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UNIVERSITY OF MUMBAI

Revised Syllabus for the M. E. Program

Program: M. E. (Mechanical Engineering)

CAD/CAM AND ROBOTICS

(As per Credit Based Semester and Grading System with effect from the academic year 2012–2013)

Program Structure for
ME Mechanical Engineering (CAD/CAM and Robotics)
Mumbai University
(With Effect from 2012-2013)

Semester I

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CCC101	Computer aided Design	04	--	--	04	--	--	04
CCC102	Control Engineering	04	--	--	04	--	--	04
CCC103	Mechatronics	04	--	--	04	--	--	04
CCE101X	Elective I	04	--	--	04	--	--	04
CCE102X	Elective II	04	--	--	04	--	--	04
CCL101	Laboratory I - CAD &FEA	--	02	--	--	01	--	01
CCL102	Laboratory II - Objected oriented Programming	--	02	--	--	01	--	01
Total		**20**	**04**	**--**	**20**	**02**	**--**	**22**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
CCC101	Computer aided Design	20	20	20	80	03	--	--	100
CCC102	Control Engineering	20	20	20	80	03	--	--	100
CCC103	Mechatronics	20	20	20	80	03	--	--	100
CCE101X	Elective I	20	20	20	80	03	--	--	100
CCE102X	Elective II	20	20	20	80	03	--	--	100
CCL101	Laboratory I - CAD &FEA	--	--	--	--	--	25	25	50
CCL102	Laboratory II - Objected Oriented Programming	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**50**	**50**	**600**

Subject Code	Elective I	Subject Code	Elective II
CCE1011	Advanced Stress Analysis*	CCE1021	Analysis and Synthesis of Mechanisms$
CCE1012	Reliability Engineering$	CCE1022	Computational Fluid Dynamics%
CCE1013	Rapid Prototyping and Tooling*	CCE1023	Product Design
CCE1014	Advanced Finite element analysis*	CCE1024	Simulation & Modeling

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$ Common for Machine Design and CAD/CAM and Robotics

% Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Energy Engineering

Semester II

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CCC201	Robotics*	04	--	--	04	--	--	04
CCC202	Optimization$	04	--	--	04	--	--	04
CCC203	Computer Aided Machining(CAM)	04	--	--	04	--	--	04
CCE203X	Elective III	04	--	--	04	--	--	04
CCE204X	Elective IV	04	--	--	04	--	--	04
CCL203	Laboratory III - CAM	--	02	--	--	01	--	01
CCL204	Laboratory IV - Mechatronics &Robotics	--	02	--	--	01	--	01
Total		**20**	**04**	**--**	**20**	**02**	**--**	**22**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
CCC201	Robotics*	20	20	20	80	03	--	--	100
CCC202	Optimization$	20	20	20	80	03	--	--	100
CCC203	Computer Aided Machining(CAM)	20	20	20	80	03	--	--	100
CCE203X	Elective III	20	20	20	80	03	--	--	100
CCE204X	Elective IV	20	20	20	80	03	--	--	100
CCL203	Laboratory III - CAM	--	--	--	--	--	25	25	50
CCL204	Laboratory IV - Mechatronics &Robotics	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**50**	**50**	**600**

Subject Code	Elective III	Subject Code	Elective IV
CCE2031	Virtual Reality	CCE2041	Supply Chain Management
CCE2032	Product Lifecycle Management@	CCE2042	Artificial Intelligence
CCE2033	Concurrent Engineering	CCE2043	Composite Material$
CCE2034	Micro Electro Mechanical Systems@	CCE2044	Smart Materials and Applications*

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$ Common for Machine Design and CAD/CAM and Robotics

@ Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Manufacturing Systems Engineering

Semester III

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CCS301	Seminar	--	06	--	--	03	--	03
CCD301	Dissertation I	--	24	--	--	12	--	12
Total		**--**	**30**	**--**	**--**	**15**	**--**	**15**

Subject Code	Subject Name	Examination Scheme						
		Theory				Term Work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam.			
		Test1	Test 2	Avg.				
CCS301	Seminar	--	--	--	--	50	50	**100**
CCD301	Dissertation I	--	--	--	--	100	--	**100**
Total		**--**	**--**	**--**	**--**	**150**	**50**	**200**

Semester IV

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CCD401	Dissertation II	--	30	--	--	15	--	15
Total		**--**	**30**	**--**	**--**	**15**	**--**	**15**

Subject Code	Subject Name	Examination Scheme						
		Theory				Term Work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam.			
		Test1	Test 2	Avg.				
CCD401	Dissertation II	--	--	--	--	100	100	**200**
Total		**--**	**--**	**--**	**--**	**100**	**100**	**200**

Note:

- In case of Seminar (CCS301), 01 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation I (CCD301) and DissertationII (CCD401), 02 Hour / week / student should be considered for the calculation of load of a teacher

Subject Code	Subject Name	Credits
CCC101	**Computer Aided Design**	**04**

Module	Detailed content	Hours
1	Introduction to computer Graphics : Definitions, Classification, Architecture of interactive computer Graphics, Applications Display & Interactive devices Scan Conversion: Pixel plotting , scan conversion of Line , Circle, ellipse, Parabola, Hyperbola. Effects of Scan conversion Polygons: Types, Poly gon filling using Boundary fill, edge fill ,Flood fill algorithms, Scan conversion with Real Time scan conversion ,Run length encoding, Cell encoding	14
2	2-D Transformations, 3-D Transformations	08
3	2-D Viewing & Clipping, 3-D Viewing & Clipping Projection: parallel & Perspective Projections	12
4	Curves : Splines, Bezier & B-Spline Curves Surfaces: Hermite ,Bezier & B-Spilne surfaces	08
5	Virtual Reality: Hidden Lines & Hidden Surfaces: Z-Buffer, Painters, Area-Subdivision, Scan Line algorithm Light , Color & Shading Models Animation	10
6	CAD & Geometric Modelling: Features of Modeling &Assembly Packages, Types of Geometric Modelling, Data Structures, Product Data exchange Formats. Fundamentals of CAE: General procedures of Numerical methods like FEM & FDM, Kinematic analysis &Animation ,Features and Application of Commercial packages of CAE.	08

References:

1. Computer Grahics by F.S Hill. Jr
2. Computer graphics by Zhigang Xiang & Roy Plastock (Schaum's outline's)
3. Computer Graphics by Hearn & Baker
4. Mathematical elements for Computer Graphics by David F. Rogers, James Alan Adams
5. Procedural elements for Computer Graphics by David F. Rogers, James Alan Adams
6. Mastering CAD/CAM by Ibrahim Zeid
7. Geometric Modelling by Mortenson, M.E.

Assessment:

Internal: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.Minimum 80% syllabus should be covered in question papers of end semester examination.

Subject Code	Subject Name	Credits
CCC102	**Control Engineering**	**04**

Module	Detailed content	Hours
1	Introduction to control systems. Classification of control system , Effect of feedback. Mathematical modeling of control systems, concept of transfer function. Block diagram algebra, and signal flow graphs,.	08
2	Time response analysis: Time response of control system, standard test signal, Time Response Analysis of First and Second order system, Time Domain specifications. Step response of second order system. steady-state errors , static error constants, steady state, analysis of Different type of systems using step. Ramp and parabolic inputs. Response with P,PI,PD,PID Controller.	10
3	Classification of control systems according to 'TYPE' of systems, Stability analysis: Introduction to concepts of stability. The Routh and Hurwitz stability criteria. Relative stability analysis.	10
4	Root locus Techniques. Frequency Response Analysis, Frequency domain specifications Correlation between time and frequency response. Polar Plots. Bode Plots, Nyquist Plots,	12
5	State space modeling: Concept of state, state variable, state model. State space representation using physical and phase variables, decomposition of transfer function, diagonalisation. State transition matrix. Transfer function from state model. Controllability and observabilty of linear system.	10
6	Compensation (Introduction only): Types of compensator, selection of compensator, Lead, Lag and Lag-Lead compensation. Control system Components : servomotor, stepper motors,Synchros, Potentiometer, amplifiers	08

References:

1. Control System Engineering: by Nagrath LT. and Gopal .M., Wiley Eastern Lid.
2. Modem Control engineering: by K.Ogata, Prentice Hall.
3. Benjamin C. Kuo, Automatic Control Systems, Pearson education, seventh edition.
4. MadanGopal, Control Systems Principles and Design, Tata McGraw Hill, seventh edition, 1997
5. Nise, control system Engineering, John wiley& sons, 3rd edition

