SYLLABUS

ADDITIVE MANUFACTURING

Class		**M. TECH**	**L**	**T**	**P**	**C**
Semester/Year		**I/I**	**3**	**-**	**-**	**3**
Subject Name		**CAD FOR ADDITIVE MANUFACTURING**				
Subject Code		**MMEAM20S101**				
Paper	**English**					
	Hindi					
Max. Marks		**100**				

Course Objectives:

1. Making the student understand how graphics created in computer world is the main goal of this course.
2. Using colors in different places and for different objects is also one of the goals of the course.
3. Learning how to rescale, transmit (shift), shear (skew), and rotate different graphical objects is another goal.
4. Animating some simple graphics is the last aim of the course.

Course Outcomes:

CO1: Apply conceptual design and geometric transformation techniques in CAD
CO2: Develop mathematical models to represent curves, surfaces and solids
CO3: Identify STL file problems and apply repair algorithms
CO4: Determine part orientation for minimum build time and part errors
CO5: Modelling of AM Process for optimum part quality

Unit	Syllabus	Periods
UNIT-I	**Introduction to Conceptual Design and CAD:** Introduction to Design Theories, develop a concept, implement a concept, creative methods for design, Introduction to CAD, CAD input devices, CAD output devices, CAD Software, Display Visualization Aids, and Requirements of Geometric Modelling, Transformations of Geometry, Developing algorithms/computer codes for transformations.	**8**
UNIT-II	**Design of Curves:** Hermite Cubic segments, Curve Trimming and Blending, Bezier segments, Bezier- subdivision, Degree elevation, Composite Bezier, B-spline, Properties of basic functions, Continuity, NURBS, Developing algorithms/computer codes for curves.**Design of Surfaces:** Surface entities, surface representation, surface analysis, design of analytical and synthetic surfaces, Developing algorithms/computer codes for surfaces	**12**

UNIT-III	**Design of Solids:** Solid entities, Boolean operations, B-rep of Solid Modeling, CSG approach of solid modeling, Advanced modelingmethods.**CAD Data Exchange Formats and Applications:** CAD Data exchange formats, Finite element analysis, 3D digitizing: Reengineering, Additive Manufacturing (AM).	**11**
UNIT-IV	**AM Data Formats:** Tessellated Models, STL Format, STL File Problems, STL File Manipulation and Repair Algorithms, AMF files, 3MF, XML, Meta Data, PLY, STEP for AM Application Protocols (AP).	**12**
UNIT-V	**AM Data Processing:** Part Orientation and Support Structure Generation, Model Slicing and Contour Data Organization, Direct and Adaptive Slicing, Hatching Strategies and Tool Path Generation. **Modelling of AM Process:** Surface Roughness due to Staircase Effect, Part Build-time, Fabrication Cost, Optimal Orientation, Quantification of Building Inaccuracy and Part Stability.	**12**

Text Books:

1. Kevin N. Otto, Kristin L. Wood, “Product Design”, Pearson Education, 2004.
2. David F. Rogers, J. A. Adams, “Mathematical Elements for Computer Graphics”, TMH, 2008.
3. Michael E. Mortenson, “Geometric Modeling”, Wiley, NY, 1997

Reference Books:

1. Anupam Saxena, Birendra Sahay, “Computer Aided Engineering Design”, Springer, 2005.
2. Patri K. Venuvinod and Weiyin Ma, “Rapid Prototyping: Laser-based and Other Technologies”, Springer, 2004.
3. L. Lu, J. Y. H. Fuh and Y.S. Wong, “Laser-Induced Materials and Processes for Rapid Prototyping”, Springer, 2001.
4. Chua Chee Kai, Leong Kah Fai, “3D Printing and Additive Manufacturing: Principles & Applications”, 4th Edition, World Scientific, 2015.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M. TECH**	**L**	**T**	**P**	**C**
Semester/Year		**I/I**	**3**	**-**	**-**	**3**
Subject Name		**Additive Manufacturing Processes**				
Subject Code		**MMEAM20S102**				
Paper	**English**					
	Hindi					
Max. Marks		**100**				

Course Objectives:
To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology and the associated Aerospace, Architecture, Art, Medical and industrial applications.

Course Outcomes:
CO1: Understand the working principle and process parameters of AM processes
CO2: Explore the applications of AM processes in various fields
CO3: Select the suitable material and process for fabricating a given product
CO4: Apply the knowledge in Material science in Additive Manufacturing Components.
CO5: Design and develop a product for AM Process.

Unit	Syllabus	Periods
UNIT-I	**Introduction to Additive Manufacturing:** Introduction to AM, AM evolution, Distinction between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM. **Vat Photo polymerization AM Processes:** Stereo lithography (SL), Materials, Process Modelling, SL resin curing process, SL scan patterns, Micro-stereo lithography, Mask Projection Processes, Two-Photon vat photo polymerization, Process Benefits and Drawbacks, Applications of Vat Photo polymerization, Material Jetting and Binder Jetting AM Processes.	**12**
UNIT-II	**Extrusion - Based AM Processes:** Fused Deposition Modelling (FDM), Principles, Materials, Process Modelling, Plotting and path control, Bio-Extrusion, Contour Crafting, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes. **Sheet Lamination AM Processes:** Bonding Mechanisms, Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.	**12**
UNIT-III	**Powder Bed Fusion AM Processes:** Selective laser Sintering (SLS), Materials, Powder fusion mechanism and powder handling, Process	**11**

	Modelling, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes**.**	
UNIT-IV	**Directed Energy Deposition AM Processes:** Process Description, Material Delivery, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Processing-structure-properties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes. Materials science for AM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship.	**12**
UNIT-V	**Post Processing of AM Parts:** Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques .Guidelines for Process Selection: Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Process Planning and Control.	**12**

Text Books:

1. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer, 2015.
2. Patri K. Venuvinod and Weiyin Ma, "Rapid Prototyping: Laser-based and Other Technologies", Springer, 2004.

Reference Books:

1. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4th Edition, World Scientific, 2015.
2. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
3. Rafiq Noorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006.

SYLLABUS

ADDITIVE MANUFACTURING

Class		M. TECH	L	T	P	C
Semester/Year		I/I	3	-	-	3
Subject Name		Polymer Engineering				
Subject Code		MMEAM20S103				
Paper	English					
	Hindi					
Max. Marks		100				

Course Objectives:

1. To equip students with basic knowledge of polymer synthesis that will help them to develop new materials.
2. To impart the awareness of recent advances in polymer material synthesis.
3. To introduce the students with current research interest and novel concepts at National and International level.
4. To teach the students to understand and evaluate new high-performance and specialty application materials.

Course Outcomes:

CO1: Understand the basic properties of polymers.

CO2: Relate polymer properties to their processing and uses for additive manufacturing.

CO3: Identify techniques of Polymerization and nano composites.

CO4: Evaluate the polymerization processes and the significance for AM.

CO5: Design of polymeric devices and polymers used for Additive Manufacturing.

