UNIVERSITY OF MUMBAI

New M. E. Programme

Programme: M. E. (Mechanical Engineering)
Product Design and Development

(As per Credit Based Semester and Grading System with effect from the academic year 2014–2015)

Program Structure for
ME (Mechanical Engineering): Product Design and Development
Semester I

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PDC101	Product Design and development	04	- -	- -	04	--	--	04
PDC102	Quality Concepts in design	04	- -	- -	04	--	--	04
PDC103	Material in Product Design and Development	04	- -	- -	04	--	--	04
PDE101X	Elective I	04	-	-	04	--	--	04
PDE102X	Elective II	04	-	--	04	--	--	04
PDL101	CAD: Solid Modeling Lab	--	02	-	--	01	--	01
PDL102	Rapid Prototyping and Tooling Lab	--	02	-	--	01	--	01
Total		**20**	**04**	**-**	**20**	**02**	**--**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
PDC101	Product Design and development	20	20	20	80	03	--	--	100
PDC102	Quality Concepts in design	20	20	20	80	03	--	--	100
PDC103	Material in Product Design and Development	20	20	20	80	03	--	--	100
PDE101X	Elective I	20	20	20	80	03	--	--	100
PDE102X	Elective II	20	20	20	80	03	--	--	100
PDL101	CAD: Solid Modeling Lab	--	--	--	--	--	25	25	50
PDL102	Rapid Prototyping and Tooling Lab	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**50**	**50**	**600**

Course Code	Elective I	Course Code	Elective II
PDE1011	Computer Aided Product Development	PDE1021	Product and process engineering tools
PDE1012	Reliability Engineering[$]	PDE1022	Optimization[$]
PDE1013	Rapid Prototyping and Tooling[*]	PDE1023	Product Packaging
PDE1014	Creativity in design	PDE1024	Die Design and Development

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

$ Common for Machine Design, CAD/CAM and Robotics and PDD

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

Semester II

Course Code	Course Name	Teaching Scheme			Credits Assigned			
		Theory	Pract	Tut.	Theory	Pract.	Tut.	Total
PDC201	Product Life Cycle Management	04	--	--	04	--	--	04
PDC202	Design for X	04	--	--	04	--	--	04
PDC203	Applied Ergonomics	04	--	--	04	--	--	04
PDE203X	Elective III	04	--	--	04	--	--	04
PDE204X	Elective IV	04	--	--	04	--	--	04
PDL203	CAD: Surface Modeling Lab	--	02	--	--	01	--	01
PDL204	CAE: Computer Aided Engineering Lab	--	02	--	--	01	--	01
Total		**20**	**04**	**--**	**20**	**02**	**--**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
PDC201	Product Life Cycle Management	20	20	20	80	03	--	--	100
PDC202	Design for X	20	20	20	80	03	-	--	100
PDC203	Applied Ergonomics	20	20	20	80	03	-	--	100
PDE203X	Elective III	20	20	20	80	03	-	--	100
PDE204X	Elective IV	20	20	20	80	03	-	--	100
PDL203	CAD:Surface Modeling Lab	--	--	--	--	--	25	25	50
PDL204	CAE: Computer Aided Engineering Lab	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**50**	**50**	**600**

Course Code	Elective III	Course Code	Elective IV
PDE2031	Vehicle Design	PDE2041	Reverse engineering
PDE2032	Polymeric Material and Processing	PDE2042	Product Marketing
PDE2033	Robotics*	PDE2043	Composite Material$
PDE2034	Micro Electro Mechanical Systems@	PDE2044	Smart Materials and Applications*

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

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

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

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PDS301	Seminar	--	06	--	--	03	--	03
PDD301	Dissertation I	--	24	--	--	12	--	12
Total		**--**	**30**	**--**	**--**	**15**	**--**	**15**

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam.			
		Test1	Test 2	Avg.				
PDS301	Seminar	--	--	--	--	50	50	**100**
PDD301	Dissertation I	--	--	--	--	100	--	**100**
Total		**--**	**--**	**--**	**--**	**150**	**50**	**200**

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
PDD401	Dissertation II	--	30	--	--	15	--	15
Total		**--**	**30**	**--**	**--**	**15**	**--**	**15**

Course Code	Course Name	Examination Scheme						
		Theory				Term Work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam.			
		Test1	Test 2	Avg.				
PDD401	Dissertation II	--	--	--	--	100	100	**200**
Total		**--**	**--**	**--**	**--**	**100**	**100**	**200**

Note:

- In case of Seminar (PDDS301), 01 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation I (PDDD301) and Dissertation II (PDDD401), 02 Hour / week / student should be considered for the calculation of load of a teacher.

Course Code	Course Name	Credits
PDC101	**PRODUCT DESIGN & DEVELOPMENT**	**04**

Module	Detailed Content	Hours
1	1.1 Introduction: Classification/ Specifications of Products. 1.2 Product life cycle. Product mix. 1.3 Introduction to product design. 1.4 Modern product development process. 1.5 Innovative thinking. 1.6 Morphology of design.	08
2	2.1 Conceptual Design: Generation, selection & embodiment of concept. 2.2 Product architecture. 2.3 Industrial design: process, need. 2.4 Robust Design: Taguchi Designs & DOE. 2.5 Design Optimization	08
3	3.1 Design for Mfg & Assembly: Methods of designing for Mfg & Assy. 3.2 Designs for Maintainability. 3.3 Designs for Environment. 3.4 Product costing. 3.5 Legal factors and social issues. Engg ethics and issues of society related to design of products.	08
4	4.1 Value Engineering / Value Analysis. : Definition. Methodology. 4.2 Case studies. 4.3 Economic analysis: Qualitative & Quantitative.	08
5	5.1 Ergonomics / Aesthetics: Gross human autonomy. 5.2 Anthropometry. 5.3 Man-Machine interaction. 5.4 Concepts of size and texture, colour .Comfort criteria. 5.5 Psychological & Physiological considerations. 5.6 Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design.	08
6	6.1 Concurrent Engg , 6.2 Rapid prototyping , 6.3 Tools for product design – Drafting / Modeling software. 6.4 CAM Interface. 6.5 Patents & IP Acts. Overview. Disclosure preparation	08

References:

1. Karl T Ulrich, Steven D Eppinger , " Product Design & Development." Tata McGrawhill New Delhi 2003
2. David G Ullman, "The Mechanical Design Process." McGrawhill Inc Singapore 1992 N J M Roozenberg , J Ekels , N F M Roozenberg " Product Design Fundamentals and Methods ." John Willey & Sons 1995
3. Kevin Otto & Kristin Wood Product Design: "Techniques in Reverse Engineering and new Product Development." 1 / e 2004 , Pearson Education New Delhi
4. L D Miles "Value Engineering."
5. Hollins B & Pugh S "Successful Product Design." Butter worths London.

