UTTARA UNIVERSITY

School of Science and Engineering
Department of Physics

Revised on 11-04-2018
Revised Syllabus for M.Sc. in Physics (2 year program)

Part I and II

Part I: New addition for those who have passed B. Sc. (pass)

Part II: Existing UGC approved M.Sc. Final program for those who have passed B.Sc. Hons or M.Sc. Preliminary in Physics or allied fields or Part-I of this course

Total credit hours: 36 credit hours for part-I +36 credit hours for part-II= 72 credit hours

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UTTARAUNIVERSITY
School of Science and Engineering
Department of Physics
Program: M. Sc. in Physics (2 year)

Introduction

Uttara University is currently offering 1-year (36 credits) M.Sc. program in Physics and 2-years (72 credits) M.Sc. program in Physics with the approval of UGC. Those having B.Sc. Honors or M.Sc. Preliminary in Physics/Applied Physics/Mathematics are eligible for the above course.

It has been noticed that a good number of students with B.Sc. (Pass) have shown their interest to enroll in M.Sc. in Physics here. In reality, many colleges have B. Sc. (pass) program, but do not have a M.Sc. program. As a result, many of the students completing B.Sc. (pass) from such a college have very little opportunity to continue their higher studies in the M.Sc. (Physics). From the above consideration and in response to the continuous pressure for admission from students desiring higher education leading to M. Sc in Physics, a 2-year program for M. Sc in Physics has been designed. This syllabus has two parts: part-I, which is the new addition and part II, the existing UGC approved 1 year and 2 rears program and improved considering the development of Physics mainly in Electronics, Information and Communication Technology, Health Physics, Renewable Energy, Atmospheric Physics and Physics of Climate Change, Space Science and Remote Sensing Technology and their Applications for Technology Development, Resource Inventory, Environment Study and Disaster Mitigation, etc. The revised 2-year program is so designed that the students having B.Sc. (Pass) will be able to enroll in this program in part I. and subsequently complete part-II to get the degree in M. Sc. in Physics. Each of part-I and Part-II has 36 credit hours (72 credit hours in total).

Admission Requirement

- Category-I: Students having B.Sc. (Pass) are eligible for admission and will have to complete the full 2-year course of 72 credit hours (i.e. Part-I & Part-II)

- Category-II: Students having a B.Sc. (Hons.) 3 year or M.Sc. (Preliminary) in Physics/Applied Physics/ Mathematics or related fields are eligible for admission and will have to complete only part-**II** course of 36 credit hours which is a 1-year course.

- Age is no bar for admission

Degree to be awarded

M. Sc. in Physics.

Degree Requirements

The M. Sc. in Physics degree requirements will be as follows:

- Category-I:Completion of 72 credit hours courses in two years (Part-I & Part-II) for those students who have B.Sc. (Pass) degree
- Category-II: Completion of 36 credit hours courses in one year (Part-II) for those students who have B.Sc. (Hons.) 3 year or M.Sc. (Preliminary) degree.
- Passing of all courses individually and maintaining a minimum CGPA of 2.25(in a scale of 4).

Grading System & Performance Evaluation:

Students having minimum 75% class attendance will be eligible to take semester examinations. Letter grading will be made to assess student's performance. The grade will be assigned on the overall evaluation of a student's performance on the basis of semester final examination, midterm test, case studies, tutorial test, term papers, assignment & class attendance in aggregate and whatever is applicable for an individual program. Grades/GPA will be determined by the teachers responsible for the course. The final result will be prepared by cumulating the grade point average (CGPA) over the courses. The Letter grade corresponding to numerical grade and grade point will be as follows (UGC provided common grading system):

Numerical Grade	Letter Grade	Grade Point
80% and above	A +	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00
	F * Failure I ** Incomplete W *** Withdrawal R **** Repeat Y***** Audit	

* "F" means failure. Credits for courses with this grade do not apply towards graduation.

** A "I" grade is given to students who have fulfilled the majority of the course requirements but have been unable to complete the rest. The student is ***not required*** to register for the course in the next semester.

*** "W" means withdrawal. A student may decide to withdraw from a course by the deadline with the consent of the instructor and the Academic Advisor.

**** "R" means repeat. To improve grade say, F to D or better. Two times repetition of a course are allowed. Failure in a compulsory course will be given two chances from the program.

***** "Y" means audit. An existing student or ex-student may decide to audit a course of his/her interest for improvement of his knowledge for the particular course. In this case, the student pays the full tuition fee for the course, attends the classes, but is not required sitting for the exams and no credit is earned.

Marking System in the Individual Courses:

5% marks are allotted to class attendance, 25% for more than one midterm or other assignments and 70% for final examination.

Semesters at the University:

There will be two semesters in an academic year, which are:

- Summer- January to June
- Winter- July to December

Workload:

The normal workload is 18credits/semester. This may be relaxed only with special permission of appropriate authorities at UU.

M.Sc. in Physics: Part-I

(1 year, 36 credit hours)

A student having B.Sc. (Pass) is to complete following 36 credit hours course for going to Part-II syllabus.

Sequence of Courses Offering in 2 (Two) Semesters

(The University reserves the right to change the sequence of courses)

SEMESTER-1			
Sl. No.	Course Code	Course Title	Credits
1	PHY 411	Mathematical Methods in Physics	3
2	PHY 412	Geometrical and Physical Optics	3
3	PHY 413	Introduction to Computer and Programming Language	3
4	PHY 414	Classical Mechanics & Relativity	3
5	PHY 421	Quantum Mechanics-I	3
6	PHY 422	Electricity and Magnetism	3
		Subtotal	18
SEMESTER-II			
Sl. No.	Course Code	Course Title	Credits
1	PHY 423	Electronics-I	3
2	PHY 424	Atomic and Molecular Physics	3
3	PHY 431	Solid State Physics-I	3
4	PHY 432	Nuclear Physics-I	3
5	PHY 433	Electrodynamics	3
6	PHY 434	Physics Lab	3
		Subtotal	18
		Total	**36**

Contents of the courses offered for Part-I of M. Sc. in Physics Program

SEMESTER-I

PHY 411: Mathematical Methods in Physics
3 credits 3 hours/week

Vector analysis: Vector differential operators: Gauss's Green's and Stoke's theorems; Vector operators in spherical, polar and Cylindrical Co-ordinates. Curvilinear coordinates.
Matrices: Fundamental definitions and operation; Rank of matrices; Orthogonal and unity matrices. Similarity transformation of matrices; solution of simultaneous linear equations; vector spaces; Characteristic roots and characteristic vectors; Diagolization of matrices.
Differential Equations: Power series solution about ordinary and regular singular points.
Function: Gamma and Beta functions, Bessel functions; Legendre and associated Legendre polynomials; Hermite polynomials.

