outcomes:

1. Students are capable to define the concept of materials i.e., conventional materials with their structure, such as electronic configuration, structure of atom, etc.
2. Students become aware of different conventional materials such as metallic and non metallic materials, structures and their applications.
3. Students will be able to demonstrate the need for newer materials by comparing the limitations of conventional materials.
4. They will be able to compare the types of newer materials along with their properties and applications.
5. They will be able to compile about the properties, structure of ceramic materials and their need for newer applications and processing techniques.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

PEPE 11 APPLIED PROBABILITY AND STATISTICS

M.Tech I Semester
Common to Industrial Engineering & Production Engineering

Lectures / Week: 3 periods

Course Objectives:

1. To identify suitable random variables for discrete and continuous probability estimation.
2. To understand the suitability of the mathematical distributions for the industrial applications
3. To study the sampling theory and apply in prediction of the event and analyze the statistical distributions by process of matrices.

Course Content:

UNIT-I

Introduction to probability: Probability, sample space — axioms of probability, Random variables — Discrete and Continuous — Expectations — Moment Generating functions. Conditional probability — Bayer's theorem — Independent Events.

UNIT-II

Discrete distributions: Binomial, Hyper geometric, Gama, Students t, Chisquare, Weibell distributions.

Bivariate random variables and their distributions (with specific reference to bivariate normal distributions only). Conditional distributions — Covariance, Correlation coefficient — Regression of the mean.

UNIT-III

Functions of random variables: Probability distribution of functions of random variables their joint probability distribution.

Sampling: Sampling Distribution — Law of Large Numbers — Central Limit theorem.

UNIT-IV

Estimation: Point Estimation, Interval Estimation and Confidence Intervals. (Maximum Likelihood Estimation), Bayesians Estimation.

Testing of Hypothesis: Simple hypothesis and the Neyman — Pearson lemma — Composite hypothesis — goodness of fit tests.

UNIT-V

Analysis of variance: One way classification — Randomized, complete block designs.

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REFERENCES

1. Ian F. Blake, An introduction to Applied Probability — John Wiley & Sons (1979)
2. Milton, J.S., Arnold, Jee C., Probability and Statistics in the Engineering and Computing Sciences — Mc Grawhill, 2003.

Course Outcomes:

At the end of the course student will be able to learn the-

1. Basic concepts of sampling applied in population enumeration.
2. Regression techniques for application and forecast the demand and related variables
3. Testing of hypothesis using statistical distributions.

Correlation between the observed values and experimental values for analysis of variance

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2										
CO2		2		3	2							
CO3		2										

PEPE 12 OPERATIONS PLANNING AND CONTROL

M.Tech I Semester

Common to Industrial Engineering & Production Engineering

Lectures / Week: 3 periods

Course Objectives:

1. To understanding the production processes involved in the manufacturing of a product
2. To forecast the production demand and estimate and plan the schedule activities.
3. To plan the loading of work stations and scheduling for line balancing and LOB.

Course Content:

UNIT-I

OPC a system approach. Types of production and OPC functions.

Forecasting: Forecasting Methods — Qualitative Methods — Quantitative methods — moving average and exponential smoothing methods for different data patterns. Forecast errors, Tracking signal.

UNIT-II

Mass Production Management Principles of flow lines, Assembly line balancing; approach to line balancing — RPW, COMSOAL, Integer and Dynamic programming formulations. Introduction to transfer lines.

Production Planning Linear programming formulations for static demand case, Product Mix Decisions. Chance constrained programming models.

UNIT-III

Aggregate Production Planning Production planning under dynamic conditions strategies, costs involved; Heuristic methods, linear production and inventory programmes. Aggregate production planning — HMMS model, search decision, parametric production planning, management coefficient models. Disaggregation — hierarchical planning, mathematical programming formulations. Master Production Schedule.

UNIT-IV

Operations Scheduling Flow shop sequencing and job scheduling.

Periodic review models. Continuous review models, lot size models with dynamic demand, inventory models of spare parts.

UNIT-V

Materials Requirement Planning (MRP) Introduction. Inventory in a manufacturing environment. Principles of MRP, MRP processing logic. MRP systems, and MRP — II, Jut-In-Time manufacturing: set-up reduction, stable MPS and Kanban control.

REFERENCES

1. Montgomery, Operations Research in Production Planning, Scheduling and Inventory Control — Prentice Hall, N.J
2. Buffa, E.S., Operations Management — John Wiley & Sons.
3. Elsyod and Boucher Analysis of Production Systems, Prentice Hall, N.J,ISE Series
4. Burbridge, Production Planning — Heinemann Publishers, 1971.

Course Outcomes:

At the end of the course student will be able to learn the-

1. Forecasting principles and techniques for short range and long range planning
2. Production requirements for each product and plan the shop floor activities
3. Work station loading and scheduling of paths to avoid bottle necks for smooth production
4. Solution for product mix decision using OR techniques.
5. Optimal job sequences to achieve the minimum make span with maximum production output

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		3										
CO2		2	2	2								
CO3		3	2	2								
CO4		2										
CO5		3										

PEPE 13 ADVANCED CASTING TECHNOLOGY
Production Engineering
Elective

Lectures / Week: 3 periods

Course Objectives:

1. Able to learn the different moulding materials of sands, binders and design of furnaces
2. Able know the basic concepts of casting design, design of running and feeding systems
3. Able to understand the concepts of nonferrous foundry metallurgical properties of liquid metals, foundry mechanization and process flow charts

Course Content:

UNIT-I

Moulding Materials Sand — Silica, Zircon, Chromite, Olivine sands; Binders — Bentonite, cement, sodium silicate, Ethyl silicate, plaster of paris, carbohydrates, setting oils, synthetic regins; Additives — Coal dust, wood flour, silica flour; Mould and core coatings; Moulds auxiliary materials; Parting agents, core paste, exothermic, insulating sleeve materials; Sand testing and controls.

UNIT-II

Furnaces Design features of Arc and Induction furnaces, heat treatment furnaces including salt bath furnaces and induction heating

UNIT-III

Principles of Casting Design Basic concepts of Engg. analysis of metal fabrication with particular reference to casting processes. Factors influencing the production' of engg., castings to customers' specifications, attem making. Chvorinov's rule, design of running and feeding systems; factors influencing the engg. design of castings. Functional design, freezing range alloys in metallic and non — metallic moulds, grain refinement, modification, various types of defects in non — ferrous alloys, influence of form and environment.

