Master of Technology Program in Mechanical Engineering

July 2015

Indian Institute of Technology Jodhpur

Master of Technology (M.Tech.) Program in Mechanical Engineering

Tentative Curriculum (Changes may occur in the second semester)

Cat.	*Course Number, Course Title*		*L-T-P*	*Credits*		*Cat.*	*Course Number, Course Title*		*L-T-P*	*Credits*
I Semester						**II Semester**				
C	ME616	Mechanical Metallurgy	3-0-3	4		C	ME623	*Experimental Techniques*	3-0-3	4
C	ME617	*Thermal Energy Conversion*	3-0-3	4		C	ME624	Engineering Optimization	3-0-3	4
C	ME618	Numerical Methods in Mechanics	3-0-0	3		C	*ME625*	Lean Manufacturing	3-0-0	3
C	ME619	Multibody Dynamic Systems	3-0-0	3		E		*Elective 2*	3-0-0	3
E		*Elective 1*	3-0-0	3		E		*Elective 3*	3-0-0	3
			Total	**17**					***Total***	**17**
III Semester						**IV Semester**				
TH	ME698	Thesis		15		TH	ME699	Thesis		15
			Total	**15**					***Total***	**15**

Electives

ME653	*Solar Thermal Design*	3-0-0	3
ME654	*Solar Refrigeration and Air conditioning*	3-0-0	3
ME665	Continuum Mechanics	3-0-0	3
ME655	*Numerical Analysis of Heat and Fluid Flow*	3-0-0	3
ME657	*Manufacturing of Plastics, Ceramics and Composites*	3-0-0	3
ME658	*Dynamics of Vibration*	3-0-0	3
ME659	*Structural Mechanics*	3-0-0	3
ME661	*Water Energy Nexus*	3-0-0	3
ME660	*Finite Element Analysis*	3-0-0	3
ME663	Design of Agricultural Implements	3-0-0	3
ME751	Advanced Fluid Mechanics	3-0-0	3
ME752	Theory of Arc Welding Processes	3-0-0	3
ME753	Vibration in Mechanical Systems	3-0-0	3
ME754	Failure Analysis	3-0-0	3
ME755	Computer Aided Manufacturing	3-0-3	4
ME756	Boundary Layer Theory	3-0-0	3
ME757	Metallurgy of Joining Processes	3-0-0	3
ME758	Vibration in Agricultural Implements	3-0-0	3
ME759	Rotor Dynamics	3-0-0	3
ME760	Quality Control of Weldments	3-0-0	3
ME761	Renewable Energy Sources	3-0-0	3

Course Title	**Mechanical Metallurgy**	Course No.	**ME616**
Department	Mechanical Engineering	Structure (L-T-P-C)	3 0 3 4
Offered for	M. Tech. Students	Status	Compulsory
Pre-requisite	*None*	To take effect from	

Objectives

To impart Mechanical Metallurgy concepts and their applications in mechanics and manufacturing

Learning Outcomes

1. Understanding of the basic concepts of Mechanical Metallurgy with emphasis on micromechanics of deformation and structure of solids.
2. imparting knowledge in two areas of material mechanical behavior: Elastic and plastic deformation.

Course Content

1. *Review:* Tensile Response of Materials, Effect of Temperature on Flow Properties Stress State (2D)
2. Stress Tensor, Stress State (3D), Description of Strain, Elasticity; Advanced Treatment Plasticity (Yield Criteria for Ductile Metals)
3. Plastic deformation, Dislocation Theory, Strengthening Mechanisms, Metalworking, Creep, Metal forming, casting and allied manufacturing processes
4. Basic fracture mechanics, ductile-brittle transition, Toughness, microstructure anisotropy, Optimizing microstructures for toughness Environmental assisted cracking (EAC) Variables affecting EAC, Introduction to Fatigue, Wear, Corrosion.

