Bio-inspired and bio-mimetic materials

UG/PG: UG	**Department: Physics**
Course Code: PHT411	**Course Name: Bio-inspired and bio-mimetic materials**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Elective	
Pre-requisite course:	

Introduction to biological and bio inspired materials, biomimetic and bioinspired engineering, inspiration from nature, bio-inspired designs, biological engineering principles, basic building blocks found in biological materials, adhesive surfaces, gecko inspired adhesion, lotus surface, nature against nature: repellency against adhesion, bio-inspired nanostructures [10 Lectures]

Introduction to nanotechnology, surface engineering, bio-inspired nanoparticles, polymer-reinforced and ceramic-toughened composites, lightweight biological and bio-inspired materials, bio-functional interfaces, components of a bio-functional interface and fabrication, biocompatibility vs. bio-functionality, bio-inspired functional interfaces, characterization of bio-functional interfaces [09 Lectures]

Introduction to tissue engineering, bio-inspired scaffolds for tissue engineering, self-healing and adaptive materials, bio-sensing, components of a biosensor, nature-inspired sensing, drug delivery, smart targeted drug delivery, micro and nano robots, lab-on-chip devices, examples of bio-inspired lab on chip devices, examples of organs on chips, modeling diseases on a chip [09 Lectures]

Books recommended:

1. Bio and bioinspired nanomaterials: Daniel Ruiz-Molina, F. Novio, C. Roscini (Wiley-VCH).
2. Bioinspired approaches for human-centric technologies: Roberto Cingolani (Springer).
3. Biological materials science: M. A. Meyers and P-Y. Chen (Cambridge).
4. Biomimetics, biologically inspired technologies: Yoseph Bar-Cohen (Taylor and Francis).
5. Materials design inspired by nature: P. Fratzl, J. W. C. Dunlop and R. Weinkamer (RSC).
6. Biomimetic: Bharat (Springer).
7. Nanobiotechnology: Oded Shoseyov and Ilan levy (Human Press).

Carbon Based Materials and Applications

UG/PG: UG	**Department: Physics**
Course Code: PHT412	**Course Name: Carbon Based Materials and Applications**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Elective	
Pre-requisite course:	

Historical background on allotropes of carbon, a brief overview of the structure, electronic and mechanical properties, newly discovered allotropes of carbon: fullerenes, carbon nanotubes, graphene. [05 Lectures]

Fullerenes: production, intercalation compounds, synthesis, characterization, physical properties and technological applications of fullerenes. [07 Lectures]

Carbon nanotubes: formation of carbon allotropes, synthesis and characterization of CNTs, interatomic potentials and forces in nanotubes, continuum and atomistic theories of mechanical properties, thermal transport in nanotubes, fluid flow in nanotubes and technological applications of carbon nanotubes. [11 Lectures]

Graphene: production and characterization, atomic structure of graphene, band description, anomalous Hall effect, spin Hall effect, technological applications. [05 Lectures]

Books Recommended:

1. The Physics of Fullerene-based and Fullerene Related Materials, Wanda Andreoni (Ed.), Kluwer Academic Publishers (2000).
2. Graphite and Precursors (World of Carbon), Pierre Delhaes (Ed.), Gordon and Breach Science Publishers (2001).
3. Computational Physics of Carbon Nanotubes, Hashem Rafii-Tabar, Cambridge University Press, 1st Edition, (2007).
4. Electronic properties of two-dimensional carbon, N.M.R. Peres, F. Guinea, and A.H. Castro Neto, Annals of Physics, vol. 321, pp. 1559 (2006).

