SHIV NADAR UNIVERSITY

DEPARTMENT OF PHYSICS

SCHOOL OF NATURAL SCIENCES

UNDERGRADUATE PHYSICS PROSPECTUS
(2019-2020)

"I wanted most to give you some appreciation of the wonderful world and the physicist way of looking at it ... Perhaps you will not only have some appreciation of this culture; it is even possible that you may want to join in ***the greatest adventure that the human mind has ever begun."***

Richard P. Feynman in the Epilogue to the Feynman Lectures on Physics

PHYSICS

It is a remarkable fact that all the phenomena we see around us, whether it is the red colour of the sunset or the light coming from the beginning of the universe, reflect the functioning of certain laws of nature. Physics is a human attempt to discover these laws and to study their consequences. What drives a physicist is the curiosity about nature and the fact that the answers to the various questions tie together in a beautiful pattern. It is also a fact that these attempts to understand the laws of nature have led to technological advances, and in turn these technological advances have provided physicist with new tools for understanding nature. This symbiosis of fundamental physics and technological advancements is one of the hall marks of our civilization.

Aim of the Physics Undergraduate Program

Research led undergraduate program in physics at SNU is designed for a student who either wishes to pursue a traditional/interdisciplinary research career in physics, or who wishes to use skills of a physicist to understand complex systems ranging from the earth's atmosphere to the human cell. The rigorous undergraduate program in physics, together with the multidisciplinary environment of SNU, will enable a student to engage creatively with problems that transcends the confines of any single discipline. The duration of B.Sc. (Research) in Physics is stipulated for 3 years (minimum) to 6 years (maximum).

Highlights of the Physics Undergraduate Program

Faculty

The SNU Physics Department comprises of faculty members who are equally passionate about their research and teaching. They are keen to bring the excitement of discovery to the classroom and to involving students in their research. Their research interests ranges from nanotechnology to the beginning of the universe. Many of them have worked at some of the leading international research and academic institutions and continue to be involved in collaborative research with these institutions.

Minor

The department is committed to equipping students to meet the challenges that contemporary society faces in the area of energy, environment and economic development. Such training is facilitated by the possibility for a student to obtain a major in physics and minor in another discipline of his or her interest. For example, a student who has major in physics and a minor in economics would have very attractive job prospects in financial and banking industry. Similarly a student interested in quantum computing, can major in physics and obtain minor in the mathematics.

Laboratory

The laboratory is an integral part of the physics program at SNU, not merely a supplement to the classroom teaching. It is the place for students to measure and explore the natural world. The salient feature of these programs is an innovative use of personal computers for data acquisition and analysis. Another important aspect is that labs will be project based and curiosity driven explorations, rather than simple repetition of standard experiments.

Tutorial Program

An essential part of learning physics is to apply abstract principles to concrete problems. With this in mind, most courses in physics will have an associated tutorial program. It is in the tutorial classes where the students will hone their skills as physicists, learning to make models, making crude estimates, and then solving the problem analytically or on a computer. It is also here that they will learn the skills of collaborative research.

Undergraduate Thesis

The goal of the physics program at SNU is to equip the students with skills to explore the unknown. The final year students will undertake a year-long research project which will lead to their undergraduate thesis. The thesis will be supervised by one of the faculty member and will address a research problem.

Major in Physics

The coursework for a student majoring in physics has three broad parts. The first part, which covers the initial two academic years, is focused on developing a firm foundation of the subject. In the second part, which is the third academic year, student learns about more advance theoretical and experimental tools, often revisiting the concepts developed in the foundation part but viewing them using these sophisticated tools. At the end of the 4^{th} semester the student will be able to appreciate and explore open research problems in physics, therefore in the final year the student will take electives from a wide range of courses, often related to the research interests of the faculty, and will start research work for his or her undergraduate thesis.

