M. Tech. DEGREE

IN

NON - DESTRUCTIVE TESTING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(From the academic year 2014-15 onwards)

DEPARTMENT OF PHYSICS
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI - 620 015
TAMIL NADU, INDIA.

CURRICULUM

The total credits required for completing the M.Tech. Programme in Non-Destructive Testing is 64.

SEMESTER I

CODE	COURSE OF STUDY	L	T	P	C
PH601	SURFACE NDE TECHNIQUES	3	0	0	3
PH603	ULTRASONIC TESTING	3	0	0	3
PH605	RADIOGRAPHIC TESTING AND RADIATION SAFETY	3	0	0	3
	ELECTIVE I	3	0	0	3
	ELECTIVE II	3	0	0	3
	ELECTIVE III	3	0	0	3
PH607	PRACTICAL I	0	0	6	2
TOTAL CREDITS					20

SEMESTER II

CODE	COURSE OF STUDY	L	T	P	C
PH602	ADVANCE NDE TECHNIQUES I	3	0	0	3
PH604	ADVANCE NDE TECHNIQUES II	3	0	0	3
PH606	FIELD WORK	3	0	0	3
	ELECTIVE IV	3	0	0	3
	ELECTIVE V	3	0	0	3
	ELECTIVE VI	3	0	0	3
PH608	PRACTICAL II	0	0	6	2
TOTAL CREDITS					20

SEMESTER III

CODE	COURSE OF STUDY	C
PH609	PROJECT WORK – PHASE I	12
	TOTAL CREDITS	12

SEMESTER IV

CODE	COURSE OF STUDY	C
PH610	PROJECT WORK – PHASE II	12
	TOTAL CREDITS	12

LIST OF ELECTIVES*

CODE	COURSE OF STUDY
	SEMESTER I
PH611	DIGITAL SIGNAL AND IMAGE PROCESSING
PH613	BASICS OF ENGINEERING MATERIALS
PH615	MATERIAL CHARACTERIZATION TECHNIQUES
PH617	COMPOSITE TECHNOLOGY
PH679	SENSORS AND TRANSDUCERS
	SEMESTER II
PH612	FABRICATION TECHNOLOGY
PH614	FRACTURE MECHANICS AND FAILURES OF MATERIALS
PH616	PROBABILITY, STATISTICS, QUALITY AND RELIABILITY
PH618	ELECTRICAL, MAGNETIC AND OPTOELECTRONIC MATERIALS
PH 674	COMPUTATIONAL TECHNIQUES

* Electives are not limited to the given list. Courses from other PG programmes can also be chosen as subjects of study. The courses will be offered based on convenience of the faculty concerned.

PH601 SURFACE NDE METHODS

COURSE OBJECTIVES:

To provide a basic understanding with case studies on different surface NDE techniques and apply them for inspecting materials in accordance with industry specifications and standards.

Unit – I: Visual Testing

Fundamentals of Visual Testing – vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods – mirrors, magnifiers, boroscopes and fibroscopes – light sources and special lighting – computer enhanced system – Employer defined applications, metallic materials including raw materials and welds – Inspection objectives, inspection checkpoints, sampling plan, inspection pattern etc – classification of indications for acceptance criteria - Codes, Standards and Specifications (ASME,ASTM,AWS etc.)

Unit – II: Liquid Penetrant Testing

Principles – types and properties of liquid penetrants – developers – advantages and limitations of various methods - Preparation of test materials – Application of penetrants to parts, removal of excess penetrants, post cleaning – Control and measurement of penetrant process variables – selection of penetrant method – solvent removable, water washable, post emulsifiable – Units and lighting for penetrant testing – Interpretation and evaluation of test results - dye penetrant process, applicable codes and standards.

Unit – III: Magnetic Particle Testing

Theory of magnetism – ferromagnetic, paramagnetic materials – characteristics of magnetic fields – magnetic hysteresis – magnetization by means of direct and alternating current – surface strength characteristics – Depth of penetration factors – Circular and longitudinal magnetization techniques, current calculation –– field produced by a current in a coil, shape and size of coils, field strength, Magnetic Bharkhausen Noise Analysis (MBN) – advantages and limitations

Unit – IV: Magnetic Particle Testing Equipments

Selecting the method of magnetization, inspection materials, wet and dry particles – portable, mobile and stationary equipment – capabilities of equipments – magnetic particle inspection of castings and welding – Dry continuous method, wet residual method – Interpretation and evaluation of test indications – Principles and methods of demagnetization – Residual magnetism – applicable codes and standards.

Unit – V: Eddy Current Testing

Generation of eddy currents – effect of change of impedance on instrumentation – properties of eddy currents – eddy current sensing elements, probes, type of coil arrangement – absolute, differential, lift off, operation, applications, advantages, limitations – Through encircling coils, type of arrangements –absolute, differential fill factor, operation, application, advantages, limitations - Factors affecting sensing elements and coil impedance - test part and test system –

Signal to noise ratio – equipment's, reference samples, calibration, inspection of tubes, cylinders, steel bars, welded tubing, plates and pipes, Remote Field Sensing - Interpretation/Evaluation – Applicable codes and standards.

Text Books:

1. *Non-Destructive Examination and Quality Control, ASM International, Vol.17, 9th edition (1989)*
2. *J. Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2011).*
3. *B. Raj, T. Jayakumar and M. Thavasimuthu, Practical Non Destructive Testing, Alpha Science International Limited, 3rd edition (2002).*
4. *T. Rangachari, J. Prasad and B.N.S. Murthy, Treatise on non-destructive testing and evaluation, Navbharath Enterprises, Vol.3, (1983).*

Reference Books:

1. *C. Hellier, Handbook of Non-Destructive Evaluation, McGraw-Hill Professional, 1st edition (2001).*
2. *J. Thomas Schmidt, K. Skeie and P. Maclntire, ASNT Non Destructive Testing Handbook: Magnetic Particle Testing, American Society for Nondestructive Testing, American Society for Metals, 2nd edition (1989).*
3. *V. S. Cecco, G. V. Drunen and F. L. Sharp, Eddy current Manual: Test method, Vol.1, Chalk River Nuclear Laboratories (1983).*
4. *B.P.C. Rao, Practical Eddy Current Testing, Alpha Science International Limited (2006).*
5. *N. A. Tracy, P. O. Moore, Non-Destructive Testing Handbook: Liquid Penetrant Testing, Vol. 2, American Society for Nondestructive Testing, 3rd edition (1999).*

COURSE OUTCOME:

After successful completion of this course the student will be able:

1. To have a basic knowledge of surface NDE techniques which enables to carry out various inspection in accordance with the established procedures.

2. To calibrate the instrument and inspect for in-service damage in the components.

3. Differentiate various defect types and select the appropriate NDT methods for better evaluation.

4. Ability to communicate their conclusions clearly to specialist and non-specialist audiences.

5. Documentation of the testing and evaluation of the results for further analysis.

PH603 ULTRASONIC TESTING

COURSE OBJECTIVES:

To introduce students to a variety of practical applications associated with ultrasonic testing and the course is especially designed to provide a sound theoretical knowledge and practical skill for Ultrasonic testing. Wide range of case studies would be covered.

UNIT – I: Fundamentals of Ultrasonic Waves

Nature of sound waves, wave propagation in metals– modes of sound wave generation – longitudinal waves, transverse waves, surface waves, lamb waves –Velocity, frequency and wavelength of ultrasonic waves – Ultrasonic pressure, intensity and impedance – Attenuation of ultrasonic waves – reflection, refraction and mode convection – Snell's law and critical angles – Fresnel and Fraunhofer effects – ultrasonic beam split – wave propagation in other engineering materials.