Introduction to Biophysics

UG/PG: UG	**Department: Physics**
Course Code: PHT413	**Course Name: Introduction to Biophysics**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Elective	
Pre-requisite course:	

Life and energy, forces and energies at nanometer scales, intermolecular interactions and electrostatic screening, chemical bonding and stability of molecules, entropy, energy and electrostatics, laws of thermodynamics, brownian motion, metabolism in animals and photosynthesis in plants, chemical composition of living systems, structure and physical properties DNA & RNA, cell membrane, protein, stability of proteins, motions within proteins, how enzymes work [10 Lectures]

Nucleic acid and genetic information, deciphering the genetic code, how structure stores information, replication process, from DNA to RNA to protein, mechanics and circuits in the cell, the cell as a basic unit of life's organization, the cell interior, brownian motion and viscosity and their influence on particle motion in the cell, basic structure of mitochondria and the generation of ATP, energy and information flow in the cell [09 Lectures]

The role of the cytoskeleton in cell motion, the role of motors within the cell, muscle, random walks, sense of a remarkable array of biophysical processes, from the diffusion of molecules to the swimming strategies of bacteria, life at low Reynolds number, the neuron, the role of channels and pumps, the biophysics of the synapse, two cases: muscle and retina [09 Lectures]

Books recommended:

1. Biophysics: Rodney M.J (Wiley).
2. The rainbow and the worm: Mae-Wan Ho (World Scientific).
3. Newton rules biology: C.J. Pennycuick (Oxford).
4. How life learned to live: Helmut Tributsch (Cambridge).
5. Essentials of biophysics: P Narayanan (New Age International).
6. An introduction to biophysics: M.R. Rajeswari (Rastogi Publications)

Introduction to Elementary Particle Physics

UG/PG: UG	**Department: Physics**
Course Code: PHT414	**Course Name: Introduction to Elementary Particle Physics**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Elective	
Pre-requisite course:	

History of particle physics, particle zoo, an introduction to the Standard model and its components, antiparticles, symmetries and conservation laws and their significance in particle physics, hadron-hadron interactions, relativistic kinematics, Feynman calculus, quark model including spectroscopy. [8 Lectures]

Quantum Chromo Dynamics (QCD), electromagnetic interactions - form factors, parton model and deep inelastic scattering - structure functions, weak interactions including beta decay, Cabbibo- Kobayashi-Maskawa mixing, unified electroweak interaction, W, Z, Higgs boson, gauge principle, Higgs mechanism. [10 Lectures]

Beyond the Standard model: the unification of strong and electroweak interaction, neutrino oscillations, supersymmetry, experimental techniques for particle acceleration and particle detection, prospects for discoveries of new phenomena, e.g. in the LHC-experiments at CERN and B-factory at KEK, Japan, international linear collider. [10 Lectures]

Books Recommended:

1. Introduction to the Elementary Particle Physics: David Griffith (Wiley).
2. Introduction to High Energy Physics by Donald H. Perkins (Cambridge University Press).
3. Quark and Leptons: An Introductory Course in Modern Particle Physics: Francis Halzen, Alan D. Martin (John Wiley and Sons).
4. Introduction to Elementary Particle Physics: Alessandro Bettini (Cambridge University Press).
5. The Higgs Hunter's Guide: John F. Gunion, Howard H. Haber, Gordon Kane and Sally Dwason (Westview Press).
6. Techniques for Nuclear and Particle Physics Experiment: W. R. Leo (Springer).
7. Radiation Detection and Measurement: Glenn F. Knoll (Wiley).

Introduction to theory of relativity and cosmology

UG/PG: UG	**Department: Physics**
Course Code: PHT415	**Course Name: Introduction to theory of relativity and cosmology**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Elective	
Pre-requisite course:	

Galilean transformations, principle of relativity, transformation of force from one inertial system to another, covariance of the physical laws, principle of relativity and speed of light, Michelson-Morley experiment, ether hypothesis, postulates of special theory of relativity, Lorentz transformations, consequences of Lorentz transformations. [7 Lectures]

Relativistic energy: mass-energy relation, examples of mass-energy conversion, relation between momentum and energy, transformation of momentum and energy, particles with zero rest mass, force in relativistic mechanics. [7 Lectures]