6. Baldwin E N & Neibel B W "Designing for Production." Edwin Homewood Illinois
7. Jones J C "Design Methods." Seeds of Human Futures. John Willey New York.
8. Bralla J G "Handbook of Product Design for Manufacture, McGrawhill NewYork**.**

Assessment:

Internal Assessment:	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.

Course Code	Course Name	Credits
PDC102	**QUALITY CONCEPTS IN DESIGN**	**04**

Module	Detailed content	Hours
1	**DESIGN FOR QUALITY** Quality Function Deployment -House of Quality-Objectives and functions-Targets- Stakeholders-Measures and Matrices-Design of Experiments –design process- Identification of control factors, noise factors, and performance metrics -developing the experimental plan- experimental design –testing noise factors-Running the experiments –Conducting the analysis-Selecting and conforming factor-Set points-reflecting and repeating.	09
2	**FAILURE MODE EFFECT ANALYSIS** Basic methods: Refining geometry and layout, general process of product embodiment- Embodiment checklist- Advanced methods: systems modeling, mechanical embodiment principles-FMEA method- linking fault states to systems modeling-Case study- computer monitor stand for a docking station.	09
3	**DESIGN OF EXPERIMENTS** Design of experiments-Basic methods- Two factorial experiments-Extended method reduced tests and fractional experiments, orthogonality, base design method, higher dimensional fractional factorial design-Statistical analysis of experiments: Degree of freedom, correlation coefficient, standard error of the residual t-test, ANOVA-ratio test, other indicators-residual plots, Advanced DOE method for product testing-Product applications of physical modeling and DOE, Blender panel display evaluation, coffee grinder experimental optimization-Taguchi method.	09
4	**STATISTICAL CONSIDERATION** Frequency distributions and Histograms- Run charts –stem and leaf plots- Pareto diagrams-Cause and Effect diagrams-Box plots- Probability distribution-Statistical Process control–Scatter diagrams –Multivariable charts –Matrix plots and 3-D plots.	07
5	**RELIABILITY** Reliability-Survival and Failure-Series and parallel systems-Mean time between failure- Weibull distributions(How to calculate or estimate in component level system level introductory only)	07
6	**DESIGN FOR SIX SIGMA** Basis of SIX SIGMA –Project selection for SIX SIGMA- SIX SIGMA problem solving- SIX SIGMA in service and small organizations - SIX SIGMA and lean production –Lean SIX SIGMA and services	07

References:

1. Product Design Techniques in Reverse Engineering and New Product Development, KEVIN OTTO & KRISTIN WOOD, Pearson Education (LPE), 2001.
2. Product Design and Development, KARL T. ULRICH, STEVEN D. EPPINGER, TATA McGraw-HILL- 3rd Edition, 2003.
3. The Management and control of Quality-6th edition-James R. Evens, William M Lindsay Pub: son south-western

4. Fundamentals of Quality control and improvement 2nd edition, AMITAVA MITRA, Pearson Education Asia, 2002.

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Course Code	Course Name	Credits
PDC103	**MATERIAL IN PRODUCT DESIGN AND DEVELOPMENT**	**04**

Module	Detailed content	Hours
1	**MATERIAL BEHAVIOR AND SELECTION** Elastic and Plastic deformation- Mechanism of Plastic deformation-yield stress and shear strength-Perfect and Real crystals- Effect of strain rate and temperature on plastic behaviour- Super plasticity- Deformation of non crystalline materials- Material selection- Cost and service requirement- Recycling- Selection of material for mechanical properties- Strength, toughness and fatigue- Material selection for durability and surface wear and Corrosion resistance- Functional relation between materials and processing- Manufacturing characteristics of metals- Material selection charts and other aids material selection for aero, auto and nuclear application-Structural Product analysis-End Use behavior – Tooling in product design- Case studies in material selection.	08
2	**PROCESS MODELING AND PRODUCT DESIGN** Methods of analysis- Slab, slip line and upper bound solutions- Numerical methods- Effect of Friction- Contact problem- Basic analysis of process- Forging, Drawing and sheet metal forming- machining- Turning- modern materials- micro alloyed and dual phase steel- High strength low alloy metals- Smart materials- Shape memory metals- Metallic Glasses- Nano Materials- Metal foams- Properties and applications for product design.	08
3	**NON METALS AND MANUFACTURING** General properties and its importance of polymers- Thermal and electrical properties mechanical properties- Criteria for selection- Composite materials- fibers- Boron, glass, carbon, organic- Ceramic and metallic fibres- - Matrix materials- Polymer, metal and ceramics- properties and applications- Manufacturing methods of plastic products- Injection and blow moulding –Rotational moulding-Compression moulding-Transfer moulding-layering of composites	08
4	**PRODUCT DESIGN AND ASSEMBLY REQUIREMENTS** Structural product analysis- End use behaviour- Effect of tooling in product design-Design for joining and assembling- Design for live hinges- Snap fits, design of corners,bushes and ribs- Design considerations- New product design-Methods of decoration-Bonding and cementing techniques- Thermal bonding-Machining of plastics-Parameters and effect- Case studies in material selection with relevance to product design and development	08
5	**DEVELOPMENT IN MATERIALS PROCESSING** Micro fabrication technologies- Tool for micro fabrication- Diamond and high speed machining- LIGA micro fabrication process- Multilayer X-ray lithography-	08
6	**Introduction to Smart / Intelligent Materials:** Overview of Smart / Intelligent Materials, Primitive Functions of Intelligent Materials, Intelligence Inherent in Materials, 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	08