Unit	Syllabus	Periods
UNIT-I	**Polymerization: Probability and statistics-** statistics of linear poly condensation, statistics of chain polymerization, branching and gelation. Kinetics of chain growth copolymerization. Copolymer sequence distribution. Chain microstructure and its characterization by spectroscopy. Order and morphology of polymers. Thermal aspects of-crystallization, crystalline melting temperature and glass transition temperature. Polymer solutions and blends- entropy of mixing, enthalpy of mixing, F-H equation, cohesive energy density, phase behavior, dilute	10

	solutions.	
UNIT-II	**Advanced polymerization mechanisms:** Metathesis polymerization, ring opening metathesis polymerization (ROMP), ring forming polymers, living cationic polymerization, living radical polymerization, NMP, ATRP, RAFT and other new methods, electrochemical polymerizations, metal catalyzed olefin polymerization, click polymerization, phase transfer polymerization, group transfer polymerization, cyclo polymerisation, oxidative polymerization, dispersion polymerization, mini-dispersion polymerization.	**10**
UNIT-III	**Advanced polymer materials and applications:** Liquid crystalline polymers, electro-active polymers, polymers for photo resists, fluorinated polymers, chiral polymers, biopolymers, polymers in lithography, fluoro polymers, polymer electrolytes and gel electrolytes, hydrophilic polymers, ionic polymers, hydrogels and stimuli sensitive hydro gels, functional polymers: photoconductive polymers, electro conductive polymers, piezoelectric polymers, light sensitive polymers, ion exchange resins, polymeric reagents, polymers as catalysts, polymers as substrates, polymer thin films, photo responsive polymers and materials.	**11**
UNIT-IV	**Specialty-application polymers:** Silicones and other inorganic polymers: silicones, polyphosphazenes, polythiazyl. Heat and fire resistant polymers: polybenzimidazole, polybenzoxazole, polybenzthiazole, Rubbers: silicones, epichlorohydrin, fluroelastomers, polysulphides, polyurethane, acrylic rubbers, silane-containing polymers.	**10**
UNIT-V	**Polymer reactions and synthesis:** Polymer supported reactions, surface fictionalization of polymers, graft copolymerization, approaches to making comb and graft architectures, grafting onto existing polymer surfaces, surface engineering using graft copolymers, oxidative coupling branched and dendrite polymers and its synthesis, new developments in telechelic polymers, microbial synthesis of polymers, biodegradable polymers, polymers from renewable resources	**10**

Text Books:

1. Comprehensive supramoleculer Chemistry, Pergamon, vol 1-10, 1999

2. Core concepts in supramoleculer chemistry and nano-chemistry, J W Steed, 1st Edition, Wiley

3. Paul C. Hiemenz and Timothy C. Lodge, Polymer Chemistry: The Basic Concepts, 2nd ed.

4. Odian, George. Principles of Polymerization. 4th ed. Hoboken, NJ: Wiley-Interscience,2004

Reference Books:

1. Polymer Chemistry an Introduction, Oxford University Press, M. P. Stevens, 1991.
2. Essentials of polymer science and engineering, P C Painter, M M Coleman, DE Stech publications, Inc., USA.
3. Principles of Polymerization, Wiley eastern, George Odian, 1991
4. Polymer Science, New age international (P) Ltd. Publishers, V.R. Gowarikar, Pearsonpublication, 2003.
5. Text book of Polymer Science, Wiley Eastern, F.W. Billmeyer Jr, 2003.
6. Polymer Molecular Weight – Vol. I and II, Slade Jr.
7. Self-Assembly and Nanotechnology Systems: Design, Characterization, and Applications, Yoon S Lee, John Wiley & Sons, Inc., 2012
8. Supra molecular Chemistry, Jonathan W. Steed, Jerry L. Atwood, John Wiley & Sons, 2009

SYLLABUS

ADDITIVE MANUFACTURING

Class		M. TECH	L	T	P	C
Semester/Year		I/I	3	-	-	3
Subject Name		Powder Metallurgy				
Subject Code		MMEAM20S104				
Paper	English					
	Hindi					
Max. Marks		100				

Course Objectives:

1. To study the basic concepts of Powder Metallurgy techniques and to develop force calculation in Powder Metallurgy process.
2. To study the thermo mechanical regimes and its requirements of Powder Metallurgy

Course Outcomes:

CO1: Distinguish and compare powder preparation techniques.

CO2: Identify the characterization techniques for powder formulation.

CO3: Differentiate between conventional powder compaction and modern compaction techniques.

CO4: Analyze the sintering mechanism of powder compacts..

CO5: Develop mechanical components through powder metallurgical techniques.

Unit	Syllabus	Periods
UNIT-I	**General Concepts:** Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM **Powder Production Techniques:** Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes, Performance Evaluation of different Processes, Design & Selection of Process.	10
UNIT-II	**Characterization Techniques**: Particle Size & Shape Distribution, Electron Microscopy of Powder, Inter particle Friction, Compression ability, Powder Structure, Chemical Characterization **Microstructure Control in Powder:** Importance of Microstructure Study, Microstructures of Powder by Different techniques	10
UNIT-III	**Sintering:** Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering, Sintering Variables, Modern Sintering Techniques,	11

	Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components.	
UNIT-IV	**Powder Shaping:** Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction, Isostatic Pressing, Injection Moulding, Powder Extrusion, Slip Casting, Tape Casting, Analysis of Defects of Powder Compact, Laser Engineering Net Shaping (LENS), 3D Printers for Ceramics .	**10**
UNIT-V	**Application of Powder Metallurgy:** Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, Biomaterials etc. A few case studies.	**8**

Text Books:

1. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002.
2. J. S. Hirschhorn: Introduction to Powder Metallurgy, American Powder Metallurgy Institute, Princeton, NJ, 1976.
3. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008. ASM Hand Book, vol. 7: Powder Metallurgy, ASM International.

Reference Books:

1. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002.
2. J. S. Hirschhorn: Introduction to Powder Metallurgy, American Powder Metallurgy Institute, Princeton, NJ, 1976.
3. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008. ASM Hand Book, vol. 7: Powder Metallurgy, ASM International.

SYLLABUS

ADDITIVE MANUFACTURING

Class		M. TECH	L	T	P	C
Semester/Year		I/I	3	-	-	3
Subject Name		Renewable Sources Of Energy				
Subject Code		MMEAM20S105				
Paper	English					
	Hindi					
Max. Marks		100				

Course Objectives:

1. To facilitate the students to achieve a clear conceptual understanding of technical and commercial aspects of Wind and Alternative Sources of Energy.
2. To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding Wind and Alternative Sources of Energy.

Course Outcomes:

CO1: Identify the renewable energy sources and their utilization.
CO2: Understand the basic concepts of the solar radiation and analyze the solar thermal systems for their utilization.
CO3: Understand the principle of working of solar cells and their modern manufacturing techniques .
CO4: Analyze wind energy conversion systems and their applications.
CO5: Design of solar thermal and energy storage systems for specific applications.

Unit	Syllabus	Periods
UNIT-I	**Introduction:** Overview of the course, Examination and Evaluation patterns. Classification of energy resources, energy scenario in the world and India **Basic sun-earth relationships:** Definitions. Celestial sphere, altitude-azimuth, declination- hour angle and declination-right ascension coordinate systems for finding the position of the sun, celestial triangle and coordinates of the sun. Greenwich Mean Time, Indian Standard Time, Local Solar Time, sun rise and sun set times & day length. Numerical problems.	10
UNIT-II	**Solar radiation:** Nature of solar radiation, solar radiation spectrum, solar constant, extra- terrestrial radiation on a horizontal surface, attenuation of solar radiation, beam, diffuse and global radiation. Measurement of global, diffuse and beam radiation. Prediction of solar radiation; Angstrom model, Page model, Hottel's model, Liu and Jordan model etc. Insulation on an inclined surface, angle of incidence, Illustrative problems.	10

UNIT-III	**Solar thermal systems:** Principle of working of solar water heating systems, solar cookers, solar desalination systems, solar ponds, solar chimney power plant, central power tower power plants etc. Classification of solar concentrators, Basic definitions such as concentration ratio, angle of acceptance etc., Tracking of the sun; description of different tracking modes of a solar collectors and the determination of angle of incidence of insolation in different tracking modes. Illustrative problems.	**11**
UNIT-IV	**Photovoltaic energy conversion:** Introduction. Single crystal silicon solar cell, i-v characteristics, effect of insulation and temperature on the performance of silicon cells. Different types of solar cells. Modern technological methods of producing these cells. Indian and world photovoltaic energy scenario**. Wind energy:** Origin of winds, nature of winds, wind data measurement, wind turbine types and their construction, **Fuel cells:** Introduction, applications, classification, different types of fuel cells such as phosphoric acid fuel cell, alkaline fuel cell, PEM fuel cell, MC fuel cell. Development and performance fuel cell.	**10**
UNIT-V	**Ocean energy: Ocean thermal energy;** open cycle & closed cycle OTEC plants, environmental impacts, challenges, present status of OTEC systems. Ocean tidal energy; Biomass: Introduction, photosynthesis, bio fuels, biomass resources, biomass conversion technologies, urban waste to energy conversion, biomass to ethanol conversion, biomass energy scenario in India, biogas production, constant pressure and constant volume biogas plants, operational parameters of the biogas	**10**

Text Books:

1. S. Rao and B. B. Parulekar, Energy Technology: Non-Conventional, Renewable and Conventional, Khanna Publishers, 2010.
2. S. P. Sukhatme and J. K. Nayak, Solar Energy - Principles of Thermal.

