Course Content - Department of Physics

Last updated 8/29/2019 10:22 PM

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Course title: **Modern Physics** **Credits:** 2 (30 L)

Course code **PH 1001**

Rationale:

Physics is about the fundamental laws governing our universe of matter, energy, space and time. "Classical physics" is typically considered to cover mechanics, acoustics, thermodynamics, electromagnetism and (classical) optics, whereas "modern physics" encompasses the theories and concepts that paved the way to develop quantum mechanics of matter and light. Modern physics is the science behind most of today's pure and applied research frontiers of physics; pure research is providing the most profound insight into the nature of matter and the universe as a whole, while applied research has given us electronic computers, mobile phones, and advanced medical technology, as well as the promise of cost-effective solar panels and massively parallel quantum computers. Such a course can also inform students of how modern physics helps us deliver, manage and improve advanced technology for tackling the grand environmental, health and security challenges facing our world.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- explain the failures of classical theories applied to microscopic world;
- interpret the conceptual basis of quantum theory;
- discuss the diverse applications of quantum theory;
- solve problems in modern physics topics;
- interpret experiments and related observations in modern physics

Course Content:

Historical background, failures in classical Physics, properties of thermal radiation, black bodies, cavity radiation, Stefan's and Wien's law, classical theory of cavity radiation, Planck's theory of cavity radiation, Planck's postulate and its` implications. Interaction of radiation with matter; the photoelectric effect, Einstein's quantum theory of photoelectric effect, Compton effect, X-rays, production of X-rays, pair production and pair annihilation, the dual nature of electromagnetic radiation, matter waves, de Broglie's postulate & de Broglie wavelength, the wave-particle duality, atomic spectra, Frank and Hertz experiment, Thomson's and Rutherford's model of the atom, Bohr model of the atom, one electron atom, energy quantization, Rydberg constant, Correspondence principle, Uncertainty principle, Introduction to Schrodinger wave equation

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Tipler, P. A., & Llewellyn, R. (2003). *Modern Physics*. London, England: Macmillan.
2. Fredriksson, H., & Åkerlind, U. (2008). *Physics of Functional Materials*. Hoboken, NJ: John Wiley & Sons.
3. Richards, J. A., Sears, F. W., Wehr, M. R., & Zemansky, M. W. (1960). *Modern university physics*.
4. Tipler, P. A., & Llewellyn, R. (2003). *Modern Physics*. London, England: Macmillan.
5. White, H. E. (1972). *Modern College Physics*.
6. Young, H. D., Freedman, R. A., & Ford, A. L. (2004). *Sears and Zemansky's University Physics*. Addison Wesley Longman

Course title: **Modern Optics** **Credits:** 1 (15 L)

Course code **PH 1002**

Rationale:

Optics is one of the most fundamental components of physics. A good understanding of interference, diffraction and polarization is important for other branches of physics too. In addition, optics has many modern applications in areas such as lasers, fiber optics, cameras and computer display.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- use the matrix method to calculate the paths of light rays through multiple optical elements
- describe the physical nature of light in terms of the electromagnetism
- describe applications of polarization of light
- perform calculations related to polarization of light
- describe interference of light in terms of wave theory of light
- perform calculations related to interference of light
- describe diffraction of light in terms of wave theory of light and
- perform calculations related to diffraction of light.

Course Content:

Ray matrix method in Geometrical Optics: reflection, refraction, transmission, lenses, surfaces, optical systems, linear polarization, Malus's Law, circular & elliptical polarization, polarizers, Matrix formulation of polarized light and elements; Jones' vectors and Jones' matrices, coherence, divisions of wave front and amplitude: Young's double slit experiment, Lloyd's mirror, Fresnel's Biprism, Fresnel's double mirror, fringes of equal inclination and fringes of equal thickness; Fraunhofer diffraction; Rectangular and circular apertures, resolving power, single slit, double slit and diffraction grating, Fresnel diffraction; Fresnel half period zones, circular division of the wave front, vibration curve, circular aperture, zone plates, strip division of the wave front, Cornu's spiral, straight edge and single slit

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Jenkins, F. A., & White, H. E. (1937). *Fundamentals of optics*. Tata McGraw-Hill Education..
2. Longhurst, R. S. (1970). *Geometrical and physical optics*. Orient BlackSwan.
3. Chakrabarti, P. (2010). *Geometrical & Physical Optics*. New Central Book Agency.
4. Fowles, G. R. (1989). *Introduction to modern optics*. Courier Corporation.

Course title: **Waves & Vibrations and Circuit Theory** **Credits:** 2 (30 L)

Course code **PH 1003**

Rationale:

Waves & vibrations is a fundamental subject in Physics. It builds ideas of vibrations and waves by first looking at simple harmonic motion and later where waves are perceived as coupled vibrations. These ideas in waves & vibrations are used to model many physical phenomena in fundamental physics (*e.g*. physical optics, quantum mechanics *etc.*.) and science in general. The course looks at using concepts perceived in waves & vibrations by building a basic mathematical basis and applications thereof to some simple physical systems including electrical circuits.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- examine the motion of free oscillators to forced oscillators
- analyse the modes of oscillations for oscillators (single or many)
- solve problems related to wave motion and properties in a variety of situations
- interpret direct current transient circuits and alternating current circuits

Course Content:

Voltage and current sources; Different types of alternating voltages and currents; root mean square (rms) values, Circuit elements; Active and passive elements, Resistor networks; Thevenin's and Norton's theorems, Conditions for maximum power and voltage transfer, loading effect, Direct current circuits; transient response of RC and RL circuits, LC oscillations, integrating and differentiating circuits, Low and high pass filters, Alternating current (AC) circuits; Analysis of series and parallel LCR circuits using complex numbers and S-domain, power in AC circuits, resonance in LCR circuits, Bridge circuits to measure LCR and frequency, Single phase and three phase systems. Periodic motions: sinusoidal vibrations, simple harmonic motion, superposition of two vibrations with 1-D and 2-D; free vibrations, damped harmonic oscillator, forced vibrations, power absorbed by a driven oscillator, resonance; wave equation, wave speeds in specific media, phase and group velocities, impedance and energy flux; reflection and transmission; impedance matching between two media; Fourier analysis of pulses; coupled oscillators; Two coupled pendulums, superposition of normal modes, sound; Velocity of sound waves, perception of sound, intensity and pressure level, Doppler effect. acoustics of buildings.

Method of Evaluation: Continuous assessments (up to 40%) and end of semester exam

References:

1. French, A. P. (2001). Vibrations and Waves, MIT Press.
2. Alexander, C., & Sadiku, M. (2006). Fundamentals of Electric Circuit. 5th Ed., McGraw Hill.

Course title: **Thermodynamics** **Credits:** 1 (15 L)

Course code **PH 1004**

Rationale:

Thermodynamics is the study of energy conversion between heat and mechanical work, and subsequently the macroscopic variables such as temperature, volume and pressure. In thermodynamics, there are four laws, all of them have been developed from experimental observations. These laws are very generally valid, can be applied to systems about which one knows nothing other than the balance of energy and matter transfer. Examples of such systems include the principles of fluorescent tubes, older television screens (cathode ray tubes), plasma display panels, lasers, light emitting diodes, *etc*., and ongoing research into the thermodynamics of different types of stars to black holes.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- interpret fundamental definitions related to systems in equilibrium thermodynamics, its variables, properties and processes.
- apply the physical laws related to systems of thermodynamics in closed systems
- apply developed notions in thermodynamics to analyse real world applications
- interpret the critical phenomena in thermodynamic systems.

Course Content:

Basic concepts of thermodynamics: thermodynamic systems, thermodynamic states and variables, thermodynamic processes; Zeroth law of thermodynamics: The equation of state, Measurement of temperature; First law of thermodynamics: heat, work, Internal energy, applications of the first law of thermodynamics; Second law of thermodynamics: Entropy, entropy change of ideal gases, Carnot cycle, applications of the second law of thermodynamics, Thermodynamic potentials, Phase transitions; Introduction to third law of thermodynamics

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Thermodynamics & Introduction to statistical physics (IGNOU series)
2. Gupta, A. B., & Roy, H. P. (1995). *Heat and Thermodynamics*.
3. Kittel, C., & Kroemer, H. (1980). *Thermal Physics*. London, England: Macmillan.
4. Zemansky, M. W. (1968). *Heat and thermodynamics: an intermediate textbook*. McGraw-Hill Science, Engineering & Mathematics.

Course title: **Physics Laboratory I** **Credits** 2 (60 P)

Course code **PH 1020**

Rationale:

It is essential for a Physics student to gain hands-on experiences in experimental classical physics. This introductory laboratory course is designed to give basic skills in conducting controlled experiments which requires handling measuring instruments, interpreting data, estimating uncertainties, and prepare them for more advanced laboratory and theoretical courses in the physics curriculum.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- measure physical quantities using instruments such as Vernier caliper, micrometer screw gauge, travelling microscope, cathetometer, etc.,. with considerations for measurement accuracy and precision
- apply basic error analysis systematically to estimate uncertainties associated with measured quantities.
- infer experimentally major physical quantities related to mechanics, thermal physics, properties of matter and geometrical optics
- understand the relationship between experiment and theory
- communicate verbally and in writing the findings from an experiment

Course Content:

Lessons on introduction to error theory, Introduction to measuring instruments, Set experiments on the properties of matter, mechanics, geometrical optics, etc.

Method of Evaluation: Continuous assessment (50%), viva-voce examination (10%) and end of semester laboratory examination (40%)

References:

1. Laboratory instruction sheets, Notes on error theory prepared by the Department of Physics, A Tyler, F. (1977). *A Laboratory Manual of Physics*. Hodder Education.

Course title: **Electronics and Computing Laboratory I** **Credits:** 2 (60 P)

Course code **PH 1021**

Rationale:

Electronics and computing have become essential tools in scientific industry, academic research as well as in everyday life. The skills of using these tools are best acquired by hands-on experience. This introductory laboratory course is designed to give basic skills of electronics and computing to students and prepare them for more advanced laboratory and theoretical courses in the physics curriculum.

Prerequisites: None

Intended Learning Outcomes:

Upon completion of this course students will be able to:

- recognize functionality of basic electronic components / programming structures
- follow instructions and build electronic circuits that perform simple tasks
- develop software to perform simple algorithms
- apply electronics and computing in basic physics experiments

Course Content:

The course focuses on providing the student with hands-on knowledge in electronics and laboratory computing through a series of experiments. The course involves exercises such as studying the characteristics of electrical & electronic components/circuits and their applications, laboratory computer programming, statistical analysis of data & interpretation of results.

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Refer practical instruction sheets.

Course title: **Analogue and Digital Electronics I** **Credits:** 2 (30 L)

Course code **PH 2001**

Rationale:

Let alone the impact of electronics on modern day appliances, skills in electronics is useful in the measurement process of many disciplines in science. This course is a basic survey of fundamental concepts related to both analogue and digital electronics and students will be introduced to basic design concepts related to electronic systems.

Prerequisites: PH 1003 is strongly recommended

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to;

- describe the operational behaviour of basic electronic elements
- analyse the function of electronic circuits using basic models
- synthesize electronic circuits for given requirements

Course Content:

Diode as a circuit element, Diode models, Rectifier circuits, Zener diodes, Voltage regulation and low voltage power supply, Limiting and clamping circuits, Special diode types, Seven segment and other displays and their applications. Bipolar transistors, Operation of an npn transistor in the active mode, Transistor biasing and transistor as an amplifier, Designing of a common emitter amplifier, Voltage gain, Transistor as a switch-Cutoff and saturation, Small signal equivalent circuit models, Frequency characteristics of an amplifier, Feedback, Four-basic feedback topologies, Voltage and current feedback, Negative feedback amplifiers, Effect of feedback on the amplifier characteristics, Positive feedback, Oscillators, Operational amplifiers, Inverting and non-inverting amplifiers, Opamp based electronic ammeters and voltmeters, Analogue differentiators and integrators, Digital electronics, Voltage levels, Basic logic gates, Introduction to logic families, Designing of combinational logic circuits, Minimization of logic expressions using algebraic and Karnaugh map methods, Construction of a full adder, Addition and Subtraction, Flip-Flop as a memory element, Sequential logic circuits, registers, Asynchronous counters.

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Horowitz, P., & Hill, W. (2015). *The Art of Electronics*. Cambridge, England: Cambridge University Press.
2. Sedra, A. S., & Smith, K. C. (1998). *Microelectronic Circuits*. New York: Oxford University Press.

Course title: **Physics of Semiconductor Devices** **Credits:** 1 (15 L)

Course code **PH 2002**

Rationale:

This course is one of the fundamental courses for undergraduate students in physics. Through this course, students apply basic physics to interpret underlying mechanics of semiconductor devices. The course is intended to develop a solid basis for more advanced studies in rapidly developing areas in materials science and technology.

Prerequisites: PH 1001 is recommended

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to;

- outline the fundamental concepts to interpret crystal structures of solids.
- interpret theories that explains the description of energy bands of materials.
- illustrate the fundamental physical laws pertaining to charge carrier characteristics of intrinsic semiconductors.
- apply developed physical laws to interpret the operation of semiconductor devices.