References

1. Serope Kalpakjian and Schmid- Manufacturing process for Engineering materials Pearson- 2005.
2. Paul Degarmo, Black and Kohsher- Materials and processes in Manufacturing- Wiley Student Edition- 9th Edition- 2005
3. Sami Franssile- Introduction to Micro Fabrication- John Wiley and Sons- UK 2004
4. Harfold Belofsky- Plastic design and processing hand book, Hanser publication- 2005
5. Beck- Plastic Product Design- van Nostrand Reignhold 2nd Edition
6. Asbhay, Selection of Materials, El Sevier Publications, 2006

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Course Code	Course Name	Credits
PDE1011	**COMPUTER AIDED PRODUCT DEVELOPMENT**	**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, Polygon filling using Boundary fill, edge fill ,Flood fill algorithms, Scan conversion with Real Time scan conversion ,Run length encoding, Cell encoding	10
2	**Graphics Programming**:- Graphics function, open GL interface, Co-ordinate systems, Primitives & Attributes **Transformations**:-2-D Transformations, 3-D Geometric & modeling Transformations	08
3	2-D Viewing & Clipping, 3-D Viewing & Clipping , 3D viewing functions **Projection:** General Projection Transformation, parallel & Perspective Projections	08
4	**Curves :** Splines, Bezier & B-Spline Curves **Surfaces**: Visible Surface detection methods, Hermite ,Bezier & B-Spilne surfaces	06
5	**Virtual Reality:** Hidden Lines & Hidden Surfaces: Z-Buffer, Painters, Ray Tracing, Area- Subdivision, Scan Line algorithm Light , Color & Shading Models Animation.	08
6	**CAD & Geometric Modeling:** Features of Modeling &Assembly Packages, Types of Geometric Modeling, geometry & topology, Data Structures, and 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.
8. Interactive Computer Graphics by E.Angel & Dave Shreiner.

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Course Code	Course Name	Credits
PDE1012	**RELIABILITY ENGINEERING[$]**	**04**

Module	Detailed content	Hours
1	**Probability theory** Probability: Standard definitions and concepts; Conditional Probability, Bayer'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, and Kurtosis.	09
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	10
3	**System Reliability** System Configurations: Series, parallel, mixed configuration, k- out of n structure, Complex systems.	06
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.	07
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.	08
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

$ Common for Machine Design and CAD/CAM, Robotics and PDD

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.

Assessment:

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Course Code	Course Name	Credits
PDE1013	**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	06
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	09
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	09
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	08

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	06

* Common for Machine Design, CAD/CAM and Robotics and PDD

References:

1. Rapid prototyping, Andreas Gebhardt, Hanser Gardener Publications, 2003.
2. Rapid Prototyping and Engineering applications: A tool box for prototype development, Liou W. Liou, Frank W. Liou, CRC Press, 2007.
3. Rapid Prototyping: Theory and practice, Ali K. Kamrani, Emad Abouel Nasr,

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Course Code	Course Name	Credits
PDE1014	**CREATIVITY IN DESIGN**	04

Module	Detailed content	Hours
1	**INTRODUCTION:** Need for design creativity – creative thinking for quality – essential theory about directed creativity	05
2	**MECHANISM OF THINKING:** Definitions and theory of mechanisms of mind heuristics and models : attitudes, Approaches and Actions that support creative thinking	05
3	**VISUALIZATION:** Advanced study of visual elements and principles- line, plane, shape, form, pattern, texture gradation, color Symmetry. Spatial relationships and compositions in 2 and 3 dimensional space - procedure for genuine graphical computer animation – Animation aerodynamics – virtual environments in scientific Visualization – Unifying principle of data management for scientific visualization - Visualization benchmarking	10
4	**CREATIVITY:** Methods and tools for Directed Creativity – Basic Principles – Tools of Directed Creativity – Tools that prepare the mind for creative thought – stimulation of new ideas – Development and Actions: - Processes in creativity ICEDIP – Inspiration, Clarification, Distillation, Perspiration, Evaluation and Incubation – Creativity and Motivation The Bridge between man creativity and the rewards of innovativeness – Applying Directed Creativity to the challenge of quality management	10
5	**DESIGN:** Process Design, Emotional Design – Three levels of Design – Viceral, Behavioral and Reflective- Recycling and availability-Creativity and customer needs analysis – Innovative product and service designs, future directions in this application of creativity thinking in quality management	09
6	**INNOVATION:** Achieving Creativity – Introduction to TRIZ methodology of Inventive Problem Solving - the essential factors – Innovator's solution – creating and sustaining successful growth – Disruptive Innovation model – Segmentive Models – New market disruption - Commoditation and DE-commoditation – Managing the Strategy Development Process – The Role of Senior Executive in Leading New Growth – Passing the Baton	09

References:

1. Rousing Creativity: Think New NowFloyd Hurr, ISBN 1560525479, Crisp Publications Inc. 1999
2. Geoffrey Petty," how to be better at Creativity", The Industrial Society 1999
3. Donald A. Norman," Emotional Design", Perseus Books Group New York , 2004
4. Clayton M. Christensen Michael E. Raynor," The Innovator's Solution", Harvard Business School Press Boston, USA, 2003
5. Semyon D. Savransky," Engineering of Creativity – TRIZ", CRC Press New York USA," 2000

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Course Code	Course Name	Credits
PDE1021	**PRODUCT AND PROCESS ENGINEERING TOOLS**	04

Module	Detailed content	Hours
1	**TOOLS FOR CONCEPT DEVELOPMENT** Products division, Quality function Deployment, concept engineering –Tools for Design Development: design failure mode and design analysis, Reliability prediction- Tools for Design Optimization: The Taguchi Loss Function, Optimizing Reliability- Tools for Design Verification: Reliability Testing.	06
2	**TOOLS FOR PROCESS IMPROVEMENT:** Process improvement methodologies, The Deming Cycle-FADE-Basic tools for process improvement: flow charts, run charts and control charts, check sheets, histograms, Pareto diagrams, Cause and Effect Diagrams-Scatter Diagrams-Other tools for process improvement: Kaizen Blitz, Poka-yoke (mistake proofing), process simulation-Engaging the work force in process improvement.	10
3	**STATISTICAL PROCESS CONTROL:** Quality control measurements-SPC Methodology-Process capacity evaluation-Control charts for variables data-Special Control charts for variables data- Process Capability Evaluation- Control Charts for Attributes- Summary of control charts construction chart, np-charts,c & u charts –Designing control charts: sampling , size, frequency-SPC.	08
4	Quality Management systems:- ISO 9000:2000 AND SIX SIGMA-Pre control- Measurement systems Evaluation.	06
5	**BENCHMARKING AND ESTABLISHING ENGINEERING SPECIFICATIONS:** A Benchmarking Approach – Support tools for the benchmarking process: intended assembly cost analysis, form diagram, trend analysis- Setting product specifications: Basic & Advanced method.	10
6	**PROJECT MANAGEMENT:** Understanding and representing tasks: Tasks, charts- Baseline project planning – Accelerating projects-project execution- Postmortem execution	08