Reference Books:

1. B. H. Khan, Non conventional Energy Resources, Tata McGraw Hill, New Delhi, 2012.

SYLLABUS

ADDITIVE MANUFACTURING

Class		M. TECH	L	T	P	C
Semester/Year		I/I	3	-	-	3
Subject Name		Sustainable Manufacturing				
Subject Code		MMEAM20S106				
Paper	English					
	Hindi					
Max. Marks		100				

Course Objectives:

1. Ability to create an environment friendly, ergonomically designed, safe workplace within a sustainable manufacturing system by assuring the reliability of equipments and optimal usage of valuable energy resources.
2. To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding production techniques.

Course Outcomes:

CO1: Understand the concept of sustainable manufacturing relates to current technologies and manufacturing decisions.

CO2: Perform carbon footprint analysis and Life Cycle Assessment (LCA) specific to manufacturing systems and processes.

CO3: Develop Green Manufacturing process, Lean manufacturing and Green supply chain techniques.

CO4: Evaluate the economics and environmental impact of sustainable.
Manufacturing alternatives – Case studies.

CO5: Students will be able to apply the cloud concepts in a sustainable and global product development.

Unit	Syllabus	Periods
UNIT-I	**Introduction :** Concept of sustainability, manufacturing, operations, processes, practices, Resources in manufacturing, five Ms, system approach to manufacturing, Basic experimental design, factor identification, quantification, comparison, Motivations and Barriers to Green	10

	Manufacturing, Environmental Impact of Manufacturing, Strategies for Green Manufacturing. Metrics for Green Manufacturing, Metrics Development Methodologies.	
UNIT-II	**Management of waste & pollution:** Types, sources and nature of wastes, waste processing, green processing & engineering operations, Energy recovery, and 3 R & 6R principle. Types of pollution and management:-Anti pollution approaches & guide lines.	**10**
UNIT-III	**Environment friendly materials :** Materials for sustainability , eco-friendly and new age energy efficient and smart materials, alternative manufacturing practices , materials and selection of manufacturing processes, control on use of renewable materials , Bio- degradable materials recycling of materials.	**13**
UNIT-IV	**Sustainable Manufacturing Tools :** Principles of green manufacturing and its efficiency, Green manufacturing and sustainability, System model architecture and module, Design and planning, control or tools for green manufacturing (Qualitative Analysis), Consumption Analysis, Life Cycle Analysis, Efficiency, Sustainability tools). Standards for green manufacturing (ISO 14000 and OHSAS 18000), Waste stream mapping and application, Design for environment and for sustainability – Discuss the Product Life Cycle of manufactured goods.	**10**
UNIT-V	**Green manufacturing techniques:** Dry and near-dry machining, edible oil based cutting fluids Green manufacturing techniques: cryogenic machining for eco-efficiency Green manufacturing, Lean manufacturing, Lean techniques for green manufacturing Waste assessment and strategies for waste reduction in green manufacturing.	**10**

Text Books:

1. Montgomery Douglas, Design of Experiments, John Wiley and Sons, Inc. 2017.
2. Dornfeld, D.A. ed., Green manufacturing: fundamentals and applications. Springer Science & Business Media, 2012.

Reference Books:

1. Ashby, M. F. Materials and the environment: eco-informed material choice. Elsevier, 2012.
2. Klemes, J., 2011. Sustainability in the process industry. McGraw - Hill. 2011.
3. M. Karpagam, Geetha Jaikumar, Green Management ,Ane Books Pvt. Ltd. 2010.
4. M. K. Ghosh Roy, Design for Environment: A guide to sustainable Product Development Sustainable Development, Ane Books Pvt. Ltd, 2009.

SYLLABUS

ADDITIVE MANUFACTURING

Class		M. TECH	L	T	P	C
Semester/Year		I/I	3	-	-	3
Subject Name		Product Life Cycle Management				
Subject Code		MMEAM20S107				
Paper	English					
	Hindi					
Max. Marks		100				

Course Objectives:

1. Ability to create an environment friendly, ergonomically designed, safe workplace within a sustainable manufacturing system by assuring the reliability of equipments and optimal usage of valuable resources.
2. To enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding production techniques.

Course Outcomes:

CO1: Understand product data, information, structures and PLM concepts.

CO2: Apply PLM systems in organization verticals including production, after sales, sales and marketing, and subcontracting.

CO3: Measure benefits of PLM implementation in daily operations, material costs, productivity of labour and quality costs.

CO4: Apply PLM concepts for service industry and E-Business.

CO5: Recognize tools and standards in PLM.

Unit	Syllabus	Periods
UNIT-I	**Fundamentals of PLM:** Product data or Product information, Product lifecycle management concept, Information models and product structures-Information model, The product information (data) model, The product model, Reasons for the deployment of PLM systems.	10
UNIT-II	**Enterprise solution with PLM:** Use of product lifecycle management systems in different organization verticals, Product development and	10

	engineering, Impact of Manufacturing with PLMChallenges of product management in the engineering and manufacturing industry, Life cycle thinking, value added services and after sales, Case 1: Electronics manufacturer, Case 2: An engineering product.	
UNIT-III	**Product Structures:** Standardized product data and materials data model, Product structure of a ship, Product structure of a customizable product, Product structure of a configurable service product.PLM service information model: Categorizing services , Rational for building service products, How to make a service more like a tangible product?, Making items out of product functions, PLM challenges in service business, An IT-service provider and a customer-specifically variable product**.**	**12**
UNIT-IV	**PLM for e-manufacturing:** Electronic business and PLM, Preconditions for electric business from the viewpoint of the individual company, Significance of product management, collaboration and electronic business for the manufacturing industry.Integration of the PLM system with other applications: Different ways to integrate PLM systems, Transfer file, Database integration, System roles, ERP, Optimization of ERP for PLM and CAD..	**10**
UNIT-V	**Implementing end to end business process management:** Product lifecycle management as a business strategy tool, Product lifecycle management as an enabler of cooperation between companies, Contents of collaboration, Successful cooperation, Tools of collaboration, From changes in the business environment to product strategy, Business Benefits of PLM.PLM applications in process and product industries examples: Case 1: Electronics manufacturer, Case 2: An engineering product, Case 3: Capital goods manufacturer and customer-specifically variable product, Case 4: An IT-service provider and a customer- specifically variable product.	**12**

Text Books:

1. Jaya Krishna S, Product Lifecycle Management: Concepts and cases, ICFAI Publications 2011.
2. SOA approach to Enterprise Integration for Product Lifecycle, IBM Red books, 2011.

Reference Books:

1. Jaya Krishna S, Product Lifecycle Management: Concepts and cases, ICFAI Publications 2011.
2. SOA approach to Enterprise Integration for Product Lifecycle, IBM Red books, 2011.
3. M. Karpagam, Geetha Jaikumar, Green Management , Ane Books Pvt.Ltd. 2010.
4. M.K. Ghosh Roy, Design for Environment: A guide to sustainable Product Development sustainable Development, Ane Books Pvt. Ltd, 2009.