Course Content:

Semiconductor materials and their properties, Intrinsic semiconductors, Electron-hole pair formation, Doped (extrinsic) semiconductors (n and p type), Relationship between electron and hole concentrations in semiconductors, p-n junction, Drift and diffusion currents, p-n junction under open circuit condition, Depletion region Built in voltage width of the depletion region, p-n junction under forward-bias and reverse-bias conditions, Current-voltage relationship, Diffusion capacitance, Bipolar transistors, Physical structure and mode of operation, Operation of pnp and npn transistor in the active mode, Current flow through the transistor, Introduction to field effect transistors and MOSFETS, IC technology, Semiconductor device applications

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Kittel, C. (1996). *Introduction to Solid State Physics*. Hoboken, NJ: John Wiley & Sons.
2. Neamen, D. A. (2003). *Semiconductor physics and devices: basic principles*. McGraw-Hill Science/Engineering/Math.

Course title: **Electromagnetic Theory** **Credits:** 2 (30 L)

Course code **PH 2003**

Rationale:

Up until the early eighteen hundred, the western scientists believed that electricity and magnetism were two unrelated phenomena. But Oersted showed that they are connected; and before long Ampere, Faraday and others worked out an exact description of magnetic action of electric current. James Clerk Maxwell in the early 1860s formulated a complete theory of classical electromagnetism. Finally, Albert Einstein gave his own interpretation of how electricity and magnetism are connected in his 1905 paper titled "On the Electrodynamics of Moving Bodies". In this course we will explore the evolution of this body of knowledge.

Prerequisites: PH 1003 and PH 2002 are strongly recommended

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to;

- explain the fundamental abstract concepts of electromagnetic theory.
- recognize the relationship between concepts of electricity and magnetism.
- apply electromagnetic theory to solve idealistic problems.

Course Content:

Electrostatics: Fields due to static charges, electric field intensity, electric potential, electric dipole, electric flux and Gauss's Law, conductors, boundary conditions at a conducting surface, Poisson and Laplace equation, capacitors, dielectrics, Boundary conditions at the interface of two dielectrics, Method of images, Current density and equation of continuity. *Magnetostatics:* Magnetic field, magnetic force on current, magnetic flux and Gauss' law of the magnetic field, Biot Savart Law, Ampere's Law *Electrodynamics:* Electric current, current density, conservation of charge, microscopic view of Ohm's law, Faraday's law of electromagnetic induction, inductance, Electric fields in different frame of reference. *Maxwell's Equations:* Maxwell's equations and displacement current, plane electromagnetic waves in free space.

Method of Evaluation: End of semester written exam 70%, Midterm exam 20%, Group activity 10%

References:

1. Purcell, E. M., & Morin, D. J. (2013). *Electricity and Magnetism*. Cambridge, England: Cambridge University Press.

Course title: **Special Relativity** **Credits:** 1 (15 L)

Course code **PH 2004**

Rationale:

Albert Einstein's idea of Special Relativity in 1905 saw the dawn of a new era in Physics. The invariance of Physics in the realm of electromagnetism is at the heart of the theory. The mathematics behind is simple, yet the implications are profound. The new flavor of space-time is surveyed in this course.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to;

- explain the underlying basis of special relativity
- apply Lorentz transformation to analyse time dilation, length contraction and non-simultaneity of events situations
- analyse paradoxes in special relativity
- solve relativistic dynamics problems
- apply space-time diagrams to relativistic problems

Course Content:

Galilean transformation equations, Newtonian relativity, Ether concept and the Michelson-Morley experiment, Lorentz-Fitzgerald contraction hypothesis and ether-drag hypothesis, Einstein's postulates of the special theory of relativity, Lorentz transformation equations, Non-absolute simultaneity; Length contraction, Time dilation, ‘Twin paradox’; Relativistic velocity and acceleration transformation equations, Aberration and Doppler effect of relativity, Relativistic dynamics: momentum, mass and kinetic energy, equivalence of mass and energy, Some experimental evidence in favour of relativity, Space-time diagrams and their uses, Time order and space separation of events, Introduction to general relativity.

Method of Evaluation: Continuous assessments (30%); End of semester exam (70%)

References:

1. Einstein, A. (2015). *Relativity: The Special and the General Theory*.
2. French, A. (1968). *Special Relativity*. Boca Raton, FL: CRC Press.

Course title: **Physics Laboratory II** **Credits:** 2 (60 P)

Course code **PH 2020**

Rationale:

It is essential for a Physics student to gain hands-on experiences in experimental classical physics. This laboratory course is designed to apply skills developed in the introductory course to more advanced classical physics experiments.

Prerequisites: PH 1020

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to

- apply error analysis in more complicated situations to estimate uncertainties associated with measured quantities.
- become more familiar with the measuring instruments available in a general physics laboratory such as Vernier caliper, micrometer screw gauge, travelling microscope, cathetometer, etc., for making precise measurements with minimum guidance.
- apply conservation laws and equations of motion to analyze advanced experiments in mechanics and determine various physical quantities.
- carryout experiments designed to determine properties of matter such as, surface tension, viscosity, Young's modulus, moment of inertia, etc.
- carryout experiments to investigate magnetic properties of certain materials such as hysteresis.
- use of spectrometer with a prism to determine the resolving power and other optical properties of glass of the prism.
- use spectrometer with diffraction gratings to analyse properties of gratings, emission spectra of certain elements produced by gas discharge tubes.
- make measurements on interference patterns such as Newton rings, wedge fringes to determine the wavelength of light, thickness of a material, diameter of a wire, Young's modulus of a material, etc.

Course Content:

Set-experiments on the properties of matter, mechanics, electromagnetism, physical optics, etc.

Method of Evaluation: Continuous assessment (50%) + Viva-voce examination (10%) + End of semester laboratory examination (40%)

References:

1. Laboratory instruction sheets, Notes on error theory prepared by the Department of Physics
2. A Tyler, F. (1977). *A Laboratory Manual of Physics*. Hodder Education.

Course title: **Electronics and Computing Laboratory II** **Credits:** 2 (60 P)

Course code **PH 2021**

Rationale:

Electronics and computing have become essential tools in scientific industry, academic research as well as in everyday life. The skills of using these tools are best acquired by hands-on experience. This laboratory course is designed to utilize skills gained in the introductory course to more advanced electronics and computing applications.

Prerequisites: PH 1021 is strongly recommended

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- design and synthesize operation of selected electronic circuits using principles related to filters, amplifiers, regulators etc..
- program of microcontrollers and apply them in simple applications
- design, draw, and construct printed circuit boards
- implement the designed electronic circuits with cost effective readily available components
- troubleshoot shortcomings in the designed circuit
- apply selected numerical methods to solve selected problems in Physics
- apply software for automation

Course Content:

This course focuses on providing the student with hands on learning in electronics and computing through relevant laboratory work. The course involves exercises such as circuit design using electronic gates, flip-flops, registers and memories to perform operations of numerical and binary data and, introduction to laboratory computing including circuit design programs such as EWB and SPICE.

Method of Evaluation: Continuous assessment (60%) and end of semester laboratory examination (40%).

References:

1. Refer laboratory instruction sheets

Course title: **Quantum Mechanics I** **Credits:** 3 (45 L)

Course code **PH 3001**

Rationale:

Quantum Mechanics is considered as the branch of physical science that deals with the behavior of matter and energy on the scale of atoms and subatomic particles. The fundamentals of Quantum Mechanics are deeply rooted on the mathematics of vector spaces. Their applications are everywhere in the modern world and are an essential in any undergraduate physics program. This course surveys the essential fundamentals of quantum mechanics and its applications to analyze idealistic potential systems to model real physical systems such as nuclei, atoms, molecules, crystal lattices and provides the students with a solid foundation to take more advanced courses related to Quantum Physics.

Prerequisites: PH 1001

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- analyze physical processes/systems using the uncertainty principle.
- evaluate the quantities: eigenvalues, eigenfunctions, position probability density, probability current density, expectation values, uncertainties ,etc, associated with quantum systems,using wave functions and operators.
- apply the Schrödinger equation to analyze idealistic (one-, two- and three-dimensional) potential systems.
- apply the Schrödinger equation in spherical polar coordinates for a hydrogenic atom to obtain possible electronic energy levels and wave functions.
- identify the spectroscopic labelling of atomic sub states and their occupation by electrons, in terms of the quantum numbers associated with orbital and spin angular momenta.

Course Content:

Inadequacies of classical physics and evolution of quantum physics; Particles and wave packets; Heisenberg uncertainty principle and its consequences, some illustrations of uncertainty principle; Wave function and its interpretation, position probability density, superposition principle; Time-dependent Schrödinger equation; Conservation of probability, probability current density; Dirac bracket notation; Linear operators and their properties: eigenvalues and eigenfunctions of operators, Hermitian operators, adjoint operator; Expansions in eigenfunctions: Orthogonality, degeneracy, probability amplitudes, discrete and continuous spectra; Commutators, commuting observables, compatibility; Expectation values; Time-independent Schrödinger equation, stationary states; Energy quantization; Properties of the energy eigenfunctions; General solution of the time-dependent Schrödinger equation; Solutions of the time-independent Schrödinger equation for a particle moving in a region of zero potential, step potential, barrier potential, finite square well potential, infinite square well potential, linear harmonic oscillator potential and square box potential; Symmetry and parity; One-electron atoms: separation of the time-independent Schrodinger equation in spherical polar coordinates, energy levels, quantum numbers, degeneracy, eigenfunctions of the bound states, probability densities; Orbital angular momentum and orbital magnetic dipole moment of electron; Stern-Gerlach experiment, existence of spatial quantization, spin angular momentum and spin magnetic dipole moment of electron; Spin-orbit interaction; Total angular momentum; Spin-orbit interaction energy and the hydrogen energy levels; Transition rates and selection rules

Method of Evaluation: Mid-semester examinations (30%) + End of semester examination (70%)

References:

1. Bransden, B. H., & Joachain, C. J. (1989). *Introduction to Quantum Mechanics*. Harlow, England: Longman Publishing Group.
2. Eisberg, R. M., & Resnick, R. (1985). *Quantum physics of atoms, molecules, solids, nuclei, and particles*. Hoboken, NJ: John Wiley & Sons.
3. Griffiths, D. (2016). *Introduction to Quantum Mechanics*. Cambridge, England: Cambridge University Press.

Course title: **Environmental Physics** **Credits:** 3 (45 L)

Course code **PH 3002**

Rationale:

Environmental protection plays a major role in almost all professions / industries today. The aim of this course is to provide students with knowledge on physical aspects of the environmental protection, certification requirements, sustainable business practices and expose students to the real environmental problems in the industry with technical know-how of solving those problems.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- describe the solar radiation and insolation, associated atmospheric circulation patterns and wind motion, weather prediction methods and the occurrence of monsoons, thunderstorms and lightning, tornados, cyclones and the disaster preparedness under extreme weather events
- evaluate the stability of the atmosphere and the presence of heat island effect and temperature inversion.
- apply pollution dispersion models in designing factories, power plants and other industries
- compute the minimum stack height of factories necessary to maintain ground level atmospheric pollution at safety levels.
- estimate building downwash, stack tip downwash and wake effects
- measure air pollution and describe design parameters of industrial pollution control equipment
- explain the Green-House Effect, carbon trading, carbon footprint and cleaner production concepts
- describe the impact of global warming, effect of oceanic currents, climate change and sea-level rise and discuss mitigatory measures.
- mitigate the effects of El Nino effect
- describe Environmental Protection Licence (EPL) procedure
- involve in preparation of physical aspects of an Environment Impact Assessment (EIA) or Strategic Environmental Assessment (SEA) report.

Course Content:

The earth's atmosphere, composition, temperature profile, exosphere and magnetosphere; Solar radiation and insolation, effect of atmosphere, pollution level and turbidity factor, the solar radiation budget; Dynamic meteorology, motions of the atmosphere; Thermodynamics of the atmosphere, temperature inversions and its effects; Greenhouse effect and global warming, three dimensional climate model; Climate change and sea level rise, feedback loops; Ozone depletion and its consequences, preventive measures; Clouds, Precipitation and Water, humidity, mist and fog, acid rains; Droughts and the E1 Nino effect, southern oscillatory index; Water pollution, hydrolic loading;

Geophysical environment, earth and its interior, geological structure, continental drift, earthquakes, volcanoes, landslips; Physical oceanography: horizontal circulation, Ekman spiral, geostrophic currents, westward intensification; Vertical circulation, wind-induced circulation, equatorial upwelling, coastal upwelling, Langmuir circulation, thermohaline circulation, surface circulation, Gulf stream eddies, deep water masses; The earth's electrical environment, atmospheric electricity, cloud electrification and thunderstorms, lightning hazards and protection; Air pollution, detection techniques, recommended buffer zones, cleaner production techniques, Pollution due to electric fields & electromagnetic radiation, potential hazards of weak alternating fields & microwaves; Sound & vibration, acoustics of buildings, reduction of noise, Sri Lanka standards, supersonic waves, inaudible sound and vibration, measurement of vibration; Energy sources & their impact on the environment; Green energy solutions, Policy making; Environment Impact assessment (EIA) or Strategic Environmental Assessment(SEA) report – physical aspects; Field visits to industrial sites exposing students to real environmental problems.

Method of Evaluation: Mid-semester examinations (30%) + End of semester examination (70%)

References:

1. Kanan, K. (1999). *Fundamentals of Environmental Pollution*.
2. Rao. (1988). *Air Pollution*. New York, NY: Tata McGraw-Hill Education.
3. Wallace, J. M., & Hobbs, P. V. (2006). *Atmospheric Science: An Introductory Survey*. Amsterdam, Netherlands: Elsevier
4. Environmental Air Analysis Trivedi, P R. and Raj, G.
5. Climate and the Environment - The Atmospheric Impact on Man Griffiths, J F.