References:

1. Product Design Techniques in Reverse Engineering and New Product Development, KEVIN OTTO & KRISTIN WOOD, Pearson Education (LPE), 2001.
2. The Management and control of Quality-6th edition-James R. Evens, William M Lindsay Pub: son south-western

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Course Code	Course Name	Credits
PDE1022	**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.	08
2	**Linear Programming Problem:** Formulation, Simplex method, Primal to Dual, Dual Simplex method, Sensitivity Analysis.	08
3	**Integer L.P. Model:** Gomory's cutting plane method, Branch & Bound Technique. Non L.P. Model: Lagrangian method & Kuhn tucker method.	08
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.	08
5	**Newtonian Method:** Newton's method, Marquardt's method, Quasi Newton method. Discrete Event Simulation: Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.	08
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	08

$ Common for Machine Design, CAD/CAM and Robotics and PDD

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.

Assessment:

Internal Assessment: Assessment consists of two tests out of which; one should be compulsory class test 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.

Course Code	Course Name	Credits
PDE1023	**PRODUCT PACKAGING**	**04**

Module	Detailed content	Hours
1	**Introduction :** **Definition** Functions of Packaging, package environment Product & Packaging, Material Characteristics, Packaging Evaluation.	08
2	**Packaging Media (Science, Technology, Manufacture, Conversion, Properties & Applications):** Paper & Board, Fibre Board Boxes, Composite Containers, Drums, Celluloses, Glass, Metal Containers and Components, Polymers and Plastics, Flexible Packaging Materials, Wooden Containers, Crates, IBCs, Flexible & Rigid, Textiles and Jute.	08
3	**Quality Assessment & Performance Evaluation:** Testing, Significance of Testing, Quality Control and Quality Assurance, SQC Techniques, Shelf- life Evaluation, Product Package Compatibility, Migration, Transport-worthiness Testing, Testing of Ancillary Materials, Machine Material Interaction, IMDG, UN / IATA Testing, etc.	09
4	**Package Printing:** Pre-Press, Printing Processes, Letterpress, Offset, Lithography, Flexography, Gravure, Screen, Pad, Foil Stamping, Digital Printing (Inkjet, Thermal), Computer-to-Plate. Colour Management, Colour Measurement, etc. **Package Graphics:** Package Design, Role of Graphics, Package Aesthetics, Decoration Aspects, Layout and Feature Selection, etc.	09
5	**Package Storage and Handling:** Storage Types, Damage Control, Warehousing and Handling Equipments & Techniques, etc.	07
6	**Packaging & Environment:** Eco Issues, Wastage Control, Wastage Disposal, Eco Friendly Packaging, etc.	07

References:

1. Walter Soroka, “Fundamentals of packaging technology”, 3rd Edition, Institute of Packaging professionals, Naperville, Illinois, USA, 2002.
2. Giles Calver, “What is Packaging Design? Essential design handbook”, Rotovision, 2004
3. Steven DuPuis, John Silva,”Package Design Workbook: The Art and Science of Successful Packaging”, Rockport Publishers, 2008.
4. William H.Erdei, “Bar Codes – Design, Printing and Quality Control”, McGrawHill inc., 1998.
5. Joseph F. Hanlon, Robert J. Kelsey, Hallie Forcinio, “Handbook of Packaging Engineering”, 3rd edition, CRC Press, 1998
6. Ronald E.Tood,” Printing Inks – Formulations, Principles, Manufacture, and Quality Control Testing,” PIRA International1996

7. Davis, C.G., “Introduction to Packaging Machinery”, Packaging Machinery Manufacturers Institute, 1997
8. M.Bakker, “Wlley Encyclopedia of Packaging Technology”, Joh Wiley & Sons Ltd., 2008
9. Sugan E. M.Solke, “Packaging and the Environment, Alternatives, Trends and Solutions”, Technomic Publication, Revised Edition, 1994.
10. Nigel Thoobald, “Packaging closures & Sealing systems”, CRC Publishers, 2006erbert F. Lund, “McGraw-Hill Recycling Handbook”, 2nd Edition, 2001.

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Course Code	Course Name	Credits
PDE1024	**DIE DESIGN AND DEVELOPMENT**	**04**

Module	Detailed content	Hours
1	**Introduction to Manufacturing Process:** Shearing, Mechanics of Shearing, Shearing Forces, Blanking and Punching Mechanisms, Bending, Mechanics of Deep Drawing, Various Forming Processes such as Stretch Forming, Nosing, Expanding, Dimpling, Spinning, Flexible Die Forming, Basic Die Classifications and Components	08
2	**Tool and Die Materials:** Carbon and Alloy Steels, Designations for Carbon and Alloy Steels, Effects of Various Alloy Elements in Steels, Carbon Steels, Alloy Steels, Machinability of Steels, Mechanical Properties of Steels, Applications of Carbon and Alloy Steels, Tool and Die Steels, Designation and Classification of Tool and Die Steels, Cold Work Tool and Die Steels, Nonferrous Metals, Non-metallic Materials	08
3	**Design of Blanking and Punching Dies:** Die Blocks, Die Opening Profile, Fastening to the Die Shoe, Sectioned Die, Calculation of Die Block Dimensions, Punches, Punch Face, Geometry, Methods for Assembling Punches, Punch Calculations, Stripper Plates, Stripper Force, Stripper Design, Die Components for Guiding and Stopping, Stock Guides and Guide Rails, Die Stops and French Notch Punch, Positioning the Individual Blank, Pilots, Centre of Die Pressure, Examples of Couting Die Designs	08
4	**Design of Bending Dies:** Simple Die Designs, U-Profile Bend Dies, V-profile Bend Dies, Universal Bending Dies, Dies of Complex Design, Closing Profile Dies, Special Bending Dies, Curling and Hinge Dies, Tube-forming Dies, Multiple-bend Dies, Combination Dies, Progressive Dies	08
5	**Deep Drawing Dies:** Draw Rings, Draw Rings with Corner Radius, Draw Rings with Conical Profile, Clearances and Tolerances, Calculation of the Dimensions of the Punch and Die, Blank Holders, Blank Holder Pressure, Blank Holder Force, Draw Beads, Single-operation Dies, Multi-operation Dies, Progressive Dies, Ironing Dies, Drawing Dies for Pieces	08
6	**Various Forming Dies:** Nosing Dies, Expanding and Bulging Dies, Expanding Dies, Bulging Dies, Flanging Dies **Die Process Quality And Automation, Die Maintenance:** Limit Switches, Sensors, Vision Control, Automation and In-Die Processes, Automated Quality Control, Die Maintenance and Adjustments, Role of Software's in Die Design	08

