DEPARTMENT OF METALLURGICAL
&
MATERIALS ENGINEERING

SCHEME OF INSTRUCTIONS AND SYLLABUS
FOR
POST GRADUATE STUDIES

M. Tech in Materials Engineering

Visvesvaraya National Institute of Technology, Nagpur

July 2015

MISSION AND VISION
OF
VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR

MISSION

The Mission of VNIT is to achieve high standards of excellence in generating and propagating knowledge in engineering and allied disciplines. V.N.I.T. is committed to providing an education that combines rigorous academics with joy of discovery. The Institute encourages its community to engage in a dialogue with society to be able to effectively contribute for the betterment of humankind.

VISION

To contribute effectively to the national endeavour of producing quality human resource of world class standard by developing a sustainable technical education system to meet the changing technological needs of the Country, incorporating relevant social concerns and to build an environment to create and propagate innovative technologies for the economic development of the Nation.

MISSION AND VISION
OF
DEPARTMENT OF METALLURGICAL & MATERIALS ENGINEERING,
V. N. I. T. NAGPUR

MISSION

The mission of the department is:

- To link the human resource with the knowledge base in the filed of metallurgical and materials engineering in such a way that the challenges faced by the mankind in optimum utilization of the materials resources are successfully met with.
- To stride on every front of knowledge dissemination through teaching learning process, research and development and offering expert solutions to technological problems.
- To integrate human resource with highest attainable level of knowledge on materials with various channels functioning for its efficient dissemination for welfare of mankind.

VISION

A department, growing at pace matching with global trends, emerging as a world's one of the leading academic organizations for its advanced knowledge base and cutting edge research contributions.

Department of Metallurgical & Materials Engineering offers one ***M. Tech program in Materials Engineering***. This is four semester program, wherein student has to complete certain number of credits as indicated in Table 1. Each subject (or course) has certain number of credits. There are two types of subjects: Core and Elective. Core courses are compulsory and some courses from electives are to be taken to complete the required credits.

TABLE 1. CREDIT REQUIREMENTS FOR POST GRADUTE STUDIES

Postgraduate Core (PC)		**Postgraduate Elective (PE)**	
Category	Credit	Category	Credit
Departmental Core (DC)	37	Departmental Electives (DE)	15
Total	37	Total	15
Grand Total PC + PE			52

The number of credits attached to a subject depends on number of classes in a week. For example a subject with 3-1-0 (L-T-P) means it has 3 Lectures, 1 Tutorial and 0 Practical in a week. This subject will have four credits (3x1 + 1x1 + 0x1 = 4). If a student is declared pass in a subject, then he/she gets the credits associated with that subject. Depending on marks scored in a subject, student is given a Grade. Each grade has got certain grade points as follows:

Grades	AA	AB	BB	BC	CC	CD	DD	FF
Grade Points	10	09	08	07	06	05	04	Fail

The performance of a student will be evaluated in terms of two indices, viz. the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. SGPA & CGPA are:

$$\boldsymbol{SGPA} = \frac{\sum_{semester}(Course\ credits\ X\ Grade\ points) for\ all\ courses\ except\ audit}{\sum_{semester}(Course\ credits\ ) for\ all\ courses\ except\ audit}$$

$$\boldsymbol{CGPA} = \frac{\sum_{All\ semester}(Course\ credits\ X\ Grade\ points) for\ all\ courses\ with\ pass\ grade\ except\ audit}{\sum_{All\ semester}(Course\ credits\ ) for\ all\ courses\ except\ audit}$$

Students can Audit a few subjects. i.e., they can attend the classes and do home work and give exam also, but they will not get any credit for that subject. Audit subjects are for self enhancement of students.

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Programme: M. Tech. in Materials Engineering

Programme Educational Objectives of M. Tech. in Materials Engineering

The educational objectives of PG programme in Materials Engineering are set to enable students:

- To understand the facets of advanced technologies/processes/ materials necessary in the engineering field.
- To apply the concepts to solve the engineering problems in a scientific and systematic way.
- For professional and research careers in the field of metallurgical and materials engineering.
- To appreciate the significance of team work and collaborations in designing, planning, and implementing solutions for practical problems and facilitate the networking with national research and academic organizations.

Programme Outcomes of M. Tech. in Materials Engineering

Programme Outcomes:

PO1 – Gain knowledge of the concepts of materials engineering.
PO2 – Ability to analyse the problem correctly.
PO3 – Apply the knowledge to design and development of possible solutions.
PO4 – Ability for a systematic investigation of complex problems in engineering.
PO5 – Should be able to handle and use modern tools in Materials Engineering.
PO6 – Foster a strong bonding with the human society.
PO7 – Appreciate the implications of environment for sustainable solutions.
PO8 – Understand and practice the profession in ethical manner.
PO9 – Ability to work as an individual and in team.
PO10 – Ability to communicate effectively in oral as well as written manner.
PO11 – Develop an approach for lifelong learning in profession.
PO12 – Ability to manage and finance the engineering projects.

Scheme for M. Tech. in Materials Engineering

Postgraduate Core (PC)		Postgraduate Elective (PE)	
Category	Credit	Category	Credit
Departmental Core (DC)	37	Departmental Electives (DE)	15
Total	37	Total	15
Grand Total PC + PE			52

Details of Credits:

Ist Semester						**IInd Semester**					
CORE						**CORE**					
S. N.	**Course Code**	**Course Title**	**Scheme L-T-P**	**Credits**	**Category**	**Sr. No.**	**Course Code**	**Course Title**	**Scheme L-T-P**	**Credits**	**Category**
1.	MML 511	Introduction to metals & alloys	3-0-0	03	DC	1.	MML 502	Design & selection of materials	3-0-0	03	DC
2.	MML 525	Thermodynamics of materials	3-0-0	03	DC	2.	MML 504	Advanced composite materials	3-0-0	03	DC
3.	MML 506	Structure & Characterization of Materials	3-0-0	03	DC	3.	MML 529	Phase transformations	3-0-0	03	DC
4.	MML 507	Polymer engineering	3-0-0	03	DC						
5.	MML 509	Ceramic engineering	3-0-0	03	DC						
6.	MMP 506	Structure & Characterization of Materials Lab.	0-0-2	01	DC						
7.	MMP 511	Introduction to metals & alloys lab	0-0-2	00	AUDIT						
Total No of Credits				**16**							
ELECTIVE						**ELECTIVE**					
						S. N.	**Course Code**	**Course Title**	**Scheme L-T-P**	**Credits**	**Category**
						4. 5. 6.	MML 508 MML 510 MML 512	**(ELECTIVE I)** **(Any One)** Powder metallurgy Welding technology Deformation behavior of materials	3-0-0	03	DE
						7. 8. 9.	MML 514 MML 516 MML 518	**(ELECTIVE II)** **(Any One)** Alloy & special steels Bio materials Corrosion process & control	3-0-0	03	DE
						10. 11.	MML 524 MML 528	**(ELECTIVE III)** **(Any One)** Process modeling & simulation Advanced Ceramics	3-0-0	03	DE
Total No of Credits				**16**			**Total No of Credits**			**18**	

IIIrd Semesters					
	MMD 501	Project Phase - I		**03**	DC
ELECTIVE					
S. N.	**Course Code**	**Course Title**	**Scheme L-T-P**	**Credits**	**Category**
		(ELECTIVE IV) (AnyOne)			DE
1.	MML 531	Casting & solidification	3-0-0	03	
2.	MML 535	Failure analysis of Engineering Materials			
		(ELECTIVE V) (Any One)			DE
3.	MML 537	Nano materials & characterization	3-0-0	03	
4.	MML 545	Non destructive Evaluation			
5.	MML 541	Environmental management			
Total No of Credits				**09**	

IVth Semester			
MMD 501	Project Phase - II	**09**	DC
ELECTIVE			
Total No of Credits		**09**	

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Course Syllabi

1. MML 501: INTRODUCTION TO METALS AND ALLOYS (3-0-0) (3 Credits)

I. Brief Description:

It's a Departmental Core (DC) course. It is designed to impart knowledge to students about structure of metals and alloys, their phase diagrams, microstructures, various heat treatments, properties, and applications of ferrous alloys, non-ferrous alloys and special alloys.