Course title: **Nuclear Physics** **Credits:** 3 (45 L)

Course code **PH 3004**

Rationale:

The impact of nuclear physics extends well beyond furthering our scientific knowledge of the nucleus and nuclear properties. Nuclear science and its techniques, instruments, and tools are widely used to address major societal problems in medicine, border protection, national security, nonproliferation, nuclear forensics, energy technology, and climate research. Further, the tools developed by nuclear physicists often have important applications to other basic sciences—medicine, computational science, and materials research, among others—while its discoveries impact astrophysics, particle physics, and cosmology, and help to describe the physics of complex systems that arise in many fields. This course equips students with fundamentals of nuclear physics to survey important applications related to nuclear science and technology.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of the course, students will be able to:

- interpret the electronic and nuclear structure of atoms,
- recognize the influence of atomic and nuclear physics on modern scientific development,
- explain the key areas in which atomic and nuclear physics affects everyday living,
- solve problems related to the structure of atoms and the effect of ionizing radiation on the body and the environment,
- analyse various aspects of experimental and theoretical physics which relate to both atomic and nuclear physics.

Course Content:

General survey of radioactive decay; Half Life; Series Decay; Artificial Radioactivity, Applications of Radioactivity; Biological effects of radiation; Alpha decay; Barrier penetration; Fine structure of Alpha spectra; The theory of Alpha decay; Systematics of Alpha decay; Rutherford scattering, Beta decay; Experiments on the neutrino; Systematics of Beta decay; The Fermi theory of Beta decay; Electron and positron energy spectra; Electron capture; The neutrino mass; The theory of Gamma decay: Internal conversion; Nuclear isomerism; Nuclear sizes and nuclear masses; The distribution of nuclear matter in nuclei; The masses and binding energies of nuclei in their ground states; The semiempirical mass formula; The Beta stability valley; The masses of the Beta stable nuclei; The energetics of Alpha decay and fission; Ground state properties of nuclei; The liquid drop model; Nuclear potential well, Introduction to shell model; Magic numbers; Nuclear chart; Power from nuclear fission; Induced fission; Neutron cross sections for U235 and U238; The fission process; The chain reaction; Nuclear reactors; Radioactive waste; Nuclear fusion; The sun; Hydrogen burning; The passage of charged particles through matter; Energy loss due to ionization; Passage of Gamma rays through matter; Introduction to particle physics; Nomenclature and Catalogue of particles; Conservation laws; Introduction to quarks and basic interactions in nature; Brief introduction to nuclear detectors

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Reid, J. M. (1984). *The atomic nucleus*. Manchester University Press.
2. Patel, S. B. (1991). *Nuclear physics: an introduction*. New Age International.Atomic Nucleus (Huygens)
3. Burcham, W. E. (1979). Elements of nuclear physics.

Course title: **Astronomy** **Credits:** 3 (45 L)

Course code **PH 3008**

Rationale:

Astronomy involves many scientific disciplines and captures the imagination more than any other science due to its far-ranging inquiries. Astronomy is also called the fountainhead of all sciences. It was the solution to the problem of planetary motion that laid the foundation of mechanics, the first systematized branch of physics. Development of astronomy shows how the scientific method evolved. This course surveys the evolution of fundamental concepts, analytical methods and observational techniques of astronomy.

Prerequisites: None. (Recommended for students with good mathematical background.)

Intended Learning Outcomes:

Upon successful completion of the course, students will be able to:

- describe the development of scientific method,
- explain the fundamental concepts of modern-day astronomy,
- describe the origin and the evolution of the universe and its constituents,
- evaluate the motion of planatary bodies,
- analyse data from telescopes, CCD images, spectrograph and photometers to evaluate stellar properties,
- use sky maps and identify objects in the night sky.

Course Content:

Development of astronomy: Introduction, geocentric and heliocentric theories; **The solar system:** origin, constituents-planets, moons, asteroids, comets; **Planetary motion:** Kepler's Laws, measurement of distances to the planets, Titius - Bode Rule, variation of earth's orbit around the sun, existence of extraterrestrial planets; **Structure of stars:** The sun as a star, equations of stellar structure, energy sources, rates of thermonuclear reactions, Schwarzschild's model, Chandrasekhar limit; **Stellar evolution:** Virial Theorem, evolution near the main sequence, Jean's criterion, dynamical collapse of a protostar, nucleosynthesis, white dwarfs, neutron stars, red giants, supernovae, black holes, pulsars, X-ray and Gamma ray sources, variable stars, Cepheid variables. **Stellar Properties:** Measurement of distances to stars**,** parallax; temperature; velocity, Doppler shift; masses and radii of stars: measuring techniques, study of variable stars and binary stars; **Luminosity and magnitude of stars:** Apparent magnitude, measurement of apparent luminosity, surface temperature, colour, UBV and RGU systems, correction for observed magnitudes, measurement of distances to nearby stars, absolute magnitude; Hertzprung-Russel diagram; **Galaxies:** classification of galaxies. Milky way and the Local Group, measurement of distances to galaxies; **Cosmology:** nature of the universe and its evolution, Big bang and isotropic models of the universe inflation in early universe, cosmological models with matter creation, gravitational red shift, Hubble Law, cosmic microwave background radiation, gravitational lenses quasars, dark matter, dark energy; **Celestial co-ordinates and guide to use star charts**: earth's axis of rotation. precession of the earth's axis, right ascension, declination, altitude, azimuth, zenith angle, concept of time, sidereal and solar time, star catalogues; **Astronomy instrumentation**: optical telescope types, photography, CCD imaging, image processing, time measurement, spectrographs and spectroscopy, photometer, radio telescopes, radio interferometry, radio spectroscopy, the Hubble Space Telescope, orbiting infrared, X-ray and gamma ray telescopes, planetary probes.

Method of Evaluation: Mid-semester examinations (30%) + End of semester examination (70%)

References:

1. Abhyankar, K. (2002). *Astrophysics: Stars and Galaxies*. Universities Press.
2. Dodelson, S. (2003). *Modern Cosmology*. Cambridge, MA: Academic Press.
3. Freedman, R., & Kaufmann, W. J. (2007). *Universe*. London, England: Macmillan.
4. Gibilisco, S. (2002). *Astronomy Demystified*. New York, NY: McGraw Hill Professional.
5. Karttunen, H., Kröger, P., Oja, H., Poutanen, M., & Donner, K. J. (2013). *Fundamental Astronomy*. Berlin, Germany: Springer Science & Business Media.

Course title: **Computational Physics Laboratory** **Credits:** 2 (60 P)

Course code **PH 3020**

Rationale:

Development of computer technology has made it possible to solve many physics problems that are not amenable to analytical solutions. Numerical methods are at the heart of solving such problems. This course is designed to give students hands-on experience in applying numerical methods for solving problems in several areas of physics.

Prerequisites: PH 1021 and PH 2021 are strongly recommended

Intended Learning Outcomes:

Upon successful completion of the course, students will be able to:

- fit straight lines, polynomials and other functions to experimental data to extract information,
- analyse non-linear dynamical systems and extract characteristics of chaotic and non-chaotic dynamical systems,
- solve differential equations numerically to analyse physical systems,
- perform Monte Carlo simulations of complex systems and analyse their behaviour,
- use Fourier techniques to analyse frequency characteristics of digitized data,
- apply various filters on digital data to remove noise.

Course Content:

This laboratory course focuses on providing the student with hands-on learning in computing through relevant laboratory work. The course involves exercises on computing such as computer programming, computer simulations. Each student is expected to prepare an individual laboratory report. The maximum number of laboratory excerciese possible will be conducted within a semester.

Method of Evaluation: Continuous assessment (60%) + End of semester laboratory examination (40%)

References:

1. Hoffmann, K. H., & Schreiber, M. (Eds.). (1996). *Computational Physics* (1st ed.). Springer-Verlag Berlin Heidelberg.Press, W. H., Teukolsky, S. A., Vetterling, W. T., & Flannery, B. P. (2007). *Numerical Recipes 3rd Edition: The Art of Scientific Computing*. Cambridge, England: Cambridge University Press

Course title: **Computational Physics Seminar** **Credits:** 1 (30 P)

Course code **PH 3021**

Rationale:

Seminars provides students with multiple skills and knowledge including review of techniques used in solving real life problems. In this course, students survey and critically review selected scientific literature in the field of computational physics and present their findings.

Prerequisites: None

Intended Learning Outcomes:

On successful completion of the course, students will be able to:

- survey computational physics research,
- critically evaluate peer-reviewed scientific literature,
- integrate relevant theory and methods in a logical way and draw conclusions,
- write and present the findings of a research with a logical structure and organization.

Course Content:

This course focuses on improving the self-learning and presentation skills of students. Students are supposed to study a specific topic in the area of Computational Physics and present their findings at a seminar.

Method of Evaluation: End of semester viva-voce examination

References:

1. Depends on the topic selected by the student

Course title: **Advanced Physics Laboratory I** **Credits:** 6 (180 P)

Course code **PH 3030**

Rationale:

The objective of this laboratory course unit is to enhance the students' experimental skills beyond classical physics. Students are expected to conduct experiments independently gaining skills in planning, recording and communicating findings.

Prerequisites: PH 1020 and PH 2020 are strongly recommended

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- assemble experiments related to physics and electronics
- measure physical variables using appropriate instrumentation
- use appropriate data acquisition techniques to gather data from custom-made apparatus troubleshoot an experimental setup
- analyse measured variables and develop mathematical/ physical models to interpret measurements
- present findings in both written and oral formats

Course Content:

Polarized Light and Optical activities, Optical Experiments with He-Ne Laser, Introduction to Microcontrollers, Design & Construction of PCBs, Dynamic Simulations, Introduction to Artificial Neural Networks, Mathematical Software in Physics, Workshop Practice, Experiments with Physics Demonstration Kit are the main experiments which are included.

Method of Evaluation: Continuous assessments (100%)

References:

1. Refer the laboratory instruction sheets where the list of references necessary for each and every laboratory exercise is given in numbers.

Course title: **Embedded Systems Laboratory** **Credits:** 3 (90 P)

Course code **PH 3032**

Rationale:

Microcontrollers are ubiquitous in modern appliances. Hence, the capability of programming microcontrollers is an essential skill for electronic designers. This course aims to provide basic theoretical knowledge on microcontrollers together with hands-on experience in programming a microcontroller-based system to satisfy specific requirements in the industry or research.

Prerequisites: PH 1021, PH 2001, PH 2021 are strongly recommended

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- design and construct microcontroller-based system to perform a specific task
- design printed circuit board artwork from a schematic diagram using an electronic design automation software
- analyse the design requirements (for a feasible solution) of a task to be automated prepare a good technical/scientific report on the design
- summarize and present technical details with proper documentation of technical records

Course Content:

Introduction: an overview on microprocessors, introduction to microcontrollers, hardware structure and concept of microcontroller, logical operations and masking; Memory mapping: program memory, data memory, SFR, Von-Neumann and Harvard architectures; Software tools: development cycle, language tools, simulators/emulators and debuggers, programmers, downloaders, boot loaders; Configuring hardware: fuse burning, power supplying, clock sources, reset sources; External device interfacing: sensors, actuators, single conditioning, power driving; Configuring internal peripherals: analogue comparators, ADC, timers, usart;

Method of Evaluation: Continuous assessments

References:

1. Barnett, R. H., Cox, S., & O'Cull, L. (2012). *Embedded C Programming and the Atmel AVR*. Boston, MA: Cengage Learning.
2. Kernighan, B. W., & Ritchie, D. (1988). *C Programming Language*. Upper Saddle River, NJ: Prentice Hall.

Course title: **Digital Image Processing I** **Credits:** (30L,30P)

Course code **PH 3034**

Rationale:

Digital image processing as opposed to analogue image processing has many advantages as it allows a much wider range of algorithms to be applied to the input data. Digital image processing has applications in many fields of study including, satellite imagery, medical imaging, character recognition, etc. This introductory course in image processing give the student a working knowledge of the most commonly used methods and procedures for image enhancement and segmentation. The course emphasizes on laboratory results which depends on understanding of the mathematics behind the algorithms as well as the ability to write software to implement the mathematics.

Prerequisites: CS 1001, CS 1002, CS 2001, CS 2002

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- perform filtering and geometrical operations on digital images
- interpret frequency domain processing
- identify and extract image descriptors based on the properties of form or shape within the image using the framework of set theory
- partition an image into mutually exclusive regions
- process an image in such a way that the image features can be adequately represented and extracted in a compact form amenable to subsequent recognition and classification

Course Content:

What is an Image: layout, resolution and quantization, color spaces, representation of images in computer; How is an image formed: linear image systems, Delta and impulse function, point spread function, convolution, Digital convolution; Pixels/voxels: operations of pixels, point based operations, pixel distributions and Histograms; Image Enhancement: kernels and linear filtering, noise removal, edge detection, edge enhancement; Fourier transformation and frequency domain processing in 1D and 2D complex Fourier transform, frequency space filtering; Geometrical processing: Shape preserving transformations, General 2-D affine transformation, nonlinear transformations, warping; Morphological processing: dilation and erosion, extraction of connected components, region filling, skeletonization, opening by reconstruction: Features: single parameter shape descriptors, texture features based on statistical measures, principal component analysis; Image segmentation: Intensity thresholding, region growing, Laplacian of Gaussian filters, Image segmentation with Markov random fields;

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Gonzalez, R. C., & Woods, R. E. (2002). *Digital Image Processing*.
2. Solomon, C., & Breckon, T. (2011). *Fundamentals of Digital Image Processing: A Practical Approach with Examples in Matlab*. Hoboken, NJ: John Wiley & Sons.