UNIT-IV

Nonferrous foundry metallurgy Properties of liquid metals, their significance in foundry practice, oxidation, solution of gases in metals, fluidity, hot tear, shrinkage and solidification Mechanisms of pure metals, Eutectic and long range freezing alloys — some advances in die casting including Acurad process — some features of steel foundry practice, specification of moulding material, Foundry practice of nonferrous metals and alloys.

UNIT-V

Foundry Mechanization and management

General principles and objectives, Plant layout Mechanization foundries, selection of equipment, operation and flow process charts

REFERENCES

1. Rosenthal et al., Principles of MetalCasting — Tata Mc Grawhill Publishers.
2. Ruddle Riser and Gating design
3. Murphi Non — ferrous Foundry Metallurgy
4. Tompkins and White Facilities planning — John wiley & Sons.
5. Filnn Metal Casting — Prentice Hall India.
6. P. L. Jam Principles ofMetal Casting — Tata McGrawhill
7. O. P. Khanna Foundry Technology — Khanna Publishers.

Course Outcomes:

At the end of the course student will be able to learn the-

1. Knowing and identification of materials for moulding the additives, coating and the methods of sand controls
2. Identification of different furnaces for metal melting and design the suitable furnace depending materials
3. Understanding of the concepts related to the casting processes and the factor those influence the design process for metals and alloys
4. Knowing the various properties of liquid metals and their compositions and attain the various alloys depending upon the temperature, Iron-carbon diagram
5. Understanding the principles of mechanization of foundries with their layouts and purchase of suitable layout

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2				2							
CO2	2		2									
CO3	2		2		3							
CO4	2											
CO5	2				2							

PEPE 21 ROBOTICS
Production Engineering
Elective

Lectures / Week: 3 periods

Course Objective:

1. To introduce the basic concepts of robots and automation.
2. To make the student familiar with the various drive systems for robot, sensors and their applications in robots and programming of robots.
3. Able to design end effectors, grippers, sensor, machine vision robot kinematics and programming and able to solve the problems relating to forward and inverse kinematics

Course Content:

UNIT-I

Fundamentals of robotics – Automation and robotics, Robot Anatomy, Four common robot configurations – SCARA robot – kinematic joints – prismatic, revolute, twisting and revolving Robot wrist motions – YPR motions– Robot work volumes – Robot characteristics – Spatial resolution, Accuracy, Repeatability.

UNIT-II

Control Systems and components – Basic control systems components and models – Mathematical models, transfer function – Block diagrams, Characteristic equations – Controllers – Proportional control , Integral control, Proportional and Derivative (PD) control, Proportional and Integral (PI) control and PID Control. Stability and speed of response of a robot arm.

UNIT-III

Drive systems and sensors –Servo controlled and non-servo controlled robots. Powering of the robot arm – Hydraulic, Pneumatic and Electric drives – Robot joint control design. Types of sensors – Contact and non – contact type sensors – Position sensors – velocity sensors – force sensors – torque sensors – Tactile sensor – proximity and range sensors – Vision sensors.

UNIT-IV

Trajectory planning of a robot arm – cubic polynomials – Trajectory planning and robot controller. Robot end – effectors – grippers and tools – Mechanical grippers – types of gripper mechanisms – gripper force analysis – vacuum grippers – magnetic grippers – Remote Centre Compliance (RCC) device.

UNIT-V

Robot arm kinematics – Homogeneous transformation matrix – DH matrix – Forward and Inverse kinematics of 2R and 3R robot manipulators, Robot Programming methods – Off – line programming and On – line programming – Manual programming, Lead through programming, robot programming languages. Industrial applications of robots.

TEXT BOOKS

1. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey, “Industrial Robotics Technology, Programming and Applications”, Mc Graw Hill Book company, 1986
2. R.K. Mittal and I.J. Nagrath, “Robotics and Control”, McGraw Hill Education (India) Private Ltd., 2014.
3. Gonzalez K.S.F.U.R.C. and Lee C.S.G., “Robotics- Control, Sensing, Vision, and Intelligence” Mcgraw-Hill Book Company (July 1987).
4. Deb S.K, Deb.S, “Robotics Technology and Flexible Automation”, Tata McGraw-Hill Education Private Limited, 2009.
5. Ganesh S. Hegde, A text book on Industrial Robotics, Laxmi Publications (P) Ltd., 2007.

REFERENCES

1. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. International Student edition, 1999
2. Mark W. Sponge & Vidya Sagar M., “Robot Dynamics and Control” ,Wiley; 1st Edition (1989)
3. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2001

Course Outcomes:

At the end of the course student will be able to learn the-

1. Importance of robotics in today and future goods production
2. Robot configuration and subsystems
3. Principles of robot programming and handle with typical robot
4. Working of mobile robots
5. The Student must be able to design automatic manufacturing cells with robotic control using the principle behind robotic drive system, end effect ors, sensor, machine vision robot kinematics and programming.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	3		2		1							
CO3	2		3									
CO4	1											
CO5	2		2		2							

PEPE 22 DESIGN FOR MANUFACTURING
Common to Industrial Engineering & Production Engineering
Elective

Lectures / Week: 3 periods

Course Objectives:

1. Understand the design rules and considerations with reference to various manufacturing processes
2. To discusses capabilities and limitations of each manufacturing process in relation to part design and cost
3. To examine DFM principles including how the design affects manufacturing cost, lean manufacturing, six sigma, etc.

Course Content:

UNIT-I

Introduction: Design philosophy-steps in design process-general design rules for manufacturability-basic principles of designing for economical production-creativity in design.

Machining processes: Overview of various machining processes-general design rules for machining-dimensional tolerance and surface roughness-Design for machining – ease –redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

UNIT-II

Metal casting: Appraisal of various casting processes, selection of casting process,-general design considerations for casting-casting tolerance-use of solidification, simulation in casting design-product design rules for sand casting.

UNIT-III

Metal joining: Appraisal of various welding processes, factors in design of weldments – general design guidelines-pre and post treatment of welds-effects of thermal stresses in weld joints-design of brazed joints. Forging: Design factors for forging – closed die forging design – parting lines of dies – drop forging die design – general design recommendations.

UNIT-IV

Extrusion & Sheet metal work: Design guide lines extruded sections-design principles for punching, blanking, bending, deep drawing-Keeler Goodman forging line diagram – component design for blanking.

UNIT-V

Plastics: Visco elastic and creep behavior in plastics-design guidelines for plastic components-design considerations for injection moulding – design guidelines for machining and joining of plastics.