Apart from the physics course, a physics major student is expected to take a broad-range of courses from natural sciences, engineering, humanities and social sciences. These courses fall in the following categories: University wide electives (UWE), Core common curriculum (CCC), Research, experiential and applied learning (REAL), Values, ethics, leadership and service (VELS). The Physics undergraduate advisor will assist all the students meeting the various departmental and university requirements.

Credit Requirements for Physics Major

Core Courses: Within the duration of UG program, a student is expected to complete 109 credits of core courses out of which 12 credits are expected to be achieved through physics elective courses.

UWE: Within the duration of UG program, a student is expected to complete a minimum of 18 credits of UWE offered by other departments of science, engineering, and humanities.

CCC: Within the duration of UG program, a student is expected to complete a minimum of 18 credits of CCC courses offered by all the departments of science, engineering, and humanities. However, the sum of CCC and UWE must be 42 credits.

REAL: Within the duration of UG program, a student is expected to complete 25 credits from courses having research and experimental learning components.

VELS: Within the duration of UG program, a student should complete 18 credits for VELS components.

An example of a flexible course organization for B.Sc. (Research) in Physics,

1st and 2nd year: The Foundation (Major 54, UWE 12, CCC 18)						
Semester 1	**PHY 103** Fundamentals of Physics - I Credit 5 (3:1:1)[$]	**PHY 105** Introduction to Computational Physics - I Credit 3 (1:1:1)	**MAT 101** Calculus - I Credit 4 (3:1:0)	**CHY 111** Chemical Principles Credit 5 (4:0:1)	**CCC/ UWE** (3:0:0)	**CCC** (3:0:0)
Semester 2	**PHY 104** Fundamentals of Physics - II Credit 5 (3:1:1)	**PHY 106** Introduction to Computational Physics - II Credit 3 (1:1:1)	**MAT 102** Calculus - II Credit 4 (3:1:0)	**UWE** (3:0:0)	**UWE** (3:0:0)	**CCC** (3:0:0)
Semester 3	**PHY 201** Fundamentals of Thermal Physics Credit 4 (3:1:0)	**PHY 203** Introduction to Mathematical Physics - I Credit 3 (2:1:0)	**PHY 205** Waves and Oscillations Credits 4 (3:1:0)	**UWE** (3:0:0)	**UWE** (3:0:0)	**CCC** (3:0:0)
Semester 4	**PHY 202** Introduction to Quantum Mechanics Credit 4 (3:1:0)	**PHY 204** Introduction to Mathematical Physics-II Credit 3 (2:1:0)	**PHY 206** Electronics - I Credit 4 (2:1:1)	**PHY 208** Advanced Experimental Physics - I Credit 3 (1:0:2)	**CCC/ UWE** (3:0:0)	**CCC** (3:0:0)
3rd year : Advanced Tools (Major 31, UWE 6, CCC 6)						
Semester 5	**PHY 301** Classical Mechanics Credit 4 (3:1:0)	**PHY 303** Classical Electrodynamics Credit 4 (3:1:0)	**PHY 305** Quantum Mechanics - I Credit 4 (3:1:0)	**PHY 307** Electronics - II Credit 4 (2:1:1)	**UWE** (3:0:0)	**CCC** (3:0:0)
Semester 6	**PHY 302** Statistical Physics Credit 4 (3:1:0)	**PHY 304** Condensed Matter Physics Credit 4 (3:1:0)	**PHY 306** Quantum Mechanics - II Credit 4 (3:1:0)	**PHY 308** Advanced Experimental Physics - II Credit 3 (1:0:2)	**UWE** (3:0:0)	**CCC** (3:0:0)
4th Year : Exploration and Research (Major 24, UWE 0, CCC 0)						
Semester 7	**PHY 4XX/5XX*** Physics Elective Credit 3 (3:0:0)	**PHY 4XX/5XX*** Physics Elective Credit 3 (3:0:0)	**PHY 499** Undergraduate Thesis Credit 6 (0:0:6)			
Semester 8	**PHY 4XX/5XX*** Physics Elective Credit 3 (3:0:0)	**PHY 4XX/5XX*** Physics Elective Credit 3 (3:0:0)	**PHY 499** Undergraduate Thesis Credit 6 (0:0:6)			
Credit	**Major** **109**	**UWE+CCC** **42**				**TOTAL** **151**