II. Course Coordinator: Prof. A. P. Patil

III. Pre-requisites and Co-requisites: None

IV. Textbook and /or Other Required Material

a. Sidney H Avner, Introduction to Physical Metalurgy, 2nd Edition, McGraw-Hill, 1974
b. Prabhudeva K H, Handbook of Heat Treatment of Steels, Tata McGraw-Hill, 2000
c. ASM International, ASM Handbook, Vol. 4: Heat Treating, 1991.

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Basic crystalline structure of the metals.
b. Phases in metals and alloys and phase diagram of binary alloys.
c. Phase diagram of Iron-Iron carbide system, its various phases, microstructure of iron alloys, their heat treatment, properties and applications.
d. Alloys steels and effect of alloying elements.
e. Non-ferrous alloys, their phase diagrams, their properties and applications
f. Special alloys.

VI. Expanded Course Description

i. Crystalline nature of metals, crystal lattice, unit cell, Miller indices, crystal structures – BCC, FCC, HCP, packing density, defects in crystal.
ii. Alloys – Binary phase diagrams, solid solutions, Hume-Rothery rules, phase rule, intermetallic compounds, lever rule, binary diagrams involving eutectic, eutectoid, peritectic reactions.
iii. Iron-Iron Carbode diagram, classification of steels and Cast irons, critical temperatures, TTT diagrams, critical cooling rate, hardenability, measurement techniques, heat treatments such as annealing, normalizing, hardening, tempering, austempering, martempering.
iv. Alloy steels: Effect of alloying elements in general and in particular, introduction to tool steels (low alloy tool steels, HCHC, HSS, OHNS steels). Stainless steels – alloying elements and their purpose, properties and applications.
v. Non-ferrous alloys: structure, properties and applications of Cu-Zn alloys - brasses, Cu-Sn alloys – bronzes, Al-Si alloys, age hardenable copper alloys etc.
vi. Introduction to special alloys – super alloys, titanium alloys, magnetic alloys

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2. MMP501: INTRODUCTION TO METALS AND ALLOYS (0-0-2) (0 Credit-Audit)

I. Brief Description:

It's a Departmental Core (DC) course. It is designed to impart knowledge to students about structure of metals and alloys, their phase diagrams, microstructures, various heat treatments, properties, and applications of ferrous alloys, non-ferrous alloys and special alloys.

II. Course Coordinator: Prof. A. P. Patil

III. Pre-requisites and Co-requisites: None

IV. Textbook and /or Other Required Material

a. Sidney H Avner, Introduction to Physical Metalurgy, 2nd Edition, McGraw-Hill, 1974
b. Prabhudeva K H, Handbook of Heat Treatment of Steels, Tata McGraw-Hill, 2000
c. ASM International, ASM Handbook, Vol. 4: Heat Treating, 1991.

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

g. Basic crystalline structure of the metals.
h. Phases in metals and alloys and phase diagram of binary alloys.
i. Phase diagram of Iron-Iron carbide system, its various phases, microstructure of iron alloys, their heat treatment, properties and applications.
j. Alloys steels and effect of alloying elements.
k. Non-ferrous alloys, their phase diagrams, their properties and applications
l. Special alloys.

VI. Course Description

I. Study of equipments used in the lab.
II. Sample preparation for optical microscopy.
III. Observe microstructure of a few steels.
IV. Observe microstructure of a few cast irons.
V. Observe microstructure of a few non-ferrous alloys
VI. Demonstration of Jominy Hardenability Test
VII. Observe microstructure of a few hardened and tempered low alloy steels.
VIII. Observe microstructure of a few hardened and tempered tool steels.

VII. Class /Laboratory Schedule

a. Lecture: Three 60 minutes sessions per week
b. Laboratory: One 100 minutes session per week for a batch of 20 students.

VIII. Evaluation of Students:

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, two class test/quizzes/home assignments and end semester exam. Precise distribution is announced in 1st lecture.
b. 6 Relative grading

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3. MML525: THERMODYNAMICS OF MATERIALS (3-0-0) (03 CREDITS)

I Brief description- MML525/DC
II Course coordinator- Dr. A. K. Srivastava
III. Pre-requisites and Co-requisites: None
IV. Text book

1. Gaskell, david, R., Introduction to metallurgical Thermodynamics, McGraw Hilll.
2. Upadhayaya, G.S., and Dube, R. K.. Problems in Metallurgical Thermodynamics and Kinetics, Pergamon.
3. Darken, L.S., and Gurry, R. W., Physical chemistry of Metals, McGraw Hill
4. Thermodynamics of Solids by R A Swalin

V. Course Objective:

To understand:
A) Fundamentals of Materials Thermodynamics
B) Applications of Thermodynamics

VI. Course description

- Introduction to Thermodynamics- different approaches, emphasis on metallurgical thermodynamics.
- Laws and related applications, concept of energy and entropy, criteria for spontaneity. Maxwell's Relations and Clausius Clayperon Relations,

- Introduction to solutions, solution model, regular and quasi chemical models, sub regular, cluster variation model, multi parameter models, statistical thermodynamics and multicomponent system, partial molar quantities, Gibbs-Duhem relations, thermodynamic aspects of metallic solutions and salt melts, Raoult's and Henry's Law,
- Thermodynamic aspect of phase transformation, similarity in thermodynamic approach towards different classes of materials, thermodynamic aspect of defect formation in metals and ceramics.

VII. Class schedule-Three 60 min/ week
VIII. Evaluation of Students:
(a) Evaluation- continuous- 2 sessional exam/ 1 end-semester/ quiz, seminar
(b) Grading- relative

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4. MML 529: PHASE TRANSFORMATION (3-0-0) (03 CREDITS)

I Brief description- MML 529/DC
II Course coordinator-

III. Pre-requisites and Co-requisites: None
IV. Text book
1. Introduction to Materials Thermodynamics - D. R. Gaskell
2. Kinetics of metallurgical processes – H. S. Ray
3. Phase transformation in metals and alloys - Porter and Easterling
4. Solid state phase transformation – V. Raghavan
5. Diffusion in solids – P. G. Shewmon
6. Physical metallurgy principles - R. Reed-Hill

V. Course Objective:
To understand:
A) Phase transformation studies on steels, non ferrous alloys and other materials systems.
B) kinetics of phase transformations
C) Some typical transformations and applications

VI. Course description
Phase diagram, free energy, composition diagram, kinetics of phase transformation, diffusion process mechanism Fick's, law solutions, kirkendall effect, diffusion in alloys, and other materials problems, mechanism of phase transformation ,nucleation and growth, homogenous and heterogeneous transformation, transformation behavior in steel- isothermal and diffusion less transformation, structure of interfaces, precipitation and strengthening mechanism problems, studies on typical transformation in steels, non ferrous alloys and other materials systems, studies on order-disorder transformation, spinodal decomposition, massive transformation, higher order transformation.

VII. Class schedule-Three 60 min/ week
VIII. Evaluation of Students:
(a) Evaluation- continuous- 2 sessional exam/ 1 end-semester/ quiz, seminar
(b) Grading- relative

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5. MML 506: STRUCTURE AND CHARACTERIZATION OF MATERIALS (3-0-0) (03 Credits)

I. **Brief Description**:
Core course providing: Crystallography, optical microscopy, scanning electron microscopy, chemical analysis using scanning electron microscope, physics of X-rays, diffraction by crystalline materials, applications of X-ray diffraction, spectrometric and thermal analysis of materials.