Tensor Algebra**:** Space of N dimensions; Co-ordinate transformations; Definition of covariant, contra variant and mixed tensors; Fundamental options with tensors.
Statistics: Approximation and rounding of numbers; Errors and their calculations; Statistical distribution; Mean, median, mode, mean deviation, standard deviation. Definition of probability; Law of probability; Binomial, Poisson and Normal distributions; Method of least squares; Weighted measurements.

PHY 412: Geometrical and Physical Optics
3 credits 3 hours/week

Geometrical Optics: Spherical aberration, chromatic aberration.
Coherence: First order coherence, spatial and temporal coherence. Higher order coherence.
Interference of waves: Principle of superposition, Phase velocity and group velocity. Hygens principle. Young's experiment. Fresnel biprism. Division of wave front and amplitude. Michelson's interferometer; shapes and positions of fringes.
Multiple reflection interference: Multiple beam fringes with a plane parallel plate, Febry-Perot interferometer, Fizeau fringes.
Fourier Optics: Fourier transforms in two dimensions, Dirac delta function, Optical applications, Fourier transforming property of a lens.
Diffraction: Diffraction; Fraunhofer and Fresnel diffraction, Single, Double and Multiple slit diffraction, Diffraction grating spectrometer, Resolving Power.
Polarization: Definition, Plane, circular and elliptic polarization, optical activity.
Dispersion and Scattering: Dispersion, Cauchy and selemeier formula,
Introduction to Optical fiber.

PHY 413: Introduction to Computer and Programming Language
3 credits 3 hours/week

Computer Fundamentals: Classification of computer, Use and Scope of computer, Basic concept of Binary number system, Software, Hardware, System software, Application software, Networking software, Logic gates.
Introduction to programming: Introduction to programming in C++, Q-basic, FORTRAN, variables, objects, and operators.
Conditional Statements and Integer Types: Input, if, if---else statement, Relational operators, Compound statements, keywords, Compound conditions, Boolean Expressions, Nested conditionals, the switch statement, the conditional expression operator.
Iteration and Floating type, Functions, Arrays, Pointers and references, Strings, Classes and Overloading Operators.

PHY 414: Classical Mechanics and Relativity
3 credits 3 hours/week

Motion of a system of particles: Conservation laws of linear momentum; angular momentum and energy.
Lagrangian Formulation: Generalized co-ordinates, Lagrange equation from Hamilton's principle.
Two-body motion: Centre of mass co-ordinates; Kepler laws, Two coordinates. Foucauls pendulum.
Motion of a Rigid Body: Inertia Tensor; Euler's angles; rotating coordinates, Foucault pendulum.
Hamilton's equation of motion: Legendre transformation and Hamilton's equations.
Canonical Transformations: Equations of canonical transformation; Lagrange and Poisson brackets.
Inertial Systems: The postulates of special theory of relativity; Michelson-morley experiment and its explanation; the Lorentz transformation, its kinematic effect and geometrical representation; Velocity addition; the mass of a moving particle and the mass energy equivalence and their experimental verification, Lorentz covariance of Maxwell's field equations; Introduction to general theory of relativity.

PHY 421: Quantum Mechanics- I
3 credits 3 hours/week

Shortcoming of Classical Theory: The two slit experiment, Measurements and observable, Commutation of observations.
Linear Operators: Eigenvalue equations-eigenvalue and eigenfunctions.
Complementary Principle: Physical postulates of Quantum mechanics, wave function and its interpretation, Eigen states, Orthonormality of eigenstates, Degeneracy, Principle of superposition, Probability amplitude and overlap integrals, Wave packets and uncertainty principle.
Correspondence principle: The SchrÖdinger wave equation and one dimensional potential problems-particle in potential box, potential step tunneling through potential barrier, rectangular potential well.

PHY 422: Electricity and Magnetism
3 credits 3 hours/week

Electric Field: The electric field strength, Electric Lines of force, Calculation of electric field strength, Electric dipole and quadruple, Point charge in electric field, and a dipole in electric field
Electric flux: Electric flux, Gauss's law and its application.
Electric Potential: Potential and field strength, Potential due to point charge, A group of point charges and a dipole, Electric potential energy, Calculation of electric field strength from potential.
Capacitor and Dielectrics: Capacitance and its calculation, Dielectric and Gauss's law, Parallel plate capacitor with dielectric, electric vectors, Energy stored in an electric field.
Current and Resistance: Current and current density, Drift speed and charge carrier, Resistance.
Electromotive force and potential difference: Kirchhoff's laws; Wheatstone bridge; RC circuits.

Magnetic field: Definition of Magnetic Induction; Magnetic force of a current; Torque on a current loop; Moving coil Galvanometer.

Magnetic materials: Classification of magnetic materials, theory of diamagnetism, para magnetism and ferromagnetism, ferromagnetic and anti ferromagnetic orders, magnetic resonance.

Amperes Law and Biot-Savart law: Ampere's law and its applications; Biot-Savart law and its application.

Electromagnetic Induction: Faraday's law of electromagnetic induction. Lenz's Law, Induction a quantitative study; Time varying magnetic fields.

Inductance: Self inductance and Mutual inductance, self inductance calculation; LR circuit; Energy and density of energy stored in a magnetic field, Magnetization, B-H curve.

Electromagnetic oscillations: LC circuit; analogy to simple harmonic function; LCR circuit, Q-Factor, analogy to Damped harmonic motion, forced oscillations and resonance.

Alternating current: The simple AC generator; RMS Value of an AC Voltage applied to resistors, capacitors and inductors; AC current and Voltage in series and parallel RL and in series and parallel RC circuits; LCR circuits; Transformer.

