MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI – 12

LIST OF PAPERS FOR THE PH.D. COURSE WORK IN

PHYSICS

S. No.	Courses
1	Materials Science
2	Nanomaterials
3	Space Physics
4	Crystal Growth
5	Thin film
6	Electronic structure calculation
7	Non linear dynamics
8	Medical Physics
9	Radiation Physics
10	Alternative energy conversion devices
11	Lasers and applications

S. No.	Online courses - NPTL
12	Advanced materials and processes
13	Introduction to nonlinear optics and its applications
14	Non-conventional energy resources
15	Design of photo-voltaic systems

Paper - 1: MATERIALS SCIENCE

Preamble: To expose the students with theoretical aspects of materials science. To provide the knowledge about phase diagrams, mechanical properties, ceramics, polymers, plastics and crystals.

Unit – I:Phase Diagrams

Solid solutions and intermediate phases – Equilibrium phase diagrams, Cu-Ni, Pb-Sn, Al-Cu system phase diagrams – Free energy and equilibrium phase diagrams – Nucleation and growth – Martenstic transformation – Strengthening mehanisms – Iron-Carbon system – Alloy steels – Aluminium-Copper system – Copper-Zinc system – Corrosion

Unit - II:Mechanical Properties

Stress- Strain curve – Elastic deformation: Characteristics, Atomic mechanism, Sheer stress, Bulk modulus, Strain energy, Strain deformation – Viscous deformation: Spring-Dashpot models – Anelastic and Viscoelastic deformation: Viscoelastic models – Plastic deformation: Dislocations and Stress-strain curves, Plasticity theory – Fracture: Ideal fracture, Brittle fracture, Fracture mechanics, Cohesive models, Ductile fracture – Mechanical testing

Unit - III:Ceramics

Structure of ceramics – Production of ceramics: Raw materials, Forming and Post-forming processes – Production of glass: Melting of glass, Glass forming and annealing – Mechanical properties of ceramics – Wear and erosion resistance – Thermal shock – Silica-Alumina system – Commercial systems: Zirconia, Sialones, Cement and Concrete

Unit - IV:Polymers and Plastics

Molecular structure: Monomers & Polymers, Synthesis, Molecular weight measurement, Branching & Tacticity, Copolymets and blend – Mechnaics of polymer chain: Freely jointed chains, Entanglements, Rubber elasticity – Thermoplastic melts: Viscosity, Shear thinning, Processing, Extrusion – Amorphous polymers: Solidification, glass transition, Various models – Crystalline polymers – Crosslinked polymers: Elastomers, Thermosets – Liquid crystal polymers – Mechanical properties: Stress-Strain behaviour – Chemical properties

Unit - V:Crystals

Crystal growth from solution – Melt growth techniques: Bridgman method, Czochralski crystal pulling technique, Crystal growth from Vapour phase – Crystal Imperfections – Point defects: Vacancies, interstitals, Impurities, electronic defects – Lline defects: Edge dislocation, Screw dislocation – Surface defects: Grain boundaries, Tilt boundaries, Twin boundaries, Stacking faults, Ferromagnetic domain walls – Volume defects: Cracks, Voids

Books for Study and References

1. J.C.Anderson, K.D.Leaver, P. Leevers and R.D.Rowlings, Materials Science for Engineers, Nelson Thomas Ltd, First Indian reprint, 2010
2. M.Arumugam, Materials Science, Anuradha Agencies, Publishers, Sechond Edition, Fifth Reprint, 2005
3. R,Balasubramaniam, Materials Science and Engineering, Wiley India (P) Ltd, 2010
4. V.Raghavan, Materials Science for Engineering, Prentice Hall of India Pvt Ltd, 2006

Paper - 2: NANOMATERIALS

Preamble: To felicitates the knowledge on nanomaterials. To make the students understanding the fundamental aspects of nanomaterials, synthesis, nanostructures, properties and characterization techniques

Unit-I: Synthesis

Sol-Gel and Precipitation technologies - Ball milling - RF plasma - Combustion Flame - Chemical Vapor Condensation process – Electrodeposition - Laser synthesis - Gas phase condensation - Sonochemical.

Unit-II: Nanostructures

Preparation of quantum nanostructures: Preparation - Size and Dimensionality Effects – Excitations - Single-Electron Tunneling - Applications. Nanomachines and Nano devices:Micoelectrochemical systems – Nano electrochemical systems - Molecular and Super molecular switches.

Unit-III: Properties

Properties of Individual Nanoparticles: Metal Nanoclusters – Semiconducting Nanoparticles - Rare Gas and Molecular clusters. Bulk Nanostructured Materials:Solid disordered Nanostructure - Nanostructured crystals.

