M. Des. Mechanical Systems (MDS)

(According to 34th Senate meeting minutes)

Course Title	Concepts of Product Design and Development	Course No	To be filled by the office		
Specialization	Mechanical Engineering	Structure (IPC)	2	3	4
Offered for	M. Des.	Status (Core / Elective)	Core		
Prerequisite	----	To take effect from			
Course Objectives	1. The course comprises theoretical sessions that are supplemented with practice sessions. 2. The students will be given an overview of systematic approach used during product design and development. 3. The course will highlight the methods for need identification, techniques for creative thinking, concept generation, concept selection, product architecture, aesthetics, ergonomics etc. 4. The students will realize the design through models of using suitable materials.				
Course Outcomes	1. The students will be able to understand the need of a customer and use the creative thinking to conceptualize designs. 2. The students will also be able to quickly visualize the concepts using models.				
Contents of the course	**Theory:** Introduction: Importance of engineering design, types of design, total life cycle- types of products, Phases of product development process, product and process cycles. (4) Problem Definition & Need Identification: Identifying customer needs, gathering information classifying customer requirements, engineering characteristics, competitive benchmarking, QFD, product design specification. (6) Conceptual Design: Creativity in design, creativity and problem solving, creative thinking methods, conceptual decomposition morphological methods-TRIZ and contradiction, Bio and Shape mimicry techniques, Decision making and concept selection-decision theories-concept screening and scoring. (8) Embodiment Design: Product architecture, steps in developing product architecture, industrial design human factors design, Nostalgia and Design, Environment factors. (8) Design Profile Preparation (2) **Practice:** Method of Expressing and communicating and documenting technical ideas through sketches (1) Clay, Foam, Wood modeling and modern 3D printing (2) Problem Definition and Need Identification (1) Conceptual design : Morphological charts, TRIZ and Contradiction, Bio and Shape mimicry, Concept selection, Screening (5) Embodiment Design : Product Architecture, Human Factors, Aesthetics, Nostalgia and Environmental factors (4) Design Profile presentation (1)				
Textbooks	1. K. Otto, Product Design, Pearson Education, 1st edition, 2011, ISBN: 8177588214. 2. U. Karl and S. Eppinger, Product Design and Development, McGraw-Hill Education, 6th edition, 2015, ISBN: 0078029066.				
References	1. C. A. Harper, Handbook of Materials for Product Design, McGraw-Hill Professional, 1st edition, 2001, ISBN: 0071354069. 2. R. Stuer and K. Eissen, Sketching: Drawing Techniques for Product Designers, Thames & Hudson, 1st edition, 2007, ISBN: 9063691718. 3. B. Hallgrimsson, Prototyping and Modelmaking for Product Design, Laurence King Publishing, 1st edition, 2012, ISBN: 9781856698764.				

