UNIVERSITY OF THE PUNJAB, LAHORE, PAKISTAN

CURRICULUM OF PHYSICS (2018)

MSc (2 Years) physics degree program under semester system

DEPARTMENT OF PHYSICS, UNIVERSITY OF THE PUNJAB, LAHORE, PAKISTAN

8/20/2018

MASTER OF SCIENCE (MSc) PHYSICS DEGREE PROGRAM

Duration of Degree Course	Two years
Teaching System	Semester System
Total number of Credit Hours	70
Session Starts	(Fall) September-October
Eligibility Qualification	As per university rules
Number of Student Enrollment	35 including all reserved seats

MISSION STATEMENT

The mission of the program is to prepare students with the latest developments in the subject of physics and its associated technologies. Moreover, it aims at helping the students to design and develop a strong background in fundamentals of physics such as quantum mechanics, solid state physics, relativity, statistical mechanics and electrodynamics. Due to the diversity of options available to students, they will learn advanced-level physics courses in the emerging fields of physics.We wish to prepare our students to conduct independent scientific and analytical investigation in the changing discipline and to develop critical and scientific thinking skills needed for a suitable career in academia and industry.

OBJECTIVES

The MSc (Physics) two year degree program is offered by the Department of Physics as a full-time period of teaching. The main objectives of the program are

- to equip students with an understanding of fundamental concepts in physics, including: classical mechanics and electromagnetism, thermodynamics and statistical physics, principles of waves and optics, and quantum mechanics.
- to apply knowledge and techniques from physics to solve problems in other physical sciences.
- to identify problems for study, conduct independent studies and be effective members of collaborative teams
- to enhance student experties in setting up experiments, collecting and analyzing data.
- to enable students understand physical aspects of a problem, formulate a strategy for solution utilizing mathematical and computational methods, make appropriate approximations, and evaluate the correctness of their solution.
- to furnish an in-depth understanding of some specialized area of physics through choice of elective courses
- to prepare stundents to know and follow the high professional and ethical standards of scientific work
- to prepare students to join an appropriate and respectable level position in a physics related field, and to maintain their professional skills in rapidly evolving industry and academia.
- to develope research based scientific thinking and to enhance professional skills for teaching, research, managerial positions in wide range of professions in national and international organizations

Semester-wise breakup and outline of courses for this program are given as under. In addition to compulsory courses, elective courses of undergraduate level are offered in various specializations in the subject of Physics. The program meets the standards of international undergraduate programs in the subject of Physics. Teaching, laboratory work and examinations are held according to semester rules of University of the Punjab.

SCHEME OF STUDIES

COURSE CODE KEY

For the course code Phys xxxx, the first letter shows the year of degree course in the university (e.g. for first year course, it is written as 1xxx, for third year course it is 3xxx and for fifth year course it is 5xxx (first year of MSc course), while second letter represents a number assigned to a specific subject area of physics (e.g. in general classification within the subject of Physics, a number is assigned to a set of similar subject titles i.e. for foundation courses, the number is 0 (Phys x0xx), for classical mechanics and related titles, the number is 1 (Phys x1xx), for electrodynamics and related titles it is 2 (Phys x2xx), for quantum mechanics and related titles, it is 3 (Phys x3xx), for solid state physics and related titles, it is 4 (Phys x4xx), for mathematical physics and related titles, it is 5 (Phys x5xx), for experimental physics and labs, it is 6 (Phys x6xx), for electronics and related titles, it is 7 (Phys x7xx), for materials and nanotechnology, it is 8 (Phys x8xx) etc. The last two letters of the course code show the sequence of the course titles in the specific subject and ranges from 01-99 (e.g. for solid state physics-I offered in third year, course code is Phys 3401 and for solid state physics-II offered in third year, it is Phys 3402, and for solid state physics-III offered in fourth year, code is Phys 4403 etc.).

SCHEME OF STUDIES (MSc 2 YEARS PROGRAM)