Course title: **Design and Machining Lab** **Credits:** 3 (90 P)

Course code **PH 3035**

Rationale:

Machining is a subtractive manufacturing process widely used in research and industry for prototyping. Knowing the capabilities of machines available for machining and the Computer-Aided Designing software applications is very important for a proper mechanical design. The course is aimed at providing students with the opportunity to develop engineering design and machine shop skills needed to produce basic prototype modules and mechanical components required for experiments.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- Identify the capabilities and limitations of manual machining tools
- design mechanical components (engineering drawings) that are required in their academic or professional disciplines
- use machine shop tools and machinery to produce their own mechanical components or prototypes
- communicate effectively and efficiently the mechanical designs in the form of professional engineering drawings with interest groups

Course Content:

Introduction to basic engineering materials: Ferrous and non-ferrous metals, polymers, basic manufacturing processes and material properties – elasticity, plasticity, ductility, toughness, materials selection guide lines; Introduction to machining: Fundamentals of machine tools, heat in machining, cutting fluids, drilling, milling, lathing, welding; Machine shop safety: General machine floor safety, equipment specific safety, and materials safety; Introduction to engineering design: Scaling and units, introduction to CAD, engineering drawings; Machining: Tool selection, machine selection, machining to design specifications.

Method of Evaluation: Continuous assessments

References:

1. Hall, H. (2010). The Metalworker's Workshop. Specialist Interest Model Books.
2. Moore, J. H., Davis, C. C., & Coplan, M. A. (2009). Building Scientific Apparatus. Cambridge, England: Cambridge University Press.

Course title: **Mobile Application Development** **Credits:** 3 (90 P)

Course code **PH 3037**

Rationale:

Mobile technology has drastically evolved over the last decade. With production cost significantly dropping, smart mobile devices are used in applications ranging from home appliances to satellites. The demand for mobile application developers are fast growing with an ability adopt mobile operating systems with different flavours for smartphones, wearables, automobile and other consumer electronics. This course aims to provide students with knowledge of different mobile platforms with special attention to application development on the Android operating system.

Prerequisites: CS 1001, CS 1002, CS 2001, CS 2002

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- contrast different mobile application platforms
- compare different types of mobile applications
- explain the working principles of Android architecture
- justify and use different IDEs for mobile application development
- design and develop mobile applications for Android platform
- distribute applications to different platforms

Course Content:

Introduction to mobile computing: types of devices, mobile operating systems, types of applications; mobile phone technologies; types of mobile apps; Introduction to Android development environments: Android Studio, Gradle, debugging tools, AVD ; Creating new application, new activity and navigate between activities: Manifest, resources, intents, broadcast receivers, Android activity life-cycle; Android UI design: layouts, fragments, supporting different devices, views; Storing and retrieving data: preferences, Sqlite, content providers; Working in background: Async Task, threads, services, notifications, network and connectivity; Sensors: types of sensors and reading sensor values; Google play services: maps and location based services; Monetizing, promoting and distributing applications;

Method of Evaluation: Continuous assessments

References:

1. Haseman, C. (2011). *Creating Android Applications: Develop and Design*. Peachpit Press.
2. Meier, R. (2012). *Professional Android 4 Application Development*. Hoboken, NJ: John Wiley & Sons.

Course title: **Electronic Circuit Design & Simulation** **Credits:** 3 (45 L)

Course code **PH 3038**

Rationale:

Electronic circuit simulation uses mathematical models to replicate the behaviour of actual electronic devices. Simulating circuit behaviour before prototyping can save time and cost. Simulating and analysing circuits with a simulator is a skill required for electronic circuit designers. The course is designed to teach how to use circuit simulators effectively for designing and analysing electronic circuits.

Prerequisites: PH 1003, PH 2001

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- design electronic circuits taking practical limitations into consideration
- analyse electronic circuits using appropriate simulation tools
- recognize limitations of simulation tools
- prepare technical reports on circuit designs
- summarize and present technical details

Course Content:

Introduction: Importance of circuit simulations, different circuit simulation packages and engines, Pspice engine; Schematic drawing: selecting, inserting, and deleting components, modification of component properties, wiring, modifications for simulations; Bias point analysis on: resistor networks, circuits with BJTS, FETS and op-amps; DC Sweep: linear circuits and non-linear circuits; AC sweep: transistor amplifiers, RC Circuits, RLC circuits, filter circuits; Time and frequency domain circuit analysis; Digital circuit simulation; Microcontroller basic simulations;

Method of Evaluation: Continuous assessments

References:

1. Malik, N. R. (1995). *Electronic Circuits: Analysis, Simulation, and Design*.
2. Tobin, P. (2007). *PSpice for Circuit Theory and Electronic Devices*. Morgan & Claypool Publishers.

Course title: **Data Acquisition Laboratory** **Credits:** 3 (90 P)

Course code **PH 3039**

Rationale:

The data acquisition requires a systematic process of making measurements of a physical event using appropriate sensors and storing gathered data in a logical form, also one of the key steps in system automation. Students will gain essential skills by working with sensors, related electronics and data conditioning with an emphasis on automation.

Prerequisites: PH 1021, PH 2001, PH 2021

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- interpret principles of operation of commonly used sensors and actuators
- select sensors and actuators with specifications matched to a given application
- apply proper communication protocols for data acquisition
- analyse and interpret data from a physical system collected through relevant sensors
- develop instrumentation systems using multiple sensors, interface and data acquisition electronics

Course Content:

Sensors and transducers: resistive, capacitive and inductive types, applications of sensors; Signal conditioning: ADC and DAC, grounding, isolation and noise, single-ended and differential measurements, attenuation, amplification, filtering; Signal transmission: impedance matching, loading, noise reduction techniques; Digital signal conditioning; Instrument control and DAQ: DAQ cards, oscilloscopes, arbitrary function generators; instrumentation project incorporating multiple sensors, signal interfacing electronics, data-acquisition hardware;

Method of Evaluation: Continuous assessments

References:

1. Emilio, M. D. (2013). *Data Acquisition Systems: From Fundamentals to Applied Design*. Berlin, Germany: Springer Science & Business Media.
2. Kirianaki, N. V., Yurish, S. Y., Shpak, N. O., & Deynega, V. P. (2002). *Data Acquisition and Signal Processing for Smart Sensors*. Hoboken, NJ: Wiley.
3. Moon, T. K., & Stirling, W. C. (2000). *Mathematical Methods and Algorithms for Signal Processing*.

Course title: **Design Patterns in Software Engineering** **Credits:** 3 (90 P)

Course code **PH 3040**

Rationale:

Design patterns are becoming a standard aspect of software engineering as it is a language independent strategy in solving common problems in object-oriented programming. During the course students will survey specific problems and apply concepts in design patterns to make object-oriented designs more flexible, elegant and reusable.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- compare different design patterns
- apply specific design patterns to real world problems
- apply functionality to designs while minimizing complexity
- evaluate code qualities needed to maintain code flexibility
- synthesize design patterns that enables high code quality

Course Content:

General Responsibility Assignment Software Patterns (GRASP); Understand when to use the following patterns and their disadvantages; Singleton Pattern; Strategy Pattern; Observer Pattern; Adapter Pattern; State Pattern; Proxy Pattern; Mediator Pattern; Façade Pattern; Composite Pattern; Template Method Pattern; Builder Pattern; Decorator Pattern; Factory Pattern; Flyweight Pattern; Chain of Responsibility Pattern; Command Pattern; Bridge Pattern; Composite Pattern; Visitor Pattern; Memento Pattern; Builder Pattern; Prototype Pattern; Abstract Factory Pattern

Method of Evaluation: Oral examination and assignments (50%); End of semester exam (50%)

References:

1. Gamma, E., Helm, R., & Vlissides, J. (1995). *Design Patterns: Elements of Reusable Object-Oriented Software*. Delhi, India: Pearson Education India.
2. Holzner, S. (2006). *Design Patterns For Dummies*. Hoboken, NJ: John Wiley & Sons.
3. Larman, C. (2005). *Applying UML and Patterns: An Introduction to Object-oriented Analysis and Design and Iterative Development*. Delhi, India: Pearson Education India.

Course title: **Computational Mathematics** **Credits:** 3 (30 L) (30 P)

Course code **PH 3041**

Rationale:

Often computers are used in the application of mathematics into real-world problems. In this course, mathematical concepts are introduced and related to the modeling of relatively simple physical systems enabling the characterization of system behavior. Students will receive a solid background in numerical methods and learn to implement them in computers.

Prerequisites: PH 1003, PH 1021, PH 2003, PH 2021

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- relate concepts in mathematics to problems in physical sciences
- apply physical laws and mathematics to model problems in physical sciences
- design computational schemes to solve mathematical models
- evaluate model parameters using practical computing
- analyze results and interpret/predict physical behavior

Course Content:

Introduction to Numerical methods: Linear algebra, Numerical differentiation and integration, Solving ordinary differential equations; **Simulating Motion:** The Equations of Motion, Modified Euler algorithms, The Motion of a Pendulum, Damped Harmonic Oscillator, Planetary Motion, Motion of a spinning top, Chaotic dynamics of a driven pendulum, Random Processes: Random Walks, Modified Random Walks, The Poisson Distribution and Nuclear Decay, Problems in Probability, Applications to Polymers, Random Walks and the Diffusion Equation; Normal Modes and Waves: Two-Dimensional Fourier Series, Power Spectrum, Wave Motion, Interference, Fraunhofer Diffraction, Fast Fourier Transform; Electrodynamics: Electric Fields, Electric Potential, Numerical Solutions of Boundary Value Problems, Random Walk Solution of Laplace's Equation, Fields Due to Moving Charges, Maxwell's Equations, Monte Carlo Simulations of Thermal Systems: The Microcanonical Ensemble, The Demon Algorithm, The Demon as a Thermometer, The Ising Model, The Metropolis Algorithm, Simulation of the Ising Model

Method of Evaluation: Continuous assessment (up to 70%) and end of semester examination (30%)

References:

1. Manassah, J. T. (2006). *Elementary Mathematical and Computational Tools for Electrical and Computer Engineers Using MATLAB*. Boca Raton, FL: CRC Press.
2. Pang, T. (2006). *An Introduction to Computational Physics*. Cambridge, England: Cambridge University Press.

Course title: **Robotics & Automation** **Credits:** 3 (90 P)

Course code **PH 3042**

Rationale:

Robots are widely used in industry to fulfil tasks which are labour intensive, repetitive, require high precision, or hazardous to humans. The aim of the course is to provide students with skills required to design and control robots.

Prerequisites: PH 1021, PH 2001, PH 2021, PH 3032

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- explain the working principle of typical sensors used in robots
- interface sensors to microcontrollers/single board computers
- apply techniques for precision controlling of motors and the other actuators using microcontrollers/single board computers
- apply mathematical, algorithmic and control principles of robots to simple robotic manipulators and simple robotic locomotives

Course Content:

Introduction: history of robots, an overview of robot types and mechanisms: manipulation, locomotion/navigation, autonomous/unmanned; planar and spatial kinematics: motion planning; mechanism design for manipulators and mobile robots; control design: actuators, sensors, drivers; wireless networking, human-machine interface, and embedded software.

Method of Evaluation: Continuous assessments

References:

1. Barnett, R. H., Cox, S., & O'Cull, L. (2012). *Embedded C Programming and the Atmel AVR*. Boston, MA: Cengage Learning.
2. Craig, J. J. (2017). *Introduction to Robotics: Mechanics and Control*. Upper Saddle River, NJ: Prentice Hall.
3. Kernighan, B. W., & Ritchie, D. M. (1988). *The C Programming Language*. La Vergne, TN: Ingram.

Course title: **Instrumentation Physics** **Credits:** 3 (45 L)

Course code **PH 3051**

Rationale:

Sensors and actuators constitute the main components of any instrument and a good understanding of the working principles of sensors and actuators is inevitable for a scientist. Variety of instruments are used for processing input signals and producing output according to a given requirement. This course is designed to give an understanding of the working principles of sensors, actuators and fundamental instruments in research and related industries.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- interpret the principles of operation of various types of sensors and transducers,
- calculate requirements for designing sensor applications,
- compare different instrumentation techniques,
- interpret principles of operation of different types of vacuum pumps and choose the appropriate type of vacuum pumps for given applications,
- carryout calculations related to the designing of vacuum systems.

Course Content:

Transducer as an electrical element; Modelling a transducer; Connecting transducer to circuit elements; Types of transducers/sensors: temperature transducers, optical transducers, displacement transducers, strain gauges, pressure sensors, Radiation detectors, Nuclear electronics, Instrumentation electronics: Gamma ray spectroscopy Single channel analyzer,

Multi-channel analyzer, Lock-in amplifier; Medical Imaging technologies;

Physical properties of vacuum: vacuum units, vacuum regions, flow regions, Knudsen number; Flow of gas through vacuum systems: conductance, coupling of conductance of tubes, effective pumping speed, general pump down equation; Sources of gas within a vacuum system; Mechanical pumps: rotary vane pump, rotary piston pump and lobe pump; High vacuum pumps: diffusion pump, turbo-molecular pump, cryogenic pump, ion pump; Vacuum gauges: thermal conductivity gauges, ionization gauges, hot cathode gauges, cold cathode gauges; Leak detection.

