SEMESTER-8 Open Electives

SEMESTER-l

Code	Name	L	T	P	C
PH441	**Quantum Computation and Cryptography**	3	0	0	6
PH442	**Theory and Simulation of Nanostructures**	3	0	0	6
PH443	**Monte Carlo Simulation Methods and Applications**	3	0	0	6
PH444	**Nanomaterials and Nanoelectronics**	3	0	0	6
PH445	**Optical Communication Systems**	3	0	0	6
PH446	**Fundamentals of Astrophysics**	3	0	0	6
PH447	**Smart Materials and Devices**	3	0	0	6
PH448	**Solar Cells: Fundamentals and Applications**	3	0	0	6

PH441: Quantum Computation and Cryptography 3-0-0-6

Basic postulates, Superposition principle, Stern-Gerlach Experiment, Pauli Matrices, Measurement in quantum mechanical syste, Density operators.
The idea of qubit gates, Quantum algorithms, Quantum Fourier transform and applications, Shor algorithm, Computational Complexity, Quantum Search, Physical realization of Quantum Computers Bell States, Quantum Teleportation, EPR Paradox. Entanglement Quantum cryptography and its protocols. Quantum information. Von Neumann Entropy, Quantum Error correction.

Texts References:

1. J. J. Sakurai, *Modern Quantum Mechanics,* Addision-Wesley (1994).
2. D. Boummeester, A Ekart and A. Zeilinger, *The Physics of Quantum Information,* Springer (2000).
3. C. Macchiavello, G. M. Palma and A. Zeilinger, *Quantum Computation and Quantum Information.Theory,* World Scientific (2000).

PH442: Theory and Simulation of Nanostructures 3-0-0-6

Interatomic Potentials: Potential energy Surface, pair potential approximation; advantages and limitations, Phenomenological potentials; Buckingham, Morse, Lennard-Jones and Berker, Pseudo potentials, Many-Body potentials.

Molecular Dynamics(MD): Models for MD calculations; initial value, Isothermal equilibrium, boundaries, Nano-design and Nano-construction, solution of the equation of motion; Verlet, Gear-Predictor, and other methods, Efficient Force Field Computation; Forcederivation, List method, Cell algorithm, Scalable parallel procedure.

Characterization: Thermal stability, Material properties, wear at the Nanometer level, Mean Values and correlation functions.

Nano-Engineering: Functional Nanostructures, Nano-Machines, Nano-clusters; influence of initial conditions, temperature, crystalline structure, etc. Simulated Nano-structure transformations.

Texts/References:

1. M. Rieth, *Nano-Engineering in Science and Technology: An Introduction to the World of Nano-Design*, World Scientific, (2003).
2. M. A. Ratner and D. Ratner, *Nanotechnology: A Gentle Introduction to the next Big Idea*, Pearson (2002).
3. J. M. Haile, *Molecular Dynamics Simulation*, John Wiley & sons (1992).

PH443: Monte Carlo Simulation Methods and Applications 3-0-0-6

Brief review of statistical mechanics. Probability theory, central limit theorem, statistical errors, Markov chains and master equations, random number generation.

Monte Carlo methods: Simple sampling technique and its application to evaluation of imroper integrals, boundary value problems, simulation of radioactive decay, simulation of transport properties, percolation problem, random walk, self-avoiding walks, and growing walks.

Importance sampling technique, Metropolis algorithm, boundary conditions, finite size effect. Applications to Simple Ising model, Ising model with competing interactions, spin glass,complex fluid, Phase separation, diffusion, configurations of polymers in dilute solution.

References:

1. D. P. Landau and K. Binder, *A Guide to Monte Carlo Simulations in Statistical Physics*,Cambridge (2000).
2. M. E. J. Newman and G. T. Barkema, *Monte Carlo Methods in Statistical Physics*,Clarendon (1999).
3. K. Binder and D. W. Heermann, *Monte Carlo Simulations in Statistical Physics*, Springer (1992).
4. C. Z. Moonley, *Monte Carlo Simulations*, Sage (1997).