Unit – II: Generation of ultrasonic waves

Methods of ultrasonic wave generation – piezo electric effect, piezo electric materials and their properties – crystal cuts and mode of vibration – Ultrasonic search Units (transducers), types (straight, angle, dual) – Construction materials and shapes – Beam intensity, characteristics, sensitivity, resolution and damping – Transducer operation, manipulations.

Unit – III: Ultrasonic Inspection Methods and Equipment

Principle of pulse echo method, through transmission method, resonance method – Advantages, limitations – contact testing, immersion testing, couplants – Data presentation A, B and C scan displays, comparison of contact and immersion method. Pulse Echo instrumentation, controls and circuits, pulse generation, signal detection, display and recording methods, gates, alarms and attenuators, detectability of defects.

Unit – IV: Calibration of Testing Equipment

Basic instrument calibration – calibration blocks (IIW Block, ASTM Blocks, Distance Amplitude Block, Area Amplitude Block, etc.), cables, connectors, test specimens etc. Reference reflectors for calibration (side drilled holes, notches, etc.) – Inspection calibration, comparison with reference blocks, reference for planned tests (straight beams angle beam. etc.), transmission factors – factors affecting the performance of ultrasonic test.

Unit – V: Testing/Evaluation/interpretation

Weld body examination with normal and angle beam by DAC and DGS methods – Ultrasonic testing and evaluation of base material product forms (a) Ingot, (b) Plate and Sheet (c) Bar and Rod (d) Castings (e) Forgings (f) Pipe and Tubular products, Ultrasonic test indications, Variables affecting ultrasonic test results- case studies in metals and composites- weld geometries, root inspection - types, origin and typical orientation of discontinuities - response of discontinuities to ultrasound – safety precautions, Test Procedure, Applicable codes and standards, specifications (ASME, ASTM, AWS, BS. etc.)

Text Books:

1. *J. Krautkramer and H. Krautkramer, Ultrasonic Testing of Materials, Springer, 4th edition (1990).*
2. *B. Raj, C.V. Subramanian and T. Jayakumar, Non Destructive Testing of Welds, Woodhead Publishing, 1st edition (2000).*
3. *L. Schmerr and J. Song, Fundamentals of Ultrasonic Nondestructive Evaluation, Springer, 1998.*

Reference Books:

1. *P. J. Shull, Nondestructive Evaluation: Theory, Techniques, and Applications, CRC Press, 1st edition (2002).*
2. *C.V.Subramanian, Practical Ultrasonics, Alpha Science International, (2006).*
3. *A.S. Birks and R.E. Green, Ultrasonic Testing, Nondestructive Handbook, Vol. 7, American Society for Nondestructive Testing, 2nd edition (1991).*

COURSE OUTCOME:

After successful completion of this course the student will be able

1. To have a basic knowledge of ultrasonic testing which enables them to perform inspection of samples.

2. To calibrate the instrument and evaluate the component for imperfections.

3. Differentiate various defect types and select the appropriate NDT methods for the specimen.

4. To document a written procedure paving the way for further training in specific techniques.

PH605 RADIOGRAPHIC TESTING AND RADIATION SAFETY

COURSE OBJECTIVES:

The course is intended to provide through grounding in the principle of Radiographic Testing (RT) and fundamentals of material and process such that the student would be able to identify suitability of RT for the material inspection. To get familiarized with codes, standards and specifications for RT with respect to safety norms.

Unit – I: Basic Principles of Radiography
Geometric exposure principles, shadow formation, shadow sharpness – Radio isotopic sources – types and characteristics – Production and processing of radioisotopes – radiographic cameras - X-ray source generation and properties – industrial X-ray tubes – target materials and characteristics – change of mA and KVP effect on "quality" and intensity of X-rays – High energy X-ray sources – linear accelerators.

Unit – II: Film Radiography
X-ray film – structure and types for industrial radiography – sensitometric properties – use of film, characteristic curves (H & D curve) – latent image formation on film – radiographic exposure, reciprocity law, photographic density – X-ray and gamma ray exposure charts – exposure time calculations – film handling and storage – Effect of film processing on film characteristics – Processing defects and their appearance on films – control and collection of unsatisfactory radiographs – Automatic film processing.

Unit – III: Radiographic Image Quality and Radiographic Techniques
Radiographic sensitivity – Radiographic Contrast, film Contrast, Subject Contrast, Definition, Radiographic density – penetrameters or Image Quality Indicators – Intensifying screens – intensification factor, control of scattered radiation, filters, diaphrams, masks – Radiography of weldments – single and double wall Radiography – panoramic radiography.

Unit – IV: Radiation Detectors and Safety
Special and SI Units of radiation – Principle of radiation detectors – ionization chamber, proportional counter, G. M. counters, scintillation counters, solid state detectors – Biological effect of ionizing radiation – Operational limits of exposures – Radiation hazards evaluation and control – Design of radiography installation and shielding calculations.

Unit – V: Special Radiographic Techniques and Interpretation of radiographs
Principles and applications of Fluoroscopy/Real-time radioscopy – advantages and limitations – recent advances, intensifier tubes, vidicon tubes etc – Principle of neutron radiography - attenuation of neutrons - direct and indirect technique - advantages and limitations – Principle and application of in-motion and flash radiography.

Interpretation of radiographs:- Interpretation for welds, castings etc, applications, various case studies, Inspection standards - applicable codes, standards and specifications (ASME, ASTM, AWS, BS, IBR etc.)

Text Books:

1. *L. E. Bryant and P. Mclntire, Non-Destructive Testing Hand Book: Radiography and Radiation Testing, Vol.3, American Society for Non-Destructive Testing, 2nd edition (1985).*
2. *R. Halmshaw, Industrial Radiography: Theory and Practice, Springer, 2nd edition (1995).*
3. *Non-Destructive Examination and Quality Control, ASM International, Vol.17, 9th edition (1989)*

Reference Books:

1. *R. H. Bossi, F. A. Iddings and G.C. Wheeler, Radiographic Testing, American Society for Nondestructive Testing, 3rd edition (2002).*
2. *B. Raj, T. Jayakumar and M. Thavasimuthu, Practical Non Destructive Testing, Alpha Science International Limited, 3rd edition (2002).*
3. *Eastmn Kodak, Radiography in modern industry, Eastman Kodak Co, 3rd edition, (1969).*

COURSE OUTCOME:

By successful completion of this course, the student will

1. Have a complete theoretical and practical understanding of the radiographic testing, interpretation and evaluation.

2. Select the appropriate technique and exposure time for a better imaging.

3. Differentiate various defect types and characterize them.

4. Follow proper safety precautions to avoid radiation hazards.

PH607 PRACTICAL I

OBJECTIVES:

To provide knowledge and enrich ideas about the conventional NDT techniques and develop a strong hands on experience for inspecting and evaluating components in accordance with industry specifications.

List of Practicals

1. Inspection of welds using solvent removable visible dye penetrant.
2. Inspection of welds using solvent removable fluorescent dye penetrant.
3. Familiarization and calibration of eddy current equipment.
4. Inspection on non magnetic/magnetic materials by eddy current method.
5. Inspection of welds by Eddy current Testing.
6. Inspection of welds by Magnetic Particle Testing - Dry method.
7. Inspection of welds by Magnetic Particle Testing- Wet method.
8. Inspection of a welded plate by radiographic single wall single image technique- X rays.
9. Inspection of a welded pipe by Panoramic Technique- Gamma rays.
10. Inspection of a welded pipe by double wall single image technique - Gamma rays.

