Vel Tech
Rangarajan Dr. Sagunthala
R&D Institute of Science and Technology
(Deemed to be University Estd. u/s 3 of UGC Act, 1956)

CURRICULUM & SYLLABUS

for

PG PROGRAMS

(Regulations: MTECH-R16)

M. Tech. – CAD/CAM

M. Tech. – INDUSTRIAL ENGINEERING

M. Tech. – INDUSTRIAL SAFETY ENGINEERING

M. Tech. – MACHINE DESIGN

M. Tech. – METALLURGICAL AND MATERIALS SCIENCE

M. Tech. – ROBOTICS

M. Tech. – THERMAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

SCHOOL OF MECHANICAL AND CONSTRUCTION

CURRICULUM & SYLLABUS

for

M. Tech. CAD/CAM

M. Tech. CAD/CAM Curriculum

FOUNDATION COURSE					
Code	**Course**	**L**	**T**	**P**	**C**
		3	2	0	4

PROGRAM CORE						
Sl. No.	**Code**	**Course**	**L**	**T**	**P**	**C**
Theory Courses						
1	2161ME149	Computer Application in Design	3	2	0	4
2	2161ME150	Finite Element Methods	3	2	0	4
3	2161ME151	Computer Control in Process Planning	3	0	0	3
4	2161ME152	Integrated Product Development and Processes	4	0	0	4
5	2161ME120	Design for Manufacturing and Assembly	3	0	0	3
6	2161ME154	Advanced Manufacturing Process	3	0	0	3
7	**2161ME155**	Applied Materials Engineering	3	2	0	4
8	**2161ME156**	Integrated Mechanical Design	2	2	0	3
					Total Credits	**28**
Laboratory Courses						
1	2161ME305	CAD & CAE Laboratory	0	0	2	1
2	**2161ME313**	CAM Laboratory	0	0	2	1
					Total credits	**2**
PROGRAM ELECTIVES						
1	2162ME111	Advanced Optimization Techniques	3	0	0	3
2	2162ME113	Quality control and Reliability Engineering	3	0	0	3
3	2162ME112	Sustainable Design	3	0	0	3
4	2162ME173	Additive Manufacturing	3	0	0	3
5	2162ME174	Industrial Robotics and Experts Systems	3	0	0	3
6	2162ME124	Advanced Tool Design	3	0	0	3
7	2162ME176	Micro Electro Mechanical Systems and Nanotechnology	3	0	0	3
8	2162ME169	Flexible Manufacturing System	3	0	0	3
9	2162ME120	Lean Manufacturing and Six Sigma	3	0	0	3
10	2162ME172	Concurrent Engineering	3	0	0	3
11	**2162ME179**	Computational Fluid Dynamics	3	0	0	3
12	**2162ME180**	Metrology and Non-Destructive testing	3	0	0	3
13	**2162ME181**	Design of Hydraulic and Pneumatic Systems.	3	0	0	3
					Total Credits to be earned from Program Electives	**12**

INDEPENDENT LEARNING COURSES					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
	Massive Open Online Course	-	-	-	2
2163ME501	Research Seminar [**OR**]	-	-	-	
2163ME801	Field Study [**OR**]	-	-	-	2
2163ME802	Internship	-	-	-	
2163GE401	Business Communication [**OR**]	-	-	-	2
2163GE402	Technical Writing Tools	-	-	-	
2163MG401	Research Methodology	-	-	-	2
				Total Credits	**8**

PROJECT WORK					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
2164ME601	Project Phase I	0	0	20	10
2164ME701	Project Phase II	0	0	32	16
				Total Credits	**26**

PROGRAMME STRUCTURE AND MINIMUM CREDITS REQUIRED

IN COURSE CATEGORIES

SECTION NUMBER	COURSE CATEGORY	MINIMUM CREDITS REQUIRED
7.2.1	**FOUNDATION COURSE**	**04**
7.2.2	**PROGRAM CORE COURSES**	**30**
7.2.3	**PROGRAM ELECTIVE COURSES**	**12**
7.2.4	**INDEPENDENT LEARNING COURSES**	**8**
7.2.5	**PROJECT WORK**	**26**
	TOTAL CREDITS	**80**

PROGRAM CORE COURSES

COURSE CODE	COMPUTER APPLICATION IN DESIGN	L	T	P	C
2161ME149		3	2	0	4

UNIT I: INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS 9 +6

Output primitives (points, lines, curves etc.,), 2-D & 3-D transformation (Translation, scaling, rotators) windowing - view ports - clipping transformation.

UNIT II: CURVES AND SURFACES MODELLING 9+6

Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations. Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface- surface manipulations.

UNIT III: NURBS AND SOLID MODELING 9+6

NURBS- Basics- curves, lines, arcs, circle and bi linear surface. Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations - constructive solid Geometry - comparison of representations - user interface for solid modeling.

UNIT IV: VISUAL REALISM 9+6

Hidden – Line – Surface – solid removal algorithms shading – coloring. Introduction to parametric and variational geometry-based software's and their principles creation of prismatic and lofted parts using these packages.

UNIT V: ASSEMBLY OF PARTS AND PRODUCT DATA EXCHANGE 9+6

Assembly modeling - interferences of positions and orientation - tolerances analysis - mass property calculations - mechanism simulation. Graphics and computing standards– Open GL Data Exchange standards – IGES, STEP etc.– Communication standards.

TOTAL: 75 PERIODS

REFERENCES

1. William M Neumann and Robert F. Sproul "Principles of Computer Graphics", Mc Graw Hill Book Co. Singapore, 1989.
2. Donald Hearn and M. Pauline Baker "Computer Graphics", Prentice Hall, Inc., 2004.
3. Ibrahim Zeid Mastering CAD/CAM – McGraw Hill, International Edition, 2007.
4. Foley, Wan Dam, Feiner and Hughes – Computer graphics principles & practices, Pearson Education – 2003.
5. David F. Rogers, James Alan Adams "Mathematical elements for computer graphics" second edition, Tata McGraw-Hill edition.

COURSE CODE	FINITE ELEMENT METHODS	L	T	P	C
2161ME150		3	2	0	4

UNIT I: INTRODUCTION **9+6**

Modeling and Discretization – Interpolation, Elements, Nodes and degrees-of-freedom. Computational Procedures–Stiffness Matrices – Boundary Conditions-Solution of Equations- Ritz method, Variational Method, Method of weighted residuals, etc. – Boundary Element Techniques.

UNIT II: BASIC ELEMENTS **9+6**

Interpolation and shape functions - element matrices-linear triangular elements (CST)-quadratic triangular elements – bilinear rectangular elements-quadratic rectangular elements-solid elements-higher order elements-nodal loads-stress calculations-example problems.

UNIT III: ISOPARAMETRIC ELEMENTS **9+6**

Introduction-bilinear quadrilateral elements – quadratic quadrilaterals – hexahedral elements – Determination of Shape Functions – Numerical Integration – quadrature – static condensation – load considerations –stress calculations -examples of 2D and 3D applications.

UNIT IV: FINITE ELEMENT FORMULATION FOR STRUCTURAL APPLICATIONS **9+6**

Linear elastic stress analysis-2D and axisymmetric problems –Structural vibration – mass and damping matrices – damping – Harmonic response – direct integration techniques – explicit and implicit methods– Case studies.

UNIT V: HEAT TRANSFER AND FLUID MECHANICS APPLICATIONS **9+6**

Nonlinear Problems – Element formulation – Heat Conduction and Fluid flow – Transient Thermal Analysis - Incompressible and rotational flow – Applications for heat conduction and 2D stress analysis- Case Studies.

TOTAL: 75 PERIODS

REFERENCES:

1. Chandrupatla & Belagundu, Finite Elements in Engineering, Prentice Hall of India Private Ltd., 2010.
2. C.A. Brebbia and S. Walker, Boundary Element Techniques in Engineering, Newness Butterworths, 2011.
3. Cook, Robert Davis et al, Concepts and Applications of Finite Element Analysis, Wiley, John & Sons, 2012.
4.O.C Zienkiewicz, The Finite Element Method, 3rd Edition, Tata McGraw-Hill, 2010.
5. C.S. Desai and J.F. Abel, Introduction to Finite Element Method, Affiliated East- West Press, 2012.

COURSE CODE	COMPUTER CONTROL IN PROCESS PLANNING	L	T	P	C
2161ME151		3	0	0	3

UNIT I: INTRODUCTION **9**

Production Planning and Process Planning - The role of Process Planning in the Manufacturing cycle -Experience based planning - Need for computer aided process planning. – Process Planning and Concurrent Engineering, Group Technology

UNIT II: PART DESIGN REPRESENTATION **9**

Basic part representation methods: CAD models - Feature based design - Design interface: syntactic pattern recognition - State transition diagram - Decomposition approach - Logic approach –Graph based approach.

UNIT III: KNOWLEDGE REPRESENTATION **9**

Process knowledge - Dimensions and tolerances - Surface properties - Process constraints – Process economics - Process capability.

UNIT IV: SYSTEM FORMULATION **9**

Logical Design of Process Planning – System structure - planning strategy - declarative knowledge of part - procedure knowledge of planning - other issues: process parameter selection, tool selection, machine selection, plan optimization, Implementation considerations – Decision table and Decision trees.

UNIT V: COMPUTER AIDED PROCESS PLANNING SYSTEMS **9**

Computer aided Process Planning – Variant process planning – Generative process planning – Forward and Backward planning, input format- Totally Integrated process planning systems – Expert process planning - Commercial systems: CAM -I, Computer Aided Process Planning (CAPP), Material Index Planning (MIPLAN), Automated Process Planning and Selection (APPAS), AUTOPLAN and PRO, Community Program Planning Process (CPPP)

TOTAL: 45 PERIODS

REFERENCES

1. Halevi, G. and Weill, R.D., Principles of Process Planning, A logical approach –Springer,2003.
2. Rao.P.N., Computer Aided Manufacturing, Tata McGraw Hill Publishing Co. 2002.
3. Chang,T.C. and Wysk, R.A., An Introduction to automated process planning systems, Prentice Hall, 1985.
4. Chang, T.C., An Expert Process Planning System, Prentice Hall, 1985.
5. Singh, N., Systems Approach to Computer Integrated Design and Manufacturing, John Wiley.
6. Vollmann, T.E. and Bery, W.E., Manufacturing Planning and Control Systems, 5thEdn., Galgotia.
7. http://claymore.engineer.gusu.edu/jackh/eod/automate/capp/capp.htm
8. http://Estraj.ute.sk/journal/englo/027/027.htm

COURSE CODE	INTEGRATED PRODUCT DEVELOPMENT AND PROCESSES	L	T	P	C
2161ME152		4	0	0	4

UNIT I: INTRODUCTION **12**

Need for IPPD-Strategic importance of Product development – integration of customer, designer, material supplier and process planner, Competitor and customer - Behaviour analysis. Understanding customer-promoting customer understanding-involve customer in development and managing requirements - Organization process management and improvement.

UNIT II: CONCEPT GENERATION, SELECTION AND TESTING **12**

Plan and establish product specifications. Task - Structured approaches - clarification - search-externally and internally-Explore systematically -reflect on the solutions and processes - concept selection - methodology - benefits. Implications - Product change - variety – component standardization - product performance - manufacturability – Concept Testing Methodologies.

UNIT III: PRODUCT ARCHITECTURE **12**

Product development management - establishing the architecture -creation - clustering - geometric layout development - Fundamental and incidental interactions - related system level design issues – secondary systems -architecture of the chunks - creating detailed interface specifications-Portfolio Architecture.

UNIT IV: INDUSTRIAL DESIGN **12**

Integrate process design - Managing costs - Robust design – Integrating CAE, CAD, CAM tools – Simulating product performance and manufacturing processes electronically - Need for industrial design-impact – design process - investigation of customer needs - conceptualization - refinement - management of the industrial design process – technology driven products - user - driven products - assessing the quality of industrial design.

UNIT V: DESIGN FOR MANUFACTURING AND PRODUCT DEVELOPMENT **12**

Definition - Estimation of Manufacturing cost-reducing the component costs and assembly costs – Minimize system complexity – Prototype basics - Principles of prototyping - Planning for prototypes – Economic Analysis - Understanding and representing tasks-baseline project planning - accelerating the project-project execution.

TOTAL: 60 PERIODS

REFERENCES:

1. Karl T. Ulrich and Steven D. Eppinger, “Product Design and Development”, McGraw –Hill International Edns., 5th edition,2011.
2. Kemnneth Crow, “Concurrent Engineering /Integrated Product Development”, DRM Associates, 6/3, Via Olivera, Palos Verdes, CA 90274(310) 377-569, Workshop Book, 1999.
3. Stephen Rosenthal, “Effective Product Design and Development”, Business One Orwin, Homewood, 1992, ISBN, 1-55623-6034.
4. Staurt Pugh, “Tool Design – Integrated Methods for successful Product Engineering”, Addison Wesley Publishing, New York, NY, 1991, ISBN 0-202-41639-5.

COURSE CODE	DESIGN FOR MANUFACTURING AND ASSEMBLY	L	T	P	C
2161ME120		3	0	0	3

UNIT I: INTRODUCTION **9**

Design philosophy steps in Design process - General Design rules for design. Materials: Selection of Materials for design Developments in Material technology - criteria for material selection - Material selection interrelationship with process selection process selection charts.

UNIT II: MACHINING PROCESS **9**

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.

METAL CASTING **-** Appraisal of various casting processes, selection of casting process, - general design considerations for casting - casting tolerances – use of solidification simulation in casting design - product design rules for sand casting.

UNIT III: METAL JOINING **9**

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 dies forging design parting lines of dies drop forging die design - general design recommendations. Extrusion & Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing - Keeler Goodman Forming Line Diagram - Component Design for Blanking.

UNIT-IV: ASSEMBLE ADVANTAGES **9**

Development of the assemble process, choice of assemble method assemble advantages social effects of automation.

AUTOMATIC ASSEMBLY TRANSFER SYSTEMS: Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine.

UNIT-V: DESIGN OF MANUAL ASSEMBLY **9**

Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic Design for Assembly (DFA) methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.

TOTAL: 45 PERIODS

REFERENCES:

1.GeoffreyBoothroyd, Peter Dewhurst and Winston Ansthony Knight, Product Design for Manufacturing and Assembly, CRC Press,2010.
2.George E. Deiter, Engineering Design - Material & Processing Approach, McGraw Hill, 2nd Ed., 2000.
3. Geoffrey Boothroyd, Assembly Automation and Product Design, Marcel Dekker Inc., NY, 1992.
4. Geoffrey Boothroyd, Hand Book of Product Design, Marcel and Dekken, N.Y. 1990.
5. Harry Peck, Design for Manufacture, Pitman, 1973.

COURSE CODE	ADVANCED MANUFACTURING PROCESSES	L	T	P	C
2161ME154		3	0	0	3

UNIT I: METAL CUTTING AND TOOL MATERIALS 9

Orthogonal and oblique cutting – Types of tool wear, abrasion, diffusion, and oxidation. Fatigue and adhesive wear – Prediction of tool life – Monitoring of wear, cutting forces and Vibration – Tool Materials - Cemented Carbide, Coated Carbide, Cermet. Ceramic, Carbon Boron Nitrite (CBN) and Polycrystalline Diamond (PCD) – Selection of machining parameters and tools.

UNIT II: SPECIAL MACHINING PROCESSES & EXPERIMENTAL TECHINIQUES 9

Deep hole drilling Honing Lapping – Super finishing – Burnishing – Broaching High speed Machining - Measurement of cutting forces, temperature, vibration and tool wear in machining processes.

UNIT III: UNCONVENTIONAL MACHINING 9

Principles, processes various influencing parameters and applications of Ultrasonic Machining, Electro Discharge Machining, Electro Chemical Machining, Electron and Laser Beam Machining, Plasma Arc Machining and Water Jet Machining.

UNIT IV: MICRO MACHINING 9

Introduction to Micro-electromechanical systems (MEMS), principle, process capabilities, types, advantages, limitations and applications of bulk micro machining, surface micro machining and tool based micro machining processes.

UNIT V: RAPID PROTOTYPING 9

Introduction – Classification – Principle advantages limitations and applications- Stereo lithography – Laminated object manufacturing – Selective laser sintering – fused disposition modeling (FDM), Solid ground curing (SGC), 3D Printing.

TOTAL: 45 PERIODS

REFERENCES

1. Marc J. Madou, Fundamentals of Microfabrication: The Science of Miniaturization, Second Edition, CRC Press (ISBN: 0849308267), 2006.
2. Shaw Milton.C., Metal Cutting Principles, Second Edition, Oxford University, Press, 2005.
3. Sadasivan T.A and Sarathy.D., Cutting Tools for Productive Machining, India Limited 1999.
4. Rich F. and Knight'K., Artificial Intelligence, McGraw Hill Inc, 1991.
5. Battacharya, Theory of metal cutting, NCB Agency, 1984.
6. Armarego E.J.A. and Brown R.H., The Machining of metals, Prentice Hall, 1982.
7. Pandley P.S. and Shah N., Modern Manufacturing Processes, 1980.
8. HMT Manual, Non – traditional Machining Methods, 1975.

COURSE CODE	APPLIED MATERIALS ENGINEERING	L	T	P	C
2161ME155		3	2	0	4

UNIT I: ELASTIC AND PLASTIC BEHAVIOUR 9+6

Mechanism of Elastic and Plastic deformation**,** Anelasticity and viscoelasticity- role of dislocations, yield stress, shear strength of perfect and real crystals –Strengthening mechanism, work, hardening, solid solutioning, grain boundary strengthening, Poly phase mixture, precipitation, particle fibre and dispersion strengthening. Effect of temperature, strain and strain rate on plastic behaviour – Super plasticity.

UNIT II: FRACTURE BEHAVIOUR 9 +6

Griffith's theory - stress intensity factor and fracture toughness-Toughening mechanisms – Ductile, brittle transition in steel-High temperature fracture, creep – Larson-Miller, Parameter – Deformation and fracture mechanism maps – Fatigue. Low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law – Residual Life Estimation- Effect of surface and metallurgical parameters on fatigue – fracture of non-metallic materials – Failure analysis, sources of failure, procedure of failure analysis.

UNIT III: SELECTION OF MATERIALS 9 +6

Motivation for selection, cost basis and service requirements – selection for Mechanical properties, strength, toughness, fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing –

UNIT IV: APPLICATION OF MATERIALS 9+6

Case studies in materials selection with Relevance to aero, auto, marine, machinery and nuclear applications.

UNIT V: MATERIAL PROCESSING 9+6

Processing of engineering materials – Primary and Secondary processes – stability, Weldability, forgeability and malleability Criteria – Process induced defects – Monitoring and control.

TOTAL: 75 PERIODS

REFERENCES:

1. George E. Dieter, Mechanical Metallurgy, McGraw Hill, 2014.
2.James K. Wessel Wiley and Intersam, John, The Hand book of Advance Materials, Wilson Publishers., 2004.
3.Thoash. Courtney, Mechanical Behaviour of Materials, (2nd edition), McGraw Hill, 2000.
4. Charles, J.A., Crane, F.A.A and Furness, J.A.G., Selection and use of Engineering Materials, 3rd Edition, Butterworth – Heiremann, 1977.
5. Tadens Z Burakonsa & T. Wierzchan, Surface Engineering of Materials - Principles of Equipment, Techniques, 1998.
6. Flinn R.A. and Trojan P.K.., Engineering Materials and their Applications (4th Edition), Jaico, 1999.
7. Metals hand book, vol. 10, Failure Analysis and Prevention, (10th edition).

COURSE CODE	INTEGRATED MECHANICAL DESIGN	L	T	P	C
2161ME156		2	2	0	3

UNIT I: STANDARDISATION **6+6**

Phases of design – Standardization and interchangeability of machine elements - Process and Function Tolerances – Individual and group tolerances – Selection of fits for different design situations – Design for assembly and modular constructions – Concepts of integration –BIS, ISO, DIN, BS, ASTM Standards. Design Thinking, Design for Additive Manufacturing.

UNIT II: PRINCIPLES OF DESIGN **6+6**

Oblique stresses – Transformation Matrix – Principal stresses – Maximum shear stress - Theories of Failure – Ductile vs. brittle component design - Analysis and Design of shafts for different applications – integrated design of shaft, bearing and casing – Design for rigidity.

UNIT III: DESIGN OF GEARS AND GEAR BOXES **6+6**

Principles of gear tooth action – Gear correction – Gear tooth failure modes – Stresses and loads – Component design of spur, helical, bevel and worm gears – Design for sub assembly – Integrated design of speed reducers and multi-speed gear boxes – application of software packages.

UNIT IV: INTEGRATED DESIGN OF BRAKES & CLUTCHES **6+6**

Dynamics and thermal aspects of brakes and clutches – Integrated design of brakes and clutches for machine tools, automobiles and mechanical handling equipment.

UNIT V: INTEGRATED DESIGN OF TRANSMISSION ELEMENTS **6+6**

Integrated Design of systems consisting of shaft, bearings, springs, motor, gears, belt, rope, chain, pulleys, Cam & Follower, flywheel etc. Example - Design of Elevators, Escalators, Gear Box, Valve gear Mechanisms, Machine Tools

TOTAL: 60 PERIODS

REFERENCES:

1. Norton L. R., Machine Design – An Integrated Approach, Pearson Education, 2005.
2.Shigley, J.E., Mechanical Engineering Design, McGraw Hill, 2001.
3.Prasad. L. V., Machine Design, Tata McGraw Hill, New Delhi, 1992.
4.Maitra G.M., Hand Book of Gear Design, Tata McGraw Hill, 1985.
5.Alexandrov, M., Materials Handling Equipment, MIR Publishers, 1981.
6. Boltzharol, A., Materials Handling Handbook, The Ronald Press Company, 1958.

Approved Data Books

P.S.G. Tech., Design Data Book, Kalaikathir Achchagam, Coimbatore, 2003.

COURSE CODE	CAD & CAE LAB	L	T	P	C
2161ME305		0	0	2	1

Syllabus: Exercises in Modelling and drafting of Mechanical Components. Assembly using Parametric and feature based Packages like PRO-E / SOLID WORKS /CATIA / NX etc. Analysis of Mechanical Components – Use of FEA Packages like ANSYS/ NASTRAN etc. Exercises shall include analysis of Machine elements under Static loads

i) Modal Analysis

ii) Machine elements under Dynamic loads

iii) Non-linear systems **TOTAL: 30 PERIODS**

List of Experiments

MODELLING

(Creation of 3D assembly model of following machine elements using 3D modeling software)

1. Piston
2. Connecting Rod
3. Flange Coupling
4. Screw Jack
5. Knuckle Joint
6. Plummer Block

ANALYSIS

(Model and analyze the following field problems using Finite Element Analysis software)

7. Structural analysis of Stepped bar
8. Structural analysis of Tapered bar
9. Stress analysis of 3D beams (simply supported, cantilever, etc.)
10. Stress analysis of rectangular plate with circular hole
11. Stress analysis of latch spring
12. Thermal analysis of rectangular plate
13. Thermal analysis of composite bars
14. Mode frequency analysis of simply supported beam
15. Mode frequency analysis of connecting rod

TOTAL: 30 PERIODS

COURSE CODE	COMPUTER AIDED MANUFACTURING LABORATORY	L	T	P	C
2161ME313		0	0	2	1

Syllabus:

Features and selection of CNC turning and milling centers. Practice in part programming and operation of CNC turning machines, subroutine techniques and use of cycles. Practice in part programming and operating a machining center, tool Joining and selection of sequences of operations, tool setting on the machine, practice in APT based NC programming.

Simulation of manufacturing system using CAM software, controller operating system commands.

List of Experiments

I. TURNING:

1. Step turning using turning cycle.
2. Step turning using turning cycle with chamfer.
3. Step turning using turning cycle with taper.
4. Step turning using canned cycle (roughing and finishing cycle).
5. Step turning using canned cycle with taper.
6. Taper turning and grooving using canned cycle.
7. External thread cutting.

II. MILLING:

8. Square milling.
9. Square milling with a cross.
10. Square milling using absolute programming.
11. Circular milling.
12. Corner radius milling.

III. GENERATION OF PART PROGRAM

13. CNC drilling machine
14. CNC milling machine to perform i) Slot milling ii) End milling

III. SIMULATION USING CAM SOFTWARE:

15. Automated CNC tool path & G code generation using Pro/E software.

TOTAL: 30 PERIODS

PRORAM ELECTIVE COURSES

COURSE CODE	ADVANCED OPTIMIZATION TECHNIQUES	L	T	P	C
2162ME111		3	0	0	3

UNIT I: INTRODUCTION **9**

General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints – Classification of optimization problem. Single variable and multivariable optimization, Techniques of unconstrained minimization

UNIT II: DECISION ANALYSIS **9**

Golden section, Random, pattern and gradient search methods – Interpolation methods; Optimization with equality and inequality constraints. Hooks and Jeeves Method

UNIT III: NON-LINEAR OPTIMIZATION **9**

Decision Trees, Utility theory, Game theory, Multi Objective Optimization, MCDM- Goal Programming, Analytic Hierarchy process

UNIT IV: NON-TRADITIONAL OPTIMIZATION-1 **9**

Classes P and NP, Polynomial time reductions, Introduction to NP- Hard problems, Overview of Genetic algorithms, Simulated Annealing, neural network based optimization

UNIT V: NON-TRADITIONAL OPTIMIZATION-2 **9**

Particle Swarm optimization, Ant Colony Optimization, Optimization of Fuzzy Systems

TOTAL: 45 PERIODS

References

1. Singiresu S.Rao, “Engineering optimization – Theory and practices”, New Age International Publishers, 2013.
2. Ravindran – Phillips –Solberg, “Operations Research – Principles and Practice”, John Wiley India, 2007.
3. Fredrick S.Hillier and G.J. Liberman, “Introduction to Operations Research”, McGraw Hill Inc. 2017.
4. Kalymanoy Deb, “Optimization for Engineering Design”, PHI, 2012.
5. Christos H. Papadimitriou, Kenneth Stieglitz, “Combinatorial Optimization”, PHI 2006.
6. Marius Durea, “An Introduction to Nonlinear optimization theory”, De Gruyter 1st edition 2014.

COURSE CODE	QUALITY CONTROL AND RELIABILITY ENGINEERING	L	T	P	C
2162ME113		3	0	0	3

UNIT I: QUALITY & STATISTICAL PROCESS CONTROL 9

Quality – Definition – Quality Assurance – Variation in process – Factors – process capability – control charts – variables X, R and X, - Attributes P, C and U-Chart tolerance design. Establishing and interpreting control charts – charts for variables – Quality rating– Short run SPC.

UNIT II: ACCEPTANCE SAMPLING 9

Lot by lot sampling – types – probability of acceptance in single, double, multiple sampling plans – OC curves – Producer's risk and consumer's risk. AQL, LTPD, AOQL, Concepts – standard sampling plans for AQL and LTPD – use of standard sampling plans.

UNIT III: EXPERIMENTAL DESIGN AND TAGUCHI METHOD 9

Fundamentals – factorial experiments – random design, Latin square design – Taguchi method – Loss function – experiments – S/N ratio and performance measure –Orthogonal array

UNIT IV: CONCEPT OF RELIABILITY 9

Definition – reliability vs quality, reliability function – Mean time between failure (MTBF), Mean time to repair (MTTR), availability, bathtub curve – time dependent failure models – distributions – normal, weibull, lognormal –Reliability of system and models – serial, parallel and combined configuration – Markove analysis, load sharing systems, standby systems, covarient models, static models, dynamic models.

UNIT V: DESIGN FOR RELIABILITY AND MAINTAINABILITY 9

Reliability design process, system effectiveness, economic analysis and life cycle cost, reliability allocation, design methods, parts and material selection, de rating, stress strength and analysis, failure analysis, identification determination of causes, assessments of effects, computation of criticality index, corrective action, system safety – analysis of down-time – the repair time distribution, stochastic point processes system repair time, reliability under preventive maintenance state dependent system with repair. MTTR – mean system down time, repair vs replacement, replacement models, proactive, preventive, predictive maintenance maintainability and availability, optimization techniques for system reliability with redundancy heuristic methods applied to optimal system reliability.

TOTAL: 45 PERIODS

REFERENCES:

1. Amata Mitra "Fundamentals of Quality Control and improvement" Pearson Education, 2002.
2. Bester field D.H., "Quality Control" Prentice Hall, 1993
3. Patrick D To' connor, Practical Reliability Engineering, John-Wiley and Sons Inc, 2002
4. Charles E Ebling, An Introduction to Reliability and Maintainability Engineering, Tata-McGraw Hill, 2000.
5. David J Smith, Reliability, Maintainability and Risk: Practical Methods for Engineers, Butterworth 2002.
6. Dhillon, Engineering Maintainability – How to design for reliability and easy maintenance, PHI, 2008.

COURSE CODE	SUSTAINABLE DESIGN	L	T	P	C
2162ME112		3	0	0	3

UNIT I: SUSTAINABILITY AND ITS APPLICATION 9

Sustainability: Past and Present, The Classic Design and Manufacture Model, The Taguchi Approach to Quality Manufacturing, The Taguchi Analogy Applied to Sustainable Engineering Design, Sustainable Sourcing (Eco sourcing),Design for Sustainable Manufacture (Sustainable Manufacture Value, or SMV),Design for Sustainable Use (Sustainable Use Value, or SUV) Design for Sustainable Maintenance, Design for Sustainable Disposal (Sustainable Disposal Value, or SDV),The Measurement of Sustainability, Sustainable Engineering Design: Necessity or Luxury.

UNIT II: THE TOOLS OF THE DESIGN PROCESS AND MANAGEMENT OF DESIGN 9

Introduction. Development Processes, Systematic Approach to Design, Design Methods, Classic Brainstorming, Brain Writing, Imaginary Brainstorming, Word-Picture Associations and Analogies, Methods of Generating Associations and Analogies, TILMAG, The Morphological Box, Design and Planning Methods

UNIT III: COMMUNICATION FOR ENGINEERS AND PERFORMANC PREDICTION 9

Communication Overview, Written Communication, Project Reports/Technical Reports, Academic Publishing (Technical or Journal Papers), Graphical Communications, General Drawing Application. Performance Prediction-Historical Aspects of Analysis, Materials Testing. Factor of Safety, Consolidation of Safety in Structures and Devices, Computing Power, Fatigue Strength Prediction, Performance Prediction Methodology and Application, Checks and Balances

UNIT IV: DESIGN FOR TOTAL CONTROL 9

Traditional Approaches, the Sustainability Umbrella Model. Total Design Control, A New Design Approach (The Umbrella of Sustainable Design), The Sustainable Design Function, Manufacturing, Lifetime Usage, Maintenance, End-of-Life Disposal

UNIT V: DRIVERS OF SUSTAINABILITY IN DESIGN 9

Legislation, Effectiveness of International Environmental Regimes and Legislation, Non-legislative Measurement and Guidance Tools, Other Drivers of Sustainable Design, Conclusion. Strategic Sustainable Design - Triple Bottom Line—The 3P Approach, Benefits to Producers and Buyers of Designed-in Sustainability, The Sustainability Measurement and Certification Industry**.** Predicting the Future - Unsustainable Futures, The Engineers' View, Conclusion

Total=45 PERIODS

REFERENCES:

1. Johnson & Gibson, Sustainability in Engineering Design, 1st Edition, Academic Press, 2014
2. David T. Allen, Sustainable Engineering: Concepts, Design and Case Studies, Prentice Hall Publications, 2011
3. Braden R. Allenby, The Theory and Practice of Sustainable Engineering, Prentice Hall Publications, 2011
4. Marc J. Epstein**,** Making Sustainability Work: Best Practices in Managing and Measuring Corporate Social, Environmental, and Economic Impacts, Greenleaf Publishing,2014.

COURSE CODE	ADDITIVE MANUFACTURING	L	T	P	C
2162ME173		3	0	0	3

UNIT-I: INTRODUCTION **9**

Rapid prototyping system – practical applications – Basic operations – CAD Model - Translator supports – slice – merge – prepare – build – cleaning – finishing – benefits of Rapid prototyping comparison with conventional manufacturing process.

UNIT II: STEREO LITHOGRAPHY FUNDAMENTALS **9**

Rapid prototyping process – The Stereo Lithography apparatus (SLA) – data gathering – data analysis – part preparation – part building – initial consideration in part building – selecting the resin – selecting system – verifying part1 files – slicing – slicer solution – slice units –post processing fundamentals – part removal – cleaning – post curing – part finishing.

UNIT-III: RAPID PROTOTYPING TECHNOLOGIES **9**

Types – Selective Laser Sintering (SLS) – Solid Ground Curing (SGC) – Laminated Object Manufacturing (LOM) – Fused Deposition Modeling (FDM) – Three-Dimensional Printing (TDP)

UNIT-IV: CASE STUDIES **9**

Rapid prototyping for rapid products – Exhaust manifold – Investment cast prototypes - Texas Instruments, USA – RP & Mini automotive – medicine.

UNIT V: TRENDS IN RAPID PROTOTYPING **9**

Laser Engineering Net Shaping (LENS), Ballistic particle manufacturing – rapid tooling Magic's, Mimics – application of rapid prototyping in medical field. Future development–Rapid prototyping in Indian scene–advances in rapid prototyping- research development in rapid prototyping

TOTAL: 45 PERIODS

REFERENCES:

1. Paul F Jacobs, Rapid Prototyping and Manufacturing fundamentals of stereo lithography, I Edition, Society of Manufacturing Engineers, Dearborn, Michigan, 2012.
2. Donald E La course, Handbook of Solid Modelling, McGraw Hill Inc., NewYork,2012.
3. Rapid Automated Prototyping: An Introduction Industrial Press Inc., New York.
4. Chowdia M.P (ED), Agile Manufacturing, International Conference on Agile Manufacturing, Bangalore, Feb22–24,1996, Tata Mc Graw Hill Pub Co., Ltd., New Delhi, 2012.
5. Dickens PM, Research Developments in rapid prototyping, Journal of Engineering Manufacture, pp261-265,2010.

COURSE CODE	INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS	L	T	P	C
2162ME174		3	0	0	3

UNIT I: INTRODUCTION AND ROBOT KINEMATICS 9

Definition need and scope of Industrial robots – Robot anatomy – Work volume – Precision movement– End effectors – Sensors. Robot Kinematics – Direct and inverse kinematics – Robot trajectories – Control of robot manipulators– Robot dynamics – Methods for orientation and location of objects.

UNIT II: ROBOT DRIVES AND CONTROL 9

Controlling the Robot motion – Position and velocity sensing devices – Design of drive systems – Hydraulic and Pneumatic drives – Linear and rotary actuators and control valves – Electro hydraulic Servo valves, electric drives – Motors – Designing of end effectors – Vacuum, grippers.

UNIT III: ROBOT SENSORS 9

Transducers and Sensors – Tactile sensor – Proximity and range sensors – Sensing joint forces – Robotic vision system – Image Representation - Image Grabbing –Image processing and analysis – Edge Enhancement – Contrast Stretching – Band Rationing - Image segmentation – Pattern Recognition – Training of vision system.

UNIT IV: ROBOT CELL DESIGN AND INDUSTRIAL AUTOMATION 9

Robot work cell design and control – Safety in Robotics – Robot cell layouts – Multiple Robots and Machine interference – Robot cycle time analysis. Industrial application of robots. Automation-types- Need for Automation, Hydraulic & Pneumatic Comparison – ISO symbols for fluid power elements, Hydraulic, pneumatic – Selection criteria- Industrial automation.

UNIT V: ROBOT PROGRAMMING, ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS 9

Methods of Robot Programming – Characteristics of task level languages lead through programming methods – Motion interpolation. Artificial intelligence – Basics – Goals of artificial intelligence – AI techniques – problem representation in *Artificial Intelligence* (AI) – Problem reduction and solution techniques – Application of AI and *Knowledge-based expert systems* (KBES) in Robots.

TOTAL: 45 PERIODS

REFERENCES

1. K.S. Fu, Gonzalez, R.C. and Lee, C.S.G., “Robotics Control, Sensing, Vision and Intelligence”, McGraw Hill, 1987. Koren,Y., “Robotics for Engineers”, McGraw-Hill, 1987.
2. Kozyrey, Yu. “Industrial Robots”, MIR Publishers Moscow, 1985.
3. Klafter, R.D., Chmielewski, T.A. and Negin, M., “Robotics Engineering – An Integrated Approach”, Prentice-Hall of India Pvt. Ltd., 1984.
4. Deb, S.R.” Robotics Technology and Flexible Automation”, Tata McGraw-Hill, 1994.
5. Groover M.P., Weis M., Nagel R.N. and Odrey N.G., “Industrial Robotics Technology, Programming and Applications”, McGraw-Hill, Int., 1986.

COURSE CODE	ADVANCED TOOL DESIGN	L	T	P	C
2162ME124		3	0	0	3

UNIT I: STATIC AND DYNAMIC STIFFNESS, FORCE ANALYSIS 9

Static stiffness and compliance- deformation caused by weight, Forces- deformation caused by cutting forces - forced vibrations, self-excited vibrations, Force distribution in different parts of Lathe, Drilling machine, Milling machine and Planning machines.

UNIT II: DESIGN OF STRUCTURES 9

Beds, columns and housing for maximum strength and rigidity – cast and welded construction – CNC machine tools - structure – main drive and feed drive- ball screws- automatic tool changers- chip conveyors- tool magazines- tool turrets.

UNIT III:DESIGN OF SLIDE WAYS 9

Selection of materials- integrated and attached ways- hydro-static guide ways-aero-static guide ways- antifriction guide ways- design of friction guide ways- plastic inserted guide ways and LM guide ways.

UNIT IV:DESIGN OF MACHINE TOOL SPINDLES AND DRIVES 9

Design requirements – standards – selection of spindle bearings- materials for spindles- typical spindle design - design consideration of Electrical, Mechanical and Hydraulic drives in machine tools.

UNIT V: MACHINE TOOL CHATTER 9

The Dynamics of cutting process - physical causes of chatter- theory of machine tool chatter- chatter in different types of machine tools- milling machines, lathes and grinding machines - the theory of chatter with several degree of freedom - chatter suppression. Design of control mechanisms – selection of standard components - dynamic measurement of forces and vibrations in machine tools - use of vibration dampers.

TOTAL: 45 PERIODS

REFERENCES:

1. Mehta. N.K, “Machine Tool Design” Tata McGraw Hill, 2010.
2. Koenisberger F. ‘Design principles of Metal cutting Machine Tools”. Pergamon press, 200L - 9.
3. Acherkan.N., “Machine Tool Design”. Vol. 3 & 4, MIR Publishers, Moscow, 2012.
4. Sen.G. and Bhattacharya A., “Principles of Machine Tools”. Vol.2, NCB. Calcutta, 2010.
5. Tobias.S.A., “Machine tool Vibration” Blackie and Son Limited, London, 200L - 9.

COURSE CODE	MICRO ELECTRO MECHANICAL SYSTEMS AND NANOTECHNOLOGY	L	T	P	C
2162ME176		3	0	0	3

UNIT I: OVER VIEW OF MEMS AND MICROSYSTEMS 9

Definition – historical development – fundamentals – properties, micro fluidics, design and fabrication micro-system, microelectronics, working principle and applications of micro system.

UNIT II: MATERIALS, FABRICATION PROCESSES AND MICRO SYSTEM PACKAGING 9

Substrates and wafers, silicon as substrate material, mechanical properties of Si, Silicon Compounds silicon piezo resistors, Gallium arsenide, quartz, polymers for MEMS, conductive polymers. Photolithography, photo resist applications, light sources, in implantation, diffusion process exudation – thermal oxidation, silicon diode, chemical vapour deposition, sputtering - deposition by epitaxy – etching – bulk and surface machining – LIGA process Micro system packaging – considerations packaging – levels of micro system packaging die level, device level and system level.

UNIT III: MICRO DEVICES AND MATERIALS 9

Sensors – classification – signal conversion ideal characterization of sensors micro actuators, mechanical sensors – measurands displacement sensors, pressure and flow sensors, micro actuators – smart materials – applications.

UNIT IV: SCIENCE OF NANO MATERIALS 9

Classification of Nano structures – effect of the nanometer length scale effects of Nano scale dimensions on various properties – structural, thermal, chemical, mechanical, magnetic, optical and electronic properties – effect of nanoscale dimensions on biological systems. Fabrication methods – Top down processes – bottom up process.

UNIT V: CHARACTERIZATION OF NANO MATERIALS 9

Nano-processing systems – Nano measuring systems – characterization – analytical imaging techniques – microscopy techniques, electron microscopy scanning electron microscopy, transmission electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, diffraction techniques – spectroscopy techniques – Raman spectroscopy, 3D surface analysis – Mechanical, Magnetic and thermal properties – Nano positioning systems.

TOTAL: 45 PERIODS

REFERENCES:

1. Tai – Ran Hsu, MEMS and Microsystems Design and Manufacture, Tata-McGraw Hill, New Delhi, 2002.
2. Mark Madou Fundamentals of Microfabrication, CRC Press, New York, 2005.
3. Norio Taniguchi, Nano Technology, Oxford University Press, New York, 2003
4. The MEMS Hand book, Mohamed Gad-el-Hak, CRC Press, New York, London.
5. Charles P Poole, Frank J Owens, Introduction to Nano technology, John Wiley and Sons, 2003
6. Julian W. Hardner Micro Sensors, Principles and Applications, CRC Press 2002.

COURSE CODE	FLEXIBLE MANUFACTURING SYSTEMS	L	T	P	C
2162ME169		3	0	0	3

UNIT-I: INTRODUCTION TO FMS **9**

Introduction to FMS - concepts, advantages, components of FMS and their integration in the data processing systems - examples of FMS installations.

UNIT-II: DISTRIBUTED DATA PROCESSING IN FMS **9**

Distributed data processing in FMS –DBMS and their applications in CAD/CAM and FMS – distributed systems in FMS -Integration of CAD and CAM - Part programming in FMS, tool data base - Clamping devices and fixtures data base.

UNIT-III: MATERIAL HANDLING SYSTEMS **9**

Material Handling systems: conveyors - AGVs – features of industrial robots - robot cell design and control- AS/RS.

UNIT- IV: INSPECTION **9**

Inspection: CMM – types – contact and non-contact inspection principles - programming and operation- in cycle gauging.

UNIT – V: INTERFACING OF COMPUTERS **9**

Interfacing of computers - machine tool controllers and handling systems: communications standards - programmable Logic Controllers (PLC's) – Interfacing - Computer aided Project planning – dynamic part scheduling.

TOTAL = 45 PERIODS

REFERENCES

1. Paul Ranky., “The design and operation of FMS”, IFS publication, 2003.
2. Mikell P Groover, “Automation Production systems, Computer Integrated Manufacturing”, Prentice Hall, 2006.
3. David J. Parrish, “Flexible Manufacturing” Butterworth-Heinemann,1990
4. Dr. Paul Ranky, “The Design and Operations of FMS” IFS (Publications) Ltd., UK, 1983.
5. Joseph Talavage and Roger G. Hannam, “Flexible Manufacturing Systems in Practice “, Marcel Dekker Inc., New York.
6. S.R. Deb,” Robotics Technology and Flexible Automation”, Tata McGraw Hill Company Ltd.

COURSE CODE	LEAN MANUFACTURING AND SIX SIGMA	L	T	P	C
2162ME120		3	0	0	3

UNIT I: INTRODUCTION TO LEAN MANUFACTURING AND SIX SIGMA 9

Introduction to Lean- Definition, Purpose, features of Lean; top seven wastes, Need for Lean, Elements of Lean Manufacturing, Lean principles, the lean metric, Hidden time traps. Introduction to quality, Definition of six sigma, origin of six sigma, Six sigma concept, Critical success factors for six sigma.

UNIT II: LEAN SIX SIGMA APPROACH 9

Evolution of lean six sigma, the synergy of Lean and six sigma, Definition of lean six sigma, the principles of lean six sigma, Scope for lean six sigma, Features of lean six sigma, the laws of lean six sigma, Benefits of lean six sigma, Introduction to Define Measure Analyze Improve Control (DMAIC) tools.

UNIT III: INITIATION FOR LEAN SIX SIGMA 9

Top management commitment – Infrastructure and deployment planning, Process focus, organizational structures, Measures – Rewards and recognition, Infrastructure tools, structure of transforming event, Launch preparation.

UNIT IV: PROJECT SELECTION FOR LEAN SIX SIGM 9

Resource and project selection, Selection of Black belts, Selecting projects – Benefit/Effort graph, Process mapping, value stream mapping, and balanced score card for project identification, project suitable for lean six sigma.