REFERENCES:

1. Design for manufacture, John cobert, Adisson Wesley. 1995
2. Design for Manufacture by Boothroyd,
3. Design for manufacture, James Bralla
4. ASM Hand book Vol.20

Course Outcomes:

At the end of the course student will be able to learn the-

1. Design components for machining.
2. Simulate the casting design and choose the best casting process for a specific product.
3. Evaluate the effect of thermal stresses in weld joints.
4. Design components for sheet metal work by understanding in depth the sheet metal processes and their formation mechanisms.
5. Design plastic components for machining and joining and selecting a proper processes
   for different joining cases.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		3									
CO2	2	2	2	2								
CO3	2		2									
CO4	2		3									
CO5	2		3									

PEPE 23 METROLOGY AND COMPUTER AIDED INSPECTION
Production Engineering
Elective

Lectures / Week: 3 periods

Course Objectives:

1. To impart the knowledge of metrology and different types of measurement systems with help of computers.
2. To impart the knowledge about the various measuring instruments to measure the linear, angular, form and surface finish measurements.
3. To introduce the applications of laser in the field of metrology, quality control and inspection.

Course Content:

UNIT-I

Metrological concepts — Abbe's principle, Need for High Precision Measurements problems associated with high precision measurements. Standards for length measurement — Shop Floor Standards and their Calibration — light Interference — Method of coincidence — Slip gauge calibration — Measurement errors. Various tolerances and their specifications, Gauging Principles Selective Assembly, Comparators.

UNIT-II

Angular measurements — Principles and instruments. Thread measurements. Surface and Form Metrology, Flatness, Roughness, Waviness, Roundness, Cylindricity, etc.

UNIT-III

Computer Aided Metrology — Principles and Interfacing Software Metrology.

UNIT-IV

Laser Metrology — Application of lasers in precision measurements, Laser Interferometer, Speckle Measurements, Laser Scanners.

UNIT-V

Coordinate Measuring Machine — Types of CMM. Probes used — Application — Non control CMM using Electro optical sensors for dimensional metrology Non — contact sensors for surface finish measurements. Signal analysis — Image processing and its application in metrology.

REFERENCES

1. S.A.J.Parsons, Metrology and Gauging, Mc Donald and Evans, UK, 1970
2. K.J. Hume, Engineering Metrology, Kalyani Publishers, INDIA, 1970
3. U. Rembold et aT, Computer Integrated Manufacturing Technology and Systems,Marcel Dekker Inc., USA, 1985.
4. S.L.Robinson and R.K.Miller, Automated Inspection and Quality Assurance, Marcel Dekker Inc. USA, 1989.

Course Outcomes:

At the end of the course student will be able to learn the-

1. Metrology, quality control and Inspection so that they can meet the challenges in the industries.
2. Various instruments and measuring systems with the help of laser and other advanced
   computer integrated systems.
3. Students will be able to measure any type of features, forms with the help of CMM.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2				2						
CO2	3	1			4							
CO3	3	2										

PECP02 PRODUCTION ENGINEERING LAB –I

COURSE OBJECTIVES:

1. Understand practical orientation of manufacturing process.
2. Knowledge on different kinds of production process and practice available for shaping or molding several daily used parts for industries.
3. Prepare assembly drawing, sectional views and bill of materials for selection of equipment for various manufacturing process will be understand

List of Experiments:

1. Inspection of drill JIG.
2. Simulation of CNC programming, using XL turning m/c
3. Simulation of CNC programming, using milling m/c
4. Screw thread measurement using profile projector
5. Straightness testing by using Wedge method.
6. Study of measuring Instruments
7. Sine bar
8. Sand analysis

COURSE OUTCOMES:

1. Describe the geometry of single point cutting tool.
2. Apply knowledge of metal cutting to perform various machining operations.
3. Explain the working and use of various components of conventional machine tools.
4. Identify the sequence of operation to process a job.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				3							
CO2	3											
CO3	3				3							
CO4	3											

PECP02 CAD LAB

COURSE OBJECTIVES

1. To apply basic concept to drawing, edit, dimension, hatching etc.
2. To develop 2D & 3D Modeling.
3. To make 3D modeling, Assembling, modification & manipulation along with detailing.

List of Experiments:

1. Initializing the graphic package, setting the paper size, space, setting the limits, units, use of snap and grid commands.
2. Drawing of Primitives (line, arc, circle, ellipse, triangle etc..
3. Drawing of a flange.
4. Drawing a bushing assembly
5. Isometric & orthographic projections and viewing three dimensions.
6. 3D modeling of simple machine components.
7. 3D modeling of Complex machine components.
8. 3D Views of cotter joint with sleeve
9. 3D Views of Knuckle joint.

COURSE OUTCOMES:

1. Draw complex geometries of machine components in sketcher mode.
2. Create complex engineering assemblies using appropriate assembly constraints.
3. Develop G and M codes for turning and milling components.
4. Generate automated tool paths for a given engineering component.
5. Generate automated tool paths for a given engineering component.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											
CO2	3		3									
CO3	3			2	3							
CO4	3			2								
CO5	3											

PGMC 01 Research Methodology and IPR
Teaching Scheme

Lectures: 1hrs/week

Syllabus Contents:

Unit 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

Unit 2: Effective literature studies approaches, analysis
Plagiarism, Research ethics,

Unit 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

Unit 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.

Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 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.

References:

- Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science &engineering students”
- Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”
- Ranjit Kumar, 2nd Edition , “Research Methodology: A Step by Step Guide for beginners”
- Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
- Mayall , “Industrial Design”, McGraw Hill, 1992.
- Niebel , “Product Design”, McGraw Hill, 1974.
- Asimov , “Introduction to Design”, Prentice Hall, 1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

COURSE OUTCOMES:

At the end of this course, students will be able to

1. Understand research problem formulation.
2. Analyze research related information
3. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
4. Understanding that when IPR would take such important place in growth of individuals & Nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
5. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2									
CO2	3	3	2									
CO3	3		2									
CO4	3		2									
CO5	3		2									

PEPC 03 COMPUTER INTEGRATED MANUFACTURING
M.Tech II Semester
Production Engineering

Lectures / Week: 3 periods

Course Objectives:

1. To impart knowledge of automated processes in a modern manufacturing environment.
2. To give broad understanding of using engineering design and modeling techniques towards flow lines, numerical control and the integration of computer control/usage in manufacturing.
3. To learn contemporary manufacturing/production strategies such as agile manufacturing and group technology.

Course Content:

UNIT-I

Introduction: Scope of computer integrated manufacturing, Product cycle, Production automation.

Group technology: Role of group technology in CAD/CAM integration, Methods for developing part families, Classification and coding, Examples of coding systems, Facility design using group technology, Benefits of G.T.

UNIT-II

Computer aided process planning: Role of Process Planning, Approaches to process planning- Manual, Variant, Generative approach; Examples of Process planning systems - CAPP, DCLASS, CMPP; Criteria for selecting a CAPP system, Benefits of CAPP.