Four-vector formalism, introduction to tensor analysis, Euclidean and non-Euclidean geometry, basic idea of general theory of relativity, principle of equivalence, non-local lift experiments, geodesics, space-time curvature. [7 Lectures]

Composition of the universe, the expanding universe, mapping the universe. Cosmological principle, homogeneous, isotropic space times, cosmological red-shift, FRW models, matter, radiation and vacuum evolution of the flat FRW Models, the big-bang and age and size of the universe. [7 Lectures]

Books recommended:

1. Theory of relativity: P.G.Bergman (Dover)
2. Gravitation and Cosmology: principals and application of general theory of relativity S.Weinberg (John Wiley and Sons).
3. Gravity: An introduction to Einstein’s general relativity J. B. Hartle (Pearson Education).
4. Introduction to Cosmology :J.V.Narlikar (Cambridge University Press).
5. Cosmology: S.Weinberg (Oxford).
6. Introduction to Relativity : J.V.Narlikar (Cambridge University Press).
7. Cosmology and particle astrophysics : A Goobar
8. Introducing Einstein's Relativity : Ray D'Inverno
9. General relativity : R.M.Wald

Introductory Nuclear Physics

UG/PG: PG	**Department: Physics**
Course Code: PHT416	**Course Name: Introductory Nuclear Physics**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Core	
Pre-requisite course:	

Nuclear structure: nuclear mass, charge, size, binding energy, spin and magnetic moment. mass spectrometer; nature of forces between nucleons, nuclear stability and nuclear binding, the liquid drop model, the Bethe-Weizsacker mass formula, application to stability considerations, single particle shell model (qualitative discussion with emphasis on phenomenology with examples).

[9 Lectures]

Unstable nuclei: alpha decay: alpha particle spectra – velocity and energy of alpha particles. Geiger-Nuttal law; beta decay: nature of beta ray spectra, the neutrino, energy levels and decay schemes, positron emission and electron capture, selection rules, beta absorption and range of beta particles, Kurie plot; gamma decay : gamma ray spectra and nuclear energy levels, isomeric states. gamma absorption in matter – photoelectric processes e.g. Compton scattering, pair production (qualitative).

[10 Lectures]

Nuclear fission and fusion: explanation in terms of liquid drop model, fission products and energy release, spontaneous and induced fission; four factor formula, chain reaction and basic principle of nuclear reactors; nuclear fusion: problems of controlled fusion.

[6 Lectures]

Nuclear detectors: GM counter, scintillation counter, semiconductor detectors.

[3 Lectures]

Books recommended:

1. Concepts Of Nuclear Physics: Bernard L. Cohen (Tata-McGraw Hill)
2. Nuclear Physics: S. N. Ghoshal (S. Chand)
3. Introductory Nuclear Physics: Kenneth S. Krane (Wiley)

Lasers: Principles and applications

UG/PG: UG	**Department: Physics**
Course Code: PHT417	**Course Name: Lasers: Principles and applications**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Elective	
Pre-requisite course:	

Radiation-matter interaction, absorption and emission of light, Einstein coefficients, basic requirements for laser, condition for light amplification, attainment of population inversion, pumping methods, threshold condition, spectral lines, line shape function, laser resonators, laser modes, axial and transverse modes, three level and four level systems, pulsed lasers.

[14 Lectures]

Properties of laser radiation, directionality, beam divergence, intensity, brightness; coherence, spatial and temporal coherence; classification of lasers, solid state laser, liquid laser, gas laser; applications of laser, scientific applications, medical applications of lasers, optical communication, industrial applications, laser fusion. [14 Lectures]

Books recommended:

1. Lasers: Fundamentals and Applications: K. Thyagarajan and A. Ghatak (Macmillian Publishers India Ltd, Second edition).
2. Introduction to Laser Physics: K.Shimoda (Springer-Verlag).
3. Principles of Lasers: O. Svelto (plenum Press).
4. Introduction to Lasers and their Applications: D.C. OShea, W.R. Callen & W.T. Rhodes (Addison-Wesley).
5. Laser Spectroscopy: A Basic Concepts and Instrumentation; W Demtrder, (SpringerVerlag).
6. Atomic and Laser Spectroscopy, A. Corney (Clarendon Press).
7. Laser Systems and Applications: V.K. Jain (Narosa Publishing House).