Thermoelectricity: Seeback, Peltier and Thomson's effect, Thermoelectric power, Thermocouple.

SEMESTER-II

PHY 423: Electronics-I
3 credits 3 hours/week

Circuit Analysis: Network theorem - Thevenen's theorem, Superposition theorem, Maximum power transfer theorem; Equivalence of T, Pi, star and delta conversion lattice networks; Wave filters; constant K-type low pass, high pass, band pass and band elimination filters.

Semiconductor Diodes: Introductions to valves, P-N junctions, Volt-ampere characteristics of both valve and P-N junction diode, capacitances of a p-n junction, Solar cell, tunnel diode, photodiode, LED, rectifier and filters, voltage multiplier, Voltage regulator.

PHY 424: Atomic and Molecular Physics
3 credits 3 hours/week

The particle properties of Wave: The photoelectric effect Einstein's photoelectric equation and its experimental verification, photoelectric cells and their applications x-ray production and diffraction of X-ray, Bremsstrahlung; continuous and characteristics X-ray; X-ray absorption; Moseley's Law; Compton effect.

The wave nature of particles: Wave particle duality; De Broglie Waves; experimental verification of particle waves; Wave and group velocities; the uncertainty principle and its applications.

The Atomic Models: Rutherford's nuclear atom, atomic spectra, the Bohr model and the structure of atom, atomic excitation, the Franck-Hertz experiment; the correspondence principle; correction for unclear motion; hydrogen-like atoms.

The Quantum theory of Hydrogen Atom: Schrödinger equation for hydrogen atom, orbital and magnetic quantum numbers; electron Probability density.

Electron Spin and Complex Atoms: Spin angular momentum; the exclusion principle; the periodic table; Starn-Gerlach experiment; spin-orbit interaction-line structure, total angular momentum of atomic spectra (helium and sodium); X-ray spectra

PHY 431: Solid State Physics-I
3 credits 3 hours/week

Crystals: Different type of crystal system, Unit cells, Bravis lattices, Miller indices, Symmetry elements, point group and space group, X-ray diffraction, Bragg's law, Diffraction of x-ray by crystals, Reciprocal lattice, Ewald sphere, Scattering and structure factors, Temperature factor.
Classification of Solid and crystal lattices: Ionic covalent molecular, Hydrogen bonded crystals, Directed bonds, Lattice energy of ionic crystals, Lattice vibrations of monatomic and diatomic lattice.
Various theories of lattice specific heat-Einstein's theory and Deby approximation, Zeeman effect.

PHY 432: Nuclear Physics-I
3 credits 3 hours/week

The Nucleus: Rutherford's atom and atomic nucleus, nuclear size; packing fraction and binding energy; Nuclear force (introduction)
Radioactivity: Radioactive decay laws: Half life and mean life; Secular and transient equilibrium; Measurement of decay constants; radioactive series; Artificial radioactivity; Uses of radio isotopes; Units of radioactivity.
Alpha, Beta and Gamma Emissions: Alpha instability. Fine structure; Long range alpha particles; theory of alpha decay and its experimental verification; Energy measurement, Beta ray spectrometers, Conservation of energy and momentum in beta decay; Neutrino hypothesis; Evidence for antineutrino, Orbital electron capture; positron emission; Energy measurement of gamma radiation; pair spectrometer; Mean lives for gamma emission; Internal conversion.
Introduction of charged particles & radiation with matter: lonization, Multiple scattering; Stopping power; Range determination; Energy loss of electrons and other charged particles; Straggling; Positronium; Pair production and annihilation; radiation length.
Nuclear Reaction: Different types of reaction, the energies of nuclear reactions, the conservation of momentum in unclear reactions, Cross section, Compound nuclear hypothesis, production and proper-time of neutrons.
Nuclear Detector: Ionization chambers, proportional counter, Geiger-Muller Counter.
Particle Accelerators: Linear accelerator, Betatron, Cyclotron, Synchrotron.
Nuclear Fission and Fusion: Fission process, energy release in fission, chain reaction, nuclear fusion, thermonuclear reaction in stars.
Fundamental particles**:** Introduction to elementary particles: Cosmic Rays.

PHY 433: Electrodynamics
3 credits 3 hours/week

Electromagnetic Field Equation: Maxwell's Equations, E.M. energy-pointing vector, Scalar and vector potentials, Gauge transformation and the wave equations.
Propagation of E.M waves: Plane waves in non-conducting media, Waves in conducting media, Reflection and Refraction at boundaries of two non conducting media.
Boundary Conditions: Total internal reflections, Propagation of E.M. Waves in bounded region, Propagation between parallel conducting plates.
Propagation of E.M. waves in Crystalline Media: Isotropic and An-isotropic crystals, Light propagation in Uni.-axial crystals, Wave surfaces.
Radiation from an accelerated charge: The Lienard and Wiechart potential, Field of charge in uniform motion, Fields of an accelerated charge, Radiation at low velocities.
Scattering and Dispersion: Scattering by individual free electron, Scattering by bound electron, Absorption of radiation by an oscillator, Rayleight scattering, Dispersion relation.

PHY 434: Physics Lab:

3 credits 6 hours/week

List of Laboratory works based on the theoretical courses

Title of the experiment	No. of experiments
1. To determine the refractive index of the material of a thin prism by the method of a normal incidence.	1
2. To measure the dispersive power of the material of a prism and a given liquid by total internal reflection using a spectrometer.	1
3. To determine the Cauchy’s constants and the resolving power of a prism using a spectrometer.	1
4. To determine the wavelength of monochromatic light by Fresnel’s bi-prism.	1
5. To determine the separation between D1 and D2 lines of sodium by Michelson interferometer.	1
6. To determine wavelength of monochromatic light by Michelson interferometer.	1
7. Determination of e/m of an electron	1
8. To study the frequency response characteristics of a RC low pass and high pass filter circuits.	2
9. Determination of resonance frequency in LRC circuit with a) L and C in series and b) L and C in parallel	2
10. Study of the characteristics of a p-n junction and a Zener diode.	2
11. Determination of transistor characteristics in common emitter configuration.	1
12. Construction of a transistor radio receiver.	1
13. Construction of a transistor radio transmitter.	1
14. Study of variation of reactance due to L and C with frequency.	1