[$]Credit X (Lecture: Tutorial: Lab), *Subject to the approval of the physics UG advisor and the course instructor

Minor in Physics

The physics department offers undergraduate students at SNU an opportunity of obtaining a minor in physics. A minor in physics has two aspects to it. First, it ensures that a student is well versed with the central core of physics, and secondly it will allow the student to learn more advanced aspects of the subject according to his or her interests. A minor in physics will equip a student to engage in challenging multi-disciplinary problems. It will be equally valuable for students seeking employment in industry or finance, where physicist skills of making quantitative models of complex situations are welcomed.

Required Courses for Engineering Major

Semester	Minor Courses	Credits
	PHY 101 - Introduction to Physics – I PHY 102 - Introduction to Physics - II	prerequisite
Monsoon	PHY 207 - Abridged course for Minor students; Credit 4 (3:1:0) PHY 201 - Fundamentals of Thermal Physics; Credit 4 (3:1:0)	8
Spring	PHY 202 - Introduction to Quantum Mechanics; Credit 4 (3:1:0) PHY 208 - Advanced Experimental Physics - I; Credit 3 (1:0:2)	7
Monsoon/ Spring	**Two courses from the following three groups (with no more than one course from a group)** Group A PHY 301- Classical Mechanics; Credit 4 (3:1:0) PHY 303- Classical Electrodynamics; Credit 4 (3:1:0) PHY 305 - Quantum Mechanics – I; Credit 4 (3:1:0) PHY 307 - Electronics - II; Credit 4 (2:1:1) Group B PHY 302 - Statistical Physics; Credit 4 (3:1:0) PHY 304 - Condensed Matter Physics; Credit 4 (3:1:0) PHY 306 - Quantum Mechanics – II; Credit 4 (3:1:0) PHY 308 - Advanced Experimental Physics - II; Credit 3 (1:0:2) Group C PHY 4XX/5XX* - Physics Elective; Credit 3 (3:0:0)	Minimum 7
Minimum Credits for Minor Degree in Physics = 22		

*Subject to the approval of the physics UG advisor and the Course instructor;

Required Courses for Non-Engineering Major

Semester	Minor Courses	Credits
Monsoon	PHY 103 - Fundamentals of Physics – I; Credit 5 (3:1:1) PHY 201 - Fundamentals of Thermal Physics; Credit 4 (3:1:0)	9
Spring	PHY 104 - Fundamentals of Physics – II; Credit 5 (3:1:1) PHY 202 - Introduction to Quantum Mechanics; Credit 4 (3:1:0) PHY 208 - Advanced Experimental Physics I; Credit 3 (1:0:2)	12
Monsoon/Spring	**Two courses from the following three groups (with no more than one course from a group)** <u>Group A</u> PHY 301- Classical Mechanics; Credit 4 (3:1:0) PHY 303- Classical Electrodynamics; Credit 4 (3:1:0) PHY 305 - Quantum Mechanics – I; Credit 4 (3:1:0) PHY 307 - Electronics - II; Credit 4 (2:1:1) <u>Group B</u> PHY 302 - Statistical Physics; Credit 4 (3:1:0) PHY 304 - Condensed Matter Physics; Credit 4 (3:1:0) PHY 306 - Quantum Mechanics – II; Credit 4 (3:1:0) PHY 308 Advanced Experimental Physics - II; Credit 3 (1:0:2) <u>Group C</u> PHY 4XX/5XX* - Physics Elective; Credit 3 (3:0:0)	Minimum 7
Minimum Credits for Minor Degree in Physics = 28		

*Subject to the approval of the physics UG advisor and the course instructor

Physics Course Catalog

Physics Core Courses

PHY 101: Introduction to Physics - I
4 credits: 3 Lectures+1 Tutorial

This is the first part of a two part introductory course for engineering students and for science students not majoring in physics. The course will introduce students to the fundamentals of mechanics and thermal physics.

