M.Tech. DEGREE

(NON-DESTRUCTIVE TESTING)

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(2006-2007 Admission onwards)

DEPARTMENT OF PHYSICS
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI - 620015

National Institute of Technology, Tiruchirappalli - 620015
DEPARTMENT OF PHYSICS

M.Tech. (Non-Destructive Testing)

Four Semester (Credit System)

		L (Periods)	T	P (Periods)	C
I SEMESTER					
PH 601	Radiographic Testing and Radiation Safety	3	-	-	3
PH 603	Basic Metallurgy and Fracture Mechanics	3	-	-	3
PH 605	Surface NDE Methods	3	-	-	3
PH 607	Practicals – I [Radiography]	-	-	6	2
	Elective – I	3	-	-	3
	Elective – II	3	-	-	3
					17
II SEMESTER					
PH 602	Ultrasonic Testing	3	-	-	3
PH 604	Field Work	3	-	-	3
PH 606	Practicals – II [Ultrasonic Testing]	-	-	6	2
	Elective – III	3	-	-	3
	Elective – IV	3	-	-	3
	Elective – V	3	-	-	3
	Elective -- VI	3	-	-	3
					20
III SEMESTER					
PH 647	Project Work - Phase I	0	0	0	12
					12
IV SEMESTER					
PH 648	Project Work & Viva Voce – Phase II	0	0	0	12
					12
	Total Credits				**61**

ELECTIVES

Semester I

PH 609 Fabrication Technology
PH 611 Digital Signal and Image Processing
PH 613 Electrical and Electronic Measurement Techniques
*MT 776 Surface Engineering

Semester II

PH 608 Thin film technology and application
PH 610 Electrical, Magnetic and Optoelectronic Materials
PH 612 Nanoscience and Technology & Applications
PH 614 Advanced NDT Techniques – I
PH 616 Advanced NDT Techniques – II
*MT 761 Engineering Materials

* ***Any other courses from other department with the consent of HOD***

PH 601 - RADIOGRAPHIC TESTING AND RADIATION SAFETY

Unit - I: Basic Principles of Radiography

Geometric exposure principles, shadow formation, shadow sharpness, etc – Radioisotopic sources – types and characteristics- Production and processing of radioisotopes - radiographic cameras - X-ray sources 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 - Ill: Radiographic Image Quality and Radiographic Techniques

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 - panaromic radiography-interpretation of radiographs and inspection standards - applicable codes, standards and specifications (ASME, ASTM, AWS, BS, IBR etc.)

Unit - IV: Special Radiographic Techniques

Principles and applications of Fluoroscopy/Real-time radioscopy - advantages and limitations - recent advances, intensifier tubes, vidicon tubes. Etc - Digital Radiography -

Principle of neutron radiography - attenuation of neutrons - direct and indirect technique - advantages and limitations – Principle and application of in-motion and flash radiography.

Unit - V: Radiation Safety

Special and SI Units of radiation - Photoelectric effect, Compton effect, Pair production -

Principle of radiation detectors - ionisation chamber, proportional counter, G. M. counters, scintillation counters, solid state detectors - Biological effect of ionising radiation - Operational limits of exposures - Radiation hazards evaluation and control - Design of radiography installation and shielding calculations.

References

1. *Non-Destructive Testing Hand Book: Radiography and Radiation Testing, VoI.3, 2nd" ed, Columbus, OH, American Society for Non-Destructive Testing, 1985.*
2. *Halmshaw. R, Industrial Radiography, Applied Science Publishers Inc. Englewood, NJ, 1982.*
3. *Radiographic Testing, Classroom training hand book, (CT -6-6) SanDiego, CA, General Dynamics/Convair Division, 1983.*

PH 603 - BASIC METALLURGY AND FRACTURE MECHANICS

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 reactions - The Iron-carbon system - Peritectic, eutectic and eutectoid reactions, 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.

Unit – II: 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 dendritic freezing - Segregation effects and grain size control – strength mechanisms – solute, dispersion and precipitation hardening.

Unit – III: Mechanical behaviour of materials

Elements of plastic deformation - work hardening, recovery, recrystallization and grain growth, types of fractures in materials and their identification - Basic Principles and different types of corrosion - Corrosion tests - protection against corrosion.

Unit - IV: Fracture Mechanics

Types of fractures - Ductile and brittle fractures - features of fracture - surface for ductile, brittle and mixed modes – fractography.