II. **Course Coordinator**: Dr. Rajesh K. Khatirkar

III. **Pre-requisites and Co-requisites**: None

IV. **Textbook and /or Other Required Material**
a. L. Yang, Materials Characterization: Introduction to microscopic and spectroscopic, Wiley.
b. Goodhew, Humphreys and Beanland, Electron Microscopy and Microanalysis, Taylor and Francis.
Upon successful completion of this course, each student should be able to understand:

V. **Course Outcomes**:
a. Basic crystallography
b. Microstructural characterization techniques.
c. IR spectroscopic techniques.
d. Thermal characterization methods.
e. Applications of each technique and its limitations.
f. Selection of a characterization method for a particular application.

VI. Expanded Course Description

1. Basic crystallography (Bravais lattices, importance of symmetry in crystallography, SC, BCC, FCC, HCP, CsCl, NaCl, DC and ZnS structure description, description of planes and directions and their representation), Ideal vs real crystals, definition of microstructure. Defect structure-points defects and its equilibrium concentration, methods of producing point defects, dislocations – edge, screw and mixed. Volterra model of dislocation, Burgers vector, dislocation line, dislocations in BCC, FCC and HCP crystals, energy of dislocations, partial dislocations, slip systems in BCC, FCC and HCP, stress field of a screw dislocation. Random vs structural dislocations. 2D defects, classification (surface, grain boundary, stacking faults, twin boundaries, anti-phase boundaries), interfaces (coherent and in-coherent), concept of terraces, ledges and kinks. Types of grains boundaries (low angle and high angle), types of twins.
2. Importance of structure-property correlation in materials, structure sensitive/insensitive properties, introduction to materials characterization and its importance in materials engineering, levels of characterization (macro, meso and micro), concept of resolution and depth of field/focus in imaging, types of aberrations (spherical, chromatic, diffraction and astigmatism), remedial measures for aberrations. Optical microscopy (OM) – reflected/transmitted light microscopy, theoretical and practical resolution of an optical microscope, numerical aperture, principles of image formation, microscope construction and working, effective/empty magnification, different light sources, importance of stage design, capturing of image, flat field correction in OM, bright field, dark field, polarized light and phase contrast microscopy and applications of each in metallurgical and materials engineering, sample preparation for optical microscopy and limitations.
3. Scanning electron microscopy (SEM) – Advantages/disadvantages as compared to OM and other imaging techniques, mechanics of SEM, types of electron gun and comparison between them (in terms of resolution, brightness, efficiency, cost, stability and applications), line diagram of SEM, its working and construction, concept of magnification as applied to SEM, electron-matter interaction, imaging modes (secondary and backscattered), effect of spot size, effect of apertures, effect of accelerating voltage on SEM imaging, signal detection (by using Everhart- Thornley, Robinson and solid state segmented detectors), atomic number and topological contrast, critical probe current, chemical analysis of phases using SEM (EDS/WDS working principle, construction and analysis, data acquisition modes – spot, line and area scans), resolution of EDS/WDS detector attached to SEM, advantages/disadvantages, working and calibration, qualitative and quantitative analysis.
4. X-ray diffraction (XRD) – Elastic and inelastic scattering, Bragg's law, basic powder diffraction, generation of X-rays, characteristic X-ray spectrum, Moseley's law, methods to remove K_b radiation, detectors, factors affecting the intensity of diffraction peaks (atomic scattering factor,

structure factor, multiplicity, Lorentz factor, Polarization factor, absorption effects), derivation of diffraction conditions for SC, BCC and FCC Bravais lattice, phase identification using XRD.

5. Thermal analysis techniques – Importance of thermal characterization techniques. Differential thermal analysis (DTA), differential scanning calorimetry (DSC) and thermogravimetric analysis (TG) analysis – working principle, differences, accuracy, sensitivity, calibration and applications (Tg, Tc, Tm determination, factors affecting them, crystallinity determination, quantification of moisture and decomposition products etc.).
6. Infrared spectroscopy (conventional and Fourier transform, working principles, differences, instrumentation and applications).

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6. MMP 506: STRUCTURE AND CHARACTERIZATION OF MATERIALS LAB

I. Brief Description:

Core course providing: Crystallography, optical microscopy, scanning electron microscopy, chemical analysis using scanning electron microscope, physics of X-rays, diffraction by crystalline materials, applications of X-ray diffraction, spectrometric and thermal analysis of materials.

II. Course Coordinator: Dr. Rajesh K. Khatirkar

III. Pre-requisites and Co-requisites: None

IV. Textbook and /or Other Required Material

a. L. Yang, Materials Characterization: Introduction to microscopic and spectroscopic, Wiley.

b. Goodhew, Humphreys and Beanland, Electron Microscopy and Microanalysis, Taylor and Francis.

Upon successful completion of this course, each student should be able to understand:

V. Course Outcomes:

g. Basic crystallography
h. Microstructural characterization techniques.
i. IR spectroscopic techniques.
j. Thermal characterization methods.
k. Applications of each technique and its limitations.
l. Selection of a characterization method for a particular application.

VI. Course Description

Typical laboratory experiments

1. Optical microscopy
2. Scanning Electron Microscopy (imaging)
3. Chemical analysis using scanning electron microscopy (EDS)
4. Phase identification using X-ray Diffraction
5. Determination of Crystallize/Grain Size and Lattice Strain using XRD
6. Determination of onset of glass transition, crystallization and melting temperature using DTA.
7. Identification and purity determination using DSC
8. Quantification of crystalline percentage of a polymer using DSC
9. Identification of polymer using FTIR.

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7. MML 507 POLYMER ENGINEERING (3-0-0) (3 Credits)

I. Brief Description:

Departmental core course for 1st Semester M.Tech. students. The course aims to provide in-depth structure-property-processing co-relation for polymeric materials.

II. Course Coordinator: Dr. R. C. Rathod, Ground Floor, Old Building of Department

III. Pre-requisites and Co-requisites: None

IV. Textbook and /or Other Required Material

a. Clegg D.W., Collyer A. A., Structure and Properties of Polymeric Materials, Mats. Publn.,
b. Fried J.R., Polymer Science and Technology, Prentice Hall of India, New Delhi 2000.
c. Willam D., Callistor J.R., Material Science and Engineering, John Wiley and Sons, 1997.
d. Dyswan R.W., Speciality Polymers, Chapman and Hall, 1987.

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Theoretical basis of polymeric materials.
b. Different polymerization process and its thermodynamic and kinetic aspect.
c. Characterization of polymer (physical, thermal, mechanical)
d. Engineering and specialty polymers – preparation, properties and application.

VI. Expanded Course Description

Introduction and classification of engineering polymers, solid state properties of polymers, deformation of polymers, polymer flow behavior, polymer structure, Properties- physical and mechanical, polymerization process and its thermodynamic and kinetic aspects, Polymer synthesis- batch or continuous –mass polymerization – solution- suspension-emulsion polymerization. Characterization of polymers, Chain end degradation and random degradation, additives, polymer processing – extrusion, blow molding, injection molding, thermoforming, calendaring, spinning, casting. Engineering and specialty polymers-preparation-properties and applications- polyolefins, styrene polymers, vinyl halide polymers, polyamide, polyester, polycarbonate, polyurethane, polyketon, inorganic polymers, conducting polymers.