PHY 102: Introduction to Physics - II
5 credits: 3 Lectures+1 Tutorial+3-hours Lab

This is a continuation of PHY 101 meant for engineers and non-physics majors. The course will introduce students to Electricity and Magnetism, Maxwell's equations, light as an electromagnetic wave, and wave optics.

PHY 103: Fundamentals of Physics - I
5 credits: 3 Lectures+1 Tutorial+3-hours Lab

PHY 104: Fundamentals of Physics - II
5 credits: 3 Lectures+1 Tutorial+3-hours Lab

PHY 103 and 104 courses together with their labs forms the foundation, by the end of 1st semester, the student would have mastered the basic concepts underlying the Newtonian physics, Special theory of Relativity, and electromagnetism.

PHY 105: Introduction to Computational Physics - I
2 credits: 1 Lecture+1 Tutorial

This course is an introduction of computational physics with main emphasize on solving differential equations encountered in PHY 103 on a personal computer.

PHY 106: Introduction to Computational Physics - II
2 credits: 1 Lecture+1 Tutorial

This course in computational physics is centered around the idea of how to solve the partial differential equations encountered in PHY 104 on a personal computer.

PHY 108: Physics for Life:
4 credits: 3 Lecture+1 Lab

This course will provide an introduction to Newtonian mechanics, Fluids, Thermodynamics, Electricity & Magnetism and wave optics. This course is specially designed for UG students who are not having background of Mathematics and Physics at 10+2 level.

PHY 201: Fundamentals of Thermal Physics
4 credits: 3 Lectures+1 Tutorial

This course introduces the fundamental of thermal physics emphasizing the universality of the laws of thermodynamics and their origin in statistical physics.

PHY 202: Introduction to Quantum Mechanics
4 credits: 3 Lectures+1 Tutorial

This course introduces the fundamental of quantum mechanics. These principles are illustrated by applying them to various interesting contemporary problems, using minimal of mathematical framework.

PHY 203: Introduction to Mathematical Physics - I
3 credits: 2 Lectures+1 Tutorial

PHY 204: Introduction to Mathematical Physics - II
3 credits: 2 Lectures+1 Tutorial

Both PHY 203 & PHY 204 courses provide a modern introduction to mathematics for physics, using the two unifying ideas of linear vector spaces and differential forms.

PHY 205: Waves and Oscillations
4 credits: 3 Lectures+1 Tutorial

This course introduces fundamental phenomenon associated with oscillating systems. It starts with normal modes for discrete systems and then generalizes it to continuous system. This leads to wave equations and the phenomenon of interference, diffraction and polarization.

PHY 206: Electronics - I
4 credits: 2 Lectures+1 Tutorial+3-hours Lab

This course is a hands-on course on electronics for undergraduate students. In this course students will be introduced to circuit design, voltage & current sources, filters, thermionic emission, and semiconductor devices like diodes, transistors, oscillators . This course also covers the application of these concepts in instruments like multi-meter, cathode ray oscilloscope and others.

PHY 207: Abridged Course for Minor Physics
3 credits: 3 Lectures+1 Tutorial

PHY 207 is a bridge course specially designed for students who have already taken PHY101 and PHY102 instead of PHY103 and PHY104. The course supplements and develops their understanding of Newtonian physics and classical electromagnetism.

PHY 208: Advanced Experimental Physics - I
3 credits: 1 Lecture+2x 3-hours Lab

PHY 208 is an advanced lab course which aims to offer an experiential learning through a wide range of experiments and projects based on Thermodynamics, Optics and Modern Physics.