15. Construction of a full wave Bridge rectifier using semiconducting diodes and study of the effect of filters.	1
16. Determination of the plateau and operating voltage of a Gieger-Muller counter.	1
17. To study the I-V characteristics and performance of a solar cell.	1
18.. Develop a computer programme using C++ or FORTRAN language to calculate a mean, standard deviation, correlation coefficient, variance of given time series data .	2
19. Develop a computer programme to generate sinusoidal waves of given frequencies and initial phases.	1
20. Develop a computer programme to estimate the Furrier co-efficient of given signal using FourTransform.	1
Total number of experiments	24

M.Sc. in Physics: Part-II

(1 year, 36 credit hours)

A student who has completed B.Sc. (Hons) or M.Sc. (Preliminary) or Part-I of this syllabus is to complete 36 credit hours course for getting M.Sc. in Physics degree according to the following breakup:

- 5 theoretical courses of 30 credit each having 2 parts (for example, Electronics-II and Electronics-III) are to be taken from among the 10 optional courses (theory), subject to the availability of teachers on that subject and approval by the Academic Committee.
- 3 credit hours from lab works and
- 3 credit hours form project/thesis.

List of courses for M. Sc. (Part-II) in Physics Program

Students shall have to take 5 courses each having 2 parts (2×3=6 credits) with the approval of the Chairman of the Department.

Course Code	**Course Title**	**Credit Hrs.**
PHY 511	Quantum Mechanics- II	3
PHY 512	Quantum Mechanics- III	3
PHY 513	Electronics-II	3
PHY 514	Electronics-III	3
PHY 515	Nuclear Physic-II	3
PHY 516	Nuclear Physic-III	3
PHY 517	Solid State Physics-II	3
PHY 518	Solid State Physics-III	3
PHY 521	Crystallography and Polymer Physics-I	3
PHY 522	Crystallography and Polymer Physics-II	3
PHY 523	Pulse and Digital Electronics-I	3
PHY 524	Pulse and Digital Electronics-II	3
PHY 525	Atmospheric Physics-I	3
PHY 526	Atmospheric Physics-II	3

PHY 527	Renewable Energy-I	3
PHY 528	Renewable Energy-II	3
PHY 531	Satellite Technology, Remote Sensing and GIS-I	3
PHY 532	Satellite Technology, Remote Sensing and GIS-II	3
PHY 533	Reactor Physics – I	3
PHY 534	Reactor Physics – II	3
PHY 535	Health and Radiation Physics –I	3
PHY 536	Health and Radiation Physics –II	3
PHY 537	Biophysics – I	3
PHY 538	Biophysics – II	3
PHY 539	Telecommunication – I	3
PHY 540	Telecommunication – II	3
PHY 550	Physics Lab	3
PHY 500	Project/Thesis	3

M.Sc. in Physics: Part-II

(1 year, 36 credit hours)

A student having B.Sc. (Pass) is to complete following 36 credit hours course for going to Part-II syllabus.

Sequence of Courses Offering in 2 (Two) Semesters

(The University reserves the right to change the sequence of courses)

SEMESTER-1			
Sl. No.	Course Code	Course Title	Credits
1	PHY 511	Quantum Mechanics-II	3
2	PHY 513	Electronics-II	
3	PHY 515	Nuclear Physics-II	3
4	PHY 517	Solid State Physics-II	
5	PHY 527	Renewable Energy-I	3
6	PHY 528	Renewable Energy-II	3
		Subtotal	18
SEMESTER-II			
Sl. No.	Course Code	Course Title	Credits
1	PHY 512	Quantum Mechanics-III	3
2	PHY 514	Electronics-III	3
3	PHY 516	Nuclear Physics-III	3
4	PHY 518	Solid State Physics-III	3
5	PHY 550	Physics Lab	3
6	PHY 500	Project/Thesis	3
		Subtotal	18
		Total	**36**

Contents of the courses offered for Part-II of M. Sc. in Physics Program

PHY 511: Quantum Mechanics- II

3 credits 3 hours/week

Matrix formulation of quantum mechanics: State vectors and Hilbert space, bra and ket notations, operators and there representations, transformation theory, Schrödinger, Heisenberg, and Dirac representations.
Theory of angular momentum: Angular momentum operators and their commutation relations, eigenvalues and eigenvectors of angular momentum operators, parity operators on the angular momentum vectors, addition of angular momenta, Clebsch-Gordon coefficient, Pauli's exclusion principle and spin matrices.
Theory of scattering: Two-body systems, Scattering by spherically symmetric potentials, Partial wave analysis, Born approximation and its applications.

PHY 512: Quantum Mechanics-III

3 credits 3 hours/week

Approximate methods: Stationary perturbation theory, Time dependent perturbation theory, Variational method, WKB approximation.
Identical particle: Symmetric and antisymmetric wave functions, exclusion principle, spin and statistics spin matrices, Projection operator, density operator, polarization vector for a spin – s particle, Scattering of identical particles.
Relativistic wave equations: Klein-Gordon and Dirac's relativistic wave equations, solution of free particle equations, negative energy state and hole theory.

PHY 513: Electronics-II

3 credits 3 hours/week

Transistor amplifiers: Bipolar junction transistor, transistor bias and thermal stabilization, CB, CE & CC amplifiers and their characteristics, transistor equivalent circuits, hybrid parameter equivalent, cascade amplifiers; high frequency amplifiers; push-pull amplifiers; Op-amp basics; Practical Op-amp circuits; Constant-gain multiplier; Voltage summing; Voltage buffer; Active filters.
Feedback and Oscillation: Feedback principle, oscillation criteria, RC oscillator, Hartley oscillator, Crystal oscillator.
Receivers and transmitters: Modulation and demodulation, transmission and reception circuits.