Course Title	Design and Analysis of Mechanisms	Course No	To be filled by the office		
Specialization	Mechanical Engineering	Structure (IPC)	3	3	5
Offered for	M. Des. (MDS)	Status (Core / Elective)	Core		
Prerequisite	----	To take effect from			
Course Objectives	To impart advanced knowledge in design and synthesis of mechanisms				
Course Outcomes	1. Ability to design and analyze planar and spatial mechanisms 2. Ability to synthesize various mechanisms 3. Ability to design and analyze mechanisms for robotic applications				
Contents of the course	**Theory:** Review of Kinematics of Planar Mechanisms: Kinematic pairs, chains and mechanisms, kinematic inversions; Velocity and acceleration of planar mechanisms-graphical and analytical methods; Loop closure equation; Four-bar mechanisms, Grashof criterion. (4) Graphical Synthesis of Planar Mechanisms: Type and number synthesis; Motion, path and function generation, Chebyshev's accuracy points; Two-three-four position synthesis with and without prescribed timing; Synthesis of dwell and Geneva mechanisms. (5) Analytical Synthesis of Planar Mechanisms: Complex algebra representation; Standard form equation; Two and three position analytical synthesis for motion, path and function generation; Introduction to commercially available software for mechanism synthesis. (8) Spatial Linkages and Parallel Mechanisms: Rigid body and spatial transformations; Displacement, velocity and acceleration analyses of spatial linkages; Introduction to the kinematic analysis of parallel mechanisms. (8) Introduction to Robotics: Introduction to Robotics: Robot kinematics-forward/inverse; Denavit-Hartenberg matrix transformation; Differential motion and Jacobian; Dynamics and position control; Path planning; Applications. (14) Introduction to Compliant Mechanisms: Flexibility and deflection; large deflection analysis; Applications. (3) **Practice:** Design, kinematic analysis and synthesis of linkages and mechanisms for various applications using free and paid software such as MechAnalyzer, Linkage 3.0, GIM Mechanism, AR-CAD, CATIA, ADAMS, Autodesk Inventor, Matlab Robotics Tool Box Construction of mechanisms using robot kits Programming and validation of kinematics using ABB robot				
Textbooks	1. A. G. Erdman and G. N. Sandor, Mechanism Design: Analysis and Synthesis: Vol. 1, Pearson, 4th edition, 2001, ISBN: 9780130408723. 2. A. G. Erdman and G. N. Sandor, Mechanism Design: Analysis and Synthesis: Vol. 2, Pearson, 2005, 4th edition, ISBN: 9780130114372. 3. K. S. Fu, R. C. Gonzalez and C. S. G. Lee, Robotics: Control, Sensing, Vision, Intelligence, McGraw-Hill Education, 1st edition, 2008, ISBN: 9780070265103. 4. A. K. Mallik, A. Ghosh and G. Dittrich, Kinematic Analysis and Synthesis of Mechanisms, CRC Press, Spl Indian edition, 2016, ISBN: 9781498771009.				
References	1. L. W. Tsai, Robot Analysis: The Mechanics of Serial and Parallel Manipulators, Wiley, 1st edition, 1999, ISBN: 9780471325932. 2. K. Russell, Q. Shen and R. S. Sodhi, Mechanism Design: Visual and Programmable Approaches, CRC Press, 1st edition, 2013, ISBN: 9781466570177. 3. R. L. Norton, Design of Machinery-An Introduction to the Synthesis and Analysis of Mechanisms and Machines, McGraw Hill, 5th edition, 2011, ISBN: 9780077421717. 4. L. L. Howell, Compliant Mechanisms, John Wiley & Sons, 1st edition, 2001, ISBN: 9780471384786. 5. J. J. Uicker, G. R. Pennock and J. E. Shigley, Theory of Machines and Mechanisms, Oxford University Press, 4th edition, 2010, ISBN: 9780195371239				

Course Title	Design with Advanced Engineering Materials	Course No	To be filled by the office		
Specialization	Mechanical Engineering	Structure (IPC)	3	0	3
Offered for	M. Des. (MDS), DD (MPD)	Status (Core / Elective)	Core		
Prerequisite	----	To take effect from			
Course Objectives	This course aims to expand the knowledge and understanding of a design engineer in the product design aspects, manufacturing considerations etc while opting for new metals, polymer, composite, ceramics etc. The various behaviors of the materials in form of products will be dealt through case studies.				
Course Outcomes	At the completion of the course, the student will be able to: 1. design engineering products with polymers such as tanks, pipes, rollers, gears, fan impeller blades and, casings and covers for numerous electronic products. 2. design composite structures for automotive, aerospace and space applications 3. design ceramic components for high temperature applications				
Contents of the course	New engineering materials: metals, polymers, composites and ceramics. (6) Mechanical behavior and properties relevant for design engineers. (6) Tailoring properties, processing and structure to meet design criteria (6) Selection of materials: materials aspects, cost and manufacturing considerations (6) Polymer, metal and ceramics matrix composites based product design (6) Surface modifications and its implications in design (7) Case studies (5)				
Textbooks	1. G. E. Dieter, Engineering Design: Materials and Processing Approach, McGraw-Hill,1999 2. M. F. Ashby, Materials Selection in Mechanical Design, Butterworth Heinemann Publishers Oxford, 1999.				
References	1. M. M. Farag, Materials Design for Engineering Design, Prentice Hall, 1997. 2. D. Ga, S. V. Hoa, S. W. Tsai, Composite Materials: Design and Applications, CRC Press 2002.				