PHY 301: Classical Mechanics
4 credits: 3 Lectures+1 Tutorial

This is an advanced course in classical mechanics at the level of Landau & Lifshitz, Volume-1. It covers: Lagrangian Mechanics, Rigid Body Motion and Hamiltonian Formalism.

PHY 302: Statistical Physics
4 credits: 3 Lectures+1 Tutorial

This course introduces the fundamental concept of statistical physics and thermodynamics from a modern point of view. It covers the fundamental principles of statistical physics and thermodynamics, Classical and Quantum gases, and Phase transitions.

PHY 303: Classical Electrodynamics

4 credits: 3 Lectures+1 Tutorial

This is an advance course in electrodynamics. It also covers techniques for solving partial differential equations encountered in solving Maxwell's equations, emphasizing the universal nature of these techniques and their connection to underlying symmetries in the problem.

PHY 304: Condensed Matter Physics

4 credits: 3 Lectures+1 Tutorial

This is an introductory course in condensed matter physics. It covers Crystals, lattices and symmetry group of lattices, lattice vibrations, electrons in solid, conductors, insulators, & semi-conductors.

PHY 305: Quantum Mechanics - I

4 credits: 3 Lectures+1 Tutorial

This is an introduction to quantum mechanics at the level of modern quantum mechanics by Sakurai. It covers The Dirac formalism, quantum dynamics, theory of angular momentum, symmetry in quantum mechanics, and approximation methods.

PHY 306: Quantum Mechanics - II

4 credits: 3 Lectures+1 Tutorial

This course in quantum mechanics builds on PHY 304. It covers scattering theory, systems with identical particles, second quantization, Bose and Fermi Statistics, introduction to atomic and nuclear physics.

PHY 307: Electronics - II

4 credits: 2 Lectures+1 Tutorial+3-hours Lab

This digital electronic course is a continuation to PHY206 course. This covers the Boolean algebra, logic gates, advanced electronic circuits including, operational amplifiers, adder, A/D and D/A convertors, flip flops, timers, counters. The underlying concepts will be further strengthened by introducing 8085/8086 microprocessor and its programming.

PHY 308: Advanced Experimental Physics - II

3 credits: 1 Lecture+2x 3-hours Lab

PHY 308 is a lab course offering an opportunity for hands-on learning through physics experiments based on various physics concepts covering Condensed matter physics and interaction of matter and energy.

PHY 499: Undergraduate Thesis

6 Credits: Research

Undergraduate thesis is a research project, spread over two consecutive semesters, in which students will work extensively on a research problem of current interest under the guidance of a faculty member.

Physics Elective Courses

PHY 255: Introduction to Biophysics
3 credits: 3 Lectures

This course aims to expose students to Physics concepts essential to understand Physical aspects of various biological systems and processes.

PHY 402: Classical Theory of Fields
3 credits: 3 Lectures

This course has two parts. The first part reformulates classical electrodynamics as a field theory. The second part introduces general theory of relativity.

PHY 406: Advanced Quantum Mechanics
3 credits: 3 Lectures

This course introduces a student to relativistic quantum mechanics. It includes the Dirac equation and an introduction to quantum electrodynamics.

PHY 408: Advanced Condensed Matter Physics
3 credits: 3 Lectures

This is an advanced course in condensed matter emphasizing the special properties of solids: magnetism, super fluidity and superconductivity, dielectrics and ferroelectrics.

PHY 409: Quantum Field Theory
3 credits: 3 Lectures

This course gives an introduction to the concepts of Quantum Field Theory, which comes about from combining Quantum Mechanics and Special Relativity. It introduces useful techniques for calculating Feynman diagrams and cross-sections for some common interactions.