PHY 514: Electronics-III
3 credits 3 hours/week

Multivibrators: Basics of multivibrators, types of multivibrators-astable, monostable and bistable multivibrators.
Sawtooth sweep generation: Nonsinusoidal waveforms, classification of Nonsinusodial oscillators, pulse definitions, basic requirements of a sawtooth generation and UJT sawtooth generation.
pnpn device: Silicon-Controlled rectifier; Basic Silicon-Controlled rectifier operation; SCR characteristics; SCR applications: a static switch, phase-control system, battery charger, temperature controller, and single-source emergency lighting system; Light activated SCR.
Transmission Lines: Current and voltage along the line; Wavelength and phase velocity; reflection coefficient; standing wave ratio; propagation constant; attenuation constant; phase constant; input impedance of open and short circuited lines.
Antenna and Radio wave propagation: Ground Wave, sky and space waves, reflection and refraction on radio waves by ionosphere; Ray path, skip distance; maximum usable frequency; Radiation from dipole antenna.
Electronic instruments: Power supply and filters; MultiMeters, avometers, signal generators, transducers and oscilloscope.

PHY 515: Nuclear Physics-II
3 credits 3 hours/week

Properties of Nuclei: mass, size, angular momentum, spin, Electric and magnetic multiple moments, Coulomb energy.
The Deuteron: Ground state of Deuteron, Deuteron wave function, Electric quadrupole and magnetic dipole moment of Deuteron, Excited state of Deuteron.
Two-body problems at low energy: Neutron – proton scattering at low energies, Spin dependence of n-p scattering, Effective range theory, Salient points for n-p for scattering at intermediate and high energies.
Nuclear forces: Nuclear stability conditions, Symmetry and charge effects, Charge effects, Charge independence of nuclear force, Mirror nuclei and Coulomb displacement energy, Exchange force.

PHY 516: Nuclear Physics-III
3 credits 3 hours/week

Nuclear cross-sections, Breit–Wigner Dispersion formula for s-state, Compound nucleus, Elastic and non-elastic processes, Direct reactions, Unified model, Optical model -- giant resonance and strength function.
Nuclear Models: Aspects of liquid drop model, Magic numbers and nuclear shell model, Single particle potentials, Prediction of spin and magnetic moments, Limitation of shell model, Collective models – Vibrational and rotational states, Optical model – Giant resonance and strength function.

PHY 517: Solid State Physics-II
3 credits 3 hours/week

Electrical properties in metals: Electrical conductivity at high frequencies, dielectric response of an electron gas, Motion in magnetic fields, electron in a periodic potential, approximate solution near a zone boundary, number of orbital in a band, construction of Fermi surface.
Theory of semiconductors: semiconductor materials, intrinsic semiconductors, impurity and defect state in semiconductors, fabrication of intrinsic and extrinsic semiconductors, Hall effects, generation and recombination of charge carriers, diffusion theory, tunnel diode.
Dielectrics: Dielectric, Piezo, Pyro and Ferro electric properties in an alternating fields, relaxation and dielectric losses, generation properties of Ferroelectric materials, dipole theory of Ferro electricity, spontaneous polarization, ferroelectric domain, piezoelectricity, electromechanical transducers.

PHY 518: Solid State Physics - III
3 credits 3 hours/week

Magnetic properties of solids: Langevin's dia- and paramagnetism; quantum theory of paramagnetism; paramagnetic susceptibility of conduction electron; ferri and ferromagnetism; anti- ferromagnetism; ferrites; Curie-Weiss law; Heisenberg model; spin waves; magnetic relaxation and resonance phenomena.
Superconductivity: Basic properties of superconductors; Type-1 and Type-2 superconductors; critical field; Meissner effect; Thermodynamics of superconductors; London equations; Penetration depth; coherence length; modern theory of superconductivity; electron-phonon interaction; electron pairs; flux quantization; Joesphson junction; superconducting magnets; high TC superconductors.
Optical phenomena in solids: Color of crystal; excitons; weakly and tightly bound excitons; photoconductivity; traps; crystal counters; phosphorescence; excitations and emission; decay mechanisms.

PHY 521: Crystallography and Polymer Physics-I
3 credits 3 hours/week

Crystal Systematic: Crystals and symmetry Point groups and space groups: Crystal structure factor and systematic absences.
Fourier Transform and Convolution: Fourier transform and the inverse transform; Real space and Fourier space; Delta function and Fourier transform; Convolution theorem; Diffraction and Fourier transforms. theory of diffraction by a three-dimensional lattice; direct and reciprocal lattices; Laue's equations and Bransorm of Fourier transform of a disordered lattice; Fourier transform of infinite continuous and discontinuous helix; Helical selection rule.

PHY 522: Crystallography and Polymer Physics-II
3 credits 3 hours/week

Experimental Techniques: X-ray source filtering and crystal setting: Laue and powder methods; Rotation. Weissenbeg and precession methods. Single crystal diffractometry.
Structure solution: Corrections of intensity data; Patterson function. Isomrphous replacement and anomalous scattering methods; inequalities and direct method; Refinement of crystal structure.

PHY 523: Pulse and Digital Electronics-I
3 credits 3 hours/week

Digital electronics: Decimal, binary, octal and hexa decimal number systems; Binary coded decimal, analogue to digital conversation.
Logical circuits and Boolean algebra, OR, NOR, NOT, AND, and NAND operations, Laws of Boolean algebra, De-Morgan's theorems, Truth tables and maps, Flip-flops, decoders, Multiplexers.
Digital arithmetic: Binary addition, subscription, division, multiplication; Addition in 2's compliment system; Arithmetic circuits; BCD adder;
Counters: Synchronous and asynchronous counters, Up-down counters, presettable counter; Decoding a counter; Shift – resister, frequency counters, Digital clock.
MIS Logical circuit: Decoders; BCD-to-7-Segment Decoder; Liquid crystal displays; Encoders; Multiplexers; Multiplexer applications; Demultiplexers;

PHY 524: Pulse and Digital Electronics-II
3 credits 3 hours/week

Memory element: RAM, ROM, static and dynamic access memories. Magnetic disk, Digital recording technique, Opto-electronics. Digital Computer operations: Basic computer system, Computer operating cycles, Microprogramming, Microprocessors, microcomputers. Pulse shaping and Generation: Pulse characteristics, RC differentiator & integrator, As-table, Mono-stable and bi-stable multi-vibrators and Schimitt trigger.