Unit – V: Modes of failure

Stresses around cracks - linear elastic fracture mechanics - fracture toughness testing in practice - General yielding fracture mechanics- Notch bar fracture mechanics and the micro mechanics of cleavage fracture. The cleavage fibrous transition - fibrous fracture and impact testing - Applications of fracture mechanics to crack growth by fatigue or stress - corrosion mechanisms.

References

1. *Physical Metallurgy Principles :-R.E.Reed - Hill*
2. *Theoretical structure Metallurgy - A.H.Cottrell*
3. Raghavan V, 'Materials Science and Engineering', 4th Edition, Prentice Hall of India, 1998.

PH 605 - SURFACE NDE METHODS

Unit – I: Visual Testing

Fundamentals of Visual Testing - Vision, lighting, material attributes, environmental factors, Visual perception, direct and indirect methods - mirrors, magnifiers, Boroscopes Fibroscopes, closed circuit television, light sources and special lighting, A systems, computer enhanced system - Employer defined applications, metallic materials including raw materials and welds - Inspection objectives, inspection checkpoints, sampling plan, inspection pattern etc. classification of indictions 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 surface 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 hysterisis - magnetisation by means of direct and alternating current - surface strength characteristics - Depth of penetration factors, Direct pulsating current typical fields, advantages - Circular magnetisation techniques, field around a strength conductors, right hand rule field - Prods technique, current calculation - Longitudinal magnetization - field produced by current in a coil, shape and size of coils, field strength, current calculations, Magnetic Burghausan Noise Analysis (MBN).

Unit - IV: Equipments

Selecting the method of magnetisation, inspection materials, wet particles, 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 demagnetisation - Residual magnetism, - applicable codes and standards.

Unit - V: Eddy Current Testing

Generation of eddy currents - effect of created fields - effect of change of impedance on instrumentation - properties of eddy currents - eddy current sensing elements, probes, type of arrangement - a) absolute b) differential lift off, operation, applications, advantages, limitations - Through encircling or around coils, type of arrangements a)absolute b) differential fill factor, operation, application, advantages, limitations - Factors affecting sensing elements and coil impedance - test part and test system - Signal to noise ratio, relationship to eddy current testing - equipment's, reference samples, calibration, inspection of tubes, cylinders, steelbars. welds, welded tubing and pipes, Remote Field Sensing - Interpretation/Evaluation.

References

1. *American Metals Society, "Non-Destructive Examination and Quality Control", Metals Hand Book, Vol.17, 9th Ed, Metals Park, OH, 1989.*

2. *Eddy Current Testing, Classroom Training Handbook, (CT-6-5), San diego, CA, General Dynamics/Convair Division, 1979.*
3. *Eddy current Manual by V.S. CEECO, Van, Drunen and F.L. Shaw, supplied by A.S.N.T.*

PH 607 – PRACTICALS - I
[Radiographic Testing and Magnetic Particle Inspection]

List of Practicals

1. Familiarisation of X-ray, Gamma ray equipments and Film Processing
2. Safety equipments and Calibration of Survey Meters
3. RT of plate butt weld by Single wall Single Image Technique - X-ray
4. RT of pipe butt weld by Panoramic Technique- Gamma rays
5. RT of pipe butt weld by Double wall Single image Technique - Gamma rays
6. RT of pipe butt weld by Double wall Double Image Technique- Gamma rays
7. Interpretation of Radiographs
8. Magnetic Particle Inspection of Welds - Dry method
9. Magnetic Particle Inspection of Welds - Wet and Fluorescent methods
10. Read Time Radiography of Tube welds.

PH 609 - FABRICATION TECHNOLOGY (Elective)

Unit - I: Casting Processes

Characteristics of major casting processes - sand casting - CO process - 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: Classification of 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 - advantages and limitations - process variables and their effects - significance of flux metal combination - modern developments - applications.

Unit - III : Gas Metal arc welding

Considerations of electrode polarity - shielding gas and filler composition nature and conditions for spray transfer - difficulties for thin sheet - Dip transfer - and CO welding - flux cored, narrow gap and pulsed MIG welding.

Unit - IV: Resistance Welding

Principles of contact resistance - surface preparation - calculation of current time and voltage for spot welding - temperature distribution - spot welding cycle - inter relationship between process variables - choice of electrode material - Heat transfer and Heat balance welding of dissimilar combinations - spot seam and projection welding - upset butt welding and flash butt welding - defects in welding - significance of defects.