PHY 410: Introduction to High Energy Particle Physics
3 credits: 3 Lectures

This course introduces the experimental results and the theoretical concepts that lead to the formulation of the standard model of particle physics

PHY 411: Classical Field theory and general relativity
3 credits: 3 Lectures

The first part of this course reformulates classical electrodynamics as a field theory and the second part introduces general theory of relativity.

PHY 412: Introduction to Experimental Techniques in Particle Physics
3 credits: 3 Lectures

This course introduces the student to detectors, data analysis and other experimental techniques used in experimental particle physics.

PHY413: General theory of relativity
3 credits: 3 Lectures

The subject of general theory of relativity will cover curved space times, idea of black holes and gravitational waves.

PHY 414: Computational and Numerical Analysis
3 credits: 2 Lectures + 1 Lab

Numeric and computational techniques to calculate roots of polynomials and other nonlinear functions; determinants, eigenvalues, and eigenvectors, solutions to differential equations; applications of FFT, finite difference expressions, interpolation and approximation, numerical differentiation and integration, by emphasizing on the algorithms and their implementation in the FORTRAN program language.

PHY415: Non-linear dynamics
3 credits: 3 Lectures

Nonlinear dynamics will deal with fundamental properties of nonlinear systems and the question of non-integrability.

PHY417: Topics in Quantum Many-Body Theory
3 credits: 3 Lectures

This course will cover a collection of topics like "Symmetry Concepts in Quantum Mechanics", "Adiabatic Perturbations and Berry Phases", "Perturbative and Non-perturbative Methods in Many Body Theory", with focus on "Strongly Correlated Electron Systems", "The Hubbard Model", "The Heisenberg and t-J Models", "Charge and Spin ordered Phases", "Mean Field Theory", etc. depending on the scope and time available.

PHY 551: Nanomaterials and Nanophysics
3 credits: 3 Lectures

This is an interdisciplinary advanced level Ph.D. course in which various nanomaterials processing techniques, including chemical and physical vapor deposition, lithography, self-assembly, and ion implantation will be introduced. Tools commonly used to characterize nanomaterials will be introduced. The structural, mechanical, optical and electronic properties which arise due to nano-scale structure will be discussed from the point of view of nano-scale devices and applications

PHY 554: Advanced Statistical Physics
3 credits: 3 Lectures

This course covers the critical phenomena, Landau-Ginzburg theory of phase transition, renormalisation group, time-dependent phenomena in condensed matter, Correlation and response, Langevin theory, Fokker Plank and Smoluchowski equations, broken symmetry, hydrodynamics of simple fluids, stochastic models and dynamical critical phenomena, nucleation and spinodal decomposition, and topological defects.

PHY 556: Introduction to Quantum Field Theory
3 credits: 3 Lectures

This course introduces the techniques of quantum field theory and its application to condensed matter physics and particle physics.

PHY 558: Semiconductor Physics and Devices
3 credits: 3 Lectures

This course outlines the physics, applications and technology of Semiconductors. The course covers energy band structures in semiconductors, dopants and defects, charge transport, electronic and optical properties, excitons and other quasi-particles, semiconductor heterostructures, diodes, LEDs, photovoltaic, LASERS and field-effect transistors (FETs). The concepts of these conventional devices will be extended to the emerging areas of new generation of flexible electronic and optoelectronics devices based on unconventional materials like metal oxides and organic semiconductors.

PHY 560: Particle Physics Phenomenology
3 credits: 3 Lectures

Introduction, decay rates and cross Sections, the Dirac equation and spin, interaction by particle exchange, electron – positron annihilation, electron – proton scattering, deep inelastic scattering, symmetries and the quark model, QCD and color, V-A and the weak interaction, leptonic weak interactions, the CKM matrix and CP violation, electroweak unification and the W and Z, tests of the standard model, the Higgs Boson and beyond.