SYLLABUS

ADDITIVE MANUFACTURING

Class		M.TECH.	L	T	P	C
Semester/Year		II/I	3	-	-	3
Subject Name		RELIABILITY ENGINEERING				
Subject Code		MMEAM20S108				
Paper	English					
	Hindi					
Max. Marks		100				

Course Objectives:

By taking this course student will be able to:

1. Identify the steps involved in re-engineering of a given component.
2. Design and fabricate an existing component with suitable modifications as per customer's requirements.
3. Select and configure a suitable re-engineering system for inspection and manufacturing.
4. Apply the re-engineering techniques in aerospace, automobile and medical sectors.

Course Outcomes:

After this course student us able to:

CO1: Identify the steps involved in re-engineering of a given component.

CO2: Design and fabricate an existing component with suitable modifications as per customer's requirements.

CO3: Select and configure a suitable re-engineering system for inspection and manufacturing.

CO4: Apply the re-engineering techniques in aerospace, automobile and medical sectors.

Unit	Syllabus	Periods
UNIT-I	**Geometric Modelling using Point Cloud Data:** Point Cloud acquisition, Surface Modelling from a point clouds, Meshed or Faceted Models.	10
UNIT-II	**Methodologies and Techniques for Re-Engineering:** The Potential for Automation with 3- D Laser Scanners, What Is Not Re-Engineering.	12

UNIT-III	**Selecting a Re-Engineering System:** The Selection Process, Some Additional Complexities, Point Capture Devices, Triangulation Approaches, "Time-of-flight" or Ranging Systems, Structured-light and Stereoscopic Imaging Systems.	**11**
UNIT-IV	**Integration Between Re-Engineering and Additive Manufacturing:** Modeling Cloud Data in Re-Engineering, Data Processing for Rapid Prototyping.	**10**
UNIT-V	**Reliable Engineering in Automotive:** Legal Aspects of Re- Engineering: Copyright Law, to Adopting Re- Engineering. A discussion on a few benchmark case studies.	**12**

Text Books:

1. Reverse Engineering: An Industrial Perspective by Raja and Fernandes, Springer - Verlag 2008.

Reference Books:

1. Anupam Saxena, Birendra Sahay, "Computer Aided Engineering Design", Springer,2005.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M. TECH**	**L**	**T**	**P**	**C**
Semester/Year		**I/I**	**-**	**-**	**4**	**2**
Subject Name		**CAD/CAM Laboratory**				
Subject Code		**MMEAM20S109**				
Paper	**English**					
	Hindi					
Max. Marks		**50**				

Course Objectives:

1. Making the student understand how graphics created in computer world is the main goal of this course.
2. Using colors in different places and for different objects is also one of the goals of the course.
3. Learning how to rescale, transmit (shift), shear (skew), and rotate different graphical objects is another goal.
4. Animating some simple graphics is the last aim of the course.

Course Outcomes:

CO1: Model geometries of complex parts in sketcher mode.
CO2: Develop open source codes for analytical and synthetic curves.
CO3: Create complex engineering assemblies using appropriate assembly constraints.
CO4: Identify and correct the problems in STL files during modelling.
CO5: Estimate build-time and material consumption for a given model.

List of Experiments :

1. Introduction to Solid Modeling Packages
2. Working with sketch mode of Solid modeling Package.
3. Working with creating features (Extrude &Revolve)
4. Develop open source code for various analytical and synthetic curves.
5. Working with various editing tools in Solid Modelling.
6. Working with advanced modeling tools (Sweep, Blend & Swept Blend).
7. Assembly modeling using appropriate assembly constrains.
8. Working with CAD Data Exchange formats: IGES, ACIS, DXF STL,AMF.
9. Identification of STL file problems using MAGICS Software.
10. Application of repair algorithms to make the model error –free using MAGICS Software
11. Part orientation, support and Tool path generation in CURA Software.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M.TECH.**	**L**	**T**	**P**	**C**
Semester/Year		**I/I**	**-**	**-**	**4**	**2**
Subject Name		**Additive Manufacturing Laboratory– I Lab**				
Subject Code		**MMEAM20S110**				
Paper	**English**					
	Hindi					
Max. Marks		**50**				

Course Objectives:

To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology and the associated Aerospace, Architecture, Art, Medical and industrial applications.

Course Outcomes:

CO1: Develop STL file for CAD models with appropriate support structures and orientation.

CO2: Build complex engineering assemblies in plastic material with minimum build-time.

CO3: Evaluate the process parameters of AM machine to improve the quality of the parts produced.

CO4: Model and fabricate working models using AM processes.

LIST OF EXPERIMENTS

1. Introduction to Additive Manufacturing.
2. Generating STL files from the CAD Models & Working on STL files.
3. Modeling Creative Designs in CAD Software.
4. Processing the CAD data in Catalyst and CURA softwares.
5. Simulation in Catalyst Software for optimizing build-time and material consumption.
6. Sending the tool path data for fabricating the physical part on RP machine.
7. Removing the supports & post processing (cleaning the surfaces).
8. Evaluating the quality of the fabricated part in terms of surface finish and dimensional accuracy.
9. Evaluating the fabricated part for its suitability to a given application.

READING:

1. Lab Instruction Manual

SYLLABUS

ADDITIVE MANUFACTURING

Class		M.TECH.	L	T	P	C
Semester/Year		I/I	0	0	4	2
Subject Name		Research Methodology and IPR				
Subject Code		MMAT20S111				
Paper	English	English				
	Hindi					
Max. Marks		100				

Course objectives:

1. To explain the functions of the literature review in research and writing a review.
2. To explain various research designs and their characteristics. Methods of data collections.

Course Outcomes:

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

CO1: Understand research problem formulation.

CO2: Analyze research related information.

CO3: Follow research ethics.

CO4: Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

CO5: Understand when IPR would take such important place in growth of individuals & Nation, it is needless to emphasis the need of information about Intellectual Property Right to be Promoted among students in general & engineering in particular.

Unit	Syllabus	Periods
UNIT-I	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	8

UNIT-II	Effective literature studies approaches, analysis plagiarism, Research ethics.	**9**
UNIT-III	Effective technical writing, how to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	**11**
UNIT-IV	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	**13**
UNIT-V	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	**14**

Text books:

1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
3. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.

References books:

1. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
2. Mayall, "Industrial Design", McGraw Hill, 1992.
3. Niebel, "Product Design", McGraw Hill, 1974.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M.TECH.**	**L**	**T**	**P**	**C**
Semester/Year		**I/I**	**2**	**0**	**0**	**0**
Subject Name		**English for Research Paper Writing**				
Subject Code		**MMEAM20S112**				
Paper	**English**	**English**				
	Hindi					
Max. Marks		**00**				

Course objectives: Students will be able to:

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

Course Outcomes:

CO1: Understand that how to improve your writing skills and level of readability.

CO2: Learn about what to write in each section Understand the skills needed when writing a Title.

CO3: Ensure the good quality of paper at very first-time submission.

CO4: Being Concise and Removing Redundancy, Avoiding Ambiguity.

CO5: Discussion, skills are needed when writing the Conclusions.

Unit	Syllabus	Periods
Unit-I	Planning and Preparation, Word Order, breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.	**8**
Unit-II	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism.	
Unit-III	Sections of a Paper, Abstracts. Introduction. Review of the Literature, Methods, Results, Discussion, Conclusions, the Final Check.	

Unit-IV	Key skills needed when writing a Title, key skills needed when writing an Abstract, key skills needed when writing an Introduction, skills needed when writing a Review of the Literature, skills needed when writing the Methods, skills needed when writing the Results, skills needed when writing the Discussion, skills are needed when writing the Conclusions,	
Unit-V	Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.	

Text books:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books).
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press.