UNIT V: THE DMAIC PROCESS AND INSTITUTIONALIZING THE LEAN SIX SIGMA 9

Predicting and improving team performance, nine team roles, Team leadership, Define Measure Analyze Improve Control (DMAIC) process, Institutionalizing lean six sigma, Design for lean six sigma, Case study presentations.

TOTAL: 45 PERIODS

REFERENCES

1. Michael L. George, Lean Six Sigma, McGraw-Hill, 2002.
2. James P. Womack, Daniel T. Jones, Lean Thinking, Free press business, 2003.
3. Forrest W. Breyfogle III, Implementing Six Sigma: Smarter solutions Using Statistical Methods.
4. Ronald G. Askin and Jeffrey B. Goldberg, Design and Analysis of Lean Production Systems, John Wiley & Sons, 2003.
5. Rother M. and hook J., Learning to See: Value Stream Mapping to add value and Eliminate Muda, Lean Enterprise Institute, Brookline.

COURSE CODE	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
2162ME179		3	0	0	3

UNIT I: GOVERNING DIFFERENTIAL EQUATION AND FINITE DIFFERENCE METHOD 9

Classification, Initial and Boundary conditions – Initial and Boundary Value problems – Finite difference method, Central, Forward, Backward difference, Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II: CONDUCTION HEAT TRANSFER 9

Steady one-dimensional conduction, Two and three-dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems.

UNIT III: INCOMPRESSIBLE FLUID FLOW 9

Governing Equations, Stream Function – Verticity method, Determination of pressure for viscous flow, SIMPLE Procedure of Patankar and Spalding, Computation of Boundary layer flow, finite difference approach.

UNIT IV: CONVECTION HEAT TRANSFER AND FEM 9

Steady One-Dimensional and Two-Dimensional Convection – diffusion, Unsteady one-dimensional convection – diffusion, Unsteady two-dimensional convection – Diffusion – Introduction to finite element method – solution of steady heat conduction by FEM – Incompressible flow – simulation by FEM.

UNIT V: TURBULENCE MODELS 9

Algebraic Models – One equation model, K – ϵ Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.

TOTAL: 45 PERIODS

REFERENCES

1. Muralidhar, K., and Sundararajan, T., Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi,Reprint 2014.
2. Ghoshdasdidar, P.S., Computer Simulation of flow and heat transfer, Tata McGraw-Hill Publishing Company Ltd., 1998.
3. Subas, V.Patankar,Numerical heat transfer fluid flow, Hemisphere Publishing Corporation, 1980.
4. Taylor, C and Hughes, J.B. ,Finite Element Programming of the Navier- Stokes Equation, Pineridge Press Limited, U.K., 1981.
5. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H.,Computational fluid Mechanics and Heat Transfer," Hemisphere Publishing Corporation, New York, USA,1984.
6. Fletcher, C.A.J. ,Computational Techniques for fluid Dynamics 2, Specific Techniques for Different Flow Categories, Springer – Verlag, 1987.
7. Bose, T.X., Numerical Fluid Dynamics,Narosa Publishing House, 1997.

COURSE CODE	METROLOGY AND NON-DESTRUCTIVE TESTING	L	T	P	C
2162ME180		3	0	0	3

UNIT I: MEASURING MACHINES **9**

Tool Maker's microscope - Co-ordinate measuring machines - Universal measuring machine - Laser viewers for production profile checks - Image shearing microscope - Use of computers - Machine vision technology - Microprocessors in metrology.

UNIT II: STATISTICAL QUALITY CONTROL **9**

Data presentation - Statistical measures and tools - Process capability - Confidence and tolerance limits - Control charts for variables and for fraction defectives - Theory of probability - Sampling - ABC standard - Reliability and life testing.

UNIT III: LIQUID PENETRANT AND MAGNETIC PARTICLE TESTS **9**

Characteristics of liquid penetrants - different washable systems - Developers - applications - Methods of production of magnetic fields - Principles of operation of magnetic particle test - Applications - Advantages and limitations.

UNIT IV: RADIO GRAPHY **9**

Sources of ray-x-ray production - properties of d and x rays - film characteristics - exposure charts - contrasts - operational characteristics of x ray equipment - applications.

UNIT V: ULTRASONIC AND ACOUSTIC EMISSION TECHNIQUES **9**

Production of ultrasonic waves - different types of waves - general characteristics of waves - 26 pulse echo method - A, B, C scans - Principles of acoustic emission techniques - Advantages and limitations - Instrumentation - applications.

TOTAL: 45 PERIODS

REFERENCES:

1. JAIN, R.K., Engineering Metrology, Khanna Publishers, 2005.
2.Baldev Raj, T. Jeyakumar & M. Thavasimuthu, Practical Non-Destructive Testing, Narosa publishing house, New Delhi, 2002.
3. J. Krautkramer, Ultra Sonic Testing of Materials, 1st Edition, Springer – Verlag Publication, New York, 1996.
4. Peter J. Shull, Non-Destructive Evaluation - Theory, Techniques and Application, Marcel Dekker, Inc., New York, 2002.

COURSE CODE	DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS	L	T	P	C
2162ME181		3	0	0	3

UNIT I: OIL HYDRAULIC SYSTEMS AND HYDRAULIC ACTUATORS 9

Hydraulic Power Generators – Selection and specification of pumps, pump characteristics. Linear and Rotary Actuators – selection, specification and characteristics.

Actuators (Cylinder): Types of mounting, Computations of force. Power Pack: Reservoir & its capacity, Power pack designs.

UNIT II: CONTROL AND REGULATION ELEMENTS 9

Pressure - direction and flow control valves - relief valves, non-return and safety valves - actuation systems.

Pressure Boosters: Pressure applied in one direction, Pressure applied in both directions, Pressure applied & intensified in both directions, Advantages of pressure boosters.

UNIT III: HYDRAULIC CIRCUITS 9

Reciprocation, quick return, sequencing, synchronizing circuits - accumulator circuits - industrial circuits - press circuits - hydraulic milling machine - grinding, planning, copying, - forklift, earth mover circuits- design and selection of components - safety and emergency mandrels.

UNIT IV: PNEUMATIC SYSTEMS AND CIRCUITS 9

Pneumatic fundamentals - control elements, position and pressure sensing - logic circuits - switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods - mapping methods - step counter method - compound circuit design - combination circuit design.

UNIT V: INSTALLATION, MAINTENANCE AND SPECIAL CIRCUITS 9

Pneumatic equipment- selection of components - design calculations – application -fault finding - hydro pneumatic circuits - use of microprocessors for sequencing - PLC, Low cost automation - Robotic circuits.

TOTAL: 45 PERIODS

REFERENCES

1. Antony Esposito, Fluid Power with Applications, Pearson New International Edition 2013.
2. K. Shanmuga Sundaram, Hydraulic and Pneumatic Controls: Understanding made Easy, S.Chand & Co Book publishers, New Delhi, 2006 (Reprint 2009).
3. Bolton. W., Pneumatic and Hydraulic Systems, Butterworth –Heinemann, 1997.
4. Andrew Parr, Hydraulic and Pneumatics (HB), Jaico Publishing House, 1999.
5. Dudleyt, A. Pease and John J. Pippenger, Basic fluid power, Prentice Hall, 1987.

CURRICULUM & SYLLABUS

for

M. Tech. – Industrial Engineering

M. Tech. – Industrial Engineering

FOUNDATION COURSE					
Code	**Course**	**L**	**T**	**P**	**C**
		3	2	0	4

PROGRAMME CORE						
Sl. No.	**Code**	**Course**	**L**	**T**	**P**	**C**
Theory Courses						
1	2161ME108	Advanced Operations Research	3	2	0	4
2	**2161ME160**	Quality, Reliability and Standards	3	2	0	4
3	**2161ME161**	Design of Experiments and Taguchi Methods	3	2	0	4
4	**2161ME162**	Production and Operations Management	3	2	0	4
5	2161ME110	Work Design and Ergonomics	3	0	0	3
6	**2161ME163**	Lean Manufacturing and Six Sigma	3	0	0	3
7	**2161ME164**	Logistics and Supply Chain Management	3	0	0	3
8	2161ME113	Modeling and Simulation	3	0	0	3
		TOTAL CREDITS				28
Practical Courses						
1	2161ME303	Industrial Management Laboratory	0	0	2	1
2	2161ME304	Simulation Lab	0	0	2	1
		TOTAL CREDITS				2
PROGRAMME ELECTIVE COURSE (CHOOSE ANY FOUR)						
1	**2162ME184**	Facilities Planning	3	0	0	3
2	**2162ME185**	Services and Operations management	3	0	0	3
3	**2162ME186**	Productivity Management and Re Engineering	3	0	0	3
4	**2162ME187**	Application of Bio-Mechanics in Production	3	0	0	3
5	2162ME111	Advanced Optimization Techniques	3	0	0	3
6	2162ME117	Enterprise Resource Planning	3	0	0	3
7	2162ME118	Group Technology and Cellular Manufacturing System	3	0	0	3
8	**2162ME188**	Engineering Economics and Costing	3	0	0	3
9	**2162ME189**	Performance Modeling Analysis and Control of Manufacturing Systems	3	0	0	3
10	2162ME121	Management Information Systems	3	0	0	3
11	2162ME122	Sequencing and Scheduling	3	0	0	3
12	2162ME122	Value Engineering	3	0	0	3
					Total Credits	**12**

INDEPENDENT LEARNING COURSES					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
	Massive Open Online Course	-	-	-	2
2163ME501	Research Seminar [**OR**]	-	-	-	
2163ME801	Field Study [**OR**]	-	-	-	2
2163ME802	Internship	-	-	-	
2163GE401	Business Communication [**OR**]	-	-	-	2
2163GE402	Technical Writing Tools	-	-	-	
2163MG401	Research Methodology	-	-	-	2
				Total Credits	**8**

PROJECT WORK					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
2164ME601	Project Phase I	0	0	20	10
2164ME701	Project Phase II	0	0	32	16
				Total Credits	**26**

PROGRAMME STRUCTURE AND MINIMUM CREDITS REQUIRED

IN COURSE CATEGORIES

SECTION NUMBER	COURSE CATEGORY	MINIMUM CREDITS REQUIRED
7.2.1	**FOUNDATION COURSE**	**04**
7.2.2	**PROGRAM CORE COURSES**	**30**
7.2.3	**PROGRAM ELECTIVE COURSES**	**12**
7.2.4	**INDEPENDENT LEARNING COURSES**	**8**
7.2.5	**PROJECT WORK**	**26**
	TOTAL CREDITS	**80**

2161ME108	ADVANCED OPERATIONS RESEARCH	L	T	P	C
		3	2	0	4

UNIT I INTRODUCTION –LINEAR PROGRAMMING 12

Concepts of Operation Research, development, applications, LP Definitions, assumptions, formulation, graphical method, Simplex algorithm, Big M method- Two Phase Method.

UNIT II LP-EXTENSIONS 12

Duality- primal dual relationships -Dual Simplex - sensitivity analysis, Integer Programming, One dimensional cutting stock problem, Knap sack problem

UNIT III NETWORKS 12

Transportation and Assignment problems, Maximal flow, Shortest route, Minimum spanning tree problems, Project Net Works.

UNIT IV DYNAMIC PROGRAMMING 12

Dynamic Programming-Concepts, formulation, Stage coach problem, Reliability problem, recursive approach; applications

UNIT V NON-LINEAR PROGRAMMING 12

Unconstrained nonlinear algorithms-Constrained algorithms- Separable programming Quadratic programming - Geometric programming - Stochastic programming

TOTAL: 60 PERIODS

References

1. Hamdy M. Taha, Operations research, an introduction, 9th edition, PHI, 2014.
2. Don T. Phillips, A. Ravindran & James Solberg, Operations Research: Principles and practice, John Wiley, India, 2007.
3. G. Srinivasan , Operations Research Principles and Applications, ,PHI 2017
4. PanneerSelvam. R Operations Research, 2nd Edition, PHI 2008.
5. Yadav S.R and Malik A.K, Operations Research, Oxford University Press, 2nd Edition 2015
6. A.P. Verma ,Operations research, S. K. Kataria & Sons, 2009.

2161ME160	QUALITY, RELIABILITY AND STANDARDS	L	T	P	C
		3	2	0	4

UNIT I QUALITY CONCEPTS **12**

Basics of quality – Quality objectives – Quality control – Quality Assurance –Total Quality Control- Quality costs – Quality loss function – Statistical tolerancing – Seven tools of Quality

UNIT II STATISTICAL PROCESS VARIABILITY AND CONTROL CHARTS **12**

Process Variability - Control charts for variables and attributes – Process capability studies

UNIT III ACCEPTANCE SAMPLING **12**

Acceptance sampling by variables and attributes – ASN – ATI – AOQL - IS2500 plans – MIL STD 105E

UNIT IV RELIABILITY CONCEPT AND LIFE DATA ANALYSIS **12**

Reliability definition – Quality and Reliability– Reliability – MTBF – MTTR – Reliability parameters – Mortality of a component –Mortality curve – Useful life- Data collection –Non Parametric methods: Time to failure distributions: Exponential, Weibull – Probability plotting – Reliability modeling - Different configurations – Redundancy – k out of n system – Complex systems: RBD – Baye‟s approach – Cut and tie sets – Fault Trees – Standby systems-Life testing methods

UNIT V QUALITY STANDARDS **12**

ISO 9000 , 9001,9002,9003 SYSTEM S- Environmental management – Implementation of Quality standards and their management- Management Representative roles- ES 14000 - quality standards- DIN standards.

TOTAL: 60 PERIODS

References

1. Philips J.Ross, Taghuchi techniques for quality engineering, McGraw Hill, New York, 2005.
2. Douglas C.Montgomery, Introduction to statistical quality control, 6th Edition, John Wiley & sons, 2008.
3. E.L. Grant, and Leavensworth, Statistical Quality Control, McGraw Hill, 2007
4. Besterfield – Total Quality Control – McGraw hill, 1997
5. Charles Ebeling, An Introduction to Reliability and Maintainability Engineering, McGraw Hill Education; 12th edition, 2017.
6. Divya Singhal, Implementing Iso 9001: 2008 Quality Management System, Prentice Hall India Learning Private Limited; 2nd edition 2012.

2161ME161	DESIGN OF EXPERIMENTS AND TAGUCHI METHODS	L	T	P	C
		3	2	0	4

UNIT I: EXPERIMENTAL DESIGN FUNDAMENTALS **12**

Importance of experiments, experimental strategies, basic principles of design, terminology, ANOVA, MANOVA, steps in experimentation, sample size, normal probability plot, linear regression models.

UNIT II: SINGLE FACTOR EXPERIMENTS **12**

Completely randomized design, Randomized block design, Latin square design. Statistical analysis, estimation of model parameters, model adequacy checking, pair wise comparison tests

UNIT III: MULTIFACTOR EXPERIMENTS **12**

Two and three factor full factorial experiments, Randomized block factorial design, Experiments with random factors, rules for expected mean squares, approximate F- tests. 2K factorial Experiments.

UNIT IV: SPECIAL EXPERIMENTAL DESIGNS **12**

Blocking and confounding in 2k designs. Two level Fractional factorial design, nested designs, Split plot design, Response Surface Methods

UNIT V: TAGUCHI METHODS **12**

Steps in experimentation, design using Orthogonal Arrays, data analysis, Robust design- control and noise factors, S/N ratios, parameter design, Multi-level experiments, Multi-response Optimization- Grey, TOPSIS and Fuzzy.

TOTAL: 60 PERIODS

References

1. Krishnaiah, K. and Shahabudeen, P. “Applied Design of Experiments and Taguchi Methods”, PHI learning private Ltd., 2012.
2. Montgomery, D.C., “Design and Analysis of experiments”, John Wiley and Sons, Eighth edition, 2013.
3. NicoloBelavendram, “Quality by Design; Taguchi techniques for industrial experimentation”, Prentice Hall, 1995.
4. PhillipJ.Rose, “Taguchi techniques for quality engineering”, McGraw Hill, 2005.
5. Montgomery, D.C., “Design and Analysis of Experiments, Minitab Manual”, John Wiley and Sons, Seventh edition, 2012
6. Gwo-HshiungTzeng and Jih-Jeng Huang, “Multiple attribute decision making methods and applications”, CRC press, A Chapman & Hall Book, 2011.

2161ME162	PRODUCTION AND OPERATIONS MANAGEMENT	L	T	P	C
		3	2	0	4

UNIT I INTRODUCTION **12**

Process planning and selection. new product development, process planning and design, value analysis and value engineering, single and multi facility location problem- mini-max and gravity location problem.

UNIT II FORECASTING **12**

Need for forecasting, the forecasting process, Forecasting methods- qualitative methods, Quantitative models-Time series forecasting models, moving averages, exponential smoothing with trend and seasonal adjustment, multi-item forecasting, Simple and multiple linear regression models, monitoring and controlling forecasts.

UNIT III INVENTORY MANAGEMENT **12**

Types of inventory, Inventory classification methods, Inventory costs, Inventory models- deterministic models, probabilistic models - safety stock and reorder points – Inventory control systems

UNIT IV: PLANNING ACTIVITIES **12**

Capacity planning- short term and long term capacity, capacity of facilities, break even capacity, use of decision trees, aggregate production planning - strategies, methods, Master Production Schedule, Spare parts management, MRP- lot sizing, MRP II,

UNIT V: PRODUCTION CONTROL ACTIVITIES **12**

Production Activity Control, Just-in-time systems, Kanban systems, Scheduling in Manufacturing, Theory of constraints and synchronous manufacturing

TOTAL: 60 PERIODS

References:

1. Seetharama L.Narasimhan, Dennis W.McLeavey, Peter J.Billington,"Production Planning and Inventory Control" , PHI, 2002.
2. Panneer selvam, R. "Production and operations management", PHI, 2010.
3. LeeJ.Krajewski, Larry P.Ritzman, "Operations Management", Pearson Education, 2006.
4. Mahadevan, B. "Operations- Theory & Practice", Pearson Education, 2007
5. Operation Management for Competitive Advantage, by Chase R.B., Jacobs F.R., Aquilano, Agarwal, McGraw Hill, 2008.
6. K.C. Jain, P.L. Verma, Mr. Prabhat Kartikey, Production and Operations Management, Dreamtech Press (2013)

2161ME110	WORK DESIGN AND ERGONOMICS	L	T	P	C
		3	0	0	3

UNIT-I : METHOD STUDY **9**

Work design, method design-procedure, work content, Different Concept of method study. Work and equipment development, Productivity and its measurements- calculations. Operation analysis , motion and micro motion study-, memo motion study- equipment used, -Hand motions-Therbliques, graphic tools -cycle graphics and chrono cycle graphics.

UNIT-II: WORK MEASUREMENT **9**

Time study – methods and procedures- Equipment used –Uses of time study, calculation to determine no. of observations, computer aided time study, operator performance rating, rating factor-types, Manual allowances- time out for personal need, wage calculations, different methods, standard data, machining time calculations, learning effect-motion picture data sheet.

U**NIT-III: APPLIED WORK MEASUREMENT** **9**

Applied work measurement-short cycle and long cycle method, computerized-methods, work sampling methods- normal distribution curve- determination of desired accuracy. alignment chart-types. Work measured by physiological methods- metabolic measurement system, heart rate method, work measured by individual organization methods, wage plan and incentive calculations-Different methods

UNIT-IV: PHYSICAL ERGONOMICS **9**

Ergonomics, physical ergonomics, physical work load and energy expenditure, Anthropometry-measure and design procedure, work postures- objective measure of work posture-types, ergonomic implications, Design of equipment and work place in industries based on product height , human height and accessibility.

UNIT-V: ENVIRONMENTAL FACTORS **9**

Factors affecting environment in factories and other work places- Noise-sources of noise effect of noise-measurement of noise- standard acceptable level-prevention, calculation for acceptable level-various standard. Lighting-sources of light- Effect of light-measurement of light- luminous intensity. Acceptable level, calculations and various standards. Temperature- sources- effect-humidity-air circulations-ventilations human comfort. calculations Vibration- Source-effect-measurements-Acceptable Standards-Prevention. Monitoring control –mitigation.

TOTAL: 45 PERIODS

References

1. Benjamin W.Niebel, Motion and time study, Richard, D. Irwin Inc., seventh edition, 2002
2. Barnes, R.M. Motion and time study, John willy, 2002
3. Introduction to work study, ILO, 3rd edition, oxford & IBH publishing, 2001
4. Martin Helander, A guide to human factors and Ergonomics, Taylor and Francis, 2006
5. Lakhwinder Pal Singh , Work Study and Ergonomics, Cambridge University Press, 2016
6. S. K. Sharma, Savita Sharma , Work Study & Ergonomics, S K Kataria and Sons, 2010

2161ME163	LEAN MANUFACTURING AND SIX SIGMA	L	T	P	C
		3	0	0	3

UNIT I: INTRODUCTION TO LEAN MANUFACTURING 9

Introduction to Lean- Value creation and waste elimination – Types of waste - Takt time – Continuous flow - Kaizen- Visual controls - Quality at the source - 5S principles –Total Productive Maintenance - Overall equipment effectiveness, Changeover/setup time (SMED) - Kanban - Poka-yoke-VSM

UNIT II: DESIGN FOR SIX SIGMA 9

Introduction to quality, Definition of six sigma, origin of six sigma, Six sigma methodology, Process Capability (Cp, Cpk), overview of Quality Function Deployment (QFD) - Theory of Inventive Problem Solving (TRIZ) - overview of Failure Modes and Effects Analysis (FMEA) –

UNIT III: LEAN SIX SIGMA APPROACH 9

Evolution of lean six sigma, synergy of Lean and six sigma, Definition of lean six sigma, the principles of lean six sigma, Scope for lean six sigma, Features of lean six sigma, the laws of lean six sigma, Benefits of lean six sigma, Introduction to DMAIC tools

UNIT IV: SELECTION LEAN SIX SIGMA PROJECTS 9

Resource and project selection, Selection of Black belts, Selecting projects – DMAIC process, Benefit/Effort graph, balanced score card for project identification, Project suitable for lean six sigma, Predicting and improving team performance, nine team roles, Team leadership.

UNIT V: LSS IN MANUFACTURING AND SERVICE SECTORS 9

Institutionalizing lean six sigma, Design for lean six sigma in manufacturing and service,. Implementation of lean six sigma in manufacturing and service industries. Case study presentations

TOTAL: 45 PERIODS

References

1. Michael L. George, “Lean Six Sigma”, McGraw-Hill, 2015.
2. James P. Womack, Daniel T. Jones, “Lean Thinking”, Free press business, 2013.
3. Forrest W. Breyfogle III, “Implementing Six Sigma: Smarter solutions Using Statistical Methods”, John Wiley & Sons, 2013.
4. RonaldG.Askin and Jeffrey B.Goldberg, “Design and Analysis of Lean Production Systems”, John Wiley & Sons, 2013.
5. Rother M , “Learning to See: Value Stream Mapping to add value and Eliminate Muda”, Lean Enterprise Institute, Brookline, 2007
6.James P. Womack, Daniel T. Joners & Daniel Roos, The Machine That Changed the World, Simon & Schuster UK; ABANDON edition (4 Jun. 2007)

2161ME164	LOGISTICS AND SUPPLY CHAIN MANAGEMENT	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION **9**

Definition of Logistics and SCM: Evolution, Scope, Importance - Supply chain stages and decision phases process view of a supply chain - Supply chain flows- Examples of supply chains- Competitive and supply chain strategies- Achieving strategic fit- Expanding strategic scope- Drivers of supply chain performance- Framework for structuring drivers -Obstacles to achieving fit-Modes of Transportation - Design options for Transportation Networks - Routing and Factors.

UNIT II LOGISTICS MANAGEMENT **9**

Scheduling – Inbound and outbound logistics- Reverse Logistics – 3PL- 4PL- Global Logistics - Integrated Logistics Concepts - Activities - Measuring logistics cost and performance – Warehouse Management - Case Analysis

UNIT-III SUPPLY CHAIN NETWORK DESIGN **9**

Distribution in Supply Chain – Factors in Distribution network design –Design Options-Network Design in Supply Chain – Framework for network Decisions

UNIT IV SOURCING AND REVENUE MANAGEMENT IN SUPPLY CHAIN **9**

Supplier selection and Contracts - Design collaboration - Procurement process. Revenue management in supply chain

UNIT V COORDINATION AND IT IN SUPPLY CHAIN **9**

Supply chain coordination - Bullwhip effect – Effect of lack of co-ordination and obstacles – IT and SCM - supply chain IT frame work- E Business and SCM. Metrics for SC performance – Case Analysis

TOTAL: 45 PERIODS

References

1. Sunil Chopra, Peter Meindl and Kalra, “Supply Chain Management, Strategy, Planning, and operation” –, Pearson Education, 2012
2. DavidJ.Bloomberg, Stephen Lemay and Joe B.Hanna, “Logistics”, PHI 2010
3. Martin Christopher, “Logistics and Supply Chain Management –Strategies for Reducing Cost and Improving Service”. Pearson Education Asia, Second Edition
4. Jeremy F.Shapiro, “Modeling the supply chain”, Thomson Duxbury, 2002
5. Sople V. V, “Logistics Management”, Pearson Education, 2012
6. D K Agrawal Textbook of Logistics and Supply Chain Management, Macmillan, 2003

2161ME113	MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION TO RANDOM NUMBERS AND VARIATES 9

Systems, modeling, general systems theory, concept of simulation, simulation as a decision making tool, types of simulation. Pseudo random numbers, methods of generating random variates, testing of random numbers and variates. types of simulation - discrete and continuous systems. Simulation of Queuing Systems - single channel and multi-channel queue. reliability problem Supply Chain Modeling job-shop model.

UNIT II DESIGN OF SIMULATION AND EXPERIMENTS 9

Simulation – Definition – Need and Advantages – Typical problems - Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow chart, starting condition, run size, experimental design consideration, output analysis and interpretation - result validation.

UNIT III SIMULATION APPLICATIONS 9

Development of simulation models using the simulation language- ARENA – GPSS - studied for systems like, Queuing systems, production systems, inventory systems, maintenance and replacement systems, investment analysis and network.

UNIT IV INPUT MODELING VERIFICATION AND VALIDATION OF SIMULATION MODELS 9

Introduction - steps to build a useful model of input data - data collection, identifying the distribution with data, parameter estimation, goodness of fit tests, selecting input models without data, models of arrival processes, model building - variance reduction techniques, calibration and validation of models. exponential distribution, uniform distribution, Weibull distribution, Triangular distribution, Empirical continuous distribution, Poisson distribution.

UNIT V: CASE STUDIES 9

Case study of simulation models like, queuing systems, production systems, inventory systems, maintenance and replacement systems, investment analysis and network, Welch Algorithm, Batch Mean Methods.

TOTAL: 45 PERIODS

REFERENCES

1. Jerry Banks, John S, Carson II, Barry L Nelson and David M Nicol, “Discrete Event System Simulation”, Prentice Hall Inc., 2006.
2. Law A M, “Simulation Modeling and Analysis”, Tata McGraw Hill Companies Inc, 2008.
3. Kelton, W. David,(2006) “Simulation with Arena”, McGraw-Hill.
4. Shahbudeen , 2005 “ Computer Simulation “ , Mc Graw hill
5. Berlekamp- Welch algorithm, Ronald Cohn Jesse Russell, VSD, 2013.
6. Geoffrey Gordon, ‘System simulation’, Prentice Hall, NJ, 1978.

2161ME303	INDUSTRIAL MANAGEMENT LABORATORY	L	T	P	C
		0	0	2	1

List of Experiments:

1. Experiments on Method Study
    a. Flow Process Chart for the Activities of Personal Assistant
    b. Outline Process Chart for the Assembly and Manufacture of Rocker Arm
    c. Two Handed Process chart for the flash light assembly
2. Experiments on Time Study
    a. Performance Rating using Card Dealing
    b. Performance Rating using Walking
    c. Determination of time required for the Assembly of Bolt and Nut
    d. The Harvard Step test using Metronome
3. Physiological Evaluation Tests
    a. Effect of Workload using Treadmill
    b. Effect of Work Rest Schedule on Physical Performance
4. Eye-Hand Coordination Experiments
    a. Time Study using Pegboard
    b. Study of Illumination in Workplace
    c. Analysis of Noise Level in Various Environment
5. Construction of Control Charts for Quality Control and Analysis Using Minitab
    a. Detection of Over dispersion and under dispersion using P chart
    b. Detection of Over dispersion and under dispersion using U chart
    c. Data analysis using X bar – R chart
    d. Data analysis using X bar – S chart
    e. Data analysis using I- MR chart
6. Acceptance sampling
    a. Determination of Actual Percentage of Workers using Work Sampling Observation Sheet

TOTAL: 30 PERIODS

2161ME304	SIMULATION LAB	L	T	P	C
		0	0	2	1

List of Experiments:

1. Modeling and simulation of facilities layout using WITNESS software
2. Create And Simulate ARENA Model For A BANK.
3. Modeling and simulation Transportation models using ARENA software
4. Create a LINGO Program Product Mix Problem.
5. Modeling and simulation job shop scheduling using QUEST software
6. Modeling and simulation in SIMQUICK software.
7. Modeling and simulation material handling system using PROMODEL software
8. Queuing & Inventory modeling in C++ language
9. Random variant generate using C++ language.
10. Modeling and simulation in GPSS
11. Simulation using simulink (MATLAB/LABVIEW)
12. Solving typical problems using Genetic Algorithm, Simulated Annealing, Etc. in MATLAB.

TOTAL: 30 PERIODS

2162ME184	FACILITIES PLANNING	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION **9**

Facilities planning, significance, objectives, requirement, process, product and schedule design, need for layout study – types of layout

UNIT II PLANT LOCATION **9**

Plant location analysis – factors, costs, location decisions – single facility location models, multi facility location models- set covering problem – warehouse location problems

UNIT III LAYOUT DESIGN **9**

Design cycle – SLP procedure, nadler's ideal approach, flow and activity analysis, computerized layout planning procedure – ALDEP, CORELAP, CRAFT

UNIT IV GROUP TECHNOLOGY AND LINE BALANCING **9**

Group technology – Production Flow analysis (PFA), ROC (Rank Order Clustering) – Line balancing, single, multi and mixed mode, parallel line and parallel station

UNIT V MATERIAL HANDLING **9**

Principles, unit load concept, material handling system design, handling equipment types, selection and specification, handling cost, containers and packaging

TOTAL: 45 PERIODS

References

1. James A. Tompkins, John A. White, Yavuz A. Bozer, J. M .A. Tanchoco, "Facilities Planning", 4th Edition, John Wiley & Sons, 2010
2. Richard Francis.L. and John A.White, "Facilities Layout and location - an analytical approach", PHI,2002
3. Pannerselvam,R, "Production and Operations Management", PHI,2012
4. Fred E. Meyers and Mathew Stephens, "Manufacturing Facilities Design and Material Handling" (3rd edition), , Pearson Prentice Hall, New Jersey, 2005, ISBN 0-13-112535-4
5. B. Mahadevan, "Operations management: Theory and Practice",2nd Edition, Pearson education South Asia, 2010.
6. J R Tony Arnold, Chapman Stephen N., "Introduction to Materials Management", Pearson Education Asia, 4th edition, 2000.

2162ME185	SERVICES AND OPERATIONS MANAGEMENT	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION TO SERVICES **9**

Manufacturing and Services, Definition of Service, Characteristic of Service, Nature of Services, Importance of Activity, Impact of technology , service concept as a strategic tool, focused and unfocused service operations.

UNIT II GLOBALIZATION AND STRATEGY MANAGEMENT **9**

Types of Globalized Services, Outsourcing, issues in Globalization, Service strategies Service strategy – service as competitive advantage, turning performance objectives into operational priorities, strategy formulation and development, sustaining a strategy.

UNIT III OPERATIONS ISSUES **9**

Forecasting, Inventory, capacity Planning, Scheduling

UNIT IV SERVICE QUALITY, DELIVERY AND PRODUCTIVITY **9**

Importance of Quality, Models for Service Quality, Service processes, Engineering service processes, Controlling service process, Service people – understanding the pressure on service providers, managing and motivating service providers, managing customers. GAPS model, issues in productivity measurement, Work measurement

UNIT V TOOLS FOR SERVICES AND SERVICE MANAGEMENT **9**

Data Envelopment Analysis, Queuing models, Vehicle Routing models, Resource utilization, Networks, performance and information

TOTAL: 45 PERIODS

References

1. Fitzsimmons, J.A. and Fitzsimmons, M.J. Service Management, Tata Mc Graw Hill India, 2006.

2. Haksever C, Render B, Russell RA and Murdick RG ,Service Management and Operations, Prentice Hall International, USA, 2000

3. Robert Johnson and Graham Clark, “Service Operations Management: Improving Service Delivery”, Pearson Education Ltd., New Delhi,2005.

4. Bill Hobins and Sadie Shinkins, “Managing Service Operations”, Sage Publications India Ltd., New Delhi, 2006.

5. Nevan Wright J and Peter Race, “The Management of Service Operations”, Thomson Learning, 2005.

6.. William J Glynn and James G Barnes, “Understanding Service management: Integrating marketing, Operational Behavior”, 1995.

2162ME186	PRODUCTIVITY MANAGEMENT AND RE ENGINEERING	L	T	P	C
		3	0	0	3

UNIT I PRODUCTIVITY **9**

Productivity Concepts – Macro and Micro factors of productivity – Dynamics of Productivity - Productivity Cycle Productivity Measurement at International, National and Organisation level - Productivity measurement models Factors influencing productivity-Techniques in improving productivity.

UNIT II SYSTEMS APPROACH TO PRODUCTIVITY MEASUREMENT **9**

Conceptual frame work, Management by Objectives (MBO), Performance Objective of Productivity (POP) – Methodology and application to manufacturing and service sector.

UNIT III ORGANIZATIONAL TRANSFORMATION **9**

Elements of Organizational Transformation and Reengineering-Principles of organizational transformation and re-engineering, fundamentals of process re-engineering, preparing the workforce for transformation and re-engineering, methodology, guidelines, LMI CIP Model – DSMC Q & PMP model.

UNIT IV RE-ENGINEERING PROCESS IMPROVEMENT MODELS **9**

PMI models, PASIM Model, Moen and Nolan Strategy for process improvement, LMICIP Model, NPRDC Model.

UNIT V RE-ENGINEERING TOOLS AND IMPLEMENTATION **9**

Analytical and process tools and techniques – Information and Communication Technology – Implementation of Reengineering Projects – Success Factors and common implementation Problem – Cases.

TOTAL: 45 PERIODS

References

1. Sumanth, D.J., 'Productivity Engineering and Management', TMH, New Delhi, 1990.
2. Edosomwan, J.A., "Organizational Transformation and Process Re-engineering", Library Cataloging in Pub. Data, 1996.
3. Rastogi, P.N., "Re-engineering and Re-inventing the Enterprise", Wheeler Pub. New Delhi, 1995.
4. Premvrat, Sardana, G.D. and Sahay, B.S., "Productivity Management – A Systems Approach", Narosa Publishing House. New Delhi, 1998.
5. Jeffrey N. Lowenthal, "Re-engineering the organization" – A step-by-step Approach to Corporate Revitalization", Tata McGraw Hill Publishing Co. LTd., New Delhi, India, 1994.
6. Michael Hammer and James Champy, "Re-engineering the corporation – A Manifesto for Business Revolution", Nicholar Barkey Publishing, London, UK,Revised Edition 2006.

2162ME187	APPLICATION OF BIO-MECHANICS IN PRODUCTION	L	T	P	C
		3	0	0	3

UNIT-1. INTRODUCTION TO BIO MECHANICS **9**

Principles of mechanics in Human movement, Qualitative and Quantitative Analysis, Key mechanical concepts of mechanics and basic units, Nine Fundamentals of Biomechanics, Nine Principles for application of Biomechanics.

UNIT-2. MECHANICS OF MUSCULOSKELETAL SYSTEM **9**

Principles of joint motions, Muscle structures, Mechanical method of Muscle action analysis, Tissue loads and forces, Biomechanics of Bones and Ligaments, Three mechanical characters of muscle, SSC.

UNIT-3. LINEAR KINETICS AND ANGULAR KINETICS **9**

Vector analysis of Angle of Pull and Muscle Angle Pull, Contact Forces, Impulse- Momentum Relationship, Force-Time Principle, Work-Energy Relationship, Segmental Interaction Principle.

Torque, Equilibrium, Center of Gravity and Principle of Balance

UNIT-4. APPLICATIONS OF ENGINEERING EDUCATION **9**

Qualitative analysis of Kicking technique, batting, catching, throwing techniques.

UNIT-5. APPLICATIONS OF BIOMECHANICS IN MEDICAL REHABITATION **9**

Injury risk assessment, Equipment design for strength training, Injury mechanics, Injury prevention.

TOTAL: 45 PERIODS

References

1. Duane Knudson, “Fundamentals of Biomechanics”, Springer, 2010.
2. Daniel J. Schneck, “Biomechanics- Principles and Applications”, CRC Press, 2002.
3. Ajay Bahl, “Basics of Biomechanics” , Jaypee Brothers Medical Publishers, first edition, 2010.
4. Joseph E.Muscolino, “ Kinesology”, Mosby, 3rd edition, 2016.
5. Ronald L.Huston, “Fundamentals of Biomechanics”, CRC Press, 1st edition
6. Robert frost, “Applied Kinesiology”, North Atlantic Books; Revised edition, 2013

2162ME111	ADVANCED OPTIMIZATION TECHNIQUES	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION **9**

General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints – Classification of optimization problem. Single variable and multivariable optimization, Techniques of unconstrained minimization

UNIT II DECISION ANALYSIS **9**

Golden section, Random, pattern and gradient search methods – Interpolation methods; Optimization with equality and inequality constraints. Hooks and Jeeves Method

UNIT III NON-LINEAR OPTIMIZATION **9**

Decision Trees, Utility theory, Game theory, Multi Objective Optimization, MCDM- Goal Programming, Analytic Hierarchy process

UNIT IV NON-TRADITIONAL OPTIMIZATION-1 **9**

Classes P and NP, Polynomial time reductions, Introduction to NP- Hard problems, Overview of Genetic algorithms, Simulated Annealing, neural network based optimization

UNIT V NON-TRADITIONAL OPTIMIZATION-2 **9**

Particle Swarm optimization, Ant Colony Optimization, Optimization of Fuzzy Systems

TOTAL: 45 PERIODS

References

1. Singiresu S.Rao, “Engineering optimization – Theory and practices”, New Age International Publishers, 2013.
2. Ravindran – Phillips –Solberg, “Operations Research – Principles and Practice”, John Wiley India, 2007.
3. Fredrick S.Hillier and G.J. Liberman, “Introduction to Operations Research”, McGraw Hill Inc. 2017.
4. Kalymanoy Deb, “Optimization for Engineering Design”, PHI, 2012.
5. Christos H. Papadimitriou, Kenneth Stieglitz, “Combinatorial Optimization”, PHI 2006.
6. Marius Durea, “An Introduction to Nonlinear optimization theory”, De Gruyter 1st edition 2014.

2162ME117	ENTERPRISE RESOURCE PLANNING	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION TO ERP **9**

Overview of ERP - Introduction and Evaluation of ERP, Reasons for the growth of the ERP-Market, Benefits of ERP, Overview of Enterprise - Integrated Management Systems, Business Modeling, Integrated Data Model

UNIT II ERP AND RELATED TECHNOLOGIES **9**

Business Process Re-engineering (BPR) - Best Practices in ERP, Reengineering Options - Clean State Re-engineering, Technology Enabled Re-engineering, Business Intelligence Systems-Data Mining, Data Warehousing, On-Line Analytical Processing (OLAP), Supply Chain Management

UNIT III IMPLEMENTATION OF ERP **9**

Implementation Life Cycle: - Implementation Methodologies and Approaches. ERP Life-Cycle and SDLC.ERP Implementation Cost and Time, ERP Project Management, Training. Implementation Stakeholder's Roles and Responsibilities: Vendors, Consultants, Top Management and End-Users.

UNIT IV ERP – THE BUSINESS MODULES **9**

Finance, Production Planning, Material Management, Control & Maintenance, Sales & Distribution, Human Resource Management (HRM),Inventory Control System, Quality Management, Marketing, Customization.

UNIT V FUTURE DIRECTIONS IN ERP **9**

Enterprise Integration Applications (EIA) - ERP and E-Commerce - ERP and Internet - Future Directions in ERP

TOTAL: 45 PERIODS

References

1. Alexis Leon, "ERP Demystified", McGraw–Hill Education, 3rd Edition 2014
2. Brady, "Enterprise Resource Planning", Thomson Learning, 2001
3. S. Sadagopan, "ERP: A managerial Perspective", Tata McGraw-Hill publishing company Limited, New Delhi, 1999.
4. Garg, V.K., and Venkitakrishnan, N.K., "Enterprise Resource Planning: Concepts and Practice", Prentice-Hall of India Private Limited, New Delhi, 1998.
5. O'Leary, D.E., "Enterprise Resource Planning Systems: System, Life cycle, Electronic Commerce and Risk", John Wiley & Sons, 2001.
6. Ellen Monk, "Concepts in Enterprise Resource Planning", South-Western College Publishing; 4th edition, 2012

2162ME118	GROUP TECHNOLOGY AND CELLULAR MANUFACTURING SYSTEM	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION **9**

Introduction to Group Technology, Recognizing part similarities, Defining similarities, The Basis for Group Technology, the benefits of Group Technology and issues in GT

UNIT II CMS PLANNING AND DESIGN **9**

Background, Types of Manufacturing Cells, How to plan a manufacturing cell, More Complex cells, Design of CMS- Production Flow Analysis, Checklist for Planning and Design, Conclusions and Future Trends

UNIT III IMPLEMENTATION OF GT/CMS **9**

Present situation of Cellular Production System, Classification of Cellular Production Systems, Structure of cellular Production Systems: Way of thinking and Basic Requirements, Introducing a cellular production system via Case Study, Linkages to JIT systems

UNIT IV PERFORMANCE MEASUREMENT AND CONTROL **9**

Measuring CMS performance - Parametric analysis - PBC in GT/CMS, cell loading, GT and MRP – framework

UNIT V ECONOMIC OF GT/CMS **9**

Conventional Vs group use of computer models in GT/CMS, Human aspects of GT/CMS - cases

TOTAL: 45 PERIODS

References

1. Burbidge, J.L, “Group Technology in Engineering Industry”, Mechanical Engineering Pub. London, 1979
2. Askin, R.G and Vakharia , A.J., “ The automated factory – Hand book: Technology and Management”,
3. Irani, S.A , “Cellular Manufacturing systems Hand book”
4. Kamrani,A.K,, Parsaei, H.R and Liles, D.H (Eds) “Planning, Design and Analysis of Cellular Manufacturing Systems”, Elsevier, 1995
5. Askin, R.G. and J.B.Goldberg, “Design and Operation of Lean Production Systems”, John Wiley and Sons, New York , 2002.
6. Kjell B.Zandin, Maynard “Industrial Engineering handbook”, Fifth Edition

2162ME188	ENGINEERING ECONOMICS AND COSTING	L	T	P	C
		3	0	0	3

UNIT I DEMAND ANALYSIS AND FORECASTING 9

Managerial Economics – Meaning, Nature and Scope – Managerial Economics and Business decision making – Role of Managerial Economist – Demand Analysis – Fundamental Concepts of Managerial Economics – Meaning, Determinants and Types of Demand – Elasticity of demand - Demand forecasting and forecasting methods.

UNIT II PRODUCTION FUNCTION AND COST ANALYSIS 9

Supply: Meaning and determinants – production function- Iso quant's – Expansion path Cobb Douglas function – Cost concepts – Cost output relationship – Economies and diseconomies of scale – Cost functions- Determination of cost- Estimation of cost

UNIT III MARKET COMPETITION AND PRICING 9

Market Structure – Various forms – Equilibrium of a firm – Perfect competition – Monopolistic competition – Oligopolistic competition – Pricing of products under different market structures – Methods of pricing – Factors affecting pricing decision – Differential pricing – Government Intervention and pricing

UNIT IV PROFIT ANALYSIS 9

The concept of profit: Profit planning, control and measurement of profits. Profit maximization – Cost volume profit analysis – Investment Analysis.

UNIT V NATIONAL INCOME AND POLICY 9

National Income – Accounting – Consumption and investment – Business Cycle and unemployment – Inflation and deflation, Balance of Payments – Monetary and Fiscal policies

TOTAL: 45 PERIODS

References

1. A. Ramachandra Aryasry and V.V. Ramana Murthy " Engineering Economics and Financial Accounting", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2004
2. V.L. Mote, Samuel and G.S.Gupta, "Managerial Economics – Concepts and cases", Tata McGraw Hill Publishing Company Ltd, New Delhi, 2004
3. A. Nag, "Macro Economics for Management Students", MacMillan India Ltd., New Delhi, 2005.
4. Philip T.koltler, "Principles of Marketing",
5. Mishra,and Sasmita Engineering Economics and Costing, entice Hall India Learning Private Limited; 2 edition (2010)
6. Panneerselvam R, Engineering Economics Paperback, Prentice Hall India Learning Private Limited; 2nd Revised edition edition (2013)

2162ME188	PERFORMANCE MODELING ANALYSIS AND CONTROL OF MANUFACTURING SYSTEMS	L	T	P	C
		3	0	0	3

UNIT I INTRODUCTION 9

The production system, Production system analysis, The information base, Kanban – Inventory control and operations scheduling under Kanban, Some issues in the implementation of Kanban, Group Technology – Lot sizing under Group Technology, Operations Scheduling Under Group Technology, Some Issues in the implementation of Group Technology

UNIT II FORECASTING AND TIME SERIES ANALYSIS 9

Introduction, Forecasting, Forecasting Procedures Gregory –Newton Interpolation Formulas, Regression Methods, Moving-Average Methods, Exponential Smoothing, Choice of α, Winters method for seasonal variation.

UNIT III PROJECT PLANNING AND SCHEDULING 9

Introduction, Project planning and scheduling: Unlimited resources, CPM and PERT background, The use of CPM /PERT in industry, Construction of Project Networks, Common Errors in Network construction, Checking the consistency of Precedence Relationships, Critical Path Algorithm, Linear Programming Formulation, Cost Models, Program Evaluation and Review Technique, Limitations of PERT and /or CPM.

UNIT IV JOB SEQUENCING AND OPERATIONS SCHEDULING 9

Introduction, Job Sequencing, n jobs-one machine, n jobs – two machine, n jobs – three machine, Two jobs- M Machines, n Jobs – M machines, Minimization of set up costs, Job shop scheduling, Assembly line balancing, Probabilistic assembly line balancing, Automatic transfer lines.

UNIT V INVENTORY MANAGEMENT 9

Introduction, Inventory costs, The terminology of Inventory Systems, Inventory Policies, Demand Characteristics and Inventory Models, Analysis of Deterministic Inventory Models, Probabilistic Inventory Models, Inventory system control practices.

TOTAL: 45 PERIODS

References

1. Elsayed A.Elsayed , Thomas O.Boucher “Analysis and control of production systems” , Prentice Hall Inc
2. Askin, R.G and Strandridge, C.R., Modelling and Analysis of Manufacturing systems, John Wiley and Sons, 1993
3. Kjell B.Zandin, Maynard Industrial Engineering handbook, Fifth Edition,
4 Altiok, and Tayfur, Performance Analysis of Manufacturing Systems, Springer-Verlag New-York, 1997.
5. Guy L. Curry · Richard M. Feldman, Manufacturing Systems Modeling and Analysis, Second Edition, Springer-Verlag Berlin Heidelberg, 2011.
6. N Viswanadham, and Y Narahari, Performance Modeling Of Automated Manufacturing Systems, Phi Learning 1st Edition (2008)

2162ME121	MANAGEMENT INFORMATION SYSTEMS	L	T	P	C
		3	0	0	3

UNIT I: MANAGING THE DIGITAL FIRM **9**

Concepts, need and scope of Information system in business organization, the competitive business environment and the emerging digital firm, transformation of business enterprise, major business functions, approaches to the development of an organization's information system; technical approach, behavioral approach, socio – technical approach, new options for organization design, the Network revolution, Internet and its functions, World Wide Web, LAN etc., positive & negative impacts of information systems

UNIT II: INFORMATION SYSTEMS IN THE ENTERPRISE **9**

Organizational levels, subsystems of information system; operational level, knowledge level, management level and strategic level information systems, transaction processing systems, office automation systems, knowledge work systems, MIS, DSS, ESS, relationship of various information systems to one another, systems from a functional perspective, System development life cycle, Nolan's model of growth of MIS in an organization, introduction to ERP

UNIT III: MANAGING DATA RESOURCES AND DECISION MAKING **9**

Components of computer based information system (CBIS), file organization terms & concepts, problems with traditional file environment, Database Management System (DBMS), types of Databases, Relational DBMS, hierarchical & network DBMS, Object oriented databases. Data-mining. Steps in decision making, Simons model of decision making, Types of decisions i.e. structured and unstructured decisions, Departmental, inter departmental and organizational decisions, role of MIS in decision making

UNIT IV: LOGICAL DATABASE DESIGN AND ARTIFICIAL INTELLIGENCE **9**

Terminologies – Entities and attributes – Data models, schema and subschema - Data Independence – ER Diagram Normalization, 1NF to 2NF to 3 NF steps. Artificial intelligence: Expert system, features of an expert system, heuristic and algorithm, human expertise vs. artificial expertise, knowledge representation: rule-based methods & frame-based methods, tasks and stages of expert system development and difficulties in developing an expert system

UNIT V: COMPUTER SIMULATION AND INTRODUCTION TO SQL **9**

concept of simulation, when is simulation an appropriate tool, when simulation is not appropriate, advantages and disadvantages of simulation, areas of application, systems & system environment, components of a system, discrete & continuous systems, model of a system, types of models, steps in a simulation study, simulation application examples, selecting simulation software. Introduction to SQL Practice of basic commands of SQL, development of MIS for simple business situations

TOTAL: 45 PERIODS

References

1.Laudon Kenneth C and Laudon Jane P, "Management Information Systems", Pearson Education Asia, Eighth Edition, 2004

2. Donald A Waterman, "A Guide to Expert Systems", Pearson Education Asia, Third Edition Reprint, 2002

3. Banks Jerry,"Discrete Event System Simulation", Pearson Education Asia, Third Edition, 2001

4. Davis & Olson, "Management Information Systems", McGraw Hill International Editions, 2017

5. Parker & Case, "Management Information Systems", McGraw Hill International Editions.

Rahul de, MIS in Business, Government and Society, Wiley India Pvt Ltd, 2012

6. Gordon Davis, Management Information System : Conceptual Foundations, Structure and Development, Tata McGraw Hill, 21st Reprint 2008.

2162ME122	SEQUENCING AND SCHEDULING	L	T	P	C
		3	0	0	3

UNIT I: SINGLE MACHINE MODELS **9**

Single machine models - Scheduling function and theory – scheduling problem: objectives, constraints – pure sequencing – performance measures, sequencing theorems - SPT, EDD. Sequence – minimization of mean flow time, mean tardiness etc – branch and bound algorithm –assignment model. Heuristic Methods for the Single-Machine Problem

UNIT II: PARALLEL MACHINE MODELS **9**

Parallel machine models - Independent jobs Minimizing make span, completion time, due date and on-line problems

UNIT III: FLOW SHOP MODELS **9**

Flow shop models - Johnson's problem – Extension of Johnson's rule for 3 machines - Problem – Jackson's method – algorithm – Palmer's method, Stochastic Flow Shop Scheduling

UNIT IV: JOB SHOP MODELS **9**

Job shop models – disjunctive, shifting bottle neck, weighted tardiness, make span, dynamic job shop simulation

UNIT V: SCHEDULING IN PRACTICES **9**

Other models - Scheduling of intermittent production: Resource smoothing – Giffler Thomson algorithm – Branch and Bound method – Scheduling of continuous production - Line balancing

TOTAL: 45 PERIODS

References

1. Michael L.Pinedo, "Scheduling: theory, algorithms and systems", (4th ed.), Prentice Hall, New Delhi, 2016
2. Kenneth R. Baker, "Introduction to sequencing and scheduling", John Wiley and Sons, 1995
3. Kenneth R. Baker, Dan Trietsch, 'Principles of Sequencing and Scheduling John Wiley and Sons, 2009
4. Simon French, Sequencing and Scheduling: An Introduction to the Mathematics of the Job-shop (Mathematics and its Applications), Ellis Horwood Ltd ,Publisher; First Edition (March 17, 1982)
5. Geza Paul Bottlik, An Introduction to the Mathematics of Planning and Scheduling, CRC Press,2017
6. M.L. Pinedo,Planning and Scheduling in Manufacturing and Services, by, Springer-Verlag, New York, 2005,

2162ME122	VALUE ENGINEERING	L	T	P	C
		3	0	0	3

UNIT I: INTRODUCTION – VALUE ENGINEERING **9**

Definition of Value, Value Analysis, Value Engineering, Value management, Value Analysis versus Value Engineering, Value Analysis versus Traditional cost reduction techniques, uses, applications, advantages and limitations of Value analysis.

UNIT II: VALUE ENGINEERING TECHNIQUES **9**

Brain storming technique, Gordon technique, Feasibility Ranking technique, Morphological Analysis Technique, ABC Analysis, Probabilistic approach, Make or Buy decisions.

UNIT III: ADVANCED VALUE ENGINEERING TECHNIQUES **9**

Advanced Value Engineering techniques: Function, Cost- Worth Analysis (FCWA) technique, Function Analysis System (FAST) technique, Weighted Evaluation method, Evaluation matrix, Break Even Analysis, Life cycle cost (LCC); Applications of value analysis/ Value Engineering.

UNIT IV: VALUE ENGINEERING IN JOB PLAN **9**

Orientation phase – information phase – functional analysis – creative phase – evaluation phase – recommendation phase – implementation phase – audit phase

UNIT V: VE IN SERVICE AND CASE STUDIES **9**

Basics, VE benefits in service, problems using VE, case studies in contract, café shop, restaurant, hospital. Examples: water treatment plant – laser printer – electric motor – two wheeler – hotel service

TOTAL: 45PERIODS

References

1. Richard J Park, "Value Engineering – A Plan for Inventions", St.Lucie Press, London, 2017.
2. Anil Kumar Mukopadhaya, "Value Engineering Concepts Techniques and Applications", Response Books, 2003.
3. Mukhophadhyaya A K, "Value Engineering", Sage Publications Pvt. Ltd., New Delhi, 2003.
4. Larry W Zimmesman , "VE –A Practical Approach for Owners Designers and Contractors", CBS Publishers, Delhi, 1992.
5. Arthus E Mudge, "Value Engineering", McGraw Hill Book Company, 1971
6. S.S Iyer, "Value Engineering", New Age Publisher, 1996.

CURRICULUM AND SYLLABUS

for

M. Tech. – Industrial Safety Engineering

FOUNDATION COURSE					
Code	**Course**	**L**	**T**	**P**	**C**
		3	2	0	4

PROGRAMME CORE						
Sl. No.	**Code**	**Course**	**L**	**T**	**P**	**C**
Theory Courses						
1	2161ME132	Principles of Safety Management	3	0	0	3
2	2161ME133	Occupational Health & Industrial Hygiene	3	0	0	3
3	2161ME134	Industrial Safety, Health and Environment	3	0	0	3
4	2161ME135	Environmental Safety	3	0	0	3
5	2161ME136	Fire Engineering and Explosion Control	3	0	0	3
6	2161ME137	Computer Aided Hazard Analysis	4	0	0	4
7	2161ME138	Safety in Engineering Industry	3	0	0	3
8	**2161ME167**	Electrical safety	3	0	0	3
9	**2161ME168**	Safety in Process Industries	3	0	0	3
					Total Credits	**28**
Laboratory Courses						
1	2161ME309	Design and Fabrication of Safety Device	0	0	2	1
2	2161ME310	Industrial Safety and Environmental Laboratory	0	0	2	1
					Total credits	**2**

PROGRAMME ELECTIVES (ANY FOUR)						
1	2162ME150	Principles of Disaster Management	3	0	0	3
2	2162ME116	Advanced Plant Layout and Materials Handling	3	0	0	3
3	2162ME151	Fireworks Safety	3	0	0	3
4	2162ME152	Safety in Chemical Industry	3	0	0	3
5	2162ME113	Quality and Reliability Engineering	3	0	0	3
6	2162ME153	Safety in On and Off Shore Drilling	3	0	0	3
7	2162ME154	Industrial Noise and Vibration Control	3	0	0	3
8	2162ME155	Occupational Health and Environmental Management System standards	3	0	0	3
9	2162ME156	Design of Industrial Ventilation System	3	0	0	3
10	2162ME180	Safety in Construction Industries	3	0	0	3
					Total credits	**8**

INDEPENDENT LEARNING COURSES					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
	Massive Open Online Course	-	-	-	2
2163ME501	Research Seminar [**OR**]	-	-	-	
2163ME801	Field Study [**OR**]	-	-	-	2
2163ME802	Internship	-	-	-	
2163GE401	Business Communication [**OR**]	-	-	-	2
2163GE402	Technical Writing Tools	-	-	-	
2163MG401	Research Methodology	-	-	-	2
				Total Credits	**8**

PROJECT WORK					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
2164ME601	Project Phase I	0	0	20	10
2164ME701	Project Phase II	0	0	32	16
				Total Credits	**26**

PROGRAMME STRUCTURE AND MINIMUM CREDITS REQUIRED

IN COURSE CATEGORIES

SECTION NUMBER	COURSE CATEGORY	MINIMUM CREDITS REQUIRED
7.2.1	**FOUNDATION COURSE**	**04**
7.2.2	**PROGRAM CORE COURSES**	**30**
7.2.3	**PROGRAM ELECTIVE COURSES**	**12**
7.2.4	**INDEPENDENT LEARNING COURSES**	**8**
7.2.5	**PROJECT WORK**	**26**
	TOTAL CREDITS	**80**

2161ME132	PRINCIPLES OF SAFETY MANAGEMENT	L	T	P	C
		3	0	0	3

UNIT I CONCEPTS AND TECHNIQUES **9**

History of Safety movement –Evolution of modern safety concept- general concepts of management – planning for safety for optimization of productivity -productivity, quality and safety-line and staff functions for safety-budgeting for safety-safety policy. Incident Recall Technique (IRT), disaster control, job safety analysis, safety survey, safety inspection, safety sampling, evaluation of performance of supervisors on safety.

UNIT II SAFETY AUDIT – INTRODUCTION **9**

Components of safety audit, types of audit, audit methodology, non-conformity reporting (NCR), audit checklist and report – review of inspection, remarks by government agencies, consultants, experts – perusal of accident and safety records, formats – implementation of audit indication - liaison with departments to ensure co-ordination – check list – identification of unsafe acts of workers and unsafe conditions in the shop floor.

UNIT III ACCIDENT INVESTIGATION AND REPORTING **9**

Concept of an accident, reportable and non-reportable accidents, reporting to statutory authorities – principles of accident prevention – accident investigation and analysis – records for accidents, 4 departmental accident reports, documentation of accidents – unsafe act and condition – domino sequence – supervisory role – role of safety committee –cost of accident.

UNIT IV SAFETY PERFORMANCE MONITORING **9**

ANSI (Z16.1) Recommended practices for compiling and measuring work injury experience – permanent total disabilities, permanent partial disabilities, temporary total disabilities - Calculation of accident indices, frequency rate, severity rate, frequency severity incidence, incident rate, accident rate, safety “t” score, safety activity rate – problems.

UNIT V SAFETY EDUCATION AND TRAINING **9**

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

TOTAL: 45 PERIODS

REFERENCES:

1. Krishnan N.V. “Safety Management in Industry” Jaico Publishing House, Bombay,1997.
2. Lees, F.P., “Loss Prevention in Process Industries” Butterworth publications, London, 2nd edition, 1990.
3. John Ridley, “Safety at Work”, Butterworth and Co., London, Sixth edition 2003.
4. Industrial Safety Management, L M Deshmukh, Tata McGraw-Hill Education,2005

2161ME133	OCCUPATIONAL HEALTH AND INDUSTRIAL HYGIENE	L	T	P	C
		3	0	0	3

UNIT I PHYSICAL HAZARDS **9**

Noise, compensation aspects, noise exposure regulation, properties of sound, occupational damage, risk factors, sound measuring instruments, octave band analyzer, noise networks, noise surveys, noise control program, industrial audiometry, hearing conservation programs- vibration, types, effects, instruments, surveying procedure, permissible exposure limit. Ionizing radiation, types, effects, monitoring instruments, control programs, OSHA standard- nonionizing radiations, effects, types, radar hazards, microwaves and radio-waves, lasers, TLV- cold environments, hypothermia, wind chill index, control measures- hot environments, thermal comfort, heat stress indices, acclimatization, estimation and control

UNIT II CHEMICAL HAZARDS **9**

Recognition of chemical hazards-dust, fumes, mist, vapour, fog, gases, types, concentration, Exposure vs. dose, TLV - Methods of Evaluation, process or operation description, Field Survey, Sampling methodology, Industrial Hygiene calculations, Comparison with OSHAS Standard. Air Sampling instruments, Types, Measurement Procedures, Instruments Procedures, Gas and Vapour monitors, dust sample collection devices, personal sampling Methods of Control - Engineering Control, Design maintenance considerations, design specifications - General Control Methods - training and education

UNIT III BIOLOGICAL AND ERGONOMICAL HAZARDS **9**

Classification of Biohazardous agents – examples, bacterial agents, rickettsial and chlamydial agents, viral agents, fungal, parasitic agents, infectious diseases - Biohazard control program, employee health program-laboratory safety program-animal care and handling-biological safety cabinets - building design. Work Related Musculo skeletal Disorders –carpal tunnel syndrome CTS- Tendon pain-disorders of the neck- back injuries.

UNIT IV OCCUPATIONAL HEALTH AND TOXICOLOGY **9**

Concept and spectrum of health - functional units and activities of occupational health services, pre-employment and post-employment medical examinations - occupational related diseases, levels of prevention of diseases, notifiable occupational diseases such as silicosis, asbestosis, pneumoconiosis, siderosis, anthracosis, aluminosis and anthrax, lead-nickel, chromium and manganese toxicity, gas poisoning (such as CO, ammonia, coal and dust etc) their effects and prevention - Industrial toxicology, local, systemic and chronic effects, temporary and cumulative effects, carcinogens entry into human systems

UNIT V OCCUPATIONAL PHYSIOLOGY **9**

Man as a system component – allocation of functions – efficiency – occupational work capacity – aerobic and anaerobic work – evaluation of physiological requirements of jobs – parameters of measurements – categorization of job heaviness – work organization – stress – strain – fatigue – rest pauses – shift work – personal hygiene.

TOTAL: 45 PERIODS

REFERENCES:

1. Fundamental Principles of Occupational Health and Safety- Benjamin O. Alli International Labour Office –Geneva - Published 2008
2. Occupational Health and Safety Management: A Practical Approach, by Reese, Third Edition 2017-, CRC PRESS

2161ME134	INDUSTRIAL SAFETY, HEALTH AND ENVIRONMENT ACTS	L	T	P	C
		3	0	0	3

UNIT I FACTORIES ACT – 1948 **9**

Stuatutory authorities – inspecting staff, health, safety, provisions relating to hazardous processes, welfare, working hours, employment of young persons – special provisions – penalties and procedures-Tamilnadu Factories Rules 1950 under Safety and health chapters of Factories Act 1948

UNIT II ENVIRONMENT ACT – 1986 **9**

General Powers of the central government, prevention, control and abatement of environmental pollution-Biomedical waste (Management and handling Rules, 1989-The noise pollution (Regulation and control) Rules, 2000-The Batteries (Management and Handling Rules) 2001- No Objection certificate from statutory authorities like pollution control board. Air Act 1981 and Water Act 1974: Central and state boards for the prevention and control of air pollution-powers and functions of boards – prevention and control of air pollution and water pollution – fund – accounts and audit, penalties and procedures.

UNIT III MANUFACTURE, STORAGE AND IMPORT OF HAZARDOUS CHEMICAL RULES 1989 **9**

Definitions – duties of authorities – responsibilities of occupier – notification of major accidents – information to be furnished – preparation of offsite and onsite plans – list of hazardous and toxic chemicals – safety reports – safety data sheets.

UNIT IV OTHER ACTS AND RULES **9**

Indian Boiler Act 1923, static and mobile pressure vessel rules (SMPV), motor vehicle rules, mines act 1952, workman compensation act, rules – electricity act and rules – hazardous wastes (management 7 and handling) rules, 1989, with amendments in 2000- the building and other construction workers act 1996., Petroleum rules, Gas cylinder rules-Explosives Act 1983-Pesticides Act

UNIT V INTERNATIONAL ACTS AND STANDARDS **9**

Occupational Safety and Health act of USA (The Williames-Steiger Act of 1970) – Health and safety work act (HASAWA 1974, UK) – OSHAS 18000 – ISO 14000 – American National Standards Institute (ANSI).

TOTAL: 45 PERIODS

REFERENCES:

1. The Factories Act 1948, Madras Book Agency, Chennai, 2000
2. The Environment Act (Protection) 1986, Commercial Law Publishers (India) Pvt.Ltd., New Delhi.
3. Water (Prevention and control of pollution) act 1974, Commercial Law publishers (India) Pvt.Ltd., New Delhi.
4. Air (Prevention and control of pollution) act 1981, Commercial Law Publishers (India) Pvt.Ltd., New Delhi.
5. The Indian boilers act 1923, Commercial Law Publishers (India) Pvt. Ltd., Allahabad.
6. Industrial Safety, Health Environment and Security, Basudev Panda Laxmi Publications, 2012

2161ME135	ENVIRONMENTAL SAFETY	L	T	P	C
		3	0	0	3

UNIT I AIR POLLUTION **9**

Classification and properties of air pollutants – Pollution sources – Effects of air pollutants on human beings, Animals, Plants and Materials - automobile pollution-hazards of air pollution-concept of clean coal combustion technology - ultra violet radiation, infrared radiation, radiation from sun-hazards due to depletion of ozone - deforestation-ozone holes-automobile exhausts-chemical factory stack emissions-CFC.

UNIT II WATER POLLUTION **9**

Classification of water pollutants-health hazards-sampling and analysis of water-water treatment - different industrial effluents and their treatment and disposal -advanced wastewater treatment - effluent quality standards and laws- chemical industries, tannery, textile effluents-common treatment.

UNIT III HAZARDOUS WASTE MANAGEMENT **9**

Hazardous waste management in India-waste identification, characterization and classification technological options for collection, treatment and disposal of hazardous waste-selection charts for the treatment of different hazardous wastes-methods of collection and disposal of solid wastes-health 5 hazards-toxic and radioactive wastes-incineration and vitrification - hazards due to bio-process- dilution-standards and restrictions – recycling and reuse.

UNIT IV ENVIRONMENTAL MEASUREMENT AND CONTROL **9**

Sampling and analysis – dust monitor – gas analyzer, particle size analyzer – lux meter-pH meter – gas chromatograph – atomic absorption spectrometer. Gravitational settling chambers-cyclone separators-scrubbers-electrostatic precipitator - bag filter – maintenance - control of gaseous emission by adsorption, absorption and combustion methods- Pollution Control Board-laws.

UNIT V POLLUTION CONTROL IN PROCESS INDUSTRIES **9**

Pollution control in process industries like cement, paper, petroleum-petroleum products-textile tanneries-thermal power plants – dying and pigment industries - eco-friendly energy.

TOTAL: 45 PERIODS

REFERENCES:

1. Rao, CS, “Environmental pollution engineering:, Wiley Eastern Limited, New Delhi, 1992.
2. S.P.Mahajan, “Pollution control in process industries”, Tata McGraw Hill Publishing Company, New Delhi, 1993.
3. Varma and Braner, “Air pollution equipment”, Springer Publishers, Second Edition.

2161ME136	FIRE ENGINEERING AND EXPLOSION CONTROL	L	T	P	C
		3	0	0	3

UNIT I PHYSICS AND CHEMISTRY OF FIRE **9**

Fire properties of solid, liquid and gases - fire spread - toxicity of products of combustion - theory of combustion and explosion – vapour clouds – flash fire – jet fires – pool fires – unconfined vapour cloud explosion, shock waves - auto-ignition – boiling liquid expanding vapour explosion – **case studies –** Peterborough and Bombay Victoria dock ship explosions.

UNIT II FIRE PREVENTION AND PROTECTION **9**

Sources of ignition – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E – types of fire extinguishers – fire stoppers – hydrant pipes – hoses – monitors – fire watchers – lay out of stand pipes – fire station-fire alarms and sirens – maintenance of fire trucks – foam generators – escape from fire rescue operations – fire drills – notice-first aid for burns.

UNIT III INDUSTRIAL FIRE PROTECTION SYSTEMS **9**

Sprinkler-hydrants-stand pipes – special fire suppression systems like deluge and emulsifier, selection criteria of the above installations, reliability, maintenance, evaluation and standards – alarm and detection systems. Other suppression systems – CO2 system, foam system, dry chemical powder (DCP) system and halon system – need for halon replacement – smoke venting. Portable extinguishers – flammable liquids – tank farms – indices of in flammability- Firefighting systems.

UNIT IV BUILDING FIRE SAFETY **9**

Objectives of fire safe building design, Fire load, fire resistant material and fire testing – structural fire protection – structural integrity – concept of egress design - exists – width calculations - fire certificates – fire safety requirements for high rise buildings – snookers.

UNIT V EXPLOSION PROTECTING SYSTEMS **9**

Principles of explosion-detonation and blast waves-explosion parameters – Explosion Protection, Containment, Flame Arrestors, isolation, suppression, venting, explosion relief of large enclosure-explosion venting-inert gases, plant for generation of inert gas-rupture disc in process vessels and lines explosion, suppression system based on carbon dioxide (CO2) and halons-hazards in LPG, ammonia (NH3), sulphur dioxide (SO3), chlorine (CL2) etc.

TOTAL: 45 PERIODS

REFERENCES:

1. Gupta, R.S., “Hand Book of Fire Technology” Orient Longman, Bombay 1977.
2. “Accident Prevention Manual for Industrial Operations” N.S.C., Chicago, 1982.
3. DinkoTuhtar, “Fire and Explosion Protection” 1989.
4. Derek, James, “Fire Prevention Hand Book”, Butter Worths and Company, London, 1986.

2161ME137	COMPUTER AIDED HAZARD ANALYSIS	L	T	P	C
		4	0	0	4

UNIT I HAZARD, RISK ISSUES AND HAZARD ASSESSMENT **12**

Introduction, hazard, hazard monitoring-risk issue, group or societal risk, individual risk, voluntary and involuntary risk, social benefits Vs technological risk, approaches for establishing risk acceptance levels, Risk estimation. Hazard assessment, procedure, methodology; safety audit, checklist analysis, what-if analysis, safety review, preliminary hazard analysis (PHA), human error analysis, hazard operability studies(HAZOP),safety warning systems.

UNIT II COMPUTER AIDED INSTRUMENTS **12**

Applications of Advanced Equipments and Instruments, Thermo Calorimetry, Differential Scanning Calorimeter(DSC), Thermo Gravimetric Analyser(TGA), Accelerated Rate Calorimeter(ARC), Reactive Calorimeter(RC), Reaction System Screening Tool(RSST) - Principles of operations, Controlling parameters, Applications, advantages. Explosive Testing, Deflagration Test, Detonation Test, Ignition Test, Minimum ignition energy Test, Sensitiveness Test, Impact Sensitiveness Test(BAM) and Friction Sensitiveness Test (BAM), Shock Sensitiveness Test, Card Gap Test.

UNIT III RISK ANALYSIS QUANTIFICATION AND SOFTWARES **12**

Fault Tree Analysis and Event Tree Analysis, Logic symbols, methodology, minimal cut set ranking - fire explosion and toxicity index(FETI), various indices - Hazard analysis(HAZAN)- Failure Mode and Effect Analysis(FMEA)- Basic concepts of Reliability- Software on Risk analysis, CISCON, FETI, HAMGARS modules on Heat radiation, Pool fire, Jet, Explosion. Reliability softwares on FMEA for mechanical and electrical systems.

UNIT IV CONSEQUENCES ANALYSIS **12**

Logics of consequences analysis- Estimation- Hazard identification based on the properties of chemicals- Chemical inventory analysis- identification of hazardous processes- Estimation of source term, Gas or vapour release, liquid release, two phase release- Heat radiation effects, BLEVE, Pool fires and Jet fire- Gas/vapour dispersion- Explosion, UVCE and Flash fire, Explosion effects and confined explosion- Toxic effects- Plotting the damage distances on plot plant/layout.

UNIT V CREDIBILITY OF RISK ASSESSMENT TECHNIQUES **12**

Past accident analysis as information sources for Hazard analysis and consequences analysis of chemical accident, Mexico disaster, Flixborough, Bhopal, Seveso, Pasadena, Feyzin disaster(1966), Port Hudson disaster- convey report, hazard assessment of non-nuclear installation- Rijnmond report, risk analysis of size potentially Hazardous Industrial objects- Rasmussen masses report, Reactor safety study of Nuclear power plant **TOTAL: 60 PERIODS**

REFERENCES:

1. Loss Prevention in Process Industries-Frank P. Less Butterworth-Hein UK 1990 (Vol.I, II and III)
2. Methodologies for Risk and Safety Assessment in Chemical Process Industries, Commonwealth Science Council, UK
3. Course Material Intensive Training Programme on Consequence Analysis, by Process Safety Centre, Indian Institute of Chemical Technology, Tarnaka and CLRI, Chennai.
4. ILO- Major Hazard control- A practical Manual, ILO, Geneva, 1993.
5. Brown, D.B. System analysis and Design for safety, Prentice Hall, 1976.

2161ME138	SAFETY IN ENGINEERING INDUSTRY	L	T	P	C
		3	0	0	3

UNIT I SAFETY IN METAL WORKING MACHINERY AND WOOD WORKING MACHINES 9

General safety rules, principles, maintenance, Inspections of turning machines, boring machines, milling machine, planning machine and grinding machines, CNC machines, Wood working machinery, types, safety principles, electrical guards, work area, material handling, inspection, standards and codes- saws, types, hazards.

UNIT II PRINCIPLES OF MACHINE GUARDING 9

Guarding during maintenance, Zero Mechanical State (ZMS), Definition, Policy for ZMS – guarding of hazards - point of operation protective devices, machine guarding, types, fixed guard, interlock guard, automatic guard, trip guard, electron eye, positional control guard, fixed guard fencing- guard construction- guard opening. Selection and suitability: lathe-drilling-boring-milling-grindingshaping-sawing-shearing-presses-forge hammer-flywheels-shafts-couplings gears-sprockets wheels and chains-pulleys and belts-authorized entry to hazardous installations-benefits of good guarding systems.

UNIT III SAFETY IN WELDING AND GAS CUTTING 9

Gas welding and oxygen cutting, resistances welding, arc welding and cutting, common hazards, personal protective equipment, training, safety precautions in brazing, soldering and metalizing – explosive welding, selection, care and maintenance of the associated equipment and instruments – safety in generation, distribution and handling of industrial gases-colour coding – flashback arrestor – leak detection-pipe line safety-storage and handling of gas cylinders.

UNIT IV SAFETY IN COLD FORMING AND HOT WORKING OF METALS 9

Cold working, power presses, point of operation safe guarding, auxiliary mechanisms, feeding and cutting mechanism, hand or foot-operated presses, power press electric controls, power press set up and die removal, inspection and maintenance-metal sheers-press brakes. Hot working safety in forging, hot rolling mill operation, safe guards in hot rolling mills – hot bending of pipes, hazards and control measures. Safety in Gas Furnace Operation, Cupola, Crucibles, Ovens, Foundry Health Hazards, Work Environment, Material Handling in Foundries, Foundry Production Cleaning And Finishing Foundry Processes.

UNIT V SAFETY IN FINISHING, INSPECTION AND TESTING 9

Heat treatment operations, Electro Plating, Paint Shops, Sand And Shot Blasting, Safety In Inspection And Testing, Dynamic Balancing, Hydro Testing, Valves, Boiler Drums And Headers, Pressure Vessels, Air Leak Test, Steam Testing, Safety In Radiography, Personal Monitoring Devices, Radiation Hazards, Engineering And Administrative Controls, Indian Boilers Regulation.

TOTAL: 45 PERIODS

REFERENCES:

1. Philip E. Hagan, John Franklin Montgomery, James T. O'Reilly “Accident Prevention Manual” – NSC, Chicago, 2009.
3. Charles D. Reese, “Occupational Health and Safety Management”, CRC Press, 2003.

COURSE CODE	ELECTRICAL SAFETY	L	T	P	C
2161ME167		3	0	0	3

UNIT I CONCEPTS AND STATUTORY REQUIREMENTS 9

Introduction – electrostatics, electro magnetism, stored energy, energy radiation and electromagnetic interference – Working principles of electrical equipment-Indian electricity act and rules-statutory requirements from electrical inspectorate-international standards on electrical safety – first aid-cardio pulmonary resuscitation(CPR).

UNIT II ELECTRICAL HAZARDS 9

Primary and secondary hazards-shocks, burns, scalds, falls-human safety in the use of electricity. Energy leakage-clearances and insulation-classes of insulation-voltage classifications-excess energy-current surges-Safety in handling of war equipment-over current and short circuit current-heating effects of current-electromagnetic forces-corona effect-static electricity –definition, sources, hazardous conditions, control, electrical causes of fire and explosion-ionization, spark and arc-ignition energy-national electrical safety code ANSI.

Lightning, hazards, lightning arrestor, installation – earthing, specifications, earth resistance, earth pit maintenance.

UNIT III PROTECTION SYSTEMS 9

Fuse, circuit breakers and overload relays – protection against over voltage and under voltage – safe limits of amperage – voltage –safe distance from lines-capacity and protection of conductor-joints-and connections, overload and short circuit protection-no load protection-earth fault protection.

FRLS insulation-insulation and continuity test-system grounding-equipment grounding-earth leakage circuit breaker (ELCB)-cable wires-maintenance of ground-ground fault circuit interrupter-use of low voltage-electrical guards-Personal protective equipment – safety in handling hand held electrical appliances tools and medical equipment.

UNIT IV SELECTION, INSTALLATION, OPERATION AND MAINTENANCE 9

Role of environment in selection-safety aspects in application - protection and interlock-self diagnostic features and fail safe concepts-lock out and work permit system-discharge rod and earthing devices-safety in the use of portable tools-cabling and cable joints-preventive maintenance.

UNIT V HAZARDOUS ZONES 9

Classification of hazardous zones-intrinsically safe and explosion proof electrical apparatus-increase safe equipment-their selection for different zones-temperature classification-grouping of gases-use of barriers and isolators-equipment certifying agencies.

TOTAL: 45 PERIODS

REFERENCES:

1. "Accident prevention manual for industrial operations", N.S.C., Chicago, 1974
2. Power Engineers – Handbook of TNEB, Chennai, 2002.
3. Martin Glov Electrostatic Hazards in powder handling, Research Studies Pvt. Ltd., England, 1988.
4. Fordham Cooper, W., "Electrical Safety Engineering" Butterworth and Company, London, 1993.

2161ME168	SAFETY IN PROCESS INDUSTRIES	L	T	P	C
		3	0	0	3

UNIT I SAFETY IN PROCESS DESIGN AND PRESSURE SYSTEM DESIGN 9

Design process, conceptual design and detail design, assessment, inherently safer design chemical reactor, types, batch reactors, reaction hazard evaluation, assessment, reactor safety, operating conditions, unit operations and equipment, utilities. Pressure system, pressure vessel design, standards and codes- pipe works and valves heat exchangers- process machinery- over pressure protection, pressure relief devices and design, fire relief, vacuum and thermal relief, special situations, disposal- flare and vent systems- failures in pressure system.

UNIT II PLANT COMMISSIONING AND INSPECTION 9

Commissioning phases and organization, pre-commissioning documents, process commissioning, commissioning problems, post commissioning documentation Plant inspection, pressure vessel, pressure piping system, non-destructive testing, pressure testing, leak testing and monitoring- plant monitoring, performance monitoring, condition, vibration, corrosion, acoustic emission-pipe line inspection.

UNIT III PLANT OPERATIONS 9

Operating discipline, operating procedure and inspection, format, emergency procedures hand over and permit system- start up and shut down operation, refinery units- operation of fired heaters, driers, storage- operating activities and hazards- trip systems- exposure of personnel-colour coding of pipes and cylinders – Corrosion prevention for underground pipes.

UNIT IV PLANT MAINTENANCE, MODIFICATION AND EMERGENCY 9

Planning Management of maintenance, hazards- preparation for maintenance, isolation, purging, cleaning, confined spaces, permit system- maintenance equipment- hot works- tank cleaning, repair and demolition- online repairs- maintenance of protective devices modification of plant, problems- controls of modifications. Emergency planning, disaster planning, onsite emergency- offsite emergency.

UNIT V STORAGES 9

General consideration, petroleum product storages, storage tanks and vessel- storages layout - segregation, separating distance, secondary containment- venting and relief, atmospheric vent, pressure, vacuum valves, flame arrestors, fire relief - fire prevention and protection - LPG storages, pressure storages, layout, instrumentation, vaporizer, refrigerated storages - LNG storages, hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages - underground storages - loading and unloading facilities- drum and cylinder storage- ware house, storage hazard assessment of LPG and LNG.

TOTAL: 45 PERIODS

REFERENCES:

1. Lees, F.P., “Loss Prevention in Process Industries” Butterworth publications, London, 2nd edition, 1990.
2. Sanoy Banerjee, “Industrial hazards and plant safety”, Taylor & Francis, London, 2003.

COURSE CODE	INDUSTRIAL SAFETY AND ENVIRONMENTAL LABORATORY	L	T	P	C
2161ME310		0	0	2	1

1. NOISE LEVEL MEASUREMENT AND ANALYSIS
   Measurement of noise level for various sources-Impact, continuous and intermittent. Frequency and spectrum analysis of noise

2. VIBRATION MEASUREMENT AND ANALYSIS
   Measurement of whole body vibration for various acceleration: Instrument – vibration simulator and vibration analyzer.

3. ILLUMINATION MEASUREMENT AND ANALYSIS
   Measurement of Illumination level for various sources using Lux meter.

4. THERMAL REACTIVITY TEST
   Measurement of thermal reactivity for unstable materials.

5. EXHAUST GAS MEASUREMENT AND ANALYSIS
   Measurement of Exhaust gas measurement of IC engines.

6. BREATHING ZONE CONCENTRATION
   Measurement of breathing zone concentration of dust and fumes

7. AMBIENT AIR MONITORING
   Measurement of respirable and non- respirable dust in the ambient air

8. CONSEQUENCE ANALYSIS
   Soft computing skills on developing effects of fire & explosion and dispersion.

9. STUDY OF PERSONAL PROTECTIVE EQUIPMENT
   Safety helmet, belt, hand gloves, goggles, safety shoe, gum boots, ankle shoes, face shield, nose mask, ear plug, ear muff, apron and leg guard.

10. STUDY OF FIRE EXTINGUISHERS
    Selection and demonstration of first-aid fire extinguishers: soda acid, foam, carbon dioxide (CO2), dry chemical powder, halon.

11. STUDY ON ELECTRICAL SAFETY
    To study various electrical hazards and safety precautions to be followed.

12. STUDY ON SAFETY AUDIT
    To study the procedure of safety audit and to perform a safety audit.

TOTAL: 30 PERIODS

2162ME150	PRINCIPLES OF DISASTER MANAGEMENT		L	T	P	C
			3	0	0	3

UNIT I INTRODUCTION **9**

Philosophy of Disaster management-Introduction to Disaster mitigation Hydrological, Coastal and Marine Disasters-Atmospheric disasters Geological, meteorological phenomena-Mass Movement and Land Disasters-Forest related disasters-Wind and water related disasters deforestation-Use of space technology for control of geological disasters-Master thesis.

UNIT II TECHNOLOGICAL DISASTERS **9**

Technological Disasters-Case studies of Technology disasters with statistical details-Emergencies and control measures-APELL-Onsite and Offsite emergencies-Crisis management groups-Emergency centers and their functions throughout the country Software on emergency controls Monitoring devices for detection of gases in the atmosphere-Right to know act.

UNIT III ENVIRONMENTAL IMPACT ASSESSMENT **9**

Introduction to Sustainable Development-Bio Diversity-Atmospheric pollution-Global warming and Ozone Depletion-ODS banking and phasing out-Sea level rise-El Nino and climate changes-Eco friendly products-Green movements-Green philosophy - Environmental Policies Environmental Impact Assessment-case studies-Life cycle.

UNIT IV POLLUTION ASPECTS **9**

Offshore and onshore drilling-control of fires-Case studies-Marine pollution and control-Toxic, hazardous and Nuclear wastes-state of India's and Global environmental issues carcinogens-complex emergencies-Earthquake disasters-the nature-extreme event analysis the immune system-proof and limits.

UNIT V POLICY INITIATIVES **9**

Environmental education-Population and community ecology-Natural resources conservation-Environmental protection and law-Research methodology and systems analysis-Natural resources conservation Policy initiatives and future prospects-Risk assessment process, assessment for different disaster types-Assessment data use, destructive capacity-risk adjustment-choice-loss acceptance-disaster aid- public liability insurance-stock taking and vulnerability analysis disaster profile of the country-national policies-objectives and standards physical event modification-preparedness, forecasting and warning, land use planning.

TOTAL: 45 PERIODS

REFERENCES:

1. Gilbert, Masters.M., "Introduction to Environmental Engineering and Science", 3rd edition, 2008.

2. Miller, Tylor.G., "Environmental Science", 14th edition 2012.

3. Bagad Vilas. "Principles of Environmental Science and Engineering", 2004.

4. Sivakumar.R., "Principles of Environmental Science and Engineering", 2005.

2162ME116	ADVANCED PLANT LAYOUT AND MATERIAL HANDLING	L	T	P	C
		3	0	0	3

Unit I Plant Location **9**

Selection of plant locations, territorial parameters, considerations of land, water, electricity, location for waste treatment and disposal, further expansions Safe location of chemical storages in the form of bullets, spheres, cylinders for LPG, LNG, CNG, acetylene, ammonia, chlorine – explosives and propellants.

Unit II Plant Layout **9**

Safe layout, equipment layout, safety system, fire hydrant locations, fire service rooms, facilities for safe effluent disposal and treatment tanks, site considerations, approach roads, plant railway lines, security towers. Safe layout for process industries, engineering industry, construction sites, pharmaceuticals, pesticides, fertilizers, refineries, food processing, nuclear power stations, thermal power stations, metal powders manufacturing, fireworks and match works.

Unit III Working Conditions **9**

Principles of good ventilation, purpose, physiological and comfort level types, local and exhaust ventilation, hood and duct design, air conditioning, ventilation standards, application. Purpose of lighting, types, advantages of good illumination, glare and its effect, lighting requirements for various work, standards- Housekeeping, principles of 5S.

Unit IV Manual Material Handling and Lifting Tackles. **9**

Preventing common injuries, lifting by hand, team lifting and carrying, handling specific shape machines and other heavy objects – accessories for manual handling, hand tools, jacks, hand trucks, dollies and wheel barrows – storage of specific materials - problems with hazardous materials, liquids, solids – storage and handling of cryogenic liquids - shipping and receiving, stock picking, dock boards, machine and tools, steel strapping and sacking, glass and nails, pitch and glue, boxes and cartons and car loading – personal protection – ergonomic considerations. Fiber rope, types, strength and working load inspection, rope in use, rope in storage - wire rope, construction, design factors, deterioration causes, sheaves and drums, lubrication, overloading, rope fitting, inspection and replacement – slings, types, method of attachment, rated capacities, alloy chain slings, hooks and attachment, inspection

Unit V Mechanical Material Handling **9**

Hoisting apparatus, types -cranes, types, design and construction, guards and limit devices, signals, operating rules, maintenance safety rules, inspection and inspection checklist – conveyors, precautions, types, applications. Powered industrial trucks, requirements, operating principles, operators selection and training and performance test, inspection and maintenance, electric trucks, gasoline operated trucks, LPG trucks – power elevators, types of drives, hoist way and machine room emergency procedure, requirements for the handicapped, types- Escalator, safety devices and brakes, moving walks – man lifts, construction, brakes, inspection.

TOTAL: 45 PERIODS

REFERENCES:

1. "Encyclopedia of occupational safety and health", ILO Publication, 1985
2. "Accident prevention manual for industrial operations" N.S.C., Chicago, 1982.
3. Alexandrov. M.P. "Material handling equipment" Mir Publishers, Moscow, 1981.
4. APPLE M. JAMES "Plant layout and material handling", 3rd edition, John Wiley & sons.
5. Spivakosky, "Conveyors and related Equipment", Vol.I& II Peace Pub. Moscow, 1982
6. Rudenko, N., "Material handling Equipments", Mir Publishers, 1981.
7. Reymond, A.Kulwice, "Material Handling Hand Book - II", John Wiley and Sons, New York, 1985.
8. "Safety and good housekeeping", N.P.C. New Delhi, 1985.

2162ME151	FIREWORKS SAFETY	L	T	P	C
		3	0	0	3

UNIT I PROPERTIES OF FIREWORKS CHEMICALS **9**

Fire properties – potassium nitrate (KNO3), potassium chlorate (KClO3), barium nitrate (BaNO3), calcium nitrate (CaNO3), Sulphur (S), Phosphorous (P), antimony (Sb) Pyro Aluminium (Ai) powder Reactions-metal powders, Borax, ammonia (NH3) – Strontium Nitrate, Sodium Nitrate, Potassium per chloride. Fire and explosion, impact and friction sensitivity.

UNIT II STATIC CHARGE AND DUST **9**

Concept-prevention-earthing-copper plates-dress materials-static charge meter lightning, Causes-effects-hazards in fireworks factories lightning arrestor: concept-installation earth pit-maintenance resistance-legal requirements-case studies. Dust: size-respirable, non-respirable-biological barriers-hazards-personal protective equipment pollution prevention.

UNIT III PROCESS SAFETY **9**

Safe-quantity, mixing-filling-fuse cutting – fuse fixing – finishing – drying at various stages-packing-storage-hand tools-materials, layout: building-distances- factories act – explosive act and rules – fire prevention and control – emergency planning in fireworks – Automation of manual process.

UNIT IV MATERIAL HANDLING **9**

Manual handling – wheel barrows-trucks-bullock carts-cycles automobiles-fuse handling – paper caps handling-nitric acid handling in snake eggs manufacture-handling the mix in this factory-material movement-godown-waste pit. Transportation: Packing-magazine-design of vehicles for explosive transports loading into automobiles transport restrictions-case studies overhead power lines-driver habits-intermediate parking-fire extinguishers-loose chemicals handling and transport.

UNIT V WASTE CONTROL AND USER SAFETY **9**

Concepts of wastes – Wastes in fireworks-Disposal-Spillages-storage of residues. Consumer anxiety-hazards in display-methods in other countries-fires, burns and scalds – sales outlets-restrictions-role of fire service.

TOTAL: 45 PERIODS

REFERENCES:

1. Ghosh, K.N. “The Principles of Firecrackers”, Economic Enterprises, Sivakasi; 1981.

2. Shanmugam. G. et al, “Fireworks safety 1999: Proceedings of the National seminar held at MSEC”, Sivakasi, on July 17 & 18, 1999.

3. Pyrotech 2013, Proceedings of the 2nd National Fireworks Conference, TamilNadu Fireworks and Amorces Manufacturers' Association (TANFAMA), 2013.

4. Conkling J., “Chemistry of Pyrotechnics: Basic Principles and Theory”, Marcel Dekker Inc., New York; 1985.

5. Shimizu. T., “Firecrackers: The Art, Science and Technique”, Maruzen Co, Tokyo; 1981.

2162ME152	SAFETY IN CHEMICAL INDUSTRY	L	T	P	C
		3	0	0	3

Unit I Safety in Process Design and Pressure System **9**

Design process, conceptual design and detail design, assessment, inherently safer design-chemical reactor, types, batch reactors, reaction hazard evaluation, assessment, reactor safety, operating conditions, unit operations and equipment, utilities. Pressure system, pressure vessel design, standards and codes- pipe works and valves- heat exchangers- process machinery- over pressure protection, pressure relief devices and design, fire relief, vacuum and thermal relief, special situations, disposal- flare and vent systems-failures in pressure system.

Unit II Plant Commissioning and Inspection **9**

Commissioning phases and organization, pre-commissioning documents, process commissioning problems, post commissioning documentation. Plant inspection, pressure vessel, pressure piping system, non -destructive testing, pressure testing, leak testing and monitoring- plant monitoring, performance monitoring, condition, vibration, corrosion, acoustic emission-pipe line inspection.

Unit III Plant Maintenance **9**

Modification and Emergency Planning Management of maintenance, hazards- preparation for maintenance, isolation, purging, cleaning, confined spaces, permit system- maintenance equipment- hot works- tank cleaning, repair and demolition- online repairs- maintenance of protective devices- modification of plant, problems- controls of modifications. Emergency planning, disaster planning, onsite emergency- offsite emergency, APELL.

Unit IV Storages and Transportation **9**

General consideration, petroleum product storages, storage tanks and vessel- storages layout-segregation, separating distance, secondary containment- venting and relief, atmospheric vent, pressure, vacuum valves, flame arrestors, fire relief- fire prevention and protection-LPG storages, pressure storages, layout, instrumentation, vaporizer, refrigerated storages-LNG storages, hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages-underground storages- loading and unloading facilities- drum and cylinder storage- ware house, storage hazard assessment of LPG and LNG Hazards during transportation – pipeline transport.

Unit V Plant Operations **9**

Operating discipline, operating procedure and inspection, format, emergency procedures-hand over and permit system- start up and shut down operation, refinery units- operation of fired heaters, driers, storage- operating activities and hazards- trip systems- exposure of personnel. Specific safety consideration for Cement, paper, pharmaceutical, petroleum, petro-chemical, rubber, fertilizer and distilleries. **TOTAL: 45 PERIODS**

REFERENCES:

1. Lees, F.P. “Loss Prevention in Process Industries” Butterworths and Company, 1996.
2. “Quantitative Risk Assessment in Chemical Process Industries” American Institute of Chemical Industries, Centre for Chemical Process safety.
3. Fawcett, H.h. and Wood, “Safety and Accident Prevention in Chemical Operations” Wiley inters, Second Edition.
4. “Accident Prevention Manual for Industrial Operations” NSC, Chicago, 1982.
5. GREEN, A.E., “High Risk Safety Technology”, John Wiley and Sons,. 1984.
6. “Petroleum Act and Rules”, Government of India. 7. “Carbide of Calcium Rules”, Government of India.

2162ME113	QUALITY AND RELIABILITY ENGINEERING	L	T	P	C
		3	0	0	3

UNIT I QUALITY CONCEPTS **9**

Basics of quality – Quality objectives – Quality control – Quality Assurance – Quality costs – Quality loss function – Statistical tolerance – Seven tools of Quality

UNIT II STATISTICAL PROCESS VARIABILITY AND CONTROL CHARTS

Process Variability - Control charts for variables and attributes – Process capability studies **9**

UNIT III ACCEPTANCE SAMPLING **9**

Design of experiments – ANOVA - Taguchi methods – Reliability – MTBF – MTTR-Acceptance sampling by variables and attributes – ASN – ATI – AOQL - IS2500 plans – MIL STD 105E

UNIT IV RELIABILITY CONCEPT AND LIFE DATA ANALYSIS **9**

Reliability definition – Quality and Reliability– Reliability mathematics – Reliability parameters – Mortality of a component –Mortality curve – Useful life- Data collection –Non Parametric methods: Ungrouped/Grouped, Complete/Censored data – Time to failure distributions: Exponential, Weibull – Probability plotting – Goodness of fit tests.

UNIT V RELIABILITY MODELING, MANAGEMENT AND IMPROVEMENT **9**

Different configurations – Redundancy – k out of n system – Complex systems: RBD – Baye's approach – Cut and tie sets – Fault Trees – Standby systems-Life testing methods: Failure terminated – Time terminated – Sequential Testing –Reliability growth monitoring – Reliability allocation – Software reliability-Human reliability-Analysis of downtime – Repair time distribution – System repair time – Maintainability prediction – Measures of maintainability – Inspection decisions – System Availability

TOTAL: 45 PERIODS

REFERENCES

1. Philips J.Ross, Taghuchi techniques for quality engineering, McGraw Hill, New York,1998.

2. Douglus C.Montgomery, Introduction to statistical quality control, 2nd Edition, Jhon Wiley & sons, 1991.

3. E.L. Trant, and Leavensworth, Statistical Quality Control, Mcgraw Hill, 1984

2162ME153	SAFETY IN ON AND OFF SHORE DRILLING	L	T	P	C
		3	0	0	3

UNIT I PRODUCTS **9**

Petroleum and Petroleum products – Fuels- Petroleum solvents – Lubricating oils – Petroleum wax, greases – Miscellaneous product

UNIT II OPERATIONS AND HAZARDS **9**

On and off shore oil operation – Construction of Installation – Pipe line Construction – Maintenance and repair activities – Safety and associated hazards

UNIT III DRILLING EQUIPMENTS AND HAZARDS **9**

Drilling oil – Technique and equipment- Work position –Working condition – safety and associated hazards- lighting and its effects

UNIT IV EXTRACTION AND TRANSPORT **9**

Petroleum Extraction and transport by sea – Oil field products – Operation – Transport of crude by sea – Crude oil hazards.

UNIT V STORAGE **9**

Petroleum product storage and transport –Storage equipment –Precaution –Tank cleaning.

TOTAL: 45 PERIODS

REFERENCES:

1. Encyclopedia of Occupational Health and Safety, Vol. I & II, International Labour Organization, Geneva, 1985.

2. D.A. Ardus and C.D. Green, “Safety in Offshore Drilling: The Role of Shallow Gas Surveys (Advances in Underwater Technology, Ocean Science and Offshore Engineering)”, Springer, 1st edition, 1990.

3. Jan-Erik Vinnem, “Offshore Risk Assessment: Principles, Modelling and Applications of QRA Studies”, Springer, 1st edition, 2010.

2162ME154	INDUSTRIAL VIBRATION AND NOISE CONTROL	L	T	P	C
		3	0	0	3

UNIT I Basics of Vibration

9

Introduction, classification of vibration: free and forced vibration, undamped and damped vibration, linear and non linear vibration, response of damped and undamped systems under harmonic force, analysis of single degree and two degree of freedom systems, torsional vibration, determination of natural frequencies.

UNIT II Basics of Noise **9**

Introduction, amplitude, frequency, wavelength and sound pressure level, addition, subtraction and averaging decibel levels, noise dose level, legislation, measurement and analysis of noise, measurement environment, equipment, frequency analysis, tracking analysis, sound quality analysis.

UNIT III Source of Noise and Control **9**

Methods for control of engine noise, combustion noise, mechanical noise, predictive analysis, palliative treatments and enclosures, automotive noise control principles, sound in enclosures, sound energy absorption, sound transmission through barriers.

UNIT IV Vibration Control **9**

Specification of Vibration Limits –Vibration severity standards- Vibration as condition Monitoring tool-Vibration Isolation methods- -Dynamic Vibration Absorber, Torsional and Pendulum Type Absorber- Damped Vibration absorbers -Static and Dynamic Balancing- Balancing machines - Field balancing – Vibration Control by Design Modification- Active Vibration Control. 9 Hours

UNIT V Experimental Methods in Vibration Analysis **9**

Vibration Analysis Overview - Experimental Methods in Vibration Analysis - Vibration Measuring Instruments - Selection of Sensors - Accelerometer Mountings – Vibration Exciters-Mechanical, Hydraulic, Electromagnetic And Electrodynamics – Frequency Measuring Instruments - System Identification from Frequency Response -Testing for resonance and mode shapes.

Total: 45 PERIODS

REFERENCES:

1. SingiresuS.Rao - “Mechanical Vibrations” - Pearson Education, ISBM –81297-0179-0 -2004.

2. KewalPujara “Vibrations and Noise for Engineers, Dhanpat Rai & Sons,1992.

3. Bernard Challen and RodicaBaranescu - “Diesel Engine Reference Book” – Second edition - SAE International - ISBN 0-7680-0403-9 – 1999.

4. Julian Happian-Smith - “An Introduction to Modern Vehicle Design”- Butterworth- Heinemann, ISBN 0750-5044-3 – 2004.

5. John Fenton - “Handbook of Automotive body Construction and Design Analysis –Professional Engineering Publishing, ISBN 1-86058-073-1998.

6. Rao V. Dukkipati and J.Srinivas ,”Text book of Mechanical Vibrations”,

2162ME155	OCCUPATIONAL HEALTH AND ENVIRONMENTAL MANAGEMENT SYSTEMS	L	T	P	C
		3	0	0	3

UNIT I OHSAS STANDARD **9**

Introduction – Development of OHSAS standard – Structure and features of OSHAS 18001 – Benefits of certification-certification procedure – OH and S management system element, specification and scope - Correspondence between OHSAS 18001:2007, ISO 14001:2004 and ISO 9001:2000-Correspondence between OHSAS 18001, OHSAS 18002, and the ILO-OSH:2001.

UNITII OHSAS 18001 POLICY AND PLANNING, IMPLEMENTATION AND OPERATION **9**

General requirements, OH&S policy, Planning - Hazard identification, risk assessment and determining controls - Legal and other requirements - Objectives and programme(s), Implementation and operation - Resources, roles, responsibility, accountability and authority Competence, training and awareness - Communication, participation and consultation - Communication - Participation and consultation, Documentation - Control of documents-Operational control - Emergency preparedness and response.

UNIT III CHECKING AND REVIEW AND GUIDELINES **9**

Checking- Performance measurement and monitoring-Evaluation of compliance-Incident investigation, nonconformity, corrective action and preventive action-Control of records-Internal audit-Management review - guidelines for implementation of 18001:2007 -Examples of items for hazard identification checklist –Comparison of risk assessment tool and methodologies.

UNIT IV ISO 14001 **9**

EMS, ISO 14001-Environmental management systems — Requirements with guidance for use-Environmental management system requirements- Environmental policy- Environmental aspects-Legal and other requirements- Objectives, targets and programme(s)- Implementation and operation- Checking- Management review- Guidance for use Principles (ISO 14004), clauses 4.1 to 4.5. Documentation requirements, 3 levels of documentation for an ISO 14000 based EMS, steps in ISO 14001.Implementation plan, Registration, Importance of ISO 14000 to the Management. Auditing Guidelines for environmental management systems auditing -General principles, Managing audit programme- Audit activities, steps in audit, Audit plan. Competence of auditors.

UNIT V ENVIRONMENT IMPACT ASSESSMENT **9**

ISO 14040(LCA), General principles of LCA, Stages of LCA, Report and Review. ISO 14020 (Eco labelling) – History, 14021, 14024, Type I labels, Type II labels, ISO 14024, principles, rules for eco labelling before company attempts for it. Advantages. EIA in EMS, Types of EIA, EIA methodology EIS, Scope, Benefits. Audit-methodology, Auditors Audit results management review-Continual improvement. **TOTAL: 45 Hours**

REFERENCES:

1. “Occupational Health and Safety Assessment Series BS (OHSAS) 18001:2007” BSI, UK, 2007.
2. “OHSAS 18002, Occupational Health and Safety Management Systems – Guidelines for the Implementation of OHSAS 18001”, OHSAS project group, 2008.
3. “ISO14001:2004, Environmental Management Systems Requirements with Guidance for Use”, ISO, 2004.
4. “Guidelines on Occupational Health and Safety Management Systems (OSH-MS)” International Labour Organization, 2001.
5. “BS 8800: 2004 Occupational Health and Safety Management

2162ME156	DESIGN OF INDUSTRIAL VENTILATION SYSTEM	L	T	P	C
		3	0	0	3

UNIT I GENERAL PRINCIPLES OF VENTILATION **9**

Introduction,-supply and Exhaust systems-Basic definitions-Principles of air flow-Acceleration of air and Hood entry losses-Duct losses Multiple hood exhaust system.

UNIT II GENERAL INDUSTRIAL VENTILATION **9**

Dilution Ventilation Principles- Dilution Ventilation for health- Dilution Ventilation for fire and explosion-Heat Control-Heat balance and Exchange-Adaptive mechanisms of the body-Acclimatisation-Acute heat disorders-Assessment of heat stress and strain-Ventilation control-and ventilation system - Radiant heat control – Enclosures and Insulation – Personal Protective Equipments-Protective suits and refrigerated suits.

UNIT III LOCAL EXHAUST HOODS AND AIR CLEANING DEVICES **9**

Air contamination Characteristics –Hood types-Hood design factors Hood losses-Minimum Duct velocity-Special hood requirements-Push –pull ventilation-Hot processes-Air cleaning devices-selection –types – Explosion venting.

UNIT IV DESIGN AND TESTING OF INDUSTRIAL VENTILATION **9**

Exhaust system design procedure-steps-duct segment calculations – Distribution of air flow-Plenum Exhaust system-Fan Pressure calculations-Corrections for velocity changes-Duct material –friction losses- Construction guidelines for local Exhaust system – Fan selection –Replacement and recirculated air-Distribution –Flow rate-Air conservation-Ventilation aspects of indoor air quality-Testing of ventilation system-Measurement of volumetric flow rate-Calibration of air measuring instrument- pressure measurement–Check out procedure.

UNIT V VENTILATION SYSTEM FOR SPECIFIC OPERATIONS **9**

Cleaner rooms-Filling operations-foundry operations-Gas treatment Laboratory Ventilation-Machining-Metal melting furnaces-Mixing operations- Movable exhaust hoods-open surface tanks-painting operations- Mechanical surface cleaning and finishing –Welding and cutting – wood working.

TOTAL: 45 PERIODS

REFERENCES:

1. ACGIH Industrial Ventilation “A Manual of Recommended Practice for Design”, 28th edition 2013.
2. “Accident Prevention Manual for Industrial Operations” N.S.C., Chicago, 1992.
3. Jeanne Mager Stellman, “Encyclopaedia of Occupational Health and Safety”, Vol. I and II, 4th edition, published by International Labour office, Geneva, 1998. 2000.

2162ME180	SAFETY IN CONSTRUCTION INDUSTRIES	L	T	P	C
		3	0	0	3

UNIT I ACCIDENTS CAUSES AND MANAGEMENT SYSTEMS 9

Problems impeding safety in construction industry- causes of fatal accidents, types and causes of accidents related to various construction activities, human factors associated with these accident – construction regulations, contractual clauses – Pre contract activates, preconstruction meeting - design aids for safe construction – permits to work – quality assurance in construction - compensation – Recording of accidents and safety measures – Education and training

UNIT II HAZARDS OF CONSTRUCTION AND PREVENTION 9

Excavations, basement and wide excavation, trenches, shafts – scaffolding , types, causes of accidents, scaffold inspection checklist – false work – erection of structural frame work, dismantling – tunneling – blasting, pre blast and post blast inspection – confined spaces – working on contaminated sites – work over water - road works – power plant constructions – construction of high rise buildings.

UNIT III WORKING AT HEIGHTS 9

Fall protection in construction OSHA 3146 – OSHA requirement for working at heights, Safe access and egress – safe use of ladders- Scaffoldings , requirement for safe work platforms, stairways, gangways and ramps – fall prevention and fall protection , safety belts, safety nets, fall arrestors, controlled access zones, safety monitoring systems – working on fragile roofs, work permit systems, height pass – accident case studies.

UNIT IV CONSTRUCTION MACHINERY 9

Selection, operation, inspection and testing of hoisting cranes, mobile cranes, tower cranes, crane work platforms inspection checklist - builder's hoist, winches, chain pulley blocks – use of conveyors - concrete mixers, concrete vibrators – safety in earth moving equipment, excavators, dozers, loaders, dumpers, motor grader, concrete pumps, welding machines, use of portable electrical tools, drills, grinding tools, manual handling scaffolding, hoisting cranes – use of conveyors and mobile cranes – manual handling.

UNIT V SAFETY IN DEMOLITION WORK 9

Safety in demolition work, manual, mechanical, using explosive - keys to safe demolition, pre survey inspection, method statement, site supervision, safe clearance zone, health hazards from demolition - Indian standard - trusses, girders and beams – first aid – fire hazards and preventing methods – interesting experiences at the construction site against the fire accidents.

TOTAL: 45 PERIODS

REFERENCES:

1. Hudson, R.,"Construction hazard and Safety Hand book, Butter Worth's, 1985.
2. Jnathea D.Sime, "Safety in the Build Environment", London, 1988.
3. V.J.Davies and K.Thomasin "Construction Safety Hand Book" Thomas Telford Ltd., London, 1990.
4. Handbook of OSHA Construction safety and health charles D. Reese and James V. Edison
5. Fulman, J.B., Construction Safety, Security, and Loss Prevention, John Wiley and Sons, 197

CURRICULUM AND SYLLABUS

for

M. Tech. – MACHINE DESIGN

FOUNDATION COURSE					
Code	**Course**	**L**	**T**	**P**	**C**
		3	2	0	4

PROGRAM CORE COURSES					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
THEORY					
2161ME169	Applied Machine Design	4	0	0	4
2161ME116	Advanced Strength of Materials	4	0	0	4
2161ME170	Analysis and Synthesis of Mechanisms	4	0	0	4
2161ME171	Finite Element Methods	3	2	0	4
2161ME172	Vibration Analysis and Control	4	0	0	4
2161ME119	Concepts of Engineering Design	4	0	0	4
2161ME173	Tribology in Design	4	0	0	4
PRACTICAL					
2161ME305	CAD & CAE Lab	0	0	2	1
2161ME314	Advanced Finite Element Analysis Lab	0	0	2	1

Total Credits Offered: 12

PRORAM ELECTIVE COURSES (ANY FOUR)					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
2162ME112	Sustainable Design	3	0	0	3
2162ME124	Advanced Tool design	3	0	0	3
2162ME193	Design of Material Handling Equipment	3	0	0	3
2162ME129	Design of Rotating Machinery	3	0	0	3
2162ME128	Experimental Stress Analysis	3	0	0	3
2162ME130	Mechanics of Fracture and Fatigue	3	0	0	3
2162ME110	Advanced Additive Manufacturing	3	0	0	3
2162ME111	Advanced Optimization Techniques	3	0	0	3
2162ME194	Mechanics of Composites	3	0	0	3
2162ME195	Design of Experiments and Taguchi Methods	3	0	0	3
2162ME196	Process Equipment Design	3	0	0	3
2162ME197	Design for Manufacturing and Assembly	3	0	0	3

INDEPENDENT LEARNING COURSES					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
	Massive Open Online Course	-	-	-	2
2163ME501	Research Seminar [**OR**]	-	-	-	
2163ME801	Field Study [**OR**]	-	-	-	2
2163ME802	Internship	-	-	-	
2163GE401	Business Communication [**OR**]	-	-	-	2
2163GE402	Technical Writing Tools	-	-	-	
2163MG401	Research Methodology	-	-	-	2
				Total Credits	**8**

PROJECT WORK					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
2164ME601	Project Phase I	0	0	20	10
2164ME701	Project Phase II	0	0	32	16
				Total Credits	**26**

PROGRAMME STRUCTURE AND MINIMUM CREDITS REQUIRED

IN COURSE CATEGORIES

SECTION NUMBER	COURSE CATEGORY	MINIMUM CREDITS REQUIRED
7.2.1	**FOUNDATION COURSE**	**04**
7.2.2	**PROGRAM CORE COURSES**	**30**
7.2.3	**PROGRAM ELECTIVE COURSES**	**12**
7.2.4	**INDEPENDENT LEARNING COURSES**	**8**
7.2.5	**PROJECT WORK**	**26**
	TOTAL CREDITS	**80**

PROGRAMME CORE

COURSE CODE	APPLIED MACHINE DESIGN	L	T	P	C
2161ME169		4	0	0	4

UNIT I DESIGN PROCESS **12**

Morphology of Design – recent developments in design techniques. Design for Production and assembly. Product design and development. Optimum design. Design performance and testing. Reliability aspects. Diagnosis and prognosis of component failures. Design against fatigue, creep and fracture. Design for maintenance.

UNIT II LUBRICATION AND DESIGN OF BEARINGS **12**

Bearings and Lubrication - Introduction to lubrication - types of lubrication and lubricants –viscosity – Design of journal bearings - Sommerfield Number, bearing materials. Rolling contact bearings-bearing types - Ball & roller bearings - Static and Dynamic load capacity -Equivalent dynamic load - Bearing life - Stribeck's equations, selection of bearings.

UNIT III DESIGN OF GEARS **12**

Design of gears - nomenclature - spur, helical, bevel and worm gears – gear materials - tooth loads - design stresses - basic tooth stresses – stress concentration-service factor - velocity factor - bending strength of gear tooth - Lewis equation and Lewis form factor. Working stress in gear teeth - Dynamic load and wear load on gear teeth - Buckingham's equation for dynamic load-surface strength and durability - design for strength and wear, Design of spur gear, Helical gear, bevel gear and worm gear.

UNIT IV DESIGN OF PRESSURE VESSELS **12**

Pressure vessel – Terminology – Types of loads – Types of pressure - Stresses in pressure vessels – Dilation of pressure vessels. Cylindrical shells, spherical shells, conical head, elliptical head – Discontinuity stresses in pressure vessels - Thermal stresses. Stresses in thin and thick walled cylinders – Lame's equation - Shrink fit stresses in Built up cylinders, autofrettage of thick cylinders – Thermal stresses and its significance. Familiarization of relevant ASME codes and standard practices.

UNIT V DESIGN OF INTERNAL COMBUSTION ENGINE PARTS **12**

Principal parts of an IC Engine. Cylinder and Cylinder liner - Design of a cylinder. Piston -Design consideration of a piston. Connecting rod - Forces acting on connecting rod - Design of connecting rod. Crankshaft-Bearing pressure and stresses in crankshafts - Design of crankshaft

TOTAL: 60 PERIODS

DESIGN DATA - HAND BOOK

1. P.S.G., Tech., Machine Design Data Handbook

REFERENCES

1. George E. Dieter and Linda C. Schmidt, Engineering Design, McGraw-Hill, 2009
2. Shigley J. E., Mechanical Engineering Design, McGraw Hill Book Company, 2014.

COURSE CODE	ADVANCED STRENGTH OF MATERIALS	L	T	P	C
2161ME116		4	0	0	4

UNIT I : Elasticity **12**

Stress-strain relations and general equations of elasticity in Cartesian polar and spherical co-ordinates, differential equations of equilibrium – Compatibility – boundary conditions – representation of 3- dimensional stress of a tensor – Generalized Hook's law St.Venant's principle – plane strain – plane stress –Airy's stress function.

UNIT II : Shear centre and Unsymmetrical bending **12**

Location of shear centre for various sections – shear flow. Stresses and deflection in beams subjected to unsymmetrical loading, kern of a section.

UNIT III : Curved flexural members **12**

Circumferential and radial stresses – deflections curved beam with restrained ends – closed ring subjected to concentrated load and uniform load – chain links and crane hooks.

UNIT IV Torsion of non-circular shafts **12**

Torsion of rectangular cross sections – St.Venant's theory – Elastic membrane analogy – Prandtl's stress function – Torsional stresses in hollow thin–walled tubes.

UNIT V : Stresses due to Rotation **12**

Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness – allowable speeds.

TOTAL: 60 PERIODS

REFERENCES:

1. L S Srinath, "Advanced Mechanics of Solids", Tata McGraw – Hill publishing Company Limited, 2010.
2. Timoshenko and Goodier, "Theory of Elasticity", Tata McGraw – Hill publishing company Limited, 2012.
3. Boreshi and Sidebottom, "Advanced Mechanics of Materials", John Wiley International Edition, 2010
4. Kamal kumar and R C Ghai, "Advanced Mechanics of Materials", Khanna publishers, 2011.
5. Den Hartong, "Advanced strength of Materials", Mc Graw – Hill Book Co. New York, 2012.
6. Robert D Cooki, Warren C. Young, "Advanced Mechanics of Material", Mac Millian publishing Co, 2011.

COURSE CODE	ANALYSIS AND SYNTHESIS OF MECHANISMS	L	T	P	C
2161ME170		4	0	0	4

UNIT I VELOCITY AND ACCELERATION ANALYSIS OF MECHANISMS 12

Review of kinematic analysis-mobility, displacement, velocity and acceleration analysis of mechanisms – Plane Complex mechanisms – Goodman Analysis – Auxiliary point method.

UNIT II CURVATURE THEORY 12

Instantaneous centre or Pole, centrode or polode, polode curvature, collineation axis, radius of curvature. The Euler-Savary equation, Inflection circle, Hartman's construction, Bobillier constructions, cubic of stationary curvature. Design based on the above

UNIT III KINEMATIC SYNTHESIS 12

Kinematic synthesis - Function generation, path generation and rigid body guidance – Type synthesis, Number Synthesis – Cognate Linkage – Coupler curve synthesis – Algebraic methods – application of instant centre in linkage design.

UNIT IV FORCE ANALYSIS OF MECHANISMS 12

Force analysis of mechanisms-static and dynamic force analysis of plane motion mechanisms-graphical method-principle of superposition-method of virtual work-frictions in mechanisms.

UNIT V CAM DYNAMICS 12

Cam Dynamics- Acceleration and Jerk. Analysis of eccentric cam, effect of sliding friction, Analysis of disc cam with reciprocating roller follower. Analysis of elastic cam systems, follower response: Phase-plane method, Johnson's numerical analysis. Position error, Jump and cross-over shock, unbalance, spring surge and wind-up. Cam force analysis.

TOTAL: 60 PERIODS

REFERENCES:

1. George N. Sandor and A.G. Erdman, Advanced Mechanism Design analysis and Synthesis, Vol.1 and 2, Prentice Hall of India, 2012.
2. Shigley J.E and Uicker J.J., Theory of Machines and Mechanisms, McGraw Hill, 2010
3. Balaguru S, "Dynamics of Machines", Scitech Publications, Chennai, 2012.
4. Hall, Kinematics and Linkage Design, Prentice Hall, 2009.
5. Robert L. Norton, Design of Machinery, McGraw Hill, 2009
6. S SRatan, Theory of Machines, McGraw Hill, 2014
7. Hartenberg and Denavit, Kinematics and synthesis of linkages, McGraw Hill, 2010
8. J.Hirschhorn, Kinematics and Dynamics of Plane Mechanisms, McGraw Hill, 2011
9. Mallik A.K, Amithabha Ghosh and Gunter Dittrich, Kinematic Analysis and Synthesis of Mechanisms, CRC Press
10. Harold A Rothbart, Cam Design Handbook, McGraw Hill

COURSE CODE	FINITE ELEMENT METHODS	L	T	P	C
2161ME171		3	2	0	4

UNIT I INTRODUCTION TO FEM **L – 9 T - 6**

Introduction to FEM, basic concepts, historical back ground, applications of FEM, general description, comparison of FEM with other methods, variational approach, Glerkin's Methods. Co-ordinates, basic element shapes, interpolation function, Virtual energy principle, Rayleigh – Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics, Basic equations of elasticity, strain- displacement relations.

UNIT II 1-D STRUCTURAL PROBLEMS **L – 9 T - 6**

Axial bar element – stiffness matrix, load vector, temperature effects, Quadratic shape functions and problems.

ANALYSIS OF TRUSSES: Plane Trusses and Space Truss elements and problems Analysis of Beams: Hermite Shape Functions – Stiffness Matrix – Load Vector – Problems.

UNIT III 2-D & 3D PROBLEMS **L – 9 T - 6**

CST, LST, force terms, Stiffness matrix and load vectors, boundary conditions, Isoperimetric elements – quadrilateral element, shape functions, Finite element modeling subjected to Axi-symmetric loading with triangular elements.

3-D PROBLEMS: Tetrahedran element – Jacobian matrix – Stiffness matrix.

UNIT IV HEAT TRANSFER AND APPLICATIONS **L – 9 T - 6**

Heat Conduction: 1-D & 2-D Heat conduction problems, Slabs, fins, Transient Thermal Analysis, Applications for heat conduction and 2D stress analysis- Case Studies. Introduction to Torsion problems.

UNIT V DYNAMIC AND FLUID MECHANICS **L – 9 T - 6**

Dynamic considerations, Dynamic equations – consistent mass matrix – Eigen Values, Eigen vector, natural frequencies – mode shapes – modal analysis, Fluid flow – Incompressible and rotational flow.

TOTAL: 75 PERIODS

REFERENCES:

1. The Finite Element Methods in Engineering / SS Rao / Pergamon.
2. Finite Element Methods: Basic Concepts and applications, Alavala, PHI
3. Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu, Prentice–Hall
4. Finite Element Method – Zincowitz / Mc Graw Hill
5. Introduction to Fininte element analysis- S.Md.Jalaludeen, Anuradha Publications, print-2012

COURSE CODE	VIBRATION ANALYSIS AND CONTROL	L	T	P	C
2161ME172		4	0	0	4

UNIT I FUNDAMENTALS OF VIBRATION **12**

Introduction - Sources of Vibration-Mathematical Models - Displacement, velocity and Acceleration - Review of Single Degree Freedom Systems - Introduction-Free Vibration of Undamped and Damped- Forced Vibration with Harmonic Excitation System Vibration isolation Vibrometers and accelerometers - Response to Arbitrary and non-harmonic Excitations – Transient Vibration – Impulse loads - Critical Speed of Shaft-Rotor systems.

UNIT II TWO DEGREE FREEDOM SYSTEM **12**

Introduction–Principal modes-Other cases like two masses fixed on string, double pendulum, torsional system-Combined rectilinear and angular modes-Two degree suspension system with damping-Semi definite systems- Coordinate Couplings and Principal Coordinates

UNIT III MULTI DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM **12**

Multi Degree Freedom System – Influence Coefficients and stiffness coefficients - Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors - Matrix Iteration Method –Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method - Geared Systems-Eigen Values & Eigen vectors for large system of equations using sub space, Multi rotor system-Lanczos method - Continuous System: Vibration of String, Shafts and Beams

UNIT IV VIBRATION CONTROL **12**

Specification of Vibration Limits – Vibration severity standards- Vibration as condition Monitoring tool - Vibration Isolation methods - Dynamic Vibration Absorber, Torsional and Pendulum type Absorber- Damped Vibration absorbers - Static and Dynamic Balancing-Balancing machines - Field balancing – Vibration Control by Design Modification - Active Vibration Control

UNIT V EXPERIMENTAL METHODS IN VIBRATION ANALYSIS **12**

Vibration Analysis Overview - Experimental Methods in Vibration Analysis. Vibration Measuring Instruments - Selection of Sensors- Accelerometer Mountings – Vibration Exciters - Mechanical, Hydraulic, Electromagnetic and Electrodynamics – Frequency Measuring Instruments - System Identification from Frequency Response - Testing for resonance and mode shapes.

TOTAL: 60 PERIODS

REFERENCES

1. Rao, S.S.," Mechanical Vibrations," Addison Wesley Longman, 2010.
2. Thomson, W.T. – "Theory of Vibration with Applications", CBS Publishers and Distributors, New Delhi, 2010
3. Balaguru S, "Dynamics of Machines", Scitech Publications, Chennai, 2012.
4. Singh V.P., "Mechanical Vibrations", DhanpatRai& Co, New Delhi, 2013

COURSE CODE	CONCEPTS OF ENGINEERING DESIGN	L	T	P	C
2161ME119		4	0	0	4

UNIT I: THE DESIGN PROCESS **12**

The design process – Morphology of Design – Design Drawings – Computer Aided Engineering – Designing of standards – Concurrent Engineering – Product life cycle – Technological Forecasting – Market Identification – Competition Bench marking – Systems Engineering – Life Cycle Engineering – Human Factors in Design – Industrial Design.

UNIT II: DESIGN METHODS **12**

Creativity and Problem Solving – Product Design Specifications – Conceptual design – Decision Theory – Decision Tree – Embodiment Design – Detail Design – Mathematical Modeling – Simulation – Geometric Modeling – Finite Element Modeling – Optimization – Search Methods – Geometric Programming – Structural and Shape Optimization.

UNIT III: MATERIAL SELECTION PROCESSING AND DESIGN **12**

Material Selection Process – Economics – Cost Vs Performance – Weighted property Index – Value Analysis – Role of Processing in Design – Classification of Manufacturing Process – Design for Manufacture – Design for Assembly –Designing for castings, Forging, Metal Forming, Machining and Welding – Residual Stresses – Fatigue, Fracture and Failure.

UNIT IV: ENGINEERING STATISTICS AND RELIABILITY **12**

Probability – Distributions – Test of Hypothesis – Design of Experiments – Reliability Theory – Design for Reliability – Reliability centered Maintenance.

UNIT V: QUALITY ENGINEERING **12**

Total Quality Concept – Quality Assurance – Statistics Process Control – Taguchi Methods – Robust Design – Failure Model Effect Analysis.

TOTAL: 60 PERIODS

REFERENCES:

1. Dieter, George E., Engineering Design - “A Materials and Processing Approach”, McGraw Hill, International Editions, Singapore, 2012.
2. Karl T. Ulrich and Steven D. Eppinger “Product Design and Development” McGraw Hill Edition 2012.
3. Pahl, G, and Beitz, W.,” Engineering Design”, Springer – Verlag, NY. 2010.
4. Ray, M.S., “Elements of Engg. Design”, Prentice Hall Inc. 2011.
5. Suh, N.P., “The principles of Design”, Oxford University Press, NY.2009.

COURSE CODE	TRIBOLOGY IN DESIGN	L	T	P	C
2161ME173		4	0	0	4

UNIT I: SURFACES, FRICTION AND WEAR **12**

Topography of Surfaces – Surface features – Surface interaction – Theory of Friction – Sliding and Rolling Friction, Friction properties of metallic and non-metallic materials – friction in extreme conditions – wear, types of wear – mechanism of wear – wear resistance materials – surface treatment – Surface modifications – surface coatings.

UNIT II: LUBRICATION THEORY **12**

Lubricants and their physical properties lubricants standards – Lubrication Regimes Hydrodynamic lubrication – Reynolds Equation, Thermal, inertia and turbulent effects – Elasto hydrodynamic and plasto hydrodynamic and magneto hydrodynamic lubrication – Hydro static lubrication – Gas lubrication.

UNIT III: HYDRODYNAMIC BEARINGS **12**

Raymond and Boyd solution for hydro – dynamic thrust bearings – fixed inclinations, single and multiple pad bearings – optimum condition with largest film thickness – Analysis of roller Bearings, Selection of Roller Bearings.

UNIT IV: HYDROSTATIC BEARINGS **12**

Thrust bearings – pad coefficients – restrictions – optimum film thickness – Journal bearings – Design procedures. Aerostatic bearings, thrust bearings – journal bearings – design procedures.

UNIT V: SEALS AND FAILURE OF TRIBOLOGICAL COMPONENTS **12**

Different types – mechanical seals, lip seals, packed glands, soft piston seals, mechanical piston rod packings, Selection of mechanical seals. Failure types, investigation and occurrences – causes of failure - Plain bearing failures, rolling bearing failures, gear failures, seal failures.

TOTAL: 60 PERIODS

REFERENCES:

1. Cameron, A. “Basic Lubrication Theory”, Ellis Herward Ltd., OK, 2011
2. Hulling, J. (Editor) – “Principles of Tribology “, Macmillian – 2011.
3. Williams J.A. “Engineering Tribology”, Oxford Univ. Press, 2012.
4. Neale, M.J. “Tribology Hand Book”, Butterworth Heinemann, 2010
5. Collacott. R.A, Mechanical Fault Diagnosis and Condition Monitoring, Chapman and Hall, 2010

COURSE CODE	CAD & CAE LAB	L	T	P	C
2161ME305		0	0	2	1

LIST OF EXPERIMENTS:

1. Introduction to cad software- features (part modeling, assembly modeling ,drafting)
2.Draw a model & simulate the wiper assembly (includes drafting)
3. Draw a model & simulate the clutch Assembly (includes drafting)
4. Draw a model & simulate the Steering Mechanism (includes drafting)
5. Draw a model & simulate the Gear Box (includes drafting)
6. Draw a model & simulate the Differential (includes drafting)
7. Draw a model & simulate the two stroke engine (includes drafting)

(Do any one experiment between 2-7)

TOTAL: 30 PERIODS

COURSE CODE	ADVANCED FINITE ELEMENT ANALYSIS LABORATORY	L	T	P	C
2161ME314		0	0	2	1

LIST OF EXPERIMENTS

1. Introduction to ANSYS
2. Structural analysis of bridge
3. Thermal analysis of t cross section
4. Thermo-mechanical analysis of beam
5. Non-linear analysis of bar
6. Shape optimization of a bracket
7. Fatigue analysis of leaf spring
8. Analysis of fracture and velocity of the crack tip in a rectangular plate
9. 2D CFD analysis of nozzle

TOTAL: 30 PERIODS

COURSE CODE	SUSTAINABLE DESIGN	L	T	P	C
2162ME112		3	0	0	3

UNIT I: SUSTAINABILITY AND ITS APPLICATION L – 9

Sustainability: Past and Present, The Classic Design and Manufacture Model, The Taguchi Approach to Quality Manufacturing, The Taguchi Analogy Applied to Sustainable Engineering Design, Sustainable Sourcing (Eco sourcing),Design for Sustainable Manufacture (Sustainable Manufacture Value, or SMV),Design for Sustainable Use (Sustainable Use Value, or SUV) Design for Sustainable Maintenance, Design for Sustainable Disposal (Sustainable Disposal Value, or SDV),The Measurement of Sustainability, Sustainable Engineering Design: Necessity or Luxury?

UNIT II: THE TOOLS OF THE DESIGN PROCESS AND MANAGEMENT OF DESIGN L – 9

Introduction. Development Processes, Systematic Approach to Design, Design Methods, Classic Brainstorming, Brain Writing, Imaginary Brainstorming, Word-Picture Associations and Analogies, Methods of Generating Associations and Analogies, TILMAG, The Morphological Box, Design and Planning Methods

UNIT III: COMMUNICATION FOR ENGINEERS AND PERFORMANCE PREDICTION L – 9

Communication Overview, Written Communication, Project Reports/Technical Reports, Academic Publishing (Technical or Journal Papers), Graphical Communications, General Drawing Application. Performance Prediction-Historical Aspects of Analysis, Materials Testing Factor of Safety, Consolidation of Safety in Structures and Devices, Computing Power ,Fatigue Strength Prediction, Performance Prediction Methodology and Application, Checks and Balances

UNIT IV: DESIGN FOR TOTAL CONTROL L – 9

Traditional Approaches, the Sustainability Umbrella Model. Total Design Control, A New Design Approach (The Umbrella of Sustainable Design), The Sustainable Design Function, Manufacturing, Lifetime Usage, Maintenance, End-of-Life Disposal

UNIT V: DRIVERS OF SUSTAINABILITY IN DESIGN L – 9

Legislation, Effectiveness of International Environmental Regimes and Legislation, Non-legislative Measurement and Guidance Tools, Other Drivers of Sustainable Design, Conclusion.

Strategic Sustainable Design - Triple Bottom Line—The 3P Approach, Benefits to Producers and Buyers of Designed-in Sustainability, The Sustainability Measurement and Certification Industry

Predicting the Future - Unsustainable Futures, The Engineers' View, Conclusion

TOTAL=45 PERIODS

REFERENCES:

1. Johnson & Gibson, Sustainability in Engineering Design, 1st Edition, Academic Press, 2014
2. David T. Allen, Sustainable Engineering: Concepts, Design and Case Studies,Prentice Hall Publications, 2011
3. Braden R. Allenby,The Theory and Practice of Sustainable Engineering, Prentice Hall Publications, 2011
4. Marc J. Epstein ,Making Sustainability Work: Best Practices in Managing and Measuring Corporate Social, Environmental, and Economic Impacts, Greenleaf Publishing,2014.

COURSE CODE	ADVANCED TOOL DESIGN	L	T	P	C
2162ME124		3	0	0	3

UNIT I: STATIC AND DYNAMIC STIFFNESS, FORCE ANALYSIS L – 9

Static stiffness and compliance- deformation caused by weight, Forces- deformation caused by cutting forces - forced vibrations, self-excited vibrations, Force distribution in different parts of Lathe, Drilling machine, Milling machine and Planning machines.

UNIT II: DESIGN OF STRUCTURES L – 9

Beds, columns and housing for maximum strength and rigidity – cast and welded construction – CNC machine tools - structure – main drive and feed drive- ball screws- automatic tool changers- chip conveyors- tool magazines- tool turrets.

UNIT III:DESIGN OF SLIDE WAYS L – 9

Selection of materials- integrated and attached ways- hydro-static guide ways-aero-static guide ways- antifriction guide ways- design of friction guide ways- plastic inserted guide ways and LM guide ways.

UNIT IV:DESIGN OF MACHINE TOOL SPINDLES AND DRIVES L – 9

Design requirements – standards – selection of spindle bearings- materials for spindles- typical spindle design - design consideration of Electrical, Mechanical and Hydraulic drives in machine tools.

UNIT V: MACHINE TOOL CHATTER L – 9

The Dynamics of cutting process - physical causes of chatter- theory of machine tool chatter- chatter in different types of machine tools- milling machines, lathes and grinding machines - the theory of chatter with several degree of freedom - chatter suppression. Design of control mechanisms – selection of standard components - dynamic measurement of forces and vibrations in machine tools - use of vibration dampers.

TOTAL: 45 PERIODS

REFERENCES:

6. Mehta. N.K, “Machine Tool Design” Tata McGraw Hill, 2010.
7. Koenisberger.F. ‘Design principles of Metal cutting Machine Tools”. Pergamon press, 200L - 9.
8. Acherkan.N., “Machine Tool Design”. Vol. 3 & 4, MIR Publishers, Moscow, 2012.
9. Sen.G. and Bhattacharya.A., “Principles of Machine Tools”. Vol.2, NCB. Calcutta, 2010.
10. Tobias.S.A., “ Machine tool Vibration” Blackie and Son Limited, London, 200L - 9.

COURSE CODE	DESIGN OF MATERIAL HANDLING EQUIPMENTS	L	T	P	C
2162ME193		3	0	0	3

UNIT I MATERIALS HANDLING EQUIPMENT **9**

Overview, consideration in material handling system design, ten principles of material handling. Types of material handling equipment - trolleys, industrial trucks, AGV, monorails and other rail guided vehicles, conveyors, cranes, hoists and elevators.

UNIT II DESIGN OF HOISTS **9**

Design of hoisting elements: Welded and roller chains - Hemp and wire ropes - Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks - crane grabs - lifting magnets - Grabbing attachments - Design of arresting gear - Brakes: shoe, band and cone types.

UNIT III DRIVES OF HOISTING GEAR **9**

Hand and power drives - Traveling gear - Rail traveling mechanism - cantilever and monorail cranes - slewing, jib and luffing gear - cogwheel drive - selecting the motor ratings.

UNIT IV CONVEYORS **9**

Types - description - design and applications of Belt conveyors, apron conveyors and escalators Pneumatic conveyors, Screw conveyors and vibratory conveyors.

UNIT V ELEVATORS **9**

Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices - Design of form lift trucks.

TOTAL: 45 PERIODS

REFERENCES:

1. Rudenko, N., Materials handling equipment, ELnvee Publishers, 2010.
2. Spivakovsy, A.O. and Dyachkov, V.K., L Conveying Machines, Volumes I and II,MIR Publishers, 2012.
3. Alexandrov, M., Materials Handling Equipments, MIR Publishers, 2007.
4. Boltzharol, A., Materials Handling Handbook, the Ronald Press Company, 2012.
5. Tech. P.S.G., “Design Data Book”, Kalaikathir Achchagam, Coimbatore, 2008.
   Lingaiah. K. and Narayana Iyengar, “Machine Design Data Hand Book”, Vol. 1 & 2, Suma Publishers, Bangalore, 2012.

COURSE CODE	DESIGN OF ROTATING MACHINERY	L	T	P	C
2162ME129		3	0	0	3

UNIT I: FLUID FILM LUBRICATION L – 9

Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings

UNIT II: STABILITY OF FLEXIBLE SHAFTS L – 9

Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field.

UNIT III: CRITICAL SPEED L – 9

Dunkerley's method, Rayleigh's method, Stodola's method.

UNIT IV: ROTOR BEARING SYSTEM L – 9

Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center.

UNIT V: TURBO ROTOR SYSTEM STABILITY BY TRANSFER MATRIX FORMULATION L – 9

General turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions.

TOTAL: 45 PERIODS

REFERENCES:

1. Rotor Dynamics - Agnieszka (Agnes) Muszynska, 2012 by Taylor & Francis Group, LLC
2. Principles of Lubrication - Cameron Longmans, 2012.
3. Nonconservative problems of the Theory of elastic stability - Bolotin, Pergamon, 2011
4. Matrix methods of Elastomechanics - Peztel, Lockie, McGraw Hil, 2011.
5. Vibration Problems in Engineering - Timosenko, Young, Von Nostrand Zienkiewicz, "The Finite Element Method", McGraw Hill, 2010.

COURSE CODE	EXPERIMENTAL STRESS ANALYSIS	L	T	P	C
2162ME128		4	0	0	4

UNIT I: Forces and Strain Measurement **L - 12**

Strain gauge, principle, types, performance and uses. Photo elasticity –Principle and applications - Moire Fringe - Hydraulic jacks and pressure gauges – Electronic load cells – Proving Rings – Calibration of Testing Machines.

UNIT II: Vibration Measurements **L - 12**

Characteristics of Structural Vibrations – Linear Variable Differential Transformer (LVDT) – Transducers for velocity and acceleration measurements. Vibration meter – Seismographs – Vibration Analyzer – Display and recording of signals – Cathode Ray Oscilloscope – XY Plotter – Chart Plotters – Digital data Acquisition systems.

UNIT III: Acoustics and Wind Flow Measures **L - 12**

Characteristics of Structural Vibrations – Linear Variable Differential Transformer (LVDT) – Transducers for velocity and acceleration measurements. Vibration meter – Seismographs – Vibration Analyzer – Display and recording of signals – Cathode Ray Oscilloscope – XY Plotter – Chart Plotters – Digital data Acquisition systems.

UNIT IV: Distress Measurements **L - 12**

Diagnosis of distress in structures – crack observation and measurements – corrosion of reinforcement in concrete – Half-cell, construction and use – damage assessment – controlled blasting for demolition.

UNIT V: Non Destructive Testing Methods **L - 12**

Load testing on structures, buildings, bridges and towers – Rebound Hammer – acoustic emission – ultrasonic testing principles and application – Holography – use of laser for structural testing – Brittle coating

TOTAL: 60PERIODS

REFERENCES:

1. Sadhu Singh – Experimental Stress Analysis, Khanna Publishers, New Delhi, 2010.
2. JW Dalley and WF Riley, Experimental Stress Analysis, McGraw Hill Book Company, N.Y. 2011
3. L.S.Srinath et al, Experimental Stress Analysis, Tata McGraw Hill Company, New Delhi, 2009
4. R.S.Sirohi, HC Radhakrishna, Mechanical Measurements, New Age International (P) Ltd. 2008
5. F.K Garas, J.L. Clarke and GST Armer, Structural assessment, Butterworths, London, 2012
6. D.E. Bray& R. K.Stanley, Non-destructive Evaluation, McGraw Hill Publishing Company, N.Y.2009

COURSE CODE	MECHANICS OF FRACTURE AND FATIGUE	L	T	P	C
2162ME194		3	0	0	3

UNIT I: ELEMENTS OF SOLID MECHANICS L–12

The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation - limit analysis.

UNIT II: STATIONARY CRACK UNDER STATIC LOADING L–12

Two dimensional elastic fields – Analytical solutions yielding near a crack front – Irwin's approximation - plastic zone size – Dugdaale model – J integral and its relation to crack opening displacement.

UNIT III: ENERGY BALANCE AND CRACK GROWTH L–12

Griffith analysis – Linear Fracture Mechanics-Crack Opening displacement – Dynamic energy balance – crack arrest.

UNIT IV: FATIGUE CRACK GROWTH CURVE L–12

Empirical Relation describing crack growth by fatigue – Life calculations for a given load amplitude – effects of changing the load spectrum – Effects of Environment.

UNIT V: ELEMENTS OF APPLIED FRACTURE MECHANICS L–12

Examples of crack-growth Analysis for cyclic loading - leak before break – crack Initiation under large scale yielding – Thickness as a Design parameter – crack instability in Thermal or Residual – stress fields.

TOTAL: 60 PERIODS

REFERENCES:

1. David Broek, "Elementary Engineering Fracture Mechanics", Fifthoff and Noerdhoff International Publisher, 2011.
2. Kare Hellan, "Introduction of Fracture Mechanics", McGraw-Hill Book Company, 2008.
3. Preshant Kumar, "Elements of Fracture Mechanics", Wheeler Publishing, 2012.

COURSE CODE	ADVANCED ADDITIVE MANUFACTURING	L	T	P	C
2162ME110		3	0	0	3

UNIT-I: INTRODUCTION **L - 9**

Rapidprototypingsystem – practicalapplications – Basic operations – CAD Model - Translator supports – slice – merge – prepare – build – cleaning – finishing – benefits of Rapid prototyping comparison with conventional manufacturing process.

UNIT-II: STEREO LITHOGRAPHY FUNDAMENTALS **L - 9**

Rapidprototypingprocess – TheStereoLithographyapparatus(SLA)–datagathering– dataanalysis– partpreparation – partbuilding– initialconsiderationinpartbuilding– selectingtheresin– selectingsystem–verifyingpart1files–slicing–slicersolution–slice units– postprocessingfundamentals–partremoval–cleaning–postcuring–part finishing.

UNIT-III: RAPIDPROTOTYPINGTECHNOLOGIES **L - 9**

Types – SelectiveLaserSintering(SLS)–SolidGroundCuring(SGC)– LaminatedObjectManufacturing(LOM)–FusedDepositionModeling(FDM)– ThreeDimensionalPrinting (TDP)

UNIT-IV: CASESTUDIES **L - 9**

Rapidprototypingforrapidproducts–Exhaustmanifold–Investmentcastprototypes-Texas Instruments, USA – RP & Mini automotive – medicine.

UNIT -V: TRENDSINRAPIDPROTOTYPING **L - 9**

Laser Engineering Net Shaping (LENS), Ballistic particle manufacturing – rapid tooling Magic's, Mimics – application of rapid prototyping in medical field. Futuredevelopment– RapidprototypinginIndianscene–advancesinrapidprototyping- research development in rapid prototyping

TOTAL: 45 PERIODS

REFERENCES:

1. Paul F Jacobs, Rapid Prototyping and Manufacturing fundamentals of stereo lithography,I Edition, Society of Manufacturing Engineers, Dearborn, Michigan, 2012.
2. Donald E Lacourse, Handbook of Solid Modelling, McGrawHillInc., NewYork, 2012.
3. Rapid Automated Prototyping: An Introduction Industrial PressInc., NewYork.
4. ChowdiaM.P(ED), Agile Manufacturing, International Conference on Agile Manufacturing, Bangalore, Feb22–24,1996, Tata Mc GrawHill Pub Co., Ltd., NewDelhi, 2012.
5. Dickens PM, Research Developments in rapid prototyping, Journal of Engineering Manufacture, pp261-265,2010.

COURSE CODE	ADVANCED OPTIMIZATION TECHNIQUES	L	T	P	C
2162ME111		3	0	0	3

UNIT I: INTRODUCTION **9**

General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints – Classification of optimization problem. Single variable and multivariable optimization, Techniques of unconstrained minimization

UNIT II: DECISION ANALYSIS **9**

Golden section, Random, pattern and gradient search methods – Interpolation methods; Optimization with equality and inequality constraints. Hooks and Jeeves Method

UNIT III: NON-LINEAR OPTIMIZATION **9**

Decision Trees, Utility theory, Game theory, Multi Objective Optimization, MCDM- Goal Programming, Analytic Hierarchy process

UNIT IV: NON-TRADITIONAL OPTIMIZATION-1 **9**

Classes P and NP, Polynomial time reductions, Introduction to NP- Hard problems, Overview of Genetic algorithms, Simulated Annealing, neural network based optimization

UNIT V: NON-TRADITIONAL OPTIMIZATION-2 **9**

Particle Swarm optimization, Ant Colony Optimization, Optimization of Fuzzy Systems

TOTAL: 45 PERIODS

REFERENCES:

1. Singiresu S.Rao, “Engineering optimization – Theory and practices”, New Age International Publishers, 2013.
2. Ravindran – Phillips –Solberg, “Operations Research – Principles and Practice”, John Wiley India, 2007.
3. Fredrick S.Hillier and G.J. Liberman, “Introduction to Operations Research”, McGraw Hill Inc. 2017.
4. Kalymanoy Deb, “Optimization for Engineering Design”, PHI, 2012.
5. Christos H. Papadimitriou, Kenneth Stieglitz, “Combinatorial Optimization”, PHI 2006.
6. Marius Durea, “An Introduction to Nonlinear optimization theory”, De Gruyter 1st edition 2014.

COURSE CODE	MECHANICS OF COMPOSITES	L	T	P	C
2162ME194		3	0	0	3

UNIT I: INTRODUCTION TO COMPOSITE MATERIALS 9

Introduction, Classification: Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon–Carbon Composites, Fiber Reinforced Composites and nature-made composites, and applications. **Reinforcements:** Fibers- Glass, Silica, Kevlar, carbon, boron, silicon carbide, and born carbide fibers. Particulate composites, Polymer composites, Thermoplastics, Thermosets, Metal matrix and ceramic composites. **Manufacturing methods:** Autoclave, tape production, moulding methods, filament winding, man layup, pultrusion, RTM.

UNIT II: MACROMECHANICAL ANALYSIS OF A LAMINA 9

Introduction, Definitions: Stress, Strain, Elastic Moduli, Strain Energy. Hooke's Law for Different Types of Materials, Engineering Constants of an Angle Lamina, Invariant Form of Stiffness and Compliance Matrices for an Angle Lamina Strength Failure Theories of an Angle Lamina: Maximum Stress Failure Theory Strength Ratio, Failure Envelopes, Maximum Strain Failure Theory, Tsai–Hill Failure Theory, Tsai–Wu Failure Theory, Comparison of Experimental Results with Failure Theories. Hygrothermal Stresses and Strains in a Lamina

UNIT III: MICROMECHANICAL ANALYSIS OF A LAMINA 9

Introduction, Volume and Mass Fractions, Density, and Void Content, Evaluation of the Four Elastic Moduli, Strength of Materials Approach, Semi Empirical Models, Elasticity Approach, Elastic Moduli of Lamina with Transversely Isotropic Fibers, Ultimate Strengths of a Unidirectional Lamina, Coefficients of Thermal Expansion, Coefficients of Moisture Expansion.

UNIT IV: MACRO MECHANICAL ANALYSIS OF LAMINATES 9

Introduction, Laminate Code, Stress–Strain Relations for a Laminate, In-Plane and Flexural Modulus of a Laminate, Hygro thermal Effects in a Laminate, Warpage of Laminates

UNIT V: FAILURE, ANALYSIS, AND DESIGN OF LAMINATES 9

Introduction, Special Cases of Laminates, Failure Criterion for a Laminate and Design of a Laminated Composite, Other Mechanical Design Issues

TOTAL: 45 PERIODS

REFERENCES:

1. Engineering Mechanics of Composite Materials by Isaac and M Daniel, Oxford University Press, 1994.
2. B. D. Agarwal and L. J. Broutman, Analysis and performance of fibre Composites, Wiley-Interscience, New York, 1980.
3. Mechanics of Composite Materials, Second Edition (Mechanical Engineering), By Autar K., Kaw Publisher: CRC PRESS.

COURSE CODE	DESIGN OF EXPERIMENTS AND TAGUCHI METHODS	L	T	P	C
2162ME195		3	0	0	3

UNIT I: EXPERIMENTAL DESIGN FUNDAMENTALS **9**

Importance of experiments, experimental strategies, basic principles of design, terminology, ANOVA, MANOVA, steps in experimentation, sample size, normal probability plot, linear regression models.

UNIT II: SINGLE FACTOR EXPERIMENTS **9**

Completely randomized design, Randomized block design, Latin square design. Statistical analysis, estimation of model parameters, model adequacy checking, pair wise comparison tests

UNIT III: MULTIFACTOR EXPERIMENTS **9**

Two and three factor full factorial experiments, Randomized block factorial design, Experiments with random factors, rules for expected mean squares, approximate F- tests. 2K factorial Experiments.

UNIT IV: SPECIAL EXPERIMENTAL DESIGNS **9**

Blocking and confounding in 2k designs. Two level Fractional factorial design, nested designs, Split plot design, Response Surface Methods

UNIT V: TAGUCHI METHODS **9**

Steps in experimentation, design using Orthogonal Arrays, data analysis, Robust design- control and noise factors, S/N ratios, parameter design, Multi-level experiments, Multi-response Optimization-Grey, TOPSIS and Fuzzy.

TOTAL: 45 PERIODS

REFERENCES:

1. Krishnaiah, K. and Shahabudeen, P. “Applied Design of Experiments and Taguchi Methods”, PHI learning private Ltd., 2012.
2. Montgomery, D.C., “Design and Analysis of experiments”, John Wiley and Sons, Eighth edition, 2013.
3. Nicolo Belavendram, “Quality by Design; Taguchi techniques for industrial experimentation”, Prentice Hall, 1995.
4. Phillip J.Rose, “Taguchi techniques for quality engineering”, McGraw Hill, 2005.
5. Montgomery, D.C., “Design and Analysis of Experiments, Minitab Manual”, John Wiley and Sons, Seventh edition, 2012
6. Gwo-Hshiung Tzeng and Jih-Jeng Huang, “Multiple attribute decision making methods and applications”, CRC press, A Chapman & Hall Book, 2011.

COURSE CODE	PROCESS EQUIPMENT DESIGN	L	T	P	C
2162ME196		3	0	0	3

UNIT I: GENERAL REQUIREMENTS **9**

Basic considerations in process equipment design; general design procedure of process equipment design; Terminology used in pressure vessel design: Design pressures, Design temperatures, Design stresses, Design Loading such as wind load, temperature load, Dead load, Maximum allowable stress values, Minimum shell thickness, Welded joint efficiency and category, Corrosion allowance, Minimum design metal temperature (MDMT),Maximum allowable working pressure, Test pressure ,Weight estimation of vessel, Development of pressure vessel construction code :Study of ASME section VIII Div. –I; Selection of material and its properties by using ASME section II for ferrous materials, Importance of codes and standards and their applications, Stress categories and stress

Testing and inspection techniques: Brief introduction: Standard hydrostatic test; Standard pneumatic test; Post weld heat 04 treatment; Radiographic examination; Process flow diagram; Process and instrumentation diagram.

UNIT II: DESIGN OF PRESSURE VESSELS **9**

Types of pressure vessels; Types of head or end closure; Complete design as per ASME code of cylindrical and spherical shells: Pressure vessel subjected to internal pressure; Pressure vessel subjected to External pressure: Design of various end closures, Design of flanged joints ,Design of opening such as nozzle ,manhole etc., Gasket selection ,Design of Tall tower; Determination of wind load and seismic load; Determination of period of vibration; Determination of deflection of tower and elastic instability

UNIT III: VESSEL SUPPORTS **9**

Introduction and types of vessel support; Design of saddle support; Design of lug supports; Design of leg supports; Design of skirt support; Design of support components: Base plate, Skirt bearing plate, Anchor bolts

UNIT IV: DESIGN OF STORAGE TANKS **9**

Introduction to API code; Types of storage tanks for storing volatile and non-volatile fluid etc.; Types of roofs used in storage vessels; Complete API design of storage tank; Calculation of shell thickness by one foot method and variable design point method; Shell attachment design; Wind girder design; Design of rectangular tank

UNIT V: HEAT EXCHANGERS AND AGITATOR **9**

Introduction to TEMA code; Classification of TEMA heat exchangers; Nomenclature of heat exchanger components: Tube and tube bundle, Tube sheet, Tube pattern ,Tube length, Baffle etc.; Calculation of effective shell side and tube side design pressure; Study of various types of jacket such as half pipe, limphet coil.

Agitator: Types of impellers; General procedure of choice of impeller type and speeds; Design of agitator shaft: Calculation of shaft diameter, Bearing load calculation, Calculation of critical speed, Calculation of deflections. **TOTAL: 45 PERIODS**

***Use ASME codes, API code and TEMA code is permissible in the end semester examination**

REFERENCES:

1. Pressure vessel Design Manual: Dennis Moss
2. Browell and Young, "Process Equipment Design: John Wiley
3. Pressure Vessel Design Handbook: Henry H Bednar
4. Pressure Vessel Handbook: Eugene F.Megyesy
5. Guidebook for the Design of ASME section VIII Pressure Vessels by James R. Farr and Maan H.Jawad
6. Standard Codes such as: ASME SEC-VIII, Div I & II; Section II part A, Part D; ASTM; API; TEMA

COURSE CODE	DESIGN FOR MANUFACTURING AND ASSEMBLY	L	T	P	C
2162ME197		3	0	0	3

UNIT I: INTRODUCTION **9**

Design philosophy steps in Design process - General Design rules for design. Materials: Selection of Materials for design Developments in Material technology - criteria for material selection - Material selection interrelationship with process selection process selection charts.

UNIT II: MACHINING PROCESS **9**

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. METAL CASTING **-** Appraisal of various casting processes, selection of casting process, - general design considerations for casting - casting tolerances – use of solidification simulation in casting design - product design rules for sand casting.

UNIT III: METAL JOINING **9**

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 dies forging design parting lines of dies drop forging die design - general design recommendations. Extrusion &Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing - Keeler Goodman Forming Line Diagram - Component Design for Blanking.

UNIT IV: DESIGN OF MANUAL ASSEMBLY **9**

Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic Design for Assembly (DFA) methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.

UNIT V: DESIGN OF AUTOMATIC ASSEMBLY **9**

Development of the assemble process, choice of assemble method assemble advantages social effects of automation. AUTOMATIC ASSEMBLY TRANSFER SYSTEMS: Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine.

TOTAL: 45 PERIODS

REFERENCES:

1. Assembly Automation and Product Design/ Geoffrey Boothroyd/ Marcel Dekker Inc., NY,1992.
2. Engineering Design - Material & Processing Approach/ George E. Deiter/McGraw Hill Intl.2nd Ed. 2000.
3. Hand Book of Product Design/ Geoffrey Boothroyd/ Marcel and Dekken, N.Y. 1990.
4. Computer Aided Assembly London/ A Delbainbre/.
5. Product Design for Manufacturing and Assembly/ Geoffrey Boothroyd, Peter Dewhurst &Winston Ansthony Knight/CRC Press/2010.

CURRICULUM AND SYLLABUS

for

M. Tech - Metallurgical and Materials Science

FOUNDATION COURSE					
Code	**Course**	**L**	**T**	**P**	**C**
		3	2	0	4

PROGRAMME CORE						
Sl. No	**Code**	**Course**	**L**	**T**	**P**	**C**
Theory Courses						
1	**2161ME158**	Advanced Industrial Process	3	2	0	4
2	**2161ME159**	Physical Metallurgy of Alloys	3	2	0	4
3	2161ME103	Mechanical Behaviour of Materials	3	2	0	4
4	2161ME104	Metallurgical Thermodynamics	3	2	0	4
5	2161ME105	Heat Treatment of Ferrous and Nonferrous Alloys	3	0	0	3
6	2161ME107	Material Characterization	3	0	0	3
7	**2161ME165**	Smart Materials	3	0	0	3
8	**2161ME166**	High Temperature Materials	3	0	0	3
		Total Credits				**28**
Laboratory Courses						
1	2161ME301	Materials Testing Laboratory	0	0	2	1
2	2161ME302	Metallography and Heat Treatment Laboratory	0	0	2	1
		Total Credits				**02**

PROGRAMME ELECTIVE (ANY FOUR)						
1	2162ME101	Polymers and Composite Materials	3	0	0	3
2	2162ME102	Non-Destructive Evaluation	3	0	0	3
3	2162ME104	Corrosion Engineering	3	0	0	3
4	2162ME105	Selection of Materials For Design	3	0	0	3
5	2162ME106	Ceramic Materials	3	0	0	3
6	2162ME108	Nano Materials	3	0	0	3
7	2162ME109	Failure Analysis of Engineering Components	3	0	0	3
8	2162ME110	Advanced Additive Manufacturing	3	0	0	3
9	2162ME112	Sustainable Design	3	0	0	3
10	2162ME111	Advanced Optimization Techniques	3	0	0	3
11	**2162ME190**	Surface Engineering	3	0	0	3
12	**2162ME191**	Quality, Reliability and Standards	3	0	0	3
13	**2162ME192**	Advanced Finite Element Methods	3	0	0	3
		Total Credits to be earned from Programme Elective				**12**

INDEPENDENT LEARNING COURSES					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
	Massive Open Online Course	-	-	-	2
2163ME501	Research Seminar [**OR**]	-	-	-	
2163ME801	Field Study [**OR**]	-	-	-	2
2163ME802	Internship	-	-	-	
2163GE401	Business Communication [**OR**]	-	-	-	2
2163GE402	Technical Writing Tools	-	-	-	
2163MG401	Research Methodology	-	-	-	2
				Total Credits	**8**

PROJECT WORK					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
2164ME601	Project Phase I	0	0	20	10
2164ME701	Project Phase II	0	0	32	16
				Total Credits	**26**

PROGRAMME STRUCTURE AND MINIMUM CREDITS REQUIRED

IN COURSE CATEGORIES

SECTION NUMBER	COURSE CATEGORY	MINIMUM CREDITS REQUIRED
7.2.1	**FOUNDATION COURSE**	**04**
7.2.2	**PROGRAM CORE COURSES**	**30**
7.2.3	**PROGRAM ELECTIVE COURSES**	**12**
7.2.4	**INDEPENDENT LEARNING COURSES**	**8**
7.2.5	**PROJECT WORK**	**26**
	TOTAL CREDITS	**80**

COURSE CODE	ADVANCED INDUSTRIAL PROCESSES	L	T	P	C
2161ME158		4	0	0	4

UNIT I: INTRODUCTION **12**

Introduction to manufacturing processes – different approaches – technical and economic considerations – significance of material properties with respect to selection of manufacturing process. Metallurgical aspects, microstructure variations among different production process

UNIT II: CASTINGS **12**

Conventional casting processes – advantages and limitations – melting practices – design of castings – special casting processes. Metallurgy of castings- solidification and cooling rate control

UNIT III: MATERIAL JOINING AND MACHINING **12**

Conventional material joining processes – concept of weldability – need for dissimilar joints- machining processes – concept of machinability – material examples – developments in machining processes. Metallurgy of weldments, residual strain on machining

UNIT IV: FORMING PROCESSES **12**

Rolling – forging – extrusion – drawing - sheet metal forming – classification, advantages and limitations. Metallurgical aspects of forging – forging defects and its relationship with composition

UNIT V: MODERN PROCESSES **12**

Introduction to EDM, ECM , Friction welding – Recent developments in metal joining processes, forging and mechanical alloying - concept of near net shape processing - concept and applications of rapid prototyping –metallic FDM- emerging technologies for nano – processing.

TOTAL: 60 PERIODS

REFERENCES

1. Rao.P.N, 'Manufacturing Technology', Tata McGraw Hill, 1996.
2. Kalpakjian.S, 'Manufacturing Engineering and Technology', 3rd Edition, Addison-Wesly.
3. Rusinoff.S.E, Forging and forming of metals, D.B. Taraporevala Son & Co. Pvt Ltd., Mumbai, 1995.
4. Sabroff.A. M. & Others, Forging Materials & Processes, Reinhold Book Corporation, New York, 1988.
5. Upton, Pressure Die Casting, Pergamon Press, 1985.
6. High Velocity Forming of Metals, ASTME, Prentice Hall of India (P) Ltd., New Delhi, 1990.

COURSE CODE	PHYSICAL METALLURGY OF ALLOYS	L	T	P	C
2161ME159		3	2	0	4

UNIT I: CRYSTALLOGRAPHY AND CRYSTAL DEFECTS **12**

Crystal systems - Detailed discussion of common crystal structures in metals and alloys – Crystal defects: Classification - Point, line, area and volume defects. Dislocation and slip, Twins - Voids-types and location in BCC, FCC and HCP structures - influence of defects on properties – Introduction to nanostructures, metallic glasses, Quasi-crystals

UNIT II: ALLOYING THEORY AND PHASE DIAGRAMS **12**

Types of solid solutions and compounds – Hume - Rothery rules for formation of substitutional solid solutions – Properties of solid solutions. Essential principles of solidification – Determination and uses of phase diagrams – Types of phase reactions with examples – Phase rule and its application to phase diagrams – Lever rule – Fe-C phase diagram – Classification of Fe Alloys -Concept of ternary phase diagrams-Exercise problems.

UNIT III: FERROUS ALLOYS & DIFFUSION **12**

Effects of alloying additions in steels; classifications of Steels and Cast iron, Effect of stabilizers in Fe-FeC Diagram, Austenite Stabilizer- Phase diagram, Ferrite Stabilizer- Phase diagram. Stainless Steels – Different types - Properties and Applications, Cast Iron – properties and applications.

Diffusion - Concept of activation energy- Mechanisms of diffusion - Fick's 1st Law of diffusion – Diffusion coefficient-factors affecting diffusion coefficient – Fick's 2nd Law of diffusions-inter diffusion – Kirkendall effect-Modes of diffusion (surface, volume and grain boundary) - Industrial applications - Numerical problems.

UNIT IV: NON-FERROUS ALLOYS **12**

Cast and wrought Aluminum Alloys - Classification system and grades of alloys- Age Hardenable Aluminum Alloys- Properties and Applications. Copper and its alloys: Classification of Alloys and Grades, Classification of Bronze and Brass - Copper – Zinc phase diagram, Copper –Tin phase diagram, Physical, chemical, mechanical properties and applications.

UNIT V: TITANIUM and OTHER ALLOYS **12**

Titanium and its Alloys - Stablizers, Alpha titanium alloys, Beta titanium alloys, Alpha–Beta Titanium alloys, Titanium Aluminide – properties and applications – Nickel based Alloys, Magnesium Alloys – Classifications, properties and applications, Zinc based alloys, Tin & Antimony base alloys, Refractory metals and alloys for high temperature applications. **TOTAL: 60 PERIODS**

REFERENCES

1. S.H.Avner, “Introduction to Physical Metallurgy”, second edition, McGraw Hill, 1985.
2. V.Raghavan, “Physical Metallurgy”, Prentice Hall of India, 1985.
3. I.J. Polmear, ”Light Alloys: Metallurgy of Light Metals”, John Wiley & Sons 1996
4. T.V.Rajan, C.P.Sharma, Ashok Sharma, “Heat Treatment Principles and Techniques” Prentice-Hall of India Pvt. Ltd., New Delhi, 2002
5. Vijendra Singh, “Heat Treatment of Metals”, First edition, Standard Publisher Distributors New Delhi, 1998.
6. Henkel & Pense, “Structure and Properties of Engineering materials”, 2001

COURSE CODE	MECHANICAL BEHAVIOUR OF MATERIALS	L	T	P	C
2161ME103		3	2	0	4

UNIT I: STRESS -STRAIN BEHAVIOUR **12**

Strength of materials- basic assumptions, elastic and plastic behaviour, stress–strain relationship for elastic behaviour, elements of plastic deformation of metallic materials – Mohr's circle, yielding theories

UNIT-II : DISLOCATION AND STRENGTHENING MECHANISMS **12**

Elements of theory of plasticity, dislocation theory properties of dislocation, stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, dispersion hardening.

UNIT-III: DUCTILE AND BRITTLE FAILURE **12**

Ductile and brittle fracture, Charpy and Izod testing, significance of DBTT, ECT, NDT and FATT; elements of fractography - Griffith's theory, LEFM– COD and J integral determination of KIC, COD and J integral

UNIT-IV: FATIGUE AND CORROSION **12**

Characteristics of fatigue failure, initiation and propagation of fatigue cracks, factors affecting fatigue strength and methods of improving fatigue behaviour – testing analysis of fatigue data, mechanics of fatigue crack propagation, Corrosion- mechanism – types of corrosion – characteristics – Effect of various parameters- measurement of corrosion –Types of corrosion prevention – Corrosion fatigue

UNIT-V: CREEP **12**

Introduction to creep - creep mechanisms, creep curve, variables affecting creep, accelerated creep testing, development of creep resistant alloys, Larsen Miller parameter – Manson Hafred parameter.

TOTAL: 60 PERIODS

REFERENCES

1. Dieter G. E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill, 1988
2. Raghavan, V., "Physical Metallurgy", Prentice Hall of India, 1985.
3. Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979.
4. Rose R. M., Shepard L. A., Wulff J., 'Structure and Properties of Materials', Volume III, 4th Edition, John Wiley, 1984

COURSE CODE	METALLURGICAL THERMODYNAMICS	L	T	P	C
2161ME104		3	2	0	4

UNIT-I: INTRODUCTION TO THERMODYNAMICS **L-9 T-6**

Introduction to thermodynamics and kinetics – different approaches – emphasis on metallurgical thermodynamics, transport phenomena and applications

UNIT-II: LAWS OF THERMODYNAMICS **L-9 T-6**

Laws of thermodynamics and related applications – concepts of free energy and entropy – criteria for spontanity

UNIT-III: INTRODUCTION TO SOLUTIONS **L-9 T-6**

Introduction to solutions – partial molar entities – Gibbs Duhem relations – thermodynamic aspects of metallic solutions and salt melts – Raoult's Law and Henry's Law - regular and quasi chemical models.

UNIT-IV: THERMODYNAMIC ASPECTS OF PHASE DIAGRAMS **L-9 T-6**

Thermodynamic aspects of phase diagrams – similarity in thermodynamic approach towards different classes of materials – thermodynamic aspects of defect formation in metals and ceramics – approaches used in chemical modeling

UNIT-V: PRINCIPLES OF METALLURGICAL KINETICS **L-9 T-6**

Principles of metallurgical kinetics – reaction rates and reaction mechanisms – overview of mass transfer, heat transfer and fluid flow – related applications in metallurgical processes – role of transport phenomena in mathematical and physical modeling.

TOTAL 45+30 = 75 PERIODS

REFERENCES

1. Gaskell, David R., 'Introduction to Metallurgical Thermodynamics', McGraw Hill, 1973
2. Mohanty, A. K., "Rate Processes in Metallurgy", Prentice Hall of India (EEE), 2000
3. David R. Gaskel,"Introduction to Metallurgical Thermodynamics" McGraw Hill, 2008

COURSE CODE	HEAT TREATMENT OF FERROUS AND NON-FERROUS ALLOYS	L	T	P	C
2161ME105		3	0	0	3

UNIT I: TRANSFORMATION IN STEELS **9**

Iron - Carbon equilibrium diagram: Transformations on heating and cooling, influence of alloying elements, general principles of heat treatment of steels, isothermal and continuous cooling transformations in steels. Continuous cooling curves TTT and CCT diagrams. Mechanism of pearlitic, bainitic and martensitic transformations.

UNIT II: HEAT TREATMENT PROCESSES **9**

Annealing, Normalizing, Hardening - retained austenite - measurement and methods of its elimination, hardenability studies- Jominy end quench test, Grossman's experiments. Tempering- Hollomon & Jaffe tempering correlations, Austempering and Martempering, Precipitation hardening, thermo-mechanical treatment, inter-critical heat treatment, other heat treatment processes - splat cooling. Induction and Flame hardening

UNIT III: CASE HARDENING **9**

Introduction, carburizing: principle, carbon potential, mechanism, application of Fick's law, depth of carburization and its control, methods of carburizing, heat treatment after carburizing, structure, properties and common problems in carburizing. Nitriding: introduction, steels used, mechanism, effect of microstructure, white layer, nitriding methods, ion nitriding and nitro-carburizing. Induction and flame hardening: principle, methods, operating variables. Measurement of case depth

UNIT IV: HEAT TREATMENT EQUIPMENT **9**

Various heating media used for heat treatment. Temperature and atmosphere control, carburizing atmosphere and carbon potential measurement, nitriding gas atmospheres. Quenching media and their characteristics. Various heat treatment furnaces, fluidized bed furnaces, cryo chamber, cryo treatment of steels, sealed quenched furnace, plasma equipment.

UNIT V: HEAT TREATMENT OF SPECIFIC ALLOYS **9**

Heat treatment of carbon steels, various types of tool steels, high speed steels, maraging steels and die steels. Heat treatment of gray cast irons, white cast irons, malleabilising and S.G irons, Austempering of S.G.Iron – Heat treatment of aluminium alloys – copper alloys and nickel alloys – Defects in heat treated parts: causes and remedies. **TOTAL: 45 PERIODS**

REFERENCES

1. Rajan, T. V., Sharma C. P., Ashok Sharma., "Heat Treatment Principles And Techniques" Prentice-Hall of India Pvt. Ltd., New Delhi, 2002
2. Vijendra Singh, "Heat Treatment of Metals", First edition, Standard Publisher Distributors New Delhi, 1998.
3. American Society for Metals, "Metals Handbook Vol. 4", ASM Metals Parks. Ohio, USA, 1991
4. Prabhudev. K H. "Handbook of Heat Treatment of Steels", Tata McGraw-Hill Publishing Co., New Delhi, 1988.
5. Novikov,.I., "Theory of Heat Treatment of Metals", MIR Publishers, Moscow, 1978
6. Thelning K. E., "Steel and its heat treatment", Bofors Handbook, 1975.

COURSE CODE	MATERIAL CHARACTERIZATION	L	T	P	C
2161ME107		3	0	0	3

UNIT-I: METALLURGICAL MICROSCOPE 9

Numerical aperture, limit of resolution, depth of field and depth of focus - lens defects and correction- bright field and dark field illumination - polarised light, phase contrast, interference contrast, hot-stage, in-situ techniques, quantitative metallography

UNIT-II: X-RAY DIFFRACTOMETER 9

Generation of X-rays- Bragg's law, Powder, rotating crystal and Laue methods, stereographic projections and reciprocal lattice; X-ray residual stress measurement

UNIT-III: SCANNING ELECTRON MICROSCOPE 9

Secondary Electrons, Back Scattered Electrons, Auger Electrons – properties, working principle construction and applications of Scanning Electron Microscope – Elemental analysis by WDS and EDS systems - Fracture Analysis of samples

UNIT-IV: TRANSMISSION ELECTRON MICROSCOPE 9

Working principle, construction and applications of TEM, TEM specimen preparation techniques;

UNIT-V: OTHER TECHNIQUES 9

X-ray fluoroscopy, spectrometry, Auger spectroscopy, DTA, DSC and TGA, working principle, applications – Types and applications of strain gauges

TOTAL: 45 PERIODS

REFERENCES

1. Smallman R. E., 'Modern Physical Metallurgy', 4th Edition, Butterworths, 1985
2. Philips V. A., 'Modern Metallographic Techniques and their Applications', Wiley Inderscience, 1971
3. Cullity B. D., 'Elements of X-ray Diffraction', 4th Edition, Addison Wiley, 1978
4. Loretto M. H., 'Electron Beam Analysis of Materials', Chapman and Hall, 1984

COURSE CODE	SMART MATERIALS	L	T	P	C
2161ME165		3	0	0	3

UNIT I: INTRODUCTION TO INTELLIGENT MATERIALS **9**

Intelligent materials: Primitive functions of intelligent materials; Intelligence inherent in materials; Materials intelligently harmonizing with humanity; Intelligent biological materials.

UNIT II: SMART MATERIALS AND STRUCTURAL SYSTEMS **9**

Actuator materials; Sensing technologies; Micro-sensors; Intelligent systems; Hybrid smart materials; Passive sensory smart structures; Reactive actuator-based smart structures; Active sensing and reactive smart structures; Smart skins

UNIT III: ELECTRO-RHEOLOGICAL (ER) FLUIDS **9**

Electro-Rheological (ER) Fluids: Suspensions and electro-rheological fluids; electro-rheological phenomenon; Charge migration mechanism for the dispersed phase; Electro-rheological fluid actuators.

Piezoelectric Materials: Background; Piezoelectricity; Industrial piezoelectric materials; Smart materials featuring piezoelectric elements.

UNIT IV: SHAPE MEMORY MATERIALS **9**

Background on shape-memory alloys; Applications of shape-memory-alloys; Continuum applications: structures and machine systems; Discrete applications; Impediments to applications of shape-memory-alloys; Shape-memory-plastics.

Fibre-optics: an overview; Advantages of fibre-optics; Light propagation in an optical fibre; Embedding optical fibre in fibrous polymeric thermosets; Fibre-optic strain sensors.

UNIT V : PIEZOELECTRIC VIBRATIONS ABSORBER SYSTEMS **9**

Introduction; The single mode absorber, theory, design solution, extension including viscous modal damping, the electromechanical coupling coefficient, inductance, experimental results; The multimode absorber, derivation of transfer function, design solution, self-tuning absorber, performance function, control scheme.

TOTAL: 45 PERIODS

REFERENCES

1. M.V. Gandhi, and B.S. Thompson, Smart Materials and structures (2nd edition), Chapman & Hall, 1992
2. Guran, H.S. Tzou, G.L. Anderson, and M. Natori, Structure Systems: Smart Structures, Devices and System (Part 1), and Materials and Structures (Part 2), World Scientific Publications, 1998
3. U. Gabbert, and H.S. Tzou, Smart Structures and Structuronic System, Kluwer Academic Publishers, 2001
4. H.T. Banks, R.C. Smith, and Y.W. Qang, Smart Material structures: Modeling, Estimation and Control (6th edition), John Wiley & Sons, 1999
5. Bryan Culshaw, Smart Structures and Materials, Artech House, 1996
6. Mel Schwartz, Encyclopedia of Smart Materials, 2 Volume set, March 2002

COURSE CODE	HIGH TEMPERATURE MATERIALS	L	T	P	C
2161ME166		3	0	0	3

UNIT I: HIGH TEMPERATURE FAILURES **9**

Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage, ductile fracture due to microvoid coalescence – diffusion controlled void growth, fracture maps for different alloys and oxides.

UNIT II: CREEP **9**

Factors influencing functional life of components at elevated temperatures, high temperature failure – creep, creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate. Expressions for rupture life for creep, Monkman - grant relationship.

UNIT III: OXIDATION AND HOT CORROSION **9**

Oxidation, Pilling – Bedworth ratio, kinetic laws of oxidation – defect structure and control of oxidation by alloy additions – sulphation, hot gas corrosion deposit, modified hot gas corrosion, effect of alloying elements on hot corrosion.

UNIT IV: FERROUS SUPER ALLOYS **9**

Iron based super alloys composition control, strengthening mechanisms, precipitation hardening, properties and applications

UNIT V: NON-FERROUS SUPER ALLOYS **9**

Nickel based super alloys and cobalt based super alloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase – embrittlement, solidification of single crystals.

TOTAL: 45 PERIODS

REFERENCES

1. Raj R, “Flow and Fracture at Elevated Temperatures” American Society for Metals, 1985
2. Hertzberg R. W, “ Deformation and Fracture Mechanics of Engineering Materials”, 4th Edition, John Wiley, 1996
3. Courtney T. H, “Mechanical Behaviour of Materials”, McGraw Hill, 1990.
4. Ceramic processing and Sintering by M.N. Rahman, Mercel Dekker,2003
5. Handbook of advanced ceramics, parts 1 and 2, S. Somiya, Academic press,2006

COURSE CODE	MATERIALS TESTING LABORATORY	L	T	P	C
2161ME301		0	0	2	1

1. Tensile Testing of Carbon steels using Universal testing machine
2. Tensile testing of Aluminum alloys using Universal testing machine
3. Hardness Measurements of carbon steels using Rockwell hardness Tester
4. Hardness Measurements of carbon steels using Brinell Hardness Tester
5. Hardness Measurements of carbon steels using Vicker's Hardness Tester
6. Impact Testing of different Materials
7. Fatigue life measurements of Aluminum Metal
8. To find the Modulus of rigidity of the material of a spring by conducting Compression

TOTAL: 30 PERIODS

COURSE CODE	METALLOGRAPHY AND HEAT TREATMENT LABORATORY	L	T	P	C
2161ME302		0	0	2	1

List of Experiments

1. Sample preparation for metallographic examination
2. Microscopic examination of Plain carbon steels
3. Microscopic examination of Cast Iron
4. Microscopic examination of Stainless steels
5. Microscopic examination of steels and Tool steels
6. Microscopic examination of Annealed, Normalized and Quenched carbon steels
7. Microscopic examination of Magnesium alloys
8. Microscopic examination of Aluminum alloys
9. Microscopic examination of Titanium Alloys
10. Microscopic examination of Copper alloys

TOTAL: 30 PERIODS

COURSE CODE	POLYMERS AND COMPOSITE MATERIALS	L	T	P	C
2162ME101		3	0	0	3

UNIT I: POLYMERS AND ELASTOMERS **9**

Polymers – Introduction, Types of Polymers – Thermosets Vs Thermoplastics, Polymerization-addition polymerization, Condensation Polymerization, Classes and types of thermoplastics: Amorphous Vs Semi-crystalline, High performance plastics, Properties, scope and limitations. Natural and Synthetic rubbers (Different Standards) like – NR, SBR, BR, IIR, NBR, SBR, fluorocarbons, silicone, etc – their functional properties and applications. Study of various additives like peptizers, antioxidants, accelerators, activators, fillers, carbon black, chords and fabrics, blowing agents, colorants, processing aids like – tackifiers, plasticizers, extender oils etc. Processing of rubbers by - extrusion, calendaring and injection molding

UNIT II: POLYMERS MANUFACTURING PROCESS **9**

Injection molding, Reaction injection molding (RIM), Transfer molding, Extrusion, compression molding, blow molding, scopes and limitations of various manufacturing processes, mold making, safety in handling of materials, hands on training on processes and applications.

UNIT III: COMPOSITES AND POLYMER MATRIX COMPOSITES **9**

Definition; Types; General properties and characteristics, Rule of Mixture; Matrix materials – characteristics, Reinforcing materials – particles, fibers- fiber length, continuous, discontinuous, short fibers, Young's Modulus – Continuous Aligned Fiber, Discontinuous fiber, whiskers and Properties. Fiber Reinforced Reinforcing materials – particles, fibers, whiskers; Properties of reinforcing materials; Matrix materials; Additives; Properties of FRP materials; applications.

UNIT IV: METAL AND CERAMIC MATRIX COMPOSITES **9**

Introduction – Matrix Material – types, advantages and characteristics, Reinforcing materials - types, advantages and characteristics – Types of MMC- Aluminum Metal Matrix Composites, Titanium Metal Matrix Composites and magnesium based composites. Ceramic Matrix Composites – carbon-carbon composites, Alumina based Composites, Titanium carbide-based composites – Applications.

UNIT V: COMPOSITE MANUFACTURING **9**

Manufacturing Processes: Open mold processes – Hand layup, Spray up, Vacuum bag, Pressure bag & autoclave, Centrifugal casting, Filament winding; Closed mold processes – Compression molding, Resin transfer molding (RTM), Injection molding, Pultrusion; SMC & DMC products, etc.

TOTAL: 45 PERIODS

REFERENCES

1. Mechanics and Analysis of Composite Materials, V.V. Vasiliev and E.V. Morozov, (2001), Elsevier
2. Science Ltd, The Boulevard, Langford Lane, Kidlington, Oxford OX5 lGB, UK.
3. Ceramic matrix composites, K.K. Chawala, 1st ed., (1993) Chapman & Hall, London.
4. Advances in composite materials, G. Piatti, (1978) Applied Science Publishers Ltd., London.
5. Premamoy Ghosh, Polymer Science and Technology, Second Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2002
6. Composite materials, K.K. Chawala, 2nd ed., (1987) Springer-Verlag, New York.
7. Nanocomposite Science and Technology, P. M. Ajayan, L. S. Schadler, P. V. Braun, (2003), Wiley-VCH Verlag GmbH Co. KGaA, Weinheim.

COURSE CODE	NON-DESTRUCTIVE EVALUATION	L	T	P	C
2162ME102		3	0	0	3

UNIT I: VISUAL INSPECTION AND LIQUID PENETRANT TESTING 9

Non Destructive Testing – definition, Benefits and advantages, Visual Inspection- tools, applications and limitations – Liquid Penetrant Inspection - principles, types and properties of penetrants and developers, Procedural steps involved in Liquid Penetrant Testing Water Washable and Post Emulsification Testing methods, Advantages and limitations, Industrial Applications of LPI.

UNIT II: MAGNETIC PARTICLE INSPECTION AND EDDY CURRENT TESTING 9

Magnetic particle inspection - Introduction, principles, types of magnetization methods – continuous and residual methods, procedural steps, advantages and limitations, Industrial applications, Eddy Current Testing – Introduction, Principle, Skin effect, Lift off, Types of probes, Types of display methods, advantages, limitations and applications.

UNIT III: ULTRASONIC TESTING 9

Ultrasonic testing (UT) - Nature of sound waves, wave propagation - modes of sound wave generation - Ultrasonic wave generation, Attenuation of sound waves, types of transducers- Normal probes, angle probes, types of Display systems – A Scan, B Scan and C Scan display systems, types inspection techniques – Transmission and reflection methods, Calibration Blocks, advantages, disadvantages and applications.

UNIT IV: RADIOGRAPHY 9

Radiography testing (RT) – Principles, Radiation sources – X rays and Gamma rays, Attenuation of radiation, Shadow formation, enlargement and distortion, Radiographic films and screens, Inspection techniques – single wall single image, double wall single image, double wall double image, panoramic and multiwall multi images techniques, Radiation hazards, protection, Real time radiography, Advantages and limitations and industrial applications.

UNIT V: ACOUSTIC EMISSION AND THERMOGRAPHY 9

Principle of AET, Instrumentation, Applications - testing of metal pressure vessels, Fatigue crack detection in aerospace structures – Thermography - Principles, types, applications, advantages, limitations and application

TOTAL: 45 PERIODS

REFERENCES

1. Practical Non – Destructive Testing, Baldev raj, Narosa Publishing House (1997).
2. Non-Destructive Testing, B.Hull and V.John, Macmillan (1988)
3. ASM Metals Handbook “Failure Analysis and Prevention”, ASM Metals Park. Ohio, Vol.10, 10th Edition, 1995
4. Colangelo.V.J. and Heiser.F.A., “Analysis of Metallurgical Failures”, John Wiley and Sons Inc. New York, USA, 1974.
5. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, 3rd edition, New York, Springer-Verlag (1983).

COURSE CODE	CORROSION ENGINEERING	L	T	P	C
2162ME104		3	0	0	3

UNIT I: BASICS OF CORROSION **9**

Principles of corrosion phenomenon: Thermodynamics and kinetics: emf / galvanic series, Pourbaix diagram, exchange current density, passivity, Evans diagram, flade potential.

UNIT II: TYPES OF CORROSION **9**

Different forms of corrosion: atmospheric / uniform, pitting crevice, inter-granular, stress corrosion, corrosion fatigue, de-alloying, high temperature oxidation – origin and mechanism with specific examples.

UNIT III: CORROSION TESTING AND MONITORING **9**

Corrosion testing and monitoring techniques, non – Electrochemical methods, weight loss method, Tafel linear polarization and impedance techniques, lab, semi plant & field tests, susceptibility test.

UNIT IV: CORROSION PREVENTION **9**

Corrosion prevention through design, coating, inhibitors, cathodic, anodic protection, specific applications, economics of corrosion control.

UNIT V: CORROSION IN INDUSTRIES **9**

Corrosion & its control in industries: power, process, petrochemical, ship building, marine and fertilizer industries. Some case studies – corrosion and its control in different engineering materials: concrete structures, duplex, super duplex stainless steel, ceramics, composites and polymers. Corrosion auditing in industries, corrosion map of India

TOTAL: 45 PERIODS

REFERENCES

1. Fontana. M.G., Corrosion Engineering, Tata Mcgraw Hill, 3rd Edition, 2005
2. Jones. D.A. Principles and Prevention of Corrosion, 2nd Edition, Prentice Hall, 1996.

COURSE CODE	SELECTION OF MATERIALS FOR DESIGN	L	T	P	C
2162ME105		3	0	0	3

UNIT I: INTRODUCTION TO MATERIALS DESIGN **9**

Classification of design – Classification of materials – Engineering materials and their properties applied to design - Technologically important properties of materials, Physical, Chemical, Mechanical and Electrical properties of materials. Selection of materials - Principles of design optimization - Future trends – CAD, Criteria of selection of materials like properties, cost, manufacturing process, availability, legal and safety factors

UNIT II: MATERIALS FOR MECHANICAL FAILURE RESISTANCE **9**

Stiffness, strength, ductility, theories of failure, notch sensitivity – Materials selection for various types of loading - ties, columns, beams, shafts, and shells – Materials selection for fracture and fatigue resistance.

UNIT III: MATERIALS FOR CORROSION AND WEAR RESISTANCE **9**

Materials for atmospheric, soil, water, acid and alkaline resistance, Corrosion prevention coatings, material for Chemical and Petroleum industries, materials and coatings for wear resistance.

UNIT IV: MATERIALS FOR HIGH AND LOW TEMPERATURES **9**

High temperature strength and stability, Hot hardness requirements, High temperature steels and super alloys, ductile to brittle transition-HSLA steel, low temperature materials.

UNIT V: MATERIALS FOR AUTOMOBILE INDUSTRY **9**

Criteria of selecting materials for automotive components viz cylinder block, Cylinder head, piston, piston ring, Gudgeon pin, connecting rod, crank shaft, crank case, cam, cam shaft, engine valve, gear wheel, clutch plate, axle, bearings, chassis, spring, body panel - radiator, brake lining etc. Application of non-metallic materials such as composite, ceramic and polymers in automobile

TOTAL = 45 PERIODS

REFERENCES

1. Michael F. Ashby, Materials Selection in Mechanical Design, Butterworth-Heinemann, 4th Edition, 2011.
2. Michael F. Ashby, Hugh Shercliff, David Cebon, Materials – Engineering, Science, Processing, and Design, Butterworth-Heinemann, 2007.
3. Gladius Lewis, Selection of Engineering Materials, Prentice Hall Inc. New Jersey, USA, 1995.
4. Charles J A and Crane. F A.A., Selection and Use of Engineering Materials, 3rd Edition, Butterworths, London UK, 1996.
5. Hiroshi Yamagata, The Science and Technology of Materials in Automotive Engines, CRC Press, 2005.
6. D. Mann, Automotive plastics and composites – Worldwide markets and trends to 2007, Elsevier Advanced Technology, 1999.
7. Ulrich, K. and Eppinger, S., Product Design and Development, McGraw-Hill, 4th Edition, 2007.

COURSE CODE	CERAMIC MATERIALS	L	T	P	C
2162ME106		3	0	0	3

UNIT I: TRADITIONAL CERAMICS **9**

History – definition – whiteware – heavy clayware – classification – raw materials, batch calculation, mixing, forming, drying, firing, glazing, decoration. heavy clayware products – face bricks, paving bricks, hollow bricks, roofing tiles, sewer pipes, stoneware pipes, floor tiles, vitrified tiles.

UNIT II: CERAMIC COATINGS **9**

Introduction, classification, Glaze – Segar formula, raw materials, glaze preparation and application, firing, glaze defects – Enamels – substrate preparation, enamel preparation, enamel coatings.

UNIT III: GLASS **9**

Introduction, classification, preparation– raw materials, mixing, charging, melting, processing, manufacture of glass products-flat ware and hollow ware.

UNIT IV: REFRACTORIES **9**

Definition – production - demand & growth of refractories in India - Layout of a refractory plan, classification of refractory, fundamental properties of refractories, factors for selection and use of refractories. Types of refractories – silica, alumina silicate, basic and special refractories

UNIT V: ADVANCED CERAMICS **9**

Introduction, properties and applications of – oxides, carbides, nitrides; Advanced ceramic Products – ceramic fibers, glass ceramics

TOTAL: 45 PERIODS

REFERENCES

1. F. Singer and S. Singer, Industrial Ceramics, Oxford and IBH Publishing Co., 1991.
2. Ryan W, Properties of Ceramic Raw Materials, Pergamon Press, 2nd Edn., 1978.
3. SudhirSen, Ceramic White ware, Oxford & IBH Publishing Co., New Delhi, 1992.
4. Tailor J.R and Bull A.C, Ceramic Glaze Technology, Pergamon Press, NY, 1986.
5. Heinz G. Pfaender, Schott Guide to Glass, Chapman and Hall, 1996.
6. Nandi D.N, Handbook of Refractories, Tata McGraw – Hill Publishing Co., New Delhi, 1991.
7. Norton F.H, Fine Ceramics: Technology and Applications, McGraw – Hill Co., NY, 1978.
8. Mohamed N.Rahaman, Ceramic Processing, Taylor & Francis, 2007.
9. Rexford Newcomb Jr, Ceramic Whitewares : History, Technology and Applications, Pitman Publishing Corporation, 1947.

COURSE CODE	NANO MATERIALS	L	T	P	C
2162ME108		3	0	0	3

UNIT I: INTRODUCTION TO NANOMATERIALS **9**

Nanoscale materials – Introduction, Definition about Nano Materials, Advantages and limitations of nanoscale materials, - Historical development of nanomaterials – Issues in fabrication and characterization of nanomaterials – Types of nanomaterials – nanoparticles, nanolayers, nanotubes, comparison of physical and mechanical properties of nanomaterials.

UNIT II: SYNTHESIS OF NANOMATERIALS **9**

Top down and Bottom Up approaches – E-beam and ion beam lithography, Ball milling, Mechanical alloying, Etching techniques, Micro and nano machining, PVD, CVD, Sol-gel, Spray conversion processing, Wet chemical synthesis, Self aseembly, Growth mechanisms of nanowires.

UNIT III: CHARACTERIZATION TECHNIQUES **9**

X-ray diffraction, Small angle X-ray scattering, Scanning Electron Microscope, Transmission Electron Microscope, Atomic Force Microscope, Scanning Tunneling Microscope, Nanoindentation

UNIT IV: NANOCOMPOSITES **9**

Metal-metal, metal-oxide, metal-ceramic nanocomposites - their preparation techniques and functionalities, Super hard nanocomposites - its designing and improvements of mechanical properties. Fractal based glass-metal nanocomposites - designing and properties, Polymer nanocomposites with CNT, nanoclay, nanosilica, grapheme – their processing and properties.

UNIT V: APPLICATIONS OF NANOMATERIALS **9**

Nanoelectronics, MEMS/NEMS, Nano sensors, Nano catalysts, Food and agriculture, Cosmetics/consumer goods, Structural applications, Defence and space applications, Energy applications, Automotive industry, Water treatment and environment, Nano-medical applications, Textiles, Paints **TOTAL: 45 PERIODS**

REFERENCES

1. Pradeep T “Nano: The Essentials”, McGraw Hill Publishing Co. Ltd., 2007
2. Mick Wilson et al, “Nanotechnology”, Overseas Press (India) Pvt. Ltd., 2005.
3. Charles P. Poole, Jr., Frank J. Owens, “Introduction to nano technology”, Wiley, 2003.
4. Gunter Schmid, “Nanoparticles: From Theory to Applications”, Wiley-VCH Verlag GmbH & Co., 2004.
5. LM Liz-Marzán, PV Kamat, Eds., Nanoscale Materials, Kluwer Academic Publishers, Boston-2003.
6. KJ Klabunde, Ed., Nanoscale Materials in Chemistry, John Wiley & Sons Inc., New York.-2001.
7. CP Poole, FJ Owens, Eds., Introduction to Nanotechnology, John Wiley & Sons Inc., New Jersey.-2003.
8. HS Nalwa, Ed., Encyclopedia of Nanoscience and Nanotechnology-2004.
9. LV Interante, MJ Hampden- Smith, Eds., Chemistry of Advanced Materials- An Overview, Wiley VCH-1998.

COURSE CODE	FAILURE ANALYSIS OF ENGINEERING COMPONENTS	L	T	P	C
2162ME109		3	0	0	3

UNIT I: INTRODUCTION TO FAILURE ANALYSIS **9**

Griffith's crack theory, stress intensity factor, stress analysis of cracks, strain energy release rate, Derivation of relationship between strain energy release rate and stress intensity factor, crack tip plastic zone

UNIT II: FRACTURE ANALYSIS **9**

Fracture mode transition: Plane stress vs. plane strain, crack opening displacement, plane strain fracture toughness (KIC) testing, Fracture toughness determination with elastic plastic analysis (JIC), concept of R-curve and Fracture toughness measurement using it, Microstructural aspect of fracture toughness.

UNIT III: FATIGUE ANALYSIS **9**

Fatigue stress life approach, Basquin's equation, Fatigue strain life approach, Low cycle fatigue, Cofin- Manson's equation, Fatigue total strain life relation, Fatigue life prediction, Neuber's analysis for notched specimens, Fatigue crack growth rate, Paris law, fatigue life calculation using this approach.

UNIT IV: CRACK ANALYSIS **9**

Mechanism of fatigue crack nucleation and propagation, factors affecting fatigue crack growth rate, influence of load interaction, short fatigue crack; stress corrosion cracking and KIscc determination.

UNIT V: CORROSION ANALYSIS **9**

Corrosion fatigue, temper embrittlement, hydrogen embrittlement, liquid metal embrittlement, neutron embrittlement.Fractographic analysis of ductile, brittle, fatigue and high temperature fractured surfaces. Failure analysis: Steps involved; case studies of some engineering failures.

TOTAL: 45PERIODS

REFERENCES

1. Failure Analysis of Engineering Materials(Hardcover) by Charles Brooks, Ashok Choudhury
2. Practical Engineering Failure Analysis by Hani M. Tawancy, Anwar UI-Hamid and Nureddin M. Abbas, CRC Press – 2004.
3. Hertzberg, R.W., Deformation and fracture mechanics of engineering materials, John Wiley.
4. Dieter, G.E., Mechanical Metallurgy, McGraw Hill
5. Metal Hand book, Failure analysis and prevention (Volume- XI), ASM Pub.
6. Metal Hand book, Fractography (Volume- XII), ASM Pub.

COURSE CODE	ADVANCED ADDITIVE MANUFACTURING	L	T	P	C
2162ME110		3	0	0	3

UNIT I: INTRODUCTION **9**

Rapid prototyping system – practical applications– Basic operations– CAD Model-Translator–supports-slice–merge–prepare–build–cleaning–finishing–benefits of Rapid prototyping-comparison with conventional manufacturing process

UNIT II: STEREOLITHOGRAPHY FUNDAMENTALS **9**

Rapid prototyping process - The Stereo Lithography apparatus(SLA) – data gathering – data analysis – part preparation — part building – Initial consideration in part building– selecting the resin – selecting system – verifying part1 files – slicing – slice resolution –slice units – post processing fundamentals – part removal – cleaning – post curing – part finishing

UNIT-III: RAPID PROTOTYPING TECHNOLOGIES **9**

Types- Selective Laser Sintering (SLS)–Solid Ground Curing (SGC)–Laminated Object Manufacturing (LOM)–Fused Deposition Modeling (FDM)–Three Dimensional Printing (TDP)

UNIT IV: CASE STUDIES **9**

Rapid prototyping for rapid products–Exhaust manifold–Investment cast prototypes- Texas Instruments, USA-RP & Min automotive–medicine

UNIT V: TRENDS IN RAPID PROTOTYPING **9**

Laser Engineering Net Shaping (LENS), Ballistic particle Manufacturing – rapid tooling Magics, Mimics – application of rapid prototyping in medical field – Future development–Rapid prototyping in Indian scene - advances in rapid prototyping research developments in rapid prototyping

TOTAL: 45 PERIODS

REFERENCES

1. Rapid Automated Prototyping: An Introduction Industrial Press Inc. New York.
2. Chowdia M.P(ED), Agile Manufacturing, International Conference on Agile Manufacturing, Bangalore, Feb22–24, 1996, Tata Mc Graw Hill Pub Co., Ltd., New Delhi, 2012.
3. Dickens PM, Research Developments in rapid prototyping, Journal of Engineering Manufacture, pp261-265,2010
4. Paul F Jacobs, Rapid Prototyping and Manufacturing fundamentals of stereo lithography, 1st Edition, Society of Manufacturing Engineers, Dearborn, Michigan, 2012.
5. Donald E Lacourse, Handbook of Solid Modelling, Mc Graw Hill Inc., New York,2012

COURSE CODE	ADVANCED OPTIMIZATION TECHNIQUES	L	T	P	C
2162ME111		3	0	0	3

UNIT I: INTRODUCTION **9**

General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints – Classification of optimization problem. Single variable and multivariable optimization, Techniques of unconstrained minimization

UNIT II: DECISION ANALYSIS **9**

Golden section, Random, pattern and gradient search methods – Interpolation methods; Optimization with equality and inequality constraints. Hooks and Jeeves Method

UNIT III: NON-LINEAR OPTIMIZATION **9**

Decision Trees, Utility theory, Game theory, Multi Objective Optimization, MCDM- Goal Programming, Analytic Hierarchy process

UNIT IV: NON-TRADITIONAL OPTIMIZATION-1 **9**

Classes P and NP, Polynomial time reductions, Introduction to NP- Hard problems, Overview of Genetic algorithms, Simulated Annealing, neural network-based optimization

UNIT V: NON-TRADITIONAL OPTIMIZATION-2 **9**

Particle Swarm optimization, Ant Colony Optimization, Optimization of Fuzzy Systems

TOTAL: 45 PERIODS

REFERENCES

1. Singiresu S.Rao, “Engineering optimization – Theory and practices”, New Age International Publishers, 2013.
2. Ravindran – Phillips –Solberg, “Operations Research – Principles and Practice”, John Wiley India, 2007.
3. Fredrick S.Hillier and G.J. Liberman, “Introduction to Operations Research”, McGraw Hill Inc. 2017.
4. Kalymanoy Deb, “Optimization for Engineering Design”, PHI, 2012.
5. Christos H. Papadimitriou, Kenneth Stieglitz, “Combinatorial Optimization”, PHI 2006.
6. Marius Durea, “An Introduction to Nonlinear optimization theory”, De Gruyter 1st edition 2014.

COURSE CODE	SUSTAINABLE DESIGN	L	T	P	C
2162ME112		3	0	0	3

UNIT I: SUSTAINABILITY AND ITS APPLICATION **9**

Sustainability: Past and Present, The Classic Design and Manufacture Model, The Taguchi Approach to Quality Manufacturing, The Taguchi Analogy Applied to Sustainable Engineering Design, Sustainable Sourcing (Eco sourcing),Design for Sustainable Manufacture (Sustainable Manufacture Value, or SMV),Design for Sustainable Use (Sustainable Use Value, or SUV) Design for Sustainable Maintenance, Design for Sustainable Disposal (Sustainable Disposal Value, or SDV),The Measurement of Sustainability, Sustainable Engineering Design: Necessity or Luxury?

UNIT II: THE TOOLS OF THE DESIGN PROCESS AND MANAGEMENT OF DESIGN **9**

Introduction – Development Processes, Systematic Approach to Design, Design Methods, Classic Brainstorming, Brain Writing, Imaginary Brainstorming, Word-Picture Associations and Analogies, Methods of Generating Associations and Analogies, TILMAG, The Morphological Box, Design and Planning Methods

UNIT III: COMMUNICATION FOR ENGINEERS AND PERFORMANCE PREDICTION **9**

Communication Overview, Written Communication, Project Reports/Technical Reports, Academic Publishing (Technical or Journal Papers), Graphical Communications, General Drawing Application
Performance Prediction-Historical Aspects of Analysis, Materials Testing Factor of Safety, Consolidation of Safety in Structures and Devices, Computing Power, Fatigue Strength Prediction, Performance Prediction Methodology and Application, Checks and Balances

UNIT IV: DESIGN FOR TOTAL CONTROL **9**

Traditional Approaches, the Sustainability Umbrella Model. Total Design Control, A New Design Approach (The Umbrella of Sustainable Design), The Sustainable Design Function, Manufacturing, Lifetime Usage, Maintenance, End-of-Life Disposal

UNIT V: DRIVERS OF SUSTAINABILITY IN DESIGN **9**

Legislation, Effectiveness of International Environmental Regimes and Legislation, Non legislative Measurement and Guidance Tools, Other Drivers of Sustainable Design, Conclusion - Strategic Sustainable Design - Triple Bottom Line— The 3P Approach, Benefits to Producers and Buyers of Designed-in Sustainability, The Sustainability Measurement and Certification Industry, Predicting the Future - Unsustainable Futures, The Engineers' View, Conclusion **TOTAL: 45 PERIODS**

REFERENCES

1. Johnson & Gibson, Sustainability in Engineering Design, 1st Edition, Academic Press, 2014
2. David T. Allen, Sustainable Engineering: Concepts, Design and Case Studies, Prentice Hall Publications, 2011
3. Braden R. Allenby, The Theory and Practice of Sustainable Engineering, Prentice Hall Publications, 2011
4. Marc J. Epstein, Making Sustainability Work: Best Practices in Managing and Measuring Corporate Social, Environmental, and Economic Impacts, Greenleaf Publishing, 2014

COURSE CODE	SURFACE ENGINEERING	L	T	P	C
2162ME190		3	0	0	3

UNIT I: BASIC CONCEPTS OF TRIBOLOGY AND CORROSION **9**

Introduction to Tribology, Surface degradation, Wear and Corrosion, Types of Wear, Adhesive, Abrasive, Oxidative, Corrosive, Erosive and Fretting Wear, Roles of Friction and Lubrication – Overview of different forms of Corrosion, Introduction to Surface Engineering, Importance of Substrate

UNIT II: CHEMICAL / THERMOCHEMICAL TREATMENTS **9**

Chemical and Electrochemical Polishing, Significance, Specific Examples, Chemical Conversion Coatings, Phosphating, Chromating, Chemical Colouring, Anodizing of Aluminium Alloys, Thermochemical Processes – Industrial Practices

UNIT III: ELECTRO AND ELECTROLESS COATINGS **9**

Surface Pre-Treatment, Deposition of Copper, Zinc, Nickel and Chromium – Principles and Practices, Alloy Plating, Electro composite Plating, Properties of Electro Deposits, Electroless Plating of Copper, Nickel-Phosphorous, Nickel-Boron, Electroless Composite Plating, Application areas, Properties, Overview of Test Standards (ASTM) for assessment of Quality deposits

UNIT IV: VAPOUR DEPOSITION **9**

Definitions and Concepts, Physical Vapour Deposition (PVD), Evaporation, Sputtering, Ion Plating, Plasma Nitriding, Process Capabilities, Chemical Vapour Deposition (CVD), Metal Organic CVD, Plasma Assisted CVD, Specific Industrial Applications

UNIT V: SURFACING **9**

Thermal Spraying Techniques, Advanced Spraying Techniques – Plasma Surfacing, Detonation Gun and High Velocity Oxy-Fuel Processes, Laser Surface Alloying, Laser Cladding, Specific Industrial Applications, Test for Assessments of Wear and Corrosion behaviour of Surface Engineered Components

TOTAL: 45 PERIODS

REFERENCES

1. Sudarshan T.S, “Surface modification technologies” – An Engineer’s guide”, Marcel Dekker, Newyork, 1989
2. Varghese C.D, “Electroplating and other surface treatments – A Practical guide”, TMH, 1993
3. D. L.Smith. Thin-Film Deposition: Principles and Practice. McGraw-Hill, 1995.
4. M. Ohring. The Materials Science of Thin Films. Academic Press, 2001.
5. ASM Metals Hand Book, “Surface Engineering”, Volume 18, 9th Edition, 1998
6. Bunshah R.F, “Handbook of deposition technologies for films and coatings science and technology applications”, Noyes, New York, 1994.
7. L.I. Maissel and R. Glang (Eds.), Handbook of Thin film Technology, McGraw- Hill, 1970.

COURSE CODE	QUALITY, RELIABILITY AND STANDARDS	L	T	P	C
2162ME191		4	0	0	4

UNIT I: QUALITY CONCEPTS **12**

Basics of quality – Quality objectives – Quality control – Quality Assurance –Total Quality Control- Quality costs – Quality loss function – Statistical tolerancing – Seven tools of Quality

UNIT II: STATISTICAL PROCESS VARIABILITY AND CONTROL CHARTS **12**

Process Variability - Control charts for variables and attributes – Process capability studies

UNIT III: ACCEPTANCE SAMPLING **12**

Acceptance sampling by variables and attributes – ASN – ATI – AOQL - IS2500 plans – MIL STD 105E

UNIT IV: RELIABILITY CONCEPT AND LIFE DATA ANALYSIS **12**

Reliability definition – Quality and Reliability– Reliability – MTBF – MTTR – Reliability parameters – Mortality of a component –Mortality curve – Useful life- Data collection – Non-Parametric methods: Time to failure distributions: Exponential, Weibull – Probability plotting – Reliability modeling - Different configurations – Redundancy – k out of n system – Complex systems: RBD – Bayes approach – Cut and tie sets – Fault Trees – Standby Systems-Life testing methods

UNIT V: QUALITY STANDARDS **12**

ISO 9000, 9001,9002,9003 SYSTEMS – Environmental management – Implementation of Quality standards and their management- Management Representative roles- ES 14000 - quality standards- DIN standards.

TOTAL: 60 PERIODS

REFERENCES

1. Philips J.Ross, Taghuchi techniques for quality engineering, McGraw Hill, New York, 2005.
2. Douglas C.Montgomery, Introduction to statistical quality control, 6th Edition, John Wiley & sons, 2008.
3. E.L. Grant, and Leavensworth, Statistical Quality Control, McGraw Hill, 2007
4. Besterfield – Total Quality Control – McGraw hill, 1997
5. Charles Ebeling, An Introduction to Reliability and Maintainability Engineering, McGraw Hill Education; 12th edition, 2017.
6. Divya Singhal, Implementing ISO 9001: 2008 Quality Management System, Prentice Hall India Learning Private Limited; 2nd edition 2012.

COURSE CODE	ADVANCED FINITE ELEMENT METHODS	L	T	P	C
2162ME192		4	0	0	4

UNIT I : INTRODUCTION **12**

Modeling and Discretization – Interpolation, Elements, Nodes and degrees-of-freedom - Computational Procedures–Stiffness Matrices – Boundary Conditions-Solution of Equations- Ritz method, Variational Method, Method of weighted residuals, etc – Boundary Element Technique

UNIT II: BASIC ELEMENTS **12**

Interpolation and shape functions - element matrices-linear triangular elements (CST)-quadratic triangular elements – bilinear rectangular elements-quadratic rectangular elements-solid elements-higher order elements-nodal loads-stress calculations-example problems

UNIT III: ISOPARAMETRIC ELEMENTS **12**

Introduction-bilinear quadrilateral elements – quadratic quadrilaterals – hexahedral elements – Determination of Shape Functions – Numerical Integration – quadrature – static condensation – load considerations –stress calculations -examples of 2D and 3D applications.

UNIT IV: FINITE ELEMENT FORMULATION FOR STRUCTURAL APPLICATIONS **12**

Linear elastic stress analysis-2D and axisymmetric problems –Structural vibration – mass and damping matrices – damping – Harmonic response – direct integration techniques – explicit and implicit methods– Case studies.

UNIT V: HEAT TRANSFER AND FLUID MECHANICS APPLICATIONS **12**

Nonlinear Problems – Element formulation – Heat Conduction and Fluid flow – Transient Thermal Analysis - Incompressible and rotational flow – Applications for heat conduction and 2D stress analysis- Case Studies.

TOTAL: 60 PERIODS

REFERENCES

1. Chandrupatla & Belagundu, “Finite Elements in Engineering”, Prentice Hall of India Private Ltd., 2010.
2. C.A. Brebbia and S. Walker, Boundary Element Techniques in Engineering, Newness Butterworths, 2011.
3. Cook, Robert Davis et al, Concepts and Applications of Finite Element Analysis, Wiley, John & Sons, 2012.
4. O.C.Zienkiewicz, The Finite Element Method, 3rd Edition, Tata McGraw-Hill, 2010.
5. C.S. Desai and J.F. Abel, Introduction to Finite Element Method, Affiliated East- West Press, 2012.

CURRICULUM AND SYLLABUS

for

M. Tech. – Robotics

FOUNDATION COURSE					
Code	**Course**	**L**	**T**	**P**	**C**
		3	2	0	4

PROGRAM CORE COURSES					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
THEORY					
2161ME140	Introduction to Robotics	3	0	0	3
2161ME141	Microcontroller and applications	3	0	0	3
2161ME142	Robot drives, actuators and controls	3	0	0	3
2161ME143	Robotic Sensors	3	0	0	3
2161ME144	Robot Dynamics & Analysis	3	2	0	4
2161ME174	Design of Mobile Robots	3	0	0	3
2161ME146	Advanced Mechanisms	3	0	0	3
2161ME147	Robot programming and industrial automation	3	0	0	3
2161ME148	Robot Vision	3	0	0	3
PRACTICAL					
2161ME311	Mechatronics Laboratory	0	0	2	1
2161ME312	Robotics Laboratory	0	0	2	1
				Total Credits	**30**

PRORAM ELECTIVE COURSES (ANY FOUR)					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
2162ME161	Industrial Automation	3	0	0	3
2162ME162	Adaptive Control	3	0	0	3
2162ME163	Automotive Virtual Instrumentation	3	0	0	3
2162ME164	Embedded Control systems	3	0	0	3
2162ME165	Real time Operating Systems	3	0	0	3
2162ME166	Advanced control systems	3	0	0	3
2162ME126	Design of Material Handling Equipment	3	0	0	3
2162ME167	Industrial Robotics	3	0	0	3
2162ME168	Optimization Techniques for Automation	3	0	0	3
2162ME169	Flexible Manufacturing System	3	0	0	3
2162ME170	Mems & Nano Technology	3	0	0	3
2162ME198	Manufacturing Systems Automation	3	0	0	3
2162ME199	Robot Economics	3	0	0	3
				Total Credits	**12**

INDEPENDENT LEARNING COURSES					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
	Massive Open Online Course	-	-	-	2
2163ME501	Research Seminar [**OR**]	-	-	-	
2163ME801	Field Study [**OR**]	-	-	-	2
2163ME802	Internship	-	-	-	
2163GE401	Business Communication [**OR**]	-	-	-	2
2163GE402	Technical Writing Tools	-	-	-	
2163MG401	Research Methodology	-	-	-	2
				Total Credits	**8**

PROJECT WORK					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
2164ME601	Project Phase I	0	0	20	10
2164ME701	Project Phase II	0	0	32	16
				Total Credits	**26**

PROGRAMME STRUCTURE AND MINIMUM CREDITS REQUIRED

IN COURSE CATEGORIES

SECTION NUMBER	COURSE CATEGORY	MINIMUM CREDITS REQUIRED
7.2.1	**FOUNDATION COURSE**	**04**
7.2.2	**PROGRAM CORE COURSES**	**30**
7.2.3	**PROGRAM ELECTIVE COURSES**	**12**
7.2.4	**INDEPENDENT LEARNING COURSES**	**8**
7.2.5	**PROJECT WORK**	**26**
	TOTAL CREDITS	**80**

PROGRAM CORE COURSES

COURSE CODE	INTRODUCTION TO ROBOTICS	L	T	P	C
2161ME140		3	0	0	3

UNIT I: Introduction **9**

Robot definition, Robotics and programmable automation Historical background, laws of Robotics. Robotics systems and Robot anatomy, specification of Robots. Robot geometrical configuration.

UNIT II: Mathematics for Robot Manipulation **9**

Homogeneous coordinate transformations, Mathematical description of objects. Description of a wedge by transformation matrices, Relative transformations in the robot workspace. Description of manipulator joints, Assignment of coordinate systems to robot joint and derivation of transformation matrices.

UNIT III: Robot and End Effectors **9**

Introduction, classification of end effectors, Types of Grippers Hooks, scoops and other devices, Gripper force analysis and design of Drive system for gripper.

UNIT IV: Coordinate Systems in Robot Applications **9**

Euler angles for specifying orientation, Euler angles for roll-yaw-roll geometry, Gripper positioning by Euler angles for roll-yaw-roll geometry - Euler angles for roll - pitch - yaw geometry, Cylindrical Robot coordinates polar Robot coordinates, calculation of cylindrical, polar coordinates, Some applications.

UNIT V: Robot Languages and Programming **9**

Programming – powered, manual. Textual robo languages – first generation, second, future generation – VAL, VAL II, simple programming – exercises.

TOTAL: 45 PERIODS

Required Resources:

1. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. International Student edition, 1999.
2. Mikell P. Grover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, Industrial Robotics, Technology programming and Applications, McGraw Hill International Edition, 1986

Recommended Resources:

1. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics Control, Sensing Vision and Intelligence, McGraw Hill Book Company, 1987
2. F. L. Lewis, D. M. Dawson and C. T. Abdallah, Robot Manipulator Control Theory and Practice, Prentice-Hall, Second edition, 2006.

Web Resources:

1. http://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/lecture-notes/
2. http://cs.stanford.edu/groups/manips/teaching/cs223a/

COURSE CODE	MICROCONTROLLER AND APPLICATIONS	L	T	P	C
2161ME141		3	0	0	3

UNIT I: 8051 Architecture **9**

Introduction to 8085 Architecture-Basic organization – 8051 CPU structure – Register file – Interrupts – Timers – Port circuits – Instruction set – Timing diagram – Addressing modes – Simple Program and Applications- Introduction to ARM 32 bit controllers.

UNIT II: Peripherals and Interfacing **9**

Typical Bus structure – Bus – memory organization – Timing characteristics – Extended Model and Memory Interfacing – Polling – Interfacing Basic I/O devices – Analog and Digital interfacing – PWM mode operation – Serial port application.

UNIT III: 8096 Architecture **9**

CPU operation – Interrupt structure – Timers – High Speed Input / Output Ports – I/O control and Status registers – Instruction Set – Addressing Modes – Simple Programming – Queues – Tables and Strings – Stack Memories – Key Switch – Parsing.

UNIT IV: Peripherals and Interfacing **9**

Analog Interface – Serial Ports – Watch dog timers – Real Time Clock – Multitasking – Bus Control – Memory Timing – External ROM and RAM expansion – PWM control – A/D interfacing.

UNIT V: Case Study for 8051 and 8096 **9**

Real Time clock – DC Motor Speed Control – Generation of Gating Signals for converters and Inverters -Frequency Measurement -Temperature Control,Basic ARM 32 bit processors, ARM cortex M.

TOTAL: 45 PERIODS

Required Resources:

1. Muhammad Ali Mazidi, Janice Gillispiemazidi. “The 8051 Microcontroller and Embedded systems”, Person Education, 2004.
2. Ayala, Kenneth, “The 8051 Microcontroller” Upper Saddle River, New Jersey Prentice Hall, 2000.

Recommended Resources:

1. John B. Peatman, “Design with Micro controllers”, McGraw Hill international Limited Singapore, 1989.
2. Michael Slater, “Microprocessor based design A comprehensive guide to effective Hardware design” Prentice Hall, New Jersey, 1989.
3. Microprocessor &Microcontroller- Author: Krishnakant, PHI
4. Microcontroller &Microcomputer Principles of H/W &S/W Engg- Author: F.M Cady-Oxford.

Web Resources:

1. This course uses exclusively for providing electronic resource, such as lecturer notes, assignment papers, and sample solutions. Students should make appropriate use of this recourse.www.nptel.in, http://nptel.iitm.ac.in/

COURSE CODE	ROBOT DRIVES, ACTUATORS AND CONTROLS	L	T	P	C
2161ME142		3	0	0	3

UNIT I: Robot Drive Mechanism **9**

Objectives, motivation, open loop control, closed loop control with velocity and position feed back, Types of drive systems. Functions of drive system. Lead Screws, Ball Screws, Chain & linkage drives, Belt drives, Gear drives, Precision gear boxes, Harmonic drives, Cyclo speed reducers.

UNIT II: Hydraulic Drives **9**

Introduction, Requirements, Hydraulic piston and transfer valve, hydraulic circuit incorporating control amplifier, hydraulic fluid considerations, hydraulic actuators Rotary and linear actuators. Hydraulic components in robots.

UNIT III: Pneumatic Drives **9**

Introduction, Advantages, pistons-Linear Pistons, Rotary pistons, Motors-Flapper motor, Geared motor, Components used in pneumatic control. Pneumatic proportional controller, pneumatically controlled prismatic joint.

UNIT IV: Electric Drives **9**

Introduction, Types, DC electric motor, AC electric motor, stepper motors, half step mode operation, micro step mode. Types of stepper motors, Direct drive actuator

UNIT V: Servo Systems For Robot Control **9**

General aspects of robot control. Basic control techniques, mathematical modeling of robot servos, error responses and steady state errors in robot servos, feed back and feed forward compensations, hydraulic position servo, computer-controlled servo system for robot applications, selection of robot drive systems. **TOTAL: 45 PERIODS**

Required Resources:

1. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. International Student edition, 1999
2. Richard D. Klafter, Thomas. A Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 1989

Recommended Resources:

1. Francis N-Nagy AndrasSiegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987
2. Richard D. Klafter, Thomas. A, Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 1989
3. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata McGraw Hill Publishing company Ltd., 1995
4. Mikell P. Groorer, Mitchell welss, Roger N. Nagel, Nicholas G.Odrey, Industrial Robotics, Technology programming and Applications, McGraw Hill International Edition, 1986
5. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing house, 1993
6. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2000
7. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2001.

COURSE CODE	ROBOTIC SENSORS	L	T	P	C
2161ME143		3	0	0	3

UNIT I: Introduction **9**

An Introduction to sensors and Transducers, History and definitions, Smart Sensing, AI sensing, Need of sensors in Robotics.

UNIT II: Sensors In Robotics **9**

Position sensors - optical, non-optical, Velocity sensors, Accelerometers, Proximity Sensors - Contact, non-contact, Range Sensing, touch and Slip Sensors, Force and Torque Sensors

UNIT III: Miscellaneous Sensors In Robotics **9**

Different sensing variables - smell, Heat or Temperature, Humidity, Light, Speech or Voice recognition Systems, Telepresence and related technologies.

UNIT IV: Vision Sensors In Robtics **9**

Robot Control through Vision sensors, Robot vision locating position, Robot guidance with vision system, End effector camera Sensor

UNIT V: Multisensor Controlled Robot Assembly **9**

Control Computer, Vision Sensor modules, Software Structure, Vision Sensor software, Robot programming, Handling, Gripper and Gripping methods, accuracy - A Case study.

TOTAL: 45 PERIODS

Required Resources:

1. Paul W Chapman, "Smart Sensors", an Independent Learning Module Series, 1996
2. Richard D. Klafer, Thomas a. Chmielewski; Michael Negin, "Robotic Engineering - An integrated approach", Prentice Hall of India Private Limited, 1989

Recommended Resources:

1. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics - Control Sensing, Vision and Intelligence", McGraw Hill International Editions, 1987
2. Mikell P. Groover, Mitchell Weiss, Roger N Nagel, Nicholas G. Odrey, "Industrial Robotics - Technology, Programming and Applications", McGraw Hill, International Editions, 1986
3. Sabric Soloman, "Sensors and Control Systems in Manufacturing", McGraw Hill, International Editions, 1994
4. Julian W Gardner, Micro Sensor MEMS and Smart Devices, John Wiley & Sons, 2001
5. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robtics and Automation Sensor - Based integration, Academic Press, 1999
6. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics Control, Sensing Vision and Intelligence, McGraw Hill Book Company, 1987

Web Resources:

1. This course uses exclusively for providing electronic resource, such as lecturer notes, assignment papers, and sample solutions. Students should make appropriate use of this recourse. www.nptel.inhttp://nptel.iitm.ac.in/

COURSE CODE	ROBOT DYNAMICS & ANALYSIS	L	T	P	C
2161ME144		3	2	0	4

UNIT I: Introduction **12**

Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector.

UNIT II: Direct Kinematics **12**

Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates, link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and six axis Articulated Robots.

UNIT III: Inverse Kinematics **12**

The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and six axis Articulated robot.

UNIT IV: Workspace Analysis and Trajectory Planning **12**

Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, continuous path motion, Interpolated motion, straight line motion.

UNIT V: Manipulator Dynamics **12**

Introduction, lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot Newton Euler formulation, Lagrange - Euler formulation, problems.

TOTAL: 60 PERIODS

Required Resources:

1. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. Pearson India, 2008.
2. F. L. Lewis, D. M. Dawson and C. T. Abdallah, Robot Manipulator Control Theory and Practice, Prentice-Hall, Second edition, 2006.

Recommended Resources:

1. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics Control, Sensing Vision and Intelligence, McGraw Hill Book Company, 1987
2. R. N Jazar, Theory of Applied Robotics: Kinematics, Dynamics, and Control,Springer; 2nd ed. 2010.

Web Resources:

1. http://www.cs.cmu.edu/~cga/kdc-06/lecture-2d-kd/
2. http://robotics.cucei.udg.mx/Index_files/notes/Dynamics.pdf
3. http://rrg.utcluj.ro/~robo/curs/3.Dynamics.pdf

COURSE CODE	DESIGN OF MOBILE ROBOTS	L	T	P	C
2161ME174		3	0	0	3

UNIT I: INTRODUCTION OF MOBILE ROBOT **9**

Main historical landmarks of general robotics and mobile robots - locomotion issues of ground (wheeled, legged) mobile robots, wheel and drive types of mobile robots (non-holonomic, omnidirectional) - concepts of mobile robot - degree of mobility, degree of steer ability and manoeuvrability.

UNIT II: MOBILE ROBOTICS KINEMATICS **9**

Fundamental analytical concepts required for the study of mobile robot kinematics - kinematic models of non-holonomic mobile robots (unicycle, differential drive, tricycle, and car-like wheeled mobile robots (WMRs)) - kinematic models of 3-wheel, 4-wheel, and multi-wheel omnidirectional WMRs.

UNIT III: MOBILE ROBOT DYNAMICS **9**

Dynamic modelling concepts and techniques of robots - study the dynamics of differential - drive mobile robots with longitudinal and lateral slip - derive a dynamic model of car - like WMRs - derive a dynamic model of three-wheel omnidirectional robots - derive a dynamic model of four - wheel mecanum omnidirectional robots.

UNIT IV: MOBILE ROBOT SENSOR SYSTEM **9**

Popular classification of sensors, along with their operational features - sonar, laser, and infrared sensors - outline of robotic vision and its principal functions (including unidirectional vision) - list the operation principles of gyroscope, compass, and force/tactile sensors - give a brief introduction to the global positioning system.