PHY 562: Experimental Techniques in Particle Physics
3 credits: 3 Lectures

This course is intended to give an in-depth study of detector, data analysis and other experimental techniques used in particle physics. Modern particle detectors such as micro-pattern gaseous detectors, drift chambers, silicon detectors, calorimeters, Cherenkov detectors and others are discussed along with advanced statistical methods and data analysis techniques to extract results.

PHY 564: Advanced Simulation Techniques
3 credits: 3 Lectures

This course gives an introduction to various simulation techniques such as Monte Carlo, Classical Molecular Dynamics, Quantum Simulations: time-independent Schrödinger equation in one dimension (radial or linear equations); scattering from a spherical potential, Born approximation, bound state solutions; single particle time-dependent Schrödinger equations; Hartree-Fock theory: restricted and unrestricted theory applied to atoms; Schrödinger equation in a basis: matrix operations, variational principle, density functional theory, quantum molecular dynamics.

PHY 566: Introduction to String Theory
3 credits: 3 Lectures

The aim of this course is to introduce the basic concepts of string theory by applying quantum mechanics to a relativistic string. In this manner the student will deepen his or her understanding of quantum mechanics and will also be able to appreciate the diverse areas of physics in which the mathematical description of a string like object is useful.

PHY 568: Multiferroics and Shape Memory Alloys
3 credits: 3 Lectures

The course covers the electric polarization and their types, dipoles, frequency and temperature dependence of polarization, local field and Clausius-Mossotti equation, dielectric constant, loss and breakdown; Applications of high-k materials, ferroelectricity, pyroelectricity and piezoelectricity, electrical memory/hysteresis loop, fatigue testing, pyro and piezo coefficients; Shape Memory alloys: types, working, properties, manufacturing and applications.

PHY 570: BIOSENSORS: General principles and advanced sensing techniques

3 credits: 3 Lectures

This course covers the basic sensor terminologies (linearity, sensitivity, selectivity, response time, etc.), analyte surface interactions, Bio-MEMS, concepts of microfluidic devices, and various advanced detection techniques such as, fluorescence, surface plasmon resonance (SPR), impedance spectroscopy, scanning probe microscopy (SPM), surface enhanced Raman spectroscopy (SERC), and electrochemical methods.

PHY 574: Materials Characterization Techniques - I

3 credits: 3 Lectures

This course covers the basic interaction of matter with photons, elastic and non–elastic scatterings, characterization techniques: Ultra-violet photoelectron spectroscopy (UPS), Raman spectroscopy, Extended X-ray absorption fine structure (XAFS), X-ray fluorescence, Fourier transform infrared spectroscopy (FTIR), UV- Visible spectroscopy, Photoluminescence (PL), Electroluminescence (EL) and Cathode luminescence (CL).

PHY 575: Materials Characterization Techniques - II

3 credits: 3 Lectures

This course covers the basic interaction of matter with electrons, neutrons, ions, energetic particles, elastic and non–elastic scatterings, and characterization techniques: Optical microscopy, Transmission electron microscopy (TEM), Scanning electron microscopy (SEM), Scanning probe microscopy (SPM), Atomic force microscopy (AFM), X-ray diffraction, Energy dispersive X-ray analysis. X- Ray photoelectron spectroscopy (XPS), Secondary ion mass spectrometry (SIMS).

PHY 578: Introduction to Thin Films

3 credits: 3 Lectures

This course covers the crystals structure, defects, bonding, phase diagram, kinetics, diffusion, nucleation and growth, trapping, surface diffusion, growth models, vacuum techniques; thin film deposition techniques: thermal evaporation, e-beam evaporation, sputtering, molecular beam epitaxy, chemical vapor deposition, pulsed laser deposition; thin film properties: materials surface, structural, mechanical, optical, electrical, magnetic properties; thin film based devises and applications.