References books:

1. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SI AM. Highman's book publication.
2. Adrian Wall work, English for Writing Research Papers, Dordrecht Heidelberg London, 2011.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M.TECH.**	**L**	**T**	**P**	**C**
Semester/Year		**II/I**	**3**	**-**	**-**	**3**
Subject Name		**Materials, Energy Sources And Bonding Mechanisms**				
Subject Code		**MMEAM20S201**				
Paper	**English**					
	Hindi					
Max. Marks		**100**				

Course Objectives:

1. Making the student understand about material and bonding mechanism.
2. Making the student understand about use of material in additive manufacturing
3. To learn various techniques associated with materials

Course Outcomes:

Upon completion of the course, the students will be able to:

CO1: Understand the essential properties and characteristics of Laser, Electron and Plasma energy sources.

CO2: Explore the energy sources on their functionality for industrial and medical applications.

CO3: Analyze the influence of process parameters on the energy-materials interaction.

CO4: Explore and evaluate non-conventional energy sources for AM Applications.

Unit	Syllabus	Periods
UNIT-I	**Materials for AM:** Atomic Structure and Bonding, Nature of Polymers, Thermoplastics and Thermosetting Polymers, Types of Polymerizations, Properties of Polymers, Degradation of Polymers, Metal and Ceramic Powders, Compaction and Sintering of Powders, Composites, Functionally Graded Materials (FGM's).	**8**
UNIT-II	**Laser Beam:** Introduction, Electromagnetic Radiation, Energy Levels, Interaction of Radiation and Matter; Generation of Laser beam: Spontaneous and Stimulated Emission, Population Inversion, Resonant Cavity; Properties of Laser Light: Line Width, Beam Divergence Angle, Coherence, Radiance, Focusing	**9**

	Properties of Laser Radiation, and Power. Types Of Lasers, Laser Optics: Light Beam Deflectors, Q-Switches, Optical Isolators, Beam Profilers, Beam Homogenizers; Laser Beam Interaction with Various forms of Materials; other Applications.	
UNIT-III	**Laser Additive Manufacturing (AM):** Classification of Laser AM Processes and Metallurgical Mechanisms, Laser Sintering (LS), Laser Melting (LM), Laser Metal Deposition (LMD), Classes of Materials for AM and Processing Mechanisms, For LM and LMD—Pure Metals Powder, For LM and LMD—Alloys Powder, For LS and LMD—Multi-Component Metals/Alloys Powder Mixture, Metal Matrix Composites (MMCs), Material/Process Considerations and Control Methods, General Physical Aspects and Design Strategies of Materials for AM, Microstructural Properties of AM-Processed Parts, Mechanical Properties and Performance Aspects of AM-Processed Parts, Structure/Property Stability of AM- Processed Parts	**11**
UNIT-IV	**Electron Beam:** Introduction, Wave Properties, and Characteristics - Constructive Interference and Destructive Interference; Generation of Electron Beam: Free Electrons, Cathode, Anode, Control Electrode, Focusing Lens, Deflecting System, Beam Correction System, and Vacuum. Parameters: Accelerating Voltage, Power Density, Beam Current, Lens Current, Focal Position, Beam Speed, Beam Deflection; Process Related Effects: Liquid and Vapour Phases, Effect of Vacuum, Solidification, and Heat Affected Zone, Internal Thermal Stresses; Electron beam Interaction with different forms of Material; other Applications	**12**
UNIT-V	**Electron Beam Technology:** EBT in Additive Manufacturing- Powder Bed Fusion- Electron Beam Melting - Materials - Powder Metallurgy Requirements for EBM - Powder Manufacturing - Gas Atomization - Induction Plasma Atomization - Armstrong Process – Hydride - Dehydride - Characterization - Parameter Development - Build Setup and Process - Latest literature Plasma Arc: Introduction, Basic Properties, Characteristics, and Types; Plasma Production; Parameters; Plasma with Various Forms of Material Interaction; Applications	**12**

Text Books:

1. Patri K. Venuvinod and Weiyin Ma, Rapid Prototyping: Laser-based and Other Technologies, Springer, 2004.
2. Dong dong Gu, Laser Additive Manufacturing of High-Performance Materials, Springer, 2015.
3. K. Thyagarajan, Ajoy Ghatak, Lasers: Fundamentals and applications, 2nd Ed., Springer, 2010.
4. Ready, J.F, Industrial applications of Lasers, Academic Press, 2nd Ed., 1997.

Reference Books:

1. Willium T Selfvast, Laser Fundamentals, Cambridge Univ. Press, 2008.
2. William M. Steen, Laser Material Processing, Springe, 1991.
3. Schultz H., Electron Beam welding, Wood head Publishing, 1994.
4. Lieberman M.A. and Lichtenberg A. J., Principles of Plasma Discharge and Materials Processing, Wiley Interscience, 1994.
5. Li Yang · Keng Hsu · Brian Baughman Donald Godfrey · Francisco Medina Mambally kalathil Menon · Soeren Wiener, Additive Manufacturing of Metals: The Technology, Materials, Design and Production, Springer, 2017.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M.TECH.**	**L**	**T**	**P**	**C**
Semester/Year		**II/I**	**3**	**-**	**-**	**3**
Subject Name		**Rapid Tooling And Industrial Applications**				
Subject Code		**MMEAM20S202**				
Paper	**English**					
	Hindi					
Max. Marks		**100**				

Course Objectives:

1. Making the student understand about rapid tooling and their application.
2. Making the student understand about use of rapid tooling in additive manufacturing.
3. To learn various techniques associated with rapid tooling.

Course Outcomes:

CO1: Understand the working principle and process parameters of rapid tooling methods.
CO2: Identify the errors during development of tool and select the suitable compensatory methods.
CO3: Apply the suitable tooling method for the given industrial application.
CO4: Design and fabricate the tool for the given medical application.
CO5: Design and fabricate the tool for the given automobile application.

Unit	Syllabus	Periods
UNIT-I	**Introduction:** Conventional Tooling, Rapid Tooling, Differences between Conventional and Rapid Tooling, Classification of Rapid Tooling: Direct and Indirect Tooling methods; Soft, Bridge (firm) and Hard Tooling methods. Introduction to Bridge tooling, CAFÉ Bridge tooling, Direct AIM Rapid Bridge tooling, Rapid Tool Rapid Bridge tooling, Shrinkage Variation, Random-noise Shrinkage**.**	**10**
UNIT-II	**Rapid Tooling Process Modeling:** Introduction to modeling, Concurrent Rapid Product and Process Development, Finite Element Modeling and Simulation, Injection-moulding, Die- casting, Blow- moulding, Thermo-forming Processes modeling.	**9**

UNIT-III	**The Express Tool Process:** Introduction, High-Thermal-Conductivity Materials, Conformal Cooling Channels, The Express Tool Process, Finite-Element Analysis of Express Tools, Express Tool Process Characteristics, Case studies of Express Tools.	**11**
UNIT-IV	**Direct Soft Tooling/Firm Tooling Methods:** Role of direct soft tooling methods in tool production, SLS of Sand Casting & Copper PA Moulds, EOS Direct Croning Process, Direct AIM (Direct ACES TM Injection Moulds), SL Composite Tooling, 3DP^{TM} Ceramic Shells, Topographic Shape Formation (TSF) tools.	**10**
UNIT-V	**Indirect Soft Tooling/Firm Tooling Methods:** Role of indirect soft tooling methods in tool production, Metal Deposition Tools, Silicon rubber mould/RTV/Vacuum Casting, Epoxy tools,Spin casting with Vulcanized Rubber moulds, Castable Resin moulds, Castable Ceramic moulds, Plaster moulds, Casting (Investment/Die/Spin/Sand Castings).**Direct Hard Tooling Methods:** Role of Direct Hard tooling methods in tool production, EOS Direct Tool/ Direct Metal Laser Sintering, DTM RapidTool, LOM Tooling in Ceramic, Pro Metal Rapid Tooling, Laser Engineered Net Shaping (LENS).	**12**

Text Books:

1. D.T. Pham and S.S Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping & Rapid Tooling, Springer, 2001.
2. Peter Hilton and Paul F Jacobs, Rapid Tooling Technologies and Industrial Applications, Marcel Dekker Inc, New York, 2001.