VII.Class /Laboratory Schedule

Lecture: Three 60 minutes sessions per week

VIII.Evaluation of Students:

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, seminars and end semester exam.
b. Grades: Relative grading

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8. MML 509: CERAMIC ENGINEERING (3-0-0) (3 CREDITS)

I. Brief Description:

Departmental Core course for 1st Semester M.Tech. students.

II. Course Coordinator:

III. Pre-requisites and Co-requisites: None

IV. Textbook and /or Other Required Material

a. Kingery W.D & Bowman.-Introduction to ceramic materials
b. Norton-Introduction to ceramics
c. Chester-Refractories :Production and properties

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Overview of ceramic applications & markets.
b. Ceramic fabrication techniques
c. Characterisation of ceramics
d. Structures &Imperfections in ceramics

VI. Expanded Course Description

Materials classification with special reference to ceramics. Structures of ceramics,History of ceramics. Classification of ceramics-AX/AmXp/AmBnXp types. Abrasives, Advanced

ceramics. Ceramic structures–Silicates, gibbsite, kaolinite, muscovite, alumina. Raw materials for ceramics & their processing, functions of additives in processing. Ceramic fabrication techniques-pressing,slip casting,tape casting.Glass forming. Processes,Drain casting,Injection moulding, Isostatic pressing. Plasticisers, binders, lubricants. Rolling/forging/extrusion techniques as a forming technique. characterization of ceramics.
Firing of ceramics, Drying & firing systems, Densification mechanisms in ceramics. Applications:Oxide/nonoxideceramics,carbie/nitride/borideceramics, traditional ceramics, pottery, Refractories-limestone, dolomite, magnesite, fireclays

VII. Class /Laboratory Schedule

Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, two class test/quizzes/home assignments and end semester exam. Precise distribution is announced in 1st lecture.

b. Grades: Relative grading

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9. MML 502: DESIGN AND SELECTION OF MATERIALS (3-0-0) (3 Credit)

I. Brief Description:

Introduction to selection of materials, Properties of engineering materials, Properties trade off, Factors influencing materials election, material selection vs. materials processing, techno-economic aspects of materials selection, Selection of materials for static strength, stiffness, fracture toughness, Design for yielding and fracture toughness fatigue , creep and wear resistance.

II. Course Coordinator: Prof. S. G. Sapate

III. Pre-requisites and Co-requisites: Testing of materials

IV. Textbook and /or Other Required Material

a. Charles J.A.; Crane FAA, Furness JAG; Selection & Use of Engineering Materials; Butterworth & Heinemann,
b. Dieter G.E.; Mechanical Metallurgy; McGraw Hill, 1988.
c. Ashby M.F., Jones D.R.; Engineering Materials; Pergamon Press, 1992.
d. Askeland DR : Engineering Materials
e. ASM Handbook : Vol.20: Material Selection : ASM

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Fundamental concepts of material selection, analysis of service conditions, property trade off, factors influencing material selection. Techno economic aspects of material selection.
b. Apply the fundamental concepts and factors involved in development of static strength and stiffness to material selection.
c. Apply the fundamental understanding of fracture toughness and fatigue to relevant material selection situations.
d. Apply the fundamental understanding of creep to relevant material selection situations
e. Analyze and solve numerical related to design for fracture toughness, fatigue and creep life estimation.
f. Understand different modes of wear, variables affecting wear by hard particles and apply the concepts to material selection for different wear situations.

VI. Expanded Course Description

Introduction to Material Selection and design, Engineering properties of Materials. Factors and property parameters in material selection. Material selection vis – a – vis design, Material selection for strength and stiffness, Material selection and design for toughness and fatigue, Material selection for creep and wear, Material selection criteria and case studies.

VII. Class /Laboratory Schedule

a. Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, two class test/quizzes/home assignments and end semester exam.
b. Grades: Relative grading

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10. MML 504: ADVANCED COMPOSITE MATERIALS (3-0-0) (3 CREDITS)

I. Brief Description:

Departmental Core Course for 2nd Semester M.Tech.

II. Course Coordinator: Dr. D.R. Peshwe

III. Pre-requisites and Co-requisites: None

IV. Textbook and /or Other Required Material

a) Matthews F.L ; Composite Materials Engg. & Science; Chapman & Hall, 1996.
b) Composites-ASM Vol.I (10th Edition), ASM Internationals, 1995.
c) Holliday L.; Composite Materials; Elseveis Publishing Co.; 1966.
d) Chawala C.K., Composite Materials; Springer Publishing Co., 1987
e) Prasad R.C. & P. Ramakrishnan, Composite Science & Technology; New Age International, 2000.

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Fundamental concepts of composite materials
b. Effect of parameters like composite matrix, reinforcing materials with respect to their structure, properties and manufacturing methods
c. Manufacturing techniques of composites
d. Structural, thermal, mechanical, physical, chemical and environmental characterization of composites and also their respective properties
e. Advanced application and degradation of composites

VI. Expanded Course Description

Introduction, concept and definition of composite materials, classification, advantages and limitations, scope and applications of composite materials.

Study of parameters like composite matrix, reinforcing materials with respect to their structure, properties and manufacturing methods.

Manufacturing techniques of composites such as vacuum bagging, filament winding, resin transfer, pultrusion, CVD, PVD etc. study of structural, thermal, mechanical, physical, chemical and environmental characterization of composites and also their respective properties. Application and degradation of composites. Study of natural composites and laminates.

VII. Class /Laboratory Schedule

c. Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, two class test/quizzes/home assignments and end semester exam. Precise distribution is announced in 1st lecture.
b. Grades: Relative grading

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11. MML 508: POWDER METALLURGY (3-0-0) (3 CREDITS)

I. Brief Description:
Departmental Elective Course for 2nd Semester M.Tech.

II. Course Coordinator:
III. Pre-requisites and Co-requisites: None
IV. Textbook and /or Other Required Material

Khanna A.K. ; Powder Metallurgy.

V. Course Outcomes:
Upon successful completion of this course, each student should be able to understand:
a. Powder production techniques
b. Powder Characterization & Treatments
c. Characterization of powders
d. Consolidation techniques
e. Concepts of Sintering
f. Applications

VI. Expanded Course Description
Status of PM industries in India, advantages / disadvantages of PM techniques. Powder production involved by comminution of solid metals like machining, crushing, milling etc. Powder production by pulverising molten metals, Physical methods of powder production, Chemical process of producing powder, **Powder Characterization & Treatments :**Thermal and mechanical treatments given to powders. Testing and evaluation of following characteristics of powder - particle size, shape & size distributions, surface topography, surface area, shape factors, apparent and tap density; mass and volume flow rates, compressibility and compression ratio etc. Compaction techniques -Pressures and pressure - less compaction methods, die compaction (single / double / multiple action); reflex action, rotary compaction; isostatic compaction; rolling / forging / extrusion as techniques of compaction; vibratory compaction, continuos compaction; high energy rate following techniques; slip casting, green compact density, laminations and their control, hot pressing, explosive compaction. **Sintering, Powder Metallurgy Applications**

VII. Class /Laboratory Schedule
d. Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:
e. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, two class test/quizzes/home assignments and end semester exam. Precise distribution is announced in 1st lecture.
f. Grades: Relative grading

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12. MML510 : WELDING TECHNOLOGY (3-0-0) (3 CREDITS)

I. **Brief Description**:
Departmental elective course.

II. **Course Coordinator**: Dr. R. V. Taiwade, First Floor, last room, Old Building of Department.

III. **Pre-requisites and Co-requisites**: None

IV. **Textbook and /or Other Required Material**

a. J. C. Lippold and D. J. Kotecki: Welding Metallurgy and Weldability of Stainless Steels, John Wiley & Sons Inc. UK, (2005).
b. S. Kou: Welding Metallurgy, 2nd ed. John Wiley & Sons Inc., NewYork, (2003).
c. J. R. Davis: Corrosion of Weldments, ASM International, Materials Park, OH, (2006).
d. R. S. Parmar: Welding Engineering and Technology, 1st ed., KhannaPublication, New Delhi, India, (2004).