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Fernow, R. C., & Fernow, R. C. (1989). *Introduction to Experimental Particle Physics*. Cambridge, England: Cambridge University Press.
2. O'Hanlon, J. F. (2005). *A User's Guide to Vacuum Technology*. Hoboken, NJ: John Wiley & Sons.
3. Sayer, m., & mansingh, a. (1999). *Measurement, instrumentation and experiment design in physics and engineering*. New delhi, delhi: phi learning pv

Course title: **Electromagnetic Fields I** **Credits:** 3 (45L)

Course code **PH 3052**

Rationale:

Since changing magnetic fields create electric fields and changing electric fields create magnetic fields, electromagnetic waves have fascinating properties compared to mechanical waves. Students will be introduced to mathematical tools and techniques that can be used to solve complex problems involving electromagnetic waves. Topics discussed in this course addresses the fundamental aspects of electromagnetism in modern technology.

Prerequisites: PH 2002

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- apply the principle of Maxwell's equations in static and dynamic conditions related to real world applications
- interpret principles related to propagation of electromagnetic waves in free space and dielectric mediums
- solve boundary value problems related to electromagnetic waves analyze principles related to generating electromagnetic waves, radiation and radiation fields
- analyze transmission of electromagnetic waves by using waveguides and transmission lines

Course Content:

Maxwell's equations, scalar potential, Poisson's and Laplace's equations, uniqueness theorem, electrostatic potential energy, Boundary-Value problems in electrostatics; method of images, method of inversion, boundary-value problems with azimuthal symmetry, boundary-value problems in cylindrical and spherical coordinates, mixed boundary conditions, Time varying fields; conservation laws, vector and scalar potentials, gauge transformations, Poynting's vector, Electromagnetic Waves; wave equation, dispersion of EM waves, EM waves in unbounded isotropic medium and good conductors, characteristic impedance, pressure of EM waves, EM waves in plasma and plasma frequency, em waves in the ionosphere, Reflection of EM waves; boundary conditions, Fresnel's relations; reflection at air/dielectric interface, reflection at air/good conductor interface, Electromagnetic Radiation; radiation fields, radiated energy, Hertz potential, electric and magnetic dipole radiation, radiation from an accelerated charge, antennas, Waveguides; cut-off frequency, modes of propagation, wave impedance, Transmission lines; equation of telegraphy, characteristic impedance, voltage standing ratio, impedance matching and stub lines

Method of Evaluation: Mid-semester examination (up to 30%) and end of semester examination

References:

1. Griffiths, D. J. (2017). *Introduction to Electrodynamics*. Cambridge, England: Cambridge University Press.

Course title: **Statistical Physics** **Credits:** 3 (45 L)

Course code **PH 3053**

Rationale:

Statistical Physics is the method of predicting thermodynamic properties of large assemblies by the analysis of average statistical behaviour of its microscopic constituents. Due to its fundamental nature it finds applications in diverse areas not limited to science. During the course students will appreciate the formulation of fundamental ideas in Statistical Physics and apply it to both classical and quantum systems of fundamental interest.

Prerequisites: PH 1004 is strongly recommended

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- explain thermodynamics as a logical consequence of the postulates of statistical physics.
- derive the statistical distributions for classical and quantum ensemble of particles
- apply statistical mechanics concepts to various ensembles in equilibrium statistical thermodynamics and analyse consequences.
- apply thermodynamic potentials and Maxwell's relations to solve problems.

Course Content:

Basic probability theory and fluctuations; kinetic theory of gases, phase space and Maxwellian distribution of velocities, Statistical Mechanics; postulates of statistical mechanics, canonical, micro-cannonical and grand canonical ensembles, Boltzman, Fermi-Dirac and Bose Einstein statistics, statistics of classical limit, Thermodynamics; statistical mechanical interpretation of equilibrium state and the laws of thermodynamics, relation between canonical partition function and thermodynamic functions, thermodynamic potentials and Maxwell’s relations, application of thermodynamics to surface tension, thermodynamics of a paramagnet, thermodynamics of a simple harmonic oscillator, Quantum Statistics; Quantum statistics of gas like assemblies, density of states, statistical mechanics of ideal gases, Gibb's paradox, rotational and vibrational degrees of freedom, rotational specific heat of gases, statistical mechanics of conduction electrons in a metal, Fermi energy, Fermi temperature, thermodynamics of Ferni-Dirac gases, white dwarf stars, statistical mechanics of Bose-Einstein gases, Bose-Einstein condensation, statistical mechanics of equilibrium radiation, thermodynamics of black body radiation, Phonons and lattice vibrations, Phase transitions; Ising model.

Method of Evaluation: Mid-semester examination (30%) End of semester examination (70%)

References:

1. Gupta, M. C. (2007). *Statistical Thermodynamics*. New Delhi, India: New Age International.
2. Landau, L. D., & Lifshitz, E. (2013). *Statistical Physics*. Amsterdam, Netherlands: Elsevier.
3. Mandl, F. (2013). *Statistical Physics*. Hoboken, NJ: John Wiley & Sons.

4. Reif, F. (2009). *Fundamentals of Statistical and Thermal Physics*. Long Grove, IL: Waveland Press.

Course title: **Classical Mechanics** **Credits:** 3 (45 L)

Course code **PH 3054**

Rationale:

Classical mechanics forms one of the fundamental pillars of physics. It is the study of the motion of non-quantum mechanical, low energy particles in weak gravitational fields. The aim of this course is to provide students with fundamental concepts in classical mechanics and the underlying mathematics.

Prerequisites: None

Upon completion of this course, students will be able to;

- evaluate the Euler-Lagrange equations for key physical problems like central force field, non-inertial frames, rigid body rotations and small oscillations,
- evaluate conserved quantities from symmetries of the system,
- evaluate equations of motion for key physical problems using Hamilton's principle,
- evaluate equations of motion for key physical problems using Hamilton's equation and appreciate the significance of the Poisson brackets,
- appreciate the significance of the canonical transformation and generating functions and solve simple systems using Hamilton-Jacobi method.

Course Content:

fundamentals of Newtonian mechanics; axiomatic foundation, Newton's laws of motion, Galilean principle of relativity, motion in resisting mediums, principles of work and energy, impulse and linear momentum, impulse and angular momentum, application to system of particles, constraints, degrees of freedom; virtual displacements. Lagrangian dynamics; generalized coordinates, configuration space, generalized forces, D'Alembert's principle, Lagrangian, Lagrange's equations of motion, Lagrangian multiplier method, generalized momenta and impulse. Conservation laws and symmetric properties; integrals of motion, cyclic coordinates, homogeneity in time and space, isotropy of space. Central force fields; central force motion, energy equation, orbital energies in inverse-square field, effective potential, stability, forces of gravitation, Kepler's Laws of planetary motion, binary star systems. Non-inertial co-ordinate systems; moving coordinate systems, motion relative to earth, Coriolis force, Foucault pendulum. Rigid body motion; plane motion about a fixed axis, compound pendulum, general plane motion, principle moment of inertia, general motion in space, pure rotation, Euler angles and equations, heavy symmetrical top. Theory of small oscillations; oscillations up to three degrees of freedom, normal coordinates, applications. Hamilton's principle; Lagrangian equations and Hamilton's principle, applications. Hamiltonian theory; phase space, Hamiltonian function, Hamilton's canonical equations, conservation theorems, Poisson brackets, classical equations of motion, Poisson theorem, Liouville's theorem, Infinitesimal transformations. Canonical transformations; generating functions, invariants, integral invariants of Poincaré, infinitesimal transformations, relativistic Hamilton's principle. Hamilton-Jacobi theory; separation of variables, applications, perturbation theory.

Method of Evaluation: Mid semester Examination (up to 30%) and end of semester examination (up to 70%)

References:

1. Schaum's Outline of Theory and Problems of Theoretical Mechanics, E. Saletan, A.H.Cromer, John Wiley & Sons, Inc. (1971), U.S.A.
2. Goldstein, H., Poole, C. P., & Safko, J. L. (2014). *Classical Mechanics: Pearson New International Edition*. New York, NY: Pearson Higher Ed.
3. K. a. i. l. w. Gamalath. (2011). *Introduction to Analytical Mechanics*. Alpha Science International.
4. Marion, J. B. (2013). *Classical Dynamics of Particles and Systems*. Cambridge, MA: Academic Press.
5. Wells, D. A. (1967). *Schaum's Outline of Lagrangian Dynamics*. New York, NY: McGraw Hill Professional.

Course title: **Data Acquisition and Signal Processing** **Credits:** 3 (45 L)

Course code **PH 3055**

Rationale:

Today microprocessor controlled electronic devices are widely used in day-to-day life and play a significant role in modern society. Thus, basics of signal conversion, device communication, mitigation of noise/interference and fundamentals of microprocessors are important concepts to learn. The course surveys the underlying basic principles related to Data Acquisition and Signal Processing and their application to measurement of physical variables.

Prerequisites: PH 2001 is strongly recommended

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- interpret significance of elements of a complete data acquisition system
- describe and evaluate the principle of operation of analogue to digital and digital to analogue converters
- select appropriate techniques for noise reduction and filtering
- evaluate the function of microprocessors and computer-controlled electronics

Course Content:

Elements of a computer controlled Data Acquisition system; Signals and Systems; continuous and discrete-time signals and their properties, Noise sources; spectral density and circuit calculations, pile-up effects, signal to noise ratio, Interference control and selectivity; passive and active filters, filter circuit design, ideal and non-ideal frequency selective filters, Sampling; reconstruction of signals, aliasing, discrete-time processing of continuous-time signals, Signal processing electronics; energy measurements, equivalent circuits of detectors, signal termination, charge amplification, voltage and current amplification, Timing methods and systems; leading edge trigger, zero crossing trigger, constant fraction trigger, Signal conversion electronics; Digital to Analogue Converters, Voltage to Frequency Converters, Analogue to Digital Converters, Time to Amplitude Converters, Time to Digital Converters, Multichannel Analyzers, Basic computer system organization, Microprocessor architecture; machine language and assembly language representation, computer arithmetic, Memory devices; semiconductor ROMs and RAMs, ROM applications, Static and Dynamic RAMs and their operations, input/output, Interfacing devices to the IBM PC; essentials of serial and parallel interfacing, interfacing sensors, signal conditioning, Microcontrollers; microcontroller applications in the laboratory, Computer controlled electronics; examples of data acquisition systems.

Method of Evaluation: Mid semester examination (up to 30%) and end of semester examination

References:

1. Leo, W. R. (2012). *Techniques for nuclear and particle physics experiments: a how-to approach*. Springer Science & Business Media.

2. Tocci, R. J. (1991). *Digital Systems: principles and applications*. Pearson Education India.Gaonkar, R. S. (1994). Microprocessor Architecture Programming and Applications.
3. Tompkins, W. J., & Webster, J. G. (1988). *Interfacing Sensors to the IBM PC* (p. 2). Upper Saddle River, NJ: Prentice Hall.

Course title: **Mathematical Physics I** **Credits:** 3 (45 L)

Course code **PH 3057**

Rationale:

Mathematics and Physics form the basis for all technical and scientific research. These two subjects are an indispensable prerequisite for technological developments in modern society. The overall goal of the course is to bridge the gap between basic mathematical techniques and their applications within physics covering common techniques of applied mathematics that are often used in theoretical physics.

Prerequisites: AM 1001, AM 1002, AM 1003, AM 2001, AM 2005

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- explain the existence of potential functions. Define orthogonal curvilinear coordinates and evaluate differential operators in any orthogonal curvilinear coordinates. Evaluate properties of Dirac delta function. Evaluate integrals using gamma and beta functions
- Classify a given second order PDE. Solve boundary value problems by separation of variables. Evaluate Laplace's equation in spherical and cylindrical boundaries and solve potential problems.
- Evaluate vector spaces, linear operators, eigenvectors, generalized eigenvectors, Sturm-Liouville Operator and solve physical problems.
- Understand Hilbert space and evaluate inner products and linear operations in it. Evaluate unitary transformations leading to Schrodinger and Heisenberg equations.
- Apply variational principle to physical problems subject to constraints and integral constraints. Evaluate Rayleigh-Ritz Variational techniques.

Course Content:

Vector and scalar fields; potential theory, theorems, vector potentials, Helmholtz theorems, curvilinear co-ordinates, differential operators in curvilinear co-ordinates. Dirac delta function, gamma and beta functions; definition and properties. Second order linear differential equations; Euler's equation, hyperbolic, parabolic and elliptic equations**, m**ethod of separation of variables. Solution of Laplace equation in spherical and cylindrical boundaries; Legendre polynomials, Bessel functions, application to potential problems. Matices; properties and operations of real and complex matrices of finite and infinite order. Vector spaces; bases, inner products, Gram-Schmidt process. Linear operators; applications, change of bases, oblique coordinates. Eigenvectors; theorems, applications, diagonalization, principal axis transformations. Generalized eigenvectors; simultaneous diagonalization, theory of small oscillations. Strum-Liouville operators; special functions, Gram-Schmidt orthonormalization. Hilbert Space; Dirac notations, hermitian operators, completeness relation, commutative relations, simultaneous eigenstates, representation. Unitary transformation;

Schrödinger equation of motion, Heisenberg equation of motion, Classical Hamiltonian equation of motion, Ehrenfest's theorem. Calculus of variation; Euler-Lagrange equation, Special cases, applications, Hamilton's principle, problems with constraints, Lagrange multipliers, Integral constraints, problems involving Sturm-Liouville operators, eigenfunction expansion, Rayleigh- Ritz method.