Unit – V: Total Quality Management

ISO 9000 Series - 14000 Series - Quality Assurance.

References

1. *Principles of Metal casting-R.W.Heine, et al.McGraw Hill 1967.*
2. *Analysis of Casting defects APF1964.*
3. *Theoretical structure metallurgy - AH. Cottrell.*

PH 611 - DIGITAL SIGNAL AND IMAGE PROCESSING (Elective)

Unit - I: Discrete Time signal and systems

Discrete-time signals - 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.

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

Design of FIR filters by window method - Rectangle -Hanning - Hamming - Kaiser - IIR Filters design - Bilinear Transformation - Discrete Fourier Transform - Computation of DFT-Decimation in time FFT and Frequency. Introduction to optimal filters.

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 - Monochrome.

Unit - V: Liner Image Processing and Image Enhancement

Generalized 2D Linear operator - Superposition - Convolution - Unitary transformations - Fourier Transform - Cosine Transformation - Image Enhancement - Contrast manipulation - Histogram modification - Noise cleaning - Edge crispening.

Reference

1. *Digital image processing, William K. Pratt, 3rd Edn, John Wiley & Sons, Inc., USA, 2001.*
2. *Digital Signal Processing, Alan V. Oppenheim and Ronald W. Schafer, New Delhi, 2000.*
3. *Theory and Applications of Digital Signal Processing, L.R. Rabiner and B. Gold, Printice-Hall Englewood Cliffs NJ, 1975.*

PH 613 - ELECTRICAL AND ELECTRONIC MEASUREMENT TECHNIQUES (Elective)

Unit - I: Measurement and Error

Accuracy and precession - Types of Error - Statistical analysis - standards and calibration - Performance Characteristics of Instruments - static and dynamic characteristics - step and ramp response of first and second order instruments - frequency responses.

Unit - II: Current Transformers

Theory and characteristics of Current Transformers - causes and reduction of errors - construction - clamp on ammeters - effect of secondary open circuit - Permanent magnetisation and demagnetization - Transformers for high frequencies – Theory, characteristics and construction of Potential Transformers - reduction of errors - high voltage potential transformer - difference between C.T. and P.T. - Capacitive Potential transformers - testing of Instrument transformers - current and potential transformer Testing - Solved Problems.

Unit - III: Measurement of Power

Power in D.C. and A.C. Circuits - electrodynamometer and wattmeters - Construction, Theory, shape of scale - wattmeter errors - Torsion head electrodynamometer wattmeters - Ferrodynamic wattmeters - Cambridge Reflecting wattmeter - low power factor Wattmeters - thermocouple wattmeter - Electrostatic wattmeters, Induction type wattmeters - Lipman type Induction wattmeter - Hall Effect Multiplier, Measurement using Instrument Transformers - Power in Poly-Phase systems - Three Phase Wattmenters, measurement of Reactive Power, summation metering, unsolved problems.

Unit - IV: Measurement of Energy

General Motor meters, braking, friction - energy meters for A.C. Circuits, single phase Induction types watt-hour meters - construction, theory and operation - lag adjustment devices, light load or friction compensation creep - over-load compensation, voltage compensation, temperature compensation, errors, adjustments - polyphase energy meters, two element energy meters, industrial metering and tariffs - maximum demand indicators, measurement of Vah and Varh - Varh metering and measurement.

Unit - V: Display Devices and Recorders

Digital display Units, strip chart and X-Y recorders, Galvanometers, CRO, Magnetic Tape Recorders.

References

1. *AK. Sawhney, " A Course in Electrical & Electronic Measurements & Instrumentation, Dhanpat Rai & Sons, Delhi, 1995.*
2. *A.D.Helfrick & W.D.Cooper," Modern Electronic Instrumentation and Measurement Techniques Prentice - Hall of India, New Delhi - 1995.*
3. *BE. Jones, "Measurement & Feed back", Tata McGraw Hill Publishing Company Ltd., 1995, New Delhi*

PH 602 - ULTRASONIC TESTING

Unit - I: Principles of Acoustics

Nature of sound waves, wave propagation - 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 - feflection, refraction and mode convection - Snell's law and critical angles - Fressnel and Faunhofer effects - ultrasonic beam split.

Unit - II: Generation of ultrasonic waves

Various 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, Equipment/Materials

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, basic instrument calibration, calibration blocks (IIW Block, ASTM Blocks, Distance Amplitude. 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.