V. **Course Outcomes**:
Upon successful completion of this course, each student should be able to understand:

a. Basic knowledge of materials joining processes.
b. Weldability
c. Welding metallurgy
d. Welding defects and remedies
e. Heat transfer during welding
f. Dissimilar metal welding

VI. **Expanded Course Description**
Survey of welding processes, present status, classification, joint design, importance of backing and welding symbols. Study of welding processes such as, gas, electrode, resistance, spot, seam, electron beam, laser beam etc.: Scope, instruments,advantages, limitations, applications and standards, welding specifications etc. Study of VA characteristics and different parameters affecting quality Electrode classification. Study of special welding processes such as TIG, MIG, submerged arc welding, thermit welding, underwater, ultrasonic welding and friction welding: Scope, instruments, advantages, limitations, applications and standards, welding specifications. Welding problems and remedies in steels, cast irons stainless steels and non-ferrous metals and alloys, requirements of quality control, inspection and testing in welding. Importance of welding metallurgy, weldability, test assessment techniques, heat flow in welding, HAZ and distortion, numerical based on heat transfer and welding metallurgy. Analysis of welding defects, dissimilar metal welding problems and remedies, welder accessibility test.

VII. **Class /Laboratory Schedule**
Lecture: Three 60 minutes sessions per week

VIII. **Evaluation of Students**:
Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, two class test/quizzes/home assignments and end semester exam. Precise distribution is announced in 1st lecture.
Grades: Relative grading

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13. MML 512: DEFORMATION BEHAVIOUR OF MATERIALS (3-0-0) (3 CREDITS)

I. **Brief Description**: Departmental elective course.
II. **Course Coordinator**: Dr. M. M. Thawre
III. **Pre-requisites and Co-requisites**: None
IV. **Textbook and /or Other Required Material**

a) Mechanical Metallurgy, G. E. Dieter

b) Mechanical Behavior of Materials, T.H.Courtney
c) ASM Handbook Vol. 14.; Forming & Forging, ASTM

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. appreciate and understand the phenomenon of elastic deformation
b. understand the basics of anisotropy in elasticity
c. analyze stress and strain at any point
d. understand the significance of empirical tools like yield criteria and their application
e. understand the phenomena occurring during plastic deformation of metals/alloys
f. co-relate the structure-property-co relationship during deformation

VI. Expanded Course Description

Elastic and Plastic behaviour of Materials, Engineering Stress – strain curve. flow curve, Important relations of flow curve. Concept of stress and strain in two dimensions. Principal stresses, Mohr's circle, Yield Criteria. Mechanistic models for elastic, plastic and time-dependant deformation, phenomenological description of plastic deformation in metals – slip, twinning, stacking faults etc. , strengthening mechanisms, deformation modes and mechanisms for polymeric and ceramic materials. Fatigue of engineering materials, S-N Curve, Characteristics of fatigue fracture, Evaluation of fatigue behavior, mechanical and metallurgical aspects of fatigue life. High temperature deformation of materials, creep, analysis of creep curve, structural changes during creep ,deformation mechanism maps, Fracture of materials, types, effect of notch, structure and temperature, concept of toughness and fracture toughness, preliminary concept of LEFM and PYFM, strain energy release rate, stress intensity factors, Fracture toughness, design.

Toughening mechanisms in various materials.

VII. Class /Laboratory Schedule

Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams,two class tests and end semester exam. Grades: Relative grading

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14. MML 514: ALLOY AND SPECIAL STEELS (3-0-0) (3 CREDITS)

I. Brief Description: Departmental elective course.

II. Course Coordinator:

III. Pre-requisites and Co-requisites: None

IV. Textbook and /or Other Required Material

a) Physical Metallurgy, S. Avner
b) Physical Metallurgy Principles- R. Reed-Hill
c) Physical Metallurgy of Stainless Steel- F.B Pickering

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Phase diagrams of alloy steels
b. Physical metallurgy of various alloy steels
c. Heat treatment of different alloy steels

VI. Expanded Course Description

Classification and Specification of Alloy Steels. Effect of Alloying Elements on the Constitution, Structure and Properties of Steels. Study of Phase Diagrams of Fe with Commonly used Alloying Elements. Low Alloy Structural and Engineering Steels, High Strength Low Alloy Steels, Dual Phase Steels. Alloy Tool Steels, Classification, Fundamental Properties, Role of Alloying Elements, Various

Carbides. Detailed Study of High Speed Steels, High Carbon High Chromium Steels, Selection of Tool Steels. Stainless and Heat Resistant Steels – Classification and Specifications. Constituents Phase Diagrams, Precipitation Hardenable Steels. Maraging Steels – Special Properties, Alloying Elements, Heat Treatment and Applications. Magnetic Steel, Classification, Heat Treatment Properties and Applications. Spring Steels Processing and Heat Treatment.

VII. Class /Laboratory Schedule

Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams,two class tests and end semester exam.

Grades: Relative grading

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15. MML 516: BIO-MATERIALS (3-0-0) (3 CREDITS)

I. **Brief Description**: Departmental elective course.

II. **Course Coordinator:**

III. **Pre-requisites and Co-requisites**: None

IV. **Textbook and /or Other Required Material**

a) Biomaterials- Sujata Bhat
b) Handbook of Materials Behaviour Models, Vol.3- Multiphase Behaviour
c) Biomaterials- Artificial organs & Tissue Engineering (Handbook)
d) Science & Engineering of Materials- D.R. Askeland
e) Light Alloys- Polmear

V. **Course Outcomes:**

Upon successful completion of this course, each student should be able to understand:

a. Various implant materials
b. Characterization methods for biomaterials
c. Aspects of tissue engineering

VI. **Expanded Course Description**

Introduction- Clasification-General Characteristics-Structure & Properties of Materials-Relevance – Crystal/Molecular Structure-Imperfections-Phase Diagrams.

Implant Materials-Metallic, Ceramic,Polymer, Composite

Characterization of Biomaterials-Mechanical, Chemical, Thermal, etc.Structural evolution of biocompatibility with reference to corrosion. Structural property correlation

Application of Biomaterials-Orthopaedic, Dentistry, Cardiac Devices, etc.

Tissue Engineering- Soft Biomaterials

Case Studies, Proliferation of Biomaterials for development of Medical Technology & mankind.

VII. Class /Laboratory Schedule

Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams,two class tests and end semester exam.

Grades**:** Relative grading

16. MML 518: CORROSION PROCESSES AND CONTROL (3-0-0) (3 CREDITS)

I. **Brief Description**:
Departmental elective course giving Introduction to corrosion, importance of corrosion studies, corrosion principles and kinetics, Different forms of corrosion, kinetics of electrochemical corrosion, Evans diagram, exchange current density, polarization, passivity, corrosion protection methods and equipments.

II. **Course Coordinator**: Dr. R. C. Rathod

III. **Pre-requisites and Co-requisites**: None

IV. **Textbook and /or Other Required Material**

a. Rajnarayan, An introduction to metallic corrosion and its prevention, New Delhi, Oxford & India Bank House-1983.
b. Banerjee S. N., An introduction to Science of Corrosion & its inhibition, 1983.
c. Fontana M.G. Green N.D., Corrosion Engineering , New York, McGraw Hill Publication
d. Uhlig H.H, Corrosion Handbook (ASM) Vol.3.01

V. **Course Outcomes**:
Upon successful completion of this course, each student should be able to understand:
a. Theoretical basis of corrosion process and method of control
b. Different form of corrosion
c. Kinetics of electrochemical corrosion
d. Corrosion testing and its control

VI. **Expanded Course Description**

Introduction to corrosion with historic and industrial cases, cost of corrosion, importance of corrosion studies, Thermodynamic aspect of corrosion reaction, Nerst equation, basic wet corrosion, electrode potential, potential Ph diagram, kinetics of corrosion reactions, Butler-Volmer equation, mixed potential theory, immunity, problems based on the theory.