References:

1. Ivana Suchy, "Handbook of Die Design" 2006, McGraw Hill, ISBN 0-07-146271-6
2. VukotaBoljanovic, "Sheet Metal Forming Processes and Die Design", Industrial Press, New York, ISBN 0-83 1 1-3 182-9
3. Joseph Vincent Woodworth, "Dies, Their Construction and Use for the Modern Working of sheet Metals; A Treatise on the Design, Construction and Use of Dies, Punches", 2010, Cambridge Scholars Publishing, ISBN-13 9781152026681

4. David Smith, “Die Design Handbook” 3rd Edition, 1990, Society Of Manufacturing Engineers, ISBN-13 9780872633759
5. VukotaBoljanovic , “Die Design Fundamentals” 3rd Edition, 2005, Industrial Press, ISBN-13 9780831131197

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Course Code	Course Name	Credits
PDL101	**CAD:SOLID MODELLING LAB**	**01**

Module	Detailed content	Hours
I	Create 3-D solid models of complex objects given a multi-view representation (minimum 2 to 3)	08
II	**Project**: For a given system consisting of four to five components do as described below; 1. Create solid models of individual parts 2. Create reference geometry features (planes, axes) 3. Create solid features using sweeping and lofting operations 4. Measure properties of 3-D CAD models 5. Create assemblies of CAD parts with appropriate mating relationships	16

Assessment:

Laboratory Project: Weightage for Laboratory Project should be 40% in Final Assessment of Laboratory Work

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

Course Code	Course Name	Credits
PDL102	**RAPID PROTOTYPING AND TOOLING LAB.**	**01**

Module	Detailed content	Hours
I	Following activity can be demonstrated either in the Institute or visiting any organization where this type of work is done. 1. Study of reverse engineering concepts 2. Demonstration of 3D scanning 3. Study of rapid prototyping machines 4. Demonstration of Fusion Deposition Modelling 5. Demonstration of Selective Laser Sintering 6. Demonstration of Vacuum casting 7. Demonstration of Virtual Reality	08
II	**Project: In a group of not more than 4 students** Identify an existing consumer product, develop CAD model, simulate in CAE environment, optimize, develop tooling and make a physical prototype. Prepare a detailed report.	16

Assessment:

Laboratory Project: Weightage for Laboratory Project should be 40% in Final Assessment of Laboratory Work

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

Course Code	Course Name	Credits
PDC201	**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	08
2	**Product and Product Data:** Product Importance, Range, Parts, Ingredients, Components, Assemblies, Identifier, Requirements From Customer, Requirement to Product Specification, Identification Standards, Unique Identifier, Unique Key, Traceability. Communication of Identifier, Product Classification, Versions, Variants, Options, Product Ownership, Product Structure and Architecture, Product Data types and importance, Product Data Models **Product Data Management (PDM):** PDM systems and importance, Components of PDM, Reason for implementing a PDM system, Financial justification of PDM, Barriers to PDM implementation	10
3	**Life Cycle Approach in Product Design:** Product–System Concept and Modelling, Product–System and Environmental Impact, Environmental Aspects of the Consumption of Energy Resources, Emission Phenomena and Environmental Effects, Life Cycle Modelling, Modelling by Elementary Function or Activity, Typologies of Activity Models, Product Life Cycle: Reference Model, Main Phases of the Life Cycle, Preproduction, Production, Distribution, Use , Retirement and Disposal, Flows of Material Resources and Recovery Levels, Life Cycle Approach in Product Design	10
4	**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	08
5	**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	06
6	**Integration of the PLM system with other applications:** Transfer file, Database integration, System roles ERP, CAD, Configurators, EAI, PLM and Service Industry, PLM and E- Business **PLM Case Studies:** PLM Softwares, Tools, PLM Success: Case Studies, Examples	06

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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Course Code	Course Name	Credits
PDC202	**DESIGN FOR X**	04

Module	Detailed content	Hours
1	**DESIGN FOR MANUFACTURE :** General design principles for manufacturability - strength and mechanical factors, mechanisms selection, evaluation method, Process capability - Feature tolerances - Geometric tolerances - Assembly limits – Datum features - Tolerance stacks	08
2	**DESIGN FOR ASSEMBLY:** Assembly processes-Handling and insertion process-Manual, automatic and robotic assembly-Cost of Assembly-Number of Parts-DFA guidelines	08
3	**VALUE ENGINEERING:** Value –types –functional –operational –aesthetic –cost- –material – Design process – value and worthiness –procedure -brainstorming sessions –evaluation –case studies – value estimation- Value analysis - Design for value - Selection of alternatives - optimization – Implementation	08
4	**PRODUCT DEVELOPMENT ECONOMICS:** Elements of Economics analysis-Quantitative and qualitative analysis-Economic Analysis process-Estimating magnitude and time of future cash inflows and out flows-Sensitivity analysis-Project trade-offs-Trade-offs rules-Limitation of quantitative analysis- Influence of qualitative factors on project success	10
5	**CONCEPT OF RELIABILITY:** Introduction: The study of Reliability and Maintainability, Concepts, Terms and Definitions, Applications, The Failure Distribution: The reliability Function, Mean Time to Failure, Hazard Rate Function, Bath tub Curve, Conditional Reliability	08
6	**MAINTAINABILITY:** Analysis of down time, Report Time Distribution, Stochastic Point Processes, Reliability under Preventive Maintenance, State-Dependant System with Repair, Design for Maintainability.	06