Textbook

1. Dieter, G. E., (1986), *Mechanical Metallurgy*, 3rd Edition, McGraw Hill Book Company

Suggested References

1. Courtney, T. H., (1990), *Mechanical Behavior of Materials*, McGraw Hill Book Company
2. Meyers, M. A. and Chawla, K. K., (1984), *Mechanical Metallurgy, Principles and Applications*, Prentice-Hall, Inc.
1. Hertzberg, R. W., (1993), *Deformation and Fracture Mechanics of Engineering Materials*, 2nd Edition, John Wiley and Sons
3. McClintock, F. A. and Argon, A. S., (1966), *Mechanical Behavior of Materi*als, Addison-Wesley
4. Honeycombe, R. W. K., (1984), *The Plastic Deformation of Metals*, 2nd Edition, Edward Arnold (Publ.) Ltd.
5. Smith, W. F., (1990), *Materials Science and Engineering*, McGraw Hill Book Company
6. Callister, W. D., (1994), *Materials Science and Engineering*, 3rd Edition, John Wiley & Sons

Online Course Material

1. Course Materials from NPTEL: http://nptel.ac.in/courses/113106032/

Course Title	***Thermal Energy Conversion***	Course No.	**ME617**
Focus Group	Mechanical Engineering	Structure	3 0 3 4
Offered for	M. Tech. Students	Status (L-T-P-C)	*Compulsory*
Pre-requisite	*Consent of Teacher*	To take effect from	

Objectives

To introduce fundamental topics and technologies related to the conversion of natural energy resources into steam for electrical power generation and value added applications

Learning Outcomes

1. Understanding the basic concepts of energy systems
2. Analysis of a thermal system using detailed and empirical approach
3. Introduction to power plant components and engineering

Course Content

1. *Overview:* Introduction to coal, gas, nuclear, concentrated solar, and wind power generation
2. *Principles:* Thermodynamic cycles for refrigeration, thermal and gas based power generation. Convective heat transfer based on differential analysis and correlations, boiling heat transfer, radiation heat transfer, combined heat transfer, flow through porous medium, heat exchange systems. Basic concepts of aerodynamics, introduction to turbo machinery
3. *Applications:* Design and operation of power plant equipments: steam generators, condensers, receivers, wind turbine rotors
4. *Introduction to cogeneration:* Energy savings and reduction of CO_2 emissions. Technologies for carbon capture and sequestration

Reference Books

1. Cenge, l Y. A., and Ghajar, A. J., (2011), *Heat and Mass Transfer*, 4th Edition, McGraw Hill
2. Incropera, F. P., and Dewitt D. P., (2006), *Fundamentals of Heat and Mass Transfer*, 6th Edition, John Wiley
3. White, F. M., (2009), *Fluid Mechanics*, 7th Edition, McGraw-Hill
4. Fox, R. W., and McDonald, A. T., (2011), *Introduction to Fluid Mechanics*, 7th Edition, Wiley
5. El-Wakil, M. M., (1985), *Power Plant Engineering*, McGraw –Hill
6. Duffie J. A., and Beckman W. A., (2006), *Solar Engineering of Thermal Processes*, 3rd Edition, John Wiley & Sons
7. Borel , L., and Favrat, D., (2010), *Thermodynamics and Energy Systems Analysis: From Energy to Exergy* (Engineering Sciences-Mechanical Engineering), EPFL Press
8. El-Wakil, M. M., (1985), *Power Plant Engineering*, McGraw Hill

Online Course Material

1. Course Materials from NPTEL: http://nptel.ac.in/courses/108105058/15

Course Title	***Numerical Methods in Mechanics***	Course No.	**ME618**
Focus Group	Mechanical Engineering	Structure(L-P-T-C)	3 0 0 3
Offered for	M. Tech. Students	Status	*Compulsory*
Pre-requisite	*Consent of Teacher*	To take effect from	

Objectives

To introduce fundamental topics in numerical analysis and their application to differential equations arising in solid and fluid mechanics

Learning Outcomes

1. Understanding the basic concepts of error analysis in computational schemes
2. Acquire knowledge of numerical integration/differentiation schemes
3. Application of numerical techniques introduced to problems in solid and fluid mechanics

Course Content

1. Basic concepts in mechanics, Eulerian and Lagrangian approaches, formulation of governing equations and their solution methodologies
2. Computer Arithmetic, computational errors: (i) Round off, overflow / underflow, Catastrophic cancellation (ii) Concept of norms, condition numbers, iterations and convergence, (iii) Basic programming
3. Linear systems: (i) systems of linear equations, (ii) matrix eigenvalue, (iii) Non Linear systems
4. Polynomial Approximation
5. Numerical Integration/Differentiation
6. Numerical methods of ODEs / PDEs: (i) Classification of Differential equations and examples from solid and fluid mechanics (ii) Explicit and Implicit schemes (iii) Concept of convergence, consistency and stability

