Tentative ME M.Tech program at IIT Jodhpur

The following curriculum is proposed for the ME M.Tech program (Total credits: 64 out of which 30 thesis credits spread over two semesters). There is no specialization during course work but the students can select their thesis in any one of the following three areas: (i) Thermal (ii) Manufacturing (iii) Solid mechanics and design depending on the consent of the faculty members.

Curriculum

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	3-0-0	3
C	ME618	Numerical Methods in Mechanics	3-0-0	3		C	*ME652*	Computer-Aided Manufacturing	3-0-3	4
C	ME651	Advanced Mechanics of solids	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**

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., *Mechanical Metallurgy*, 3rd Edition, McGraw Hill Book Company, 1986

Suggested References

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

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

Overview: Introduction to coal, gas, nuclear, concentrated solar, and wind power generation

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

Applications: Design and operation of power plant equipments: steam generators, condensers, receivers, wind turbine rotors

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

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*., *Numerical Recipes in C*, 2nd Edition, 2003
2. Anderson, John D., *Computational Fluid Dynamics*, New York: McGraw-Hill, 1995
3. Fung, Y.C., *First Course in Continuum Mechanics*, 1993, Prentice Hall

Online Course Material

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

Course Title	**Computer Aided Manufacturing**	Course No.	**ME 652**			
Focus Group	Mechanical Engineering	Structure	3	0	3	4
Offered for	PhD	Status	Core			
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

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

Course Contents

- **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)
- **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
- **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,
- **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
- **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
- **Computer Aided Process Planning (CAPP):** General Concept, Manual process planning, Framework for CAPP, Variant and Generative CAPP, Selection of machine tools, Future trends

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., Computer Numerical Control of Machine Tools, Industrial Press, 1988
2. Smid P, CNC Programming Handbook, Industrial Press, 2008
3. Madison J, CNC Machining Handbook: Basic Theory, Production Data and Machining Procedures, Industrial Press, 1996
4. Mattson M, CNC Programming Principles and Applications, Cengage Learning, 2009
5. Gibbs D and Crandell T M, Introduction to CNC Machining and Programming, Industrial Press, 2003
6. Marciniak K, Geometric Modeling for Numerically Controlled Machining, Oxford University Press, 1991
7. Mortenson M, Geometric Modeling, John Wiley and Sons, 1985

Online Course Materials:

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

Course Title	**Engineering Optimization**	Course No.	**ME624**			
Focus Group	Mechanical Engineering	Structure	3	0	0	3
Offered for	M. Tech	Status			*Core*	
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. S.S. Rao, Engineering *Optimization: theory and Practice, New Age International Publishers, 2010.*
2. Kalyanmoy Deb, Optimization for Engineering Design, PHI, second edition, 2012

Course Title	**Advanced Mechanics of Solids**	Course No.	**ME651**			
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

1. Enable students to learn advanced concepts of stress analysis
3. Apply concepts to analysis of mechanical systems such as rotating disks, thick cylinders etc.

Learning Outcomes

1. Develop Ability to solve advanced stress analysis problems using analytical and numerical methods
2. Ability to formulate and solve 3D problems in stress analysis

Course Content

Introduction: Review of basic concepts and equations in mechanics, Classification of materials, Outline of general techniques to solve boundary value problems, Mathematical Preliminaries: Indicial notation, Introduction to tensors, Representation of tensors, Gradient and related operators, Divergence theorem

Kinematics: Motion field, Displacement field, Deformation gradient, strain measures, linearized strain measures, Principal strains and principal directions, Concept of traction, Cauchy's stress theorem, Postulate of Cauchy stress tensor, Extreme normal and shear traction, Octahedral shear stress

Equilibrium equations: Derive equilibrium equations in Cartesian and cylindrical polar coordinates, Constitutive relations: Restrictions on constitutive relations, General relationship between Cauchy stress and Cauchy Green strain for isotropic materials, General Hooke's law and its reduction for isotropic and orthotropic materials

Applications: Boundary value problems in plane stress and plain strain, torsion of non circular cross section, Thick-walled annular cylinder, Failure theories, plasticity, fracture mecahnics; Wave propagation, numerical and experimental methods: Stress waves in 1-D; Large deformations; Numerical and Experimental methods.

Finite element method: Basic concepts, 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. L. S. Srinath, "Advanced Mechanics of Solids" Tata McGraw Hill, 2007.
2. A. R. Ragab, and S. E. Bayoumi, "Engineering Solid Mechanics: Fundamentals and Applications", CRC Press, 1999.
3. M. H. Sadd, "Elasticity: Theory, Applications and Numerics", Academic Press, 2006.
4. Timoshenko and Goodier, Theory of Elasticity, Tata McGraw-Hill, 1980,
5. R.D. Cook et al., Concepts and applications of Finite element analysis, Fourth edition, Wiley India, 2009.
6. Shabana., A. A., *Dynamics of Multibody Systems,* Cambridge University Press, 4th Edition, 2013
7. *Reddy.,* J. N., *An introduction to the Finite Element Method, Tata McGrawhill, 3rd Edition, 2005*

Online Course Material

http://nptel.ac.in/courses/105106049/

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

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.
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
Sensors: Thermocouples, strain gages, load cells, accelerometers, gas and air quality sensors, pyranometer and pyrheliometer, dynamometer and sensors in smart phones
Data acquisition systems: Acquiring sensor data, processing and interpretation in lab view/matlab and other interfaces, user interfaces and uncertainty in measurement
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., *Experimental Methods for Engineers*, McGraw Hill Education India, 7th Edition, 2007
2. Beckwith, T.G., Marangoni, R. D., and Lienhard, J.H., *Mechanical Measurements*, Prentice Hall, 6th Edition, 2006
3. Northrop, R.B., *Introduction to Instrumentation and Measurements*, CRC Press, Third Edition, 2014
4. Doebelin, E.O., and Manik, D.N., *Measurement Systems*, McGraw Hill, 6th Edition, 2012

Online Course Material

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