References:

1. Harry Peck, Designing for Manufacture, Pitman Publications, 1983.
2. George E Dieter, Engineering Design, McGraw-Hill Int Editions, 2000
3. S.S.Iyer, Value Engineering, New Age International, 2000
4. Charles E. Ebeling, An Introduction to Reliability and Maintainability Engineering, TMH 2000

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Course	Course Name	Credits
PDC203	**APPLIED ERGONOMICS**	04

Module	Detailed content	Hours
1	**Human Factors Basics:** Introduction to Human Factors, Research Methods, Design and Evaluation Tools, Visual Sensory System, Auditory, Tactile, and Vestibular Systems.	08
2	**Human-Machine System:** Cognition, Decision Making, Displays, Control	06
3	**Human Performance in the Workplace:** Anthropometry and Workplace Design, Biomechanics of Work, Work Physiology, Stress and Workload	08
4	**Ergonomics - Physical design :** User-technology physical interface design Who are the users? How does the technology fit different user dimensions? How does the technology fit user anatomy? How does the technology fit user strength? How does the technology accommodate different abilities? How safe is the technology (health, comfort, performance)? How do users interact with technology?	10
5	**Introduction to the concept of system design and Ergonomics** Ergonomics in product design, the interface design, Body dimensions and its application in design, Dimensional optimization for the population and use of percentile, The musculo-skeletal system and joint motion study, Human body following the principle of lever, biomechanical stresses on our body. Effect of stresses imposed on body. Design from the view point of biomechanics, Work posture analysis, Static and Dynamic work, the visual, auditory and thermal environment and their impact on design. Controls and display aspects of design. Research techniques in Ergonomic data generation, interpretation and application of statistical methods.	10
6	**Introduction to basic elements of design and Ergonomics :** Line, texture, colour, form, symmetry, balance, scale, mass, unity and variety. Concept of visual language and visual design. Introduction to Gestalt laws, composition and figure and ground relationships. Introduction to concept of negative space, Use of symmetry. Generation of patterns and textures using simple elements.	06

References:

1. M. S. Sanders and Ernest J. McCormick: Human Factors in engineering and Design, Sixth Edi.,McGraw-Hill International Editions, 1987.
2. P.O. Astrand and K. Rodahl, Textbook of work physiology, McGraw Hill, New York, 1970.
3. Wickens, C.D., Lee, J.D., Liu, Y., Gordon Becker, S.E. (2004). An Introduction to Human Factors in Engineering (2nd Ed.). Upper Saddle River, New Jersey: Pearson Prentice-Hall

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Course Code	Course Name	Credits
PDE2031	**VEHICLE DESIGN**	**04**

Module	Detailed content	Hours
1.	**Automotive engineering development:** Innovation and Inventions, Styling Development, Streamlining, Engine Developments, Transmission Developments, Steering, Brakes, Suspension, Wheels and Tyres, Interior Refinement, Safety Design	08
2.	**Modern materials and their incorporation into vehicle design:** Structure and manufacturing technology of automotive materials, Metals and Alloys, Plastics and Polymers, Ceramics and Glasses, Composite Materials, Mechanical and Physical Properties of Automotive Materials, Selection of Automotive Materials	08
3.	**Body design: The styling process:** The Studios, working environment and structure, Product Planning, Concept sketching and Package related sketching, Full sized tape drawing, Clay Modelling, Use of 2D CAD system, Use of 3D CAD System, Rendering Techniques	08
4.	**Body design: Aerodynamics:** Aerodynamic forces, Drag, Drag reduction, Stability and cross winds, Noise, Ventilation, Wind tunnel testing, Use of CFD **Basic Concepts in Design and Analysis:** Chassis, Suspension systems, Braking systems, Transmission and driveline, Noise and Vibration	08
5.	**Occupant accommodation: an ergonomics approach:** Ergonomics in Automotive Industry, Ergonomic methods and tools to promote occupant accommodation, Standards, Guidelines and Recommendations, Anthropometry, Testing	08
6.	**Future trends in automobile design:** Mechanical possibilities, Advances in Manufacturing Methods, Materials advances, Energy conservation, Power systems, Electrical, Electronic and Hybrid possibilities, Vehicle information and navigation systems	08

References:

1. Julian Happian-Smith , "An Introduction to Modern Vehicle Design", 2002, Butterworth-Heinemann, ISBN 07506 5044 3
2. John Fenton, "Advances in Vehicle Design", 1999, Professional Engineering Publishing, ISBN-13 9781860581816
3. Sanders, M.S. and McCormick, E.J., "Human Factors in Engineering and Design" (7th edition) McGraw-Hill
4. Smith, W.F. (1993). "Fundamentals of Materials Science and Engineering." McGraw-Hill ,ISBN 0-07-059202-0
5. Beranek, L.L. (1971). "Noise and Vibration Control". McGraw-Hill.
6. Bralla, J.B. (ed.) (1986). "Handbook of Product Design for Manufacturing – a Practical Guide to Low Cost Production." McGraw-Hill. ISBN 0-07-007130-6.
7. Ryan Boroff, Tony Lewin, "How to Design Cars Like a Pro",2010, Motorbooks International, ISBN-13 9780760336953
8. Geoff Wardle, Freeman Thomas, Stacey Macey, Ralph Gilles, Gordon Murray, Stuart Macey, "H-point: The Fundamentals of Car Design and Packaging",2009, Ingram Pub Services, ISBN-13 9781933492377

9. MR Fernando F. Palma P., “Car Design: Futuristic Concepts”,2009, Createspace, ISBN-13 9781448618767
10. Bilal Salim, “Design and Fabrication of a Hybrid Car”,2012, LAP Lambert Academic Publishing, ISBN-13 9783659157264

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Course Code	Course Name	Credits
PDE2032	**POLYMERIC MATERIAL AND PROCESSING**	**4**