Text and Reference Books

1. Flannery *et al*., (2003), *Numerical Recipes in C*, 2nd Edition, Cambridge University Press
2. Anderson, J, D., (1995), *Computational Fluid Dynamics*, McGraw-Hill
3. Fung, Y. C., (1993), *First Course in Continuum Mechanics*, Prentice Hall

Online Course Material

1. http://nptel.ac.in/courses/111101003/

Course Title	**Multibody Dynamic Systems**	Course No.	**ME619**
Focus Group	Mechanical Engineering	Structure (L-P-T-C)	3 0 0 3
Offered for	M. Tech. Students	Status	*Compulsory*
Pre-requisite	*Consent of Teacher*	To take effect from	

Objectives

To understand various abstractions in dynamics of rigid bodies to model real life problems in mechanisms, robotics and vehicles

Learning Outcomes

1. Understanding the basic concepts of classical rigid body dynamics and robotics
2. Formulation of equations of motion and their solution
3. Applications in the area of robotics and mechanisms and vehicles

Course Content

1. Multibody systems, reference frames, constrained motion, kinematics, Euler angles, Denavit-Hartenberg notation, Relationship among various conventions
2. Analytical techniques, generailized co-ordinates, generalized forces, , Lagrangian dynamics, calculus of variations, Newton-Euler equations, mechanics of deformable bodies, formulation of equation of motion for multibody systems with deformable components, compliant mechanisms
3. Finite element method, variational formulation, discretization procedures, element shape functions, formulation of mass, stiffness matrices and their assembly for various boundary conditions and solution methodologies.

Text and Reference Books

1. Shabana., A. A., (2013), *Dynamics of Multibody Systems,* Cambridge University Press, 4th Edition
2. *Reddy., J.* N., (2005), *An Introduction to the Finite Element Method, Tata McGraw Hill, 3rd Edition*

Online Course Material

1. http://real.uwaterloo.ca/~mbody/

Course Title	**Experimental Techniques**	Course No.	**ME623**
Focus Group	Mechanical Engineering	Structure (L-P-T-C)	3 0 3 4
Offered for	M. Tech. Students	Status	*Compulsory*
Pre-requisite	*Consent of Teacher*	To take effect from	

Objectives

To introduce various sensors to measure mechanical properties and to monitor mechanical systems

Learning Outcomes

1. Basic concepts of sensing and transduction
2. Develop familiarity with data acquisition systems
3. Ability to measure relevant parameters needed to monitor mechanical systems

Course Content

1. *Overview:* Basic concepts of sensing, classification, generalized configurations and functional descriptions of measuring instruments, active and passive transducers, analog and digital modes of operation, null and deflection methods, input-output models of various sensing elements.
2. *Performance characteristics:* Static characteristics, static calibration, dynamic characteristics and dynamic performance measures, time domain and frequency domain methods, stability and drift of the sensors and their compensation techniques
3. *Sensors:* Thermocouples, strain gages, load cells, accelerometers, gas and air quality sensors, pyranometer and pyrheliometer, dynamometer and sensors in smart phones
4. *Data acquisition systems:* Acquiring sensor data, processing and interpretation in lab view/matlab and other interfaces, user interfaces and uncertainty in measurement
5. *Experiments:* Applications in three stream of mechanical engineering: (i) Manufacturing (ii) Solid mechanics and Design (iii) Thermal sciences

Text and Reference Books

1. Holman, J. P., (2007), *Experimental Methods for Engineers*, 7th Edition, McGraw Hill Education India
2. Beckwith, T. G., Marangoni, R. D., and Lienhard, J. H., (2006), *Mechanical Measurements*, 6th Edition, Prentice Hall
3. Northrop, R. B., (2004), *Introduction to Instrumentation and Measurements*, 3rd Edition, CRC Press
4. Doebelin, E. O., and Manik, D. N., (2012), *Measurement Systems*, 6th Edition, McGraw Hill

Online Course Material

1. http://nptel.ac.in/courses/112106140/
2. http://nptel.iitg.ernet.in/Mech_Engg/IIT%20Madras/Mechanical%20Measurements%20and%20Metrology.htm

Course Title	**Engineering Optimization**	Course No.	**ME624**
Focus Group	Mechanical Engineering	Structure (L-P-T-C)	3 0 3 4
Offered for	M. Tech. Students	Status	*Compulsory*
Pre-requisite	*Consent of Teacher*	To take effect from	

Objectives

To understand the multi-objective nature of engineering design problems and to be able to apply classical and modern techniques to solve them.