Unit - IV:

Recent advances in ultrasonic testing, Ultrasonic imaging, Synthetic Aperture Focussing Techniques (SAFT), Time of Flight Diffraction (TOFD), Signal Analysis, Artificial Intelligence, Neural Network, Fussy logic, Guided waves ultrasonic testing.

Unit - V: Testing/Evaluation/interpretation

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 – weld geometries, root

inspection - weld body examination with normal and angle beam by DAC and DGS methods - types, origin and typical orientation of discontinuities - response of discontinuities to ultrasound - Applicable codes standards, specifications (ASME, ASTM, AWS, BS. etc.) - Variables affecting ultrasonic test results

References

1. *Krautkramer, Josef and Hebert Krautkramer, "Ultrasonic Testing of Materials", 3rd Ed, Newyork, Springer- verlag, 1983.*
2. *American Metals Society, "Non-Destructive Examination and Quality Control": Metals Hand Book:Vol 19, 9th Ed, Metals Park, OH, 1989.*
3. *"Ultrasonic Testing", Classroom Training Handbook (CT-6-4) San Diego, C.A.General Dynamics/Convair Division, 1967.*

PH 604 - FIELD WORK

The Students will undergo field work in the following areas in various advanced R&D Centers and Industries.

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

Field	Industry / R& D center
1. Uses of Strain Gauges for Stress Analysis	**WRI , BHEL**
2. 2.Fracture Analysis studies	**WRI , BHEL**
3. Conventional NDE Techniques including Real Time Radioscopy	**NDTL, BHEL**
4. NDE for Residual Life Assesment Studies	**R&D, BHEL, Hyderabad**

PH 606 - PRACTICALS – II
[Ultrasonic Testing and Liquid Penetrant Testing]

List of Practicals

1. Familiarisation of operations of Ultrasonic equipment
2. Basic calibrations of UT equipment
3. Drawing of DAC Curves by normal and angle probes

4. Ultrasonic Testing of Plate butt welds
5. Ultrasonic Testing of Pipe butt welds
6. Ultrasonic Testing of Tube butt welds
7. Testing of Raw materials - Plate
8. Testing of Raw materials - Forgings
9. Testing of Raw materials - Catings
10. Penetrant Testing of welds - Solvent Removable method

PH 608 – THIN FILM TECHNOLOGY AND APPLICATIONS (Elective)

Unit - I: **Preparation of Thin-films**

Kinetic aspects of Gases in a vacuum chamber - Classifications of vacuum ranges Production of vacuum - Pressure measurement in vacuum systems - Physical vapour deposition - Evaporation Techniques - Sputtering (RF & DC) - Pulsed Laser deposition- Liquid Phase Epitaxy- Vapour Phase Epitaxy- Molecular Beam Epitaxy.

Unit – II: **Film growth and measurement of thickness**

Thermodynamics and Kinetics of thin film formation - Film growth – five stages - In corporation of defects and impurities in films - Deposition parameters and grain size - structure of thin films - Microbalance technique - quartz crystal monitor photometric - Ellipsometry and interferometers - Measurement of rate of deposition using ratemeter - cleaning of substrate.

Unit - III: Characterization

X-ray Diffraction(XRD) - SEM, Photoluminescence(PL) - Raman Sepectroscopy, UV-Vis-IR Spectrophotometer – AFM - Hall effect – SIMS - X-ray Photoemission Spectroscopy (XPS) - Vibrational Sample Magnetometers, Rutherford Back Scattering (RBS).

Unit - IV: Properties of thin films

Dielectric properties - Experimental techniques for dielectric film - annealing effect, effect of film thickness on dielectric properties – determination of optical constants – Experimental techniques for determination of optical parameters - Magnetic and mechanical properties - Hall effect compilations - Adhesion, stress, strength, Raleigh surface waves - Ferromagnetic properties of Thin films - Experimental methods for measurement of mechanical properties of thin films.

Unit – V: Applications

Micro and optoelectronic devices, quantum dots, Data storage, corrosion and wear coatings - Polymer films, MEMS, optical applications - Applications in electronics – electric contacts, connections and resistors, capacitors and inductances - Applications of ferromagnetic and super conducting films - active electronic elements, micro acoustic elements using surface waves - integrated circuits - thin films in optoelectronics and integrated optics.