Reference Books:

1. Willium T Selfvast, *Laser Fundamentals*, Cambridge Univ. Press, 2008.
2. Schultz H., Electron Beam welding, Wood head Publishing, 1994.
3. Wanlong Wang, Henry W. Stoll and James G. Conley, Rapid Tooling Guidelines for Sand Casting, Springer, 2010.
4. Andreas Gebhardt, Understanding Additive Manufacture: Rapid Prototyping, Rapid Tooling and Rapid Manufacture, Hanser Publishers, 2013.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M.TECH.**	**L**	**T**	**P**	**C**
Semester/Year		**II/I**	**3**	**-**	**-**	**3**
Subject Name		**Micro And Nano Manufacturing**				
Subject Code		**MMEAM20S203**				
Paper	**English**					
	Hindi					
Max. Marks		**100**				

Course Objectives:

1. To make student learn about synthesize and characterize nanomaterials for engineering applications.
2. To make student learn about Design and analyze methods and tools for micro and nano manufacturing.
3. To make student learn about improve the quality of MEMS by analysing the variables of the underlying micro and nano manufacturing method
4. To make student learn about Select appropriate industrially-viable process, equipment and tools fora specific product.

Course Outcomes:

At the end of the course, the student will be able to

CO1: Understand different techniques for the synthesis and Characterization of nano materials.

CO2: Design and analyze methods and tools for micro and nano-manufacturing.

CO3: Select micro and nano - manufacturing methods and identify key variables to improve quality of MEMS.

CO4: Choose appropriate industrially viable process, equipment and tools for a specific product.

Unit	Syllabus	Periods
UNIT-I	**Introduction**: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology, Scaling Laws/Sizing effects, Nano materials-safety precautions.	**10**
UNIT-II	**Nano-materials Synthesis and Processing:** Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical	**9**

	Synthesis of nano- materials- sol-gel process, Liquid solid reactions; Gas Phase synthesis of nano-materials- Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC)- Cold Plasma Methods, Laser ablation, Vapour – liquid–solid growth, particle precipitation aided CVD, summary of Gas Condensation Processing(GPC).	
UNIT-III	**Structural Characterization:** X-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM).	**11**
UNIT-IV	**Micro fabrication Techniques:** Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques, Bulk Micromachining, Surface Micromachining, High- Aspect-Ratio Micromachining.	**10**
UNIT-V	**Nanofabrication Techniques:** E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing. MEMS devices and applications: Pressure sensor, Inertial sensor, Optical MEMS and RF- MEMS, Micro-actuators for dual-stage servo systems.	**12**

Text Books:

1. Marc Madou, Fundamentals of Micro fabrication: The Science of Miniaturization, Second Edition CRC Press, 2002.
2. Mark James Jackson, Micro fabrication and Nano manufacturing, CRC Press, 2005.
3. Gabor L. Hornyak, H. F Tibbals, Joydeep Dutta & John J Moore, Introduction to Nano science and Nanotechnology, CRC Press, 2009.

Reference Books:

1. Ray F. Egerton, Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM, Springer, 2005.
2. Robert F Speyer, Thermal Analysis of Materials, Marcel Dekker Inc, New York, 1994.
3. B.D. Cullity -Elements of X-Ray Diffraction, 3rd edition, Prentice Hall, 2002.
4. Tai-Ran Hsu, “MEMS and Microsystems: Design and Manufacture,” McGraw- Hill, 2008.

SYLLABUS

ADDITIVE MANUFACTURING

Class		M.TECH.	L	T	P	C
Semester/Year		II/I	3	-	-	3
Subject Name		INDUSTRY 4.0 and IIoT				
Subject Code		MMEAM20S204				
Paper	English					
	Hindi					
Max. Marks		100				

Course Objectives:

This course introduces the concepts of Industrial Internet of Things, and Cloud Computing. The students are exposed to the architectures, and various frameworks in IIoT and Cloud Computing.

Course Outcomes:

CO1: Explore how Industry 4.0 will change the current manufacturing technologies and processes by digitizing the value chain.

CO2: Understand the drivers and enablers of Industry 4.0.

CO3: Learn about various IIoT - related protocols.

CO4: Build simple IoT Systems using Arduino and Raspberry Pi.

CO5: Implement a prototype of the IoT cloud system design.

Unit	Syllabus	Periods
UNIT-I	**Introduction to Industry 4.0:** Industry 4.0: Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories, Industry 4.0: Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis	10
UNIT-II	**Introduction to IIoT:** Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service (XaaS), Role of Cloud in	9

	IoT, Security aspects in IoT**.**	
UNIT-III	**Elements of IIoT:** Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.	**11**
UNIT-IV	**IIoT Application Development:** Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices.	**10**
UNIT-V	**Case Studies:**IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation.	**12**

Text Books:

1. Vijay Madisetti, ArshdeepBahga, Ïnternet of Things, "A Hands on Approach", University Press.
2. Dr. SRN Reddy, RachitThukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs.

Reference Books:

1. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press.
2. Adrian McEwen, "Designing the Internet of Things", Wiley.
3. Raj Kamal, "Internet of Things: Architecture and Design", Mc Graw Hill.

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ADDITIVE MANUFACTURING

Class		M.TECH.	L	T	P	C
Semester/Year		II/I	3	-	-	3
Subject Name		Additive Manufacturing For Medical Applications				
Subject Code		MMEAM20S205				
Paper	English					
	Hindi					
Max. Marks		100				

Course Objectives:

At the end of the course, the student will be able to

1. Able to apply the concepts of medical imaging and 3D scanning for accurate 3D model reconstruction.
2. Identify the errors during processing of medical image data and minimize them.
3. Select the suitable material for a given medical application Analyze and select an additive manufacturing technology for a given medical application.

Course Outcomes:

CO1: Apply the concepts of medical imaging and 3D scanning for accurate 3D model reconstruction.

CO2: Identify the errors during processing of medical image data and minimize them.

CO3: Select the suitable material for a given medical application.

CO4: Analyze and select an additive manufacturing technology for a given medical application.

CO5: Design and fabricate customized implant for the given medical application.

Unit	Syllabus	Periods
UNIT-I	**3-Dimensional Data Capture and Medical Scanning Technologies:** Introduction to medical imaging, Human Anatomy, X-Ray technology, Computed Tomography (CT), Basic Components of CT, Different Types of CT Scanners, Magnetic Resonance Imaging (MRI), Ultrasound imaging, 3-D laser scanners, Industrial CT Scanners, 3D reconstruction and Reverse Engineering (RE), Image Reconstruction Procedure, Digital Communication in Medicine (DICOM) format, Types of Artifacts.	10

UNIT-II	**Medical Image Processing Software Systems:** Processing of medical data from CT/MRI scan to 3D model in MIMICS, 3D-Doctor, Velocity2Pro, Vo Xim, Surgi Guide, SimPlant Software, MIMICS software modules, Importing data, thresholding, segmentation, Editing, region growing, volume reduction, 3D Visualization, surgical simulation, Meshing, Measurement tools, Smoothing tools, STL conversion , Morphological operations, Labelling, volume, RP file generation, Practice on Medical Modelling.	**12**
UNIT-III	**Biomaterials:** Introduction to Biomaterials, Metallic Biomaterials, Ceramic Biomaterials, Polymeric Biomaterials, Composite Biomaterials, Biodegradable Polymeric Biomaterials, Tissue-derived Biomaterials.	**11**
UNIT-IV	**Planning and Simulation of Complex Surgeries:** Cranioplasty of large cranial defect, Congential malformation of facial bones, Cosmetic facial reconstruction, Separation of conjoined twins, Tumor in the jaw, Cancerous brain, Dental precision planning and Spinal instrumentation.	**10**
UNIT-V	**Design and Fabrication of Customized Implants and Prosthesis**: Cranium implants, Hip implants, Knee implants, Intervertebral spacers, Buccopharyngeal stent, Tracheobronchial stents, Obturator prosthesis and Tissue engineering scaffolds. A discussion on few benchmark case studies.	**12**

Text Books:

1. Richard Bibb, Dominic Eggbeer and Abby Paterson, Medical Modelling: The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Wood head publishing, 2015.
2. Ian Gibson, Advanced Manufacturing Technology for Medical Applications, John Wiley, 2005.