Learning Outcomes

1. Understanding the basic concepts of classical optimization
2. Analysis of optimization algorithms
3. Applications of optimization in Mechanical engineering

Course Content

1. *Introduction to classical optimization techniques:* Single variable optimization, Jacobian, multivariable optimization, Hessian, convexity, Lagrange multipliers, steepest descent and conjugate gradient methods
2. *Linear and Non-linear programming:* Simplex method, duality and sensitivity analysis, KKT conditions
3. *Modern techniques:* Travelling salesmen problem, dynamic programming, simulated annealing
4. Case studies and projects on selected applications in mechanical engineering

Text and Reference Books

1. Rao, S. S., (2010), *Engineering Optimization: Theory and Practice, New Age International Publishers*
2. Kalyanmoy, D., (2012), *Optimization for Engineering Design*, 2nd Edition, Prentice Hall of India

Online Course Material

1. http://nptel.ac.in/courses/106108056/

Course Title	***Lean Manufacturing***	Course No.	**ME625**
Focus Group	Mechanical Engineering	Structure (L-P-T-C)	3 0 0 3
Offered for	M. Tech. Students	Status	*Elective*
Pre-requisite	*None*	To take effect from	

Objectives

To impart knowledge to the students in the area of Sustainable manufacturing as a methodology for manufacturing with energy efficiency that minimizes waste and pollution

Learning Outcomes

1. Understanding of the basic concepts of Sustainable Manufacturing
2. To enable understanding and effective application of sustainable design of products and processes
3. Facilitate understanding and familiarity of the environmentally conscious manufacturing processes, remanufacturing, rapid manufacturing technologies

Course Content

1. Environmentally-conscious manufacturing, environmental analysis of manufacturing processes and products, sustainable design of products and processes for prevention pollution, remanufacturing, products and recycling systems, rapid manufacturing technologies.
2. Material resources analysis, including not only the materials used in the delivery of products and services, but also the effects on major material cycles such as carbon, water, and nitrogen.
3. Life cycle assessment of products and services, including variations on the method such as input-output models, hybrid models, and exergy methods that can incorporate ecosystem services. Energy/exergy flows in materials processing and manufacturing
4. Design for sustainability accounting for the role of ecosystem services in supporting industrial activities, and an assessment of alternative sustainability solution approaches

References

1. Ashby, M. F., (2013), *Materials and the Environment*, 2nd Edition, Butterworth-Heinemann
2. Allwood, J. M., and Cullen, J. M., (2012), *Sustainable Materials – With Both Eyes Open*, UIT Cambridge Ltd.
3. Bakshi , B. R., Gutowski, T. G., and Sekulic, D. P., (2011), *Thermodynamics and the Destruction of Resources*, Cambridge University Press
4. Dornfeld, D. A., (2012), *Green Manufacturing Fundamentals and Applications*, Springer
5. Davim, J. P., (2013), *Green Manufacturing Processes and Systems*, Springer

Online Course Material

1. http://nptel.ac.in/courses/index.php?subjectId=110105039

Course Title	**Continuum Mechanics**	Course No.	**ME 664**
Focus Group	Mechanical Engineering	Structure (L-P-T-C)	3 0 0 3
Offered for	M. Tech. Students	Status	*Elective*
Pre-requisite	*Consent of Teacher*	To take effect from	

Objectives

1. To introduce unified concepts of solid and fluid mechanics
2. To develop suitable mathematical abstractions of deformable bodies and fluids
3. To provide solutions to mechanical engineering problems modeled using continuum mechanics

Learning Outcomes

1. Understanding mathematical foundations of continuum mechanics
2. An appreciation of constitutive equations of relevance in mechanical engineering
3. Ability to solve partial differential equations of continuum mechanics

Course Content

1. The concept of continuum, Eulerian and Lagrangian frameworks, Cauchy stress tensor, strain tensor, Invariants of the stress tensor, deviatoric component and hydrostatic component, equations of equilibrium, Continuum thermodynamics, constitutive equations, theories of failure, Classical boundary value problems
2. Approximate solutions: Reduction to the engineering theories: Mass transfer theory, Heat transfer theory, Fluid mechanics theory, Elasticity theory with examples and an appreciation of multi-scale approach to modelling.