	Course Code	Course Title	Cr. Hrs.	Course Type
YEAR -I	**SEMESTER-I**			
	Phys 3101	Classical Mechanics	3	Maj-1
	Phys 3501	Mathematical Methods of Physics-I	3	Maj-2
	Phys 3401	Solid State Physics-I	3	Maj-3
	Phys 3701	Electronics-I	3	Maj-4
	Phys 3605L	Physics Lab-I	2	Maj-5
	Phys 3502	Computational Physics-I	3	Maj-6
	Credit Hours		**17**	
	SEMESTER-II			
	Phys 3503	Mathematical Methods of Physics-II	3	Maj-7
	Phys 3402	Solid State Physics-II	3	Maj-8
	Phys 3301	Quantum Mechanics-I	3	Maj-9
	Phys 3504	Computational Physics-II	3	Maj-10
	Phys 3702	Electronics-II	3	Maj-11
	Phys 3606 L	Physics Lab-II	2	Maj-12
	Credit Hours		**17**	
YEAR-II	**SEMESTER-III**			
	Phys 4302	Quantum Mechanics-II	3	Maj-13
	Phys 4403	Statistical Physics	3	Maj-14
	Phys 4201	Classical Electrodynamics-I	3	Maj-15
	Phys 4303	Nuclear Physics-I	3	Maj-16
	Phys xxxx	Elective-I	3	Elective
	Phys xxxx	Elective-II	3	Elective
	Credits Hours		**18**	
	Semester-IV			
	Phys 4404	Solid State Physics-III	3	Maj-17
	Phys 4202	Classical Electrodynamics-II	3	Maj-18
	Phys 4304	Nuclear Physics-II	3	Maj-19
	Phys 4102	Relativity and Cosmology	3	Maj-20
	Phys xxxx	Elective-III	3	Elective
	Phys xxxx	Elective-IV	3	Elective
	Credit Hours		**18**	
	Total Credit Hours		**70**	

List of Elective Courses

Elective courses will be offered from the following list by the Department of Physics in view avaialability of instructors and related resources. More titles in the list of elective courses can be added from time to time subject to the approval by relevant academic bodies.

Course Code	Course Title	Cr. Hrs.	Course Type
Phys 4305	Introductory Particle Physics	3	Elective
Phys 4306	Relativistic Quantum Mechanics	3	Elective
Phys 4405	Topics in Solid State Physics	3	Elective
Phys 4406	Advanced Solid State Physics	3	Elective
Phys 4308	Quantum Information Theory	3	Elective
Phys 4703	Introduction to Photonics	3	Elective
Phys 4309	Quntum Solid State Magnetism	3	Elective
Phys 4310	Quantum Electronics	3	Elective
Phys 4103	Astrophysics	3	Elective
Phys 4607	Medical Physics	3	Elective

OUTLINES OF COURSES

Phys 3101	CLASSICAL MECHANICS	(CR3)
Preq.	BSc (Two Years) Physics	

Objectives
To understand basic concepts of dynamical systems and to develop Lagrangian and Hamiltonian formulation of mechanics.

Syllabus
Kinematics, description of motion, space, time and coordinate systems, displacement, velocity and acceleration, Newtonian mechanics, laws of motion, inertial and noninertial frames, work, energy and conservation theorems, system of particles and conservation theorems for system of particles. Lagrangian formulation in generalized coordinates, constraints, principle of virtual work, D'Alembert's principle, Lagrange equations of motion, cyclic coordinates, Routhian function and noncyclic coordinates, forces of constraints and Lagrange multipliers, velocity dependent potentials, charged particle in an electromagnetic field. Central force problem, reduction of two-body problem, reduced mass, conservation in central force field, Kepler laws, properties of motion in central force field, effective potential, calculations of orbits of planets, derivation of Kepler's laws, stability of circular orbits, Rutherford scattering, impact parameter and scattering angle, scattering cross section, derivation of Rutherford scattering formula. Methods in calculus of variations, Euler's equations, second form of Euler's equations, Beltrami identity, some examples of calculus of variations, Hamilton's principle of least action, Lagrange equations. Space time symmetries and conservation laws, homogeneity and isotropy, cyclic coordinates, integrals of motion, Noether's Theorem, Legendre's transformation, Hamiltonian and Hamilton's equations of motion, Poisson brackets and their properties, phase space and phase portrate. Canonical transformations and their properties,

canonical transformation of the free particle Hamiltonian, invariance of Poisson's brackets under canonical transformations.

Recommended Books

1. *Classical Mechanics by H. Goldstein, C. P. Poole and J. L. Safko, Pearson New International Edition, (2014)*
2. *Classical Dynamics of Particles and Systems, S. T. Thornton and J. B. Marion, Cengage Learning, 5th Edition, (2012)*
3. *Classical Mechanics by T. L. Chow (2^{nd}Edition), CRC Press (2013)*
4. *Classical Mechanics, D. Strauch, Springer (2009)*
5. *Classical Mechanics, M. J. Benacquista and J. D. Romano, Springer (2018)*

Phys 3501	**MATHEMATICAL METHODS OF PHYSICS-I**	**(CR3)**
Preq.	**BSc (Two Years) Physics**	

Objectives

To understand the working knowledge of mathematical methods used in physics.