Reference Books:

1. Chua Chee Kai and Yeong Wai Yee, Bio-Printing: Principles and Applications, World Scientific Publishing, 2015.
2. Paulo Bartolo and Bopaya Bidanda, Bio-materials and Prototyping Applications.

SYLLABUS

ADDITIVE MANUFACTURING

Class		M.TECH.	L	T	P	C
Semester/Year		II/I	3	-	-	3
Subject Name		INTEGRATED PRODUCT DESIGN				
Subject Code		MMEAM20S206				
Paper	English					
	Hindi					
Max. Marks		100				

Course Objectives:

This course will motivate students to:

1. Apply design strategies for the development of innovative products.
2. Develop physical models by applying the concepts of product design theory and robust design.

Course Outcomes:

CO1: Apply design strategies for the development of innovative products.

CO2: Develop physical models by applying the concepts of product design theory and robust design.

CO3: Apply embodiment principles in product development process.

CO4: Develop products by considering the social, environmental and ethical Concerns.

Unit	Syllabus	Periods
UNIT-I	**Introduction:** Modern Product Development and Design Theories: Understanding the opportunity, Develop a concept, Implement a concept, Reverse engineering and redesign methodology.	10
UNIT-II	**Product Design Process:** Need Identification, Kano diagram, Establishing Engineering Characteristics, Quality Function Deployment (QFD), Product Design Specification (PDS), Information Gathering for EDP.	12
UNIT-III	**Concept Generation:** Creative methods for design, Functional decomposition and synthesis, Morphological methods, Theory of Inventive Problem solving, Axiomatic Design (AD).	11

UNIT-IV	**Concept evaluation and decision making:** Decision Theory, Evaluation methods, Pugh's concept, weighted decision Matrix. Embodiment Design: Product Architecture, Configuration and Parametric design Concepts, Ergonomics and Design for Environment, and detailed design.	**10**
UNIT-V	**Ethical Issues and Team Management:** Ethical issues considered during Engineering design process, Product liability, Tort law, functioning, discharge, Team Dynamics and problem solving tools in design, Case studies.	**12**

Text Books:

1. George E Dieter, "Engineering Design" 3rd Ed., , McGraw Hill, 2001.
2. Kevin N. Otto, Kristin L. Wood, "Product Design", Pearson Education, 2004.
3. Gahl, W Beitz J Feldhusun, K. G. Grote, "Engineering Design", 3rd Edition, Springer, 2007.

Reference Books:

1. W. Ernest Eder, S. Hosendl., "Design Engineering", CRC Press, 2008.
2. Ali K. Kamrani and Emad Abouel Nasr, "Engineering Design and Rapid Prototyping", Springer, 2000.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M.TECH.**	**L**	**T**	**P**	**C**
Semester/Year		**II/I**	**3**	**-**	**-**	**3**
Subject Name		**ADVANCED METAL FORMING**				
Subject Code		**MMEAM20S207**				
Paper	**English**					
	Hindi					
Max. Marks		**100**				

Course Objectives:

1. To study the basic concepts of metal forming techniques and to develop force Calculation in metal forming process.
2. To study the thermo mechanical regimes and its requirements of metal Forming.

Course Outcomes:

CO1: Solve for strain rates, temperatures and metallurgical states in forming Problems.

CO2: Develop process maps for metal forming processes using plasticity Principles.

CO3: Estimate formability limits for sheets and bulk metals.

CO4: Evaluate workability of different ductile materials.

CO5: Apply FE principles to simulate metal forming processes.

Unit	Syllabus	Periods
UNIT-I	**Introduction Metal forming as a manufacturing process and its relation with other processes-** Classification based on type of stresses - Examples.Theoretical analysis (theory of plasticity), Stress-strain relationship, Strain hardening, Material incompressibility, Work of plastic deformation, Work hardening, Yield criteria, Flow rule, Yield criterion and flow rule for Anisotropic material, Initiation and extent of plastic flow- Problems.	**10**
UNIT-II	**Overview of various metal forming operations:** Mechanics of Various Plastic Flow Problems Introduction to; (i). Theory of slip lines, Upper bound theorem, Lower bound theorem. Forging processes: Metal flow in forging, Analysis of plane strain compression, Analysis of compression of circular disc with slab method.	**12**

UNIT-III	**Extrusion Processes:** Calculation of extrusion load using slab method, slip line method and upper bound method. Defects in extrusion. Direct & indirect extrusion. **Wire Drawing Processes**: Introduction, wire drawing load calculation using slab method. **Rolling Processes:** Analysis of longitudinal strip or sheet rolling process (calculation of roll separating force, torque & power, angle of bite, maximum reduction in rolling), rolling defects.	**11**
UNIT-IV	**Sheet forming: Mechanics –** Flow Rules – Anisotropy - Formability of sheet, Formability tests, forming limit diagrams, Case studies. Pressing and Sintering: Workability Studies – Densification - Problems & Case Studies Incremental Forming: Statics and Kinematics of Incremental Stresses and Strains - The Kinematics of Two-Dimensional Strain, The Kinematics of Three-Dimensional Strain, Incremental Stresses in Two Dimensions, Incremental Stresses in Three Dimensions, Equilibrium Equations for the Stress Field in Two Dimensions, Equilibrium Equations for the Stress Field in Three Dimensions.	**10**
UNIT-V	**Modeling and Simulation in Metal Forming:** Plasticity and Viscoelasticity – Constitutive relations - The Plane Strain Compression Test, FEM Model and Input Data to the Model - Deformations in the Compression Gap - Effective Strain and Strain-Rate Distributions in Deformed Zones - Damage Parameter and Edge Cracking.	**12**

Text Books:

1. Surender Kumar, Technology of Metal Forming Processes, Prentice - Hall, Inc.,2008.
2. Henry S. Valberg, Applied Metal Forming - Including FEM Analysis, Cambridge University Press, 2010.

Reference Books:

1. Metal Forming: Mechanics and Metallurgy by William F. Hosford and Robert M. Caddell, Prentice-Hall (USA) , 2012.
2. Slater. R A. C. Engineering Plasticity – Theory & Applications to Metal Forming, John Wiley and Sons,1987.

SYLLABUS

ADDITIVE MANUFACTURING

Class		M.TECH.	L	T	P	C
Semester/Year		II/I	3	-	-	3
Subject Name		RE- ENGINEERING				
Subject Code		MMEAM20S208				
Paper	English					
	Hindi					
Max. Marks		100				

Course Objectives:

By taking this course student will be able to

1. Identify the steps involved in re-engineering of a given component.
2. Design and fabricate an existing component with suitable modifications as per customer's requirements.
3. Select and configure a suitable re-engineering system for inspection and manufacturing.
4. Apply the re-engineering techniques in aerospace, automobile and medical sectors.

Course Outcomes:

After this course student us able to:

CO1: Identify the steps involved in re-engineering of a given component.

CO2: Design and fabricate an existing component with suitable modifications as per customer's requirements.

CO3: Select and configure a suitable re-engineering system for inspection and manufacturing.

CO4 Apply the re-engineering techniques in aerospace, automobile and medical sectors.