Module	Detailed content	Hours
1	**Introduction** The terminology of plastics The early history of polymers The development of plastic products Designing a polymer structure for improved properties	6
2	**Plastic properties:** Mechanical Properties, Reinforced Properties, Electrical properties, Optical properties, Thermal Properties, Testing of Plastics	8
3	**Fabrication process:** Types of process, tooling for plastic processing, compression moulding, Transfer moulding, Injection moulding of thermoplastics, Injection moulding of thermosetting resins, Extrusion, Blow Moulding, Calendaring. Casting process, Foaming Process, Reinforcing process,	10
4	**Industrial Polymers:** 4.1 Addition Polymers: Polyolefins, Olefins copolymers, Acrylic, Vinayl polymers. 4.2 Condensation polymers: Polyesters, polyamides, formaldehydes resins Polyurethanes, Eather polymers, cellulosic Polymer, Silicones, Polyblends Interpenetrating polymer Network.	8
5	**Polymers in special uses :** High temperature and fire resistance, liquid crystal Polymers, electro active polymer, Polymer supported catalystes optical Information storage.	8
6	**Plastics and the environment** how plastics affect the environment, how environmental factors affect plastics behavior of plastics in outdoors environments, behavior of plastics in biotic environments, behavior of plastics in fires environment.	8

References:

1. Industrial Polymers, Specialty Polymers, and Their Applications Manas Chanda and Salil K . Roy CRC Press 2008 Print ISBN: 978-1-4200-8058-2 eBook ISBN: 978-1-4200-8059-9
2. Plastics and the Environment Anthony L. Andrady ISBN: 978-0-471-09520-0
3. Design of Plastic Products Charles A. Harper: Modern Plastics Handbook. (McGraw-Hill Professional, 2000),
4. Life Cycle Engineering of Plastics: Technology, Economy and Environment Edited By L. Lundquist Y. Leterrier P. Sunderland Imprint: Elsevier ISBN: 978-0-08-043886-3
5. Plastic product design Ronald D. Beck Van Nostrand Reinhold Co., 1980 - Technology & Engineering -3 .Plastics Technology Handbook, Third Edition, edited by Manas Chanda, Salil K. Roy
6. Plastics and the Environment Anthony L. Andrady John Wiley & Sons

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Course	Course Name	Credits
PDE2033	**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**.**	08
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	08
3	**Robot Kinematics**: Coordinate Frames, Rotations, Homogeneous Coordinates, Arm Equation of Planer Robot, Four axes SCARA Robot, TCV, Inverse Kinematics of Planer Robot, and Four Axis SCARA Robot.	08
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.	08

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

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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Course Code	Course Name	Credits
PDE2034	**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.	06
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.	10
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.	08
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, microhinges, compound microstructures. • Linear & Nonlinear Model. • Numerical Methods used for MEMS analysis.	08

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	10
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	06

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

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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Course Code	Course Name	Credits
PDE2041	**REVERSE ENGINEERING**	**04**

Module	Detailed content	Hours
1	**Introduction** Historical Background, Industrial Evolution, Reinvention of Engineering Marvels from Nature, Reverse Engineering in Modern Industries, Reverse Engineering vs. Machine Design, Motivation and Challenge, Analysis and Verification, Accreditation, Part Criticality, Applications of Reverse Engineering	08
2	**Geometrical Form** Surface and Solid Model Reconstruction, Scanning Instruments and Technology, Principles of Imaging, Cross-Sectional Scanning, Digital Data, Computational Graphics and Modeling, Data Refinement and Exchangeability, Dimensional Measurement, Case Studies, Part Tolerance, Prototyping, Additive Prototyping Technologies, Subtractive Prototyping Processes, Rapid Injection Molding, Steps of Geometric Modeling	08
3	**Material Characteristics and Analysis** Alloy Structure Equivalency, Phase Formation and Identification, Mechanical Strength, Hardness **Part Durability and Life Limitation** Part Failure Analysis, Fatigue, Creep and Stress Rupture, Environmentally Induced Failure	08
4	**Material Identification and Process Verification** Material Specification, Composition Determination, Microstructure Analysis, Manufacturing Process Verification	08
5	**Data Process and Analysis** Statistical Analysis, Data Analysis, Reliability and the Theory of Interference, Weibull Analysis, Data Conformity and Acceptance, Data Report **Part Performance and System Compatibility** Performance Criteria, Methodology of Performance Evaluation, System Compatibility	08
6	**Acceptance and Legality** Legality of Reverse Engineering, Legal Definition of Reverse Engineering, Legal Precedents on Reverse Engineering, Patent, Copyrights, Copyright Codes, Legal Precedents on Copyrights, Trade Secret, Case Study of Reverse Engineering a Trade Secret, Third-Party Materials	08

References:

1. Wego Wang, "Reverse Engineering: Technology of Reinvention", ISBN-13: 978-1439806302, CRC Press
2. Kevin Otto , "Product Design : Techniques in Reverse Engineering and New Product Development", ISBN-13: 9788177588217, Dorling Kindersley
3. Robert Messler, "Reverse Engineering: Mechanisms, Structures, Systems & Materials", McGraw Hill Education, ISBN: 9780071825160
4. Raja, Vinesh, Fernandes, Kiran J. , "Reverse Engineering An Industrial Perspective" ISBN 978-1-84628-856-2, Springer

Assessment:

Internal Assessment: Assessment consists of two tests out of which; one should be compulsory class test 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.

