Open Electives (for Semesters 6/7/8)

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
PH465	Optoelectronics	3	0	0	6
PH551	Non-linear dynamics and chaos	3	0	0	6
PH552	Image Formation in Optical Systems	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. A.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 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

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.
Basics of Semiconductor Physics: Band gap in semiconductors, doping and carrier concentration, shift of Fermi level, Photon absorption, Optical generation and recombination of carriers.
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.
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.
Principle of Cell Design:Cell type, optical design, ways to overcome recombination losses at surface and in bulk, design and fabrication of metal contacts.
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.
Photovoltaic system engineering: Solar PV module arrays, Solar PV design and integration, Grid connected solar PV power system.

Texts/References:

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

PH465: Optoelectronics 3-0-0-6

Basic Principles of laser: Spontaneous and stimulated emission, Einstein coefficient, broadening of energy levels. absorption and amplification of light in a medium, population inversion and threshold condition for a laser, gain coefficient, efficiency, optical resonator, Fabry Perot resonator, spherical resonator, longitudinal & transverse modes, properties of laser, modulation of laser, semiconductor lasers.
Optoelectronic devices: Ideal photon detector, noise in detection process, photomultipliers, photoconductors, junction photodiodes, avalanche photodiode, charge coupled devices, energy sensitive devices, Electro-optic, magneto-optic and acousto-optic effects, applications of various optoelectronics devices.
Optical Fibre: Propagation of radiation in dielectric wave guides, step index and graded index fibre, modes in fibre, dispersion in multimode & monomode fibres, attenuation in fibres, signal distortion, mode coupling, power launching and coupling, fibre parameters specifications, applications of optical fibre.

Text/References:
1. W. T. Silfvast, Laser Fundamentals, 2nd Edn., Cambridge University Press, 2004.
2. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, 2nd Edn., Wiley, 2007.
3. A. Ghatak and K. Thyagarajan, Optical Electronics, Cambridge University Press, 2009.

4. J. Wilson and J. Hawks, Optoelectronics an Introduction, 3rd Edn., Prentice Hall. 2004.
5. A. Yariv and P. Yeh, Photonics, 6th Edn., Oxford University press, 2007.

PH551: Non-linear dynamics and chaos 3-0-0-6

Dynamical systems: Importance of concepts of chaos, Fractals, and nonlinear dynamics in different natural and engineering processes. Introduction to dynamical systems, state space: continuous state with discrete time or continuous time variable, discrete state with discrete or continous time variable.
One-dimensional system: Fixed points and their local and global stability analysis, converting the dynamical problem into equivalent problem of potentials.
Two-dimensional system: Fixed points and linear stability analysis. Nonlinear analysis with examples of pendulum. Dissipation and the divergence theorem, Poincare-Bendixon's Theorem, weakely nonlinear oscillators.
Three-dimensional system: Linear and nonlinear stability analysis with examples of Lorentz system, forced nonlinear oscillator, Poincare section and maps. Bifurcation theory: Bifurcations in 1D and 2D flows with examples of sadle-node, transcritical, pitchfork bifurcations in different physical systems. Hopf-bifurcations. Homoclinic and hetroclinic bifurcations.
One dimensional Maps and Chaos: Stability of fixed point and periodic orbits, quadratic maps, bifurcation in maps, characterization of chaos using Lyapunov exponents and Fourier spectrum.
Different Routes to Chaos: Quasiperiodic, intermittency, period doubling, etc.
Fractals and attractors: Introduction to countable and non-countable sets, Cantor set, Dimension of self-similar Fractals. Henon map, Rossler systems, Chemical chaos, forced-double well oscillators.
A brief phenomenology of turbulent flow: Phenomenology of Turbulent flow in classical (Kolgmogorov phenomenology for energy cascade) and quantum system (especially generation and phenomenology of turbulence in Bose-Einstein condensation and superfluid Helium).

Text/References:

1. Strogatz, S. Nonlinear Dynamics and Chaos. Reading, MA: Addison-Wesley, 2007.
2. Hilborn, Robert C. Chaos and Nonlinear Dynamics. Oxford University Press, Second edition, 2000.
3. Guckenheimer, J., and P. Holmes. Nonlinear Oscillations, Dynamical Systems and Bifurcations of Vector Fields. New York, NY: Springer-Verlag, 2002.
4. Drazin, P. G. Nonlinear systems. Cambridge, UK: Cambridge University Press, 1992.
5. Parker, T. S., and L. O. Chua. Practical Numerical Algorithms for Chaotic Systems. New York, NY: Springer-Verlag, December 20, 1991.
6. Berge, P., Y. Pomeau, and C. Vidal. Order Within Chaos. New York, NY: Wiley 1987.
7. Lakshmanan, M and R. Rajasekar, Nonlinear Dynamics: Integrability, Chaos and Patterns, Springer, 2003.

PH552: Image Formation in Optical Systems 3-0-0-6

Review of paraxial geometrical optics: Matrix formulation of lens and mirrors, images by thin lenses; exact ray tracing;
Wavefront aberrations: Monochromatic aberrations, Zernike polynomial representation, Chromatic aberration; Wavefront shaping;
Computation of Fraunhofer diffraction pattern using Fourier transform: rectangular aperture, circular aperture and limit of resolution, periodic objects and diffraction efficiency;
Fourier optics: Fourier transforming properties of a lens; Diffraction limited imaging systems, Point spread functions, Airy pattern, convolution, Point spread function with aberrations; Strehl ratio. Coherent and incoherent imaging; Optical transfer function; effects of aberrations.
Applications: Confocal scanning microscopy, Optical super-resolution, holographic microscopy, imaging by speckle interferometry.

Text/References:

1. J W Goodman, Introduction to Fourier Optics, McGraw-Hill (2004).
2. Lipson, Lipson and Lipson, Optical Physics, Cambridge University Press (2011).
3. M Born and E Wolf, Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light, Cambridge University Press (1999).
4. E G Steward, Fourier Optics: An introduction, Dover Publication (2004)