UNIT-III

Integrative manufacturing planning and control: Role of integrative manufacturing in CAD/CAM integration, Over view of production control - Forecasting, Master production schedule, Rough – Cut Capacity planning, M.R.P., Capacity Planning, Order release, Shop-floor control, Quality assurance, Manufacturing Planning and control systems; Cellular manufacturing, JIT manufacturing.

UNIT-IV

Computer aided quality control: Terminology in quality control, Contact inspection methods, Non-contact inspection methods, Computer aided testing, Integration of CAQC with CAD/CAM.

UNIT-V

Computer integrated manufacturing systems: Types of manufacturing systems, Machine tools and related equipment, Material handling systems, Computer control systems, CIMS Benefits.

REFERENCES*:*

1. Computer Integrated Design and Manufacturing by David D. Bedworth, Mark R. Henderson, Philip M. Wolfe.
2. CAD / CAM by Groover & Zimmers (PHI)
3. Automation, Production systems and Computer Integrated Manufacturing- by M.P.Groover (PHI)
4. “Computer Integrated Manufacturing System”, Yorem koren, McGraw-Hill, 1983.
5. “Computer Integrated Manufacturing”, Ranky, Paul G., Prentice Hall International, 1986.

Course Outcomes:

At the end of the course student will be able to learn the-

1. Understand the effect of manufacturing automation strategies and derive production metrics.
2. Analyze automated flow lines and assembly systems, and balance the line.
3. Design automated material handling and storage systems for a typical production system.
4. Design a manufacturing cell and cellular manufacturing system.
5. Develop CAPP systems for rotational and prismatic parts.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

PEPC 04 METAL CUTTING AND CUTTING TOOL DESIGN

M.Tech II Semester
Production Engineering

Lectures / Week: 3 periods

Course Objectives:

1. To learn the modeling technique for machining processes and interpretation of data for process selection
2. To understand the mechanics and thermal issues associated with chip formation
3. To learn the concept of the effects of tool geometry on machining force components and surface finish, machining surface finish and material removal rate

Course Content:

UNIT-I

Cutting tool geometry – Tool terminology – Tool signature/nomenclature of single point cutting tool – Tool geometry in ASA, ORS and NRS systems – Functional angles – true rake and inclination angle – Deformation of metals during cutting – Basic mechanics of metal cutting process – Mechanism of chip formation – Orthogonal cutting and Oblique cutting – Thin zone model and thick zone model – Types of chip – Chip curl – Chip breakers.

UNIT-II

Thin zone model – Merchant analysis – Kinematics of chip –Calculation of metal cutting strain – Measurement of Cutting forces – Dynamometry – Merchant theory and Lee and Shaffer theory – Friction in metal cutting – Effect of friction. Cutting tool materials – Coating of cutting tools – chemical vapour deposition and physical vapour deposition methods.

UNIT-III

Thermal aspects of machining and cutting temperatures and Acoustic Emission (AE) in metal cutting. Cutting fluids – Basic forms of wear in metal cutting – Adhesive, Abrasive and solid – state diffusion. Tool wear and Tool failure – crater wear and flank wear – wear land – Tool life equation – Variables affecting tool life. Economics of machining.

UNIT-IV

Fundamentals of drilling and grinding – Power of drilling – Theory of grinding – Cutting tool design – Types – single point and multi – point cutting tools – Design of a single point turning tool – strength and rigidity criteria – Design of multi – point cutting tools – Profile milling cutters, Drills, Broach and design of Form tools.

UNIT-V

Developments in cutting tool materials for high speed machining, Introduction to micromachining, Differences between macro cutting and micro cutting, characteristics of micro cutting – size effect, minimum chip thickness, specific power consumption etc.

REFERENCES:

1. N. Lopenz de Lacalle et al. Machine tools for high performance machining, Springer, 2009
2. Cyril Donaldson, Tool Design, Tata McGraw Hill Edition
3. ASTME Handbook Tool Design,PHI.
4. Tool Design Pollock,Reston D Taraporevala Sons,1983
5. Tool Design Nagpal, Khanna Publishers — 1991
6. G.Kuppuswamy, Principles of Metal Cutting, Orient Longmans, Hyderabad, India
7. B.L Juneja G.S.Sekhon — Fundamentals of Metal Cutting and M.K tools, New Age
8. India Pvt. Ltd. Publihers.

Course Outcomes:

At the end of the course student will be able to learn the-

1. Ability to extend, through modeling techniques, the single point, multiple point and abrasive machining processes
2. Estimate the material removal rate and cutting force, in an industrially useful manner, for practical machining processes
3. Prediction of the surface finish in machining processes
4. Understand the practical aspects of tool wear and tool life, and their influence on economics

Understand the tool and work piece temperatures and their effect on quality

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

PEPE 31 AUTOMATION IN MANUFACTURING
M.Tech II Semester
Production Engineering

Lectures / Week: 3 periods

Course Objectives:

1. To study the types and strategies and various components in Automated Systems.
2. To understand the automated flow lines, line balancing, material storage and retrieval and inspection
3. To learn the adaptive control systems.

Course Content:

UNIT-I

Introduction: Types and strategies of automation, pneumatic and hydraulic components, circuits, automation in machine tools, mechanical feeding and tool changing and machine tool control.

UNIT-II

Automated Flow Lines: Methods of part transport, transfer mechanism, buffer storage, control function, design and fabrication considerations.
Analysis of automated flow lines - General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines.

UNIT-III

Assembly System And Line Balancing: Assembly process and systems, assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.

Automated Material Handling And Storage Systems: Types of equipment, functions, analysis and design of material handling systems, conveyor systems, automated guided vehicle systems. Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

UNIT-IV

Adaptive Control Systems: Introduction, adaptive control with optimization, adaptive control with constraints, application of adaptive control in machining operations. Consideration of various parameters such as cutting force, temperatures, vibration and acoustic emission in the adaptive controls systems.

UNIT-V

Automated Inspection: Fundamentals, types of inspection methods and equipment, Coordinate Measuring Machines, Machine Vision.