Magnetic Memory Devices

UG/PG: UG	**Department: Physics**
Course Code: PHT418	**Course Name: Magnetic Memory Devices**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Elective	
Pre-requisite course:	

History and overview of magnetic recording, basics of magnetism, various forms of magnetic energies, hard and soft magnetic materials, magnetic anisotropies, exchange bias, spin relaxation mechanisms, concepts of spin detection and magnetic memory, magnetic domains and domain walls, single domain nano-particles, materials for magnetic memory, thin magnetic films, particulate media, flexible media and rigid disk substrates, nanostructures for spin electronics. [11 Lectures]

Fundamental recording theory, media magnetization, erasure and overwrite, recording zone and losses, play back theory, magnetic head circuits, magnetoresistance, anisotropic magnetoresistance, giant magnetoresistance heads, tunneling magnetoresistance heads, field from magnetic heads, perpendicular head fields, flux linkage, and leakage. [10 Lectures]

High density data storage: MRAM, Savtchenko switching and toggle MRAM, ultra-high density devices, spin torque effect, current and spin transfer torque driven domain wall motion, race track memory, shift resistor, Q-bits and spin logic. [7 Lectures]

Books recommended:

1. Magnetoelectronics, M. Johnson, Academic Press 2004.
2. Introduction to Spintronics, S. Bandyopadhyay, M. Cathay, CRC Press, 2008.
3. The Physics of Ultra-high Density Magnetic Recording, Martin L. Plumer, Johannes Van Ek and D. Weller, Springer (2001).
4. Introduction to Magnetic Materials, B. D. Cullity and C. D. Grahm, Willey, 2009.
5. Magnetic Recording Technology, C.D. Mee and E.D. Daniel, McGraw-Hill Professional (1996).

Physics of Nanomaterials

UG/PG: UG	**Department: Physics**
Course Code: PHT419	**Course Name: Physics of Nanomaterials**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Elective	
Pre-requisite course:	

Introduction to nanomaterials, fundamental concepts and physical properties of nanomaterials, quantum confinement, quantum wells, quantum wires, quantum dots, density of states, effect of reduction of dimensions and size dependent properties of nanomaterials.

[8 Lectures]

Synthesis of nanomaterials using top-down & bottom-up approaches, thin film deposition methods, RF sputtering, e-beam evaporation, pulsed laser deposition, lithography, sol-gel, chemical vapor deposition, modification of nanostructured materials. [10 Lectures]

Characterization of nanomaterials using transmission electron microscopy, scanning electron microscopy, atomic force microscopy, X-ray diffraction and Raman spectroscopy. Applications of nanomaterials in solar energy, electronics and medicine. [10 Lectures]

Books recommended:

1. Nanostructures and Nanomaterials Synthesis, Properties and Applications: G. Cao (Imperial College Press-2006).
2. Introduction to Nanotechnology: Charles P. Poole Jr. and Frank J. Owens (Wiley Publications- 2003).
3. Introduction to Nanoscience and Nanotechnology: Chatopadhyaya K.K, and Banerjee A.N (PHI Learning Pvt. Limited, 2009)
4. NANO: The Essentials, understanding Nanoscience and Nanotechnology: T. Pradeep (Tata McGraw-Hill Publishing Company Limited, 2007).