Method of Evaluation: Mid semester examination (up to 30%) and end of semester examination

References:

1. Mathematical Physics, E. Butkov, Addison-Wesley pub. Co. (1973)U.S.A.
2. Mathematical Methods for Physicists, G. Arfken, Academic press (1985)U.S.A.
3. Schaums Outline Series - Advanced Mathematics for Engineers and Scientists, M.R. Spiegel, McGraw-Hill, (1971), USA..
4. Introduction to mathematical Physics, Charles Harper (1976).
5. Calculus of variation, Charles F., Oxford University Press (1950).
6. Introduction to Vector Spaces, K.A.I.L.Wijewardena Gamalath, Cambridge University press, India (2007).

Course title: **Circuit Analysis and Simulation** **Credits:** 3 (30L/30P)

Course code **PH 3058**

Rationale:

Circuit analysis and simulation using mathematical models is essential to understand the inherent limitations and to optimize the performance of electronic circuits. In industry, simulating circuit behaviour before prototyping can also save time and cost. The course is designed to survey physical models of operation of semiconductor devices and to examine design and operation of important circuits using circuit simulation software thereby helping students gain essential skills in circuit analysis and simulation.

Prerequisites: PH1021, PH 2001, PH 2021

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- apply various methods of circuit analysis, including methods such as nodal analysis, mesh analysis, loop analysis, source transformation, Norton's theorem
- develop and employ circuit models for elementary electronic components, e.g., resistors, sources, inductors, capacitors, diodes and transistors.
- analyse techniques for equation formulation and determining dynamic model properties.
- represent elements from the different domains and develop input & output relationships.
- define engineering tasks, the modelling objectives and to follow steps in the modelling process.
- construct models of simple systems using basic modelling elements and simulate the system response.
- use simulation software to design and validate electronic circuits.

Course Content:

Basic Elements and Law, Introduction to Circuit Analysis Techniques, Nodal analysis for circuits with voltage sources, Mesh analysis for circuits with current sources, Loop analysis, Introduction to Circuit Concepts, Non-ideal sources, independent and dependant sources, Norton's theorem, The principle of superposition, Ramp and step functions, The impulse function, Integral relationships, Important circuit concepts, Initial conditions, First-order and Second-order Circuits, The Zero-input circuits and response, the zero-state response, Linearity and superposition, Circuits with nonzero inputs, Numerical analysis of zero-input circuits, Rules for writing circuit equations, Sinusoidal Analysis, Time domain analysis, Frequency domain circuit concepts and analysis, Important AC Concepts and Power, Important power concepts, Power measurements, Frequency response, Bode plots, Resonance, Complex frequency, Poles and zeros, Analysis using Laplace Transform, Application to linear systems, Analysis using Fourier Transform, Application of Fourier transforms to linear systems.

Introduction to circuit simulation and modeling; modeling the diode forward characteristics, exponential model, graphical & Iterative analysis using the exponential model, piecewise-linear model, constant-voltage-drop model, ideal-diode model, small-signal model, modeling reverse characteristics of the diode, specifying and modeling the Zener diode, SPICE diode model and simulation; BJT transistors and amplifier circuits, Ebers-Moll (EM) model, hybrid-π model, T model, and high-frequency hybrid-π model, SPICE BJT model and simulation, circuit models for amplifiers, relationship between four Amplifier models, practical op-amp characteristics and modeling, SPICE op-amp model and simulation.

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. S. Sedra and Kenneth C. Smith, Microelectronic circuits, Seventh Edition, Oxford University Press, 2014.
2. Leonard S. Bobrow, Elementary Linear Circuit Analysis, Oxford University Press, 1987
3. Luis Moura and Izzat Darwazeh, Introduction to Linear Circuit Analysis and Modelling: From DC to RF, Elsevier, 2005

Course title: **Solid state physics** **Credits:** 3 (45 L)

Course code **PH 4001**

Rationale:

Extending ideas from statistical mechanics and quantum mechanics this course covers the principles and techniques of solid-state physics; the physical understanding of matter from an atomic viewpoint. Course is designed to appreciate the analytical framework provided to interpret structure, thermal and electrical properties of matter, specifically that of crystalline materials. Students will experience the applicability of fundamental theories in solid state physics to explain some of the properties of materials as well as discuss some of the limitations of the existing models.

Prerequisites: PH 3001, PH 3053

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- describe qualitatively the processes, relationships and techniques relevant to the main concepts in solid state physics.
- analyse and apply theories and techniques to solve general classes of problems both qualitatively and quantitatively.
- apply the underlying principles of the subject to the broader topics encountered during research or other related studies.

Course Content:

Crystal structure of solids: Elementary crystallography, Typical crystal structures, Imaging of crystal structures: Scattering, Reciprocal lattices, X-ray diffraction, electron scattering, Crystal Dynamics: Lattice Vibrations in one-dimensional crystals, Lattice Vibrations in three dimensional crystals, Heat capacity from lattice vibrations, Anharmonic effects, Thermal conduction by phonons, Free electrons in metals: The free electron model, Transport properties of the conduction electrons, Nearly free electron theory, Band theory of solids: Classification of crystalline solids, Band structure effective masses, Semiconductors: Holes, Optical properties of semiconductors, The Hall effect, Non-equilibrium carrier densities, Magnetism: Diamagnetism and paramagnetism, Ordered magnetic materials, Ferromagnetism, Hard and soft magnets, Superconductivity: Magnetic properties of superconductors, Theory of superconductors, High temperature superconductors; Electrical properties of insulators: Dielectrics, Real metals: Fermi surfaces, Experimental determination of Fermi surfaces; Crystallization and amorphous solids, Polymers.

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Kittel, C., McEuen, P., & McEuen, P. (1996). *Introduction to solid state physics* (Vol. 8, pp. 105-130). New York: Wiley.
2. Ashcroft, N. W., & Mermin, N. D. (2010). Solid state physics (saunders college, philadelphia,

1976). *Appendix N*.

Course title: **Methods in Computational Physics** **Credits:** 3 (15 L, 60 P)

Course code **PH 4002**

Rationale:

Science related disciplines in the modern world often involve the use of computers. Data collection and analysis, application of numerical techniques and simulations are crucial in solving complex problems in physics. This course surveys a variety of computational methods used to solve problems in physics.

Prerequisites: CS 1001 and CS 2002 are strongly recommended.

Intended Learning Outcomes:

On completion of this course, students should be able to:

- interpret the basics of scientific, numerical simulation and modeling
- apply computational methods to solve first order differential equations
- analyze, simulate, visualize and interpret physics problems by step by step computation.

Course Content:

Experimental errors; random & systematic errors, combining errors, linear situations, non-linear situations, Distributions; Binomial, Poisson, Gaussian, correlated variables, error matrix manipulations, Parameter fitting & hypothesis testing; Maximum likelihood method, Least square fitting, Kinematic fitting, Basic mathematical operations; numerical differentiation, numerical quadrature, finding roots, Ordinary differential equations; simple methods, multistep and implicit methods, Runge-kutta methods, stability, Boundary value and Eigenvalue problems; Numerov algorithm, Matrix operations; inversion, eigenvalues of a tri-diagonal matrix, reduction to tri-diagonal form, Minimisation; Golden section search, search with first derivatives, Downhill simplex method, Powell's method, Modelling data; fitting data to a model, data with errors in both co-ordinates, non-linear models, Monte-Carlo calculations; simple Monte-Carlo applications, using random numbers, generating random variables with a specified distribution, algorithm of Metropolis et. al., the Ising model in 2D, non-uniform distributions and correlated variables, non-physics applications.

Method of Evaluation: Continuous assessment (up to 40%) and end of semester laboratory examination

References:

1. Koonin, S. E. (2018). *Computational physics: Fortran version*. CRC Press.
2. Press, W. H., Teukolsky, S. A., Vetterling, W. T., & Flannery, B. P. (2007). *Numerical recipes 3rd edition: The art of scientific computing*. Cambridge university press.
3. Lyons, L. (1989). *Statistics for nuclear and particle physicists*. cambridge university press.

Course title: **Electronic Communication Techniques** **Credits:** 3 (45 L)

Course code: **PH 4005**

Rationale:

Electronic communication is one of the key factors of today's development and it finds applications everywhere. In general, electronic communication utilizes electronic signals or electromagnetic waves. This course aims to provide students with modern electronic communication techniques; includes a well-balanced coverage of basic concepts, state-of-art technologies and practical applications.

Prerequisites: PH 2001, PH 3007, PH 3055, PH 3058 is strongly recommended

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- analyse transmitter and receiver circuits.
- analyse and design filter circuits in communication.
- analyse and contrast the working principles related to antennas.
- evaluate the effect of noise in communication systems
- apply and contrast methods in modulation and demodulation in communication systems.
- compare and contrast design issues, advantages, disadvantages and limitations of analogue and digital communication systems.

Course Content:

Basics of electronic communication techniques, Radio frequency amplifiers, Small signal RF amplifier analysis and design, Coupling tuned circuits, Oscillators, Oscillator circuit analysis, Hartley, Colpitts, Clapp, tuned/untuned oscillators, Stability and spectral purity, Crystal oscillators, Signal Modulation, Voice transmission and multiplexing, Amplitude modulation (AM) and demodulation, AM receiver systems, Gain and stability, Noise considerations, Transmitter circuits, Power amplifiers, Impedance-matching networks, Receiver circuits, Mixers, tuning and filter requirements, Distortion and feedback, Frequency and phase modulation, FM transmitter and receiver circuits, Pulse and digital modulation, Pulse code modulation (PCM), Data communication concepts, Coding, Signalling (Baud) rate, Bandwidth considerations, Power in digital signals, PCM system analysis, PCM telephone circuitry, Error detection, Data errors and error control, Serial transmission and interfacing, Carrier systems and modems, Synchronous communication techniques, Open system inter-connect and ISDN, Computer applications in digital communication systems, Antennas and radio wave propagation, Antenna radiation, Power and electric field strength, Dipole antenna, Folded dipole, Yagi-Uda antenna, Loop antenna, Dish antennas, Basics of TV reception and transmission, Digital radio and space communication, Fibre-optics communication systems.

Method of Evaluation: End of semester written examination

References:

1. Paul H Young, Electronic Communication Techniques, Fifth Edition, Prentice-Hall, Inc, New Jersey, 2004.

2. Gary M Miller, Modern Electronic Communication, Sixth Edition, Prentice-Hall, Inc, New Jersey, 1999.
3. George Kennedy and Bernard Davis, Electronic Communication Systems, Fourth Edition, McGraw-Hill, New York, 1999.
4. William Sinnema and Tom McGovern, Digital, Analog, and data Communication, Second Edition, Prentice-Hall, Inc, New Jersey, 1986.

Course title: **Industrial Management** **Credits:** 3 (45 L)

Course code: **PH 4007**

Rationale:

Science graduates often find employment in industrial settings and methods in industrial management will be essential for the success of companies within the manufacturing sector. As a field of business administration, students will be able to study the structure and organization of industrial companies comprising the fields of primarily operations management, intellectual property, marketing, and financial management.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- interpret basic principles related to operations management, intellectual property, marketing, and financial management.
- use information systems and related tools to optimize industrial processes
- interpret ideas related to human resource management
- explain the legislative basis of selected organizational structure and function and protection of intellectual property
- awareness of corporate social responsibility both on the society and environment

Course Content:

Industry and Business: characteristics, competitive advantage, business strategy, entrepreneurship, Financial Management: functions, the double entry system, ledgers and journals, trial balance, trading and profit & loss account, balance sheet, manufacturing accounts, cash flow, financial analysis. Cost and Management Accountancy: allocation of overheads, depreciation methods, job costing, process costing, standard costing, variance analysis, marginal costing, break-even analysis, profitability analysis, valuation of stocks. Management Information Systems: scope of Information Technology in an industrial organization, design of MIS, decision support systems, software requirements analysis. Project and operations planning: project scheduling using network methods, resource allocation, optimization, materials management, manufacturing resources planning systems (MRP), Organizational management: overview of organizational theory, relevant industrial psychology, human relations and counseling, organizational growth and development, organizational structures and systems, understanding the environment and strategy, management and leadership roles, management of organizations and introducing changes, fundamentals of marketing, Industrial law: contract of employment and its relevance in present day context, comparison between law of contract and employment contract, companies Act in general, Partnership law, employment relationships, introducing sale of goods, bills of exchange and insurance law, Industrial disputes Act, Trade union Act, Termination of employment Act, Social welfare legislation; EPF Act, ETF Act, Payment of gratuity

Act, etc.

Method of Evaluation: End of semester written examination

References:

1. Wheldon, H. J., Brown, J. L., & Owler, L. W. J. (1962). Wheldon's Costing Simplified. Completely Revised by LWJ Owler... and JL Brown. Macdonald & Evans.
2. Eskew, R. K., & Jensen, D. L. (1986). Financial accounting. Random House, Business Division.
3. Fogarty, D., Blackstone Jr, J. H., & Hoffmann, T. R. (1991). Production And Inventory Management. South.
4. Hersey, P., Blanchard, K. H., & Johnson, D. E. (2007). Management of organizational behavior (Vol. 9). Upper Saddle River, NJ: Prentice hall.
5. Graham, H. T., & Bennett, R. (1995). Human Resources Management.. The M & E Handbook Series.

Course title: **Nuclear and Particle Physics** **Credits:** 3 (45 L)

Course code: **PH 4008**

Rationale:

Research in the fields of nuclear and particle physics starting from the beginning of the 20th century have increased our understanding of the nature. These fields have also made an enormous contribution to our modern life. This course surveys the underpinning concepts related to nuclear and particle physics.