PHY 588: Fundamentals of Ion-Solid Interactions

3 credits: 3 Lectures

Introduction to ion beam processes, ion implanter and applications, interatomic potential, Thomas-Fermi statistical model, classical two-particle scattering theory, differential scattering cross-section, energy-loss process in solid, Fermi-teller model, ZBL universal scattering function, ion range & distribution, Straggling, radiation damage in solid, Thermal spikes, Mono-Carlo simulation, diffusion in solid, sputtering, applications of ion beam, ordering-disordering, alloying, Hume-Rothery rules, ion-mixing, phase transition, doping semiconductors, location of dopants via Rutherford backscattering and ion channeling.

PHY 589: Ion Beam Based Materials Characterization Techniques
3 credits: 3 Lectures

Ion accelerator, instrumentations, basic interaction of matter with ions, energy loss process, elastic and non–elastic scatterings, characterization techniques: Rutherford backscattering spectrometry (RBS), Ion channeling, Resonance channeling, Proton induced X-ray emission (PIXE), Elastic recoil detection analysis (ERDA), Nuclear reaction analysis (NRA), pitfalls in ion beam analysis, and radiation safety.

Common Core Courses (CCC)

CCC: Early History of the Universe: The First Three Minutes
1.5 credits: 3 Lectures (Half a semester)
PLS: *Foundational Course in Physical & Living systems*

The course poses the questions: How do we know that the universe had a beginning in the form of a "Big Bang"? In answering the question we will be going outward bound, to the beginning of the universe and will chart out the first three minutes of its existence.

CCC: Visible and invisible light waves: How they have changed our modern life
1.5 credits: 3 Lectures (Half a semester)
TAS: *Technology and Society*

In our everyday life visible and invisible light surround us. Both, visible and invisible light travels in waves. These waves allow us to see the unseen, carry signals to our mobile, TV and radios, and heat our food. Without these visible and invisible light waves we simply do not exist!! It is well known that there are seven kinds of light waves; Radio Waves, Microwaves, Infrared Waves, Visible Light Waves, Ultraviolet Waves, X-rays and Gamma-rays. In this module students will be familiarized with all kinds of light waves, and their fundamental nature, as well as how we interact with these waves in everyday life. The course covers the generation and detection methods of theses waves, their applications in various fields and their socio-economic impact.

CCC: Atmospheric Aerosols & Climate
1.5 credits: 3 Lectures (Half a semester)

This course will deal with the introduction of Aerosols, their types and properties. Further the impact of aerosols on human health will be discussed in Indian context.

CCC: Science, Engineering, and the Modern World
1.5 credits: 3 Lectures (Half a semester)

This course generates curiosity on topics like "Without engineering, science is just philosophy". The pre-modern world and the history of Knowledge will be discussed in the context of the concept of modern society.

CCC: Energy for a Sustainable Future
1.5 credits: 3 Lectures (Half a semester)

This course aims to provide an understanding of energy issues and options in the context of sustainable development.

CCC: Uses of Energy in Our Daily Life
1.5 credits: 3 Lectures (Half a semester)

The word 'energy' has multiple meanings depending on where it is being used and the efficient use of energy is very important in modern days. This course is designed for students to understand energy and its various forms with daily life examples.

CCC: *Physical Laws: From Non-living to Living*
1.5 credits: 3 Lectures (Half a semester)

Most of the fundamental physical laws that deal with non-living matters are based on few simple assumptions. Interestingly, such laws can follow the extremely complex living systems. Further, the same laws are employed to develop industrial products that bring billion dollars business. This course aims to explain how these physical laws are applied from biology to business.

CCC : **Let's understand devices at home**
1.5 credits: 3 Lectures (Half a semester)

The focus of this course will be to make students comfortable in understanding fundamentals of physics working in almost all household devices. The malfunctioning is very common with these devices and developing our aptitude to rectify issues is important to realize the value of labor and etiquettes of use. For example- skewed door locks, fan speed issues, burnt switches, fluctuating tube lights, inefficient cooling through air-conditioners, issues with heat convectors, coil heaters and geysers, use of adaptors, choked grinders, leaking taps and so many.

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