REFERENCES:

1. Automation, Production Systems and Computer Integrated Manufacturing/ M.P. Groover./ Prentice Hall

2. Computer Control of Manufacturing Systems / Yoram Coren/Tata McGraw-Hill edition
3. CAD / CAM/ CIM /P. Radhakrishnan, S.Subrahmanyam,V.Raju/New Age international Publishers
4. Automation / W. Buekinsham, 3rd Edition/PHI Publications

Course Outcomes:

At the end of the course student will be able to learn the-

1. Solve the line balancing problems in the various flow line systems with and without use buffer storage
2. Understand the different automated material handling, storage and retrieval systems and automated inspection systems.
3. Use of Adaptive Control principles and implement the same online inspection and control

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							

PEPE 32 METAL FORMING TECHNOLOGY
Production Engineering
Elective

Lectures / Week: 3 periods

Course Objectives:

1. To understand the characteristics of different processes
2. Able to solve the problems arising in metal forming technology
3. Able to analyze the design requirements of drawing and extrusion processes

Course Contents:

UNIT-I

Characteristics of presses types of drives of crank, eccentric, knuckle joint, rocker arm, non — geared and geared fly wheel type number of suspensions, use of counterbalances etc. Types of friction screw presses — 3 wheel, 4 — wheel vinunt, percussion, Belta drive, electric and hydraulic screw drives.

UNIT-II

Input — output balance diagrams of these drives. Characteristics and stroke rating of these machines. Horizontal forge machine, press frame design, guides.

UNIT-III

Fundamental theories of plasticity and mechanics of plastic deformation equations, methods for solution of problems in metal formation processes.

UNIT-IV

Fluid power in metal forming and related machine tools. Introduction of symbols, pumps, accumulators, valves. Classification of hydraulic presses extrusion, forging and deep drawing presses — design features — choice of fluid in hydraulic presses.

UNIT-V

Column design in hydraulic presses. Comprehensive design analysis of a deep drawing press and extrusion press. Hammers for hammer forgings. Classification based on action, stands, controls, and power medium. Theoretical principles involved in estimating efficiency of hammer, number of strokes, and power variation during — a play hammer.

REFERENCES

1. Row., Metal Forming Technology
2. Crane, Press Working of Metals, John Weliy & Sons; 1957

Course Outcomes:

At the end of the course student will be able to learn the-

1. Metal forming fundamentals and applications.
2. Metal forming mechanics.
3. Workability of testing techniques.
4. Tribology in metal forming and other phenomena

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							

PEPE 33 ADDITIVE MANUFACTURING
M.Tech II Semester
Production Engineering

Lectures / Week: 3 periods

Course Objectives:

1. To learn the time compression technologies in the product development and manufacturing.
2. Able to model and fabrication of various complex engineering products.
3. Applications of additive manufacturing technologies in product development and manufacturing.

Course Content:

UNIT-I

Introduction: Introduction to Prototyping, Traditional Prototyping Vs Rapid Prototyping (RP), Need for time compression in product development, Usage of RP parts, Generic RP process, Distinction between RP and CNC and other related technologies, Classification of RP, Need for RP software, MIMICS, Magics, SurgiGuide, 3-matic, 3D-Doctor, Simplant, Velocity2, VoXim, SolidView, 3DView, etc., Preparation of CAD models, Problems with STL files, STL file manipulation, RP data formats: SLC, CLI, RPI, LEAF, IGES, HP/GL, CT, STEP.

UNIT-II

Rapid Prototyping (RP) Processes:

Photopolymerization RP Processes: Stereolithography (SL), SL resin curing process, SL scan patterns, Microstereolithography, Applications of Photopolymerization Processes,

Powder Bed Fusion RP Processes: Stereolithography (SL), SL resin curing process, SL scan patterns, Microstereolithography, Applications of Photopolymerization Processes

Extrusion Based RP Processes: Fused Deposition Modelling (FDM), Principles, Plotting and path control, Applications of Extrusion-Based Processes

Printing RP Processes: 3D printing (3DP), Research achievements in printing deposition, Technical challenges in printing, Printing process modelling, Applications of Printing Processes

Sheet Lamination RP Processes: Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications

Beam Deposition RP Processes: Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Processing-structure-properties, relationships, Benefits and drawbacks

UNIT-III

Rapid tooling: Conventional Tooling Vs. Rapid Tooling, Classification of Rapid Tooling, Direct and Indirect Tooling Methods, Soft and Hard Tooling methods

UNIT-IV

Reverse engineering: Reverse Engineering (RE) Methodologies and Techniques, Selection of RE systems, RE software, RE hardware, RE in product development

UNIT-V

Errors in RP processes and applications: Pre-processing, processing, post-processing errors, Part building errors in SLA, SLS, etc., Design, Engineering Analysis and planning applications, Rapid Tooling, Reverse Engineering, Medical Applications of RP

REFERENCES:

1. Chua Chee Kai., Leong Kah Fai., Chu Sing Lim, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific, 2010.
2. Ian Gibson., David W Rosen., Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010.
3. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.
4. D. T. Pham, S. S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer, 2011,

Course Outcomes:

At the end of the course student will be able to learn the-

1. Identify the need for time compression in product development and manufacturing.
2. Model and fabricate any complex engineering product.
3. Select the rapid manufacturing technology for a given application.
4. Minimize various errors that are occurring during conversion of CAD models.
5. Illustrate the working principles of various rapid manufacturing technologies.
6. Optimize the quality of parts produced by the various rapid manufacturing technologies.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							
CO6												

PEPE 41 ENERGY MANAGEMENT
Common to Industrial Engineering & Production Engineering
Elective

Lectures / Week: 3 periods

Course Objectives:

1. Familiarizing with management, especially with management in energy sector engineering.
2. Studying methods of energy accounting and energy auditing in energy sector, industry and final consumption.
3. Able to understand the fundamentals of product strategy management and Finding opportunities to increase the rational use of alternative energies.

Course Content:

UNIT-I

Introduction: Principles of energy management. Managerial organization, Functional areas for i) manufacturing industry, ii) Process industry, iii) Commerce, iv) Government, Role of Energy manager in each of these organizations. Initiating, Organizing and managing energy management programs

UNIT-II

Energy Audit: Definition and concepts. Types of energy audits, Basic energy concepts, Resources for plant energy studies. Data gathering, Analytical techniques. Energy Conservation: Technologies for energy conservation, Design for conservation of energy materials, Energy flow networks. Critical assessment of energy usage. Formulation of objectives and constrains, Synthesis of alternative options and technical analysis of options. Process integration.

UNIT-III

Economic Analysis: Scope, Characterization of an investment project. Types of depreciation, Time value of money. Budget considerations, Risk analysis.

UNIT-IV

Alternative Energy Sources:

Solar Energy – Types of devices for Solar Energy Collection – Thermal Storage System – Control Systems-

Wind Energy – Availability – Wind Devices – Wind Characteristics – Performance of Turbines and systems.

UNIT-V

Bio-Mass: Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield,combustion characteristics of bio-gas, utilization for cooking, I.C.Engine operation and economic aspects.

Geothermal Energy: Resources, types of wells, methods of harnessing the energy, potential in India.

Ocean Energy: OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles

REFERENCES:

1. Energy Management Hand Book / W.C. Turner (Ed)
2. Renewable Energy Sources fTwideil & Weir
3. Solar Energy /Sukhatme
4. Energy Management Principles / CB Smith/ Pergamon Press
5. Energy Management / W.R.Murthy and G.Mc.Kay / BS Publication
6. Management / H.Koontz and Cyrill Donnel / McGraw Hill
7. Rai G.D. : Non-conventional Energy Sources, Standard Publishers Distributors

Course Outcomes:

At the end of the course student will be able to learn the-

1. Understanding basics of demand side management and mechanisms (technical, legal or financial) that influence energy consumption.
2. Recognizing opportunities for increasing rational use of alternative energies.
3. Learning the basics of energy auditing with application on different sectors.
4. Able to take the decisions in budget estimations and evaluate risk analysis

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							

PEPE 42 ADVANCED WELDING PROCESSES
Production Engineering
Elective

Lectures / Week: 3 periods

Course Objectives:

1. Able to perform different weldability testing for different metals.
2. To understand the application of preheat and PWHT of weld joints in industry
3. Able to apply the knowledge about various methods for increasing service life of equipments

Course Content:

UNIT-I

General survey and classification of welding processes. Conventional gas welding and cutting. Manual metal arc welding. Electrode coverings and their functions. Continuous processes based on above.

UNIT-II

Submerged arc welding — types of fluxes and their compounding Wire and strip electrodes. Gas shielded welding TIG and MIG and MAG/ C02processes. Consideration of shielding gases, electrode polarity, current setting, metal transfer and arc length control. Plasma welding and cutting processes. Equipment maintenance, application of the above.

UNIT-III

Electrical power sources for welding; General characteristics of transformer, transformer — rectifier and motor generator sets. Use of pulsed currents. Pressure welding processes Solid phase bonding, friction welding, ultrasonic welding.

UNIT-IV

Explosive welding, Diffusion bonding and adhesive bonding. Resistance welding Spot, Seam and projection welding, Flash and upset butt welding.

UNIT-V

Brazing and soldering Electron Beam, Laser and Infrared Welding. Principles, Operational details, Process controls and application of above processes.

REFERENCES

1. The Science and Practice of Welding by Davies, A.C., Cambridge Low Price Edition
2. Welding Processes by Houldcroft, P. T., PHI Publications
3. Welding Technology by Konigsberger, F. Mc Graw Hill Publications
4. Welding and Welding Technology by Little, Richard L , TATA Mc Graw Hill Publications.
5. Welding Engineering by Rossi, Boniface E, PHI, Publications
6. Advanced Welding Systems. Vol.1 ; Vol.2 and Vol.3 by Jean Cornu, USA Edition.

Course Outcomes:

At the end of the course student will be able to learn the-

1. Weld ability and perform different weld ability testing for different metals.
2. Different dissimilar metal and its cladding.
3. Application of preheat and PWHT of weld joints as per codes and standards used in fabrication industry.
4. Knowledge about different methods for increasing service life of equipment.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							

PEPE 43 OIL HYDRAULICS AND PNEUMATICS
Production Engineering
Elective

Lectures / Week: 3 periods

Course Objectives:

1. To understand the concepts of power transmission systems
2. Able to identify the components of hydraulic and pneumatic systems
3. Able to learn the concepts and to built different hydraulic and pneumatic circuits for different engineering applications

Course Content:

UNIT-I

Introduction

Functional requirements of a power transmission, different type of power transmission systems and their combinations; Fundamentals of oil hydraulics and pneumatics, Control functions of oil hydraulic systems; Comparison between Mechanical, Oil Hydraulic, Pneumatic and Electrical power transmission systems; Advantages, disadvantages and Applications of Oil Hydraulic and Pneumatic power transmissions.

UNIT-II

System Components

Hydraulic & Pneumatic Symbols as per ISO/ANSI, Properties and selection of hydraulic fluids, Filtration, Hydraulic Reservoirs and Accumulators, Intensifiers or Pressure Boosters, Seals and Packing.

UNIT-III

Oil Hydraulic Pumps and Actuators

Construction, working principle and operation of rotary & reciprocating pumps like Gear, Vane, Generated-Rotor, Screw, Axial Piston, Radial Piston, Pump characteristics, Specifications and selection of pumps; Linear actuators like Ram type, Telescopic and Single acting/double acting, types of their constructions, types of mountings, cylinder materials, cushioning of hydraulic cylinders, Rotary actuators, specifications, sizing and selection of pumps and actuators.

UNIT-IV

Control Valves

Construction, working principle and operation of Direction control valves, Flow control valves and Pressure control valves; including Check, Pressure relief, Compound Pilot operated Pressure Relief, Safety, Sequence, Pressure Reducing, Unloading, Counterbalance valves. Different types of center positions of DCVs, Methods of actuation of DCVs.

Hydraulic and Pneumatic Controllers used in Feedback Control systems

Construction, working principle and operation of Proportional and Servo control valves including Servo-type DCV like nozzle valve, flapper type valve, mechanical servo valve, single and double stage servo valves; Applications of servomotor systems in feedback control systems.

UNIT-V

Hydraulic Circuits

Reciprocation, quick return, sequencing, flow control circuits, synchronizing circuits, accumulator circuits, industrial circuits like press circuits, machine tool circuits, forklift, earth mover circuits- design and selection of components.

Pneumatic circuits

Compressed air production and distribution, pneumatic control components, examples of application including electro-pneumatic and hydro pneumatic controls.

REFERENCES:

1. Industrial Hydraulics by John Pippenger and Tyler Hicks, McGraw Hill.
2. Oil Hydraulic Systems, Principle and Maintenance by S R Majumdar, McGraw-Hill.
3. Fluid Power with Applications by Anthony Esposito, Pearson.
4. Fluid Power: Generation, Transmission and Control, Jagadeesha T., Thammaiah Gowda, Wiley.
5. The Analysis & Design of Pneumatic Systems by B. W. Anderson, John Wiley.
6. Control of Fluid Power Analysis and Design by Mc Clay Donaldson, Ellis Horwood Ltd.
7. Hydraulic and Pneumatic Controls: Understanding made Easy, K.Shanmuga Sundaram, S.Chand & Co Book publishers, New Delhi, 2006 (Reprint 2009)
8. Basic Pneumatic Systems, Principle and Maintenance by S R Majumdar, McGraw-Hill.
9. Basic fluid power Dudley, A. Pease and John J. Pippenger, , Prentice Hall, 1987