PHY 525: Atmospheric Physics-I
3 credits 3 hours/week

Some Basic Idea about the Atmosphere: Planetary atmosphere, Vertical structure, composition, Equilibrium temperature, Hydrostatic equation.
Atmospheric thermodynamics, Gas law, Mixing ratio, Dew point temperature, Equivalent temperature, Potential temperature, Adiabatic lapse rate. Atmospheric instability, Convections: dry adiabatic and moist adiabatic convections, Thermodynamic charts: cloud base and cloud top, energy of instability, First law of thermodynamics. Total potential energy of an air column, Available potential energy, Zonal and eddy energy.

A Radiative equilibrium Model: Blackbody radiation, Absorption and emission, reflection, molecular and aerosol scattering, transmission, Radiative transfer equations, Radiation Balance, Greenhouse effect, Energy balance.
Clouds: Cloud formation; the growth of cloud particles; The radiation properties of clouds, Radiative transfer in clouds.
General Circulation of the atmosphere: Mean global thermal fields. Mean circulation of the atmosphere, Meridional & Zonal circulation, Trade winds, Pressure centres, Air masses, Fronts, Itertropical Convergent Zone (ITCZ).

PHY 526: Atmospheric Physics-II
3 credits 3 hours/week

Atmospheric Dynamics: Total & partial derivatives, Equation of motion, the geostropic approximation, cyclostrophic motion; surfaces of constant pressure; the thermal wind equation, Vorticity and Divergence equations, prognostic equations.
Atmospheric Waves: Introduction, Sound Waves; Gravity waves; Rossby waves The Vorticity equation; Three dimensional Rossby-type waves; Turbulence.
The Atmospheric Circulation: Intertial instability Barotropic & Baroclinic instability Sloping convection, Energy transport, Transport of angular momentum; the general circulation of the lower midddle and upper atmosphere, Monsoon circulation and its characteristic features, Monsoon Trough, Atmospheric Teleconnections with El Nino La Nina and Southern Oscillation Indices.
Mesoscale Connective systems and Tropical disturbances: Thunderstorm, Squall lines, Norwesters, Tornadoes, Tropical Cyclones and Monsoon Depression.
Numerical Weather Prediction (NWP): Finite difference techniques, Time integration: forward & central differencing, Boundary layer parameterization, convective parameterization schemes, Solution of primitive equations and vorticity equation using finite difference techniques, Spectral modelling.
Climate Change: Global warming and climate change, Causes of climate change, Increase of atmospheric and oceanic temperature, Sea level rise, Challenges of climate and climate change research.

PHY 527: Renewable Energy-I
3 credits 3 hours/week

Introduction: Man and energy, World’s Production and reserves of commercial energy sources, Non commercial sources, Renewable Energy and Its classification, The solar Energy option, Solar thermal conversions, Solar Photovoltaic conversions, Wind Energy, Energy from Biomass, Biogas Energy, Ocean Thermal Energy Conversion (OTEC), Wave Energy, Tidal Energy, Zeothermal Energy, Water Energy.
Solar Radiation: Solar Radiation Outside the Earth’s Atmosphere, Solar Radiation at the earth’s surface, The solar constant, Pyrheliometer and pyranometer, Measurement of Duration of Sunshine, Beam, Diffuse and Global Radiations, Beam Radiation on Moving Surface, Solar Radiations on tilted surfaces, The electromagnetic spectrum.

Theory of Flat-Plate Collectors: General description of Flat-Plate collector, The basic Flat-Plate energy balance equation, Collector Performance tests, Collector time constant, Flow distribution of collectors.
Solar Air Heaters: Introduction, Performance Analysis of a conventional Air Heater, Other types of Air Heaters, Testing Procedures.
Photovoltaic Conversion: Introduction of PV conversion, Electrical Characteristics of PV generator, Solar cell, Module, Panel, Arrays, short circuit current (Isc), Open circuit voltage (Voc), Maximum power operation, Loading conditions, parametric Analysis of the PV generator characteristics, Influence of solar Radiation Intensity, Influence of Temperature, Definitions: Peak power, conversion efficiency and Fill Factor (FF), Hot-Spot problem.

PHY 528: Renewable Energy -II
3 credits 3 hours/week

Concentrating Collectors: Introduction, Flat-plate collectors with plane reflectors, Cylindrical parabolic collector, compound parabolic collector (CPC), Central Receiver Tower.
Solar Pond: Introduction, Description, Performance Analysis, Experimental studies, Operational Problems.
Solar Thermal Technology for Rural Industries: Solar candle production, Solar soap production, solar Medical sterilizer, Solar thermal steam production, Solar salt production, Solar tobacco curing, solar paddy boiling.
Wind Power: Introduction, Wind power-How it works, wind behavior and site selection, The components of a wind energy conversion system, Wind power in the U.S.A. and Canada, Wind power catalog.
Wave Energy: Introduction Wave energy economics, Wave energy converters; PELAMIS, LIMPGET, FWP, Sting Ray Tidal Stream Generator (SRTSG).
Solar PV system storage and Applications: Introduction, Solar Inverter solar charge controller, Solar Battery, Solar Integrated Building system (SIBS), Grid connected Solar Electricity (GCSE), Solar Irrigation systems, Solar Lantern etc.

PHY 531: Satellite Technology, Remote Sensing and GIS-I
3 credits 3 hours/week

1. Satellite Technology:
-Dynamics of Satellites, orbits and types of satellites
-Communication, Disaster management, Educational Satellites, Resource and Environmental Satellites, Navigation Satellites
2. Remote Sensing and GIS technology
2.1 Principles of remote sensing:
Definition of Remote Sensing, Principles of Remote Sensing, Electromagnetic Waves and their interactions with the atmosphere and land surfaces-absorption, scattering, transmission and reflection, atmospheric windows, electromagnetic spectra. Types of Remote sensing: i. Optical (passive remote sensing): solar, infrared radiation and microwaves and ii. Radar remote sensing
2.2 Spectral characteristics of the interaction of the electromagnetic waves with the atmospheric and surface features.

2.3 Satellites and Sensors: Environmental satellites, resources satellites and radar satellites and their sensors; resolution and spectral properties
2.4 Satellite data interpretation and thematic mapping
2.5 Principles of GIS: The concept and functions of GIS
3.0 Global Positioning Systems: Basic technology and principles of its operations, determination of coordinates (x.y.z) and accurate mapping of environmental features, resources and locating the changes.