Syllabus

Series solutions about an ordinary point and regular singular point, Sturm-Liouville theory, self-adjoint ODEs, orthogonal functions, Gram-Schmidt orthognonalization, Hermitian operators, eigenvalue problems, completeness of eigen functions, Green's Functions, Green's function for one-dimensional problem, eigenfunction expansion of Green's function, special Functions, Gamma Function, digamma and polygamma functions, Stirling's series, Beta function, Bessel Functions of first kind, , orthogonality, Neumann Functions, Bessel Functions of the second kind, Hankel functions, modified Bessel functions, asymptotic expansions, sherical bessel functions, Legendre functions, Legendre polynomials, orthogonality, generating function, recurrence relation, associated Legendre equation, spherical harmonics, orbital angular momentum operator, addition theorem for sherical harmonics, Legendre functions of the second kind, Hermite functions, Hermite equation as Schrodinger equation of quatum harmonic oscillator, Laguerre functions and associated Laguerre functions, Chebyshev polynomials, Fourier series, properties of Fourier series, Fourier transform, properties of Fourier transforms, Fourier convolution theorem, Fourier transform, discrete Fourier transform, Laplace transforms, properties of Laplace transforms, Laplace transform of derivatives, Laplace Convolution theorem, inverse Laplace transform.

Recommended Books

1. *Mathematical Methods for Physicists (7^{th} Edition) by G. B. Arfken, H. J. Weber and F. E. Harris, Academic Press (2012)*
2. *A Guide to Mathematical Methods for Physicists by M. Petrini, G. Pradisi and A. Zaffaroni, World Scientific Press (2017)*
3. *Mathematical physics: A modern introduction to its foundations by S. Hassani, Sadri, Springer (2013)*
4. *Dennery, Philippe, and André Krzywicki, Mathematics for physicists, Dover Publications (2012)*
5. *Mathematical methods for physics and engineering by K. F. Riley, M. P. Hobson, and S. J. Bence (3rd Edition), Cambridge (1999)*
6. *Mathematical Methods for Physicists: A Concise Introduction by T. L. Chow, Cambridge (2000)*

Phys 3401	**SOLID STATE PHYSICS-I**	**(CR3)**
Preq.	**BSc (Two Years) Physics**	

Objectives
This course deals with basic principles and techniques of solid state physics.

Syllabus
Crystal structure, periodic arrays of atoms, fundamental types of lattices, index system for crystal planes, simple crystal structures, direct imaging of atomic structure, non-ideal crystal structures, reciprocal lattice, diffraction of waves by crystals, scattered wave amplitude, Brillouin zones, Fourier analysis of the basis, quasi crystals, crystal binding and elastic constants, crystals of inert gases, ionic crystals, covalent crystals, metals, hydrogen bonds, analysis of elastic strains, elastic compliance and stiffness constants, elastic waves in cubic crystals, vibrations of crystals with monatomic basis, two atoms per primitive basis, quantization of elastic waves, phonon momentum, inelastic scattering by phonons, Phonon heat capacity, anharmonic crystal interactions, thermal conductivity, electronic heat capacity, noncrystalline solids, diffraction pattern, glasses, amorphous ferromagnets and semiconductors.

Recommended Books

1. *Introduction to Solid State Physics by C. Kittle (8th Edition), John Wiley (2012)*
2. *Solid State Physics by Neil W. Ashcroft, N. David Mermin, CBS Publishing (1987)*
3. *Solid State Physics by J. S. Blakemore, Cambridge (1991)*
4. *Solid State Physics by M. A. Wahab, Narosa Publishing House (1999)*
5. *Elementary and Solid State Physics by M. A. Omar, Pearson (2000)*

Phys 3701	**ELECTORNICS-I**	**(CR3)**
Preq.	**BSc (Two Years) Physics**	

Objectives
To make students acquire a basic knowledge in solid state electronics including diodes, BJT, FET etc.

Syllabus
The Semiconductor Diode, P-type, N-type semiconductors, the junction diode (biasing and characteristics). The Diode as Rectifier and Switch: The ideal diode model, the half wave rectifier, the full wave rectifier, the bridge rectifier, measurement of ripple factor, the capacitor filter, the π filter, the π -R filter, diode wave shaping circuits (clippers and clampers). Special Diodes: Zener Diode, Light Emitting Diode, Photodiode, Tunnel Diode, Shockley Diode, Other diodes. Circuit Theory and Analysis: Models for circuit, one-port and two-port networks, network theorems, hybrid parameters and equivalent circuit, Power in decibels. The Junction Transistor as an Amplifier: Transistor voltage and current designations, the junction transistors, the volt-ampere curve of a transistor, the current amplification factors, the load line and Q point, the common emitter amplifier, the trans-conductance g_m, performance of a CE amplifier, relation between A_i and A_v, the CB amplifier, the CC amplifier, comparison of amplifier performance. DC Bias for the Transistor: Choice of Q point, variation of Q point, fixed transistor bias, the four resistor bias circuit, design of a voltage feedback bias circuit, Common emitter, common collector, common base biasing. Field Effect Transistor: introduction to field effect transistor (FET), Junction field effect transistor (JFET): operation and static characteristics. Metal oxide semiconductor Field Effect Transistor (MOSFET): operation in enhancement and depletion modes. FET configurations and biasing: Common drain, common source and common gate, load line, fixed bias, self-bias and voltage-divider bias.