OUTCOME:

After completing these experiments the students will be able to

1. Handle the eddy current instrument and perform inspection of weldments with unknown defects.
2. Inspect and evaluate the surface imperfections using penetrant testing method.
3. Inspect subsurface defects by magnetic particle and eddy current testing method.
4. Evaluate and Interpret radiographs for defect analysis.

PH611 DIGITAL SIGNAL AND IMAGE PROCESSING
(Elective)

COURSE OBJECTIVES:

To introduce discrete signal and image processing concepts and their application.

Unit – I: Discrete Time signal and systems
Basics of signals – Periods, frequency, phase – Mathematical representation of signals –Discrete time signals, data acquisition – Sequences – Linear shift-invariant systems – Stability and Causality – Linear constant Co-efficient difference equations – Frequency-domain – Representation of Discrete-time systems and signals – Representation of discrete-time signals by Fourier transform – signal analysis - time-domain analysis- determination of signal power and energy – gating methods – time gate – peak determination- echo detection – time-frequency analysis – short time Fourier transform – wavelet.

Unit – II: Transform analysis of linear time invariant systems
Z-transform – Region of convergence – Relation between Z- transform and Fourier Transform – Frequency response –Phase distortion and delay – system functions – Frequency response of rational system functions–first-order systems – Basic Digital filter structures – FIR and IIR filters.

Unit – III: Filter Design Techniques and Fast Fourier Transform
Signal noise – inherent noise, EMI noise, random noise, speckle noise, process induced noises etc – Design of FIR filters by window method – Rectangle – Hanning – Hamming – Kaiser – IIR Filters design – Bilinear Transformation – Discrete Fourier Transform – Computation of DFT.

Unit – IV: Continuous and Digital Image Characterization
Image representation - 2D-systems - 2D-Fourier Transform - Light perception - Eye Physiology - Visual phenomena - Monochrome vision model - 2D Image sampling & reconstruction - Image sampling systems - Aliasing effects - Image reconstruction systems - Vector-space Image representation - Image Quantisation.

Unit – V: Liner Image Processing methods and Image Enhancement
Introduction to image representation – spatial and frequency domain –. Generalized 2D Linear operator - Superposition – Filtering – Convolution and De-convolution - Unitary transformations - Fourier Transform - Cosine Transformation - Image reconstruction and Enhancement - Contrast manipulation - Histogram modification - Noise cleaning – Image analysis – Edge detection and crispening –contour quantification –texture analysis– statistical analysis.

Text Books:

1. *A.V. Oppenheim and R. W. Schafer, Digital Signal Processing, Prentice-Hall of India* (*2000)*
2. *W. K. Pratt, Digital Image Processing, John Wiley & Sons, 3rd edition, (2001).*
3. *R. C. Gonzalez and R. E. Woods, Digital Image Processing, Pearson Education, 3rd edition. (2008).*
4. R. Crane, A Simplified Approach to Image Processing: Classical and Modern Techniques in C, Prentice Hall, (1997)

Reference Books:

1. *L.R. Rabiner and B. Gold, Theory and Applications of Digital Signal Processing, Prentice-Hall Englewood Cliffs, 1975.*
2. *T. Bose, Digital Signal and Image Processing, John Wiley, 1st edition (2003)*
3. *A.V. Oppenheim, A. S. Will Sky and S. H. Nawab, Signals and Systems, Prentice-Hall of India, 2nd edition,* (*2004).*
4. *N. Efford, Digital image processing: a practical introduction using Java, Addison-Wesley, (2000).*

COURSE OUTCOME:

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

1. Design digital signals filters.

2. Use different image processing techniques for specific applications.

3. Apply applications like signal processing of ultrasonic signals and image processing of radiographic images.

PH613 BASICS OF ENGINEERING MATERIALS
(Elective)

COURSE OBJECTIVES:

This introductory course is aimed to obtain basic exposure to the concepts of crystalline solids, its imperfections and basics of various advance engineering materials finding wide spread application in several industries. Understanding these material systems are vital for investigating the defects and their nature on these classes of materials.

Unit –I: Structure of Metals

Different types of bonding in solids – Elements of crystal structure– Imperfections in crystals – dislocation theory - Grain boundaries and poly crystalline aggregates - Principles of Alloying – Solid solutions and intermediate phases – Gibbs phase rule and equilibrium diagram - types of binary phase diagrams - Isomorphous – Eutectic - Peritectic and Peritectoid, eutectoid reactions.

Unit –II: Steel and Heat Treatment of Steels

The Iron-carbon system – structural changes on slow and rapid cooling - martensitic transformation –concept of hardenability – TTT and CCT diagrams. Effects of carbon and alloying elements – Classification of steels.

Heat Treatment of Steels: Annealing (various types), normalizing, quenching and tempering – Case hardening, Austempering and martempering – Solidification of Metals and alloys – Nucleation and crystal growth from the liquid phase – Ingot structure dendrite freezing – Segregation effects and grain size control – strength mechanisms – solute, dispersion and precipitation hardening.

Unit– III: Non-Ferrous Metals & Ceramics

Aluminum, Aluminum alloys, Advantages and Application, Copper & Copper Alloys, Application and advantages, Titanium & Titanium Alloys, Advantages & Applications, Defects in Non ferrous metals – types, significance. Industrial importance of engineering ceramic materials, building stone, clay products, refractories, cement and concrete, ceramic matrix composite materials; high temperature ceramic materials. Application of engineering ceramic materials– Defects in ceramic materials.

Unit –IV: Composites

Importance of composites – constituents – functions of fiber and matrix – properties of fibers :aligned and random fiber composites-types of fibers-glass fiber, carbon fiber, metallic fibers, ceramic fibers-Matrix materials – Metallic and Polymer matrix composites – Manufacture methods – hand lay up & prepeg techniques, pultrusion, pulforming, therforming, resin-transfer moulding, injection moulding, Bulk moulding compound, sheet moulding compound- Defects in Composites – Fabrication & In-service Defects.

Unit –V: Mechanical behavior of materials

Elements of elastic and plastic deformation – stress-strain relation-work hardening, recovery, re-crystallization and grain growth, types of fractures in materials and their identification – Mechanical testing of metals – Tensile, Hardness, Fatigue, Creep tests and their interpretation. Mechanical testing on composites – compression, tension, ILSS, flexural.

Text Books:

1. *W. D. Callister, Materials Science and Engineering: An Introduction, Wiley, 7th edition, (2006)*
2. *V. Raghavan, Materials Science and Engineering, Prentice Hall of India, 5th edition (2013).*
3. *G.E. Dieter, Mechanical Metallurgy, Mc-Graw Hill, 3rd edition (2004).*
4. *A.V.K. Suryanarayana, Testing of Metallic Materials, Prentice -Hall of India, 2nd edition (2007).*
5. *V. B. John, Introduction to Engineering Materials, Palgrave Macmillan Limited, 3rd edition, (1992).*

Reference Books:

1. *Robert E. Reed Hill and R. Abbaschian, Physical Metallurgy Principles, PWS-Kent Publishing Company 3rd edition (1992).*
2. *L. H. Van Vlack, Elements of Materials Science and Engineering, Addison Wesley, 6th edition (1989).*
3. *I. J. Polmear, Light Alloys: Metallurgy of the Light Metals, Wiley, 3rd edition (1995).*
4. *V. Raghavan, Physical Metallurgy: Principles and Practice, PHI Learning Private Limited, 2nd edition (2006).*

COURSE OUTCOME:

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

1. Select different materials and emphasis the need of modern materials other than conventional metals and alloys for specific engineering applications.