Text and Reference Books

1. Fung, Y. C., (1993), *First Course in Continuum Mechanics*, Prentice Hall
2. Tadmor, E. B., Miller, R. E., and Elliot, R. S., (2011), *Continuum Mechanics and Thermodynamics*, Cambridge University Press
3. Tadmor E. B., and Miller, R. E., (2011), *Modeling Materials: Continuum, Atomistic and Multi-scale Techniques*, Cambridge University Press
4. Landau and Lifschitz, (1986), *Theory of Elasticity*, Pergamon Press

Online Course Material

1. http://nptel.ac.in/syllabus/112103167/

Course Title	**Computer Aided Manufacturing**	Course No.	**ME 762**
Focus Group	Mechanical Engineering	Structure (L-P-T-C)	3 0 3 4
Offered for	Ph. D. Students	Status	Elective
Pre-requisite	*Consent of Teacher*	To take effect from	*July 2015*

Objectives

To introduce the concepts of computer controlled machines and their usefulness in manufacturing

Learning Outcomes

1. Understanding fundamentals of CNC machine programming and its construction
2. Establishing the importance of CAD/CAM integration in manufacturing industry
3. Appreciating the concept of automated process planning and automated assembly operations

Course Contents

1. *Introduction:* Introduction to Automation, Numerical Control (NC) Technology, Computer Numerical Control (CNC), Direct and Distributed Numerical Control (DNC), Importance of CNC machines in Flexible Manufacturing Systems (FMS) and Computer Integrated Manufacturing Systems (CIMS)
2. *CNC Hardware:* Components of CNC system, Classification of CNC machines, Axes Designation, CNC Hardware elements including drives, actuators, sensors, controllers and machine tool elements, CNC interpolators, Tooling and work-holding devices for CNC machines, Fixture design for CNC machine tools, Automatic tool changers and automatic pallet changers
3. *CNC Programming:* Axes designation in CNC machines, Fundamentals part programming, Programming formats, Programming for CNC Lathes and Milling machines, Use of advanced programming features such as subroutines, canned cycles, Automated Programmed Tools, Compensation in CNC machine tools,
4. *Computational Geometry for Manufacturing:* Representation of Curves, Surfaces and Solids for manufacturing applications, Geometric and Product Data Exchange, Machining of free-form surfaces, CNC program generation from CAD models, CNC Program verification and Virtual CNC
5. *Computer Aided Assembly Planning:* Introduction to Assembly Planning, representation of assembly and assembly plans, Generation of assembly plans and sequence, Integration with CAD systems, Integration with task and motion planners, Benefits of CAPP
6. *Computer Aided Process Planning (CAPP):* General Concept, Manual process planning, Framework for CAPP, Variant and Generative CAPP, Selection of machine tools, Future trends
7. Recent Developments in CNC machine tools

Laboratory Exercises: The laboratory work in this course includes manual part programming exercises on CNC lathe and CNC milling machines using CNC simulation software, Application of various canned cycles in programming, Machine setting on CNC lathe and CNC vertical milling machine, Representing free form curves on CAD/CAM software, Generation of part programs from CAD/CAM software for CNC Lathe and milling machines,

Importance of data exchange formats such as IGES, STEP, DMIS etc.

References

1. Thyer, G. E., (1988), *Computer Numerical Control of Machine Tools*, Industrial Press
2. Smid, P., (2008), CNC *Programming Handbook*, Industrial Press
3. Madison, J., (1996), CNC *Machining Handbook: Basic Theory, Production Data and Machining Procedures*, Industrial Press
4. Mattson, M., (2009), *CNC Programming Principles and Applications*, Cengage Learning
5. Gibbs, D., and Crandell, T. M., (2003), *Introduction to CNC Machining and Programming*, Industrial Press
6. Marciniak, K., *Geometric Modeling for Numerically Controlled Machining*, Oxford University Press
7. Mortenson, M., (1985), *Geometric Modeling*, John Wiley & Sons

Online Course Material

1. Course Material from NPTEL: http://nptel.ac.in/courses/112102101/
2. MIT Courseware: http://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003

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ME2

Course Booklet for M.Tech.

(Mechanical Engineering)

2015