Reference

1. *K.L. Chopra, Thin film phenomena, McGraw- Hill book company New York, 1969*
2. *Ludminla Eckertova, 'Physics of thin films', Plenum press, New York 1977.*

3. *A. Goswami, "Thin film fundamentals", New age international (P) Ltd. Publishers, New Delhi, 1996.*

PH 610 - ELECTRICAL, MAGNETIC AND OPTOELECTRONIC MATERIALS (Elective)

Unit - I: Electrical and Dielectric Materials

Review of electrical conduction - resistivity and dielectric phenomena - concept of polarization - effects of composition, frequency and temperature on these properties - discussion on specific materials used as conductors (OFHC Copper, Al alloys, Fe-Si alloys, amorphous metals) - discussion on specific materials used as dielectrics (ceramics and polymers) - 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 and garnets - (Ag - Mn - Al) alloys - (Cu - Ni- Co) alloy - fine particle magnets - applications of hard and soft magnetic materials - Giant magneto resistance- Nanomaterials.

Unit - III: Semiconducting and Superconducting Materials

Review of semiconducting materials - concept of doping - simple and compound semi conductors - amorphous silicon, oxide semiconductors; amorphous semiconductors - FER, MOSFET and CMOS - Concept of super conductivity - theories and examples for high temperature superconductivity - discussion on specific super conducting materials - comments on fabrication and engineering applications.

Unit - IV: Production of Electronic Materials

Review of electronic materials - methods of crystal growth for bulk single crystals - zone melting-refining, leveling - synthesis of epitaxial films by VPE, PVD, MBE and MOCVD techniques - lithography; production of silicon - starting applications.

Unit - V: Optical and Optoelectronic Materials

Principles of photoconductivity - simple models - effect of impurities - Principles of luminescence - types, Laser Principles - ruby, He-Ne, injection, Nd-Yag and Dye lasers; LED materials - binary, ternary photo electronic materials - effect of composition on band gap, crystal structure, phase equilibria and properties - 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.

References

1. *Raghavan V, Materials Science and Engineering, 4th Edition, Prentice Hall of India, 1998.*

2. *Kittel C, Introduction to Solid State Physics, 6th Edition, Wiley Eastern, New International Publishers, 1997.*
3. *Dekker A.J, Solid State Physics, MacMillan India, 1995.*

PH 612 - NANOSCIENCE AND TECHNOLOGY & APPLICATIONS (Elective)

Unit - I: Nanomaterials and Structures

Nanomaterials – Types: Nanowires, Nanotubes, Fullerenes, Quantum Dots, Dendrimers, Nanocomposites – Properties – Methods of preparation: Top Down , Bottom Up.

Unit - II: Characterization Tools

Electron Microscopy Techniques - SEM, TEM, X ray methods - Optical Methods Fluorescence Microscopy - Single Molecule Surface Enhanced Resonance Raman Spectroscpy – Atomic Force Microscopy, MRI, STM and SPM.

Unit - III: Nanomagnetism

Mesoscopic magnetism – Magnetic measurements: Miniature Hall Detectors, Intgrated DC SQUID Microsusceptometry – Magnetic recording technology, Biological Magnets

Unit - IV: Nanoelectronics and integrated systems

Basics of nanoelectronics – Single Electron Transistor - Quantum Computation – Parallel architechture for nanosystems – nanolithography - basic structures and integrated structures – MEMS and NEMS – Dynamics of NEMS – limits of integrated electronics.

Unit – V: Biomedical Applications of Nanotechnology

Biological structures and functions – Bio molecular motors - Drug delivery systems – Nanofluidics.

References

1. *Semiconductors for micro and nanotechnology: an introduction for engineers, Jan Korvink & Andreas Greiner, Weinheim Cambridge: Wiley-VCH, 2001.*
2. *Nanoscale characterisation of surfaces & interfaces, N John Dinardo, Weinheim Cambridge: Wiley-VCH, 2000 2nd ed*
3. *Nanotechnology, G Timp (ed), AIP press/Springer, 1999.*

PH 614 - ADVANCED NDT TECHNIQUES – I

Unit - I: Acoustic emission inspection

Types of acoustic emissions - Basic concepts - instrumentation and read out - signal description - background noise - inspection of pressure vessels - flaw location - inspection of wire ‘ropes - inspection of welds - inspection of ceramic materials - Brazed metal to ceramic bonds - inspection of composite materials.