2. Understand the heat treatment of steels using TTT and CCT diagrams.

3. Analyze the various metallurgical factors influencing the performance of materials for different structural engineering applications.

4. Define various mechanical properties of materials and their importance in materials selection criteria.

5. Classify different mechanical properties and how they can influence the materials behavior with respect to applied load.

PH615 MATERIAL CHARACTERIZATION TECHNIQUES

(Elective)

COURSE OBJECTIVES:

To familiarize the students with the fundamental principles and common material characterization methods to determine the structure and composition of solids.

UNIT – I: Optical Metallographic Techniques:

Importance of material characterization – classification of material characterization techniques – mechanical characterization process – measurement of hardness – fracture toughness through nano indentation – adhesion test-surface profilometry – tribological studies of materials, Optical microscopic techniques.
Macro examination-applications – metallurgical microscope – principle, construction and working, metallographic specimen preparation – optical properties – magnification, numerical aperture, resolving power, depth of focus, depth of field, various illumination techniques – bright field , dark field, phase-contrast polarized light illuminations, interference microscopy – Image analysis.

UNIT – II: Surface Analysis Techniques:

Importance of surface characterization techniques–principle, working and applications of AFM, Surface area, pore volume measurements by B.E.T. method, Mercury porosimetry - Particle size measurement, Principle and working of SEM, STEM, TEM, imaging dark and bright field–specimen preparation techniques–merits and demerits- applications.

UNIT– III: X Ray Diffraction Techniques:

Characteristic X–ray spectrum-Bragg's Law–Diffraction methods-Laue method, rotating crystal method, powder method – X ray diffractometer – determination of crystal structure–lattice parameter-measurement of residual stress.

UNIT – IV: Analytical Techniques:

Principles, working and application of DTA, TGA, TMA and DSC– UV–Visible (UV–VIS), IR & Raman spectroscopy–FTIR, NMR, X-ray fluorescence spectroscopy – EDXRF, WDXRF. Auger Electron spectroscopy, X-ray photoelectron spectroscopy – Optical emission spectroscopy

UNIT – V: Ion Beam Techniques:

Rutherford Backscattering Spectrometry (RBS), Secondary Ion Mass Spectroscopy, Electron backscatter diffraction (EBSD), Focused Ion Beam (FIB), elastic recoil detection analysis and nuclear reaction analysis

Text Books:

1. *K. R. Hebbar, Basics of X-Ray Diffraction and its Applications, I.K. International Publishing House Pvt Ltd, (2007)*
2. *V. A. Phillips, Modern Metallographic Techniques and their Applications, John Wiley & Sons, 1st edition, (1972).*
3. *V. T. Cherepin and A. K. Mallic, Experimental Techniques in Physical Metallurgy, Asia Publishing Compny, (1967).*

Reference Books:

1. *B. D. Cullity, Elements of X-ray Diffraction, Prentice Hall, 3rd edition, (2001).*
2. *A. Mammoli, C. A. Brebbia and A. Klemm, Materials Characterisation, WIT Press, 1st edition, (2011).*
3. *V. Voort, Metallography: Principle and practice, ASM International, (1999).*

COURSE OUTCOMES:

By successful completion of this course, the student will be able to

1. Have an understanding of the basic physics, mechanisms and applications of the characterization methods commonly used in materials engineering.
2. Know the principles of metallurgical microscope, X-ray Diffractrometer (XRD), scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Thermal analysis and dilatometer.
3. Perform various sample/specimen preparation techniques for XRD, SEM and TEM.
4. Can determine the crystal structure, lattice parameter, surface topography using different methods.
5. Can select appropriate tool to characterize the material by knowing its merits and demerits.

PH617 COMPOSITE TECHNOLOGY
(Elective)

<u>COURSE OBJECTIVES:</u>

The objective for this course is to give an introduction to the basic theory, properties and applications of composite materials which has advance applications ranging from aerospace to automotive, industrial and consumer products.

UNIT– I: Introduction to Composites
Importance of composites- constituents – functions of fiber and matrix – properties of fibers: aligned and random fiber composites-types of fibers-glass fiber, carbon fiber, metallic fibers, ceramic fibers and various types of fibers – Matrix materials –Metallic, polymer and ceramic matrix materials, Polymer matrix composites -Thermosetting and thermoplastic polymers, properties of polymers like epoxies, phenolics, polyester peek etc.

UNIT – II: Manufacturing of Composites
Manufacturing Process – hand lay up and curing technique, prepeg technique, open and closed mould processes – pressure bag and vacuum bag molding techniques, pultrusion, pulforming, therforming, resin-transfer moulding, injection moulding, Bulk moulding compound, sheet moulding compound.

UNIT – III: Sandwich structures and Joining of Composites
Sandwich Structures:- Face and core materials–Honeycomb types, properties, manufacturing–Adhesive materials–Honeycomb process–sandwich fabrications– Design aspects-Laminate lay.
Joining Process: - Bonded joints–joint design–tooling for composites–Failure criteria.

UNIT– IV: Defects and Inspection of Composites
Production Defects:- Porosity, fiber orientation, waviness, breakage, fiber misalignment, shrinkage, fiber volume fraction, resin rich and resin starved, inclusions, voids, disbonds, ply misalignment – ***In service Defects:-*** Delaminations, Impact damage, Heat damage, Stress Rupture, matrix cracking, matric-fiber debonding, fiber breakage.

Inspection methods:- NDI techniques – Ultrasonics – choice of frequency, defect detection, characterization and imaging– acoustic emission, acousto ultrasonics and ultrasonic spectroscopy-Thermal methods – pulsed and lock In thermogrphy and IR imaging, shearography and laser Doppler vibrometry – simualtion and modelling .

UNIT– V: Applications and case studies

Standards- specifications- Various structural applications of composites in aerospace, automobiles, marine industries and concrete structures– safety precautions– merits and demerits-few case studies.

Text Books:

1. *K. K. Chawla, Composite Material: Science and Engineering, Springer, 3rd edition, (2012).*
2. *D. Hull and T. W. Clyne, An Introduction to Composite Materials, Cambridge University Press, 2nd edition (1996).*

Reference Books:

1. *L. J. Broutman and R. H. Krock, Modern Composite Materials, Addison-Wesley, 1st edition (1967).*
2. *Vistap M. Karbhari, Non-Destructive Evaluation (NDE) of Polymer Matrix Composites, Woodhead Publishing, 1st edition (2013).*

COURSE OUTCOME:

After the successful completion of this course, the student would be able to:

1. Understand about fibers, matrix and resins in a composite material.
2. Fabricate different varieties of composite materials and find its properties.
3. Implement various inspection methods to find its imperfections and its application in various industries.

PH679 SENSORS AND TRANSDUCERS

(Elective)

COURSE OBJECTIVES:

To introduce the basic concepts and technology of modern sensors used in industrial applications and in scientific equipments.

Unit – I: Temperature Sensors

Introduction to sensors – classification of sensor – sensor characteristics **-** physical principles of sensing **–** thermal sensors gas thermometric sensors – thermal expansion type sensors – thermoresistive Sensors – resistance temperature detectors – silicon resistive sensors – thermistors – thermoelectric contact sensors – thermoelectric law – thermocouples – thermocouple assemblies – semiconductor p-n junction sensors – optical temperature sensors – interferometric sensors – thermochromic solution sensor – acoustic temperature sensor – piezoelectric temperature sensors.