UNIT V: MOBILE ROBOTS AT WORKS **9**

Mobile robots and manipulators in the factory and industry - robots in the society (rescue, guidance, hospital) - mobile robots for home services (cleaning, other services) - assistive mobile robots (autonomous wheelchairs, service mobile manipulators for the impaired), mobile tele-robots and web robots, other mobile robot applications.

TOTAL = 45 PERIODS

LEARNING RESOURCES:

1. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, Industrial Robotics, Technology programming and Applications, McGraw Hill International Edition, 2014
2. Roland Siewart, Illah R, Nourbakhsh, Davide Scaramuzza. Introduction to autonomous mobile robot 2e, 2011
3. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics Control, Sensing Vision and Intelligence, McGraw Hill Book Company, 2008
4. Skubch, Hendrik, Modeling and Controlling Behavior for of Autonomous Mobile Robots, 2013
5. https://www.sciencedirect.com/science/article/pii/B9780128042045000019

COURSE CODE	ADVANCED MECHANISMS	L	T	P	C
2161ME146		3	0	0	3

UNIT I: VELOCITY AND ACCELERATION ANALYSIS OF MECHANISMS **9**

Review of kinematic analysis-mobility, displacement, velocity and acceleration analysis of mechanisms – Plane Complex mechanisms – Goodman Analysis – Auxiliary point method.

UNIT II: PATH CURVATURE THEORY **9**

Fixed and Moving centrodes, Inflection points and Inflection circle. Euler Savary equation, Graphical constructions – Cubic of stationary curvature.

UNIT III: KINEMATIC SYNTHESIS **9**

Kinematic synthesis - Function generation, path generation and rigid body guidance – Type synthesis, Number Synthesis – Cognate Linkage – Coupler curve synthesis – Algebraic methods – application of instant centre in linkage design.

UNIT IV: DYNAMICS OF MACHINES **9**

Static force analysis with friction – Inertia force analysis – combined static and inertia analysis.

UNIT V: SPATIAL MECHANISM AND ROBOTICS **9**

Kinematic analysis of spatial RSSR mechanism – Denavit – Hartenberg parameters. Forward and inverse kinematics of robotic manipulators. Tutorial and use of mechanical software packages.

TOTAL: 45 PERIODS

Required Resources:

1.George N. Sandor and A.G. Erdman, Advanced Mechanism Design analysis and Synthesis, Vol.1 and 2, Prentice Hall of India, 2012.

2. Shigley J.E and Uicker J.J., Theory of Machines and Mechanisms, McGraw Hill, 2010

Recommended Resources:

1. Hall, Kinematics and Linkage Design, Prentice Hall, 2009.

2. Robert L. Norton, Design of Machinery, McGraw Hill, 2009

3. Hartenberg and Denavit, Kinematics and synthesis of linkages, McGraw Hill, 2010

4. J.Hirschhorn, Kinematics and Dynamics of Plane Mechanisms, McGraw Hill, 2011

Web Resources

1. This course uses various resources, such as lecturer notes, materials from electronic media, assignment papers, and sample solutions. Students should make appropriate use of these resources.
2. www.nptel.ac.in

COURSE CODE	ROBOT PROGRAMMING AND INDUSTRIAL AUTOMATION	L	T	P	C
2161ME147		3	0	0	3

UNIT I: INTRODUCTION TO ROBOT PROGRAMMING **9**

Robot software functions - coordinate systems, position control, other control functions, subroutines, Program planning for Robot flow charting for robot programs with few examples.

UNIT II: METHODS OF ROBOT PROGRAMMING **9**

Online programming, off-line programming, advantages of off-line programming, lead through methods - powered lead through, manual lead through, Teach pendant, Robot program as a path in space, defining position in space, motion interpolation, WAIT, SIGNAL and DELAY commands, Branching capabilities and Limitations of head through methods.

UNIT III: ROBOT LANGUAGES **9**

Textual ROBOT Languages, first generation and second generation languages, structure of a robot language - operating systems, Elements and Functions, constants, variables and other data objects, Motion commands, points in workspace, End effector and sensor commands, computations and operations, program control and subroutines, communications and Data processing.

UNIT IV: AUTOMATION **9**

Case studies, multiple robots, machine interface, robots in manufacturing and non-manufacturing applications, robot cell design, selection of a robot. Factory automation-Flexible Manufacturing Systems concept – Automatic feeding lines, transfer lines, automatic inspection – Computer Integrated Manufacture – CNC, intelligent automation, Industrial networking, bus standards.

UNIT V: AUTOMATED INSPECTION AND TESTING **9**

Automated Inspection and Testing: Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods.

TOTAL: 45 PERIODS

Recommended Resources:

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. Bernard Hodges, 'Industrial Robotics', Second Edition, Jaico Publishing House, 1993.
3. Asfahl C.R, Robots and Manufacturing Automation, John Wiley & Sons, 1992.
4. Mikell P Groover, Automation Production Systems and Computer Integrated Manufacturing, Second edition.
5. N.Viswanadham and Y.Narahari, Performance Modeling of Automated Manufacturing Syetms,Printice Hall India Pvt. Ltd.
6. Stephen J. Derby, Design of Automatic Machinary, Special Indian Edition, Marcel Decker, New York,Yesdee publishing Pvt. Ltd, Chennai

Web Resources:

1. This course uses exclusively for providing electronic resource, such as lecturer notes, assignment papers, and sample solutions. Students should make appropriate use of this resource. www.nptel.in http://nptel.iitm.ac.in/

COURSE CODE	ROBOT VISION	L	T	P	C
2161ME148		3	0	0	3

UNIT I: ELEMENTS OF IMAGE PROCESSING **9**

Introduction, Discretization, preprocessing, Neighbourhood averaging, Mediun filtering. Smoothening of binary images. Thresholding, Edge detection

UNITII: IMAGING COMPONENTS **9**

Point sensor, line sensor, planar sensor, camera transfer characteristic, Raster scan, Image capture time, volume sensors, Image representation, picture coding techniques.

UNIT III: OBJECT RECOGNITION BY METHOD OF MOMENTS **9**

Introduction, Feature set, Recognition procedure, mahalanobic procedure, Template - matching, structural techniques.

UNIT IV: COLLISON FRONTS ALGORITHM **9**

Introduction, skeleton of objects. Gradients, propagation, Definitions, propagation algorithm, Thinning Algorithm, Skeleton lengths of Top most objects.

UNIT V: NEED FOR VISION TRAINING AND ADAPTATIONS **9**

Review of existing systems - Binary, Gray level, structure of light, character recognition system, examples. Automatic part Recognition by SRI vision system - Automated Navigation guidance by vision system - A case study.

TOTAL : 45 PERIODS

Required Resources:

1. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata McGraw Hill Publishing company Ltd., 1995
2. Richard D. Klafter, Thomas. A Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 1989

Recommended Resources:

1. Richard D. Klafter, Thomas. A Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 1989
2. Mikell P. Groover, Mitchell weiss, Roger N. Nagel, Nicholas G.Odrey, Industrial Robotics, Technology programming and Applications, 1986
3. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. International Student edition, 1999
4. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robtics and Automation Sensor - Based integration, Academic Press, 1999
5. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw Hill Publishing company Ltd., 1994
6. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics Control, Sensing Vision and Intelligence, McGraw Hill Book Company, 1987

Web Resources:

1. This course uses exclusively for providing electronic resource, such as lecturer notes, assignment papers, and sample solutions. Students should make appropriate use of this recourse.www. nptel.in,
2. http://nptel.iitm.ac.in/

COURSE CODE	MECHATRONICS LABORATORY	L	T	P	C
2161ME311		0	0	4	2

LIST OF EXPERIMENTS

1. Design and control of following circuits using Breadboard
   (a)Light Activated LED (b) Dark Activated LED
2. Design the circuit for Home Security Alarm system
3. Design of circuits with logic sequence using Electro pneumatic trainer kits.
4. Simulation of basic Hydraulic, Pneumatic and Electric circuits using Automation Software
5. Circuits with multiple cylinder sequences in Electro pneumatic using PLC
6. Speed Control of AC & DC drives with PID controller interfacing
7. Stepper motor interfacing with 8051 Micro controller
   (a) Full step resolution (b) Half step resolution
8. Modeling and analysis of basic electrical, hydraulic and pneumatic systems using LAB VIEW
9. Computerized data logging system with control for process variables like (a) Pressure (b) Flow (c) Temperature.

TOTAL: 30 PERIODS

COURSE CODE	ROBOTICS LABORATORY	L	T	P	C
2161ME312		0	0	4	2

LIST OF EXPERIMENTS

1. Forward Kinematic Study – Articulated Robot
2. Programming Robot Arm for Straight Line, Circular and igzag Motions.
3. Arduino based Programming based – Assembling and/Blinking
4. Study on Robotics applications-Quad rotor experiment
5. Programming of Bipedal Walking Robot/Blinking LED
6. Modeling and PID characteristics of DC Motor speed control using Matlab
7. Design of Bread Board based autonomous robot – Glowing/Blinking LED
8. Design of Bread Board based autonomous robot – Line follower, Light tracing Bot, obstacle avoider
9. Study on Mobile Robotic platform – Embedded C and Assembly Language Programming for microcontrollers

TOTAL: 30 PERIODS

PRORAM ELECTIVE COURSES

COURSE CODE	INDUSTRIAL AUTOMATION	L	T	P	C
2162ME161		3	0	0	3

UNIT I REVIEW OF COMPUTERS IN PROCESS CONTROL: 9

Data loggers, Data Acquisition Systems (DAS), Direct Digital Control (DDC). Supervisory Control and Data Acquisition Systems (SCADA), sampling considerations. Functional block diagram of computer control systems. alarms, interrupts. Characteristics of digital data, controller software, linearization. Digital controller modes: Error, proportional, derivative and composite controller modes.

UNIT II PROGRAMMABLE LOGIC CONTROLLER (PLC) BASICS: 9

Definition, overview of PLC systems, input/output modules, power supplies, isolators. General PLC programming procedures, programming on-off inputs/ outputs. Auxiliary commands and functions: PLC Basic Functions: Register basics, timer functions, counter functions.

UNIT III PLC INTERMEDIATE FUNCTIONS: 9

Arithmetic functions, number comparison functions, Skip and MCR functions, data move systems. PLC Advanced intermediate functions: Utilizing digital bits, sequencer functions, matrix functions. PLC Advanced functions: Alternate programming languages, analog PLC operation, networking of PLC, PLC-PID functions, PLC installation, troubleshooting and maintenance, design of interlocks and alarms using PLC. Creating ladder diagrams from process control descriptions.

UNIT IV INTERFACEAND BACKPLANE BUS STANDARDS FOR INSTRUMENTATION SYSTEMS. 9

Field bus: Introduction, concept. HART protocol: Method of operation, structure, operating conditions and applications. Smart transmitters, examples, smart valves and smart actuators.

UNIT V DISTRIBUTEDCONTROL SYSTEMS (DCS) AND SCADA: 9

Definition, Local Control (LCU) architecture, LCU languages, LCU - Process interfacing issues, communication facilities, configuration of DCS, displays, redundancy concept - case studies in DCS - - Basic building blocks of Computer controlled systems – SCADA **TOTAL: 45 PERIODS**

Required Resources:

1. John. W.Webb Ronald A Reis , Programmable Logic Controllers - Principles and Applications, Third edition, Prentice Hall Inc., New Jersey, 1995.
2. Lukcas M.P Distributed Control Systems, Van Nostrand Reinhold Co., New York, 1986.

Recommended Resources:

1. Deshpande P.B and Ash R.H, Elements of Process Control Applications, ISA Press, New York, 1995.
2. Curtis D. Johnson, Process Control Instrumentation Technology, Fourth edition, Prentice Hall of India, New Delhi, 1999.
3. MikellP.Groover, "Automation, Production Systems and Computer Integrated Manufacturing" PHI, 2003.
4. Weatherall, "Computer Integrated Manufacturing – A total company strategy", 2ndedition, 1995.

Web Resources:

1. This course uses exclusively for providing electronic resource, such as lecturer notes, assignment papers, and sample solutions. Students should make appropriate use of this recourse.www. nptel.inhttp://nptel.iitm.ac.in/, www.engineersgarage.com/articles/scada-systems

COURSE CODE	ADAPTIVE CONTROL	L	T	P	C
2162ME162		3	0	0	3

UNIT I: INTRODUCTION **9**

Introduction- Adaptive Schemes- The adaptive Control Problem- Applications- Real-time parameter estimation: - Least squares and regression methods- Estimating parameters in dynamical systems

UNIT II: GAIN SCHEDULING **9**

Introduction- The principle - Design of gain scheduling controllers- Nonlinear transformations - application of gain scheduling - Auto-tuning techniques:- Methods based on Relay feedback

UNIT III: DETERMINISTIC SELF-TUNING REGULATORS **9**

Introduction- Pole Placement design - Indirect Self-tuning regulators - direct self-tuning regulators – Disturbances with known characteristics

UNIT IV: STOCHASTIC AND PREDICTIVE SELF-TUNING REGULATORS **9**

Introduction – Design of minimum variance controller - Design of moving average controller - stochastic self-tuning regulators

UNIT V: MODEL – REFERENCE ADAPTIVE SYSTEM **9**

Introduction- MIT rule – Determination of adaptation gain - Lyapunov theory –Design of MRAS using Lyapunov theory – Relations between MRAS and STR

TOTAL: 45 PERIODS

Required Resources:

1. K.J. Astrom and B. J. Wittenmark, “Adaptive Control”, Addison-Wesley Publishing House, 1995.

2. Chalam, V.V., “Adaptive Control Systems”, Techniques & Applications, Marcel Dekker, Inc. NY and Basel, 1987.

Recommended Resources:

1. T. Soderstorm and Peter Stoica, “System Identification”, Prentice Hall International, 1989.

2. Ljung L, “System Identification: Theory for the user”, Prentice Hall, Englewood Cliffs, 1987.

Web Resources:

1. http://home.iitk.ac.in/~premkani/Lecture/Basics-Adaptive-Control_DDEB.pdf
2. http://image.sciencenet.cn/olddata/kexue.com.cn/upload/blog/file/2009/9/2009930810151118.).pdf
3. http://www.eecs.berkeley.edu/~ananth/223Fall08/Textbook.pdf

COURSE CODE	AUTOMOTIVE VIRTUAL INSTRUMENTATION	L	T	P	C
2162ME163		3	0	0	3

UNIT I: VIRTUAL INSTRUMENTATION **10**

Historical perspective, advantages, blocks diagram and architecture of a virtual instrument, data-flow techniques, graphical programming in data flow, comparison with conventional programming. Development of Virtual Instrument using GUI, Real-time systems, Embedded Controller, OPC, HMI / SCADA software, Active X programming.

UNIT II: PROGRAMMING TECHNIQUES **08**

VIS and sub-VIS, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O, Instrument Drivers, Publishing measurement data in the web.

UNIT III: DATA ACQUISITION BASICS **09**

Introduction to data acquisition on PC, Sampling fundamentals, Input/output techniques and buses. ADC, DAC, Digital I/O, counters and timers, DMA, Software and hardware installation, Calibration, Resolution, Data acquisition interface requirements.

UNIT VI: CHASSIS REQUIREMENTS **09**

Common Instrument Interfaces: Current loop, RS 232C/ RS485, GPIB. Bus Interfaces: USB, PCMCIA, VXI, SCSI, PCI, PXI, Fire wire. PXI system controllers, Ethernet control of PXI. Networking basics for office & Industrial applications, VISA and IVI.

UNIT V: TOOL SETS **09**

Distributed I/O modules. Application of Virtual Instrumentation: Instrument Control, Development of process database management system, Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion control. **TOTAL: 45 PERIODS**

Required Resources:

1. Gary Johnson, Lab VIEW Graphical Programming, Second edition, McGraw Hill, Newyork, 1997.
2. Lisa K. wells & Jeffrey Travis, Lab VIEW for everyone, Prentice Hall, New Jersey, 1997.

Recommended Resources:

1. Kevin James, PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control, Newnes, 2000.
2. Dr. S.S Thipse, Alternative Fuels, Jaico Publications, 2010.
3. Ganesan.V, Internal Combustion Engines, Tata McGraw Hill, 1994.
4. Crouse.W.M, Anglin.A.L. Automotive Emission Control, McGraw Hill 1995.
5. Patterson, D.J, Henin.N.A, Emissions from Combustion engines and their Control, Anna Arbor Science, 1985. Linden.D, Handbook of Batteries and Fuel Cells, McGraw Hill, 1995.
6. Maxwell et al, Alternative Fuel : Emission, Economic and Performance, SAE, 1995
7. Holt and Danniel, Fuel cell powered vehicles: Automotive technology for the future, SAE, 2001.
8. Vora K C &Ghosh B, Monograph on Automotive Catalytic Converter, ARAI Publication, 1995.

Web Resources:

1. This course uses exclusively for providing electronic resource, such as lecturer notes, assignment papers, and sample solutions. Students should make appropriate use of this resource. www.nptel.in. http://nptel.iitm.ac.in/

COURSE CODE	EMBEDDED CONTROL SYSTEMS	L	T	P	C
2162ME164		3	0	0	3

UNIT I: INTRODUCTION **9**

Controlling the hardware with software – Data lines – Address lines - Ports – Schematic representation – Bit masking – Programmable peripheral interface – Switch input detection – 74 LS 244

UNIT II: INPUT-OUTPUT DEVICES **9**

Keyboard basics – Keyboard scanning algorithm – Multiplexed LED displays – Character LCD modules – LCD module display – Configuration – Time-of-day clock – Timer manager - Interrupts - Interrupt service routines – IRQ - ISR - Interrupt vector or dispatch table multiple-point - Interrupt-driven pulse width modulation.

UNIT III: D/A AND A/D CONVERSION **9**

R 2R ladder - Resistor network analysis - Port offsets - Triangle waves analog vs. digital values - ADC0809 – Auto port detect - Recording and playing back voice - Capturing analog information in the timer interrupt service routine - Automatic, multiple channel analog to digital data acquisition.

UNIT IV: ASYNCHRONOUS SERIAL COMMUNICATION **9**

Asynchronous serial communication – RS-232 – RS-485 – Sending and receiving data – Serial ports on PC – Low-level PC serial I/O module - Buffered serial I/O.

UNIT V: CASE STUDIES: EMBEDDED C PROGRAMMING **9**

Multiple closure problems – Basic outputs with PPI – Controlling motors – Bi-directional control of motors – H bridge – Telephonic systems – Stepper control – Inventory control systems.

TOTAL: 45 PERIODS

Required Resources:

1. Jean J. Labrosse, “Embedded Systems Building Blocks: Complete and Ready-To-Use Modules in C”, The publisher, Paul Temme, 1999.
2. Ball S.R., ‘Embedded microprocessor Systems – Real World Design’, Prentice Hall, 1996.

Recommended Resources:

1. Herma K, “Real Time Systems – Design for distributed Embedded Applications”, Kluwer Academic, 1997.
2. Daniel W. Lewis, “Fundamentals of Embedded Software where C and Assembly meet”, PHI, 2002.

Web Resources:

1. This course uses exclusively for providing electronic resource, such as lecturer notes, assignment papers, and sample solutions. Students should make appropriate use of this recourse.www. nptel.inhttp://nptel.iitm.ac.in/

COURSE CODE	REAL TIME OPERATING SYSTEMS	L	T	P	C
2162ME165		3	0	0	3

UNIT I: REVIEW OF OPERATING SYSTEMS **9**

Basic Principles - Operating System structures – System Calls – Files – Processes – Design and Implementation of processes – Communication between processes – Introduction to Distributed operating system – Distributed scheduling.

UNIT II: OVERVIEW OF RTOS **9**

RTOS Task and Task state - Process Synchronisation- Message queues – Mail boxes - pipes – Critical section – Semaphores – Classical synchronisation problem – Deadlocks

UNIT III: REAL TIME MODELS AND LANGUAGES **9**

Event Based – Process Based and Graph based Models – Real Time Languages – RTOS Tasks – RT scheduling - Interrupt processing – Synchronization – Control Blocks – Memory Requirements.

UNIT IV: REAL TIME KERNEL **9**

Principles – Design issues – Polled Loop Systems – RTOS Porting to a Target – Comparison and study of various RTOS like QNX – VX works – PSOS – C Executive – Case studies.

UNIT V: RTOS APPLICATION DOMAINS **9**

RTOS for Image Processing – Embedded RTOS for voice over IP – RTOS for fault Tolerant Applications – RTOS for Control Systems.

Recommended Resources:

1. Raj Kamal, “Embedded Systems- Architecture, Programming and Design” Tata McGraw Hill, 2006.
2. Herma K., “Real Time Systems – Design for distributed Embedded Applications”, Kluwer Academic, 1997.
3. Charles Crowley, “Operating Systems-A Design Oriented approach” McGraw Hill 1997.
4. C.M. Krishna, Kang, G.Shin, “Real Time Systems”, McGraw Hill, 1997.
5. Raymond J.A.Bhur, Donald L.Bailey, “An Introduction to Real Time Systems”, PHI 1999.
6. MukeshSighal and N G Shi “Advanced Concepts in Operating System”, McGraw Hill 2000.

Web Resources:

1. This course uses exclusively for providing electronic resource, such as lecturer notes, assignment papers, and sample solutions. Students should make appropriate use of this resource. www.nptel.in http://nptel.iitm.ac.in/
2. http://www.cis.upenn.edu/~lee/06cse480/lec-RTOS_RTlinux.pdf
3. http://www.iar.com/Global/Resources/Developers_Toolbox/RTOS_and_Middleware/Basic_Concepts_for_Real_Time_Operating_Systems.pdf
4. http://www.iar.com/Global/Resources/Developers_Toolbox/RTOS_and_Middleware/Basic_Concepts_for_Real_Time_Operating_Systems.pdf

COURSE CODE	ADVANCED CONTROL SYSTEM	L	T	P	C
2162ME166		3	0	0	3

UNIT I: SYSTEM MODELS **9**

Examples, Building blocks of state space models, Canonical forms, State equation and its solution, Properties of the state transition matrix, Special cases, Modelling Discrete-time systems with delay operators.

UNIT II: NUMERICAL COMPUTATIONS **9**

Basic linear algebra, Eigenvalues and Eigenvectors, Similarity transformation, Gram-Schmidt Orthonormalization, Computing the matrix exponential using different algorithms, State transition matrix for discrete-time systems, Computational complexity.

UNIT III: STABILITY **9**

Modelling energy of the system in terms of quadratic functions, Lyapunov's criterion for continuous- and discrete-time systems, Numerical methods for solving the Lyapunov equation, Computational complexity.

UNIT IV: CONTROLLABILITY & OBSERVABILITY **9**

Definitions, Rank tests, Computational methods of determining rank, Computational complexity, Lyapunov equation and Grammians.

UNIT V: DESIGN IN STATE SPACE **9**

State feedback control for controllable canonical form, State feedback control in general, State feedback for discrete-time systems, Computational algorithms and their complexity, Output feedback control. Full-order and reduced-order observers, Physical aspects of control system design in state space. **TOTAL: 45 PERIODS**

Required Resources:

1. Ramakalyan, A., Control Engineering: A Comprehensive Foundation, Vikas Publishing House, New Delhi, 2003.
2. Datta, B.N., Numerical Methods for Linear Control Systems, Elsevier, 2004. (A cheaper Indian reprint is available)

Recommended Resources:

1. Gopal.M "Digital Control & State Variables methods, 2nd Edition, TMH, 2007
2. Franklin G.F. David Powell.J Michael Workman, "Digital control of Dynamic Systems", 3rd Edition, Addison Wesley, 2000.
3. K. Ogata, "Modern control engineering", prentice Hall Englewood chiffs, N.J., 2000.
4. Nagrath, I.J. and Gopal, M., "Control Systems Engineering", New Age International Publishers, Fifteenth Edition, 2007

Web Resources:

1. This course uses exclusively for providing electronic resource, such as lecturer notes, assignment papers, and sample solutions. Students should make appropriate use of this recourse. www. nptel.in. http://nptel.iitm.ac.in/
2. www.eecs.berkeley.edu/~ananth/223Fall08/Textbook.pdf
3. www.computer-ebook.com/Artificial-intelligence/.../1000451.html
4. www.ebookweb.org/s/adaptive-control
5. www.intechopen.com/download/pdf/5929

COURSE CODE	DESIGN OF MATERIAL HANDLING EQUIPMENTS	L	T	P	C
2162ME126		3	0	0	3

UNIT I: MATERIALS HANDLING EQUIPMENT **5**

Types, selection and applications

UNIT II: DESIGN OF HOISTS **10**

Design of hoisting elements: Welded and roller chains - Hemp and wire ropes - Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks – crane grabs - lifting magnets - Grabbing attachments - Design of arresting gear - Brakes: shoe, band and cone types.

UNIT III: DRIVES OF HOISTING GEAR **10**

Hand and power drives - Traveling gear - Rail traveling mechanism - cantilever and monorail cranes - slewing, jib and luffing gear - cogwheel drive - selecting the motor ratings.

UNIT IV: CONVEYORS **10**

Types - description - design and applications of Belt conveyors, apron conveyors and escalators Pneumatic conveyors, Screw conveyors and vibratory conveyors.

UNIT V: ELEVATORS **10**

Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices - Design of fork lift trucks.

TOTAL: 45 PERIODS

REFERENCES

1. Rudenko, N., Materials handling equipment, ELnvee Publishers, 1970.

2. Spivakovsy, A.O. and Dyachkov, V.K., Conveying Machines, Volumes I and II, MIR Publishers, 1985.

3. Alexandrov, M., Materials Handling Equipments, MIR Publishers, 1981.

4. Boltzharol, A., Materials Handling Handbook, The Ronald Press Company, 1958.

5. P.S.G. Tech., “Design Data Book”, Kalaikathir Achchagam, Coimbatore, 2003.

6. Lingaiah. K. and Narayana Iyengar, “Machine Design Data Hand Book”, Vol.1 & 2, Suma Publishers, Bangalore, 1983

COURSE CODE	INDUSTRIAL ROBOTICS	L	T	P	C
2162ME167		3	0	0	3

UNIT- I: BASIC OF ROBOTICS **9**

Definition, need and scope of industrial robots– Classification - selection of robot - Robot anatomy - Robot configurations - work volume - Precision movement - Basic robot motions - safety considerations

UNIT- II: ROBOT KINEMATICS AND DYNAMICS **9**

Robot kinematics - Direct and inverse kinematics- Vector operations - Translational transformations and Rotational transformations - Properties of transformation matrices-Homogeneous transformations and Manipulator - Forward solution - Inverse solution-Trajectory planning - Differential kinematics & statics - Robot dynamics -Methods for orientation and location of objects - Rigid body mechanics.

UNIT- III: DRIVES, CONTROLS AND ROBOT END EFFECTORS **9**

Design of drive systems-Hydraulic and Pneumatic drives-Linear and rotary actuators and control valves-Electro hydraulic servo valves - electric drives. End effectors design - Mechanical - Magnetic -Vacuum - Adhesive - air operated grippers. Force analysis and Robot motion control - Adaptive and optimal control - electronic control- feedback control- interfacing.

UNIT -IV: SENSORS IN ROBOTICS AND APPLICATIONS **9**

Robot position sensors - proximity and range sensors – tactile sensors – velocity and acceleration sensors - force and torque sensing devices- sensing joint forces and slip. Robot work cell design - Robot cell layouts -Multiple robots and machine interference-Robot cycle time analysis-Industrial applications of robots - material handling - processing - assembly and inspection- tele operations

UNIT- V: PROGRAMMING OF ROBOTS AND VISION SYSTEMS **9**

Robot programming methods and languages - lead through programming -Motion interpolation. Computer control and Robot Softwares - task planning. Robotic vision system-Image components and representation - Hardware - Image processing and analysis- Object recognition and categorization- Image segmentation- Software consideration- Training of vision system. Robot intelligence-Artificial intelligence techniques - problems representation in AI - Problem reduction and solution techniques - Application of AI and knowledge based expert systems in robots.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Groover M.P., "Industrial robotics Technology, programming and applications", McGraw-Hill Book Co., 2005.
2. K.S.Fu, R.C. Gonzalez and C.S.G. Lee, “Robotics Control, Sensing, Vision and Intelligence”, Mc Graw Hill, 2007.
2. Yoram Koren,” Robotics for Engineers’ Mc Graw-Hill, 2008.
3. Kozyrey, Yu. “Industrial Robots”, MIR Publishers Moscow, 2012.

REFERENCES

1 Richard. D, Klafter, Thomas, A, Chmielewski, Michael Negin, “Robotics Engineering – An Integrated Approach”, Prentice-Hall of India Pvt. Ltd., 2009.
2 Deb, S.R.” Robotics Technology and Flexible Automation”, Tata Mc Graw-Hill, 2010.
3 Mikell, P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey,” Industrial Robotics Technology, Programming and Applications”, Mc Graw-Hill, Int. 2011.
4 Timothy Jordanides et al,” Expert Systems and Robotics “, Springer –Verlag, New York, May 2012.

COURSE CODE	OPTIMIZATION TECHNIQUES FOR AUTOMATION	L	T	P	C
2162ME168		3	0	0	3

UNIT I: INTRODUCTION **5**

General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints – Classification of optimization problem.

UNIT II: OPTIMIZATION TECHNIQUES **10**

Single variable and multivariable optimization, Techniques of unconstrained minimization – Golden section, Random, pattern and gradient search methods – Interpolation methods; Optimization with equality and inequality constraints.

UNIT III: MULTI OBJECTIVE OPTIMIZATION **10**

Direct methods – Indirect methods using penalty functions, Lagrange multipliers; Geometric programming and stochastic programming; Multi objective optimization, Genetic algorithms and Simulated Annealing techniques.

UNIT IV: STATIC APPLICATIONS **10**

Structural applications – Design of simple truss members. Design applications – Design of simple axial, transverse loaded members for minimum cost, maximum weight – Design of shafts and torsionally loaded members – Design of springs

UNIT V: DYNAMIC APPLICATIONS **10**

Dynamic Applications – Optimum design of single, two degree of freedom systems, vibration absorbers. Application in Mechanisms – Optimum design of simple linkage mechanisms.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Optimization for Engineering Design – Kalyanmoy Deb, PHI Publishers, 2008
2. Engineering Optimization – S.S.Rao, New Age Publishers, 2012
3. Genetic Programming- Koza, 2010

REFERENCES

1. 1.Genetic algorithms in Search, Optimization, and Machine learning – D.E.Goldberg, Addison- Wesley Publishers, 2009
2. Multi objective Genetic algorithms - Kalyanmoy Deb, PHI Publishers, 2010
3. Optimal design – Jasbir Arora, Mc Graw Hill (International) Publishers, 2011

COURSE CODE	FLEXIBLE MANUFACTURING SYSTEMS	L	T	P	C
2162ME169		3	0	0	3

UNIT-I: INTRODUCTION TO FMS **9**

Introduction to FMS - concepts, advantages, components of FMS and their integration in the data processing systems - examples of FMS installations.

UNIT-II: DISTRIBUTED DATA PROCESSING IN FMS **9**

Distributed data processing in FMS –DBMS and their applications in CAD/CAM and FMS – distributed systems in FMS -Integration of CAD and CAM - Part programming in FMS, tool data base - Clamping devices and fixtures data base.

UNIT-III: MATERIAL HANDLING SYSTEMS **9**

Material Handling systems: conveyors - AGVs – features of industrial robots - robot cell design and control- AS/RS.

UNIT- IV: INSPECTION **9**

Inspection: CMM – types – contact and non contact inspection principles - programming and operation- incycle gauging.

UNIT – V: INTERFACING OF COMPUTERS **9**

Interfacing of computers - machine tool controllers and handling systems: communications standards - programmable Logic Controllers (PLC's) – Interfacing - Computer aided Project planning – dynamic part scheduling.

TOTAL: 45 PERIODS

TEXT BOOK

1. Paul Ranky., “The design and operation of FMS”, IFS publication, 2003.

REFRENCES

1. Mikell P Groover, “Automation Production systems, Computer Integrated Manufacturing”, Prentice Hall, 2006.

2. David J. Parrish, “Flexible Manufacturing” Butterworth-Heinemann,

URL:

http://www.eod.gvsu.edu/~jackh/books/plcs/chapters/plc_intro.pdf

COURSE CODE	MEMS & NANO TECHNOLOGY	L	T	P	C
2162ME170		3	0	0	3

UNIT I: OVER VIEW OF MEMS AND MICROSYSTEMS **6**

Definition – historical development – fundamentals – properties, micro fluidics, design and fabrication micro-system, microelectronics, working principle and applications of micro system.

UNIT II: MATERIALS, FABRICATION PROCESSES AND MICRO SYSTEM PACKAGING **10**

Substrates and wafers, silicon as substrate material, mechanical properties of Si, Silicon Compounds silicon piezo resistors, Galium arsenide, quartz, polymers for MEMS, conductive polymers. Photolithography, photo resist applications, light sources, in implantation, diffusion process exudation – thermal oxidation, silicon diode, chemical
vapour deposition, sputtering - deposition by epitoxy – etching – bulk and surface machining – LIGA process Micro system packaging – considerations packaging – levels of micro system packaging die level, device level and system level.

UNIT III: MICRO DEVICES AND MATERIALS **8**

Sensors – classification – signal conversion ideal characterization of sensors microactuators, mechanical sensors – measurands displacement sensors, pressure and flow sensors, micro actuators – smart materials – applications.

UNIT IV: SCIENCE OF NANO MATERIALS **10**

Classification of nano structures – effect of the nanometer length scale effects of nano scale dimensions on various properties – structural, thermal, chemical, mechanical, magnetic, optical and electronic properties – effect of nanoscale dimensions on biological systems. Fabrication methods – Top down processes – bottom up process.

UNIT V: CHARACTERIZATION OF NANO MATERIALS **11**

Nano-processing systems – Nano measuring systems – characterization – analytical imaging techniques – microscopy techniques, electron microscopy scanning electron microscopy, transmission electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy, diffraction techniques – spectroscopy techniques – Raman spectroscopy, 3D surface analysis – Mechanical, Magnetic and thermal properties – Nano positioning systems. **TOTAL: 45 PERIODS**

TEXT BOOKS

1. Tai – Ran Hsu, MEMS and Microsystems Design and Manufacture, Tata-McGraw Hill, New Delhi, 2002.

2. Mark Madou Fundamentals of Microfabrication, CRC Press, New York, 2005.

3. Norio Taniguchi, Nano Technology, Oxford University Press, New York, 2003

REFERENCES:

1. The MEMS Hand book, Mohamed Gad-el-Hak, CRC Press, New York, London.

2. Charles P Poole, Frank J Owens, Introduction to Nano technology, John Wiley and Sons, 2003

3. Julian W. Hardner Micro Sensors, Principles and Applications, CRC Press 2002.

COURSE CODE	MANUFACTURING SYSTEMS AUTOMATION	L	T	P	C
2162ME198		3	0	0	3

UNIT I: FUNDAMENTALS OF MANUFACTURING AUTOMATION **9**

Production operations and Automation strategies - Types of production, Functions in manufacturing, Plant Layout, Production concepts and Mathematical models, Automation strategies. Production Economics - Cost in manufacturing, Break even analysis, Unit cost of production, Cost of manufacturing lead time and work-in-progress.

UNIT II: HIGH VOLUME PRODUCTION SYSTEMS **9**

Detroit - Type automation - Automated flow line, workpart transport, Transfer mechanism, Buffer storage, Control functions, Automation for machining operations, Design and fabrication consideration. Analysis of Automated Flow lines. General terminology and analysis, Analysis of transfer lines without storage, partial automation, Automated flow lines, with storage buffer, simulation of automation flow lines.

UNIT III: NUMERICAL CONTROL PRODUCTION SYSTEM **9**

Numerical Control, Types of NC Systems, Machine tool applications, other applications of NC Systems, Components of NC System, Introduction to NC part programming, Types of part programming, Direct Numerical Control, Computer Numerical Control, Adaptive Control Machining.

UNIT IV: AUTOMATED ASSEMBLY SYSTEMS AND LINE BALANCING **9**

The assembly process, assembly systems, manual assembly lines, The line balancing problem, Methods of line balancing, Computerized line balancing method, flexible manual assembly lines. Design for automated assembly, types of automated assembly system, parts feeding devices, Analysis of single station and multistation assembly machine

UNIT V: MATERIAL HANDLING AND STORAGE **9**

Automated materials handling: Types of material handling equipment, analysis for material handling systems, design of the system, conveyor system, automated guided vehicle systems. Automated storage systems: Automated storage / Retrieval systems, Carousel storage systems, work-in-process storage, interfacing handling and storage with manufacturing.

TOTAL: 45 PERIODS

LEARNING RESOURCES:

1. Mikell.P.Groover, Automation, Production Systems and Computer Integrated Manufacturing, Prentice Hall of India Pvt. Ltd., Thirteenth Indian Reprint, 2016.
2. P.N.Rao, 'CAD/CAM Principles and Applications' Tata McGraw Hill Publishing Company Ltd., 2012.

COURSE CODE	ROBOT ECONOMICS	L	T	P	C
2162ME199		3	0	0	3

UNIT I: ROBOT COMPONENTS AND THEIR SELECTION **9**

Power supply, movement and drive systems, sensors, end effector and grippers, Control techniques, Characteristics and factor considered for selection.

UNIT II: ECONOMIC ANALYSIS FOR ROBOTICS **9**

Economic analysis for robotics. Economic analysis, basic data required methods of Economic analysis, subsequent uses of robot, Difference in production rates, other factors Robot project analysis form.

UNIT III: IMPLEMENTING ROBOTICS **9**

Familiarization with robotics technology, plant survey to identify potential applications, Selection of the best applications, Selection of a robot, Detailed economic analysis, planning and installation

UNIT IV: SOCIAL ISSUES **9**

Safety in Robotics, Training, Maintenance, Quality improvement, productivity and capital formation, Robotics and labour. Education and training, international impacts, future applications.

UNIT V: ROBOTICS TECHNOLOGY OF THE FUTURE **9**

Robot intelligence, Advanced Sensors, Capabilities, Mobility, locomotion and Navigation. The universal Robots in RPT. Tele robotics, Mechanical design Features, Hand Systems Integration and Networking

TOTAL: 45 PERIODS

LEARNING RESOURCES:

1. Mikell P. Groover, Mitchell weiss, Roger N. Nagel, Nicholas G.Odrey, Industrial Robotics, Technology programming and Applications, 2014
2. Richard D. Klafter, Thomas. A, Chri elewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd., 2009
3. P. Radhakrishnan, R. Srivatsavan, P.V. Mohan Ram and R. Radharamanan, CAD/CAM, Robotics and factories of the future, Proceeding of the 14th International Conference on CAR and FOF '98 editors, Narosa Publishing house, 1999
4. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics Control, Sensing Vision and Intelligence, Mc Graw Hill Book Company, 2008

CURRICULUM AND SYLLABUS

for

M. Tech. - THERMAL ENGINEERING

M. Tech. - THERMAL ENGINEERING

FOUNDATION COURSE					
Code	**Course**	**L**	**T**	**P**	**C**
		3	2	0	4

PROGRAM CORE						
Sl. No.	**Code**	**Course**	**L**	**T**	**P**	**C**
Theory Courses						
1	2161ME121	Advanced Fluid Mechanics	4	0	0	4
2	2161ME122	Advanced Thermodynamics	4	0	0	4
3	2161ME123	Advanced Heat Transfer	4	0	0	4
4	2161ME124	Combustion Engineering	4	0	0	4
5	2161ME125	Computational Fluid Dynamics	4	0	0	4
6	2161ME126	Design of Thermal Equipment	4	0	0	4
7	**2161ME157**	Turbo Machines	4	0	0	4
					Total Credits	**28**
Laboratory Courses						
1	2161ME307	Advanced Thermal Engineering Lab	0	0	2	1
2	2161ME308	Simulation and Analysis Lab	0	0	2	1
					Total credits	**2**
PROGRAM ELECTIVES (ANY FOUR)						
1	2162ME133	Solar Energy Engineering	3	0	0	3
2	2162ME134	Bio Energy Engineering	3	0	0	3
3	2162ME136	Refrigeration and Air Conditioning	3	0	0	3
4	2162ME137	Advanced Power Plant Engineering	3	0	0	3
5	2162ME138	Environmental Engineering and Pollution Control	3	0	0	3
6	2162ME139	Industrial Refrigeration Systems	3	0	0	3
7	2162ME140	Energy Management in Thermal Systems	3	0	0	3
8	2162ME142	Advanced Thermal Storage Technologies	3	0	0	3
9	2162ME144	Energy Efficient Buildings	3	0	0	3
10	2162ME146	Measurements in Thermal Engineering	3	0	0	3
11	**2162ME182**	Design and Optimization of Thermal Systems	3	0	0	3
12	**2162ME183**	Cryogenics Engineering	3	0	0	3
					Total Credits to be earned from Program Electives	**12**

INDEPENDENT LEARNING COURSES					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
	Massive Open Online Course	-	-	-	2
2163ME501	Research Seminar [**OR**]	-	-	-	
2163ME801	Field Study [**OR**]	-	-	-	2
2163ME802	Internship	-	-	-	
2163GE401	Business Communication [**OR**]	-	-	-	2
2163GE402	Technical Writing Tools	-	-	-	
2163MG401	Research Methodology	-	-	-	2
				Total Credits	**8**

PROJECT WORK					
COURSE CODE	**COURSE TITLE**	**L**	**T**	**P**	**C**
2164ME601	Project Phase I	0	0	20	10
2164ME701	Project Phase II	0	0	32	16
				Total Credits	**26**

PROGRAMME STRUCTURE AND MINIMUM CREDITS REQUIRED

IN COURSE CATEGORIES

SECTION NUMBER	COURSE CATEGORY	MINIMUM CREDITS REQUIRED
7.2.1	**FOUNDATION COURSE**	**04**
7.2.2	**PROGRAM CORE COURSES**	**30**
7.2.3	**PROGRAM ELECTIVE COURSES**	**12**
7.2.4	**INDEPENDENT LEARNING COURSES**	**8**
7.2.5	**PROJECT WORK**	**26**
	TOTAL CREDITS	**80**

COURSE CODE	ADVANCED FLUID MECHANICS	L	T	P	C
2161ME121		4	0	0	4

UNIT I: BASIC EQUATIONS OF FLOW **12**

Three-dimensional continuity equation - differential and integral forms – equations of motion momentum and energy and their engineering applications.

UNIT II: POTENTIAL FLOW THEORY **12**

Rotational and irrotational flows - circulation – vorticity - stream and potential functions for standard flows and combined flows – representation of solid bodies by flow patters - Pressure distribution over stationery and rotating cylinders in a uniform flow - magnus effect - Kutta – Zhukovsky theorem - Complex potential functions. Conformal transformation to analyze the flow over flat plate, cylinder, oval body and airfoils. Thin airfoil theory – generalized airfoil theory for cambered and flapped airfoils.

UNIT III: VISCOUS FLOW THEORY **12**

Laminar and turbulent Flow - laminar flow between parallel plates - Poiseuille's equation for flow through circular pipes. Turbulent flow - Darcy Weisbach equation for flow through circular pipe – friction factor - smooth and rough Pipes - Moody diagram – losses during flow through pipes. Pipes in series and parallel – transmission of power through pipes.

UNIT IV: BOUNDARY LAYER CONCEPT **12**

Boundary Layer - displacement and momentum thickness - laminar and turbulent boundary layers in flat plates - velocity distribution in turbulent flows in smooth and rough boundaries - laminar sub layer.

UNIT V: COMPRESSIBLE FLUID FLOW **12**

One dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers – fundamentals of supersonics – normal and oblique shock waves and calculation of flow and fluid properties over solid bodies (like flat plate, wedge, diamond) using gas tables

TOTAL: 60 PERIODS

REFERENCES

1. Houghten, E.L. and Carruthers, N.B., Aerodynamics for Engineering Students, Arnold Publishers, 1993.
2. Anderson, J.D., Fundamentals of Aerodynamics, McGraw Hill, Boston, 2001.
3. Streeter, V.L., Wylie, E.B., and Bedford, K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 1998.
4. Munson, B.R., Young, D.F. and Okiisi, T.H., Fundamentals of Fluid Mechanics, John Wiley and Sons Inc., NewYork, 1990
5. Kumar, K.L., Engineering Fluid Mechanics, Eurasia Publishing House, New Delhi, 2002
6. Bansal, R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 1985.