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Subject Code	Subject Name	Credits
CCC103	**Mechatronics**	**04**

Module	Detailed content	Hours
1	Introduction to Mechatronics, Traditional and Mechatronics design, Mechatronics Key elements, Basic Components of Mechatronics Systems, Integrated design issues in Mechatronics, Mechatronics design process, Mechatronics Systems in Factory, Home and Business Applications, Objectives, Advantages , disadvantages of Mechatronics	06
2	Overview of micro processors and micro-controllers ,8051 microcontrollers: Functional block diagram and architecture, Instruction set and assembly language programming.	12
3	Interfacing hardware with real world, analog interface and data acquisition, digital i/o interfacing, special function interfacing signal conditioning, special utility support hardware Interfacing of: HEX-keyboards, LCD display, ADC, DAC and stepper motor with 8051 Micro controller	10
4	Overview of Sensors and Transducers- Sensors for motion and position, Force Torque and Tactile Sensors, Range Sensors, Proximity Sensors, Ultrasonic Sensors. Interfacing of sensors with microcomputer system. Micro and Nano Sensors in Mechatronics	08
5	Electro-Pneumatic systems Electro- Hydraulic systems. Development of circuits for Industrial-automation. **Logic Gates -** AND, OR, NOT, NAND and NOR, applications of basic control circuits based on these gates, Karnaugh map for signal simplification **Programmable logic controllers-** Over viewand applications of programmable logic controllers in manufacturing,Relay logic, programming a PLC using ladder diagram programming,Ladder logic programme for control of single cylinder and two cylinder pneumatic systems and hydraulic systems	14
6	Case Studies of Mechatronics Systems- Timed Switch, Pick and Place Robot, Car Park Barriers, Automatic Camera, Car Engine Management, Bar Code System, CNC Machine, ABS,Artificial Intelligence in Mechatronics, Fuzzy Logic applications in Mechatronics	10

References:

1. The 8051 microcontroller and embedded systems using assembly and C by M.A.Mazidi, J. c:.Mazidi and R. D. McKinlay. PHI, second edition
2. The 8051 microcontroiler Architecture, Programming anJ Applications Kenn'th J T Ayala, Pemam International Publishing, (India).
3. Process control & Instrumentation technology : Cirtis D Johnson
4. Industrial control & instrumentation W Bolaton, (Orient Longman)
5. Mechatronics - Electronic Control Systems in Mechanical Engineering, Bolton Pearson education
6. Mechatronics. HMT
7. Fundamentals of Electro-Pneumatics :Festo Series
8. Fundamentals of Electro-Hydraulics: Festo Series

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Subject Code	Subject Name	Credits
CCE1011	**Advanced Stress Analysis***	**04**

Module	Detailed content	Hrs.
1	**Analysis of stress in three dimensions:** Stress at a point – components of stress; Principal stresses; Determination of principal stresses; Stress invariants; Determination of maximum shear stresses; Octahedral shear stress, Hydrostatic and Deviatoric Stress Tensors Mohr's Circle for 2D and 3D stress problem.	12
2	**Analysis of strain:** Strain at a point – Components of strain; Differential equations of equilibrium; Conditions of compatibility, Hydrostatic and Deviatoric Strain Tensors Mohr's Circle for 2D and 3D strain problem.	10
3	**Stress Strain relationship:** Generalized Hooke's law, Elastic behavior for different materials (Isotropic, Orthotropic and Anisotropic).	10
4	**Electrical Strain Gauges:** Principle of operation and requirements, Types and their uses, Materials for strain gauge. Calibration and temperature compensation, cross sensitivity, Rosette analysis, Wheastone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators. Load cell and its types Introduction to Recent Trends in Strain Measurement	08
5	**Fatigue and Fracture:** Introduction to fatigue and fracture mechanics of ductile and brittle fractures mechanism of fatigue failure. Factors affecting fatigue. Methods of improving fatigue strength. Cumulative damage theories. Linear elastic fracture mechanics. Finite life, infinite life, design of machine components, Fracture toughness, Crack growth studies	10
6	**Environmental considerations in design:** Corrosion, corrosion under stress, fretting corrosion and effects of other chemicals. Methods of improving corrosion resistance.	10

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References:

1. Srinath, L.S., Raghava, M.R., Lingaiah, K., Garagesha, G., Pant B., and Ramachandra, K., "Experimental Stress Analysis", Tata McGraw-Hill, New Delhi, 1984.
2. M. Ameen, "Computational Elasticity", Narosa Publishing House.
3. Dally, J.W., and Riley, W.F., "Experimental Stress Analysis", McGraw-Hill Inc., New York, 1998.
4. Cook and Young, "Advanced Mechanics of Materials", Prentice Hall
5. Richard G. Budynas, "Advanced Strength and Applied Stress Analysis", McGraw Hill
6. Boresi, Schmidt, "Advanced Mechanics of Materials", Sidebottom, Willey
7. Timoshenko and Goodier, "Theory of Elasticity", McGraw Hill
8. Timoshenko, "Advanced Strength of Materials, Vol. 1,2", CBS
9. T.L. Anderson, "Fracture Mechanics – Fundamentals and Applications " CRC Press

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Subject Code	Subject Name	Credits
CCE1012	**Reliability Engineering[$]**	**04**

Module	Detailed content	Hours
1	**Probability theory** Probability : Standard definitions and concepts; Conditional Probability, Baye's Theorem. Probability Distributions: Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. Measures of Dispersion: Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness, Kurtosis.	12
2	**Reliability Concepts** Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. Reliability Hazard Models : Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	14
3	**System Reliability** System Configurations : Series, parallel, mixed configuration, k- out of n structure, Complex systems.	08
4	**Reliability Improvement** Redundancy Techniques : Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.	08
5	**Maintainability and Availability** System downtime, Design for Maintainability : Maintenance requirements, Design methods : Fault Isolation and self diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	10
6	**Failure Mode, Effects and Criticality Analysis** Failure mode effects analysis, severity/criticality analysis , FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis	08

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References:

1. L.S. Srinath, “Reliability Engineering”, Affiliated East-West Press (P) Ltd., 1985.
2. Charles E. Ebeling, “Reliability and Maintainability Engineering”, Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, “Engineering Reliability”, John Wiley & Sons, 1980.
4. P.D.T. Conor, “Practical Reliability Engineering”, John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, “Reliability in Engineering Design”, John Wiley & Sons.
6. Murray R. Spiegel, “Probability and Statistics”, Tata McGraw-Hill Publishing Co. Ltd.

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Subject Code	Subject Name	Credits
CCE1013	Rapid Prototyping and Tooling*	04

Module	Detailed content	Hours
1	**Rapid Prototyping** • Historical Development • Applications: Design, Planning, Manufacturing and Tooling • Applications: Automotive, Jewelry, Coin and Bio-Medical • Fundamentals of Rapid Prototyping, Design Process • Rapid Prototyping Process Chain	10
2	**Subsystems of RP Machine** • Subsystems of RP machine o Optical System o Mechanical Scanning System o Computer Interfacing hardware, DAQs o Signal Flow, 3D Model to RP Prototype • Introduction to 3D Modeling Softwares (Auto-CAD, PROE, CATIA, IDEAs etc.) • Slicing and Scan Path Generation Algorithms • Data Conversion and Transmission • File Formats, IGES, STL • Preprocessing and Post-processing	10
3	**Liquid Based Rapid Prototyping Systems** • Materials • Stereolithography • Solid Ground Curing • Solid Object UV (Ultra-Violet) Printer • Two Laser System • Micro-stereolithography	10
4	**Solid Based Rapid Prototyping Systems** • Materials • LOM (Laminated Object Manufacturing) System • FDM (Fuse Deposition Modeling) System • Multi-Jet Modeling (MJM) System • Model Maker and Pattern Master • Shape Deposition Manufacturing Process	10
5	**Powder Based Rapid Prototyping Systems** • Materials • SLS (Selective Laser Sintering) • (3DP) Three-Dimensional Printing • (LENS) Laser Engineered Net Shaping • (MJS) Multiphase Jet Solidification • (EBM) Electron Beam Melting	10
6	**Advances in RP Systems and Case Studies** • Advances in RP: Resolution & Accuracy issues, Integrated Hardening Process, Two Photon Process for Micro/Nano Fabrication, Reverse Engineering Process and Applications. • Case Study: Wind-Tunnel Testing with RP Models Case Study: Investment Casting with RP	10

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References:

1. Chua C.K., Leong K.F., and Lim C.S., "Rapid Prototyping Principles and Applications", World Publishing Co. Pte. Ltd.
2. James O. Hamblen, and Michael D. Furman, "Rapid Prototyping of Digital Systems", Kluwer Academic Publishers.
3. Kenneth G. Cooper, "Rapid Prototyping Technology Selection and Application", 2001, Marcel Dekker Inc, New York.
4. Ali Kamrani, EmadAbouel Nasr, "Rapid Prototyping Theory and Practice", 2006, Springer Inc.
5. BopayaBidanda, Paulo J. Bartolo, "Virtual Prototyping and Bio Manufacturing in Medical Applications", 2008, Springer Inc.
6. I. Gibson, D.W. Rosen, and B. Stucker, "Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing", 2010, Springer Inc.