Course Outcome:

At the end of the course student will be able to learn the-

1. Identify and analyze the functional requirements of a power transmission system for a given application. (Application involving fluid power transmission)
2. Design an appropriate hydraulic or pneumatic circuit or combination circuit like electro-hydraulics, electro-pneumatics for a given application. Develop a circuit diagram.
3. Visualize how the hydraulic/pneumatic circuit will work to accomplish the function.
4. Selection and sizing of components of the circuit.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							

PECP03 PRODUCTION ENGINEERING LAB -II

List of Experiments:

1. Measurement of cutting forces using lathe tool dynamometer.
2. Measuring of cutting forces using drill dynamometer
3. To determine the major & minor flank angle of a particular screw by using tool makers microscope.
4. To arrange the dividing head for differential Indexing, to divide a circular part into number of parts, using differential indexing.
5. Surface roughness measurement by using Talysurf
6. Measurement of cutting forces in milling
7. Spur gear measurement
8. Welding
9. To write manual part program for profile turning cycle to the given dimensions for a typical part.
10. To write the manual part program for drilling operation

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

PECP04 CAM Lab.

Syllabus

- Preparation of process planning.
- CNC programming using G & M codes for the given work piece & also show the simulation using CNC lathe software.
- Simulation & executions of part programme for given component using CNC milling.

Note: Conduct at least 8 Exercises in above topics.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

PEPE 51 FINITE ELEMENT METHOD
Production Engineering
Elective

Lectures / Week: 3 periods

Course Objectives:

1. Possess a good understanding of the theoretical basis of the weighted residual Finite Element Method.
2. Be able to implement the Galerkin residual weak formulation into the Finite Element Method for the solution of Ordinary and Partial Differential Equations, using mathematical software such as Maple.
3. Able to know various applications solid mechanics, heat transfer and fluid mechanics

Course Content:

UNIT-I

Overview of FEM: Basic concepts – Historical background – General applicability of methods – one dimensional heat transfer, fluid flow, solid bar under axial load – Engineering applications of finite element method – general procedure in FEM – comparison of FEM and other methods of solutions.

UNIT-II

Approximate methods of Analysis: Methods of Weighted residuals – point collocation – Collection of sub-regions – least squares - Galerkin method, - Rayleigh`s method, Rayleigh – Ritz method, Ritz method, FDM

Discritization of Domain: Introduction to discritization of Domain – Basic element shapes – Descritization process – Types of elements and sizes – Finite representation of bodies – Node Numbering scheme – Automatic mesh generation methods –

UNIT-III

Interpolation methods: Introduction to interpolation polynomials – Polynomial forms of interpolation functions – Simplex, complex and multiplex elements – interpolation polynomial in terms of nodal degrees of freedom – Selection of order of interpolation polynomial – Convergence requirements – linear interpolation polynomials in terms of global co-ordinates - interpolation polynomials in terms of local co-ordinates

UNIT-IV

Higher Order and Isoparametric elements: Higher order one dimensional elements – Higher order elements in terms of natural coordinates - Higher order elements in terms of interpolation polynomials – One Dimensional elements and two dimensional elements using classical interpolation polynomials – comparative studies of elements – Isoparametric elements - shape function in co-ordinate transformation – continuity and compatibility – Numerical integration

UNIT-V

Applications in solid mechanics: Introduction - Plane stress – Plain strain rectangular element – Isoparametric formulation – Axisymetric stress analysis

Applications in heat transfer: Introduction – One dimensional heat conduction : quadratic element – One dimensional heat conduction with convection

Applications in fluid mechanics: Introduction – Governing equation for incompressible flow : Rotational and Irrotational.

REFERENCES:

1. Finite element method in Engineering – SS. Rao, Edition 4, Elsevier Publications, 2004
2. Fundamentals of Finite Element Analysis, David V. Hutton., Mc Graw Hill Publications, 2004
3. An Introduction to Finite Element Method , Reddy J.N., Mc Graw Hill Publications
4. Introduction to Finite Elements in Engineering:Chnandrupatla T.R.& Belegundu A.D, pearson education publishers, 4th edition. 2009
5. Finite Element Procedures, Klaus-Jurgen Bathe, Prentice Hall Professional, Revised Edition.1995.

Course Outcomes:

At the end of the course student will be able to learn the-

1. Able to design, set up, and conduct engineering experiments and analyze the results.
2. An ability to carry out projects and research in interdisciplinary areas.
3. Graduates will possess managerial and leadership skills with professional ethical practices and will understand the proper use of technical papers, copyrights and patents, recent advances in Finite Element Method field.
4. Able to understand the impact of Finite Element Method solutions in a global, economic, environmental, and societal context by participating at national level competitions like technical paper presentation, quiz programs, essay writing competitions, Industrial tours, Alumni association.
5. Recognition of the need for, and an ability to engage in lifelong learning and comprehend the current professional issues.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

PEPE 52 EXPERT SYSTEMS IN MANUFACTURING
Production Engineering
Elective

Lectures / Week3 periods

Course Objectives:

1. Able to understand the concepts of Artificial Intelligence and expert systems
2. To learn, how to represent knowledge and interface in manufacturing application

Course Content:

UNIT-I

Artificial Intelligence & Expert Systems, (Knowledge based systems); Definition — Justification — Structure Knowledge acquisition; Knowledge base, Inference engine, User interface, Explanatory module, Forward and backward chaining

UNIT-II

Knowledge representation and inferencing. Building expert systems Suitability of task, architecture, hardware, software, personnel — Expert system building tools language, shells.

UNIT-III

Commercial software for manufacturing applications in CAD, CAPP, MRP, CAM, MRP II, Adaptive control of devices, Robotics, Process control, Fault diagnosis, Failure analysis etc.;

UNIT-IV

Linking expert systems to other software such as DBMS, MIS, MDB, Process control and office — automation.

UNIT-V

Case studies of typical applications in process planning tool selection, cutting tool selection, part classification, inventory control, facilities planning, etc. The IITM rule selection.

REFERENCES

1. Adodji. B, BAd1I. N Expert System Applications in Engineering & Manufacturing — John Wiley & Sons(I 995)
2. Peter Jackson Introduction to Expert Systems.
3. Martin Merry Expert System — 85.

Course Outcomes:

At the end of the course student will be able to learn the-

1. Fundamental theories, concepts, and applications of computer science in solving real-time problems.

2. Able to Demonstrate working knowledge of reasoning in the presence of incomplete and/or uncertain information.
3. Ability to apply knowledge representation, reasoning, and machine learning techniques to real-world problems.
4. Able to solve the problems in the field of machining, inventory control, process planning with the help of expert systems.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							

OPEN ELECTIVES
PGOP 11 Business Analytics

Lecture: - 3 h/week

Course objective

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. To become familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail,software, banking and finance, sports, pharmaceutical, aerospace etc.