Unit – II: Position and Displacement Detectors

Ultrasonic sensors – microwave motion detectors – capacitive occupancy detectors – tribo electric detectors – optoelectronic motion detectors – visible and near-infrared light motion detectors – far-infrared motion detectors – potentiometric sensors – gravitational sensors – capacitive sensors – inductive and magnetic sensors – LVDT and RVDT - eddy current sensors – transverse inductive sensor – Hall effect sensors – magnetoresistive sensors – magnetostrictive detector – optical sensors – optical bridge-proximity detector with polarized light – fiber optic sensors – radar sensors – thickness and level Sensors – liquid-level sensors

Unit – III: Acceleration and Pressure Sensors

Accelerometer characteristics – capacitive accelerometers – piezo-resistive accelerometers – piezoelectric accelerometers – thermal accelerometers – heated plate accelerometer – heated gas accelerometer – gyroscopes – rotor gyroscope - monolithic silicon gyroscopes – optical gyroscopes – piezoelectric cables. Strain Gauges - tactile sensors – piezoelectric force sensors – pressure gauges: mercury pressure sensor – bellows, membranes and thin plates – piezo-resistive sensors – capacitive sensors – VRP Sensors – optoelectronic sensors.

Unit – IV: Flow, Acoustic and Humidity Sensors

Basics of flow dynamics – pressure gradient technique – thermal transport sensors –ultrasonic sensors – electromagnetic sensors – microflow sensors – breeze sensor – coriolis mass flow sensors – drag force flow sensors. Acoustic sensors: resistive microphones –condenser microphones – fiber optic microphone – fiezoelectric microphones – electric microphones – solid state acoustic detectors – humidity and moisture sensors – concept of humidity – capacitive sensors – electrical conductivity sensors – thermal conductivity sensor.

Unit – V: Chemical Sensors and Smart Sensors

Chemical sensor characteristics – classification of chemical-sensing mechanisms-direct sensors – metal-oxide chemical sensors – chemfet – electrochemical sensors – potentiometric sensors – conductometric sensors – amperometric sensors – enhanced catalytic gas sensors – thermal sensors – optical chemical sensors – biochemical sensors – enzyme sensors – smart sensors – MEMS sensors – nano sensors.

Text Books:

1. *D. Patranabis, Sensors and Transducers, Prentice-Hall of India, 2nd edition (2005).*
2. *J. Fraden, Hand book of modern sensors: Physics, design, and application, Springer, 3rd edition (2004).*

Reference Books:

1. *E. O. Deoblin, Measurement Systems, Tata Mc-Grow Hill, 6th edition (2012).*
2. *I. R. Sinclair, Sensors and Transducers, Newnes, 3rd edition (2001).*
3. *M. J. Usher, Sensors and Transducers, Macmillan Publishers Limited, (1985).*

COURSE OUTCOME:

After the successful completion of this course, the student would be able to:

1. Understand many modern devices and technologies used in sensors.

2. Appreciate various material properties which are used in engineering applications and devices.

3. Understand the application of various sensors for direct contact and non-contact measurements.

PH602 ADVANCED NDE TECHNIQUES I

COURSE OBJECTIVES:

To introduce students with the recent advances in the field of ultrasonics and to equip them with the knowledge of different process for a better evaluation in complex geometries.

UNIT – I: Phased Array Techniques
Principles of phased array inspection – phased array probes and their characteristics – Phased array wedges – Focal law sequencing – Beam shaping, steering – principles of inspection sensitivity – Scanning with phased array probes- linear, sectorial, C scan mapping – **I**nstrumentation – phased array instruments, calibration methods, checking probe elements – beam angles and beam shape – data collection and data analysis, principles of data analysis – data acquisition, defect detection, sizing, interpretation and characterization – procedures for verification of flaw existence and position, reporting, applications – Case studies.
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UNIT – II: Time of Flight Diffraction
Theory and principles of Time of Flight Diffraction (TOFD) – Mathematical model, Data acquisition and interpretation – TOFD techniques – selection of probe angle – calibration and optimization, optimizing angles – flaw location and sizing – types of scan, equipment requirements – advantages, limitations of detection and resolution – codes and standards – interpretation, evaluation, applications, case studies.
Synthetic Aperture Focusing Technique (SAFT):- Principles of (SAFT), focusing and reconstruction of images, Signal processing of SAFT data, Advantages, Limitations, Applications with few case studies.

UNIT– III: Ultrasonic Guided Waves
Types of guided waves – Generation of guided waves – Plate theory – Rayleigh-Lamb Equation, Guided waves in Plates, Pipes and rods – Wave structure analysis – Dispersion curves –Modes in guided waves – Air coupled ultrasonic guided waves – advantages and limitations – Applications, few case studies.
Electro Magnetic Acoustic Transducer (EMAT)-Basic principles – types of coil and design – Generation and defect detection of guided waves using EMATS- - advantages and limitations – Applications- case studies.

UNIT – IV: Optical methods in Ultrasonics
Laser Ultrasonics – Laser fundamentals – types of lasers – bulk wave and lamb wave generation mechanisms – optical detection of ultrasound – measurement of in plane displacement and velocity – holographic NDT – recording and reconstruction of a hologram – Two wave mixing interferometry – Laser shearography – Applications (Laser ultrasonics for flaw detection and material characterization) – Case studies.

UNIT– V: Non Linear Ultrasonics and Structural Health Monitoring

Non Linear Ultrasonics:- Higher harmonic generation-Principles of non linearity in elastic solids – non linear ultrasonics of fatigue damage – Non linearity of surface and Lamb waves – applications – case studies.

Structural Heath Monitoring (SHM):- Condition Monitoring (CM)- life and integrity assessment-comparison between SHM and CM – acousto ultrsonics – vibrational NDT methods.

Text Books:

1. *J. L. Rose, Ultrasonic waves in solid media, Cambridge University Press, (2004).*
2. *T. Kundu, Ultrasonic Non-Destructive Evaluation: Engineering and Biological Material Characterization, CRC Press, 1st edition, (2003).*
3. *L. W. Schmerr, Fundamentals of Ultrasonic Phased Arrays, Springer, (2014)*
4. *Phased Array Testing: Basic Theory for Industrial Applications, Olympus NDT, (2004).*
5. *Introduction to Phased Array Ultrasonic Technology Applications, R/D Tech, (2004).*

Reference Books:

1. *Z. Shu and L. Ye, Identification of Damage Using Lamb Waves: From Fundamentals to Applications, Springer, (2009).*
2. *Advances in Phased Array Ultrasonic Technology Applications, Olympus NDT, (2007).*
3. *J. A. Ogilvy and A.G. Temple, Diffraction of elastic waves by cracks: Application to Time of Flight Inspection, Ultrasonics, volume 7, 259-269, (1983).*
4. *G. Baskaran, K. Balasubrmaniam and C. L. Rao, Shear wave time of flight diffraction (S-TOFD) technique, NDT&E International, volume 39, 458-467, (2005).*
5. *S. Mondal, An overview of TOFD method and its mathematical model, www.ndt.net/rticle/v05n04/mondal*
6. *L.J. Busse, Three dimensional imaging using a frequency domain synthetic aperture focusing technique, IEEE Transac.UFFC 39, 174-179, (1992)*
7. *Phased array techniques-Olympus NDT, (1999).*
8. *C. B. Scruby and L. E. Drain, Laser Ultrasonics: Techniques and Applications, CRC Press, (1990).*

COURSE OUTCOME:

After successful completion of this course the student will be able

1. To have a better knowledge in the field of advanced techniques in ultrasonic NDE.
2. To plot dispersion curves and perform long range inspection using guided waves for plates, pipes and rods.
3. To size the defects using TOFD technique.
4. To carry out examination by optical techniques to measure the inplane displacement and velocity.
5. To differentiate various defect types and select the appropriate NDT method for inspecting the component.

PH604 ADVANCED NDE TECHNIQUES II

COURSE OBJECTIVES

To develop a fundamental knowledge about the advanced techniques and the recent developments in non-destructive testing so as to control the quality in manufacturing engineering components.

Unit – I: Acoustic emission inspection
Principles and Theory – Signal Propagation – Physical Considerations – The AE Process Chain - Time Considerations – AE Parameters –The AE Measurement Chain – Types of displays – Noise – Location calculation and Clustering – Advantages – Limitations – Relationship to other test methods - inspection of pressure vessels/welds/composite materials – AE testing during grinding – pipelines – steam turbines – AE location of faults in power transformers.

Unit – II: Leak Testing
Introduction to leak testing– objectives – terminologies – measurement of leakage –Types of leak – Types of flow in leaks – Principles of Fluid dynamics – Leak Testing of Pressure Systems Without and with a Tracer Gas – Halogen diode leak testing – Helium mass spectrometer leak testing and subsystems – Choosing the Optimum Leak Testing Method – System response in leak testing – Measurement of Leak Rate Using Calibrated Leaks – Common errors in Leak testing- Leak testing for special applications-standards.

Unit – III: Thermographic NDE
Introduction and fundamentals to infrared and thermal testing – Heat transfer – Active and passive techniques – Lock in and pulse thermography – Contact and non contact thermal inspection methods – Heat sensitive paints – Heat sensitive papers –- thermally quenched phosphors liquid crystals – techniques for applying liquid crystals – other temperature sensitive coatings – Inspection methods – Infrared radiation and infrared detectors – thermo mechanical behavior of materials – IR imaging in aerospace applications, electronic components, Honey comb and sandwich structures – Case studies.

Unit – IV: Digital Radiography
Principles of Digital Radiography – applications – merits of digital radiography over conventional radiography – methods of digital radiography – digitization of X-ray films – computed radiography(CR) and direct radiography (DR) – process of image formation in CR – comparison of film, CR and DR method- applications.

Unit – V: Industrial Computed Tomography (CT)
Computed Tomography – Radiation Sources – X-Ray Detectors – CT image reconstruction algorithm – Capabilities, comparison to other NDT methods – industrial CT applications – CT System design and equipment – CT scanning geometries, data acquisition system – Image quality, image artifacts, special features, reconstruction techniques.

Text Books:

1. *X. P. V. Maldague, Nondestructive evaluation of materials by infrared thermography, Springer-Verlag, 1st edition, (1993).*
2. *A. S. Paipetis,T. E Matikas and D. G. Aggelis, Emerging Technologies in Non-Destructive Testing, CRC Press, (2012).*
3. *C. U. Grosse, Acoustic Emission Testing, Springer, (2008).*

Reference Books:

1. *X. P.V. Maldague, Non-Destructive Testing Handbook; Infrared and Thermal Testing , Vol-3, series III, American Society for Non-Destructive Testing, 3rd edition (2001).*
2. *C. N. Jackson and N.Sherlock , Non-Destructive Testing Handbook; Leak Testing , Vol -1, , series VI, American Society for Non-Destructive Testing, 3rd edition, (1998).*
3. *R. K.Miller and V.K.Hill, Non-Destructive Testing Handbook; Acoustic Emission Testing, Vol-6, series V, American Society for Non-Destructive Testing, 3rd edition, (2005).*

<u>COURSE OUTCOME:</u>

After successful completion of this course the student will be able to

1. Understand the recent developments in NDE and their application in various industries.
2. Select proper advanced NDE technique for a better inspection and evaluation of components.
3. Apply all the NDE methods on a component and compare the best technique for specific applications.

PH 606 - FIELD WORK

COURSE OBJECTIVES:

To undergo industrial experience and gain practical training in various testing and joining process from reputed industries and R&D centers.

1. Evaluation of manufacturing process of Drums
2. Evaluation of manufacturing process of Pipes
3. Evaluation of manufacturing process of Headers
4. Evaluation of manufacturing process of Tubular products
5. Evaluation of manufacturing process of Valves
6. Evaluation of manufacturing process of Fittings
7. Evaluation of manufacturing process of Nuclear Components
8. Mechanical and Metallurgical testing of materials and welds
9. Calibration of tools and equipments used in fabrication
10. Quality Assurance and systems audits

Industry / R& D center

1. Uses of Strain Gauges for Stress Analysis	**WRI , BHEL**
2. Fracture Analysis studies	**WRI , BHEL**
3. Conventional NDE Techniques including Real Time Radioscopy	**NDTL, BHEL**
4. NDE for Residual Life Assessment Studies	**NDTL, BHEL**
5. Structural Integrity and evaluation of composites	**NAL, Bangalore**

PH608 PRACTICAL II

OBJECTIVES:

To provide knowledge about the advanced NDT techniques and develop a strong practical skill for inspecting and evaluating components in accordance with industry specifications.

List of Practicals

1. Familiarization of ultrasonic flaw detectors
2. Familiarization and Calibration of reference bocks using ultrasonic flaw detector.
3. Plotting DAC curves by normal and angle beam probes.
4. Inspection of welds in plates by ultrasonic angle beam testing.
5. Inspection of welds in plates by ultrasonic angle beam testing.
6. Inspection of butt welds in pipes by ultrasonic angle beam testing.
7. C -Scan Imaging of metal samples using ultrasonic immersion transducer.
8. Characterization of defects in honey comb and composite laminates using thermography.
9. Calibration of Phased Array equipment for defect detection.
10. Determination of mechanical properties of materials using ultrasonic pulse echo method.

OUTCOME:

After completing these experiments the students will be able to

1. Handle the ultrasonic instrument and perform inspection of weldments with unknown defects.
2. Evaluate the A, B and C Scan profile using ultrasonic immersion testing.
3. Inspect composite structures using IR camera.
4. Operate Phased array equipment for a effective defect detection.

PH612 FABRICATION TECHNOLOGY
(Elective)

COURSE OBJECTIVE:

To understand the basic concepts of metal casting, forming and joining technology in order to produce new materials.
To know the concepts of metal joining technology and apply them for various manufacturing processes.

Unit – I: Casting and Forging Processes
Principles and characteristics of major casting processes – sand casting – shell mould casting- permanent mould casting – die casting – centrifugal casting – continuous casting – plaster mould casting – investment casting – ceramic mould casting – shaw process – unicast process – Slush casting and composites mould casting – Metal forming processes – types – design of forging dies–metal spread during forging and forging defects – rotary swaging.

Unit – II: Welding processes
Heat sources and shielding methods – Gas Welding – flame characteristics – different kinds of flame and applications – manual metal arc welding – functions of flux covering – different types of electrodes and applications – Submerged arc welding – Gas Metal arc welding - resistance welding – pulsed MIG and TIG welding- flash butt welding- advantages and limitations –

Unit – III: Friction Stir Welding
Friction stir welding:- Concepts – Metal flow phenomena, tools, process variables and applications and induction pressure welding: Process characteristics, defects during FSW, NDE of FSW, applications

Unit – IV: Welding defects
Effect of pre and post welding structural changes in different materials- process induced defects in welds – their causes and remedies – effect of metallurgical parameters – concept of weldability test and assessment.