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Subject Code	Subject Name	Credits
CCE1014	**Advanced Finite Element Analysis***	**04**

Module	Detailed content	Hrs.
1	• Introduction to FEA, General FEM procedure, • Approximate solutions of differential equations: FDM method, W-R technique, collocation least square sub-domain and Galerkin method • Numerical integration, Gauss quadrature in 2-D and 3-D • Structure of FEA program, Pre and Post processor, commercially available standard packages, and desirable features of FEA packages. • Principal of minimum total potential, elements of variational calculus, minimization of functional, Rayleigh-Ritz method, Formulation of elemental matrix equation, and assembly concepts.	14
2	**One Dimensional FEM:** • Coordinate system: Global, local, natural coordinate system. Shape functions: Polynomial shape functions, Derivation of shape functions, Natural co-ordinate and coordinate transformation, Linear quadratic and cubic elements, Shape functions using Lagrange polynomials. Convergence and compatibility requirement of shape functions. • One dimensional field problems: structural analysis (step-bar, taper-bar). Structural analysis with temperature effect, Thermal analysis, heat transfer from composite bar, fins. Fluid network and flow through porous medium, analysis of electrical network problems by FEA	12
3	• Trusses, Thermal effects in truss members, Beams. • Two dimensional finite elements formulations, Threenoded triangular element, Four-noded rectangular element, Four-noded quadrilateral element, derivation of shape functions: natural coordinates, triangular elements, and quadrilateral elements. • Six-noded triangular elements, Eight-noded quadrilateral elements, Nine-noded quadrilateral element; Strain displacement matrix for CST element	10
4	• Penalty Method, Lagrange methods, Multipoint Constraints • Concept of Master/Slave entities • Examples of Contact problems. • Iso-parametric concepts, basic theorem, Iso-parametric, super-parametric, sub-parametric elements, Concept of Jacobian	08
5	• Finite element formulation of Dynamics, application to free-vibration problems, Lump and consistent mass matrices, Eigen value problems. • Transient dynamic problems in heat transfer and solid mechanics. • Introduction to time-integration methods: Implicit and Explicit methods, Convergence, Impact of Mesh quality on convergence	08
6	• Three dimensional elements: Tetrahedron, Rectangular prism (brick), Arbitrary hexahedron; Three Dimensional polynomial shape functions, Natural co-ordinates in 3D, Three dimensional Truss(space trusses) • Introduction to material models: Introduction to plasticity (Von-Mises Plasticity), Hyper –elasticity. Generating and using experimental data to model material behaviour. • Errors in FEA, sources of errors, method of elimination, Patch test.	08

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References:

1. O.C.Zienkiewicz, R.L.Taylor&J.Z.Zhu, “The Finite Element Method its Basis and Fundamentals”, Butterworth-Heinemann,Elsevier
2. Reddy J. N., “Finite Element Method”, McGraw-Hill
3. S.S.Rao, “The Finite Element Method in Engineering” , 4th Edition, Academic Press, Elsevier
4. U.S.Dixit, “Finite Element Methods for Engineers”,Cengage Learning
5. P.Seshu, “Textbook of FE Analysis”, Prentice Hall
6. Desai and Abel, “Introduction to Finite Elements Methods”, CBS Publication
7. Tirupati R. Chandrupatla and Ashok D.Belegundu, “Introduction to Finite Elements in Engineering”
8. Erik Thompson, “Introduction to Finite Element Methods”, Wiley India
9. H. Kardestuneer, “Finite Elements Hand Book”
10. R.D.Cook, “Concepts & Applications of Finite Element Analysis”
11. Bathe K.J., “Finite Element Procedures in Engineering Analysis”, Prentice Hall of India
12. Huebener K.H., Dewhirst D.D., Smith D.E. and Byrom T.G., “The Finite Element Method for Engineers”, John Wiley, New York
13. Logan, “Finite Element Methods” Cengage Learning
14. George Buchanan, “Finite Elements Analysis”, McGrawHill
15. C.S.Krishnamoorthy, “Finite Elements Analysis”, Tata McGraw-Hill
16. RobertCook, “Concept and Application of Finite Element Methods”, Wiley India.

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Subject Code	Subject Name	Credits
CCE1021	**Analysis and Synthesis of Mechanisms[$]**	**04**

Module	Detailed content	Hrs.
1	**Basics of Mechanism:** Rigid body, Kinematic pairs, Lower pairs connections, Higher pair connections, Kinematic chain, Mechanism, Four bar mechanism, Slider crank mechanism, Transmission, deviation and pressure angles, Equivalent mechanisms.	10
2	**Type Synthesis, Number Synthesis, Dimensional Synthesis** Type synthesis, Number synthesis, Dimensional synthesis, Accuracy points, Spacing of of accuracy points, Chebyshev polynomials.	10
3	**Four Bar Coupler Point Curve:** Four bar linkage, coupler curve equation, double points and symmetry, Roberts-Chebyshev theorem.	10
4	**The Euler Savary Equation and Cubic of Stationary Curvature:** The Euler Savary equation and the Inflection circle, The cubic of stationary curvature.	10
5	**Linkage Synthesis with ThreeAccuracy Points (Geometric Methods):** Concept of poles, relative poles, pole triangle of four bar and slider crank mechanism. Application in position generation, function generation problems. **Linkage Synthesis with Four Accuracy Points (Geometric Methods):** Concept of opposite pole quadrilateral, Center point curve, Circle point curve, Application in position generation problems.	10
6	**Linkage Synthesis with Three Accuracy Points (Algebraic Method)** Fredeinstain displacement equation of four bar linkage for three accuracy points, Crank-follower linkage synthesis angular velocities and acceleration **Linkage Synthesis with Three Accuracy Points:** Complex Number Method	10

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References:

1. Rudolf Beyer, "The Kinematic Synthesis of Mechanisms", Chapman & Hall
2. Asok Kumar Malik, Amitabh Ghosh,"Kinematic Analysis and Synthesis of Mechanism"
3. Deh Chang Tao,"Applied Linkage Synthesis", Addison-Wesley Pub. Co.
4. Richard ScheunemannHartenberg andJacques Denavit,"Kinematic Synthesis of Linkages", McGraw-Hill
5. Delbert Tesar,"Graphical Procedures for Kinematic Synthesis of Mechanism", University of Florida

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Subject Code	Subject Name	Credits
CCE1022	**Computational Fluid Dynamics[%]**	**04**

Module	Detailed content	Hours
1	**Introduction:** Definition and overview of CFD, Advantages and applications, CFD methodology	06
2	**Governing Differential Equations:** Governing equations for mass, momentum and energy; Navier-Stokes equations; Mathematical behaviour of PDE's viz. parabolic, elliptic and hyperbolic, Initial and boundary conditions, Initial and Boundary value problems.	10
3	**Discretization Techniques:** Introduction to Finite difference Method, Finite Volume method and Finite Element method Finite difference methods; Finite difference representation of PDE's; Solutions to Finite Difference Equations; Implicit, semi-implicit and explicit methods; Errors and stability criteria	12
4	**Finite Volume Methods:** FVM solutions to steady one, two and three dimensional diffusion problems and unsteady one and two dimensional diffusion problems FVM solutions to convection-diffusion problems - one and two dimensional, steady and unsteady; Advection schemes; Pressure velocity coupling; SIMPLE family of algorithms	14
5	**Grid Generation:** Structured and Unstructured Grids; General transformations of the equations; body fitted coordinate systems; Algebraic and Elliptic Methods; multi block structured grids; adaptive grids	10
6	**Turbulence Modeling:** Effect of turbulence on governing equations; RANS, LES and DNS Models	08

% Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Energy Engineering

References:

1. Muralidhar, K., Sundararajan, T., “Computational fluid flow and heat transfer”, NArosa Publishing House, New Delhi1995
2. Ghosdhasdidar, P.S., “Computer simulation of flow and heat transfer”,TataMcGraw-Hill Publishing company Ltd., 1998.
3. Subas, V.Patankar, “Numerical heat transfer fluid flow”, Hemisphere publishing Corporation.
4. Taylor, C and Hughes J.B., “Finite Element Programming of the Navier Stokes Equation”, Pineridge Press Ltd., U.K , 1981.
5. Anderson, D.A., Tannehill , I.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 1”, Fundamental and General Techniques, Springer- Verlag , 1987

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Subject Code	Subject Name	Credits
CCE1023	**Product Design**	**04**

Module	**Detailed content**	**Hours**
1	Importance of product design, type of design product definition, product specification, Phases of product development: conceptual, embodiment and detailed design, product and technology development cycle, conceptgeneration and evaluation methods.Product life cycle with management with case studies,Creativitivity& Idea generation techniques.Importance of QualityDimensions:Performance,Features,aesthetics,Ergonomics,Reliabilty ,Sustainability,Serviceability,Brand value, Value Vs cost,Importance of shape, color,feature &Resemblance.	10
2	Material selection– Importance, classification material performance characteristic, selection criteria Ashby Material selection chart.New developments in materials:Special alloys, Composites and Ceramics.	06
3	Process selection – Importance types of manufacturing process and their classification, Sources of information selection criteria Material and Process selection Methods, Expert systems. Computer Database Approach, performance indices decision matrix, AHP and fuzzy approach introduction to material and process selection software.Axiomatic design principles and case studies.	10
4	Benchmarking – DFM, DFA, DFX, supplier involvement robust design, QFD and concurrent engineering.Design & process FMEA.	10
5	Mathematics of Times Value of Money, Cost Comparison, Depreciation,Taxes. Inflation profitability of Investment and Investment Decision Analysis,Sensitivity Analysis. Methods of cost Estimates, Industrial EngineeringApproach, parametric Approach. Introduction to Assembly Modeling, Top-Down and Bottom-Up Approaches of AM,Mating Conditions, representation Schemes. Generation of Assembly Sequences.	10
6	Product Development Cycle and Importance of Prototyping. Types of prototypes. Principal and advantages & Different Type of Generative Manufacturing process, Viz. Stereo lithography. FDM, SLS etc. Factors Concerning to RP: Consideration for Adoptions, Advantages, Accuracy andEconomic Consideration Case studies	14

References:

1. Product Design and Manufacturing by A.K.Chitale, R.C.Gupta, PHI.
2. Product Design and Development by Ulirich Karl T. and Eppinger Steven D,McGraw Hill.
3. Engineering Design by Dieter George E., McGraw Hill.
4. Handboook of Product Design for Manufacturing by Bralla, James G,McGraw Hill.
5. Product Design by Kevin Otto & Kristin Wood

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Subject Code	Subject Name	Credits
CCE1024	**Simulation and Modeling**	**04**

Module	**Detailed content**	**Hrs.**
1	**Principle of computer modelling and simulation:** Monte Carlo simulation. Nature of computer- modeling and simulation. Limitations of simulation, areas of applications. Components of a system -discrete and continuous systems, Models of a system -a variety of modeling approaches.	07
2	**Discrete Event Formalisms** Concepts of discrete event simulation, model components, a discrete event system simulation, simulation world views or formalisms. Characteristics of queueing systems, queueing notations, long run measures of performance of queueing systems, Steady state behavior of Markovian models (M/G/1, M/M/1, M/M/c) overview of finite capacity and finite calling population models, Network of Queues simulation of single channel queue, multi channel queue, inventory system and dump truck problem using event scheduling approach.	10
3	**Statistical Models in Simulation** Overview of probability and statistics, useful statistical model, discrete distribution, continuous distribution, empirical distribution and Poisson process. Discrete uniform -distribution poisson distribution -geometric distribution -acceptance -rejection technique for Poisson distribution gamma distribution.	10
4	**RANDOM NUMBER GENERATION:** Techniques for generating random numbers- Mid square method -the mod product method -Constant multiplier technique -Additive congruential method -Linear congruential method -Tests for random numbers -The Kolmogorov-Smimov test -the Chi-square test.. **RANDOM VARIABLE GENERATION:** Inversion transforms technique-exponential distribution. uniform distribution, weibul distribution, continuous distribution, generating approximate normal variates-Erlang distribution.	11
5	**Input Modeling** Introduction, steps to build a useful model of input data, data collection, identifying the distribution with data, parameter estimation, suggested estimators, goodness of fit tests, selection input model without data, covariance and correlation, multivariate and time series input models.	12
6	**Verification and Validation of Simulation Model** Introduction, model building, verification of simulation models, calibration and validation of models:- validation process, face validity, validation of model, validating input-output transformation, t-test, power of test, input output validation using historical data and Turing test. **Output Analysis** Types of simulations with respect to output analysis, stochastic nature of output data, measure of performance and their estimation, output analysis of terminating simulators, output analysis for steady state simulation. variance reduction techniques -antithetic variables, variables-verification and validation of simulation models.	10

References:

1. Banks J., Carson J. S., Nelson B. L., and Nicol D. M., “Discrete Event System Simulation”, 3rd edition, Pearson Education, 2001.
2. Gordon Geoffrey, “System Simulation”, 2nd edition, PHI, 1978.
3. Law A. M., and Kelton, W. D., “Simulation Modeling and Analysis”, 3rd edition, McGraw-Hill, 2000.
4. NarsingDeo, “System Simulation with Digital Computer”, PHI.
5. Frank L. Severance, “System Modeling and Simulation”
6. Trivedi K. S., “Probability and Statistics with Reliability, Queueing, and Computer Science Applications”, PHI, 1982.
7. Wadsworth G. P., and Bryan, J. G., “Introduction to Probability and Random Variables”, McGraw-Hill, 1960.
8. Donald W. Body, “System Analysis and Modeling”, Academic Press Harcourt India.
9. Bernard, “Theory Of Modeling and Simulation”
10. Levin & Ruben, “Statistics for Management”
11. Aczel&Sounderpandian, “Business Statistics”

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Subject Code	Subject Name	Credits
CCL101	**CAD and FEA**	**01**

Module	**Detailed content**	**Lab. Sessions**
1	3D- Modeling and Assembly & Drafting	05
2	Kinematic &Kinetic Analysis of Mechanisms	05
3	Static & Dynamic analysis using FEA	05

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
CCL102	**Object Oriented Programming**	**01**

Module	**Detailed content**	**Lab. Sessions**
1	Object oriented programming using C++	08
2	Object oriented programming using Java	07

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
CCC201	**Robotics***	**04**

Module	Detailed content	Hours
1	**Introduction:** Automation & robotics, Robotic System & Anatomy Classification, Future Prospects **Robotic Application in Manufacturing:** Material transfer, Machine loading & unloading, Processing operations, Assembly & Inspectors **Social Issues and Economics of robotics** **Drives:** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators , Power Transmission Systems**.**	12
2	**Robot &its Peripherals:** End Effecters - types, Mechanical & other grippers, Tool as end effecter **Sensors:** Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems **Robotic Cell Design & Control.**	08
3	**Robot Kinematics**: Coordinate Frames, Rotations, Homogeneous Coordinates, Arm Equation of Planer Robot, Four axis SCARA Robot, TCV, Inverse Kinematics of Planer Robot, Four Axis SCARA Robot.	12
4	**Trajectory Planning & Robot Dynamics:** Manipulator Path Control- Linear, Quadratic and Cubic Interpolation, Work Space Analysis, Robot Dynamics –Langrangian Dynamics of one and two link robot arm	08
5	**Machine Vision:** Introduction, Low level & High level vision, Sensing &Digitising, Image processing & analysis, Segmentation, Edge detection, Object description& recognition, Interpretation, Noises in Image, Applications	08
6	**Programming For Robots:** Methods, Robot programme as a path in space, Motion interpolation, level & task level languages, Robot languages; Programming in suitable languages Characteristics of robot **Robot Intellgence& Task Planning:** Introduction, State space search, Problem reduction, Use of predictive logic, Means -Ends Analysis, Problem solving, Robot learning,Robot task planning.	12