Course Title	Design for Manufacture and Assembly	Course No	To be filled by the office		
Specialization	Mechanical Engineering	Structure (IPC)	3	3	5
Offered for	M. Des. (MDS), DD (MPD)	Status (Core / Elective)	Core		
Prerequisite	Basic Concepts in Manufacturing Processes, Concepts in Engineering Design	To take effect from			
Course Objectives	The course is intended to expose students to a range of manufacturing system constraints to designing various shapes during material and process selection.				
Course Outcomes	1. Students will understand the impact of manufacturing constraints on product design and process planning. 2. Students will gain an understanding of variation to the shapes that control the production rate and influence the quality, cost and flexibility of processes and systems.				
Contents of the course	**Theory:** Introduction to Design Methodology, Need Identification and Problem Definition, Concept Generation and Evaluation, Embodiment Design, Concurrent Engineering. (3) Material Selection: Properties of Engineering Materials, Selection of Materials, Case Studies, Selection of Shapes, Case Studies. (9) Process Selection: Review of Manufacturing Processes, Design for Casting, Design for Bulk Deformation Processes, Design for Sheet Metal Forming Processes. (6) Design for Machining, Design for Powder Metallurgy, Design for Polymer Processing, Design for Additive Manufacturing, Case-Studies. (7) Review of Assembly Processes, Design for Welding, Design for Brazing and Soldering, Design for Adhesive Bonding, Design for Joining of Polymers, Design for Heat Treatment, Case-Studies. (10) Manual assembly, Design for PCB Manufacturing and assembly, Electrical Connections and Wire harness assembly, Design for Automated and Robotic Assembly. (9) **Practice:** Cost estimation of case-study parts and assemblies using DFMA software. Design modification of parts and assemblies using DFMA software to reduce total cost.				
Textbooks	1. M. F. Ashby, K. Johnson, Materials and Design: The Art and Science of Material Selection in Product Design, 3rd edition, Butterworth-Heinemann Ltd, 2014. ISBN: 978-0080982052. 2. P. Dewhurst, W. Knight, G. Boothroyd, Product Design for Manufacture and Assembly, 3rd edition, CRC Press, 2010. 3. L. C. Schmidt, G. Dieter, Engineering Design, 4th edition, McGraw Hill Education India Private Limited, 2013. ISBN: 978-1259064852.				
References	1. M. F. Ashby, Materials Selection in Mechanical Design, 4th edition, Elsevier, 2011. ISBN: 978-9380931722. 2. M. F. Ashby, Materials and the Environment: Eco-informed Material Choice, 2nd edition, Butterworth-Heinemann, 2012. 3. G. Boothroyd, Assembly Automation and Product Design, 2nd edition, CRC Press 2005. 4. J. G. Bralla, Design for Manufacturability Handbook, 2nd edition, McGraw-Hill Professional, 1998. ISBN: 978-0070071391.				