COURSE CODE	ADVANCED THERMODYNAMICS	L	T	P	C
2161ME122		4	0	0	4

UNIT I: ENTROPY **12**

Clausius theorem - the property of entropy – the inequality of Clausius – entropy change in an irreversible process – entropy principle – applications of entropy principle to the processes of transfer of heat through a finite temperature difference, and mixing of two fluids maximum work obtainable from a finite body and a thermal energy reservoir – entropy transfer with heat flow - entropy generation in a closed system – entropy generation in an open system.

UNIT II: AVAILABLE ENERGY **12**

Available energy referred to a cycle - available energy from a finite energy source – maximum work in a reversible process – dead state – availability in a steady flow process – availability in a non-flow process – availability in chemical reactions.

UNIT III: PROPERTIES OF GASES **12**

Equations of state – Vander Waal's equation – law of corresponding states – Beattie-Bridgeman equation, Redlich-Kwong equation. **Gas Mixtures:** Dalton's law of partial pressures – enthalpy and entropy of gas mixtures. **Reactive Systems:** Degree of reaction – reaction equilibrium – law of mass action – heat of reaction – temperature dependence of the heat of reaction – temperature dependence of the equilibrium constant – change in Gibbs function – Fugacity and activity.

UNIT IV: THERMODYNAMIC RELATIONS & POWER CYCLES **12**

Maxwell's equations –TdS equations – difference in heat capacities – ratio of heat capacities – Joule-Kelvin effect – Clausius-Clapeyron equation. Brayton cycle – comparison between Brayton cycle and Rankine cycle – effect of regeneration on Brayton cycle efficiency – Brayton-Rankine combined cycle.

UNIT V: STATISTICAL THERMODYNAMICS **12**

Thermodynamic equilibrium distribution – thermodynamic distribution function – thermodynamic ensemble, micro canonical ensemble, canonical ensemble, grand canonical ensemble. Maxwell-Boltzmann statistics and distribution – Fermi-Dirac statistics and distribution – Bose-Einstein statistics and distribution – phase space – Liouville equation – equilibrium constant by statistical thermodynamic approach.

TOTAL: 60 PERIODS

REFERENCES

1. P.K. Nag, "Engineering Thermodynamics", 4th Edition, Tata McGraw-Hill Education Private Limited, 2010.
2. S.S. Thipse, "Advanced Thermodynamics", Narosa Publishing House, New Delhi, 2013
3. Y.A. Cengel and M.A. Boles, "Thermodynamics – An Engineering Approach", 5th Edition in SI Units, Tata McGraw Hill Publishing Company Limited, New Delhi, 2006.
4. C. Borganakke and R.E. Sonntag, "Fundamentals of Thermodynamics", 7th Edition, Wiley India, Delhi, 2012.

COURSE CODE	ADVANCED HEAT TRANSFER	L	T	P	C
2161ME123		4	0	0	4

UNIT I: CONDUCTION AND RADIATION HEAT TRANSFER 12

One dimensional energy equations and boundary condition - three-dimensional heat conduction equations - extended surface heat transfer - conduction with moving boundaries - radiation in gases and vapour. Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media – interaction of radiation with conduction and convection.

UNIT II: TURBULENT FORCED CONVECTIVE HEAT TRANSFER 12

Momentum and energy equations - turbulent boundary layer heat transfer - mixing length concept - turbulence model – k Є model - analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube - high speed flows.

UNIT III: PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER 12

Condensation with shears edge on bank of tubes - boiling – pool and flow boiling - heat exchanger –Є – NTU approach and design procedure - compact heat exchangers.

UNIT IV: NUMERICAL METHODS IN HEAT TRANSFER 12

Finite difference formulation of steady and transient heat conduction problems – discretization schemes – explicit - Crank Nicolson and fully implicit schemes - control volume formulation –steady one-dimensional convection and diffusion problems - calculation of the flow field – SIMPLER Algorithm.

UNIT V: MASS TRANSFER AND ENGINE HEAT TRANSFER CORRELATION 12

Mass transfer - vaporization of droplets - combined heat and mass transfers - heat transfer correlations in various applications like I.C. engines - compressors and turbines.

TOTAL: 60 PERIODS

REFERENCES

1. Holman, J.P., “Heat Transfer”, 10th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2010.
2. David Reay and Peter Kew, “Heat pipes – Theory, Design and Applications”, 5th Edition, Butterworth and Heinemann (Elsevier), 2006.
3. M. Thirumaleswar, “Fundamentals of Heat and Mass Transfer”, 2nd Edition, Pearson Education, New Delhi, 2009.
4. Incropera, F.P., Dewitt, D.P., Bergman, T.L., Lavine, A.S., Seetharamu, K.N. and Seetharam,T.R., “Fundamentals of Heat and Mass Transfer”,1st Edition, WileyIndia, 2013.
5. Sachdeva, T.R., “Fundamentals of Engineering Heat and Mass Transfer” (SI UNITs), 4th Edition, New Age International, 2010.

COURSE CODE	COMBUSTION ENGINEERING	L	T	P	C
2161ME124		4	0	0	4

UNIT I: CHARACTERIZATION **12**

Fuels - Types and Characteristics of Fuels - Determination of Properties of Fuels - Fuels Analysis - Proximate and Ultimate Analysis - Moisture Determination - Calorific Value - Gross & Net Calorific Values - Calorimetry – Du Long's Formula for Calorific Value Estimation - Flue gas Analysis - Orsat Apparatus - Fuel & Ash Storage & Handling - Spontaneous Ignition Temperatures.

UNIT II: SOLID FUELS & LIQUID FUELS **12**

Types - Coal Family - Properties - Calorific Value - Run of Mine (ROM), Dry and mineral matter free (DMMF), Dry and ash free (DAF) and Bone-Dry Basis - Ranking - Bulk & Apparent Density - Storage - Washability - Coking & Caking Coals – Renewable Solid Fuels - Biomass - Wood Waste - Agro Fuels - Manufactured Solid Fuels. Types - Sources - Petroleum Fractions - Classification - Refining - Properties of Liquid Fuels - Calorific Value, Specific Gravity, Flash & Fire Point, Octane Number, Cetane Number - Alcohols -Tar Sand - Liquefaction of Solid Fuels.

UNIT III: GASEOUS FUELS **12**

Classification - Composition & Properties - Estimation of Calorific Value - Gas Calorimeter. Rich & Lean Gas - Wobbe Index - Natural Gas(NG) - Dry & Wet Natural Gas - Stripped NG - Foul & Sweet Natural Gas(NG) - Liquid petroleum gas (LPG) - Liquefied Natural Gas(LNG) - Compressed Natural Gas(CNG) - Methane - Producer Gas - Gasifiers - Water Gas - Town Gas - Coal Gasification - Gasification Efficiency - Non-Thermal Route - Biogas - Digesters - Reactions - Viability - Economics.

UNIT IV: COMBUSTION: STOICHIOMETRY & KINETICS **12**

Stoichiometry - Mass Basis & Volume Basis - Excess Air Calculation - Fuel & Flue Gas Compositions - Calculations - Rapid Methods - Combustion Processes - Stationary Flame - Surface or Flameless Combustion - Submerged Combustion - Pulsating & Slow Combustion Explosive Combustion. Mechanism of Combustion - Ignition & Ignition Energy - Spontaneous Combustion – Flame Propagation - Solid, Liquid & Gaseous Fuels Combustion - Flame Temperature - Theoretical, Adiabatic & Actual - Ignition Limits - Limits of Inflammability.

UNIT V: COMBUSTION EQUIPMENTS **12**

Coal Burning Equipment - Types - Pulverized Coal Firing - Fluidized Bed Firing - Fixed Bed & Recycled Bed - Cyclone Firing - Spreader Stokers - Vibrating Grate Stokers - Sprinkler Stokers, Traveling Grate Stokers. Oil Burners - Vaporizing Burners, Atomizing Burners - Design of Burners. Gas Burners - Atmospheric Gas Burners - Air Aspiration Gas Burners - Burners Classification according to Flame Structures - Factors Affecting Burners & Combustion.

TOTAL: 60 PERIODS

REFERENCES

1. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990
2. Bhatt, Vora Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1984
3. Blokh AG, Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988.
4. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966
5. Sharma SP, Mohan Chander, Fuels & Combustion, Tata Mcgraw Hill, 1984

COURSE CODE	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
2161ME125		4	0	0	4

UNIT I: GOVERNING DIFFERENTIAL EQUATION AND FINITE DIFFERENCE METHOD 12

Classification, Initial and Boundary conditions, Initial and Boundary value problems. Finite difference method, Central, Forward, Backward difference, Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II: CONDUCTION HEAT TRANSFER 12

Steady one-dimensional conduction, Two and Three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems.

UNIT III: INCOMPRESSIBLE FLUID FLOW 12

Governing Equations, Stream Function – Verticity method, Determination of pressure for viscous flow, SIMPLE Procedure of Patankar and spalding, Computation of Boundary layer flow, Finite difference approach.

UNIT IV: CONVECTION HEAT TRANSFER AND FEM 12

Steady One-Dimensional and Two-Dimensional Convection – Diffusion, Unsteady one-dimensional convection – Diffusion, Unsteady two-dimensional convection – Diffusion – Introduction to finite element method – Solution of steady heat conduction by FEM – Incompressible flow – Simulation by FEM.

UNIT V: TURBULENCE MODELS 12

Algebraic Models – One equation model, K - Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.

TOTAL: 60 PERIODS

REFERENCES

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
2. Ghoshdasdidar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw Hill Publishing Company Ltd., 1998.
3. Subas, V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
4. Taylor, C and Hughes, J.B. "Finite Element Programming of the Navier Stock Equation", Pineridge Press Limited, U.K., 1981.
5. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., "Computational fluid Mechanic and Heat Transfer " Hemisphere Publishing Corporation, Newyork, USA, 1984.
6. Fletcher, C.A.J. "Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer – Verlag, 1987.
7. Fletcher, C.A.J. "Computational Techniques for Fluid Dynamics 2" Specific Techniques for Different Flow Categories, Springer – Verlag, 1987.

COURSE CODE	DESIGN OF THERMAL EQUIPMENTS	L	T	P	C
2161ME126		4	0	0	4

UNIT-I: HEAT EXCHANGERS **12**

Classification of heat exchangers: Tubular heat exchangers, plate heat exchangers, extended surface heat exchangers – flow arrangements – applications. Basic design methods of heat exchangers: Overall heat transfer coefficient – multi pass and cross flow heat exchangers - log mean temperature difference method – effectiveness-Number of transfer units method for heat exchanger analysis– heat exchanger design calculation–heat exchanger design methodology.

UNIT-II: HEAT TRANSFER ANALYSIS **12**

Correlations for forced convection heat transfer coefficients: Laminar forced convection in ducts and concentric annuli – turbulent forced convection in circular pipes – heat transfer in helical coils and spirals – heat transfer in bends.

UNIT-III: PRESSURE DROP AND PUMPING POWER **12**

Heat exchanger pressure drop and pumping power: Tube side pressure drop in laminar and turbulent flows – pressure drop in helical and spiral coils – pressure drop in bends and fittings. Fouling of heat exchangers: Basic considerations – effect of fouling and heat transfer and pressure drop – aspects of fouling – design of heat exchangers subject to fouling.

UNIT-IV: DOUBLE PIPE HEAT EXCHANGERS **12**

Double pipe heat exchangers: Pressure drop – hydraulic diameter – hairpin heat exchanger – parallel and series arrangements of hairpins – total pressure drop. Compact heat exchangers: Plate-fin heat exchangers – tube-fin heat exchangers – pressure drop for finned-tube heat exchangers – pressure drop for plate-fin heat exchangers.

UNIT-V: CONDENSERS AND EVAPORATORS **12**

Condensers and evaporators: Horizontal shell-and-tube condensers – horizontal in-tube condensers – plate condensers – air-cooled condensers, thermal design of shell-and-tube condensers – design and operational considerations.

TOTAL: 60 PERIODS

REFERENCES

1. Sadik Kakac and Hongtan Liu, “Heat Exchangers – Selection, Rating and Thermal Design”, CRC Press, New York, USA, 2000.
2. Donald Q. Kern, “Process Heat Transfer”, Tata McGraw-Hill, 2001.
3. S. Kakac, A.E. Bergles and F. Mayinger, “Heat Exchangers: Thermal-Hydraulic Fundamentals and Design”, Hemisphere Pub., 1981.
4. “Standards of the Tubular Exchanger Manufacturers Association (TEMA)”, Inc., 7th Edition, New-York, 1988.

COURSE CODE	TURBOMACHINES	L	T	P	C
2161ME157		4	0	0	4

UNIT I: COMPONENTS 12

Turbo machines, turbines, pumps and compressors, fans and blowers, compressible flow machines, incompressible flow machines, turbine, compressor and fan stages, extended turbo machines, axial stages, radial stages, mixed flow stages, impulse stages, reaction stages, variable reaction stages, multistage machines, stage velocity triangles, design conditions, off-design conditions, applications.

UNIT II: GAS AND STEAM TURBINE PLANTS 12

Gas and steam turbine plants - open and closed circuit plants - aircraft gas turbine plants - gas turbines for surface vehicles, electric power station, petro-chemical plants and cryogenics. Types of steam turbines – steam power cycle – industrial steam turbines – combined steam and gas turbine plants.

UNIT III: COMPRESSOR 12

Axial compressor stages -stage velocity triangles, enthalpy-entropy diagram, flow through blade rows, stage losses and efficiency, work done factor, low hub-tip ratio stages, supersonic and transonic stages, performance characteristics. Centrifugal compressor stages -elements of centrifugal compressor stage, stage velocity triangle, enthalpy-entropy diagram, nature of impeller flow, slip factor, diffuser, volute casing, stage losses and performance characteristics.

UNIT IV: TURBINE STAGES 12

Axial turbine stages -stage velocity triangle, single impulse stage, multi stage velocity and pressure compounded impulses, reaction stages, blade-to-gas speed ratio, losses and efficiencies, performance charts, low hub-trip ratio stages. Radial turbine stages -elements of a radial turbine stage, stage velocity triangles, enthalpy-entropy diagram, stage losses, performance characteristics, outward flow radial stages.

UNIT V: FANS **12**

Axial fans and centrifugal fans -fan applications, axial fans, fan stage parameters, types of axial fan stages, types of centrifugal fans, centrifugal fan stage parameters, design parameters.

TOTAL: 60 PERIODS

REFERENCES

1. S.M. Yahya, “Turbines, Pumps, Compressors”, 4th Edition, Tata McGraw Hill, 2010.

2. Charles A, Earsons, “The steam turbine”, Cambridge University Press, 2012.

3. Norman Davey, “Gas Turbines – Theory and practice”, 3rd Edition, Merchant Books, 2006.

4. S.M. Yahya, “Fundamentals of Compressible flow with aircraft and rocket propulsion”, New Age International, 2010.

COURSE CODE	ADVANCED THERMAL ENGINEERING LAB	L	T	P	C
2161ME307		0	0	2	1

1. Performance evaluation of vapour compression refrigeration
2. Measurement and Analysis of combustion parameters in I.C. engines
3. Emission measurement in Spark Ignition and Compression Ignition Engines.
4. Performance Study in a solar water heater
5. Performance study of shell and tube Heat Exchangers
6. Performance analysis of Air conditioning unit
7. Performance Study in Solar Flat Plate Collector
8. Performance study of concentric tube Heat Exchangers

TOTAL: 30 PERIODS

COURSE CODE	SIMULATION AND ANALYSIS LAB	L	T	P	C
2161ME308		0	0	2	1

1. Heat conduction analysis
2. Fluid flow analysis
3. Heat transfer analysis of fins
4. Modeling of flow around aero foils
5. Exercises on natural and mixed convection problems
6. Exercises on laminar/turbulent flows,
7. Exercises on forced¬ convection problems
8. Exercises on hydrodynamic and thermal boundary layer problems

TOTAL: 30 PERIODS

COURSE CODE	SOLAR ENERGY ENGINEERING	L	T	P	C
2162ME133		3	0	0	3

UNIT I: INTRODUCTION **9**

Source of radiation – solar constant– solar charts – Measurement of diffuse, global and direct solar radiation: pyrheliometer, pyranometer, pyregeometer, net pyradiometer-sunshine recorder.

UNIT II: SOLAR COLLECTORS **9**

Solar Non-Concentrating Collectors- Design considerations – Classification- air, liquid heating collectors –Derivation of efficiency and testing of flat plate collectors –Analysis of concentric tube collector - Solar green house.

UNIT III: SOLAR CONCENTRATORS **9**

Design – Classification– Concentrator mounting –Focusing solar concentrators- Heliostats. Solar powered absorption A/C system, water pump, chimney, drier, dehumidifier, still, cooker.

UNIT IV: PV CELL **9**

Photo-voltaic cell – characteristics-cell arrays-power electric circuits for output of solar panels-choppers-inverters-batteries-charge regulators, Construction concepts.

UNIT V: ENERGY STORAGE **9**

Energy Storage -Sensible, latent heat and thermo-chemical storage-pebble bed etc. materials for phase change-Glauber's salt-organic compounds. Solar ponds.

TOTAL: 45 PERIODS

REFERENCES

1. D. Yogi Goswami, Frank Kreith, Jan. F. Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003
2. Edward E. Anderson, "Fundamentals for solar energy conversion", Addison Wesley Publ. Co., 1983.
3. Duffie J. A and Beckman, W .A., "Solar Engineering of Thermal Process", John Wiley, 1991.
4. G. N. Tiwari and M. K. Ghosal, "Fundamentals of Renewable energy Sources", Narosa Publishing House, New Delhi, 2007
5. Energy Studies, Second Edition, by W. Shepherd and D. W. Shepherd, Imperial College Press, London, 2004

COURSE CODE	BIO ENERGY ENGINEERING	L	T	P	C
2162ME134		3	0	0	3

UNIT I: INTRODUCTION **9**

Sources and Classification. Chemical composition, properties of biomass. Energy plantations. Size reduction, Briquetting, Drying, Storage and handling of biomass.

UNIT II: BIOGAS **9**

Feedstock for biogas, Microbial and biochemical aspects- operating parameters for biogas production. Kinetics and mechanism- High rate digesters for industrial waste water treatment.

UNIT III: THERMO CHEMICAL CONVERSION **9**

Thermo chemical conversion of lignocelluloses biomass. Incineration, Processing for liquid fuel production. Pyrolysis -Effect of particle size, temperature, and products obtained.

UNIT IV: THERMO CHEMICAL PRINCIPLES **9**

Thermo chemical Principles: Effect of pressure, temperature , steam and oxygen. Fixed and fluidized bed Gasifiers- Partial gasification of biomass by CFB.

UNIT V: AGRICULTURAL WASTE UTILIZATION **9**

Combustion of woody biomass-Design of equipment. Cogeneration using bagasse- Case studies: Combustion of rice husk.

TOTAL: 45 PERIODS

REFERENCES

1. Chakraverthy A, “Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes”, Oxford & IBH publishing Co, 1989.
2. D. Yogi Goswami, Frank Kreith, Jan. F .Kreider, “Principles of Solar Engineering”, 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003[chapter 10]
3. Mital K.M, “Biogas Systems: Principles and Applications”, New Age International publishers (P) Ltd., 1996.
4. Nijaguna, B.T.,Biogas Technology, New Age International publishers (P) Ltd.,2002
5. VenkataRamana P and Srinivas S.N, “Biomass Energy Systems”, Tata Energy Research Institute, 1996.

COURSE CODE	REFRIGERATION AND AIR-CONDITIONING	L	T	P	C
2162ME136		3	0	0	3

UNIT I: SYSTEM COMPONENTS **8**

Refrigeration system components - compressors – general classification – comparison – advantages and disadvantages, condensers and cooling towers – classification – working principles, evaporators – classification – working principles, expansion devices – types – working principles.

UNIT II: VAPOR COMPRESSION REFRIGERATION **10**

Vapor compression refrigeration -working principle and essential components of the plant – simple vapor compression refrigeration cycle – co efficient of performance (COP) – representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – methods to improve the COP - use of p-h charts – wet versus dry compression. Multi-evaporator and compressors - methods of improving COP, sub- cooler heat exchanger, optimum inter stage pressure for two stage refrigeration system –single load systems-multi load systems with single compressor-multiple evaporator and compressor system - dry ice system-cascade systems.

UNIT III: VAPOR ABSORPTION SYSTEM **9**

Vapor absorption refrigeration system(VARS) – simple absorption system –practical ammonia absorption system – Electrolux Refrigerator- comparison of VARS COP with Carnot COP- Domestic Electrolux Refrigerator-Lithium–Bromide system-actual analysis of ammonia absorption system-advantages of VARS over Vapor compression refrigeration system(VCRS).

UNIT IV: NON-CONVENTIONAL REFRIGERATION SYSTEMS **9**

Non-conventional refrigeration systems - thermoelectric refrigerator - Vortex tube or Hilsch tube Methods of defrosting - automatic periodic defrosting–solid absorbent system- water defrosting-defrosting by reversing cycle-automatic hot gas defrosting-thermo bank defrosting-electric defrosting -electric air switch defrosting system-two outdoor unit system-multiple evaporators defrosting system.

UNIT V: COOLING LOAD ESTIMATION **9**

Design of air conditioning systems -cooling load calculations - different heat sources-bypass factor (BF) - effective sensible heat factor (ESHF) - cooling coils and dehumidifying air washers.

TOTAL: 45 PERIODS

REFERENCES

1. S.C. Arora and S. Domkundwar, “A Course in Refrigeration and Air Conditioning”, 8th Edition, DhanpatRai & Co., 2012.

2. C.P.Arora, “Refrigeration and Air Conditioning”, 2nd Edition, Tata McGraw-Hill, 2008.

3. W.P. Stoeker, “Refrigeration and Air Conditioning”, Tata McGraw-Hill, 1989.

4. R.J. Dossat, “Principles of Refrigeration”, John Willey and sons, John Wiley (SI Version), 1989.

COURSE CODE	ADVANCED POWER PLANT ENGINEERING	L	T	P	C
2162ME137		3	0	0	3

UNIT I: INTRODUCTION **8**

Overview of Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection - Economics of power plants.

UNIT II: STEAM POWER PLANTS **8**

Basics of typical power plant utilities - Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system - Rankine Cycle – thermodynamic analysis. Cycle improvements – Superheat, Reheat, Regeneration.

UNIT III: DIESEL AND GAS TURBINE POWER PLANTS **9**

I.C Engine Cycles - Otto, Diesel & Dual –Theoretical vis-a-vis actual – Typical diesel power plant – Types – Components - Layout - Performance analysis and improvement - Combustion in CI engines - E.C cycles – Gas turbine & Stirling - Gas turbine cycles – thermodynamic analysis – cycle improvements - Intercoolers, Re heaters, regenerators.

UNIT IV: ADVANCED POWER CYCLES **10**

Cogeneration systems – topping & bottoming cycles - Performance indices of cogeneration systems – Heat to power ratio - Thermodynamic performance of steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems- Binary Cycle - Combined cycle – Integrated gasification combined cycle (IGCC) – Atmospheric fluidized bed combustion (AFBC) / Pressurized fluidized bed combustion (PFBC) cycles – Thermionic steam power plant. Magnetohydrodynamics (MHD) – Open cycle and closed cycle- Hybrid MHD & steam power plants

UNIT V: HYDROELECTRIC & NUCLEAR POWER PLANTS **10**

Hydroelectric Power plants – classifications - essential elements – pumped storage systems – micro and mini hydel power plants. General aspects of Nuclear Engineering – Components of nuclear power plants - Nuclear reactors & types – pressurized water reactors (PWR), Boiling water reactors (BWR), CANADA Deuterium Uranium reactor (CANDU), Gas Cooled, Liquid Metal Cooled and Breeder reactor - nuclear safety – Environmental issues.

TOTAL: 45 PERIODS

REFERENCES

1. Nag, P.K., Power Plant Engineering, Tata Mcgraw Hill Publishing Co Ltd, New Delhi, 1998.
2. Arora and Domkundwar, A course in power Plant Engineering, Dhanpat Rai and CO, 2004.
3. Haywood, R.W., Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991.
4. Wood, A.J., Wollenberg, B.F., Power Generation, operation and control, John Wiley, New York,1984.
5. Gill, A.B., Power Plant Performance, Butterworths, 1984.
6. Lamarsh, J.R., Introduction to Nuclear Engg.2nd edition, Addison-Wesley, 1983.

COURSE CODE	ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL	L	T	P	C
2162ME138		3	0	0	3

UNIT I: INTRODUCTION **9**

Environmental Pollution- units of measurements, material balance and energy fundamentals, classification of pollution

UNIT II: AIR POLLUTION **9**

Air Pollution Control Methods & Equipment- sources and effects of air pollution –Sampling measurement and analysis of air pollutants- Control.

UNIT III: WASTE MANAGEMENT **9**

Solid Waste Management-Sources & Classification –Solid Waste Disposal Options - Toxic Waste Management.

UNIT IV: WATER POLLUTION **9**

Water Pollution - sources of water pollutants– Classification and effects of Water Pollutants – Water pollution Laws and Standards

UNIT V: ENVIRONMENT CONTROL **9**

Environment for Comfort Living & Working - Comfort & Climate –Temperature, humidity and ventilation Control– AC load, Natural & Artificial Lighting, Noise Sources, control.

TOTAL: 45 PERIODS

REFERENCES

1. Rao C.S. "Environmental Pollution Control Engineering," 2nd Edition, New Age International Publishers, 2006.
2. Gilbert M. Masters, "Introduction to Environmental Engineering and Science", 2nd Edition, Prentice Hall, 1998.
3. A.P.Sincero and G.A. Sincero, Environmental Engineering: A Design Approach, Prentice Hall of India Pvt. Ltd, N.Delhi.1996.
4. Pandey G.N and Carney G.C., "Environmental Engineering", Tata McGraw Hill Publishing Co., 1989.
5. Bishop P., Pollution Prevention: Fundamentals and Practice, McGraw-Hill International Edition, McGraw-Hill book Co, Singapore, 2000.

COURSE CODE	INDUSTRIAL REFRIGERATION SYSTEMS	L	T	P	C
2162ME139		3	0	0	3

UNIT I: INTRODUCTION **8**

Introduction to industrial refrigeration - difference from conventional system - applications – industrial and comfort air - conditioning - conditions for high COP

UNIT II: COMPRESSORS **8**

Reciprocating and screw compressor: Multistage industrial applications, cylinder arrangement, cooling methods - oil injection and refrigeration injection, capacity regulations - Economizers.

UNIT III: EVAPORATORS AND CONDENSERS **12**

Types of Evaporators, Liquid circulation: Mechanical pumping and gas pumping - advantage and disadvantage of liquid re-circulation - circulation ratio - top feed and bottom feed refrigerant – Net Positive Suction Head (NPSH) - two pumping vessel system - suction risers – design - piping loses. Different Industrial Condensers arrangement, Evaporators-Types and arrangement, liquid circulation, type of feed, refrigerant piping design, functional aspects. Lubricating oil: types - physical properties, types of circulation and oil separator

UNIT IV: VESSELS **8**

Vessels in industrial refrigeration: High pressure receiver - flash tank - liquid and vapour separator - separation enhancers - low pressure receivers - surge drum - surge line accumulator – thermosyphon receiver - oil pots.

UNIT V: ENERGY CONSERVATION **9**

Energy conservation and design considerations - source of losses - energy efficient components - heat reclaim - thermal storage: ice builder and ice harvester. Insulation: critical thickness – insulation cost and energy cost - vapour barriers - construction methods of refrigerated spaces.

TOTAL: 45 PERIODS

REFERENCES

1. Wilbert F.Stoecker, Industrial Refrigeration Hand Book, McGraw-Hill, 1998.

2. ASHRAE Hand Book: Fundamentals, 1997.

3. ASHRAE Hand Book: Refrigeration, 1998.

4. ASHRAE Hand Book: HVAC Systems and Equipment, 1996.

5. Transport properties of SUVA Refrigerants, Du-Pont Chemicals, 1993.

COURSE CODE	ENERGY MANAGEMENT IN THERMAL SYSTEMS	L	T	P	C
2162ME140		3	0	0	3

UNIT I: INTRODUCTION **10**

Energy Scenario – world and India. Energy Resources Availability in India. Energy consumption pattern. Energy conservation potential in various Industries and commercial establishments. Energy intensive industries – an overview. Energy conservation and energy efficiency – needs and advantages. Energy auditing – types, methodologies, barriers. Role of energy manager – Energy audit questionnaire – energy Conservation Act 2003.

UNIT II: INSTRUMENTS FOR ENERGY AUDITING **8**

Instrument characteristics – sensitivity, readability, accuracy, precision, hystersis. Error and calibration. Measurement of flow, velocity, pressure, temperature, speed, Lux, power and humidity. Analysis of stack, water quality, power and fuel quality.

UNIT III: THERMAL UTILITIES **10**

(i) Boilers (ii) Thermic Fluid Heaters (iii) Furnaces (iv) Waste Heat Recovery Systems (v) Thermal Storage

UNIT IV: THERMAL ENERGY TRANSMISSION / PROTECTION SYSTEMS **7**

Steam traps – refractories – optimum insulation thickness – insulation – piping design

UNIT V: FINANCIAL MANAGEMENT **10**

Investment – need, appraisal and criteria, financial analysis techniques – break even analysis – simple payback period, return on investment, net present value, internal rate of return, cash flows, (Debt-Service Coverage Ratio) DSCR, financing options, ESCO concept.

TOTAL: 45 PERIODS

REFERENCES

1. Smith, CB Energy Management Principles, Pergamon Press, New York, 1981

2. Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case study, Hemisphere, Washington, 1980

3. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997

4. Write, Larry C, Industrial Energy Management and Utilization, Hemisphere Publishers, Washington, 1988

5. Diamant, RME, Total Energy, Pergamon, Oxford, 1970

6. Handbook on Energy Efficiency, TERI, New Delhi, 2001

COURSE CODE	ADVANCED THERMAL STORAGE TECHNOLOGIES	L	T	P	C
2162ME142		3	0	0	3

UNIT I: INTRODUCTION **L –8**

Necessity of thermal storage – types-energy storage devices – comparison of energy storage technologies - seasonal thermal energy storage - storage materials.

UNIT II: SENSIBLE HEAT STORAGE SYSTEM **L –9**

Basic concepts and modeling of heat storage units - modeling of simple water and rock bed storage system – use of TRNSYS – pressurized water storage system for power plant applications – packed beds.

UNIT III: REGENERATORS **L –10**

Parallel flow and counter flow regenerators – finite conductivity model – non – linear model – transient performance – step changes in inlet gas temperature – step changes in gas flow rate – parameterization of transient response – heat storage exchangers.

UNIT IV: LATENT HEAT STORAGE SYSTEMS **L –9**

Modeling of phase change problems – temperature-based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

UNIT V: APPLICATIONS **L –9**

Specific areas of application of energy storage – food preservation – waste heat recovery – solar energy storage – green house heating – power plant applications – drying and heating for process industries.

TOTAL: 45 PERIODS

REFERENCES

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.

2. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.

3. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.

COURSE CODE	ENERGY EFFICIENT BUILDINGS	L	T	P	C
2162ME144		3	0	0	3

UNIT I: BUILDING SCIENCE **9**

Architecture- Building Science and its significance. Indoor Environment. Components of Indoor Environment. Quality of Indoor Environment.

UNIT II: HUMAN COMFORT **9**

Human Comfort-Thermal, Visual, Acoustical and Olfactory comfort. Concept of Sol-air temperature and its significance. Ventilation and is significance.

UNIT III: ENERY INTENSITY **9**

Cooling and heating concepts, Passive concepts appropriate for the various climatic zones in India. Classification of building materials based on energy intensity.

UNIT IV: ENERGY MANAGEMENT **9**

Energy Management of Buildings and Energy Audit of Buildings. - Energy management matrix monitoring and targeting.

UNIT V: ENERGY CONSERVATION **9**

Energy Efficient Landscape Design -Modification of microclimate through landscape elements for energy conservation.

TOTAL: 45 PERIODS

REFERENCES

1. SodhaM.,Bansal, N.K., Bansal,P.K., Kumar, A.. and Malik, M.A.S.,"Solar Passive Buildings", Pergamon Press, 1986.
2. Koenigsberger, O.H., Ingersoll, T.G., Mayhew Alan and Szokolay, S. V., "Manual of Tropical Housing and Building part 1: Climatic Design", OLBN 0 00212 0011,Orient Longman Limited, 1973.
3. Bureau of Indian Standards, I.S. 11907 –1986 Recommendations for calculation of Solar Radiation Buildings, 1986.
4. Givoni,B., "Man, Climate and Architecture", Elsevier, Amsterdam, 1986.
5. Smith, R. J., Phillips, G.M. and Sweeney, M. "Environmental Science", Longman Scientific and Technical, Essex, 1982.

COURSE CODE	MEASUREMENTS IN THERMAL ENGINEERING	L	T	P	C
2162ME146		3	0	0	3

UNIT I: INTRODUCTION **9**

Instrument classification, static and dynamic characteristics of instruments, experimental error analysis, systematic and random errors, statistical analysis, uncertainty, reliability of instruments, Variable resistance transducers, capacitive transducers, piezoelectric transducers, photoconductive transducers, photovoltaic cells, ionization transducers, Hall effect transducers.

UNIT II: DYNAMIC MEASUREMENT **9**

Dynamic response considerations, Bridgman gauge, McLeod gauge, Pirani thermal conductivity gauge, Knudsen gauge, Alphatron.

UNIT III: FLOW AND TEMPERATURE MEASUREMENT **9**

Flow measurement by drag effects; hot-wire anemometers, magnetic flow meters, flow visualization methods, interferometer, Laser Doppler anemometer.

Temperature measurement by mechanical effect, temperature measurement by radiation, transient response of thermal systems, thermocouple compensation, temperature measurements in high- speed flow.

UNIT IV: THERMAL CONDUCTIVITY MEASUREMENT **9**

Thermal conductivity measurement of solids, liquids, and gases, measurement of gas diffusion, convection heat transfer measurements, humidity measurements, heat-flux meters. Detection of thermal radiation, measurement of emissivity, reflectivity and transmissivity, solar radiation measurement.

UNIT V: CONTROL SYSTEMS **9**

Review of open and closed loop control systems and servo mechanisms, Transfer functions of Mechanical Systems, input and output systems.

TOTAL: 45 PERIODS

REFERENCES

1. Holman, J.P., “Experimental methods for engineers”, Tata McGraw-Hill, 7th Edition, 2007.

2. Prebrashensky. V., “Measurement and Instrumentation in Heat Engineering”, Vol.1, MIR Publishers, 1980.

3. Raman, C.S. Sharma, G.R., Mani, V.S.V., “Instrumentation Devices and Systems”, 2nd Edition, Tata McGraw-Hill., 2001.

4. Morris. A.S, “Principles of Measurements and Instrumentation”, 3rd Edition, Butterworth-Heinemann, 2001.

COURSE CODE	Design and Optimization of Thermal Systems	L	T	P	C
2162ME182		3	0	0	3

UNIT I: DESIGN CONCEPTS **9**

Design Principles, Workable Systems, Optimal Systems, Matching of System Components, Economic Analysis, Depreciation, Gradient Present Worth factor, modelling overview – levels and steps in model development - Examples of models – curve fitting and regression analysis

UNIT II: MODELLING AND SYSTEMS SIMULATION **10**

Modelling of thermal energy systems – heat exchanger - solar collectors – distillation - rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of nonlinear algebraic equations - successive substitution - Newton Raphson method- examples of thermal systems simulation

UNIT III: OPTIMIZATION **10**

Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis - New generation optimization techniques – examples

UNIT IV: DYNAMIC BEHAVIOUR **8**

Steady state Simulation, Laplace Transformation, Feedback Control Loops, Stability Analysis, Non-Linearity

UNIT V: APPLICATIONS AND CASE STUDIES **8**

Case studies of optimization in thermal systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis

TOTAL: 45 PERIODS

REFERENCES

1. B.K.Hodge, Analysis and Design of Thermal Systems, Prentice Hall Inc., 1990.
2. Bejan A., George Tsatsaronis , Michael J. Moran , Thermal Design and Optimization, Wiley 1996
3. D.J. Wide, Globally Optimal Design, Wiley- Interscience, 1978.
4. Kapur J. N., Mathematical Modelling , Wiley Eastern Ltd , New York , 1989.
5. Rao S. S., Engineering Optimization Theory and Practice, New Age Publishers, 2000.
6. Stoecker W. F., Design of Thermal Systems, McGraw Hill Edition, 1989.
7. YogeshJaluria , Design and Optimization of Thermal Systems , CRC Press , 2007.

COURSE CODE	CRYOGENIC ENGINEERING	L	T	P	C
2162ME183		4	0	0	4

UNIT I: INTRODUCTION **9**

Insight on Cryogenics, Properties of Cryogenic fluids, Material properties at Cryogenic Temperatures. Applications of Cryogenics in Space Programs, Superconductivity, Cryo Metallurgy, Medical applications.

UNIT II: LIQUEFACTION CYCLES **9**

Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles. Inversion Curve - Joule Thomson Effect. Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claudes Cycle Dual Cycle, Ortho-Para hydrogen conversion, Eollins cycle, Simpson cycle, Critical Components in Liquefaction Systems.

UNIT III: SEPARATION OF CRYOGENIC GASES **9**

Binary Mixtures, T-C and H-C Diagrams, Principle of Rectification, Rectification Column Analysis - McCabe Thiele Method. Adsorption Systems for purification.

UNIT IV: CRYOGENIC REFRIGERATORS **9**

Joule Thompson Cryocoolers, Stirling Cycle Refrigerators, Gifford-McMahon Cryocoolers, Pulse Tube Refrigerators Regenerators used in Cryogenic Refrigerators, Dilution refrigerators, Magnetic Refrigerators.

UNIT V: HANDLING OF CRYOGENS **9**

Cryogenic Dewar, Cryogenic Transfer Lines. Insulations used in Cryogenic Systems, Instrumentation to measure Flow, Level and Temperature**.**

TOTAL: 45 PERIODS

REFERENCES

1. Klaus D. Timmerhaus and Thomas M. Flynn, Cryogenic Process Engineering, Plenum Press, New York, 1989

2. Randall F. Barron, Cryogenic Systems, McGraw-Hill, 1985.

3. Scott R.B., Cryogenic Engineering, Van Nostrand and Co., 1962.

4. Herald Weinstock, Cryogenic Technology, 1969.

5. Robert W. Vance, Cryogenic Technology, Johnwiley & Sons, Inc., New York, London

INDEPENDENT LEARNING COURSES

2163GE401	BUSINESS COMMUNICATION	L	T	P	C
		2	0	0	2

UNIT-I: BUSINESS CORRESPONDENCE **10**

Communication – Process of Communication, Barriers in Communication, Written Communication - Business letters (Quotations, Orders, Tenders, Complaint, Responding/reply to enquiry), Email (Email Etiquettes), Minutes, Memorandum, Circular, Notice, Agenda.

UNIT- II: JOB RELATED COMMUNICATION **10**

Job Application, Resume Writing, Profile Summary and Employment Interview, Presentation

UNIT- III: REPORT WRITING AND OTHER BUSINESS COMMUNICATIONS **10**

Project writing, Technical Proposal, Report Writing (Business and Technical Report), Journal Writing (Research Article), Technical Description

TOTAL: 30 PERIODS

TEXT BOOK:

1. Sharma R C., Mohan Krishna, Business Correspondence and Report Writing. 5th ed. Chennai:Mc Graw Hill Education (India) Pvt. Ltd,2016.

REFERENCES:

1. Padmaja T.V.S., Pfeiffer William Sanborn. Technical Communication. 6th ed. Noida: Pearson India Education Services Pvt. Ltd, 2008.
2. Anderson V. Paul, Technical Communication.6th ed.New Delhi: Cengage Learning, 2010.
3. Kumar Sanjay, Lata Pushp, Communication Skills. 2nd ed. New Delhi: Oxford University Press, 2015.

WEB RESOURCES

1. https://saylordotorg.github.io/text_business-communication-for-success/index.html
2. http://www.managementstudyguide.com/communication-flows.htm

2163MG401	RESEARCH METHODOLOGY	L	T	P	C
		2	0	0	2

UNIT I: RESEARCH FORMULATION AND DESIGN **L-9**

Motivation and objectives – Research methods *vs.* Methodology. Types of research – Descriptive *vs*. Analytical, Applied *vs*. Fundamental, Quantitative *vs*. Qualitative, Conceptual *vs*. Empirical, concept of applied and basic research process, criteria of good research.
Defining and formulating the research problem, selecting the problem, necessity of defining the problem, importance of literature review in defining a problem, literature review-primary and secondary sources, reviews, monograph, patents, research databases, web as a source, searching the web, critical literature review, identifying gap areas from literature and research database, development of working hypothesis.

UNIT II: DATA COLLECTION AND ANALYSIS **L-9 T-15**

Accepts of method validation, observation and collection of data, methods of data collection, sampling methods, data processing and analysis strategies and tools, data analysis with statically package (Sigma STAT,SPSS for student t-test, ANOVA, etc.), hypothesis testing.

UNIT III: SOFT COMPUTING **L-9**

Computer and its role in research, Use of statistical software SPSS, GRETL etc. in research. Introduction to evolutionary algorithms - Fundamentals of Genetic algorithms, Simulated Annealing, Neural Network based optimization, Optimization of fuzzy systems.

UNIT IV: RESEARCH ETHICS, IPR AND SCHOLARY PUBLISHING **L-9**

Ethics-ethical issues, ethical committees (human & animal); IPR- intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS); scholarly publishing- IMRAD concept and design of research paper, citation and acknowledgement, plagiarism, reproducibility and accountability.

UNIT V: INTERPRRETATION ANDREPORT WRITING **L-9**

Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions.

TOTAL: 60 PERIODS

REFERENCES

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5. Wadehra, B.L. 2000. Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.

ADDITIONAL READING

1. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
3. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
4. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
5. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
6. Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.
7. Satarkar, S.V., 2000. Intellectual property rights and Copy right. Ess Ess Publications.

LIST OF NPTEL ONLINE COURSES UNDER INDEPENDENT LEARNING CATEGORY (MOOC)

Sl. No.	Course Code	Name of the course	Result published	Course offered by	Credit
1	2163ME405	Introduction to composites	12 Weeks (30 hr)	NPTEL	2
2	2163ME406	Compliant Mechanisms : Principles and Design	12 Weeks (30 hr)	NPTEL	2
3	2163ME407	Machinery Fault Diagnosis And Signal Processing	12 Weeks (30 hr)	NPTEL	2
4	2163ME408	Design and Analysis of Experiments	12 Weeks (30 hr)	NPTEL	2
5	2163ME409	Transport Processes I: Heat and Mass Transfer	12 Weeks (30 hr)	NPTEL	2
6	2163ME410	Fundamentals of Nuclear Power Generation	12 Weeks (30 hr)	NPTEL	2
7	2163ME411	Convective Heat Transfer	12 Weeks (30 hr)	NPTEL	2
8	2163ME412	Rheology of Complex Materials	12 Weeks (30 hr)	NPTEL	2
9	2163ME413	Physics of Materials	12 Weeks (30 hr)	NPTEL	2
10	2163ME414	Introduction to Mechanical Micro Machining	12 Weeks (30 hr)	NPTEL	2
11	2163ME415	Material Characterization	12 Weeks (30 hr)	NPTEL	2
12	2163ME416	Theory of Production Processes	12 Weeks (30 hr)	NPTEL	2
13	2163ME417	Lean Six Sigma Green Belt	≈ 50 hr	ASQ with IIT Kharagpur	2
14	2163ME418	Quality Design and Control	12 Weeks (30 hr)	NPTEL	2
15	2163ME419	Business Analytics for Management Decision	12 Weeks (30 hr)	NPTEL	2
16	2163ME420	Industrial automation and control	12 Weeks (30 hr)	NPTEL	2
17	2163ME421	Six Sigma	12 Weeks (30 hr)	NPTEL	2

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…CONTINUATION

Sl. No.	Course Code	Name of the course	Result published	Credit
1	2163ME422	System Design for Sustainability	12 Weeks (30 hr)	2
2	2163ME423	Advanced Composites	12 Weeks (30 hr)	2
3	2163ME424	Fundamentals of Surface Engineering	12 Weeks (30 hr)	2
4	2163ME425	Energy Conservation and Waste Heat Recovery	12 Weeks (30 hr)	2
5	2163ME426	Management of Inventory System	12 Weeks (30 hr)	2
6	2163ME427	Noise Management and Control	12 Weeks (30 hr)	2
7	2163ME428	Fundamentals of Manufacturing Processes	12 Weeks (30 hr)	2