PHY 532: Satellite Technology and remote sensing and GIS-II
3 credits 3 hours/week

1. Digital Image Processing: Image rectification and geo-referencing, Image enhancement, Image filtering and noise removal, 3 band color composites, image interpretation, Image Arithmetic, Vegetation Indices calculation , Image classification (Supervised and unsupervised classifications) and interpretation, ground verification.
2. Applications of remote sensing in Water resources, Agriculture, Coastal Zone Management, Flood mapping, Mapping of Fogs and cold waves, Nor'westers and tropical cyclone monitoring.
3. GIS database creation, environmental modeling and decision making using GIS in disaster management, land use planning, water resources management and other geophysical, environmental and socio-economic applications.

PHY 533: Reactor Physics-I
3 credits 3 hours/week

1. Basic Nuclear Physics (review): Neutron reaction; slow meutron reaction; neutron cross section; macroscopic cross sections and mean free path; neutron flux; reaction rate; classification of neutron according to energy.
2. Nuclear Fission : Classification of fission; The mechanism of fission; practical fission fuels; cross sections of fissionable nuclel; products of fission; energy of fission; reactor power; fuel burn up; fuel consumption.
3. Thermal Neutrons: Meaning of thermal neutrons; energy distribution and effective cross section of thermal neutrons; scattering angles in L and C.M. systems; Angular and energy distribution; Forward scattering in the L system Transport mean free path and transport cross section; Average logarithmic energy decrement; slowing downs time; resonance escape probability; the effective resonance integral.
4. Neutron Diffusion: Meaning of neutron diffusion; Thermal neutron diffusion, Diffusion equation; The thermal diffusion length; the exponential piles; the diffusion length for a fuel moderator mixture; Fast neutron diffusion and Fermi age equation; physical significance of Fermi age equation.
5. Neutron Chain Reaction: Introduction; neutron cycle and four factor formula; Neutron leakage and critical size; nuclear reactors and their classifications; homogenous and heterogeneous reactor system; power reactors reactor control reactor shielding, research reactor; breeder reactor; solid fuel reactors.

PHY 534: Reactor Physics-II
3 credits 3 hours/week

1. The critical equation: Diffusion equation applied to a thermal reactor; thermal neutron source as obtained from the fermi age equation; critical equation and reactor bucking; the no leakage factor; criticality of large thermal reactors, critical size and geometrical bucking, effect of reflection.
2. Reactor Control: Thermal problems in reactor design; coolant circuits; heat transmission principle; various reactor coolants and their characteristics.
3. Heat Transfer: Thermal problems in reactor design; coolant circuits; Heat transmission principle; various reactor coolants and their characteristics.
4. Reactor Materials: Radiation effects on materials; structural materials; moderation and reflector materials; fuel materials; production of reactor fuels properties of fuel element materials, Waste disposal

PHY 535: Health and Radiation Physics-I
3 credits 3 hours/week

1. Radioactivity: Radioactivity and transformation mechanism; Alpha emission; Positron emission; Orbital electron capture; Gamma rays, Internal conversion; Transformation Kinetics; half-life; Average life; Activity; The Becquerel, The curie, specific activity, Naturally occurring radioactivity; serial transformation.
2. Interaction of Radiation with Matter: Introduction; Beta-rays; Range-energy relationship; Mechanisms of energy loss; Ionization and excitation, Bramsstrahlung; Alpha-rays: range energy relationship, Energy transfer Gamma rays; Exponential absorption, Interaction mechanisms, Pair production; Compton scattering; photoelectric absorption; photodisintegration; combined effects; Neutrons production, Classification; Interaction, Scattering, Absorption, Neutron activation.
3. Radiation Dosimetry: Units, Absorbed dose; Exposure; Exposure measurement of free air chamber, Exposure measurement of free wall chamber, Exposure dose relationship, Absorbed dose measurement, Bragg-Gray principle, Kerma, Source Strength; specific Gamma-ray Emission; Interally deposited radioisotopes Corpuscular Radiation, Effective half-life. Total dose, Dose commitment, Gamma emitters, MIRD method, Neutrons.
4. Biological Effects of Radiation: Dose response characteristics; Direct action indirect action; radiation effects; acute effect; blood change; Hemopoirtic syndrome; gastrointestinal syndrome; central nervous system syndrome; other acute effects; delayed effects; cancer, leukemia, bone cancer, lung cancer; genetic effects; hazard and toxicity life shortening; cataracts; Risk estimator BEIR III Relative biological Effectiveness (RBE) and Quality Factor (QF); High energy radiation.

PHY 536: Health and Radiation Physics-II
3 credits 3 hours/week

1. Health Physics instrument: Radiation Detectors; particle counting instruments, Gas-filled particle counts; Ionization chamber counter; proportional counter Geiger counter; Quenching Geiger counter. Resolving time; Measurement of resolving time; scintillation counters, Nuclear Spectroscopy; Cenenkov detector, semiconductor detector, Dose measuring instruments, pocket dosimeters, film badges, thermo-luminescent dosimeter, Ion current chamber; neutron measurements; Detection reactions; Neutron counting with a proportional counter Long counter, proton recoil counter, and neutron dosimetry.
2. External radiation protection: Basic Principles; Techniques of external radiation protection; time; distance; shielding; x-ray shielding; Beta-ray shielding Neutron shielding.
3. Internal radiation protection: Internal radiation hazard; principles of control; control of the source-confinement Environment control of man protective clothing; control of man; respiratory protection; surface contamination limits; Waste management, High level Liquid Wastes; intermediate and low level liquid wastes; Airborne wastes; Meteorological considerations Dispersion of gas from a continuous source; Solid wastes; Assessment of Hazard.
4. Criticality: Criticality hazard; Nuclear fission; fission products; criticality; multiplication factor; four factor formula, nuclear reactor; reactivity and reactor control; fission product inventory criticality control.