PH 444: Nanomaterials and Nanoelectronics 3-0-0-6

Low dimensional structures and energy quantization, Plasmon band and exciton, Quantum dots, quantum wires and quantum wells.

Synthesis, characterization and properties: Metallic, semiconducting, magnetic, and carbon based nanostructures, nanocomposites, biological nanomaterials.

Nanofabrication: Lithographic techniques for nanoprinting, nanomanipulation techniques, self assembly.

Nanoelectronics: Heterojunction band line-up, Resonant tunneling devices, Coulomb blockade, Single electron transistors, Quantum dot, quantum wire and quantum well lasers, nanosensors, nano-photonics, Nano electro-mechanical systems (NEMS).

Texts/References:

1. Nanomaterials: Synthesis, properties and Applications, Ed. A. S. Edelstein and R.C.Cammarata, IOP (UK, 1996).
2. Nanoelectronics and information technology: Advanced Electronic Materials and Novel Devices, Ed. Rainer Waser, WileyVCH (2003).
3. Characterization of nanophase materials, Ed. Z. L. Wang, Wiley-VCH (2001).
4. Mesoscopic electronics in Solid State Nanostructures, T. Heinzel, Wiley-VCH (2003).
5. Introduction to nanotechnology, Charles P. Poole and Frank J. Owens (Wiley-Interscience, May 2003).

PH 445: Optical Communication Systems 3-0-0-6

Review of propagation of Electromagnetic Waves in dielectric Media.
Optical signaling scheme (Intensity Modulation, Phase modulation, Pulse-Code-Modulation etc.)
Modal analysis of step and graded index multimode fibers, Single mode fibers, Mode cutoff. Loss mechanism in optical fiber, Pulse dispersion and chirping in singlemode fibers, Polarization mode dispersion.
Nonlinear effects in optical communication systems. Optical transmitters and receivers. Noise and receiver sensitivity, Bit Error Rate, Power budget, Rise-time budget, Power penalty.
Coherent light-wave systems: Amplitude-Shift-Keying, Frequency-Shift-Keying, Phase Shift-Keying. Wavelength Division Multiplexing, light-wave systems and components, Time Division Multiplexing, Optical amplifiers and Laser. Dispersion compensation mechanism, Fiber solitons.

Texts

1. G. P. Agarwal, *Fiber Optic Communication Systems*, John Wiley Sons (1997).
2. K. Ghatak & K. Thyagarajan, *Introduction to Fiber Optics*, Cambridge University Press (1998).

References

1. J. M. Senior, *Optical Fiber Communication*, Prentice Hall (1999).
2. G. Keiser, *Optical Fiber Communications*, McGraw Hill (2000).
3. Kaminov & T. L. Koch, *Optical Fiber Telecommunications III A & IV A*, Academic Press, (1997).
4. F. Allard, *Fiber Optics Handbook for Engineers and Scientist*, McGraw-Hill, New York,1990.

PH 446: Fundamentals of Astrophysics 3-0-0-6

Celestial Mechanics; Electromagnetic Radiation; Basic Radiative Processes; Observations and Telescope: Optical, Radio, X-ray; Solar System: Physical processes in the Solar System, Terrestrial and Jovian Planets, Small bodies of the Solar System, Formation of the Solar System; The Sun: A Model Star, Stellar Properties, Stellar Structure, Hertzsprung-Russell Diagram, Star Formation, Stellar Evolution and Stellar Death; Compact Objects: White Dwarfs, Neutron Stars and Black Holes; Mass flow in binary system and Accretion disk; Nature of Galaxies; The Milky Way Galaxy; Active Galaxies and Quasars; Hubble's Law; Structure of Universe.

Text and References

1. Bradley W. Carroll and Dale A. Ostlie, *An Introduction to Modern Astrophysics*, 2nd Ed., Addison-Wesley, Reading, MA, 2007.
2. Stephen A. Gregory and Michael Zeilik, *Introductory Astronomy and Astrophysics*, 4 th Ed. Brooks Cole, 1997.
3. Eric Chaisson and Steve McMillan, Astronomy Today, 6th Ed., Benjamin Cummings, 2007.
4. Dale A. Ostlie and Bradley W. Carroll, *An Introduction to Modern Stellar Astrophysics*, 2nd Ed, , Addison-Wesley, Reading, MA, 2007.
5. Bradley W. Carroll and Dale A. Ostlie, *An Introduction to Modern Galactic Astrophysics and Cosmology*, 2nd Ed, , Addison-Wesley, Reading, MA, 2007.