*** Common for Machine Design, Automobile Engineering and CAD/CAM and Robotics**

References:

1. YoremKoren, “Robotics for Engineers”
2. J. F. Engelberger, “Robotics in Practice”
3. Ulrich Rembolds, ChristialBlume, “Computer Integrated Manufacturing Technology and Systems”
4. Ramamurthy, “Computer Aided Design in Mechanical Engineering”
5. Mark Spong, “Robot Dynamics and Control”, Wiley India
6. John Craig, “Robotics”
7. Paul R.P., “Robot Manipulators: Mathematics, Programming and Control”
8. Groover and Simmers,“Industrial Robotics”
9. Ernest Deoblin,“Measurement systems”
10. Beckwith and Lewisbuck, “Mechanical Measurements”
11. K. Ogata,“Modern Control Engineering”,PHI
12. Benjamin Kuo, “Automatic Control Systems”, Wiley India
13. Richard D. KIafter et al, “Robotic Engineering -an Integrated Approach”, PHI
14. Spyros G. Tzafestas, “Intelligent Robotic Systems”

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Subject Code	Subject Name	Credits
CCC202	**Optimization[$]**	**04**

Module	Detailed content	Hours
1	**Basic Concepts:** Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization, Optimality Criteria for Constrained Optimization, Engineering Application of Optimization, Overview of optimization technique, Interdisciplinary nature, Introduction to related software.	10
2	**Linear Programming Problem:** Formulation, Simplex method, Primal to Dual, Dual Simplex method, Sensitivity Analysis.	10
3	**Integer L.P. Model:** Gomory's cutting plane method, Branch & Bound Technique. **Non L.P. Model:** Lagrangian method & Kuhn tucker method.	10
4	**Unconstrained Optimization Technique:** Necessary and sufficient condition – search method (unrestricted Fibonacci and Golden) – Interpolation method (Quadratic, Cubic & Direct root method). Direct search method – Random search, Pattern search and Rosen Brock's hill climbing method.	10
5	**Newtonian Method**: Newton's method, Marquardt's method, Quasi Newton method. **Discrete Event Simulation**: Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.	10
6	**Response Surface Method:**Response Surface, The Least-Squares Methods, Two-Level Factorial Design, Addition of Center Points, Central Composite Design(CCD), Sequential Nature of RSM, Other Experimental Design	10

$ **Common for Machine Design and CAD/CAM and Robotics**

References:

1. RanjanGanguli, "Engineering Optimization - A Modern Approach" Universities Press
2. Pablo Pedregal, "Introduction to Optimization", Springer
3. S.S. Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc.
4. L.C. Jhamb, "Quantitative Techniques Vol. 1 and 2", Everest Pub. House
5. Pierre D.A., "Optimization, Theory with Application", John Wiley & sons.

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Subject Code	Subject Name	Credits
CCC203	**Computer Aided Machining**	**04**

Module	Detailed content	Hours
1	**Introduction to Computer Numerical Control**. History of various NC machines like TNC, NC, CNC, DNC, Elements of CAM, Various CNC applications in different industries, Computer control concepts, Data processing units, Binary execution.	10
2	**CNC Hardware** Structure of CNC machine tools, Spindle design, Spindle and axis drives, Various actuation systems and feedback devices like encoder, tachogenerator, etc.	10
3	**CNC Control System and Machine Tools.** CNC motion controller, Linear, circular, helical interpolator, Positioning and contouring control loops, MCU, adaptive control system, CNC machining centre, turning, grinding, EDM, wire EDM, boring, turn mill and CNC gear cutting, Study of two control systems.	10
4	**CNC Tooling.** Latest CNC tool materials and manufacturing, Turning and milling tool geometry, Tool probing and presetting, Automatic Pallet Changer (APC) and Automatic Turret Changer (ATC), Study of various probes and special tools.	10
5	**CNC Programming.** Part programming fundamentals, Manual part programming methods, Various G & M codes, Absolute and incremental system, TNRC, Tool length and diameter compensation, Programming of turning, machining centre and EDM, Use of canned cycles, loop, jump, subroutines, CAPP, APT, Post processing.	12
6	R Parameter programming,Macros,3D programming	08

References:

1. P. Radhakrishnan& S. Subramanyan “CAD/CAM/CIM” Willey Eastern Limited New Delhi.
2. Hans B. Kief and J. Frederick Waters “CNC” Glencae Macmillan / McGraw Hill
3. Steve Krar and Arthar Gill “CNC Technology and Programming”, McGraw Hill Pub. Company, New Delhi.
4. P.N. Rao, N. K. Tewariet el “CAM” Tata McGraw Hill Pub. New Delhi

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Subject Code	Subject Name	Credits
CCE2031	**Virtual Reality**	**04**

Module	Detailed content	Hrs.
1	**Introduction:** A short history of early virtual reality, early commercial VR Technology, VR becomes an Industry, The five classical components of VR Systems. **Input Devices: Trackers, Navigations and Gesture Interfaces.** Three Dimensional Position Trackers: Tracker performance parameters, Mechanical trackers, Magnetic trackers, Ultrasonic trackers, Optical Trackers and Hybrid Inertial Trackers Navigation and Manipulation Interfaces: Tracker based Navigation/Manipulation Interfaces, Trackballs, and three Dimensional Probes Gesture Interfaces: The Pinch Glove, the 5DT Data Glove, the Didjiglove, the Cyberglove	08
2	**Output Devices: Graphical, Three Dimensional Sound and Haptic Displays.** Graphical Display: The human visual system, personal graphics displays, large volume displays.Sound displays: the human auditory system, the convolvotron, Speaker based three dimentional sound. Haptic Feedback: The human haptic system, Tactile Feedback Interfaces, Force Feedback Interfaces.	10
3	**Computing Architectures for Virtual Reality:** The Rendering Pipeline: The graphical rendering pipeline, The haptics rendering pipeline. PC Graphics Architectures: Pc Graphics Accelerators, Graphics Benchmarks. Work Station Based Architectures: the Sun Blade 1000 Architecture, The SGI Infinite Reality Architecture. Distributed VR Architectures: Multipipeline Synchronization, Colocated rendering Pipelines, Distributed Virtual Environments.	10
4	**4. Modeling:** Geometric Modeling: Virtual Object Shape, Object Visual Appearance. Kinematics Modeling: Homogeneous Transformation Matrices, Object Position, Transformation Invariants, Object Hierarchies, viewing the three dimensional words.Physical Modeling: Collision Detection, Surface Deformation, Force Computation, Force Smoothing and Mapping, Haptic Texturing. Behavior Modeling and Model Management: Level of Detail Management, Cell Segmentation.	10
5	**Virtual Reality Programming:** Toolkits and Scene Graphs. World Toolkit: Model Geometry and Appearance, The WTK Scene Graph, Sensors and Action Functions, WTK Networking, JAVA 3D: Model Geometry and Appearance, Java 3D Scene graph, Sensors and Behaviors, Java 3D Networking, WTK and Java 3D Performance Comparison. General Haptics Open Software Toolkit: GHOST Integration with the Graphics Pipeline, The GHOST Haptic Scene Graph, Collision Detection and response, Graphics and PHANToM Calibration. **Human Factors in Virtual Reality:** Methodology and Terminology: Data Collection and Analysis, Usability Engineering Methodology. User Performance Studies: Test bed Evaluation of universal VR Tasks, Influence of System Responsiveness on User Performance, Influence of Feedback Multimodality.	12

6	**Traditional Virtual Reality Applications:** Medical Application of VR: Virtual Anatomy, Triage and Diagnostic, Surgery and Rehabilitation. Education, Arts and Entertainment: VR in Education, VR and the Arts, Entertainment Application of VR. Military VR Application: Army use of VR, VR Application in Navy, Air Force use of VR. **Emerging Application of VR:** VR Application and Manufacturing: Virtual Prototyping, other VR Application in Manufacturing, Application of VR in Robotics: Robot Programming, Robot Tele operation. Information Visualization: Oil Exploration and Well Management, Volumetric Data Visualization.	10

References:

1. GrigoreBurdea, Philippe Coiffet, " Virtual Reality Technology" 2nd edition. Wiley India
2. John vince, "Virtual Reality Systems" Pearson Education Asia
3. Understanding Virtual Reality ,Sherman,Elsever.