Unit – V: Other Engineering Joining Process
Brazing, soldering, cutting, surfacing, adhesive joints, bolted and riveted- processes – joining materials, advantages and limitations- applications – inspection of the joints – case studies.

Text Books:

1. *R. W. Heine, C. R. Loper P. C. Rosentha, Principles of Metal Casting, McGraw -Hill, 2nd edition, (1967).*
2. *P. L. Jain, Principles of Foundary Technology, McGraw Hill, 5th edition, (1995).*
3. *R. S. Parmer, Welding Engineering and Technology, Khanna Publishers, 2nd edition, (2010).*

Reference Books:

1. *N. K. Srinivasan, Foundary Technology, Khanna Publications, (1986).*
2. *H. B. Carry and S. Helzer, Modern Welding Technology, Prentice Hall, 6th edition, (2004).*
3. *R. S. Mishra, M.V. Mahoney,Y. Sato and Y. Hovanski, Friction Stir Welding and Processing, John Wiley & Sons, (2013).*
4. *M. D. Jackson, Welding Methods and Metallurgy, Grffin, (1967).*

COURSE OUTCOME:

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

1. Design a new pattern or mould for required applications, if needed.
2. Classify the different welding processes with their inherent merits and limitations.
3. Solve the materials problems associated with joining technology.
4. Produce low cost manufacturing possibilities with dissimilar materials and by selecting proper joining process.
5. Provide the low cast manufacturing possibilities by appropriate selection of the joining process.

PH614 FRACTURE MECHANICS AND FAILURES OF MATERIALS
(Elective)

COURSE OBJECTIVES:

This introductory course is aimed to obtain exposure to the concepts of failure mechanism of materials on structural application. Also to provide a valuable roadmap for investigating, analyzing and solving current materials failure issues and preventing mechanisms.

Unit –I: Fracture of Materials
Types of fractures in metals– Ductile and brittle fractures – Cohesive strength of metals, Griffith theory of brittle fracture, metallographic aspects of fracture, dislocation theories of brittle fracture, ductile fracture, fracture under combined stresses.

Unit –II: Fracture Mechanics
Introduction to Linear elastic fracture mechanics (LEFM) and elastic plastic fracture mechanics (EPFM) – Strain energy release rate, stress intensity factor, fracture mechanics toughness, fracture toughness testing– Anelastic deformation at the crack tip, Notch bar fracture mechanics and the micro mechanics of cleavage fracture. CTOD – Relation between CTOD, KI and G1. J–integral & R-curve.

Unit– III: Fatigue of Materials
Introduction to fatigue of materials, stress cycles. S-N curve, Low-cycle fatigue, stress life & strain life equations, fatigue crack propagation, concepts of damage tolerance under fatigue cracks, cumulative damage concepts, modifiers in fatigue – stress concentration, temperature, corrosion, defects, surface effects, residual stresses.

Unit –IV: Corrosion
Basic principles – different forms of corrosion – atmospheric corrosion, galvanic corrosion, general biological corrosion – Localized corrosion -, pitting corrosion- mechanism of stress corrosion cracking, Hydrogen embrittlement – prevention and control of corrosion – Corrosion monitoring.

Unit –V: Failure Analysis
Failure mechanism-effect of variables-part shape, type of loading, stress concentration, wear failure-adhesive, abrasive, erosive, corrosive wear, corrosion failures-elevated temperature failures, creep, thermal fatigue, oxidation, micro structural instability - Cause of failure in components - misuse, assembly errors, manufacturing defects, improper maintenance-design errors, improper material, improper heat treatment, operating conditions, inadequate quality assurance, and discontinuities.

Text Books:

1. *G.E. Dieter, Mechanical Metallurgy, Mc-Graw-Hill Book Company, 3rd edition (2004).*
2. *P. Kumar, Elements of Fracture Mechanics, Tata McGraw-Hill Education, 1st edition (2009).*
3. A. *K. Das, Metallurgy of Failure Analysis, McGraw Hill Professional, 1st edition (1997).*
4. *P. Roberge, Corrosion Engineering: Principles and Practice, McGraw - Hill Professional, 1st edition (2008).*

Reference Books:

1. *N. E. Dowling, Mechanical Behavior of Materials;* Engineering Methods for *Deformation, Fracture, and Fatigue, Pearson Prentice Hal, 3rd edition (2007).*
2. *S. R. Lampmn and N. D. DiMatteo, Fatigue and Fracture, Vol.19, ASM Handbook, ASM International, (1996).*
3. *S. D. Cramer and B. S. Covino, ASM Handbook Volume 13B: Corrosion: Materials, ASM International,(2005).*
4. *D. A. Jones, Principles and Prevention of Corrosion Pearson Education, 2nd edition (2013).*
5. *D. Broek, Elementary engineering in fracture mechanics, Springer, 4th edition, (1986).*
6. *S. Suresh, Fatigue of materials, Cambridge University Press, 2nd edition, (1998).*

COURSE OUTCOME:

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

1. Find the life assessment of engineering materials and analyze various factors affecting fatigue and corrosion.

2. Provide suitable remedial measure to prevent premature failure and reduction in performance.

3. Describe the failure modes and root cause of the materials failure based on fracture mechanics and fractography approach.

PH616 PROBABILITY, STATISTICS, QUALITY AND RELIABILITY
(Elective)

COURSE OBJECTIVES:

To strengthen and improve the ability to use theory, design and techniques of quality control systems and to utilize reliability considerations in engineering design for a improved safety life. To learn statistical tools and quality philosophy in order to control the quality in manufacturing and production engineering components.

UNIT –I: Probability and Random Variable
Concepts of probability – Random variables – Baye's Theorem – Standard Probability Distributions – Binomial, Poisson, Normal, Geometric, Exponential distributions – Correlation and Regression.

UNIT– II: Statistical Quality Control
Statistical basis for control charts – control limits – control charts and types – control charts for variables, defective and defects – introduction to six sigma – inspections by sampling – OC curves – acceptance sampling plans.

Unit – III: Quality
Basics of quality – Quality philosophy – quality control – quality assurance – design for quality management system – Quality certification and accreditation schemes – total quality management and Taguchi's method – quality standards and procedures – ISO 9000 Series – 14000 Series.

UNIT– IV: Reliability
Basic concepts of reliability – Reliability Vs Quality – Hazard and failure rate analysis – mean time between failures (MTBF) – mean time to failure (MTTF) – Mathematical models for reliability studies – Normal, Exponential and Weibull failure laws – Reliability of systems – Series system, Parallel system, Series-Parallel system.

UNIT–V: NDE Reliability
Applications of reliability to systems - General Considerations: NDE response, NDE systems management and schedule – Procedure selection/development of NDE Engineering – System/process – performance characteristics - Conditional probability in NDE discrimination Signal/ noise relationships, reference standards personnel – Modeling of NDE reliability– PoD – Benefits of PoD – approaches to modeling PoD – Applications (case studies) – Air frames – gas turbine engines – Space shuttle - Statistical nature of NDE process.