Unit - IV: Characterization Techniques

Structural: Powder XRD & particle size determination, Neutron diffraction; Spectroscopic: X-ray Photoelectron (XPS), Photoluminescence, Impedance and Energy Dispersive X-ray (EDAX) spectroscopy.

Unit - V: Characterization Techniques

Thermal: Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC); Microscopic: Atomic Force Microscopy (AFM); Electrical and Magnetic: Four - probe method, Vibrating sample Magnetometer.

Books for Study and Reference

1. Evgenij Barsoukov and J. Ross Macdonald : Impedance Spectroscopy : Theory, Experiment and Applications, (John Wiley & Sons, Inc., Hoboken, New Jersey, second edition), 2005.
2. G. Cao: Nanostructures & Nanomaterials: Synthesis, Properties & Applications, (ImperialCollege Press), 2004.
3. Koch CC, Nanostructured Materials processing, properties and potential applications, WilliamsAndrew Publishing, Noyes, 2002
4. Pavia, Lampman, Kriz and Vyvyan, Spectroscopy, Cengage Learning India Pvt Ltd., 2011.
5. Willard, Merritt, Dean and Settle, Instrumental Methods of Analysis. CBS Publishers &Distributors, Delhi, 1986.
6. J.Ross Mcdonald, Impedance Spectroscopy Emphasizing solid materials and systems, JohnWiley & sons, New York, 1996.
7. T. Pradeep, NANO: The Essentials, Tata Mc Graw-Hill Pvt. Ltd., New Delhi, 2007.
8. Charles P. Poole Jr & Frank J. Owens, Introduction to Nanotechnology, John Wiley & Sons(Asia) Pvt. Ltd., New Delhi, 2006.
9. Jackie Y.Ying, Nanostructured Materials, Academic Press, USA, 2001.

Paper – 3: SPACE PHYSICS

Preamble: To enlighten the students with the concepts of space physics. To make the students understanding the concepts of remote sensing of earth's climate system, space and plasma physics, space weather, introduction to magneto hydrodynamics, x-ray astronomy

Unit – I: Remote Sensing of Earth's Climate System

Remote sensing of earth's climate system- requirements for remote sensing of climate system- methodology- constrains- basic concept of remote sensing- surface factors- atmospheric factors- instrumental factors- using reflected sunlight- global vegetation remote sensing- using thermal emission- global sea surface temperature measurement- radar altimetry- surface effects- atmospheric effects- ocean and ice monitoring by radar altimetry.

Unit - II: Space and Plasma Physics

Basic plasma physics- principle- application- space plasma- the frozen in-flux-MHD plasma waves- solar wind and IMF- collision less shocks- bow shocks- shock jumps- shock structure- shock acceleration- magnetic reconnection- terrestrial magnetosphere- closed, open and flux transfer events- storms , sub storms- solar wind interaction with ionosphere- planets- insulator bodies(moon)- comets.

Unit – III: Space Weather

Space weather- structure of sun- solar cycle- solar activity- coronal heating. The solar wind- wind- Aurora- Auroral sub storms- co-rotating interaction region(CIR)- solar flares- the ionosphere- solar energetic particle events(SEP)- coronal mass ejections(CME) and geomagnetic storms- Halo CME's- interplanetary CME's- magnetic clouds.

Unit - IV:Introduction to Magneto Hydrodynamics

Maxwell's equations in MHD- magnetic Reynold's number- Alfven speed- plasma beta parameter- force free magnetic field- magnetic buoyancy- magneto ststic equilibrium- magnetic reconnection- current sheet- acoustic waves- Alfven waves compressional Alfven waves- magneto acoustic waves- inertial waves.

Unit – V: X-Ray Astronomy

Origin of X-rays astronomy- X-ray binaries- black hole- neutron stars- pulsars- white dwarfs- clusters of galaxies.

Books for Study and References

1. Thomas E Cravens, Physics of Solar System Plasma, (Cambridge University Press), 1997.
2. Thomas I Gombosi, Physics for Space Environment, (Cambridge University Press), 2004.
3. Louise K Hara and Keith O Mason, Space Science, (University of London, World Scientific Publishing Co.), 2004.
4. Margaret G Kivelson and Christopher T Russell, Introduction to Space Physics, (Cambridge University Press), 1995.

Paper –4 : CRYSTAL GROWTH

Preamble: To introduce the knowledge on crystal growth and characterization. To expose the students with theories of nucleation & crystal growth, crystal growth from various techniques such as, solution, melt and vapour phase and their characterization.

Unit – I: Fundamentals of Crystal Growth

Importance of crystal growth – Classification of crystal growth methods – Basic steps: Generation, transport and adsorption of growth reactants – Nucleation: Kinds of nucleation –Classical theory of nucleation: Gibbs Thomson equations for vapour and solution – Kinetic theory of nucleation – Becker and Doring concept on nucleation rate – Energy of formation of a spherical nucleus – Statistical theory on nucleation: Equilibrium concentration of critical nuclei, Free energy of formation.

Unit – II: Theories of Crystal Growth

An introductory note to Surface energy theory, Diffusion theory and Adsorption layer theory – Concepts of Volmer theory, Bravais theory, Kossel theory and Stranski's treatment – Two-dimensional nucleation theory: Free energy of formation, Possible shapes and Rate of nucleation – Mononuclear, Polynuclear and Birth and Spread models – Modified Birth and Spread model – Crystal growth by mass transfer processes: Burton, Cabrera and Frank (BCF) bulk diffusion model, Surface diffusion growth theory.

Unit – III: Experimental Crystal Growth-Part-I: Melt Growth Techniques

Basics of melt growth – Heat and mass transfer – Conservative growth processes: Bridgman-Stockbarger method – Czochralski pulling method – Kyropolous method – Non-conservative processes: Zone-refining – Vertical and horizontal float zone methods – Skull melting method – Vernueil flame fusion method.

Unit – IV: Experimental Crystal Growth-Part-Ii: Solution Growth Techniques

Growth from low temperature solutions: Selection of solvents and solubility – Meir's solubility diagram – Saturation and supersaturation – Metastable zone width – Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods– Crystal growth in Gel media: Chemical reaction and solubility reduction methods – Growth from high temperature solutions: Flux growth Principles of flux method – Choice of flux – Growth by slow evaporation and slow cooling methods – Hydrothermal growth method.

Unit –V: Experimental Crystal Growth-Part-Iii: Vapour Growth Techniques

Basic principles – Physical VapourDoposition (PVD): Vapour phase crystallization in a closed system – Gas flow crystallization – Chemical Vapour Deposition (CVD): Advantageous and disadvantageous – Growth by chemical vapour transport reaction: Transporting agents, Sealed capsule method, Open flow systems – Temperature variation method: Stationary temperature profile, Linearly time varying temperature profile and Oscillatory temperature profile.

Books for Study and Reference

1. 'Crystal Growth Processes' by J.C. Brice, 1986, John Wiley and Sons, New York.
2. 'Crystallization' by J.W. Mullin, 2004, Elsevier Butterworth-Heinemann, London.
3. 'Crystal Growth: Principles and Progress' by A.W. Vere, 1987, Plenum Press, New York.
4. 'Crystals: Growth, Morphology and Perfection' by Ichiro Sunagawa, 2005, Cambridge University Press, Cambridge.
5. 'Crystal Growth' by B.R. Pamplin, 1975, Pergamon Press, Oxford.

PAPER –5: Thin film

Preamble: To expose the students with knowledge of understanding the basic preparation and to get knowledge about the various properties of thin films. To make the understand the preparation and various necessary techniques used for analyzing the thin films

Unit- I: Preparation of Thin Films

Spray pyrolytic process – characteristic feature of the spray pyrolytic process – ion plating – Vacuum evaporation – Evaporation theory – The construction and use of vapour sources – sputtering Methods of sputtering – Reactive sputtering – RF sputtering - DC planar m magnetron sputtering .

Unit - II: (Thickness Measurement and Nucleation and Growth in Thin Film

Thickness measurement: electrical methods – optical interference methods – multiple beam interferometry – Fizeau – FECO methods – Quartz crystal thickness monitor. Theories of thin film nucleation – Four stages of film growth incorporation of defects during growth.

Unit - III: Electrical Properties of Metallic Thin Films

Sources of resistivity in metallic conductors – sheet resistance - Temperature coefficient of resistance (TCR) – influence of thickness on resistivity – Hall effect and magneto resistance – Annealing – Agglomeration and oxidation.

Unit - IV: Transport Properties of Semiconducting and Insulating Films

Semiconducting films ; Theoretical considerations - Experimental results – Photoconduction – Field effect thin films – transistors, Insulation films Dielectric properties – dielectric losses – Ohmic contracts – Metal – Insulator and Metal – metal contacts – DC and AC conduction mechanism

Unit - V: Optical Properties of Thin Films and Thin Films Solar Cells

Thin films optics –Theory – Optical constants of thin films – Experimental techniques – Multilayer optical system – interference filers – Antireflection coating ,Thin films solar cells : Role, Progress , and production of thin solar cells – Photovoltaic parameter, Thin film silicon (Poly crystalline) solar cells : current status of bulk silicon solar cells – Fabrication technology – Photo voltaic performance : Emerging solar cells : GaAs and CulnSe.

Books for study and reference

1. Hand book of Thin films Technology: L I Maissel and R Clang .
2. Thin film Phenomena : K L Chopra .
3. Physics of thin films, vol. 12 , Ed George Hass and others .
4. Thin films solar cells – K L Chopra and S R Das .
5. Thin films processes – J L vilsan
6. vacuum deposition of thin films – L Holland .
7. The use of thin films in physical investigation – J C Anderson.
8. Thin films technology – Berry, Koil and Harri

PAPER –6: ELECTRONIC STRUCTURE CALCULATION

Preamble: To introduce knowledge on electronic structure calculation. To make the students to understand basic concepts, various analysis on natural bond Orbitals, normal coordinates and different experimental methods

Unit – I: FTIR Raman Spectra

Normal modes of vibration – Group frequencies – Origin of Infrared and Raman spectra – Infrared and Raman activity – IR and Raman spectral characteristics – FTIR and Raman spectra and their interpretation – Factors affecting Vibrational spectra - Hydrogen bonding – Structure elucidation using IR and Raman spectra – Resonance Raman scattering – Vibrational spectra of aromatic molecules

Unit – II: Quantum Chemical Computation

Molecular Orbital Theory - Basis set – Electronic structure methods – Semi empirical methods – *Ab initio* methods - density functional theory methods - Z-matrix – geometry optimization – Harmonic Vibrational analysis – Atoms in molecules charges and Bond order – Potential energy surface – Mullican population analysis – Vibrational circular dichroism intensities – Software: MOPAC, Gaussian

Unit – III: Natural Bond Orbital Analysis

Natural bond orbitals and one-particle density matrix – Atomic eigenvectors – Natural atomic orbitals and natural population analysis – Bond eigenvectors – natural hybrids and natural bond orbitals – Natural localized molecular orbitals – Hyperconjugative interaction in NBO analysis.

Unit – IV: Normal Coordinate Analysis

Classical theory of molecular vibrations – Construction of force constant matrix F – Internal coordinates in force field calculations – Theory of lattice vibrations – Scale factor calculation – Intensity calculation – Natural internal coordinates – MOLVIB software: General structure input data – Control parameters

Unit – V: Experimental Techniques

IR spectrometer instrumentation – IR sources – Sample handling techniques – IR detectors – FTIR spectrometer – FTIR Raman spectrometer – Sample handling techniques – Laser exciting sources – Raman detectors – SERS techniques.

BOOKS FOR REFERENCE

1. Brain Smith, Infrared Spectral Interpretation – A Systematic Approach , CRC Press, New York, (1999)
2. G.Aruldhas, Molecular structure and spectroscopy, prentice-Hall of India (P) Ltd., New Delhi-1110001, (2001).
3. G.Socrates, Infrared characteristic group frequencies, John Wiley & Sons, New York, (1980)
4. Ira N.Levine, Quantum chemistry V Ed., Prentice Hall International, Inc., London (2003).
5. Alan E. Reed et al., Chem. Rev. 88 (1988) 899-906.
6. Tom Sundius, MOLVIB User's guide Ver. 2, Helsinki (June 2002)
7. Robert M. Silverstein et al., Spectrometric identification of organic compounds, John Wiley & Sons, Inc., New York, (2003).

PAPER – 7: NONLINEAR DYNAMICS

Preamble: To understand the basic concepts of nonlinear dynamics. This course provides knowledge about the effects of nonlinearity on dynamical systems

Unit – I: Nonlinearity, linear and nonlinear oscillators

Dynamical systems - linear and nonlinear forces - Mathematical implications of nonlinearlty - Working definition of nonlinearity - Effects of nonlinearity-Linear oscillators and predictability - Damped and driven nonlinear oscillators.

Unit – II: Equilibrium points, bifurcations and chaos

Equilibrium points - General criteria for stability – Classification - Some simple bifurcations - Saddle node, pitch fork, transcritical and Hopf bifurcations - Discrete dynamical systems - Logistic map - Equilibrium points and their stability - period doubling phenomenon - chaos.

Unit – III: Chaos in nonlinear electronic circuits

Linear and nonlinear circuit elements - nonlinear circuits - Chua's diode - Autonomous case - Bifurcations and chaos - Chaotic dynamics of MLC circuit-Analogue circuit simulation - Some other useful nonlinear circuit - Colpitt's oscillator.

Unit – IV: Fractals

Self similarity - Properties and examples of fractals - Fractal dimension - Construction and properties of some fractals-Middle one third cantor set-Koch curve - Sierpinski triangle-Julia set - Mandelbrot set - Applications of fractals.

Unit – V: Solitons

Linear waves - Linear non dispersive wave propagation - Linear dispersive wave propagation - Nonlinear dispersive systems - Korteweg de vries equation - solitary and cnoidal waves - Numerical experiments of Zabusky and Kruskal - birth of solitons - Properties of solitons - applications of solitons.

Book For Study:

Nonlinear dynamics, Integr ability, Chaos, Patterns, M. Lakshmanan and S.Rajasekar, Springer, Berlin, 2003.

Books for Reference:

1. Chaos in nonlinear oscillator, controlling and synchronization, M.Lakshmanan and K.Murali (World Scientific, Singapor,1997.)
2. Deterministic chaos, H.G.Schuster, (Verlag,Weinheim,1998.)

PAPER – 8: MEDICAL PHYSICS

Preamble: To study the basic concepts of medical physics. To make the students to understanding the concepts of Physics in lungs and breathing, sound in medicine, light in medicine, physics of diagnostic X-rays and cardio vascular systems.

Unit - I: The Physics of the Lungs and Breathing

The Airways– How the blood interact – Measurement of Lung Volumes – Pressure, Airflow, Volume Relationships of the Lungs – Physics of the Alveoli – The Breathing Mechanism – Airway Resistance – work of Breathing – Physics of some common Lung Diseases. Electricity within the Body: Electric signals – from the Heart (Electro Cardiogram) – From the Brain (Electro encephalogram) – From the Eye (Electro retinogram and electrooculogram) – Magnetic signals from Heart and Brain (Magnetocardiogram and Magnetoencephalogram) – Current Research involving electricity in the body.

Unit – II: Sound in Medicine

General properties of sound, the body as a drum (percussion in medicine) – The stethoscope – ultrasound pictures of the body – ultrasound to measure motion – physiological effects of ultrasound in therapy – the production of speech – Physics of the ear and hearing : The outer ear – the middle ear – the inner ear – sensitivity of the ears – testing your hearing – deafness and hearing aids

Unit – III: Light in Medicine

Measurement of light and its units – applications of visible light in medicine – applications of ultraviolet and infrared light in medicine – Lasers in Medicine applications of microscopes in medicine – Physics of eye and vision: Focusing elements of the eye – some other elements of the eye – the retina – the light detector of the eye – how sharp are your eye? Optical illusions and related phenomena – defective vision and its correction – colour vision and chromatic aberration – instruments used in ophthalmology.

Unit – IV: Physics of Diagnostic X-Rays

Production of X-ray beam – how X-ray are absorbed – making an X-ray image – radiation to patients from X-rays – producting live X-ray images – fluoroscopy – X-ray slices of the body – radiographs taken without film Physics of Radiation Therapy: The dose units used in radiotherapy – the red and the gray – principles of radiation therapy – a short course in radiotherapy planning – megavoltage therapy – short distance radiotherapy or brachytherapy other radiation sources – closing thought of radiotherapy.

Unit – V: Physics of the Cardiovascular System

Major Components of the Cardiovascular system – O_2 and CO_2 Exchange in the Capillary system – Work done by the Heart – Blood pressure and its measurement Transmural Pressure– Bernoulli's Principle – Blood flow – Heart Sounds – Cardiovascular Diseases – Functions of Blood Cardiovascular Instrumentation: Biopotentials of the Heart – Electrodes – Amplifiers – Patient Monitoring – Defibrillators – Pacemakers

BOOK FOR STUDY

Medical Physics–John R.Cameron & James G.Skofronick (John Wiley&Sons, New York1978)

PAPER – 9: RADIATION PHYSICS

Preamble: To teach the students about the basic concepts of radiation physics. To impart knowledge on radiation and interaction, principles of radiation detection and measurement, radiation therapy techniques, diagnostic radiology and radiation protection.

Unit-I: Radiation and Interactions

Interaction of Electromagnetic radiation with matter – Photoelectric and Compton process – pair production – interaction of particles with matter – neutrons – heavy ions – nuclear reactions and production of radioisotopes – radiation sources – natural and artificial radio active for medical applications – Bethe- Bloch formula.

Unit – II: Principles of Radiation Detection and Measurement

Radiation units and definitions – G.M. Counter – Scintillation detectors – Solid state detectors – Photofilm method - Pocket dosimeter – TLD - FBX dosimeters.

Unit – III: Radio Therapy Techniques

Telegamma unit – accelerators for therapy – Iridium and cobalt needles – preparation of tracers and labeled compound – uses of radioisotopes (Gamma and beta) in brachytherapy. Dosimetry in medical applications – beta particles dose computation for biological models – dosimetry of internally administered isotopes Principles and overview of conformal radiotherapy, SRS, SRT and IMRT.

Unit – IV: Diagnostic Radiology

The physical basis of diagnostic radiology – the diagnostic X-ray tube – electrical circuits – rating of the x-ray unit – factors on which quality and quantity of x-ray production depends – geometric factor which influences the radiographic image – fluoroscopy – tomography – radio isotopes in clinical medicine – rectilinear scanner – gamma camera.

Unit – V: Radiation Protection

Philosophy behind radiation protection – basic concepts of MPD – recent ICRP recommendations – tissues at risk – risk factor – evaluation of internal and external radiation hazards – transport and waste disposal of radioactive materials.

REFERENCES

1. Meredith and Massay. "Fundamental Physics of Radiology", John Wright & Sons Jones M.E. and Cunningham J, "Physics of Radiology", Charles C. Thomas, USA, 1984.
2. Knoll, "Radiation Detection and Measurement", John Wiley and Sons, New York, 1982.
3. Mould R.F, "Radiation Protection", Adam Hilger's Boston, 1985.
4. Govindarajan K.N, "Advanced Medical Radiation Dosimetry", Prentice Hall of India, New Delhi, 1992

PAPER- 10: ALTERNATIVE ENERGY CONVERSION DEVICES

Preamble: To introduce knowledge on alternative energy sources. To introduce the importance and overview of alternate energy sources. To make the students learn the basics of various energy conversion devices

Unit – I: Introduction and Overview of Alternative Energy Sources and Utilization

Global energy budget – origins of fossil fuels – Principles of energy conversion: thermodynamic first and second laws – the Carnot cycle – Solar energy: Solar intensity and spectrum – global solar energy potential and current level of utilization – Photovoltaic: history – principles and theoretical limits – Solar cells and modules – semiconductor materials – single and multiple layer p-n junction diodes – Solar cells and modules – maximum power output – energy efficiency – quantum efficiency – Solar cells: characterization and modeling – Photovoltaic utilization.

Unit – II: Fundamentals of Electrochemistry and Electrode Kinetics

Charge transfer reaction and reaction kinetics – Third-generation solar cells: dye-sensitized photocell – organic/polymer solar cell-Fuel cells: overview of types – basic operation and performance – Fuel cells: catalysis – Fuel cells: charge and mass transport – PEM fuel cells' Molten carbonate fuel cells – Solid oxide fuel cells – Overview of fuel cell systems: fuel-cell stack and thermal management.

Unit – III: Hydrogen as a Renewable Energy Source

Sources of Hydrogen, Fuel cell – Principle of working – construction and applications – Fuel for Vehicles – Hydrogen Production: Direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production – Storage of Hydrogen: Gaseous, Cryogenic and Metal hydride – Environmental impact.

Unit – IV: Batteries

Primary and Secondary batteries - principles and application – Lithium batteries, Lithium ion and polymer batteries. Super-capacitors: principles and working, electrode materials synthesis process, fabrication of the devices and their applications.

Unit – V: Biomass Utilization

Biodiesel and ethanol, Biomass utilization, Nuclear Energy: Potential of Nuclear Energy, International Nuclear Energy Policies and Regulations. Nuclear Energy Technologies – Fuel enrichment, Different Types of Nuclear Reactors, Nuclear Waste Disposal, and Nuclear Fusion.

REFERENCES:

1. Renewable Sources of Energy and Conversion Systems: N.K.Bansal and M.K.Kleeman.
2. Principles of Thermal Process : Duffie -Beckman
3. Solar Energy Handbook: Kreith and Kreider (McGrawHill)
4. Solar Cell : Marteen A. Green
5. Solar Hydrogen Energy Systems -T. Ohta (Ed.) (Pergamon Press)
6. Hydrogen Technology for Energy – D.A.Maths (Noyes Data Corp.)
7. Handbook : Batteries and Fuel cell – Linden (Mc.Graw Hill)
8. Batteries Volume (I) and (II) – Collins
9. Fuel Cell Fundamentals :O'Hayre, Suk-Won Cha, Whitney Colella, and Fritz B. Prinz, 2nd ed, John Wiley & Sons, New York.
10. Energy Storage Materials: S.Selladurai Proceedings, 2010
11. Practical Photovoltaics: Electricity from Solar Cells, 3rd Ed.Richard J. Komp, Aatec Publications, Ann Arbor, MI, 2002

PAPER – 11 : LASERS AND APPLICATIONS

Preamble: To facilitates the students with theoretical aspects of laser theory and its applications. To provide the knowledge on laser theory, resonators and switching theory, gas & liquid lasers, solid state & semiconductor lasers and their applications.

Unit – I: Laser Theory

Absorption - Spontaneous and stimulated emission - Einstein's coefficients - threshold conditions for laser action - Line broadening, Mechanism - Lorentzian and Doppler line shapes - Small signal gain - Gain coefficient - gain saturation - Rate equations for 3 and 4 level systems.

Unit – II: Resonators and Switching Theory

Resonant cavity - Fox and Li - Boyd and Gorden's theory on resonators - modes - Spot size - Types of resonators - Mode selection - Q switching theory and technique - Mode locking theory and technique.

Unit – III: Gas and Liquid Lasers

He-Ne, Argon Ion, Carbon dioxide, Nitrogen - Metal vapour - Gas dynamics - Excimer - Free electron lasers - Dye lasers organic dyes - Pulsed and CW dye lasers - Threshold conditions - Puming configurations.

Unit – IV: Solid State And Semiconductor Lasers

Ruby, Nd : YAG, Nd : Glass, Ti-sapphire, Alexandrite, lasers - Semiconductor lasers - Homo function - Hetro function - Quantum well laser.

Unit – V: Applications

Speckle, speckle interferometry - Holography - Holographic interferometry - Material processing - Surface treatment - welding, drilling - Laser ranging - Laser Doppler Velocimetry - Pollution monitoring - Medical applications.

REFERENCES

1. Laser Fundamentals, William T. Silfvast, Cambridge University Press, 1999.
2. Oshea, Callen and Rhcdes, "An Introduction to Lasers and their Applications", Addison Wesley, 1985.
3. A.Yariv, "Quantum Electronics", Third Edn., Addison-Wesley 1990.
4. Hariharan, "Optical Holography", Academic Press, New York, 1983.
5. Erf.R.K."Speckle Metrology", Academic Press, New York, 1978.

PAPER – 12: Advanced Materials and Processes

Preamble: This course provides a fundamental understanding of materials' properties, their processing and classification, which are essential for product commercialization from the concept phase. It also includes the development of new materials and the improvement and application of current materials in new and novel structures.

Unit-I: Introduction and classification of structural and functional materials

Introduction to metastable and functional alloys - Bulk Metallic glasses Part I: Fundamental concepts - Bulk Metallic glasses Part II: Mechanical and Functional properties

Unit – II: High Temperature Materials

Introduction to high temperature materials - Superalloys: Alloy design, Microstructure and Properties -Shape memory alloys and Pseduelasticity - Shape memory alloys: Applications and case studies

Unit – III: Nano-materials

Nano-materials: Classification, size effect on structural and functional properties, Processing and properties of nanocrystalline materials, thin films and multilayered coatings, single walled and multiwalled carbon nanotubes

Unit – IV: Soft and hard magnetic materials

Soft and hard magnetic materials for storage devices: Design and Processing; Piezoelectric Materials: Processing and Properties

Unit – V: Advanced Processes applied for Advanced Materials

Non-equilibrium Processes, Single Crystal Growth, Rapid Solidification, Inert Gas Condensation - Advanced Functional Alloys -, Physical and Chemical Vapour Deposition of Thin Films

Reference

https://onlinecourses.nptel.ac.in/noc18_mm12/preview

PAPER – 13: Introduction to Non-linear Optics and its Applications

Preamble: To introduce the basic concepts and theory of Nonlinear Optics. To study the basic nonlinear optical effects (like higher harmonic generation, optical Kerr effect, self-phase modulation etc). The course offers the subject matter by giving a rigorous theoretical background and framework for a nonlinear effect, followed by details of how such an effect is implemented in real applications.

Unit – I

Introduction & Linear Optics: Maxwell's Equation (in free space and medium), Wave equation (Homogeneous and Isotropic medium), Plane wave solution, Poynting Theorem, Intensity and Amplitude relation, Linear Polarization, Classical 1D anharmonic oscillator , Refractive Index, Dispersion (Damped Harmonic Oscillator Model, Sellmeier Equation) - Polarization Tensor, Susceptibility Tensor , Wave motion in Crystal, E-Ray & O-Ray, Walk Off.

Unit – II

Nonlinear Optics: Nonlinear Susceptibility, 2 nd order nonlinear effect (χ (2) $\neq$ 0)- Optical Rectification, 2 nd harmonic generation, , Nonlinear Maxwell's equation, Concept of phase matching - Birefringence Phase Matching (BPM) , Kleinman's symmetry, Index contraction, d-matrix ,Quasi Phase Matching (QPM)

Unit – III

Parametric Processes, Three wave interaction, Difference frequency generation, Manley-Rowe Relation - Phase sensitive and insensitive amplification, Sum frequency Generation - Optical Parametric Oscillator (OPO)- (i) Singly Resonant Oscillator (SRO), (ii) Doubly Resonant Oscillator.

Unit – IV

Third order nonlinear effect (χ (3) $\neq$ 0), Optical Kerr effect, Self Phase Modulation (SPM) - 3 rd harmonic generation, Two wave interaction, Cross Phase Modulation (XPM) - Nonlinear absorption / Two Photon Absorption (TPA), Four Wave mixing, Cross Talk, Optical Phase Conjugation

Unit – V

Stimulated Raman Scattering, Classical Picture of SRS, Raman Gain, Applications -Nonlinear Schrödinger Equation, Optical soliton, Applications

Reference

https://onlinecourses.nptel.ac.in/noc18_ph10/preview

PAPER – 14: Non-Conventional Energy Resources

Preamble: To study the operating principle of a range of non-conventional energy resources, materials used, characterization, and key performance characteristics. The technologies looked at will include, Solar energy, Wind, Batteries, Fuel cells, and Geothermal conversion. The advantages and limitations of these technologies in comparison to conventional sources of energy will also be examined.

Unit – I: Conventional and non-conventional sources

Scale of quantities - Impact of current energy usage - Conventional sources of energy - Overview of non-conventional energy resources - Consumption by sector

Unit – II: Solar energy

Solar energy incident on earth - solar spectrum - Overview of solar energy technologies - Solar Thermal devices - Solar Photovoltaic devices - Performance and durability of solar devices

Unit – III: wind, Geothermal and biomass energies

Wind energy - technology and geographical aspects - Geothermal - Biomass

Unit – IV: Battery

Battery basics – types – Testing - performance of batteries

Unit – V: Fuel cells

Fuel cell types - Fuel processing - concept to product - Characterization and durability of fuel cells - Flywheels and super capacitors

Reference

https://onlinecourses.nptel.ac.in/noc18_ge14/preview

PAPER – 15: Design of Photovoltaic Systems

Preamble: To discus about the PV cell electrical characteristics and interconnections. Estimation of insolation and PV sizing is addressed in some detail. Maximum power point tracking and circuits related to it are discussed. Later, applications related to peltier refrigeration, water pumping, grid connection and micro grids are discussed in detail. Lastly a brief discussion on life cycle costing is also discussed in order to bring in a measure of completeness to the course.

Unit – I: The PV cell

A historical perspective, PV cell characteristics and equivalent circuit, Model of PV cell, Short Circuit, Open Circuit and peak power parameters, Datasheet study, Cell efficiency, Effect of temperature, Temperature effect calculation example, Fill factor, PV cell simulation - Identical cells in series, Load line, Non-identical cells in series, Protecting cells in series, Interconnecting modules in series, Simulation of cells in series, Identical cells in parallel, Non-identical cells in parallel, Protecting cells in parallel, Interconnecting modules in parallel, Simulation of cells in parallel, Measuring I-V characteristics, PV source emulation

Unit – II: Energy from sun

Insolation and irradiance, Insolation variation with time of day, Earth centric viewpoint and declination, Solar geometry, Insolation on a horizontal flat plate, Energy on a horizontal flat plate, Sunrise and sunset hour angles - Energy on a tilted flat plate, Energy plots in octave, Atmospheric effects, Air Mass, Energy with atmospheric effects, Clearness index, Clearness index and energy scripts in Octave

Unit – III: Maximum power point tracking

MPPT concept, Input impedance of DC-DC converters -Boost converter, Buck converter, Buck-Boost converter, PV module in SPICE , Simulation - PV and DC-DC interface - Impedance control methods, Reference cell, Sampling method, Power slope methods, Hill climbing method, Practical points - Housekeeping power supply, Gate driver, MPPT for non-resistive loads, Simulation

Unit – IV: PV-battery interfaces

Direct PV-battery connection, Charge controller, Battery charger - Understanding current control, slope compensation, simulation of current control, Batteries in series - charge equalisation, Batteries in parallel - Peltier device - principle, Peltier element - datasheet, Peltier cooling, Thermal aspects - Conduction, Convection , A peltier refrigeration example, Radiation and mass transport, Demo of Peltier cooling

Unit – V: PV and water pumping, grid interface

Water pumping principle, Hydraulic energy and power, Total dynamic head, Numerical solution - Colebrook formula, Octave script for head calculation, Octave script for hydraulic power, Centrifugal pump, Reciprocating pump, PV power, Pumped hydro application - Grid connection principle, PV to grid topologies, 3ph d-q controlled grid connection, dq-axis theory, AC to DC transformations, DC to AC transformations, Complete 3ph grid connection, 1ph d-q controlled grid connection - SVPWM, Application of integrated magnetics, Life cycle costing, Growth models, Annual payment and present worth factor, LCC with examples

Reference

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