Types of corrosion-recognition and mechanisms- uniform corrosion-galvanic-pitting, dealloying-crevice corrosion-intergranular corrosion-filiform corrosion- impingement attack-cavitation-fretting-corrosion cracking process.

Corrosion measurements-methods of measurement of corrosion based on study of various ASTM standards for corrosion-weight loss-electrochemical-electrical-thickness.

Corrosion protection-principles of different methods of corrosion protection, anodic protection, cathodic protection-protective coatings.

VII. **Class /Laboratory Schedule**
Lecture: Three 60 minutes sessions per week

VIII. **Evaluation of Students:**
a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, seminars and end semester exam.
b. Grades: Relative grading

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17. MML 524: PROCESS MODELLING AND SIMULATION (3-0-0) (3 CREDITS)

I. **Brief Description**:
Departmental elective course giving Introduction to corrosion, importance of corrosion studies, corrosion principles and kinetics, Different forms of corrosion, kinetics of electrochemical corrosion, Evans diagram, exchange current density, polarization, passivity, corrosion protection methods and equipments.

II. **Course Coordinator**: Dr. A.P. Patil

III. **Pre-requisites and Co-requisites**: None

IV. Textbook and /or Other Required Material

a) Hangos KM and Cameroon IT; Process modeling and model analysis, Academic Press, London, 2001.

b) Rao SS; Optimization – Theory and Applications, Wiley Eastern, 1978.

c) Aris R; Mathematical Modeling Techniques, Dover, New York, 1994.

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Theoretical basis of metallurgical processes
b. System analysis
c. Presentation of simulation results

VI. Expanded Course Description

Essence of Modeling of Metallurgical Processes.
Introduction to Simulation and its Importance in Engineering.
Analysis of Transport Processes and their Application in Modeling.
System Analysis, Development of Mathematical Model and Algorithm for Simulation, Presentation of Simulation Results.
Physical Modeling and its Importance in Engineering Studies.
Case Studies on Modeling and Simulation of some Metallurgical Processes e.g. Melting of Scrap, Refining of Melt, Solidification, Re-heating, Heat Treatment, Fluid Flow in Laddle, Tundish etc.

VII. Class /Laboratory Schedule

Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, seminars and end semester exam.
b. Grades: Relative grading

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18. MML 528: ADVANCED CERAMICS (3-0-0) (3 CREDITS)

I. Brief Description:

Departmental elective course for third semester M.Tech. students

II. Course Coordinator: Dr. A.R. Ballal

III. Pre-requisites and Co-requisites: Ceramic Engineering

IV. Textbook and /or Other Required Material

a) Modern ceramic engineering, Taylor and Francis, D.W. Richerson
b) Ceramic materials, B. Carter and G. Norton
c) Sintering theory and practice, R.M. German
d) Powder metallurgy and particulate materials processing, R.M. German.

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Advanced techniques of powder synthesis, consolidation, sintering
b. Advanced oxide and non-oxide ceramics
c. Functional ceramics

VI. Expanded Course Description

Background, Classification – Traditional v/s advanced ceramics, Spectrum of applications
Novel processing techniques – Powder synthesis routes, consolidation/shaping techniques, advanced sintering techniques (Spark plasma sintering, microwave sintering), thin films
Processing and properties of advanced ceramics –
Oxide Ceramics - alumina, zirconia, titania, ceria
Non-Oxide Ceramics - silicon carbide, silicon nitride

Materials, structure, processing of functional ceramics: Electro ceramics, Bioceramics, Ultra-high temperature ceramics, Magnetic ceramics

Glass ceramics – Synthesis, Processing, applications

VII. Class /Laboratory Schedule

Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

c. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, seminars and end semester exam.

d. Grades: Relative grading

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19. MML 531: CASTING AND SOLIDIFICATION (3-0-0) (3 CREDITS)

I. Brief Description:

Departmental elective course for third semester M.Tech. students

II. Course Coordinator: Dr. D.R. Peshwe

III. Pre-requisites and Co-requisites: None

IV. Textbook and /or Other Required Material

a) R.W. Heine & Rosenthal ; Principles of Metal Castings (2nd Edition); Tata McGraw Hill

b) Wolf, Taylor and Flemmings; Foundry Technology, Wiley Eastern Pvt. Ltd., 1973.

c) Bailey P.R.; Foundry Technology (2nd Edition); Butterworth Heinemann, 2001.

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Solidification mechanisms in metals and alloys
b. Design aspects in foundry
c. Foundry practices and defects

VI. Expanded Course Description

1. Introduction to various terms in foundry, design considerations, raw materials requirements & special casting techniques. Solidification of metals and alloys, study of segregation & shrinkage in casting. Calculations of solidification with reference to teat transfer principles, study of solidification Characters.
2. Design considerations used in gating system, fluid flow applications. Gating designs for cast irons and steels castings & stack molding.
3. Risering technique and design, feeding distance calculations, efficiency of the riser, principles of chill design, exothermic and insulating sleeves and directional solidification.
4. Foundry practices for cast iron, steel and non-ferrous materials, study of plant and foundry layout.
5. Casting defects and their remedies - case studies and recent trends in casting and solidification.

VII. Class /Laboratory Schedule

Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, seminars and end semester exam.

b. Grades: Relative grading

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20. MML 535: FAILURE ANALYSIS OF ENGINEERING MATERIALS (3-0-0) (3 CREDITS)

I.Brief Description:
Departmental elective course for third semester M.Tech. students

II. Course Coordinator: Dr. A. A. Likhite
III. Pre-requisites and Co-requisites: None
IV.Textbook and /or Other Required Material

a) Bob Ross; Investigating Mechanical Failures; Chapman & Hall (1st Edition), 1995.
b) Wulpi D.J; Understanding How Components Fail; (2nd Edition), 1999.
c) Collins J.S.; Failure of Materials in Mechanical Design; A Wiley Interscience Publications, (2nd Edition), 1993.
d) ASM; Failure Analysis; The British Engine Technical Reports, 1981.

V.Course Outcomes:
Upon successful completion of this course, each student should be able to understand:

a. Techniques of failure analysis
b. Procedure for failure analysis and report writing
c. Detailed analysis of failures associated with metallurgical parameters

VI.Expanded Course Description

1. Techniques of failure analysis Stage of analysis, procedural sequence, collection of background data, classification of various failure needs, preparation of questionnaire, review of mechanical testing methods used in failure analysis, review of NDT method and their application in failure analysis
2. Classification of fatigue and fracture modes, fractography and preparation of samples for fractography. Distortion failure, residual stress in engineering components, ductile and brittle fractures, fatigue fractures, Fundamentals of fracture mechanics; Casting / Welding related failures, Metallurgical failure in cast products and weldments ,Corrosion related failures. Practical examples and case studies, Elevated temperature failures. Creep Mechanism ,Elevated temperature fatigue ,Thermal fatigue , Metallurgical Instabilities, Environmentally induced failures.
3. Wear Related failure: Wear types, Contact stress fatigue prevention methods. Subsurface origin and surface origin fatigue; Sub-case origin, cavitation fatigue, Case Studies on : (Metallurgical aspects) Failure of Shaft, bearings etc ,Failure of Mechanical fasteners ,Failure in Pressure vessels, Failure in Welded structure, Failure of gears, Advanced experimental techniques in failure analysis.