Course Title	Quality and Reliability based Design	Course No	To be filled by the office		
Specialization	Mechanical Engineering	Structure (IPC)	2	3	4
Offered for	M. Des.	Status (Core / Elective)	Core		
Prerequisite	----	To take effect from			
Course Objectives	The course aims to provide an in-depth coverage of Statistical Quality control and Reliability Engineering.				
Course Outcomes	Students will be exposed to various aspects such as Control Charts, Statistical tools, basics of reliability, maintainability, etc. The course would equip students with skills required for effective Design based on Quality and Reliability Concepts.				
Contents of the course	**Theory:** Introduction: Introduction to Statistical techniques, Basics of Quality control, Quality Assurance and Cost Process Control: Statistical Tools, Causes of Variations, Control Charts for Variables and Attributes Design for Quality: Quality Loss Function, Quality Function Deployment, Fault Tree Analysis, Failure Mode and Effect Analysis. Life Data Analysis: Data collection – Non Parametric methods: Ungrouped/Grouped, Complete/Censored data-Time of failure distributions: Exponential, Weibull – Probability plotting – Goodness of fit tests Reliability Engineering: Reliabilty analysis, Reliabilty Prediction, Load- Strength Analysis, Reliability Testing, Modeling and Reliability Analysis of Multi state systems. Reliability Improvement: Analysis of Downtime, Repair time Distributions **Practice:** Exercise on Control Charts for Variables and Attributes Case Study on FTA and FMEA Case study on Quality Function Deployment Exercise on reliability concepts and calculations of MTBF and MTTF Exercise on reliability prediction model.				
Textbooks	1. C. E. Ebeling, An introduction to Reliability and Maintainability engineering, Tata Mc Graw Hill, 2000. 2. A. Mitra, Fundamentals of Quality control and Improvement, 4th edition, John Wiley & Sons, 2016				
References	1. D. C. Montgomery, Introduction to Statistical Quality Control, 2nd edition, John Wiley & Sons, 1991.				

Course Title	Advanced Mechanics of Materials	Course No	To be filled by the office		
Specialization	Mechanical Engineering	Structure (IPC)	3	3	5
Offered for	M. Des. (MDS)	Status (Core / Elective)	Core		
Prerequisite	----	To take effect from			
Course Objectives	This course is intended to give necessary 1. understanding of behavior of solid materials in terms of their motion and deformation under the action of static forces and dynamic forces. 2. analytical methods to analyze the behavior of various structural members. 3. numerical formulation to predict stresses, and in-turn life of complex shaped structures.				
Course Outcomes	At the completion of the course, the student will be able to 1. formulate the behavior of various structural elements and 2. predict life of various products of different shapes made with wide variety of materials.				
Contents of the course	**Theory:** Theories of stress and strain, and, stress-strain relations. (6) Formulation and methods of analytical solution of linear elasticity problems-plane stress and plane strain, asymmetrical bending, torsion of prismatic bars, axisymmetrically loaded members, beams on elastic foundation, plates and shells. (18) Energy methods, Finite Difference method, Finite element method - formulation of axial element, beam element, 2D plane and plate elements and solid elements. (12) Modeling material failure - static failure theories, Linear elastic fracture mechanics, fatigue failure theories and life prediction approaches for zero and nonzero mean stress, variable amplitude and multiaxial stresses. (6) **Practice:** Finite difference solutions for torsion of prismatic bars, beams with varying forces and cross section along the span, beams on elastic foundation. (3) Finite element solutions for axially and transversely loaded members, thin plates or discs with inplane and lateral forces, long pipes and dams, and brackets. (9)				
Textbooks	1. A. C. Ugural and S. K. Fenster, Advanced Strength and Applied Elasticity, Prentice Hall, 5th edition, 2013, ISBN-13: 978-0-13-707920-9.				
References	1. A. P. Boresi and R. J. Schmidt, Advanced Mechanics of Materials, John Wiley & Sons, Inc., 6th edition, 2003, ISBN 978-0-471-43881-6. 2. R. G. Budynas, Advanced strength and Applied Stress Analysis, McGraw-Hill, 2nd edition, 1999, ISBN: 9780070089853. 3. L. S. Srinath, Advanced Mechanics of Solids, Tata McGraw-Hill, 1st edition, 2009, ISBN: 9780070139886. 4. S. P. Timoshenko and J. N. Goodier, Theory of Elasticity, Tata McGraw-Hill, 3rd edition, 2013, ISBN-13: 978-0-07-070122-9. 5. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Pearson, 4th edition, 2011, ISBN: 978-0132162746. 6. S. Moaveni, Finite Element Analysis: Theory and Application with ANSYS, Pearson 2013, ISBN-13: 978-0133840803.				