Text Books:

1. *D. C. Montgomery, Introduction to Statistical Quality Control, John Wiley & Sons, 6th edition, (2009).*
2. *S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand, 10th edition, (2000).*
3. *A. Birolini, Reliability Engineering: Theory and Practice, Springer, 6th edition, (2010).*

Reference Books:

1. *Thomas Pyzdek, The Six Sigma Handbook, McGraw-Hill, 2000.*
2. *C. E. Ebeling, An introduction to Reliability and Maintainability engineering, Waveland, 2nd edition, (2009).*
3. *J. S. Oakland, Total Quality Management, Butterworth–Hcinemann Ltd., 3rd edition, (2003).*
4. *R. S. Leavenworth and E. L. Grant, Statistical Quality Control, Tata McGraw –Hill Education, 7th edition, (2000).*

COURSE OUTCOME:

On successfully completing this course, the students will be able to:

1. Understand the key concepts of life-cycle cost analysis and to make considered judgements regarding optimal maintenance and/or repair strategies.

2. Apply simulation and sampling techniques to evaluate the reliability of structural components or systems qualitatively.

3. Perform simple calculation in SQC and reliability to real applications.

4. Evaluate the nominal probability of failure of a structure using a time-independent reliability formulation.

PH618 ELECTRICAL, MAGNETIC AND OPTOELECTRONIC MATERIALS

(Elective)

COURSE OBJECTIVES:

To understand the fundamentals and applications of electrical, magnetic and optical properties of materials. Apply a multi-disciplinary approach to plan, design, identify and address future needs of all the conventional and novel materials utilizing their properties for the society.

Unit – I: Electrical and Dielectric Materials

Review of electrical conduction – discussion on specific materials used as conductors (OFHC, Ag, Al, other alloys) – temperature dependent resistivity of Copper and CuNi alloy – Nordheim rule – CuAu alloy – dielectric phenomena – concept of polarization – effects of composition, frequency and temperature on these properties – discussion on specific materials used as dielectrics (ceramics and polymers) – $BaTiO_3$ – dielectric loss, dielectric breakdown – ferro electricity – piezo and pyro electricity.

Unit – II: Magnetic Materials

Introduction to dia, para, ferri and ferro magnetism – hard and soft magnetic materials – iron-silicon alloys – iron, nickel alloys – ferrites, garnets and LCMO – rare earth alloys – Pt alloys – fine particle magnetism – applications of hard and soft magnetic materials – Giant Magneto Resistance – magnetocaloric effect – spintronics – multiferroics – nanomagnetic materials.

Unit – III: Superconducting and Semiconducting Materials

Concept of super conductivity – theories and examples for high temperature superconductivity – discussion on specific super conducting materials – Nb_3Sn – YBCO – MgB_2 – Carbon based – comments on fabrication and engineering applications – review of semiconducting materials – concept of doping – simple and compound semiconductors – amorphous semiconductor – oxide semiconductors – organic semiconductor – low dimensional semiconductor – materials for solar cell applications – Hall effect – homojunction – schottky barrier – heterojunction – materials and applications.

Unit – IV: Production of Electronic Materials

Binary alloy phase diagram (PbSn and CuNi) – homogeneous and heterogeneous nucleation – methods of crystal growth for bulk single crystals – Czochralski – Bridgman – low and high temperature solution growth – floating zone method - synthesis of epitaxial films by LPE, VPE, PVD, MBE and MOCVD techniques – lithography – production of silicon – applications.

Unit – V: Optical and Optoelectronic Materials

Principles of photoconductivity – simple models – effect of impurities – principles of luminescence – types and materials, Laser Principles – ruby, He-Ne, injection, Nd-YAG and Dye lasers – LED materials – binary, ternary photo electronic materials – Optical storage materials –

LCD materials – photo detectors – applications of optoelectronic materials – introduction to optical fibers – light propagation – electro optic effect – electro optic modulators – Kerr effect – Pockel's effect.

Text Books:

1. *C. Kittel, Introduction to Solid State Physics, John Wiley and Sons, 7th edition,New Delhi, (2004).*
2. *A. J. Dekker, Electrical Engineering Materials, Prentice Hall, NJ, (1959).*
3. *L. H. Van Vlack, Elements of Materials Science and Engineering, Addison –Wesley, 6th edition, New York, (1989).*

Reference Books:

1. *V. Raghavan, Materials Science and Engineering, Prentice Hall of India, 5th edition, New Delhi, (2013).*
2. *B. G. Yacobi, Semiconductor Materials: An Introduction to Basic Principles, Springer, 1st edition, New York, (2013).*
3. *S. Kasap and P. Capper (eds.), Handbook of Electronic and Photonic Materials, Springer, New York, (2007).*

COURSE OUTCOME:

Upon completion of this course, the student will be able to:

1. Obtain knowledge about the electrical, magnetic and optoelectronic materials, their properties and applications.

2. Successfully apply advanced concepts of materials engineering for the design, development and analysis of materials and devices.

3. Develop novel materials from the fundamental understanding of materials and apply them to societal needs.

PH674 COMPUTATIONAL TECHNIQUES

(Elective)

COURSE OBJECTIVES:

To introduce Programming tools in C language, MATLAB and LABView which will be useful for further research studies.

Unit – I: C programming

C programming basics - arithmetic operators– library functions – data input and output – relational operators – control statements – looping arrays functions – simple programs – user defined functions – pointers – passing pointers to functions – structures.

Unit – II: Introduction to MATLAB

MATLAB environment – working with data sets – data input/output – logical variables and operators – array and X-Y Plotting – simple graphics – data types matrix, string, cell and structure – file input and output – matlab files – simple programs.

Unit – III: Applications of MATLAB

Matrices and array operation – elemental matrix functions – file functions – application of matlab – solving linear algebraic equations – curve fitting – interpolation – numerical integration – basic 2D Plots – overlay plots – specialized 2D plots – 3D plots – view.

Unit – IV: Introduction to LABVIEW

Introduction to LABVIEW tools palette, controls & functions palette, data types, conversion – front panel, block diagram construction, parallel data flow, create indicators/controls/constants math operations, booleans, arrays, case structures, sequences – for loops, while loops – I/O reading and writing to files, paths, graphing, timed loops, signal generation/processing, waveform types, connecting to hardware, DAQ, serial, GPIB, TCP/IP and USB interface

Unit – V: Modeling Approaches:

Artificial Intelligence: artificial neural networks, fuzzy logic, genetic algorithm; applications in NDT. *Finite Element Methods:* Introduction to 1D FEM – Problems in wave propagation and structural mechanics using 2D elements- Plane stress and plane strain analysis, 3D stress analysis-Simulation packages – ABAQUS, ANSYS, COMSOL multiphysics for structural health monitoring applications.

Text Books:

1. *S. Chandra, Applications of Numerical Techniques with C, Narosa Publishing House Pvt. Limited, (2006).*
2. *R. Pratap, Getting Started with MATLAB: A Quick Introduction for Scientist and Engineers, Oxford University Press, (2010).*
3. *K. L. Ashley, Analog Electronics with LabVIEW, Prentice Hall Professional, 2003.*
4. *T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 4^{th} edition, (2011).*

Reference Books:

1. *V. K. Ingle and J. G. Proakis, Digitals signal processing using MATLAB, Cengage Learning, 3rd edition, (2011).*
2. *Ross L. Spencer and Michael Ware, Introduction to MATLAB, Brigham Young University, 2010.*
3. *Rafael C. Gonzalez, Richard E. Woods and Steven L. Eddins, Digital Image Processing Using MATLAB, Tata McGraw-Hill Education, 2nd edition, (2010).*
4. *Learning MATLAB – The MathWorks, Inc. (1999).*
5. *LabVIEW Basics I Course Manual, National Instruments Corporation.*

COURSE OUTCOME:

Upon completion of this class, the student will be able to:

1. Familiarize with the computational tools available in MATLAB, LabVIEW and COMSOL for variety of physical problems.
2. Model the structural behavior using various simulation tools.

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