VII. Class /Laboratory Schedule
Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, seminars and end semester exam.
b. Grades: Relative grading

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21. MML 537: NANO MATERIALS AND CHARACTERIZATION (3-0-0) (3 CREDITS)

I. Brief Description:
It is a Departmental Elective (DE) subject at Master level. This subject is designed to give students to understand fundamental mechanism controlling formation of nanostructures and its effect on functional properties. Thrust is also given on use of modern characterization tools which are used for to study structure and properties of nanomaterials.

II. **Course Coordinator**: Dr. Jatin Bhatt

III. **Pre-requisites and Co-requisites**: None

IV. **Textbook and /or Other Required Material**

a. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties and Applications, , Imperial College Press, 2nd Edition, 2004

b. T. Pradeep , Nano- The Essentials, Tata McGraw-Hill, 1st Edition, 2008

c. H. S. Nalwa, Handbook of Nano structured Materials and Nano Technology, H. S. Nalwa, Vols 1-5, Academic Press(2000)

d. M.S, Ashby, P.J. Ferreira, D. L. Schodek, Nanomateials, Nanotechnologies and Design, Elsevier Press, 2009

V. **Course Outcomes**:

Upon successful completion of this course, each student should be able to understand:

a. Origin of novel properties in nanomaterials

b. Understanding of novel properties using modern testing tools

c. In-situ and Ex-situ structural characterization of nanostructured materials

d. Mechanism involved in synthesis of nanostructured materials

e. Application of nanostructured materials in biomedical and device industry

f. Social implication and long term environmental effects of nanomaterials

VI. **Expanded Course Description**

i. Introduction: Emergence of Nanotechnology, Bottom up and top down approaches, Challenges in nanotechnology.

ii. Fundamentals of solid surfaces in nanoscale: Surface energy, nucleation theory, Chemical potential and stabilization

iii. Synthesis and Fabrication of Nanostructures: nanoparticle (OD), nanowire and nanorod (1D), Thin films (2D) and bulk nanostructured materials.

iv. Investigating and Manipulating materials in Nanoscale: Electron Microscopy, Scanning Probe Microscopy, Optical Microscopy and Chemical Spectroscopy.

v. Properties of Nanomaterials: Electronic, Optical, Chemical, Mechanical, Thermal and Magnetic properties.

vi. Applications of Nanomaterials: Existing and emerging in Electrical, optical, catalytic, magnetic, biology, medicine and energy.

vii. Society and Nano/ Safety: Societal Implications of Nanoscience and Nanotechnology, Environment and Health Issues of nanomaterials.

VII. **Class Schedule**

Lecture: Three 50 minutes sessions per week

VIII. **Evaluation of Students:**

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, two class test/quizzes/home assignments and end semester exam.

b. Grades: Relative grading

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22. MML 545: NON-DESTRUCTIVE EVALUATION (3-0-0) (3 CREDITS)

I. **Brief Description**:

It is a Departmental Elective (DE) course for 3rd Semester M.Tech. students.

II. **Course Coordinator**: Dr. M M Thawre

III. **Pre-requisites and Co-requisites**: None

IV. **Textbook and /or Other Required Material**

a) Baldev Raj & T. Jayakumar ; Practical Non-destructive Testing; Nanda Publishers, 1997.

b) Gordon & Breach ; Non-Destructive Testing, 1971

c) Ultrasonic Testing, - Krautkrammer Norsa Publ., 1993

d) Feigenbanm A.V.; Total Quality Control,
e) Metal Handbook ASM 8th Edition, Vol. II
f) Davis Toxell; Non destructive evaluation of properties of materials

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Principles of various NDT techniques
b. Imaging techniques in NDT
c. Advanced methods of NDE

VI. Expanded Course Description

1. Introduction and scope of non-destructive testing and evaluation (NDT/NDE) methods. Visual examination, principles and equipments ,optical aids. Liquid penetrant testing:, principle, procedure, penetrant materials and methods, applications.Principles of magnetic particle testing, procedures and equipment's for MPT ,magnetic field testing; limitations of MP methods ,electromagnetic testing for residual stress measurement. Eddy current testing, principle and instrumentation, techniques like high sensitivity, multifrequency, high area, pulsed ECT, inspection of ferro-magnetic material, application and limitation ECT.
2. Radiographic inspection, principle, radiation sources, radiation attenuation's; film effect.Radiographic imaging, Imaging techniques: single wall, double wall, penetration ,single image etc., applications and case studies; limitations. Ultrasonic Testing, case studies, limitations. Special / advanced techniques of NDE /AET, thermography, replica microscopy (in situ). Leak testing, remote field ECT, microwave inspection, topography, holography.
3. Criteria for selection of NDT methods and instruments related to metallurgical processes / defect in cast ,forged and rolled, heat treated and fabricated items (one case study for each category), reliability in NDT. Statistical method & quality control in NDT codes and standard specifications.

VII. Class Schedule

Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, two class test/quizzes/home assignments and end semester exam.
b. Grades: Relative grading

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23. MML 541 ENVIRONMENTAL MANAGEMENT (3-0-0) (3 CREDITS)

I. Brief Description:

It is a Departmental Elective (DE) course for 3rd Semester M.Tech. students.

II. Course Coordinator:

III. Pre-requisites and Co-requisites: None

IV. Textbook and /or Other Required Material

a) Rau GJ and Wooten CD; EIA Handbook, Tata Mc-Graw Hill, 1986.
b) Dameja SK; Environmental Engineering and Management, SK Kataria and Sons, 2002.
c) Mo EF; Govt. Of India current documents and guidelines for EIA.

V. Course Outcomes:

Upon successful completion of this course, each student should be able to understand:

a. Pollution prevention strategies
b. Environmental legislation
c. Environmental audit

VI. Expanded Course Description

1. Eco System : Concept, Structure and functions; Biodiversity and it's conservation.Sustainable development; definition, significant issues in the context of India, Environmental carrying capacity.
2. Environmental Pollution; Air, Water, Land, Noise etc., Pollution Prevention Strategies: Cleaner technologies of Production, Principles of waste minimization.
3. Environmental legislation in India: Water Act 1974 , Air Act 1981, EPA 1986 and other important Acts.Environmental Impact Assessment (EIA): Identification, Prediction and Evaluation of Impacts on various environmental Components including Socio-economic, Methodologies, Environmental Management Plan, Environmental Impact Statement, EIA process in India for Industries and Infrastructure Development Projects.
4. ISO 1400, EMS, LCA, Environmental labeling, Environmental Audit, Design for Environment, environmental TQM.

VII. Class Schedule

Lecture: Three 60 minutes sessions per week

VIII. Evaluation of Students:

a. Evaluation: A process of continuous evaluation is followed. It comprises of two sessional exams, two class test/quizzes/home assignments and end semester exam.
b. Grades: Relative grading

24. MMD501 PROJECT PHASE - I (6 CREDITS)

25. MMD502 PROJECT PHASE - II (18 CREDITS)

ABOUT THE DEPARTMENT

The Department of Metallurgical and Materials Engineering was founded in 1965, offers under-graduate course in Metallurgical & Materials Engineering (ME) . Both the UG/ PG program have been periodically accredited by AICTE. The department is actively engaged in various activities such as R & D, testing, consultancy and continuous education programs. The department has established materials engineering center in 1998, under India-RECs- UK project which is equipped with sophisticated and state-of-the-art equipments for materials development, characterization, and evaluation of metallic, polymeric, ceramic, QIP center and composite materials. The departmental is also a QIP center for Ph. D. Programme.

DEGREE PROGRAMMES:

B.Tech, M. Tech. (Materials Engineering), M. Tech. (by Research), Ph. D.

Area of Research:

Ferrous & non ferrous Extraction, Physical and structural metallurgy, materials engineering, foundry, process metallurgy (welding, tribology), Corrosion, Powder Metallurgy, Polymers, Composites etc.

MAJOR LABORATORY FACILITIES:

- Mechanical :- Creep, Fatigue, Hardness, Impact, Tensile Testing, NDT
- Structural :- XRD, SEM-EDS, Metallographs, Hot Stage Microscope
- Thermal :- TG/DTA, DSC, FTIR, TMA, Spectrometers

PROCESS METALLURGY:

- Wear Analysis - Pin-on-Disc
- Corrosion – Potentiostate, Salt spray, Stress corrosion cracking
- welding
- Foundry – Melting units, sand testing
- Mineral Dressing - Crushers, Mills, Classifiers
- Furnaces – Induction melting, resistance

POLYMER PROCESSING/TESTING:

- Single Screw Extruder
- Environmental Stabilizer
- Polymer Moulding and Testing
- Vacuum Forming
- Melt Flow Indexer
- Heat Distortion Temperature (HDT), Vicat Softening Point (VSP)
- Dart Impact Tester
- Dual Column Densitometer

MAJOR RESEARCH PROJECTS:

- Fatigue of Composite Laminates containing ply-drops,2004 –2008 **(AR & DB sponsored)**
- Evaluation of gas turbine/Compressor blade materials,2002 - 2005 **(DST – UISTRF sponsored)**
- Corrosion behavior of Cu-Ni-Mn alloys,2004 - 2006 **(MHRD sponsored)**
- High Temperature Mechanical (LCF, Creep) Testing of nuclear materials 2006 – onwards **(IGCAR)**
- Effect of weld metal chemistry, process parameters on weld metal with 7018 electrode -2008-onwards **(M/s Ador Welding Systems, Mumbai)**
- Effect of retrogression & re-ageing parameters on mechanical & stress corrosion properties of 7010-alloys, 2008-onwards, NRB.
- Development of carbidic austempered inoculated low carbon equivalent iron, __ -onwards , 2011-2014 (**DST)**
- Influence of normalization & tempering heat treatment on tensile & creep properties of grade 92 steel, 2011- 2015 , **(BRNS)**
- Testing for damage evaluation of new composite materials and components (at features level), 2011 – onwards, (**ACECOST**)

IMPORTANT CONSULTANCY PROJECTS:

Actively involved in testing & consultancy activities for industries in and around Nagpur in following areas:

- Failure investigations
- Coating and tribological behaviors
- Corrosion investigations
- Mechanical characterization
- Chemical characterization
- Assessment of capacities and performance evaluation of various equipments
- Materials selection and specifications
- Re-engineering of critical and import substitute components

AWARDS AND HONORS:

- “S&T Best Innovation Award” from KVIC (GoI) for development of rural technologies
- “Parkhe Award” for development of C-free ferrochrome
- “Parkhe Award” for developing Test Rig for Formability Testing of Thick Plates
- About a dozen students have achieved ranks in top 100 at national level exam, GATE-2008 etc.

SPECIAL INITIATIVES

- Hosted 14th NASAS and 18th NASAS on fatigue, Fracture, and Ageing Structures. VNIT-IGCAR MoU was signed
- Training for rural blacksmiths to better the efficiency and quality of the product

COLLABORATION:-

Since its inception, the department has established regular interactions with reputed organizations like ARCI Hyderabad, Bhabha Atomic research Center (BARC) Mumbai, DMRL Hyderabad, Indira Gandhi Center for Atomic Research (IGCAR) Kalpakkam, NML Jamshedpur, JNARDDC Nagpur, Sheffield Hallam University UK in addition to all major metallurgical based industries in and around Nagpur.

INDUSTRIAL COLLABORATIONS:

1. M/s Ador Welding Systems, Mumbai
2. Western Coal Fields Ltd., Nagpur
3. FACOR, Nagpur
4. Sunflag Steel Industries, Bhandara
5. Llyods Steels Ltd., Wardha
6. Welmet Technology, Nagpur
7. Duraweld Wear Plates Pvt. Ltd.
8. ACC Nihon Castings Ltd., Butibori
9. Pooja Castings, Pune
10. Kalyani Carpenters Ltd. Pune
11. Star wires Ltd. Faridabad
12. Koradi Thermal power Station
13. Ace Refractories, Nagpur
14. Indorama Synthetics India Pvt. Ltd., Butibori,
15. Arctec Systems Ltd. Butibori, Nagpur Nagpur
16. Power Grid Corporation, Nagpur

INSTITUTIONAL COLLABORATIONS:-

1. A.R.C.I., Hyderabad
2. D.M.R.L. Hyderabad
3. I.G.C.A.R. Kalpakkam
4. J.N.A.R.D.D.C Nagpur
5. N.A.L, Bangalore
6. N.M.L. Jamshedpur

COMMUNITY SERVICE:

The department is actively working in rural sector under following programmes:

a) Improvement in tools life of agriculture and blackmithy tools and optimization of heat treatment parameters

b) Development of laminates from agricultural and forest wastes

DISTINGUISHED ALUMNI:

- Dr. R.S. Chandel – Professor, University of Utah, Canada
- Dr. G.S. Gupta – Professor, IISc Bangalore
- Mr. P. Jayade – CTO, UNISYS Corp, New York
- Mr. P.N. Joglekar – GM (Tech.), EWAC Alloys, L&T
- Mr. P.V. Kulkarni – CEO & VP, Star Wires, Ballabgarh
- Dr. B.S. Murthy – Professor, IIT Madras
- Dr. M. Thubrikar – Professor of Surgerey, USA
- Dr. B.S. Rao – Scientist, IGCAR Kalpakkam

FACULTY MEMBERS

Sr. No.	Name of Faculty Members	Designation	Specialization
1)	Dr. D.R. Peshwe	Professor & Head	Physical Metallurgy, Composites and Solidification Process
2)	Dr. A.P. Patil	Professor	Corrosion Engineering
3)	Dr. S.G. Sapate	Professor	Wear, Heat Transfer
4)	Dr. S. U. Pathak	Steel Chair Professor	Failure Analysis, Foundry Technology, Extractive Metallurgy
5)	Dr. S.N. Paul	Associate Professor	Polymer Engineering
6)	Prof. D.V. Moghe	Associate Professor	Iron & Steelmaking , Direct Reduction, Clean Steelmaking
7)	Dr. A.A. Likhite	Associate Professor	Aus tempered Ductile Iron, Solidification Processing, Process Control, Taguchi Methods, Foundry Technology
8)	Dr. Jatin Bhatt	Associate Professor	Nano and Biomaterials, Semiconductor Material Science, Metallurgical Thermodynamics and Kinetics, Non Equilibrium Materials Processing and Technology, Metallic glasses
9)	Dr. R.C. Rathod	Assistant Professor	Corrosion Engineering
10)	Dr. A.R. Ballal	Assistant Professor	Ceramic Engineering, Mechanical Metallurgy
11)	Dr. R.K. Khatirkar	Assistant Professor	Deformation, Texture
12)	Prof. Y.Y. Mahajan	Assistant Professor	Physical Metallurgy , Welding
13)	Dr. R.V. Taiwade	Assistant Professor	Corrosion , Modeling and Simulation
14)	Dr. M. M. Thawre	Assistant Professor	Fatigue Behavior of Composites, Joining of Materials , Mechanical Metallurgy
15)	Dr. A. K. Shrivastava	Assistant Professor	Nonequilibrium Processing, Alloying Behavior and Phase Transformation, Thermally Stable Nanoscale Materials, Nanomagnetism