Unit	Syllabus	Periods
UNIT-I	**Geometric Modelling using Point Cloud Data:** Point Cloud acquisition, Surface Modelling from a point clouds, Meshed or Faceted Models, Planar Contour Models, Points to Contour Models, Surface Models, Segmentation and Surface Fitting for Prismatic objects and Free Form Shapes.	10
UNIT-II	**Methodologies and Techniques for Re-Engineering:** The Potential for	12

	Automation with 3- D Laser Scanners, What Is Not Re-Engineering, What is Computer-aided (Forward) Engineering, What Is Computer-aided Reverse Engineering, Computer Vision and Re- Engineering	
UNIT-III	**Selecting a Re-Engineering System:** The Selection Process, Some Additional Complexities, Point Capture Devices, Triangulation Approaches, "Time-of-flight" or Ranging Systems, Structured-light and Stereoscopic Imaging Systems, issues with Light-based Approaches, Tracking Systems, Internal Measurement Systems, X-ray Tomography, Destructive Systems, Some Comments on Accuracy, Positioning the Probe, Post processing the Captured Data, Handling Data Points, Curve and Surface Creation, Inspection Applications, Manufacturing Approaches.	**11**
UNIT-IV	**Integration Between Re-Engineering and Additive Manufacturing:** Modeling Cloud Data in Re-Engineering, Data Processing for Rapid Prototyping, Integration of RE and RP for Layer-based Model Generation, Adaptive Slicing Approach for Cloud Data Modeling, Planar Polygon Curve Construction for a Layer, Determination of Adaptive Layer Thickness.	**10**
UNIT-V	**Re-Engineering in Automotive, Aerospace, Medical sectors**: Legal Aspects of Re- Engineering: Copyright Law, Re-Engineering, Recent Case Law, Barriers to Adopting Re- Engineering. A discussion on a few benchmark case studies.	**12**

Text Books:

1. Otto and K. Wood, Product Design: Techniques in Reverse Engineering and New Product Development, Prentice Hall, 2001.
2. Reverse Engineering: An Industrial Perspective by Raja and Fernandes, Springer-Verlag 2008.

Reference Books:

1. AnupamSaxena, Birendra Sahay, "Computer Aided Engineering Design", Springer, 2005.
2. Ali K. Kamrani and Emad Abouel Nasr, "Engineering Design and Rapid Prototyping", Springer,2010.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M.TECH.**	**L**	**T**	**P**	**C**
Semester/Year		**II/I**	**-**	**-**	**4**	**2**
Subject Name		**Additive Manufacturing Laboratory – II**				
Subject Code		**MMEAM20S209**				
Paper	**English**					
	Hindi					
Max. Marks		**50**				

Course Objectives:

1. Review of product design, CAD, basic principles and development of additive manufacturing.
2. Explain the various processes of additive manufacturing.
3. Design for additive manufacturing.
4. Process selection and software issues.
5. Direct digital manufacturing and medical application.

Course Outcomes:

CO1: Model complex geometry of engineering components.

CO2: Make use of point cloud data to reconstruct industrial and medical Components.

CO3: Evaluate the process parameters of SLM and LENS metal AM machines to improve the qualityof the parts produced.

CO4: Improve surface finish of fabricated components by post- processing techniques.

CO5: Construct low cost desktop 3D Printer and test for performance.

List of Experiments:

1. Modeling of Metal Parts in CAD Software.
2. Body/head scanning using Sense 3DScanner.
3. Object Scanning using Ein Scan 3DScanner.
4. Slicing of corrected STL files in SLM RP Tools Software.
5. Process Parameters (laser power, scan speed, hatch width, hatch space, etc.,) Optimization in PSW Software for fabrication on SLM RP Machine.
6. Laser path generation in DMDCAM Software for fabrication on LENS Machine.
7. Laser path generation in UG CAM Software for fabrication on Micro stereo lithography (MSL) RP machine.
8. Fabrication of Metal parts on SLM RP Machine.
9. Fabrication of Metal parts on LENS RP Machine.
10. Building and testing a low cost desktop 3D printer.
11. Post-processing of Fabricated metal parts by Wire EDM.
12. Post-processing of Fabricated metal parts by Shot-peening, polishing, etc., to prove the surface quality of the produced parts.

Text Books:

1. . Lab Instruction Manual.

SYLLABUS

ADDITIVE MANUFACTURING

Class		M.TECH.	L	T	P	C
Semester/Year		II/I	-	-	4	2
Subject Name		MATERIALS AND PART CHARACTERIZATION LABORATORY				
Subject Code		MMEAM20S210				
Paper	English					
	Hindi					
Max. Marks		50				

Course Objectives:

After this course student will be able to

1. Analyze the microstructure in cast, welded and formed components.
2. Analyze the mechanical properties of components produced by AM process.
3. Interpret the defective analysis and correlate it to the mechanical properties.
4. Analyze surface roughness characteristics of AM parts by image analysis.

Course Outcomes:

After this course student is able to

CO1: Analyze the microstructure in cast, welded and formed components.

CO2: Analyze the mechanical properties of components produced by AM process.

CO3: Interpret the defective analysis and correlate it to the mechanical properties.

CO4: Analyze surface roughness characteristics of AM parts by image analysis.

LIST OF EXPERIMENT

1. Modeling of Metal Parts in CAD Software.
2. Body/head scanning using Sense 3D Scanner.
3. Object Scanning using Ein Scan 3DScanner
4. Slicing of corrected STL files in SLM RP Tools Software
5. Process Parameters (laser power, scan speed, hatch width, hatch space, etc.,) Optimization in PSW Software for fabrication on SLM RP Machine.
6. Laser path generation in DMDCAM Software for fabrication on LENS Machine.
7. Laser path generation in UG CAM Software for fabrication on Micro stereo lithography (MSL) RP machine.
8. Fabrication of Metal parts on SLM RP Machine.
9. Fabrication of Metal parts on LENS RP Machine.
10. Building and testing a low-cost desktop 3D printer.
11. Post-processing of Fabricated metal parts by Wire EDM.
12. Post-processing of Fabricated metal parts by Shot-peening, polishing, etc., to improve the surface quality of the produced parts.

Text Books:

1. Lab Instruction Manual.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M.TECH.**	**L**	**T**	**P**	**C**
Semester/Year		**II/I**	**0**	**0**	**4**	**2**
Subject Name		**Mini Project**				
Subject Code		**MMEAM20S211**				
Paper	**English**	**English**				
	Hindi					
Max. Marks		**50**				

Course Objective:

1. The aim of the mini project is that the student has to understand the structural engineering problems

2. The student should gain a thorough knowledge in the problem, he/she has selected and to analyze complex structural systems.

Course Outcomes: At the end of the Subject, the student will be able to:

CO1: Identify structural engineering problems reviewing available literature.

CO2: Study different techniques used to analyze complex structural systems.

CO3: Work on the solutions given and present solution by using his/her technique applying engineering principles.

Contents

1. Mini Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available.
2. End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals ‘contribution.
3. Continuous assessment of Mini Project at Mid Sem and End-Sem will be monitored by the departmental committee.

SYLLABUS

ADDITIVE MANUFACTURING

Class		**M.TECH.**	**L**	**T**	**P**	**C**
Semester/Year		**II/I**	**2**	**0**	**0**	**0**
Subject Name		**Stress Management by Yoga**				
Subject Code		**MMEAM20S212**				
Paper	**English**	**English**				
	Hindi					
Max. Marks		**00**				

Syllabus
1. Definitions of Eight parts of yog. (Ashtanga). 2. Yam and Niyam. Do`s and Don’ts’s in life. 3. Ahinsa, satya, astheya, bramhacharya and aparigraha, Shaucha, santosh, tapa, swadhyay, ishwarpranidhan. 4. Asan and Pranayam. 5. Various yog poses and their benefits for mind &body, Regularization of breathing techniques and its effects-Types of pranayam
Suggested reading: 1. ‘Yogic Asanas for Group Training - Part I”:JanardanSwamiYogabhyasiMandal,Nagpur 2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata.