PH6B01U - **Computational Physics**

Credits – 4 (Theory 3+ Practical 1)

No. of contact hours – 54.

Scope: This course is intended to give an insight to computer hardware and computer applications.

Prerequisites: Basic mathematics and electronics

Module 1

Microprocessors (20 hrs)

Introduction to microprocessors- microprocessor operations (with relevance to 8085 microprocessor): 8085 bus organization-address bus- data bus- control bus, internal data operations- 8085 registers- accumulator- flags- program counter- stack pointer, externally initiated operations

The 8085 microprocessor architecture- pinout and signals- internal architecture of 8085 microprocessor

Machine language- assembly language- high level language.

Instruction cycle, machine cycle and T state- instruction format- addressing modes. The 8085 instruction set- simple programmes for data transfer, addition and subtraction.

Microprocessor architecture, programming and applications- Ramesh S. Gaonkar (Penram Int. Pub.) Chapter.1,2,3,5,6,7

Module II

Computer hardware (5 hrs)

Characteristics of a computer- I/O devices- memory and storage devices- RAM, ROM, Primary and secondary memory

Fundamentals of Microprocessors and microcomputers- B. Ram (Dhanpat Rai Pub.)

Chapter 1

Programming in C^{++} (17 hrs)

Introduction- C^{++} programming basics- loops and decisions- basic ideas of structures, arrays, functions, objects and classes

Object oriented programming in Turbo C^{++}- Robert Lafore (Galgotia Pub.) Chapter 1,2,3,4

Module III

Numerical methods (12 hrs)

Iteration principle- solution of algebraic and transcendental equations- bisection, false position and Newton-Raphson methods- algorithms - numerical integration-trapezoidal rule and Simpson's 1/3 rule - algorithm- Numerical solution of differential equation- Euler's method and second order Runge-Kutta method-algorithm. Computer oriented numerical methods using C++

Computer oriented numerical methods. V Rajaraman 3rd Edn PHI, Ch. 3,8and 9 References

1. Microprocessor architecture, programming and applications- Ramesh S. Gaonkar (Penram Int. Pub.)
2. Fundamentals of Microprocessors and microcomputers- B. Ram (Dhanpat Rai Pub.)
3. Microcomputers and Microprocessors- John Uffenbeck (PHI Pub.)
4. Object oriented programming in Turbo C^{++} - Robert Lafore (Galgotia Pub.)
5. Programming with C^{++} - John R. Hubbard (Mc Graw Hill Pub.)
6. Numerical method- V. Rajaram (PHI Pub.)
7. Introductory methods of Numerical methods -S.S .Sastry (PHI Pub.)
8. Numerical method with computer programming in C^{++} - Ghosh (PHI Pub.)

SEMESTER VI

PH6B02U – **Nuclear and Particle Physics**

Credits – 4 (Theory 3+ Practical 1)

No. of contact hours – 54

Scope: This course intended to explore the interior of nucleus and interaction between nucleons

Prerequisites: Basic mathematics and quantum mechanics.

Module I

Nuclear structure & General properties of nuclei (15 hr)

Classification of nuclei – Isotopes, Isobars, Isomers, Mirror nuclei. General properties of nucleus – size, nuclear mass, density, charge, angular momentum, nuclear magnetic dipole moments, electric quadrupole moment, Mass defect, B.E, B.E. curve, packing fraction, nuclear stability. Theories of nuclear composition – proton-electron hypothesis – proton-neutron hypothesis. Properties of Nuclear forces – Meson theory of nuclear forces. Nuclear shell model. Determination of nuclear mass by Bainbridge's mass spectrograph. Detectors of nuclear radiations – ionisation chamber - G.M Counter.

Modern Physics	**(Ch. 8)**	**R. MurugeshanS.Chand**
Modern Physics	**(Ch.3)**	**R. MurugeshanS.Chand**
Atomic and Nuclear Physics	**(Ch.2)**	**S.N Ghoshal)S.Chand**
Modern Physics	**(Ch. 9)**	**R. MurugeshanS.Chand**

Module II

Radioactivity(18 hr)

Natural radioactivity – Radioactive disintegration law – half life – Mean life Radioactive series. Radioactive dating – Uranium dating & Carbon dating Range of $\propto$ particles – range – energy relationship. Geiger – Nuttal law Alpha particle

disintegration energy Theory of ∝ - delay – Gamow's theory β- decay - β ray energy spectrum Neutrino hypothesis Positron emission, orbital electron capture (Basic ideas only) γ decay – Internal conversion Electron positron pair production by γ rays. Electron positron annihilation. Artificial radioactivity & Transuranic elements. (Basic ideas only)

Atomic and Nuclear Physics (Ch.3) S.N Ghoshal S.chand

Modern Physics (Ch. 11) R MurugesanS.Chand

Module III

Nuclear fission & Fusion (11 hr)

Discovery of nuclear fission – Fission products. Neutron emission in fission. Energy release in fission. Nuclear fission on the basis of liquid drop model chain reaction – Nuclear reactor – Breeder reactor Nuclear fusion Energy production in stars – Proton-Proton cycle and Carbon - Nitrogen cycle Peaceful utilization fusion power Controlled thermo nuclear reactions Toroidal confinement – Tokamak Nuclear waste disposal and radiation hazards from nuclear explosion – radiation dosage.

Modern Physics (Ch. 13) R. Murugeshan

Atomic and Nuclear Physics (Ch. 14) S.N Goshal

Elementary particles(10 hr)

Particles and antiparticles – Fundamental interactions in nature. Classification of elementary particles according to nuclear interactions. Resonance particles Elementary particle quantum numbers and conservation laws. The quark model – compositions of hadron according to quark model. Cosmic rays – Primary and secondary- lattitude effect- altitude effect- eastwest effect

Modern Physics (Ch. 18) S.N Ghoshal S.Chand

Atomic and Nuclear Physics (Ch. 15) R. Murugeshan

S.Chand

References:

1. Nuclear Physics Principles and Applications. Lilley, Pub. John. Wiley
2. Nuclear and Particle Physics S L Kakani and Subhra Kakani -Viva Books 2008

SEMESTER VI

PH6B03U –- **Condensed Matter Physics**

Credits – 4 (Theory 3+ Practical 1)

No. of contact hours – 54

Scope: This course is intended to provide an introduction to the physics of Condensed Matter. This study attempts to explain various types of phenomena like electro-magnetic properties, super-conductivity and super fluidity.

Prerequisites: Basics of Mathematics, quantum mechanics

Module I

Crystal structure and Bonding (12 hrs)

Crystal Structure - Crystalline Matter - Bravias Lattice - Crystal Systems - Crystal Planes - and Miller Indices - Lattice Constants - Reciprocal Lattice - Crystal Structures - sc, bcc, fcc and hcp - Bragg's Law - Experimental Methods of X-Ray diffraction - Powder method.

Bonding in Solids - Ionic, Covalent, Van der Waal and Metallic Bonding (qualitative) - Binding Energy in Crystals - Madelung Constant.

Free Electron Theory and Band Theory of Solids (15 hrs)

Free Electron theory in one dimension- Formation of Energy Bands-Bloch Theorem (Statement) - Kronig Penney Model –Brillouin Zones (qualitative) – Effective Mass-Carriers in Solids- Metals, Insulators and Semiconductors-Band Structure-Intrinsic and Extrinsic Semiconductors- Electric Conductivity-Temperature Dependence-Hall effect.

M. Elementary Solid State Physics: (Pearson) Chapter1,2,5&6, Ali Omar

Solid State Physics, P.K. Palanisamy, Scitech publications Chapter 1,2&6

Solid State Physics, S.Chand R.K Puri & V.K.Babber, Chapter 3&6.

Module II

Dielectric and Magnetic Properties of Solids(10Hrs)

Review of Basic Equations - Dielectric Constant - Dipole Moment-Polarizability-Clausius-Mosotti Relation- Ferrroelectricity - Classification of Magnetic Materials-Langevin's theory - Paramagmetism - Curie-Weiss Law- Curie temperature - Antiferromagnetism and Ferrimagnetism – Magnetisation - Magnetic Domain Structure – Spintronics - Spin Waves.

M. Elementary Solid State Physics: Ali Omar (Pearson) Chapter 8& 9

Solid State Physics, P.K. Palanisamy, Scitech publications , Chapter

7&8 Solid State Physics, R.K Puri & V.K.Babber, S.Chand Chapter8

Mircea.S.Rogalski & B.Palmer, Solid State Physics. Chapter 8&9

Module III

Superconductivity (10 hrs)

Zero resistance - Superconducting Phenomenon - Critical Temperature - Meissner Effect-Type I& II Superconductors - BCS theory (qualitative) - London Equation - Josephson Effect – SQUID - High Tc superconductors and applications.

Elementary Solid State Physics: Ali Omar (Pearson) Chapter 10

Solid State Physics, P.K. Palanisamy, Scitech publications , Chapter 10

Materials Science and Technology (7hrs)

Amorphous Semiconductors - Liquid Crystals – Polymers - Thin films - Properties-Crystalline Materials and Applications - Nanostructures and Nanometerials-Applications.

Elementary Solid State Physics: Ali Omar (Pearson) Chapter 12

Thin film fundamentals, A.Goswami.New Age International,2008. Chapter1

Nanostructures And Nanomaterials Synthesis, Properties, And Applications,

Guozhong Cao, Imperial College Press, 2004 Chapter 3 And 5.

References

1. Kittel, C. Introduction to Solid State Physics, 8th edition (Wiley)

2. Ashcroft, N.W. & Mermin, N.D. Solid State Physics, TMH

3. Blakemore, J.S. Solid State Physics, 2nd edition (Cambridge)

4 C.L. Arora, Solid State Physics. S Chand.

5. S.O.Pillai, Solid State Physics. New Age International Pub.

6. Superconductivity, Superfluids and Condensate James F Annett Oxford

SEMESTER VI

PH6B04U - **Relativity and Spectroscopy**

Credits – 4 (Theory 3+ Practical 1)

No. of contact hours – 54

Scope: This course is intended to introduce principles of spectroscopy and special theory of relativity.

Prerequisites: Basics courses in Mathematics and Quantum mechanics

Module I

Special Theory of Relativity.(18 hours)

Inertial and non inertial frames of reference – Galilean transformation – Significance of Michelson – Morley experiment – postulates of STR- Lorentz transformation – spatial contraction - time dilation – composition of velocities – Mass of a moving particle – Equivalence of mass and energy – Introductory concepts of general theory of relativity

Concepts of modern Physics, Arthur Beiser

Classical Mechanics – K. Sankara Rao, Prentice Hall of India

Module II

Atomic spectroscopy (18 hours)

Historical introduction. Electromagnetic spectrum. Types of spectra. Absorption and emission of light by atoms- quantum theory- early atom models -Bohr model- – electron spin and magnetic moment - Exclusion principle - Stern- Gerlach experiment - Vector atom model - quantum numbers associated with vector atom models- Total angular momentum and LS coupling– fine structure of Sodium D-lines. Zeeman effect- quantum mechanical explanation for anomalous Zeeman effect – Paschen– Back effect. NMR and ESR spectroscopy (qualitative ideas only)

Concepts of Modern Physics, Arthur Beiser;Tata McGraw-Hill

Fundamentals of Molecular Spectroscopy, C. Banwell and E. Mccash; TMH

Module III

Molecular Spectroscopy (18 hours)

Molecular energy levels. Electronic, rotational and vibrational energies – rotational spectra – explanation in terms of rigid rotator model – vibrational energy levels – explanation in terms of harmonic oscillator.

Electronic energy levels of atoms – Fluorescence and phosphorescence - Raman effect – experimental arrangement and results - classical theory and its failure – quantum theory of Raman effect.

IR and Microwave spectroscopes.

Fundamentals of Molecular Spectroscopy, C. Banwell and E. Mccash; Tata McGraw-Hill

Molecular structure and Spectroscopy, G. Aruldhas, Prentice Hall of India

References:

1. Arthur Beiser;Concepts of modern Physics.
2. C. Banwell and E. Mccash; Fundamentals of Molecular Spectroscopy.
3. G. Aruldhas; Molecular structure and Spectroscopy.
4. Classical Mechanics – K. Sankara Rao,Prentice Hallof India

SEMESTER VI

Choice Based course:

PH6B05.1U **– Astronomy and Astrophysics**

Credits –3

No. of contact hours – 90

Scope: A good introduction to the basics of astronomy and astrophysics will be given in the course. It is expected that some of the students will opt for this specialization for their post graduation.

Prerequisites: This is a specialized course. Students are supposed to have attended basic courses on thermal physics, statistical mechanics and quantum mechanics prior to this course.

Module I

Introduction to observational astronomy (30 hours)

Celestial sphere. Constellations and nomenclature of stars. The cardinal points and circles on the celestial sphere. Equatorial. ecliptic and galactic system of co-ordinates. Aspects of sky from different places on the earth. Sidereal, Apparent and Mean solar time and their relations. Equation of time. Ephemeris and Atomic Times. Calendar. Julian date and heliocentric correction. Introduction to telescopes. Amateur Refracting telescopes and their design. Newtonian reflectors, Cassegrain telescopes. Telescope mounts - equatorial and alt-azimuth, telescope drives. Distances of stars from parallaxes. Stellar motions. Magnitude scale and magnitude systems. Black-body approximation to the continuous radiation and temperatures of stars. Variable stars as distance indicators

World Book Encyclopedia of Science, Volume. 1

Textbook of Astronomy and Astrophysics with Elements of Cosmology, V. B. Bhatia, Narosa Publishing House.

Exploring the Night Sky with Binoculars, Patrick Moore, Cambridge University Press.

Module II

Stars (30 hours)

Sun –internal structure and atmosphere- photosphere- sunspots - chromospheres – corona –solar flares –prominences. Stellar structure - hydrostatic equilibrium- structure equations - energy sources - energy transport. Types of stars – classification and HR diagram.

Formation - Interstellar dust and gas – Jeans' mass - formation of protostars – evolution of planetary systems with special reference to Sun -Pre-main sequence evolution; nuclear fusion. P-P chain and CNO cycle. Energy production in massive stars. Evolution on the main sequence - Late stages of evolution. Fate of massive stars, supernovae - White dwarfs - Chandrasekhar limit - Neutron stars – Pulsars – Black holes

Astrophysics: Stars and galaxies, K. D. Abhyankar, Tata McGraw Hill

The Physics of Stars, A.C. Philips, Wiley

Module III

Galaxies and the expanding Universe (30 hours)

Galaxies-their morphology and classification. Cepheid variables and distance measurements. Origin and evolution of Galaxies. Large scale structure of the universe – isotropy and homogeneity. Expanding universe – Doppler effect – red shift – distance scale –Hubble law. Standard Big bang theory , cosmic microwave background and its discovery ; early universe – nucleosynthesis in early universe – inflationary model of the universe – age of the universe and its determination.

Introduction to Cosmology, J. V. Narlikar, Cambridge University Press. Particle Astrophysics, Donald Perkins, Oxford

Astrophysics: Stars and galaxies, K. D. Abhyankar, Tata McGraw Hill

References: 1. Baidyanath basu, An Introduction to Astrophysics. PHI

2. James B. Seaborn, Understanding the Universe, Springer
3. The Physical Universe – An Introduction to Astronomy – Frank H. Shu-University Science Books.
4. The First Three Minutes. Steven Weinberg

SEMESTER VI

Choice Based Course

PH6B05.2U **– Information Technology**

Credits – 3

No. of contact hours – 90

Scope: To learn about the fascinating world of information technology and to use the tools available in Internet and the World Wide Web for a deep study of the subjects related to physics in better way by the students themselves.

Prerequisites: Awareness of basic computer operations.

Module – I (32 hrs)

Information And Its Use : Information Technology – Quality of information – Message transmission – Electronic Office – E mail – Document storage – Computers in Industry – Different types – Graphical user interface

"Information Technology – The Breaking Wave", D.Curtin, K.Sen and K.Morin, Tata McGraw Hill, 1999. Chapter – 1, 2

Computer Networks: Importance of Networks. Components of Networks. Classification of Networks: Broad cast networks-Switched networks. Switching Techniques. Types of Networks – LAN – MAN – WAN. Networking Models – OSI reference model – TCP/IP reference model-Comparison between the OSI and TCP/IP models. Network Topology – Bus-Star-Ring-Tree-Mesh-Cellular. Network Architecture – Client/Server, Peer-to-Peer

Computer Networks – A.S. Tanenbaum - Prentice Hall of India, Chapter - 1
Computer Fundamentals – P.K. Sinha 3rd Edn. BPB Publications, Chapter – 17

THE INTERNET: Internet Protocols – Internet Protocol (IP)-Transmission Control Protocol (TCP) -Internet Address – Structure of Internet Servers Address-Address Space-Internet Infrastructure -Services on Internet – Domain Name System-SMTP and Electronic mail – Http and World Wide Web-Usenet and News groups-FTP-Telnet-Network Security – Ideas of secret key Algorithms and Public key Algorithms-Digital Signature-E-mail Privacy-Internet Tools – Search Engines-Web browsers- Internet explorer, Netscape Navigator, Mozilla Firefox(Working Knowledge)

Computer Networks – A.S. Tanenbaum – PHI, Chapter – 5,6,7

Computer Fundamentals – P.K. Sinha 3rd Edn. BPB Publications, Chapter – 18

Module – II (32 hrs)

THE HTML: What is HTML? Basic Tags of HTML – HTML-TITLE-BODY - Starting an HTML document – The <!DOCTYPE>declaration-setting boundaries with <HTML>-the HEAD element-the BODY element-the STYLE element and the SCRIPT element. -Formatting of text

– Headers-Formatting Tags-PRE tag-FONT tag-Special Characters. Working with Images-META tag -Links – Anchor Tag -Lists – Unordered Lists-Ordered Lists-Definition Lists -Tables – TABLE, TR and TD Tags-Cell Spacing and Cell Padding-Colspan and Rowspan -Frames – Frameset-FRAME Tag-NOFRAMES Tag - Forms – FORM and INPUT Tag-Text Box-Radio Button-Checkbox-SELECT Tag and Pull Down Lists-Hidden-Submit and Reset -Some Special Tags–COLGROUP-THREAD,TBODY-TFOOT-_blank-_self,_parent-_top-IRFRAME-LABEL-Attribute for <SELECT>- TEXTAREA

HTML4 – 2nd Edn. Rick Darnell, Techmedia, Chapter – 1, 2,3,4,5

Module – III (26 hrs)

Basic Idea of DBMS: Need for Data Base – Database Systems versus File systems - View of Data - Data Abstraction-Instances and Schemas - Data Models – ER Model-Relational Model-Network Model-Hierarchical Model (general ideas) -Basic ideas about Structured Query Language

Fundaments of Database System – Elmasri, Ramez and Navathe Shamkant B. 4th Edn. Person Education, India, 2004. Chapter – 1

MS – OFFICE/OPEN OFFICE (Working Knowledge): Word processors – PowerPoint **-Spreadsheets – Databases**

(No specific text book is preferred. MS office (97, 98, 2000, /Open Office which is installed in the lab can be used. Working practice must be given)

Reference

1. "Information Technology – The Breaking Wave", D.Curtin, K.Sen and K.Morin, Tata McGraw Hill, 1999.
2. Computer Networks – A.S. Tanenbaum - Prentice Hall of India
3. Computer Fundamentals – P.K. Sinha 3rd Edn. BPB Publications
4. Internet and World Wide Web – Deitel
5. HTML4 – 2nd Edn. Rick Darnell, Techmedia

6. Database System Concepts – Silberschatz-Korth-Sudarshan 4th Edn – Tata Mac Graw Hill

7. "Information Technology and systems", Green, B.C., Longman Scientific & Technical Publishers, England, 1994.

8. Networks – Tirothy S. Ramteke – 2ndEdn. Pearson Edn – New Delhi,2004

9. Data and Computer Communucation, William Stalling, PHI, New Delhi.

10. Mastering HTML4 – Ray D.S. and Ray E.J. – BPB

11. HTML – The Complete Reference – Tata Mc Graw Hill

12. Fundaments of Database System – Elmasri, Ramez and Navathe Shamkant B. 4th Edn.v Pearson Education, India, 2004.

Choice Based Course

SEMESTER VI

PH6B05.3U **– Renewable Energy Technology**

Credits – 3

No. of contact hours – 90

Scope: This course is designed to make the students aware of challenging energy crisis and alternative energy solutions.

Prerequisites: Concepts of work- power- energy, heat energy- Modes of energy transfer- Heat engines, Concepts of Physical optics, Fundamental of Electricity.

Module I

Introduction to Energy Sources (6 hours)

Energy consumption as a measure of Prosperity – World energy futures – Energy sources and their availability – New energy technologies – Renewable energy sources

Non-conventional Sources of Energy- G D Rai Chapter 1

Solar Energy (20 hours)

Solar radiation geometry – Solar radiation measurements – Principles of the conversion of solar radiation in to heat – Flat plate collectors – Energy balance equation and collector efficiency – Concentrating collector: Focusing type – Performance analysis of a parabolic collector – Selective absorber coatings – Solar energy storage systems – Solar pond – Principle of operation and extraction of thermal energy – Solar heating and solar cooling of buildings – Solar electric power generation: Solar photo-voltaic cells

Non-conventional Sources of Energy- G D Rai Chapters 2,3,4&5

Module II

Wind Energy (14 hours)

Basic principles of wind energy conversion – site selection considerations – Classification of wind energy conversion systems – types of wind machines – Performance analysis of wind machines – Schemes for electric generation – Applications of wind energy – Environmental aspects.

Non-conventional Sources of Energy - G D Rai Chapter 6

Geothermal Energy (14 hours)

Nature of geothermal fields - Geothermal resources – Hot dry rock resources – Magma resources – Geothermal exploration – Advantages and disadvantages of geothermal energy – Applications of geothermal energy – Operational and environmental problems.

Non-conventional Sources of Energy - G D Rai Chapter 8

Energy from Biomass (11 hours)

Biomass conversion technologies – Biomass as a source of energy – Energy plantation – Methods for obtaining energy from biomass – Biogas generation – Biodegradation – Biogas plants – Biogas from waste – Community biogas plants – Thermal gasification of biomass.

Non-conventional Sources of Energy - G D Rai Chapter 7

Module III

Energy from the Oceans (15 hours)

Ocean thermal electric conversion (OTEC) – Introduction – Open cycle OTEC system – Closed cycle OTEC system – Hybrid cycle – Prospects of OTEC in India.

Energy from Tides – Basic principle of tidal power – Operation methods of utilization of tidal energy – Single cycle and double cycle systems – Advantages and limitations of tidal power generation - Prospects of tidal energy in India.

Ocean waves – Energy and power from the waves – Wave energy conversion devices - Advantages and limitations of wave energy.

Non-conventional Sources of Energy - G D Rai Chapter 9

Energy storage (10 hours)

Fuel cells – Design and principle of operation of a fuel cell – Classification of fuel cells – Conversion efficiency of fuel cells – Applications of fuel cells.

Non-conventional Sources of Energy - G D Rai Chapter 10

Hydrogen energy – Hydrogen production (Electrolysis, thermochemical methods) – Hydrogen storage – hydrogen as an alternative fuel for motor vehicles.

Non-conventional Sources of Energy - G D Rai Chapter 11

References:

1. Non – Conventional Energy Sources: G D Rai (Khanna Publishers)
2. Renewable Energy Technologies : Solanki C S (Prentice-hall Of India Pvt Ltd)
3. Renewable Energy Sources & Their Environmetal Impact : Abbasi (Prentice-hall of India Pvt Ltd)
4. Renewable Energy Sources for Sustainable Development N.S.Rathore N.L.Panwar (New India Publishing Agency)
5. Renewable Energy : Ulrich Laumanns And Dieter Uh Dirk Abmann (James & James Science Publishers)
6. Understanding Renewable Energy Systems : Volker Quaschning (James & James Science Publishers)
7. Renewable Energy: Global Perspectives : Azmal Hussain (Icfai University Press)
8. New And Renewable Energy Technologies For Sustainable Development : Naim Hamdia Afgan, Da Graca Carvalho Maria, Maria Da Graca Carvalho (Taylor & Francis Group)
9. Renewable Energy from the Ocean : Avery, William H.; Wu, Chih; Craven, John P. (Oxford University Press)
10. Fundamentals of Renewable Energy Systems : Mukherjee D (New Age International (p) Limited)
11. Renewable Energy Sources & Emerging Tech., : Kothari D P (Prentice-hall Of India Pvt Ltd)
12. Energy From Biomass : Willeke Palz, D. Pirrwitz (Springer)
13. Understanding Renewable Energy Systems : Volker Quaschning (James & James

Science Publishers)

14. Ocean, Tidal, And Wave Energy: Power From The Sea : Lynn Peppas (Crabtree Publishing Company)
15. Fuel Cells, Geothermal Energy And Tidal Power: Emerging Scenario In Alternate Energy : Sameer A Zodgekar (Icfai University Press)

SEMESTER VI

Choice Based Course

PH6B05.4U – Nanoscience and Nanotechnology

Credits – 3

No. of contact hours – 90

Scope: Today's science and engineering disciplines are at a crossroad where they can couple strongly with each other to give rise to new and emerging disciplines such as, the field of Nanoscience and Nanotechnology. This field is truly interdisciplinary in nature, and concerns with the fabrication and manipulations of few atoms and molecules to form mesocpic structures with dimensions ranging between 1-100 nm. In order to get a nano object to functions is necessary to assemble the constituent atoms or molecules, perhaps into a large single molecule such as a protein. These objects are of the size of a nanometer (10^{-9} m). The science of nanometer scale objects is Nanoscience. The resulting technology is called Nanotechnology. This introductory course is provided to get knowledge in Nanoscience and nanotechnology.

Prerequisites: Basics of Mathematics, quantum mechanics, semiconductor physics.

Module I

Basic Physical Properties of Nanostructures (11hrs)

Structure - Size Dependence of Properties -Crystal Structures -Face-Centered Cubic Nanoparticles -Tetrahedrally Bonded Semiconductor Structures -Lattice Vibrations - Size Dependence of Properties -Energy Bands -Reciprocal Space-Effective Masses - Fermi Surfaces -Insulators, Semiconductors, and Conductors -Energy Bands and Gaps of Semiconductors -Localized Particles - Mobility –Excitons-Donors, Acceptors, and Deep Traps.

Methods of Characterization (11hrs)

Structure- Atomic Structures - Crystallography- Particle Size Determination- Surface Structure-Microscopy-Transmission Electron Microscopy- Field Ion Microscopy-Scanning Microscopy.

Properties of Individual Nanoparticles (11hrs)

Metal Nanoclusters -Magic Numbers -Geometric Structure -Electronic Structure -Reactivity -Fluctuations -Magnetic Clusters -Bulk to Nanotransition- Semiconducting Nanoparticles -Optical Properties -Photofragmentation -Coulombic Explosion -Rare Gas and Molecular Clusters -Inert-Gas Clusters -Superfluid Clusters -Molecular Clusters -Theoretical Modeling of Nanoparticles -Methods of Synthesis -RF Plasma -Chemical Methods -Thermolysis -Pulsed Laser Methods.

Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, 2003 Chapter 2,3 and 4

Module II

Carbon Nanostructures (11hrs)

Carbon Molecules -Nature of the Carbon Bond -New Carbon Structures-Carbon Clusters -Small Carbon Clusters -Carbon Nanotubes -Fabrication -Structure -Electrical Properties-Vibrational Properties-Mechanical Properties -Applications of Carbon Nanotubes -Computers -Fuel Cells -Chemical Sensors-Catalysis -Mechanical Reinforcement -Field Emission and Shielding.

Bulk Nanostructured Materials (11hrs)

Solid Disordered Nanostructures -Methods of Synthesis -Failure Mechanisms of Conventional Grain-Sized Materials -Mechanical Properties -Nanostructured Multilayers -Electrical Properties-Porous Silicon -Metal Nanocluster Composite Glasses -Nanostructured Crystals -Natural Nanocrystals -Crystals of Metal Nanoparticles -Nanoparticle Lattices in Colloidal Suspensions -Photonic Crystals.

Nanostructured Ferromagnetism (11hrs)

Basics of Ferromagnetism -Dynamics of Nanomagnets -Nanopore Containment of Magnetic Particles -Nanocarbon Ferromagnets -Ferrofluids -Effect of Bulk Nanostructuring of Magnetic Properties -Giant and Colossal Magnetoresistance.

Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, 2003 Chapter 5,6 and 7

Module III

Quantum Wells, Wires, and Dots (12hrs)

Preparation of Quantum Nanostructures -Size and Dimensionality Effects -Size Effects -Potential Wells-Partial Confinement -Conduction Electrons and Dimensionality -Fermi Gas and Density of States-properties Dependent on Density of States -Excitons -Single-Electron Tunneling -Applications -Infrared Detectors -Quantum Dot Lasers-Superconductivity.

Nanomachines and Nanodevices (12hrs)

Microelectromechanical Systems (MEMSs) -Nanoelectromechanical Systems (NEMSs) -Fabrication Nanodevices and Nanomachines -Molecular and Supramolecular Switches.

Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, 2003 Chapter 9 and 13

References:

1. MEMS/NEMS ; micro electro mechanical systems/nano electro mechanical systems Volume 1,Design Methods,, Cornelius T. Leondes, Springer, 2006.
2. Nano:the essentials, T. PRADEEP,TMH ,2007.
3. Nanoscale Materials ,Luis M. Liz-Marzán and Prashant V. Kamat, Kluwer Academic Publishers, 2003
4. Nanoscience,Nanotechnologies and Nanophysics, C. Dupas, P. Houdy and M. Lahmani,Springer-Verlag , 2007.
5. Nanotechnology 101, John Mongillo, Greenwood Press, 2007.

6. Semiconductor Nanostructures for Optoelectronic Applications, Todd Steiner, ARTECH HOUSE, 2004.

7. What is What in the Nanoworld,A Handbook on Nanoscience and Nanotechnology,

Victor E. Borisenko and Stefano Ossicini , WILEY-VCH Verlag, 2008.

8. Nanotechnology and Nano-Interface Controlled Electronic Devices, M. Iwamoto,K. Kaneto,S. Mashiko Elsevier Science, Elsevier Science, 2003.

9. S emiconductors for Micro and Nanotechnology—An Introduction for Engineers Jan G. Korvink and Andreas Greiner, WILEY-VCH Verlag ,2002.

SEMESTER VI

Choice Based Course

PH6B05.5U – **Optoelectronics**

Credits – 3

No. of contact hours – 90

Scope: This century is going to be the century of Optoelectronics or Photonics – the light wave technology. Today we have optical technologies replacing electronic memories, amplifiers etc. These enable high speed computing. Hence no Physics student can avoid this latest field of science and technology.

Prerequisites: Basic concepts of Optics, Quantum Mechanics, Electronics and Solid State Physics.

Module I

Optoelectronic Fundamentals

Introduction to Photonics (12 hrs)

(i) Optical radiation and light- Luminescence and Radiation-Radiation source parameters– Receiver parameters (1.1.1, 1.1.2,1.1.4 &1.1.5 of Ref.1)-Photometric and Radiometric terms and units- Inverse square law – verification by photometer-comparison of efficiency of light sources available in the market and recommended values of illumination for various activities (General awareness) (Ch.6 of Ref.2).

(ii) Introduction to Photonics – electrons Vs photons – Electronics Vs Optics Photonics (1.1 to 1.3 of Ref.3)- Photonics and light technology and applications-introduction (1.2 to 1.5 of Ref.4)

(iii) Properties of Photons (2.1 of Ref.4)-

(iv) Gausian beams – beam characteristics and parameters (2.4 of Ref.4)

(v) Light Characteristics – Power, energy, peak power, beam radius, intensity, divergence, beam quality, brightness, brilliance, radiation pressure, optical levitation (2.7 of Ref.4)

Optical process in semiconductors (16 hrs)

Electron hole pair formation and recombination. Radiative and non radiative recombination. Absorption in semiconductors – indirect transitions, exciton absorption, donor- acceptor band impurity band absorption. Long wavelength absorption. Franz Keldysh and Stark effect. Radiation in semiconductors. Stokes shift in optical transitions. Deep level transitions, Auger recombination. (Ch.3 of Ref.5)

Module II

Optical Devices

Radiation sources (12hrs)

(i) LED –Principle –characteristics (V-I & light – current)–materials- efficiencies- LED structures- hetero junction and edge emitting LED-. Applications &advantages.

(ii) Semiconductor lasers – Homo junction and hetero junction and Quantum well lasers **–** Principle -Optical and carrier confinement

Photodetectors (12hrs)

Introduction- Classification of detectors- Qualitative idea of each type- Photo detector parameters – Noise mechanisms (Ch.4 of Ref.1, Ch.5.3 of Ref.3)– Principle and operation of Photodiode, APD, Phototransistor, PIN photodiode- opto isolators

Solar cells (6 hrs)

Principle-. V-I characteristics- Fill factor – conversion efficiency (Qualitative study)-Hetero junction solar cells. (Ch.10 of Ref.5, Ch.6 of Ref.1)

Module III

Optical Communication

(i) Introduction (5hrs)

Introduction to Optical communication- Historical perspective- Advantages and disadvantages of optical communication links in comparison with radio and microwave system and with guided systems- measurement of information and the

capacity of telecommunication channel- Communication system architecture- basic optical communication system – Definition of attenuation, pulse duration and band width. Ch. 1 of Ref.9)

(ii) Optical Modulation. (15hrs)

Direct modulation of LED and diode laser. Digital and analog modulation of LED and diode laser. External modulation. Birefringence, Pockel effect , phase modulation. Wave guide modulators . Electro-optic , Magneto- optic and acousto-optic modulators. Bipolar controller modulator. (Ref.1,7,10)

(iii) Fibre optic communication (12hrs)

Introduction to Optical fibres and fibre optic communication (Ch.1 of Ref.11 and Ch.1.1 to1.3 of Ref.13)- Types of optical fibres- Numerical aperture- Fibre bundles, cables- strength-fibre optical properties- Fibre materials – Classification of fibres – Step index and graded index- mono mode and multi mode fibres –plastic fibres- latest developed fibres (Ch.2,3 of Ref.11)- Fibre loses.

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2. A Text book of Optics- Brijlal, Subramoniam, S Chand & Co
3. Photonics Elements and Devices, V. V. Rampal , Wheeler Publishing Co
4. Photonics, Ralf Menzel, Springer
5. Semiconductor optoelectronic devices – Pallab BhattacharyaPHI
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8. Semiconductor Physics and Devices – Donald A Neamen, Tata McGraw-Hill
9. Optical communication system- John Gowar , Prentice Hall of India
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15. Physics of Semiconductor devices, S M Sze, Wiley Eastern Limited