Unit1:

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.
Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Unit 2:

Trendiness and Regression Analysis: Modelling 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.

Unit 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 Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Unit 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, Newsvendor Model, Overbooking Model, Cash Budget Model.

Unit 5:

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Unit 6:
Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Reference:
1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G.Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

COURSE OUTCOMES
1. Students will demonstrate knowledge of data analytics.
2. Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
3. Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
4. Students will demonstrate the ability to translate data into clear, actionable insights.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							

OPEN ELECTIVES
PGOP 12 Industrial Safety

Lecture: - 3 h/week

Unit-I: Industrial safety: Accident, causes, types, results and control, mechanical and electricalhazards, 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 color codes. Fire prevention and firefighting, equipment and methods.

Unit-II: 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.

Unit-III: 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.

Unit-IV: Fault tracing: Fault tracing-concept and importance, decision treeconcept, 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.

Unit-V: Periodic and preventive maintenance: Periodic inspection-concept and 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

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							

CO3	3		2		2							
CO4	3				2							
CO5	3				2							

OPEN ELECTIVES
PGOP 13 Operations Research

Lectures: 3 hrs/week

Course Outcomes: At the end of the course, the student should be able to
1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

Syllabus Contents:

Unit 1:
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Unit 2
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex
method - sensitivity analysis - parametric programming

Unit 3:
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow
problem - CPM/PERT

Unit 4
Scheduling and sequencing - single server and multiple server models - deterministic inventory
models - Probabilistic inventory control models - Geometric Programming.

Unit 5
Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

References:
1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

Open Elective

PGOP 14 Cost Management of Engineering Projects

Lecture: - 3 h/week

UNIT-I

Introduction and Overview of the Strategic Cost Management Process
Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunitycost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

UNIT-II

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 nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance.

UNIT-III

Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process Cost Behavior 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. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector.

UNIT-IV

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. Measurement of
Divisional profitability pricing decisions including transfer pricing.

UNIT-V

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

References:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							

CO5	3				2							

Open Elective
PGOP15 Composite Materials

Lecture: - 3 h/week

UNIT–I: 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.
UNIT – II: 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.
UNIT – III: 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.
UNIT–IV: 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.
UNIT – V: 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.

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

References:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W.Tasi.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

Open Elective
PGOP 16 Waste to Energy

Lecture: - 3 h/week

Unit-I: Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit-II: Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-III: 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.

Unit-IV: 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.

Unit-V: 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.

References:

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

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

Course objectives:

Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title
Ensure the good quality of paper at very first-time submission

Syllabus

Units CONTENTS Hours

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts.

Introduction

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction,

skills needed when writing a Review of the Literature,
skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Suggested Studies:

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

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							

CO3	3		2		2							
CO4	3				2							
CO5	3				2							

AUDIT 1 and 2: DISASTER MANAGEMENT

Course Objectives: -Students will be able to:
1. learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
4. 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

Syllabus

Units CONTENTS Hours

1 **Introduction**

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

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.

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 **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.

5 **Risk Assessment**

Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global 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.

SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New
Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of
India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep
Publication Pvt. Ltd., New Delhi.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

Course Objectives

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power
4. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Syllabus

Unit *Content Hours*

1 · Alphabets in Sanskrit,

· Past/Present/Future Tense,

· Simple Sentences

2 · Order

· Introduction of roots

· Technical information about Sanskrit Literature

3 · Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

Suggested reading

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

Course Output

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

AUDIT 1 and 2: VALUE EDUCATION

Course Objectives

Students will be able to

1.Understand value of education and self- development

2. Imbibe good values in students

3. Let the should know about the importance of character

Syllabus

Unit *Content Hours*

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 judgements

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

3 · Personality and Behavior 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

4 · Character and Competence –Holy books vs Blind faith.

· Self-management and Good health.

· Science of reincarnation.

· Equality, Nonviolence ,Humility, Role of Women.

· All religions and same message.

· Mind your Mind, Self-control.

· Honesty, Studying effectively

Suggested reading

1 Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University
Press, New Delhi

Course outcomes

Students will be able to

1.Knowledge of self-development
2.Learn the importance of Human values
3.Developing the overall personality

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							

AUDIT 1 and 2: CONSTITUTION OF INDIA

Course Objectives:

Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Syllabus

Units Content Hours

1 · History of Making of the Indian Constitution:

HistoryDrafting Committee, (Composition & Working)

2 · Philosophy of the Indian Constitution:

Preamble

Salient Features

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.

4 · Organs of Governance:

· Parliament
· Composition
· Qualifications and Disqualifications
· Powers and Functions
· 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 · 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.

Suggested reading

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

Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. 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.
4. Discuss the passage of the Hindu Code Bill of 1956.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							

AUDIT 1 and 2: PEDAGOGY STUDIES

Course Objectives:

Students will be able to:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development.

Syllabus

Units Content Hours

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.

2 · Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries.

· Curriculum, Teacher education.

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.

4 · Professional development: alignment with classroom practices and followup support

· Peer support

· Support from the head teacher and the community.

· Curriculum and assessment

· Barriers to learning: limited resources and large class sizes

5 · Research gaps and future directions

· Research design

· Contexts

· Pedagogy

· Teacher education

· Curriculum and assessment
· Dissemination and research impact.

Suggested reading

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

Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in
developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and
with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance
materials best support effective pedagogy?

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							
CO4	3				2							
CO5	3				2							

AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

Course Objectives

1. To achieve overall health of body and mind
2. To overcome stress

Syllabus

Unit *Content Hours*

1 ・ Definitions of Eight parts of yog. (Ashtanga) 8

2 ・ Yam and Niyam.

Do`s and Don't's in life.
i) Ahinsa, satya, astheya, bramhacharya and aparigraha
ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

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

Suggested reading

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

Course Outcomes:

Students will be able to:
1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3				2							
CO2	3		2		2							

AUDIT 1 and 2: PERSONALITY DEVELOPMENT

THROUGH LIFE ENLIGHTENMENT SKILLS

Course Objectives

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

Syllabus

Unit Content Hours

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 (dont's)
- Verses- 71,73,75,78 (do's)

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.

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

Suggested reading

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata

2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath,Rashtriya Sanskrit Sansthanam, New Delhi.

Course Outcomes

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve
the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

MAPPING OF COURSE OUTCOMES WITH PROGRAM OUTCOMES:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3				2							
CO2	3		2		2							
CO3	3		2		2							