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Subject Code	Subject Name	Credits
CCE2032	**Product Lifecycle Management@**	**04**

Module	Detailed content	Hours
1	**Introduction to Product Lifecycle Management (PLM):** Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy , Change management for PLM	10
2	**ProductDesign:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	10
3	**Product Data Management (PDM):** Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation **Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	10
4	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment,Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	10
5	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	10

6	**Technology Forecasting:** Evolution for technology forecasting and its importance, Future mapping, Methods of technology forecasting such as Relevance Trees, Morphological Methods and Mission Flow Diagram, Combining forecast of different technologies	10

@ Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Manufacturing Systems Engineering

References:

1. John Stark, "Product Lifecycle Management: Paradigm for 21st Century Product Realisation", Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, AntoninoRisitano, "Product Design for the environment-A life cycle approach", Taylor & Francis 2006, ISBN: 0849327229
3. SaaksvuoriAntti, ImmonenAnselmie, "Product Life Cycle Management", Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, "Product Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

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Subject Code	Subject Name	Credits
CCE2033	**Concurrent Engineering**	**04**

Module	Detailed content	Hours
1	Introduction: Concurrent design of products and systems - Product design - Fabrication andassembly system design - designing production systems for robustness and structure	08
2	Strategic approach and technical aspects of product design: Steps in the strategicapproach to product design - Comparison to other product design methods –Assemblysequence generation - Choosing a good assembly sequence - Tolerances and their relation toassembly - Design for material handling and part mating - Creation and evaluation of testingstrategies.	10
3	Basic issues in manufacturing system design: System design procedure - Design factors -Intangibles - Assembly resource alternatives - Task assignment - Tools and tool changing -Part feeding alternatives - Material handling alternatives - Floor layout and systemarchitecture alternatives.	14
4	Assembly workstation design: Strategic issues - Technical issues analysis	08
5	Design of automated fabrication systems: Objectives of modern fabrication system design -System design methodology - Preliminary system feasibility study - Perform detailed workcontent analysis - Define alternative fabrication configurations - Configuration design andlayout - Human resource considerations - Evaluate technical performance of solution.	10
6	System Simulation: Simulation as an alternative to analysis,Discrete event simulation tools Case Studies	10

References:

1. Concurrent Design of Product and Processes by James L. Nevins and Daniel E. Whitney,McGraw-Hill Publishing Company, 1989
2. Engineering Productivity through CAD/CAM by Dimitris.N.Chorafas Butterworth
3. Automatic assembly by Boothroyd
4. Discrete Event Simulation by Jerry Banks

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Subject Code	Subject Name	Credits
CCE2034	**Micro Electro Mechanical Systems[@]**	**04**

Module	Detailed content	Hours
1	**Introduction to MEMS & Applications** • Introduction to Micro-Electro-Mechanical Systems, • Applications and Materials, • Advantages & Disadvantages of Micro-sensors, and micro-actuators.	**08**
2	**Sensors and Actuators in Micro-domain** • Concept of Sensors & Actuators, • Sensing & Actuation Principles: Mechanical Sensing, Capacitive, Electrostatic, Electromagnetic, Piezo Resistive, Piezo Electric, Thin Films, Shape Memory Alloys • Comb Drive Actuation & Sensing. Micro-mechanisms, Air-Bag Sensors, Chemical Sensors • Sensors & Actuators for Automotive, Biomedical, Industrial applications • Design of sensor and actuator for few applications such as automobile accelerometer, bimetallic temperature sensor, etc.	**12**
3	**Fabrication Methods** Microfabrication Methods (VLSI Techniques) • Positive and Negative Photoresists, • Bulk Micromachining, • Surface Micromachining, • Etching (Isotropic and Anisotropic), • Deposition techniques such as CVD (Chemical Vapor Deposition), Metallization Techniques. 3D High Aspect Ratio Techniques • LIGA, • AMANDA, • Microstereolithography, • IH-Process, • X-Ray Techniques, • Ion-beam Lithography etc.	**10**
4	**Modelling and Simulation Techniques** • Scaling Laws, Governing Equations • Modelling of Mechanical Structures via classical methods, Newtons Laws, Thermal Laws, Fluid Flow Analysis • Micro-mechanism modelling and analysis techniques : Lumped Parameter Modelling and Distributed Parameter Modeling • Modelling of Micro-channel as heat exchanger, accelerometers, micro-hinges, compound microstructures. • Linear & Nonlinear Model. • Numerical Methods used for MEMS analysis.	**10**

5	**Characterization Techniques** Topography Methods (Optical, Electrical and Mechanical Methods) • Microscopy, STM (Scanning Tunneling Microscopes), • SEM (Scanning Electron Microscopes),SPM(Scanning Probe Microscopes), AFM (Atomic Force Microscopes) Mechanical Structure Analysis • Deformation & Vibration Measurement Techniques (Piezo resistive and piezo electric) • Interferometry Techniques, • SPI (Speckle Pattern Interferometry), • ESPI (Electronic Speckle Pattern Interferometry), • Laser Techniques, Laser Doppler Vibro-meters Fluid, Thermal and Chemical Analysis • Thermal Analysis Techniques (Theoretical and Experimental), • Fluid Flow Pattern Analysis, Electro-chemical Analysis, • PIV Techniques • Spectroscopy	**12**
6	**Introduction to Advances of MEMS and Nanotechnology** • CNT (Carbon Nano Tubes) Applications, its properties, and Fabrication Method, • Nano-mechanical Systems (NEMS), • Nano-tribology, &nano-indentation techniques, • Domestic and Industrial Applications of nanotechnology • Molecular Modelling Techniques. • Social and Ethical Implications of nanotechnology in Society	**08**

@ Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics and Manufacturing Systems Engineering

References:

1. Julian W. Garden, Vijay K. Varadan and Osama O. Awadelkarim “Microsensors MEMS and Smart devices”, John Wiley and sons, Ltd.
2. NadimMulaf and Kirt Williams, “An Introduction to Microelectromechanical systems Engineering”, Artech House.
3. NicolaeLobontiu and Ephrahim Garcia, “Mechanics of Microelectromechanical systems”, Kluwer Academic Publication.
4. Stanley Wolf and Richard Tauber, “Silicon Processing for the VLSI era Volume -1 Technology”, Lattice press.
5. Vijay K. Varadan, K.J.Vinoy and S. Gopalkrishnan, “Smart Material Systems and MEMS: Design and Development Methodologies”, John Wiley and sons Ltd.
6. Bhushan, “Springer Handbook of Nanotechnology”, Springer Inc.

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Subject Code	Subject Name	Credits
CCE2041	**Supply Chain Management**	**04**

Module	Detailed content	Hours
1	**INTRODUCTION TO SUPPLY CHAIN MANAGEMENT**: **Understanding Supply Chain**: Current Business Scenario, what is supply chain? , Need of the Supply Chain, How Supply chain works? Evolution of SCM Function, Theme, objective, Decision phases and Pillars of SCM System, Process view of supply chain, CODP Concepts. **Supply Chain Performance**: Achieving strategies and fit, Supply chain drivers and metric.	08
2	**MATERIALS MANAGEMENT IN SUPPLY CHAIN** **Purchasing And Procurement:** Scope, importance, classification of materials, Procurement management in SC, Types of Purchases and its policies. **Inventory Management In SC: (**roles, estimation)–managing Economics of scale in a supply chain - cycle inventory and managing uncertainty in a supply chain- safety inventory, determining the optimal levels of product availability, Cost elements of procurement. VMI &CMI. Use of computers for materials function. JIT,Kanban,other modern methods.	10
3	**SUPPLY CHAIN NETWORK**: **Designing SC Network**: Role, factor influencing, channels, design option for Distribution Network in supply chain, Network Design in supply chain (roles, factor, models for facility location and capacity allocation), impact of Globlisation on supply chain. **Planning Demand And Supply In Supply Chain**:Demand forecasting-roles characteristics, components of forecast and forecasting methods, measure of forecast error. Aggregate planning in supply chain, Managing demand and supply in supply chain. New Supply Planning Paradigms.	10
4	**DESIGNING AND PLANNING TRANSPORTATION NETWORK** **Transportation In Supply Chain**: Evolution& Role of transportation in Supply Chain, Modes of transport and their performance characteristics, design options, trade-offs in transportation design, Intermodal transportation , international transportation, types of carrier and its selection and evaluation methods; **Transportation Management**: Transport decisions, routing decisions, routing models. Intermodal transportation, International transportation, Ocean carrier management, port administration and regulation, costing and pricing issues of logistics, cost transport Claim management, Reverse Logistics. Containerization, Packaging, Material handling, Storage systems, Warehousing, warehouse management.	10