Unit –II: Leak Testing

Introduction to leak testing - visible indications of leak locations - Electronic indication of leak locations - basic methods of leakage measurements - Technology and characteristics of gaseous tracers used in leak testing - reference standard gaseous leaks - Design and operating characteristics of reference leaks - Operation of standards - Halogen leaks - Helium leaks - calibration of standard reference leaks - safety aspects of leak testing - Managements and application of leak testing.

Unit –III: Principles of Thermography

Contact and non contact inspection methods - Heat sensitive paints - Heat sensitive papers - thermally quenched phosphors liquid crystals - techniques for applying liquid crystals - calibration and sensitivity - other temperature sensitive coatings - non contact thermographic inspection - Advantages and limitation - infrared radiation and infrared detectors, Instrumentations and methods, applications.

Unit - IV: 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.

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 - Control of inspection materials, Qualification of inspection processes - Qualification of inspection Curves Relative operating Characteristic curves (RDC) Applications (case studies)

References

1. *Miller, Ronnie; and Paul Mclntire, ed, Non-Destructive Testing Handbook; Acoustic Emission Testing, VoL-5, 2" ed, Columbus, OH: American Society for Non-Destructive Testing, 1987.*
2. *Spanner, J.C. "Acoustic Emission Techniques and Applications, Evanston, I, L.: latex Publishing Co., 1974.*
3. *American Society for Metals, Non-Destructive Inspection and Quality Control: Metals hand Book, Vol-11, 8th Ed, Metals park Oh, 1976.*

PH 616 - ADVANCED NDT TECHNIQUES – II (Elective)

Unit - I: **Advance Methods of Material Characterization**

Microstructure Analysis - Optical and Scanning Electron Microscopy - Phase Analysis - X-ray diffraction-Transfer Electron Microscopy - Energy dispersive spectroscopy (EDS) - Electron Probe Micro Analysis (EPMA) - Secondary Iron Mass Spectroscopy (SIMS) - Rutherford Back Scattering (RBS) - Rockwell Hardness Test - Brinell Hardness Test- Vickers Hardness Test - Mohs Hardness Test.

Unit - II: Optical Holography and Speckle Metrology

Laser fundamentals – coherence – types of lasers – holography, recording and reconstruction – holographic interferometry – real-time, double-exposure & time-averaged techniques – holographic NDT – methods of stressing and fringe analysis – typical applications – requirements – advantages and disadvantages – laser speckle metrology basics – electronic speckle pattern interferometry (ESPI) – shearography – applications.

Unit - III: Acoustical Holography

Liquid Surface Acoustical Holography - Optical System, Object size and shape, sensitivity and resolution, commercial liquid surface equipment - Scanning Acoustical Holography - Reconstruction, Object size, Sensitivity and resolution, Commercial Scanning equipment - Comparison of liquid surface and scanning systems - Readout methods, calibration, Interpretation of results - Applications - Inspection of welds in thick materials.

Unit - IV: Stress Analysis

Polariscope - compensators -model materials - calibration of photo elastic materials - isochromatic and isoclinical fringes - stress determination - time edge effects - three dimensional photo - elasticity - Moire fringes techniques - Photo elasticity, strain gages, X- ray residual stress analysis.

Unit – V: Basics of Magnetic resonance Imaging

Tamographic window, contrast and sensitivity - Magnetic resonance phenomenon - Chemical shift, relaxation phenomena - Back projection imaging techniques, two dimensional and three dimensional back methods - Practical considerations of experimental set up - Magnetic Resonance Imaging System - Applications - Composite and elastometic material imaging.

References

1. *American Metals Society. Non-Destructive Examination and Quality Control : Metals Hand Book, Vol, 17, 9th Ed, Metals Park, 1989.*
2. *Dewit, D.P., Theory and Practice of Radiation Thermometry, Wiley-lnterscience, John Wiley & Sons, Inc, 1989.*
3. *Non - Destructive Evaluation and Quality control, ASM Hand book, Vol. 17.*

PH 647 - PROJECT WORK - Phase I

Proposed work

a) Problem Identification.
b) Literature survey.
c) Finalization of scope of study.
d) Specimen Preparation.
e) Search Unit identification and procurement necessary.
f) Preliminary studies related to phase II.
g) Report.

PH 648 - PROJECT WORK AND VIVA VOICE - Phase II

Proposed work (Continuation of Phase 1):

i) Design of Experiment.
ii) Experimental measurement.
iii) Observations and analysis.
iv) Comparison with references.
v) Conclusion and suggestions for future work.