Prerequisites: PH 3004

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- appreciate the structure and stability of atomic nuclei
- describe the constituents of matter and their interactions and
- describe the experimental methods used in nuclear and particle physics.

Course Content:

Nuclear forces; The deuteron; Charge independence of nuclear forces; Isotopic spin; Spin dependent and Tensor forces; Nucleon-nucleon forces; Exchange forces; Nuclear reactions; General features of cross-sections; Inverse reaction; Detailed balance; Reaction mechanisms; Q valve; Threshold energy; The scattering theory, The compound nucleus; Direct reactions; Heavy-Ion nuclear reactions; Nuclear models; The shell model; Energy shells and angular momentum; The magnetic dipole moment of the nucleus; Calculation of the magnetic dipole moment. The electric quadruple moment of the nucleus; Excited states of nuclei; Some general features of excited states; The decay of excited states; Collective nuclear model; Rotational levels; Leptons and the electromagnetic and weak interactions; The quarks Mass; Lifetime and other particle properties; The instability of the heavy leptons; Muon decay; Parity violation; Nucleon and the strong interactions; Properties of the proton and the neutron; The quark model of nucleons; pions and other bosons and their decay modes; Feynmann diagrams Spin; and intrinsic parity; Classification of Hadrons and Quarks; Particle accelerators; The Cyclotron, Betatron and the Synchrotron; Colliding beams.

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination
End of semester written examination

References:

1. Evans, R. D., & Evans, R. D. (1955). The atomic nucleus., ,
2. Segre, E. (1964). Nuclei and particles: an introduction to nuclear and subnuclear physics.
3. Reid, J. M. (1984). *The atomic nucleus*. Manchester University Press.
4. Povh, B., Rith, K., & Zetsche, F. (1995). *Particles and nuclei*(Vol. 4). Berlin: Springer.

5. Heyde, K. (2004). *Basic ideas and concepts in nuclear physics: an introductory approach*. CRC Press.
6. Khanna, M. P. (1999). *Introduction to particle physics*. PHI Learning Pvt. Ltd.

Course title: **Mathematical Physics II** **Credits:** 3 (45 L)

Course code: **PH 4009**

Rationale:

Mathematics and Physics form the basis for all technical and scientific research. These two subjects are an indispensable prerequisite for technological developments in modern society. Building on the concepts developed in PH 3057: Mathematical Physics I, the overall goal of the course is to bridge the gap between basic mathematical techniques and their applications within physics covering advanced mathematical techniques commonly used in theoretical physics.

Prerequisites: PH3057

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- Use the method of Laplace transforms to solve initial-value problems for linear differential equations. Develop facility with complex numbers and the geometry of the complex plane. Evaluate conformal mappings. Evaluate definite integrals of single valued and multivalued functions using contour integration. Evaluate Cauchy Principal value integrals.
- Apply Fourier series to analyze wave forms and to solve differential equations. Solve one, two and three dimensional linear differential equations of common physical problems using Fourier transform techniques. Evaluate convolution, auto-correlation, cross-correlation, and transfer functions of signals. Implement Fourier transforms to Fraunhoffer diffraction.
- Describe analytic and structural properties of response functions and Green's functions. Evaluate Green's functions for one, two and three dimensions. Solve second order linear differential equations using Green's functions. Evaluate Green's functions using eigenfunction expansion method in Cartesian, spherical and cylindrical coordinates.
- Formulate and express a physical law in terms of tensors, and simplify it by use of coordinate transforms. Evaluate metric tensor in any coordinate system. Compute, explicitly, the covariant derivative of an arbitrary tensor and Christoffel symbols.
- Evaluate four vectors and Lorentz transformation of four vectors in Minkowski and Euclidean spacetime. Solve relativistic dynamics and collisions problems using four-vectors. Evaluate energy momentum tensor. Formulate relativistic electrodynamics and evaluate Lorentz transformation of electric and magnetic vectors. Derive covariant form of equation of motions..

Course Content:

Laplace transforms; Complex numbers; complex variables; Contour Integration; Fourier series; Fourier transforms; Green's functions and Response functions; Tensors; Special Lorentz transformation in 4 dimensional spacetime, Four vectors.

Method of Evaluation: Mid semester examination (up to 30%) and end of semester examination

70% from 3-hour Examination at the end of the year.

30% from 1-hour mid semester Examination

References:

1. Mathematical Methods for Physicists, Arfken, G., Academic Press, Inc. (1985).
2. Mathematical Physics, Butkov, E., Addison-Wesley Pub. Co. (1973).
3. Introduction to Fourier Transforms in Physics, K..A.I.L. Wijewardena. Gamalath, Cambridge university press, India (2007).
4. Theoretical Physics: Applications of Vectors, Matrices, Tensors and Quaternion, Kyrala A., W.B. Saunders Co. (1967).
5. Advanced Engineering Mathematics, O'Neil,P.V., Wadsworth Pu. Co. (1983).
6. Fourier Transforms and Convolution for the Experimentalists, R.C. Jeninson, Pergamon Press (1961) U.K.
7. Relativity: Special theory, Synge J.L., North holand pub. Co. (1956).
8. Theory of relativity, Moller C., Clarendon press, Oxford (1952).

Course title: **Quantum Mechanics II** **Credits:** 3 (45 L)

Course code: **PH 4010**

Rationale:

As a continuation of PH 3001: Quantum Mechanics I, in this more advanced course, concepts will be applied to analyse complicated real physical systems using approximation methods in order to understand the behaviour of systems such as nuclei, atoms and molecules which provides the basis for learning more advanced subjects in physics.

Prerequisites: PH 3001

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- derive the momentum space wave function of quantum systems and use it to extract information of these systems in a more convenient way.
- obtain matrix representation of operators and wave functions, specifically of angular momentum operators and their eigenfunctions.
- add up angular momentum vector operators to find resultant angular momentum states arising under different angular momentumcoupling schemes in many-electron atoms.
- take into account the influence of relativistic effects and studythe splitting in energy levels of real hydrogenic atoms.
- Solve problems associated with quantum systems approximately by applying approximation methods such as the perturbation theory and variational principle, as necessary.
- apply approximation methods to obtain ground and excited state energies of two-electron atoms.
- get the physical meaning of identity, study systems of identical particles and construct symmetric and anti-symmetric wave functions.
- study energy spectrum of hydrogenic atoms under their interaction with constant external electric and magnetic fields

Course Content:

Wave packets; Momentum space wave function; Time variation of expectation values; Ehrenfest's theorem; Virial theorem; Matrix representation of wave functions and operators; Time evolution of a quantum system; Angular momentum**:** orbital angular momentum operator, eigenvalues and eigenfunctions, matrix representations of angular momentum operators, spin angular momentum operator and its general properties, addition of angular momenta; Approximation methods: time-independent perturbation theory for non-degenerate and degenerate levels, fine-structure of one-electron atoms, variational method, time-dependent perturbation theory for transitions induced by constant and periodic perturbations, Fermi's golden rule; Several- and many-particle systems: systems of identical particles and the physical meaning of identity, symmetric and anti-symmetric wave functions and their construction from unsymmetrized functions, Fermi gas, Pauli exclusion principle, two-electron atoms and application of approximation methods to obtain their ground and excited state energies, *L-S* coupling and *j-j* coupling schemes for many-electron atoms; Interaction of one-electron atoms with: electromagnetic radiation, constant external electric fields, constant external magnetic fields; Introduction to quantum collision theory.

Method of Evaluation: Two mid-semester examinations (15% from each) + End of semester examination (70%)

References:

1. Bransden, B. H., & Joachain, C. J. (1989). Introduction to quantum mechanics. *Harlow, England: Longman Scientific and Technical*.,
2. Griffiths, D. J., & Schroeter, D. F. (2018). *Introduction to quantum mechanics*. Cambridge University Press.,
3. Liboff, R. L. (2003). *Introductory quantum mechanics*. Pearson Education India.

Course title: **Electromagnetic Fields II** **Credits:** 3 (45 L)

Course code: **PH 4011**

Rationale:

his course is an extension of PH 3052 in the study of electromagnetism. The course will guide students to acquire advanced knowledge in electromagnetism. Students will be introduced to advance mathematical tools and to use them to solve more complex problems involving Maxwell's equations for static and dynamic cases.

Prerequisites: PH 3052

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- interpret principles of electromagnetism to analyze advance problems in static fields
- apply mathematical techniques such as separation of variables in the solution of boundary value problems in electromagnetism in rectangular, spherical and cylindrical geometries.
- apply Green's function method to solve Poisson's equation in rectangular, spherical and cylindrical geometries, and the wave equation in free space.
- apply conservation principles to discuss the evolution of electromagnetic systems.
- apply special relativity to solve problems in fields of moving charges.

Course Content:

Electrostatics: Electric moments, dipole moments, quadrupole moments and multipole moments, multipole fields, multipole expansion, Electric Potentials and Special techniques for calculating/solving potentials; Electric fields due to Potential distributions with spherical and cylindrical symmetries, use of Legendre Polynomials, Bessel/Hankel functions, Green's function, Problem solving using computer software, Magnetostatic: Magnetic energy, magnetic force, Maxwell's stress tensor, Problem solving in magnetostatics using special techniques, Gauge transformation, radiation gauge Lienard-Wiechert Potentials, Electromagnetic theory and Special Relativity; transformation of electric and magnetic fields, the fields of moving charges, radiation by moving charges

Method of Evaluation: 70% from 3-hour Examination at the end of the year.
30% from 1-hour mid-semester Examination

References:

1. Jackson, J. D. (1999). Classical electrodynamics.

Course title: **Advanced Optics** **Credits:** 3 (45 L)

Course code: **PH 4012**

Rationale:

Optics is a rapidly developing field with many practical applications ranging from metrological instruments to optical clocks. Most of the electronics systems are now being replaced with optical systems especially in the fields of data communication and storages. The course is designed to explain optical phenomena using concepts in physical optics and quantum optics.

Prerequisites: PH 1002

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- analyse scattering, interference, diffraction and polarization of light in terms of wave theory of light
- describe the theory (principle) behind the different types of lasers and optical fibres
- apply essential theories to design anti-reflection films, reflection-enhancement films and different types of wave plates
- apply the theory related to interference, diffraction, polarization of light to perform mathematical analysis and calculate the relevant optical parameters
- explain practical applications of scattering, interference, diffraction, polarization of light, Fourier optics and lasers

Course Content:

Light in bulk matter; Quantum field theory; Polarization: Dichroism; Birefringence; Polarization by scattering and reflection; Optical modulators; Liquid crystals; Mathematical description of polarized light; Measurements of the state of polarization; Role of polarization in optical instrumentation; Interference: Wavefront-splitting and amplitude-splitting interferometers; Multiple-beam interference; Applications of single and multi-layer films; Applications of interferometry; Diffraction: Some applications in Fraunhofer and Fresnel diffraction; Fourier Optics: Fourier transforms; Optical applications; Basics of coherence theory: Visibility; Degree of coherence; Stellar interferometry; Modern optics: Lasers and laser light: Production; Different types: Technological applications; Spatial distribution of optical information; Holography: Holographic recording; Different types, properties and requirements of holograms; Nonlinear optics: Polarization; Optical coefficient; Symmetry properties; Wave propagation in a medium; Conservation of energy and momentum; Optical fibres: Introduction; Ray theory transmission; Mode theory for propagation; Graded and step index fibres.

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. Hecht, E. (1998). Optics, ed. *MA: Addison-Wesley Publishing Company*.
2. Guenther, R. Modern Optics. 1990.

3. Fowles, G. R. (1989). *Introduction to modern optics*. Courier Corporation.
4. Clarke, D. N., & Grainger, J. F. (2013). *Polarized light and optical measurement: international series of monographs in natural philosophy* (Vol. 35). Elsevier.

Course title: **Introduction to Robotics** **Credits:** 3 (15 L,60 P)

Course code: **PH 4014**

Rationale:

Robotics is a rapidly developing area in modern technology. It is a field that merge several areas such as dynamics, kinematics, electronics and instrumentation commonly taught under the physics curriculum, it is a natural extension of physics in the direction of engineering physics. The course will survey the design principles of robotics and provide hand-on experience in the design process and implementation of robotic systems.

Prerequisites: PH1021, PH2021

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- program microcontrollers and the use of microcontroller-based systems for motor control
- perform calculations on kinematics of robot motion
- perform calculations on dynamics of simple robotic systems
- analyse the performance of control systems for robotics, and carryout path planning for simple robotic systems
- use various sensors to obtain feedback from robotics systems and to develop simple robotic vehicles
- appreciate the use of coordinate transformations to analyse the behaviour of robotic arms and to develop robotic arms

Course Content:

Theory: Robot components, coordinate transformations, kinematics, dynamics, control systems for robotics, path planning.

Laboratory exercises: AVR microcontroller programming, Microcontroller - PC communication, Control of servo motors and DC motors, navigation based on sensors (proximity sensors, magnetometers, accelerometers, etc.) line following, path planning, control of robotic arms,

Method of Evaluation: Continuous assessment (up to 60%) and end of semester examination (40%)

References:

1. Niku, S. B. (2010). *Introduction to robotics: analysis, control, applications*. John Wiley & Sons.

Course title: **Computational Statistical Mechanics** **Credits:** 3 (15 L,60 P)

Course code: **PH 4015**

Rationale:

Statistical Physics is the method of predicting thermodynamic properties of large assemblies by the analysis of average statistical behavior of its microscopic constituents. Extending on the concepts built in level III, during this course students will get a flavor of how to apply mathematical schemes and computational algorithms to popular problems in statistical mechanics. The physical problems will be solved in silico and the numerical results analyzed/ interpreted and related to its physical significance.