6	**SUPPLY CHAIN COORDINATION** The Bullwhip effect. Effect on performance of lack of Coordination , Collaborative Planning, Forecasting, and Replenishment, CRM, SRM and Supply Chain Integration, Optimization Modeling, **PERFORMANCE MEASURE ALONG SUPPLY CHAIN:** Tradition Performance measures, world class performance measures, SC performance measures, SCOR model , Benchmarking and Balanced Score card modeling., total distribution cost analysis, future of supply chain management.	10

References:

1. Supply Chain Management: Concepts and Cases, Altekar Rahul V., Prentice Hall of India
2. Supply Chain Management: Janat Shah, Pearson Education
3. Supply Chain Management Theories and Practices, R.P. Mohanty and S. G. Deshmukh , Biztantra Publication.
4. Logistics and Supply Chain Management, Martin Christopher, Richard Irwin
5. Principles of Supply Chain Management, Joel Wisner, G. Keong, Keah-Choon Tan, Cengage Learning
6. Materials Management and purchasing, Ammer DS Taraporewala
7. "Modeling the Supply Chain", Jeremy F. Shapiro, Thomson Learning Publication
8. Supply Chain Management-strategy, planning and operation, sunilchopra, Peter Meindl, D V Kalra, Pearson.

Assessment:

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Subject Code	Subject Name	Credits
CCE2042	**Artificial Intelligence**	**04**

Module	Detailed content	Hours
1	**AI AND INTERNAL REPRESENTATION:** Artificial Intelligence and the World, Representation in AI, Properties of Internal Representation, The Predicate Calculus **Intelligent Agents:** Concept of Rational Agent, Structure of Intelligent agents, Agent Environments**.** **Problem Solving :** Solving problems by searching, Problem Formulation, Search Strategies, Uninformed Search Techniques, DFS, BFS, Uniform cost search, Iterative Deepening, Comparing different Techniques, Informed search methods – Best First Search, heuristic functions, Hill Climbing, A*.IDA*. Crypt Arithmetic, Bactracking for CSP	12
2	**Programming in LISP or PROLOG** Lisps, Typing at Lisp, Defining Programs, Basic Flow of Control in Lisp, Lisp Style, Atoms and Lists, Basic Debugging, Building Up List Structure, More on Predicates, Properties, Pointers, Cell Notation and the Internals (Almost) of Lisp, Destructive Modification of Lists, The for Function, Recursion, Scope of Variables Input/Output, Macros	08
3	**Fundamentals Concepts and Models of Artificial Neural Systems** Biological Neuron and their Artificial Models, Models of ANN, Learning and Adaptation, Neural Networking Learning Rules. Single-layer Perception Classifiers **Multilayer Feedforward Networks :** Linearly Nonseparable Pattern Classification, Delta Learning Rule, Feedforward Recall and Error Back-Propagation Training, Learning Factor	12
4	**Fuzzy Systems.** **Fuzzy Sets :**Fuzzy Relations, Fuzzy Function, Fuzzy Measures, probabilities possibilities. Fuzzy Modeling and applications of Fuzzy Control Neural and fuzzy machine Intelligence	08
5	**Genetic Algorithm** Simple genetic algorithm, Simulation by hands, similarity templates(Schemata), Mathematical foundations, Schema Processing at work The two- armed and k- armed Bandit Problem, The building block hypothesis, The minimal Deceptive Problem Computer implementation of Genetic algorithm, Data Structures, Reproduction, Cross over and Mutation. Time to reproduce and time to Cross Mapping objective function to fitness, form, Fitness scaling. Applications of genetic algorithm, De Jong and Function Optimization, Improvement in basic techniques, Introduction to Genetics based machine learning, applications of genetic based machine leaning.	10

6	**DATA MINING & INFORMATION RETRIEVAL** Data warehousing & Data Mining. Online Analytic Processing [OLAP]: its architecture and its use. Java implementations, classification trees and exploratory data analysis [EDA]. EDA Vs Hypothesis Testing, Computational EDA Techniques, Graphical [Data Visualization] EDA techniques for function fitting, data smoothing, layering, tessellations, contour projections, Verification of results of EDA. Applications & trends in data mining. Case Studies	10

References:

1. Introduction to Artificial intelligence By Eugene Charniak, Drew McDermott Addison Wesley
1. Artificial Neural Networks- B.Yegnanarayana, PHI, 1999.
2. Genetic Algorithms in search, Optimization & Machine Learning by David E Goldberg-Addison wesley
3. Data Mining by Pieter Adriaans and Dolt Zantinge - Pearson Education Asia
4. Data Warehousing in the Real World by Sam Anahory and Dennis Murray.
5. Artificial Intelligence, Elaine Rich, Kevin Knight, S. Nair, McGraw Hill Publishing Company Ltd
6. Principles of Artificial Intelligence – N.J. Nilsson, Tioga Hill, 1992.
7. Artificial Intelligence and Design of Expert Systems – C.F. Luger & W.A. Stubblefeild, Addison-Wesley.
8. Introduction to Data Mining & Knowledge Discovery – Edelstein, Herbert A.
9. Introduction to Artificial Neural Systems – Jacek M. Zurada, Jaico Publishing House, 2001.
10. Neural Network – SimsonHaykin, Macmillan Publication, 1994.
11. Fuzzy Set Theory & its Applications – H.J.Zimmermann, Allied Publishers Ltd, 1996.

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Subject Code	Subject Name	Credits
CCE2043	**Composite Materials[$]**	**04**

Module	Detailed content	Hrs
1	**Introduction to Composite Materials** • Basic Concepts and Terminology • Classification - Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon–Carbon Composites • Current and Potential Advantages and Applications of Composite Materials	10
2	**MacromechanicalBehaviour of a Lamina** • Review of Definitions: - Stress, Strain, Elastic Moduli, Strain Energy • Hooke's Law for Different Types of Materials - Anisotropic Material, Monoclinic Material, Orthotropic Material (Orthogonally Anisotropic)/SpeciallyOrthotropic, Transversely Isotropic Material, Isotropic Material • Hooke's Law for a Two-Dimensional Unidirectional Lamina - Plane Stress Assumption, Reduction of Hooke's Law in Three Dimensions to TwoDimensions, Relationship of Compliance and Stiffness Matrix toEngineering Elastic Constants of a Lamina • Hooke's Law for a Two-Dimensional AngleLamina • Engineering Constants of an Angle Lamina • Invariant Form of Stiffness and Compliance Matrices for anAngle 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	10
3	**Micromechanical Behaviour of a Lamina** • Volume and Mass Fractions, Density, and Void Content - Volume Fractions, Mass Fractions, Density, Void Content • Evaluation of the Four Elastic Moduli by Strength of Materials Approach, Semi-Empirical Models and Elasticity Approach • Elastic Moduli of Lamina with Transversely Isotropic Fibers • Ultimate Strengths of a Unidirectional Lamina - Longitudinal Tensile Strength, Longitudinal Compressive, Transverse Tensile Strength, Transverse Compressive Strength, In-Plane Shear Strength	10
4	**MacromechanicalBehaviour of a Laminate** • Introduction • Laminate Code • Classical Laminated Plate Theory • First Order Laminated Plate Theory • Laminated Stiffnesses for Selected Laminates - Single Layered Configurations, Symmetric Laminates, Antisymmetric Laminates, Balanced and Quasi-Isotropic Laminates	10

5	**Failure, Analysis and Design of Laminates** • Introduction • Failure Criterion for a Laminate • Design of a Laminated Composite • Other Mechanical Design Issues - Sandwich Composites, Long-Term Environmental Effects, Interlaminar Stresses, Impact Resistance, Fracture Resistance, Fatigue Resistance	10
6	**Introduction to Fabrication Techniques for Composites** • Polymer Composites - Liquid Resin Impregnation Routes, Pressurized Consolidation of Resin Pre-Pregs, Consolidation of Resin Moulding Compounds, Injection Moulding of Thermoplastics, Hot Press Moulding of Thermoplastics • Metal Composites - Squeeze Infiltration, Stir Casting, Spray Deposition, Powder Blending and Consolidation, Diffusion Bonding of Foils, Physical Vapour Deposition (PVD) • Ceramic Composites - Powder-Based Routes, Reactive Processing, Layered Ceramic Composites, Carbon/Carbon Composites	10