PHY 537: Biophysics-I
3 credits 3 hours/week

1. Molecular Design of life: Biochemistry and genomic revolution; The chemical component of cell; from single cell to multi cellular organism; DNA, RNA and flow of genetic information; Exploring genes; Energy currency of cell.
2. Structure of Macromolecules: Atomic and molecular forces, Behavior of macromolecules, Physical techniques for structure determination (X-ray diffraction, spectroscopy, and NMR).
3. Properties of Nucleic Acid: Structure of DNA and RNA; Viruses method of replication.
4. Protein Structure and Function: Primary, Secondary and tertiary structures of amino acids, Protein function, Protein synthesis.
5. Properties of Protein: Protein folding, mechanical properties; Elastic properties of protein; Electrical and magnetic properties of proteins, rigidity of actin filaments and microtubules; physical forces and magnitude at single molecule level.
6. Mechanics of Motor Proteins: Introduction to Kinesin; Myosin; Dynin; F1-AT pase, force generation by the motors and cytoskeletal filaments; thermal rachet models for motor proteins.

PHY 538: Biophysics-II
3 credits 3 hours/week

1. Optical tweezers: Basic laser tweezers; Optical tweezers set up; calibration of trap by measuring trap stiffness, forces of the gradient trap of spheres; arbitrary trap location.
2. Physics of Muscle Proteins: Myosin superfamily; cardiac muscle, smooth muscle ATP hydrolysis; Actin potential; Actomyosin interaction; possessive and non-possessive movement of protein molecule.
3. Single Molecule Biophysics: Observation of the mechanism of a single molecule under and optical microscope, mobility of single molecules; unconstrained movement of single motor molecules, force, velocity and step size measurement single-molecule fluorescence.
4. Basic Enzyme Behavior: Michelis Manten mechanism and MWC model
5. Membrane Biophysics: Membrane proteins; Basic membrane properties membrane transport and exchanges; chemical pumping and membrane potential.
6. Physics of Nervous System: Electrical activity of the central nervous system; cable system; cable theory; Huxley-Hoxley-Hodgkin theory; Neurotransmitters.

PHY 539: Telecommunication – I
3 credits 3 hours/week

Communication Theory: Overview of communication systems. Information theory: Measure of information, source encoding, error free communication over a noisy channel, channel capacity. Modulation and demodulation: base-band transmission, carrier transmission; amplitude, phase and frequency modulation and their spectral analysis. Sampling theorem, Nyquist criterion, PAM, PCM and quantization error, bandwidth requirements, delta modulation (DM). Digital modulation: principle, bandwidth requirements, detection and noise performance of OOK, PSK, differential PSK, quadrature PSK, FSK Multiplexing: TDM, FDM. Multiple-access network - time-division multiple-access, frequency-division multiple access; code-division multiple- access (CDMA) - spread spectrum multiplexing, coding techniques and constraints of CDMA. Communication system design: design parameters, channel selection criteria and performance simulation.

Telecommunications Networks & Switching**:** Telephone Switching: Simple telephone connection, introduction to switching and signaling systems, single and multi- stage space switching analysis and design. Time/Digital switching systems, TS, ST, STS, TST systems, concept of packet switching and ATM, practical systems, circuit switching hierarchy and routing, signaling systems - SS7., telephone instruments, pulse and tone dialing, BORSCHT functions, modems, digital subscribers loops, telephone traffic theory. Telephone Networks: Motivation for ISDN, New services, network and protocol architecture, transmission channels, user-network interfaces, service characterization, internetworking, ISDN standards, expert systems in ISDN, B-ISDN, voice data integration.

PHY 540: Telecommunication – II
3 credits 3 hours/week

Optical Communication: Overview of optical communication; free space optical communication; Optical fibre communication: Optical fibres, modes of propagation, transmission characteristics and wave guide analysis, fibre choice, future prospects; Optical sources- lasers and LEDs. Optical amplifiers and photo detectors, integrated optics; Optical modulation and demodulation techniques. Optical transmission link analysis and optical networks, Fibre distributed data interface (FDDI), Synchronous optical network (SONET), optical frequency division multiplexing (OFDM), wavelength division multiplexing (WDM) transmission systems

Wireless & Mobile Communications: Evolution of mobile cellular communication, concept of cell and reuse pattern, RBS, MTSO, cell sectoring, cell splitting, roaming, handoff, forced termination, FCA and DCA technique, standards of GSM, GSM architecture, HLR, VLR, ILR, EIR, channel coding, interleaving, frequency hopping, cell planning and traffic analysis, concept of CDMA, convolutional coding, block interleaver, Walsh function, PN sequence generator, QPSK and OQPSK modulation, long code generator, pilot channel, synch channel, paging channel, access channel and traffic channel, ad-hoc mobile cellular communication, satellite based mobile cellular communication, IMT-2000, Mobile IP.

PHY 550: Physics Lab
3 credits 6 hours/week

List of Laboratory works based on the theoretical courses

Title of the experiment	No. of experiments
1. To determine of energy gap parameters of solid sample.	1
2. Measurement of h-parameter of a transistor (AC-128) at 1000 cycle/s.	1
3. To determine (a) Hall voltage (b) Hall Co-efficient (c) the number of charges carriers per unit volume and (d) Hall angle and mobility in an N-type semiconductor.	3
4. Verification of Inverse square law for gamma rays and comparison of source intensities.	1
5. Study of the absorption of gamma rays by matter; determination of absorption coefficient.	1
6. Determination of the maximum energy of beta particles emitted from a source and to estimate the thickness of an unknown foil.	1
7. Study of the back scattering of beta particles and to determine the effect of atomic number of the back scattering materials on back scattering.	1
8. Half adder and full adder circuits.	2

9. Transistor pulse generator and pulse shaper: (a) Astable multivibrator, (b) monostable multivibrator and (c) Schmidt trigger.	3
10. FF operation, RS and JK.	2
11. OR, AND, NAND, NOR, EX-OR and EX-NOR operations (hardware connections) and universal gate operation.	2
12. Design and construct a saw tooth wave generator employing a given unijunction transistor and determine its repetitive frequency.	1
13. To determine conversion efficiency (η_c) of a Solar Cell.	1
14. To determine of Fill Factor (FF) of a Solar Cell.	1
15. To study the performance of two identical Solar Cell in series combination.	1
16. To study the performance of two identical Solar Cell in parallel combination.	1
Total number of experiments	23

PHY 500: Project/Thesis
3 credits 6 hours/week

The project/thesis topic will be selected by concern student following the advice of the supervisor.