Prerequisites: PH 3053, PH 3001

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- apply Monte Carlo algorithms to problems in statistical mechanics.
- apply molecular dynamics to simple model systems such as the 2D hard sphere problem.
- recognize the equivalence between the Newtonian and Boltzmann approaches.
- apply the concepts of density matrix, trotter decomposition to quantum statistical mechanics.
- apply the Feynman path integrals in quantum Monte Carlo calculations.
- simulate the behaviour of simple classical/quantum model systems using the concepts discussed.

Course Content:

Monte Carlo methods: Direct sampling, Markov-chain sampling, Detailed balance, Metropolis algorithm, Distributions and sample transformation; Molecular dynamics: Newtonian mechanics, Pair and wall collisions, Periodic boundary conditions, Virial expansion and thermodynamic quantities; Boltzmann's statistical mechanics: Direct disk sampling, Partition function for hard disks, Markov-chain hard-sphere algorithm, Maxwell distribution, Constant-pressure simulation of hard spheres, Large hard-sphere systems, Grid/cell schemes, Liquid–solid transitions; Entropic forces: Asakura–Oosawa depletion interaction, Binary mixtures, Entropic lattice model for dimmers, Monte Carlo algorithms for monomer–dimer problem; Density matrices and path integrals: The quantum harmonic oscillator, Free density matrix, Trotter decomposition, Feynman path integral, L´evy construction, Pair density matrices, Geometry of Paths; Bosons: Single-particle density of states, Trapped bosons in canonical/ grand canonical ensembles, Bosonic density matrix, Condensate fraction, Direct-sampling algorithm for ideal bosons, Interacting bosons; Spin systems: Ising model—exact computations, Heat bath and perfect sampling, Cluster algorithms, The two-dimensional spin glass, Liquids as Ising-spin-glass models; Dynamic Monte Carlo methods: Random sequential deposition, Faster-than-the-clock algorithms, Dynamic spin algorithms, Spin-flips and dice throws, Accelerated algorithms for discrete systems, Simulated annealing.

Method of Evaluation: Continuous assessments (60%); End of semester exam (40%)

References:

1. Krauth, Werner. Statistical mechanics: algorithms and computations, Oxford University Press, 2006.
2. Chandler, David. Introduction to modern statistical mechanics, Oxford University Press, 1987.

Course title: **Power Electronics** **Credits:** 3 (45 P)

Course code: **PH 4016**

Rationale:

Power electronics find many applications ranging from AC/DC converters in consumer electronic devices to precision controlling systems in electric vehicles. Power electronics brings electronics, magnetics, energy conversion, and control systems into one platform for controlling and converting electric power. This course provides students with the ability to design power electronic systems for precision controlling and converting electric power.

Prerequisites: PH 1003, PH 2001, PH 2003, PH 3007

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- interpret the fundamental principles and applications of power electronics circuits to solve related problems
- design switching regulators according to specifications
- use computer-aided techniques for the design of power converter circuits
- appreciate the latest developments in power electronics

Course Content:

Power electronics systems applications and future development; Basic Switching Regulator Topologies: Basic operations, Critical inductance criterion, Continuous and discontinuous-conduction modes; Mathematical Modeling of Switching Regulators: Small-signal approximation for linearity, Approximation techniques, Switching regulator transfer functions and salient features; Switching Regulators with Transformer Isolation: Fly back converter. Forward converter. Half- and full-bridge converters. Push-pull converter; Feedback Control Design: Classical control design, Bode plot and Nyquist stability criterion, Voltage and current-mode controls; Converter Dynamics and Control: AC equivalent circuit modeling, converter transfer functions, controller design, input filter design, AC and DC equivalent circuit modeling of the discontinuous conduction Mode, current programmed control; Magnetic Components: Inductor, Transformer, Saturation, hysteresis, and residual flux. Motor controlling, Power driving

Method of Evaluation: Continuous assessment (up to 30%) and end of semester examination

References:

1. John G. Kassakian (1991) Principles of power electronics, Reading, Mass: Addison-Wesley.
2. Erickson, R. W., & Maksimovic, D. (2007). Fundamentals of power electronics. Springer Science & Business Media.
3. J.G. Kassakian, M.F. Schlecht and G.C. Verghese, *Principles of Power Electronics*, Addison-Wesley, 1991.
4. Y.S. Lee, *Computer-Aided Analysis and Design of Switch-Mode Power Supplies*, Marcel Dekker,

New York, 1993.

Course title: **Industrial Automation** **Credits:** 3 (45 P)

Course code: **PH 4019**

Rationale:

Automation facilitates improving product quality, reliability, production rate while decreasing production cost in industries. A basic understanding of automation technologies is essential for science graduates who wish to join the industry. In this course, principles of industrial automation are surveyed with a focus on industrial automation controllers.

Prerequisites: PH 3032

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- explain the use of pneumatics/hydraulics in automation
- develop applications using PLCs
- model, design and implement micro-level automation system using PLCs and SCADA
- diagnose automation systems

Course Content:

Introduction to hydraulics and pneumatics: pneumatic generation, purification and flow control, control valves, pure pneumatic/hydraulic control systems, electro-pneumatic/hydraulic control systems; Sensors: limit switches, photo sensors, magnetic sensors, inductive sensors, ultrasonic sensors, process control sensors used for humidity, pressure, temperature, load and flow measurements; actuators: motors and electrical linear drives, pneumatic and hydraulic cylinders and linear drives, pneumatic and hydraulic rotary drives and motors; PLCs operation and construction of switching modules and PLCs, high-end PLCs, programming methods: STL and CSF, FBD and Ladder methods, simple instructions, NC and NO contacts, latch and unlatch outputs, pulse edge evaluation, on-delay and off-delay timers, counters, timer/counter applications, program control instructions, data manipulation instructions, math instructions, converting relay ladder diagram into PLC relay ladder diagram, PID and PWM functions; SCADA: principles of SCADA and industrial network security, SCADA system components, regulatory requirements and architecture protocol;

Method of Evaluation: Continuous assessment (up to 50%) and end of semester examination

References:

1. Groover, P., M., 2015. Automation, Production Systems, and Computer-Integrated Manufacturing. Pearson Education.Y.S. Lee,
2. Lee, Y. S. S. (1993). *Computer-aided analysis and design of switch-mode power supplies*. Marcel Dekker, Inc..

Course title: **Advanced Physics Laboratory II** **Credits:** 6 (180 P)

Course code: **PH 4030**

Rationale:

Continuing from level III of the special degree program in Physics, the objective of this laboratory course unit is to further enhance the students' experimental skills beyond classical physics. Students are expected to conduct experiments independently gaining skills in planning, recording and communicating findings. Students are encouraged to device methods to further improve precision of measurements.

Prerequisites: PH 1020, PH 2020 and PH 3030 are strongly recommended

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- assemble experiments related to quantum physics, dynamical systems, electromagnetism, optics, or semiconductor physics
- use appropriate data acquisition techniques to gather data from custom-made apparatus
- measure physical variables using appropriate instrumentation
- analyse measured variables and compare with physical models
- troubleshoot an experimental setup
- analyse measured variables and develop mathematical models
- present and critically analyse findings in both written and oral formats

Course Content:

The list of advanced laboratory exercises may vary over years. Fundamental experiments related to Millikan's Oil drop experiment, Michelson Interferometry, Reflection of Polarized light, Fresnel Diffraction, Magnetic susceptibility of materials, Hall effect are just a few experiments which are included.

Method of Evaluation: Continuous assessments (100%)

References:

1. Refer the laboratory instruction sheets

Course title:	**Engineering Physics Laboratory**	**Credits:**	6 (180 P)
Course code:	**PH 4131**		

Rationale:

Modern day experimental physics requires sophistication in data acquisition and signal processing. The course gives a comprehensive training on designing and critically evaluating data acquisition systems. Students learn to conduct complex experiments independently and report the findings both in the written and oral forms. As a consequence students develop essential skills useful for advance research in experimental physics.

Prerequisites: PH1021, PH2021

Intended Learning Outcomes:

Upon successful completion of this course students will be able to:

- observe electrical characteristics using appropriate instrumentation
- troubleshoot in an experimental setting
- analyze measured variables and compare with theoretical models
- keep records of their own work
- prepare a good technical/scientific report on the design
- summarize and present technical details in oral form

Course Content:

Fundamental exercises related to operational amplifiers, oscillators, thyristors, single board computers and hardware interfacing are included in this course.

Method of Evaluation: 100% for continuous assessment

References:

1. Refer the laboratory cards

Course title: **Physics Research Project** **Credits:** 6 (180 P)

Course code: **PH 4140**

Rationale:

Research discovers, elucidates and evaluates new knowledge, ideas, and the technologies essential in driving the future of society and humanity. Skills in designing and conducting research is vital for a scientist. Incorporating a research component along with a sound academic foundation enables students to develop independent critical thinking skills along with oral and written communication skills, foster a foundation for the scientific process and create hands-on experiences.

In this year long course, students are encouraged to independently design and conduct a research project in the field of Physics under the guidance of a supervisor.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course students will be able to:

- apply knowledge gained during undergraduate studies in practice
- design and interpret experimental design and methods of an independent research project
- work independently and as a part of a team
- communicate with research supervisor/s
- critically review scientific literature
- present research outcomes in written and oral forms

Course Content:

A project should be designed jointly with a supervisor/s from the department and/or outside institution. Project proposal should be approved by the department committee.

Method of Evaluation: Continuous assessment, dissertation, and viva-voce examination

Course title: **Engineering Physics Research Project** **Credits:** 6 (180 P)

Course code: **PH 4141**

Rationale:

Research discovers, elucidates and evaluates new knowledge, ideas, and the technologies essential in driving the future of society and humanity. Skills in designing and conducting research is vital for a scientist. Incorporating a research component along with a sound academic foundation enables students to develop independent critical thinking skills along with oral and written communication skills, foster a foundation for the scientific process and create hands-on experiences.

In this year long course, students are encouraged to independently design and conduct a research project in the field of applied physics under the guidance of a supervisor.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- apply knowledge gained during undergraduate studies in practice
- design and interpret experimental design and methods of an independent research project
- work independently and as a part of a team
- communicate with research supervisor/s
- critically review scientific literature
- present research outcomes in written and oral forms

Course Content:

A project should be designed jointly with a supervisor/s from the department and/or outside institution. Project proposal should be approved by the department committee.

Method of Evaluation: Continuous assessment, dissertation, and viva-voce examination

Course title: **Computational Physics Project** **Credits:** 6 (180 P)

Course code **PH 4042**

Rationale:

Research discovers, elucidates and evaluates new knowledge, ideas, and the technologies essential in driving the future of society and humanity. Skills in designing and conducting research is vital for a scientist. Incorporating a research component along with a sound academic foundation enables students to develop independent critical thinking skills along with oral and written communication skills, foster a foundation for the scientific process and create hands-on experiences.

In this year long course, students are encouraged to independently design and conduct a research project in the field of computational physics under the guidance of a supervisor.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- apply knowledge gain during undergraduate studies in practice
- design and interpret experimental design and methods of an independent research project
- work independently and as a part of a team
- communicate with research supervisor/s
- read and understand research materials
- Present research outcomes in written and oral forms

Course Content:

A project should be designed jointly with a supervisor/s from the department and/or outside institution. Project proposal should be approved by the department committee.

Method of Evaluation: Continuous assessment, dissertation, and viva-voce examination

Course title: **Industrial Research Project** **Credits:** 6 (180 P)

Course code: **PH 4020**

Rationale:

Although industries usually have matured processes for their operations, there is room for improvement. Knowledge creation and technology development require considerable capital investments and people with different thinking patterns. This course aims to provide students with the opportunity to identify process bottle necks in an industrial setting, and to contribute towards the improvement and optimisation of such processes.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- identify real world problems and integrate suitable IT/electronics-based solutions
- apply the theories in order to find solutions to the industrial problems and develop IT based solutions.

Course Content:

Students are required to identify an industrial based problem and they are expected to work independently for 6-month duration, develop a suitable IT-based solution and present their work based on Proposal, Progress, and results. At the end of the 6 months the students are expected to submit the final report. Students will be evaluated through a VIVA.

Method of Evaluation: Continuous assessment (40%), report (30%) and viva-voce examination (30%)

Course title: **Industrial Training** **Credits:** 6 (180 P)

Course code: **PH 4021**

Rationale:

Industrial training integrates classroom knowledge and theory with practical application and skills developed in a professional setting. It boosts the performance of students and help them meet career objectives. The course is designed to expose students to a real working environment and enhances their work-related skills by allowing utilizing their theoretical knowledge into practice.

Prerequisites: None

Intended Learning Outcomes:

Upon successful completion of this course, students will be able to:

- explore career alternatives prior to graduation.
- integrate theory and practice in an industrial setting.
- assess interests and abilities in IT/Electronics field of study.
- develop work habits and attitudes necessary for job success.
- develop communication, interpersonal and other critical skills in the job interview process.
- build a record of work experience

Course Content:

Students are assigned to IT/electronics and or IT/electronics related companies and they are expected to work under the supervision of the company for 6-month duration and present their training experience through progress reports and a final report. At the end of the 6 months the students are expected to submit the training report. Students will be evaluated through a VIVA.

Method of Evaluation: Continuous assessment (40%), report (30%) and viva-voce examination (30%)