Physics of Particle Detectors and Technology

UG/PG: UG	**Department: Physics**
Course Code: PHT420	**Course Name: Physics of Particle Detectors and Technology**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Elective	
Pre-requisite course:	

Overview on the detector technology used in the particle physics experiments starting from Rutherford scattering experiment to the present world's largest experiments at Large Hadron Collider (LHC), basic concept of energy loss by excitation and ionization, Bethe-Bloch formula, density effects, mean energy loss as a function of velocity, fluctuations in energy loss, interaction of electrons with matter: Bremsstrahlung, interaction of photon with matter: photo-electric effect, compton scattering, pair production. [10 Lectures]

Fundamental physics principle of particle detectors: ionization and excitation, construction, working and operational characteristics of particle detectors: gaseous detectors, ionization chambers, proportional counters, drift chambers, bubble chambers, semiconductor detectors: introduce silicon detectors technology, pixel and strip detectors, CCDs, electromagnetic calorimetry, hadronic calorimetry, general characteristics of particle detectors, development of a detector system concept.

[10 Lectures]

Signal formation, electronic noise, optimization of signal-to-noise ratio, pulse processing electronics, amplification, applications: position, tracking and energy measurements in modern particle physics experiments, radiation detection in space applications: advanced space radiation detector technology at NASA, radiation detectors for medical imaging: beam monitoring and 3D imaging, nuclear techniques for material analysis. [8 Lectures]

Books Recommended:

1. Techniques for Nuclear and Particle Physics Experiment: W. R. Leo (Springer).
2. Radiation Detection and Measurement: Glenn F. Knoll (Wiley).
3. Particle Detectors: Claus Grupen and Boris Shwartz (Cambridge University Press).
4. Physics of Particle Detectors: Dan Green (Cambridge University Press).
5. Evaluation of Silicon sensor technology in particle physics: Frank Hartmann (Springer).
6. Semiconductor Radiation Detectors, Device Physics: Gerhard Lutz (Springer).
7. Handbook of Particle Detection and Imaging: Grupen, Claus, Buvat, Irene (Springer).

Solar Energy and Physics of Photovoltaics

UG/PG: UG	**Department: Physics**
Course Code: PHT421	**Course Name: Solar Energy and Physics of Photovoltaics**
Credits: 3	**L-T-P: 2-1-0**
Course Type: Elective	
Pre-requisite course:	

Solar Energy: origin, solar constant, spectral distribution of solar radiation, absorption of solar radiation in the atmosphere, global and diffused radiation, seasonal and daily variation of solar radiation. [04 Lectures]

Photo-thermal conversion, types of solar energy collectors, concentrating/non-concentrating solar collectors, collector efficiency and its dependence on various parameters. Thermal energy storage, solar energy water storage, stratification of water storage, packed-bad storage, solar ponds, and chemical storage. [08 Lectures]

P-N junction solar cells: p-n diode structure, band diagram, the contact potential, junction analysis at equilibrium, p-n junction under reverse and forward bias, linear graded junction asymmetrical doped junction, computation of parameters of depletion region, signal, breakdown voltage, dynamic resistance, diffusion capacitance and recombination current, quantitative analysis of heterojunctions. [08 Lectures]

Photo voltaic effect, current generation in illuminated p-n junction, photodiodes, solar cell characteristics and parameters, back surface fields in solar cells, types of solar cells, single crystal, polycrystalline and amorphous silicon solar cells, photovoltaic module and arrays, energy storage, recent trends in solar cell research. [08 Lectures]

Books Recommended:

1. Solar Cell Device Physics: Fonash.
2. Solar Engineering of Thermal Process: Duffie and Backman (John Wiley).
3. Solar Energy: S.P. Sukhatme, (Tata McGraw Hill).
4. Semiconductor Devices, Physics, and Technology, Second Edition, S. M., Sze, New York, NY: Wiley.
5. Solid State Electronic Devices, New Edition, Ben. G. Streetman, Sanjay Kumar Banerjee, PHI Leaning Pvt. Ltd.
6. Fundamentals of Renewable Energy Processes, Aldo Vieira da Rosa, Elsevier Academic Press.