$ **Common for Machine Design and CAD/CAM and Robotics**

References:

1. R.M. Jones, “Mechanics of Composite Materials”, Taylor and Francis, Inc.
2. J.N. Reddy, “Mechanics of Laminated Composite Plates and Shells – Theory and Analysis”, CRC Press
3. A.K. Kaw, “Mechanics of Composite Materials”, Taylor and Francis Group, LLC
4. D. Hull and T.W. Clyne, “An Introduction to Composite Materials”, Cambridge University Press
5. L.P. Kollar, G.S. Springer, “Mechanics of Composite Structures”, Cambridge University Press

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Subject Code	Subject Name	Credits
CCE2044	**Smart Materials and Applications***	**04**

Module	Detailed content	Hours
1	**Introduction to Smart / Intelligent Materials:** Overview of Smart / Intelligent Materials, Primitive Functions of Intelligent Materials, Intelligence Inherent in Materials, Actuator Materials, Sensing Technologies, Microsensors, Intelligent Systems, Hybrid Smart Materials, Passive Sensory Smart Structures, Reactive Actuator based Smart Structures, Active Sensing and Reactive Smart Structures, Smart Skins	08
2	**Introduction to Highbandwidth - Low straingenerating (HBLS) SmartMaterials** **Piezoelectric Materials** constitutive relationship,electromechanicalcoupling coefficients,piezoelectric constants,piezoceramic materials,variation of couplingcoefficients in hard andsoft piezoceramics,polycrystalline vs singlecrystal piezoelectricmaterials, polyvinyldenefluoride, piezoelectriccomposites **MagnetostrictiveMaterials** constitutiverelationship, magnetomechanicalcouplingcoefficients, Joule Effect,Villari Effect, MatteuciEffect, Wiedemanneffect, Giantmagnetostriction inTerfenol-D, Terfenol-Dparticulate composites,Galfenol and Metglasmaterials.	10
3	**Actuators based on HBLSSmart Materials** **Piezoelectric Actuators** Induced Strain actuationmodel, Unimorph andBimorph Actuators,Actuators embedded incomposite laminate,Impedance matching inactuator design,Feedback Control, PulseDrive, Resonance Drive. **MagnetostrictiveActuators** Magnetostrictive MiniActuators, Thermalinstabilities, Discretelydistributed actuation,ManetostrictiveComposites. **MEMS based Actuators** PiezoelectricMicropumps,Magnetostrictivemicromechanisms,Imaging SystemApplications, InchwormDevices, Inkjet Printers,Piezoelectric Relays,Ultrasonic Motors, andMicroscale Walking Machines. **Sensors based on HBLSSmart Materials** Piezoelectric Sensors, MagnetostrictiveSensors, Techniques of Self-Sensing,MEMS Sensors	12
4	**Introduction to Lowbandwidth - High straingenerating (LBHS) materials** Shape Memory Alloys(SMA) Electro-active Polymers (EAP)	08
5	**Actuators based on LBHSSmart Materials** Shape Memory Alloybased actuators forShape Control Electro-active Polymersfor Work-Volume Generation **Sensors based on LBHSSmart Materials** EAP based sensors, SMA based encoders	12

	Optical Fibre based Sensing	
6	**Advances in Smart Materials** • Active Fibre Composites (AFC) • Energy Harvesting Actuators and Energy Scavenging Sensors • Self-healing and Autophagous Smart Materials	10

*** Common for Machine Design, Automobile Engineering and CAD/CAM and Robotics**

References:

1. M.V. Gandhi and B.S. Thompson, "Smart Materials and Structures", Chapman & Hall,London; New York, 1992 (ISBN: 0412370107)
2. Bryan Culshaw, "Smart Structures and Materials", Artech House
3. Mel Scwartz, "Encyclopedia of Smart Materials Vol. I and II", John Wiley & Sons
4. SenolUtku, "Theory of Adaptive Structures : Incorporating Intelligence into Engineered Products", CRC Press
5. H. Janocha, "Actuators - Basics and Applications",Springer
6. B. Culshaw, "Smart Structures and Materials", Artech House, Boston, 1996 (ISBN: 0890066817)
7. A.V. Srinivasan, "Smart Structures: Analysis and Design", Cambridge University Press,Cambridge; New York, 2001 (ISBN: 0521650267)
8. A.J. Moulson and J.M. Herbert, "Electroceramics: Materials, Properties, Applications",2nd Edition, John Wiley & Sons, Chichester, West Sussex; New York, 2003 (ISBN:0471497479)
9. G. Gautschi, "Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors, Materials and Amplifiers", Springer, Berlin; New York, 2002 (ISBN:3540422595)
10. K. Uchino, "Piezoelectric Actuators and Ultrasonic Motors", Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114)
11. G. Engdahl, "Handbook of Giant Magnetostrictive Materials", Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X)
12. K. Otsuka and C.M. Wayman, "Shape Memory Materials", Cambridge University Press, Cambridge; New York, 1998 (ISBN: 052144487X)
13. Eric Udd, "Fiber Optic Sensors: An Introduction for Engineers and Scientists", John Wiley & Sons, New York, 1991 (ISBN: 0471830070)
14. André Preumont, "Vibration Control of Active Structures: An Introduction", 2nd Edition, Kluwer Academic Publishers, Dordrecht; Boston, 2002 (ISBN: 1402004966)
15. HojjatAdeli, "Control, Optimization, and Smart Structures: High-Performance Bridges and Buildings of the Future", John Wiley, New York, 1999 (ISBN: 047135094X)
16. T.T. Soong, "Passive Energy Dissipation Systems in Structural Engineering", Wiley, Chichester; New York, 1997 (ISBN: 0471968218)

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Subject Code	Subject Name	Credits
CCL203	**CAM**	**01**

Module	**Detailed content**	**Lab. Sessions**
1	Manufacturing Simulation	05
2	CNC Programming on Machining Centre	05
3	CNC programming on Turning Centre	05

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
CCL204	**Mechatronics & Robotics**	**01**

Module	**Detailed content**	**Lab. Sessions**
1	Automation using Pneumatics and Hydraulics	03
2	Programmable logic controllers	04
3	Interfacing Servo motor/Stepper motor /Keyboard etc. with Micro controller	04
4	Programming & Manipulating an Industrial Manipulator	04

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
CCS301	**Seminar**	**03**

Guidelines for Seminar

- Seminar should be based on thrust areas in Mechanical Engineering
- Students should do literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literatures (at least 10 papers from Refereed Journals) and understand the topic and compile the report in standard format and present in front of Panel of Examiners(pair of Internal and External examiners appointed by the University of Mumbai)
- **Seminar should be assessed based on following points**
  - Quality of Literature survey and Novelty in the topic
  - Relevance to the specialization
  - Understanding of the topic
  - Quality of Written and Oral Presentation

NOTE :

1. Assessment of Seminar will be carried out by a pair of Internal and External examiner. The external examiner should be selected from approved panel of examiners for Seminar by University of Mumbai,OR faculty from Premier EducationalInstitutions /Research Organizations such as IIT, NIT, BARC, TIFR, DRDO, etc. ORa person having minimum Post-Graduate qualification with at least five years' experience in Industries.

2. Literature survey in case of seminar is based on the broader area of interest in recent developments and for dissertation it should be focused mainly on identified problem.

3. At least 4-5 hours of course on Research Methodology should be conducted which includes literature survey, identification of problems, analysis and interpretation of results and technical paper writing in the beginning of 3rd semester.

Subject Code	Subject Name	Credits
CCD301 / CCD401	**Dissertation (I and II)**	**12 + 15**

Guidelines for Dissertation

- Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation I

- Dissertation I should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problemdefinition and Feasibility of problem solution
  - Relevance to the specialization
  - Clarity of objective and scope
- Dissertation I should be assessed through a presentation by a panel of Internal examiners appointed by the Head of the Department/Institute of respective Programme.

Guidelines for Assessment of Dissertation II

- Dissertation II should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problemdefinition and Feasibility of problem solution
  - Relevance to the specialization or current Research / Industrial trends
  - Clarity of objective and scope
  - Quality of work attempted
  - Validation of results
  - Quality of Written and Oral Presentation
- Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai
- Students should publish at least one paper based on the work in reputed International / National Conference (desirably in Refereed Journal)