PH 447: Smart Materials and Devices 3-0-0-6

Introduction: Historical account of the discovery and development of smart materials and their classifications; types (I & II) of smart materials.

Physical principles of optical, electrical, dialectric, piezoelectric, ferroelectric, pyroelectric and magnetic properties of smart materials.

Synthesis of smart materials: Solid state, chemical route, mechanical alloying and thin film deposition techniques.

Characterization techniques: X-ray diffraction, scanning and transmission microscopes, and other basic techniques used to for shape memory alloys, magnetostrictive, optoelectronic, piezoelectric, metamaterials, electro-rheological and magneto-rheological materials and composite materials.

Characteristics of shape memory alloys, magnetostrictive, optoelectronic, piezoelectric, metamaterials, electro-rheological and magneto-rheological materials and composite materials.

Devices based on smart materials: Sensors & Actuators, MEMS and intelligent devices Future scope of the smart materials.

Texts/References:

1. M. Addington and D. L. Schodek, Smart Materials and Technologies, Elsevier, 2005.
2. R. Rai, Synthesis, Characterization and Application of smart Materials, Nova Science, 2011.
3. A.J. Moulson and J.M. Herbert, Electroceramics: Materials, Properties, Applications, 2ndEdn., John Wiley & Sons, 2003.

4. G. Gautschi, Piezoelectric Sensorics: Force, Strain, Pressure, Accele ration and Acoustic
1. Emission Sensors, Materials and Amplifiers, Springer, 2002.
5. W. Cai and V. Shalaev, Optical Metamaterials: Fundamentals and Applications, Springer, 2010.
6. P. L Reece, Smart Materials and Structures: New Research, Nova Science, 2007.
7. M. V. Gandhi and B.S. Thompson, Smart Materials and Structures, Champman and Hall, 1992.

PH 448: Solar Cells: Fundamentals and Applications 3-0-0-6

1. Introduction: World Energy requirement, Annual solar energy received by earth, Solar irradiation curve,, generation of electrical energy from solar energy using solar cells, Solar cells design, advantage and disadvantages of solar cells, myths and truth about solar energy conversion. Introduction to different generations of solar cells. (4 lectures)
2. Basics of Semiconductor Physics: Band gap in semiconductors, doping and carrier concentration, shift of Fermi level, Photon absorption, Optical generation and recombination of carriers. (6 lectures)
3. Theory of p-n junction: p-n junction formation, depletion region, band bending, Current Voltage characteristics under forward and reverse bias, and under dark and light. (6 lectures)
4. Fundamentals of solar cells: I-V characteristics, solar cell parameters (Voc, Isc, FF, power conversion efficiency, quantum efficiency), influence of parasitic resistance, effect of temperature and band gap of solar cell material on conversion efficiency. (4 lectures)
5. Principle of Cell Design:Cell type, optical design, ways to overcome recombination losses at surface and in bulk, design and fabrication of metal contacts. (4 lectures)
6. Fabrication of solar cells and modules: Crystalline silicon and multi-crystalline silicon solar cells, thin film solar cells: amorphous silicon, cadmium telluride and copper indium gallium diselenide solar cells, Organic, polymer based and hybrid solar cells. (10 lectures)
7. Photovoltaic system engineering: Solar PV module arrays, Solar PV design and integration, Grid connected solar PV power system. (6 lectures)

Remaining two lecture hours are reserved for the quiz

Texts/References:

1. U. Misra and J. Singh, Semiconductor Device Physics and Design, Springer, 2008
2. C. Solanki, Solar Photovolatics: Fundamental Technology and Applications, 2ndEdn. PHI India
3. T. Markvart and L Castner (Eds.), Solar Cells: Materials Manufacture and operation, Elsevier India, 2010