Course Code	Course Name	Credits
PDE2042	**PRODUCT MARKETING**	**04**

Module	Detailed content	Hours
1	**Advanced Marketing Planning** **Introduction:** Concept, nature, scope and importance of marketing; Marketing concept and its evolution; Marketing mix; Strategic marketing planning – an overview. **Market Analysis and Selection:** Marketing environment – macro and micro components and their impact on marketing decisions; Market segmentation and positioning;	08
2	**Consumer Behaviour** Introduction to Consumer Behaviour (CB): Nature and Importance of CB, application of CB in Marketing , Consumer Research process. Consumer Decision making Process: · Problem recognition · Information Search Process and Evaluation · Purchasing process · Post purchase behaviour	08
3	**Marketing Research** An overview of the Marketing Research Process, Research Designs, Exploratory Research, Descriptive Research, Experimental Research, Uncontrollable Variables: History, Maturation, Testing Effect, Measurement of Variation and Interactive Effect. Types of Data-Primary Data and Secondary Data, Secondary Data Sources for MR in India.	10
4	**Pricing Strategies** An Introduction to Pricing Basic Frameworks Overview of common pricing methods Psychology and Measurement The role of consumer psychology in pricing Price Discrimination Effective market segmentation New product pricing and building	08
5	**Brand Strategy** Concept of Brand, Significance of Branding for Consumers and for Firms, Branding Challenges and Opportunities, Concept of Brand Equity, Cost based, Price based and Customer based Brand Equity, Customer Based Brand Equity Sources of Brand Equity- Brand Awareness and Brand Image, Keller's CBBE Model- Identity, Meaning, Response and Relationships. Brand Positioning Definition of Target Market & Market Segmentation, Defining the Competitive Frame of Reference, Establishing the Points of Parity & Points of difference.	08
6	**Designing the Supply Chain network** Understanding the supply Chain, Designing the distribution network, Designing and Planning Transportation Network	06

References:

1. Kotlar, Philip, Marketing Management, Prentice Hall, New Delhi.
2. Loudan, David L and Bitta, A.J. Della Consumer Behaviour
3. Schiffman LG and Kanuk LL Consumer Behaviour
4. Nair, Suja R, Consumer Behaviour in Indian
5. Marketing Research: Text & Cases, Boyd, Westfall & Stasch, R D Irwin
6. Research For Marketing Decisions, Green & Tull, Prentice Hall
7. Thomas T. Nagle, the Strategy and Tactics of Pricing, Prentice Hall
8. Pricing a Portfolio of Products complements & substitutes new product pricing
9. Strategic Brand Management, Keller, Parmeswaran & Jacob, Pearson
10. Brand Management, Kirti Dutta, Oxford Publishing
11. Supply Chain Management Strategy, Planning and Operationby Sunil Chopra, Pearson Education

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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.

Course Code	Course Name	Credits
PDE2043	**COMPOSITE MATERIAL[$]**	**04**

Module	Detailed content	Hours
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	08
2	**Macromechanical Behaviour 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	08
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	08
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	08

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	08
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	08

$ Common for Machine Design, CAD/CAM and Robotics and PDD

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

Assessment:

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

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Course Code	Course Name	Credits
PDE2044	**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, Micro sensors, Intelligent Systems, Hybrid Smart Materials, Passive Sensory Smart Structures, Reactive Actuator based Smart Structures, Active Sensing and Reactive Smart Structures, Smart Skins	06
2	**Introduction to High bandwidth - Low strain generating (HBLS)** **Smart Materials** **Piezoelectric Materials** constitutive relationship, electromechanicalcoupling coefficients, piezoelectric constants, piezoceramic materials, variation of coupling coefficients in hard and soft piezoceramics, polycrystalline vs. single crystal piezoelectric materials, polyvinyldenefluoride, piezoelectric composites **Magnetostrictive Materials** constitutive relationship, magnetomechanical couplingcoefficients, Joule Effect, Villari Effect, MatteuciEffect, Wiedemanneffect, Giantmagnetostriction, InTerfenol-D, Terfenol-Dparticulate composites, Galfenol and Metglasmaterials.	08
3	**Actuators based on HBLS Smart Materials** **Piezoelectric Actuators** Induced Strain actuation model, Unimorph and Bimorph Actuators, Actuators embedded in composite laminate, Impedance matching in actuator design, Feedback Control, Pulse Drive, Resonance Drive. **Magnetostrictive Actuators** Magnetostrictive MiniActuators, Thermal instabilities, Discretely distributed actuation,ManetostrictiveComposites. **MEMS based Actuators** Piezoelectric Micropumps, Magnetostrictive micromechanisms, Imaging System Applications, Inchworm Devices, Inkjet Printers, Piezoelectric Relays, Ultrasonic Motors, and Micro scale Walking Machines. **Sensors based on HBLS Smart Materials** Piezoelectric Sensors, Magnetostrictive Sensors, Techniques of Self- Sensing, MEMS Sensors	10
4	**Introduction to Low bandwidth** - High strain generating (LBHS) materials Shape Memory Alloys(SMA) Electro-active Polymers (EAP)	07
5	**Actuators based on LBHS Smart Materials** Shape Memory Alloy based actuators for Shape Control Electro- active Polymers for Work-Volume Generation Sensors based on LBHS Smart Materials EAP based sensors SMA based encoders, Optical Fibre based Sensing	09
6	**Advances in Smart Materials** • Active Fibre Composites (AFC) • Energy Harvesting Actuators and Energy Scavenging Sensors • Self-healing and Autophagous Smart Materials	08

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

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, "Fibre 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)

Assessment:

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Course Code	Course Name	Credits
PDL203	**CAD: SURFACE MODELLING LAB**	**01**

Module	**Detailed content**	**Hours**
I	Introduction to surface modelling 1. Coordinate transformations (translation, rotation, scaling, reflection) 2. Working with drawings, views, dimensions and tolerances. 3. Sheet metal design 4. Surface Modelling	10
II	**Project**: Create CAD models of any two given objects involving above features, such as car side mirror body, mouse body, bottles etc.	14

Assessment:

Laboratory Project: Weightage for Laboratory Project should be 40% in Final Assessment of Laboratory Work

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

Course Code	Course Name	Credits
PDL204	**COMPUTER AIDED ENGINEERING LAB.**	**01**

Module	Detailed content	Hours
I	Introduction to computer aided engineering 1. Modelling of an element/system 2. Finite Element Analysis of an element/system (Involves element selection, assigning properties, meshing, assigning loads and boundary conditions, analysis and result interpretation) 3. Optimization of an element/system (minimization of mass) through FEA.	14
II	**Project**: Select any engineering element/system and optimize the design through FEA approach	10

Assessment:

Laboratory Project: Weightage for Laboratory Project should be 40% in Final Assessment of Laboratory Work

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

Course Code	Course Name	Credits
PDS301	**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 literature and understand the topic and compile the report in standard format and present in front of Panel of Examiners appointed by the Head of the Department/Institute of respective Programme.
- 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

Course Code	Course Name	Credits
PDD 301 / PDD 401	**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 Problem definition 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 Problem definition 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)