Recommended Books

1. *Electronic Devices (Conventional Current Version), by T. L. Floyd, Pearson, 10th Edition, (2017)*

2. *Electronics Fundamentals: Circuits, Devices and Applications, by Thomas L. Floyd , David M. Buchla, Prentice Hall, 8th Edition, (2009)*
3. *Electronic Principles, by A. P. Malvino, D. J. Bates, McGraw-Hill, 8th Edition, (2015)*
4. *Solid State Electronic Devices, by B. Streetman and S. K. Banerjee, Pearson, 7th edition, (2015)*
5. *Grob's Basic Electronics, by M. E Schultz, McGraw-Hill Education, 12th edition, (201)5*
6. *Electronic Devices and Circuit Theory, by R. L. Boylestad, L. Nashelsky, Pearson, 11th edition, (2012)*
7. *Introductory Electronic Devices and Circuits (Conventional Flow Version), by R. T. Paynter, Prentice Hall, 7th edition, (2005)*

Phys 3502	**COMPUTATIONAL PHYSICS-I**	**(CR3)**
Preq.	**BSc (Two Years) Physics**	

Objectives
To give students an understanding of various computational and numerical techniques used in physics.

Syllabus
Physics problems solving using numerical methods, basics of numerical analysis, Euler-Newton method for solving differential equations, Simpson method, Taylor expansion method, Runge-Kutta method, the trapezoidal rule for numerical quadrature, Newton-Cotes rule, Gauss-Legendre quadrature, numerical solution of problems in mechanics such as Kepler problem, numerical solution of double pendulum, applications of random number, brownian motion, solution of integral equations, linear algebra, solution of linear algebraic equations, matrix algebra, matrix inverse, sorting and curve fitting and best fit using linear and nonlinear least square fits, interpolation, splines and analysis of experimental and simulation data. Programming techniques in practical applications to advanced physics problems. Introduction to simulation techniques and computer graphics**,** use of computation and computer graphics to simulate the behavior of complex physical systems, computational techniques in investigating and visualizing fundamental physics, scientific packages, introduction to scientific work bench for problem solving in electronics and other branches of physics.

Recommended Books
1. *Introduction to Computational Physics, by T. Pang, Cambridge (2010)*
2. *Numerical methods for Physics, A. L.Garcia,Createspace,(2017)*
3. *Computational Methods in Physics, Chemistry and Biology by P. Harrison, Wiley, (2001).*
4. *More Physics with MATLAB, by D. Green, World Scientific, (2015)*
5. *Computational Physics by H. J. Gardner, World Scientific, Singapore (1997).*
6. *Numerical Recipes: The Art of Scientific Computing by W. H. Press, B. P. Flannery, Saul A. Teukolsky, and William T. Vetterling Cambridge University Press, (1988).*
7. *Mathematica for Physics: R. L. Zimmerman Addison Wesley Publishing Company, (1994.)*

Phys 3503	**MATHEMATICAL METHODS OF PHYSICS-II**	**(CR3)**
Preq.	**Phys 3501**	

Objectives
To understand mathematical tool such as tensor analysis, group theory and complex analysis.

Syllabus

Tensor analysis, some notations, Cartesian tensors, First- and zero-order Cartesian tensors, second- and higher-order Cartesian tensors, the algebra of tensors, the quotient law, Kronecker delta δ_{ij} and Levi Civita tensor ε_{ijk}, Isotropic tensors, improper rotations and pseudo tensors, dual tensors, physical applications of tensors, integral theorems for tensors, non-Cartesian coordinates, the metric tensor, General coordinate transformations and tensors, relative tensors, derivatives of basis vectors and Christoffel symbols, covariant differentiation, vector operators in tensor form, absolute derivatives along curves, Riemann curvature tensor, Complex Anaylsis Complex numbers, powers and roots, Sets in the Complex planes, Functions of a complex variables, Cauchy–Riemann equations, Exponential and Logarithmic functions, Contour Integrals, Cauchy-Goursat theorem, Independence of path, Cauchy's Integral formulas, Sequences and Series, Taylor series, Laurent Expansion , Zeros and Poles, Singularities, Residues and Residues Theorem, Evaluation of real Integrals, Groups Theory, subgroup, cyclic groups, and permutation groups, isomorphism, Cayley's theorem, properties of isomorphism, automorphism, cosets, properties of cosets, Lagrange's theorem, an application of cosets to permutation groups, the rotation groups of a cube and soccer ball, conjugate classes and invariant subgroups, group representations, some special groups, the symmetry group D_2, D_3, one-dimensional unitary group $U(1)$, orthogonal groups $SO(2)$ and $SO(3)$, the $SU(n)$ groups, Homogeneous Lorentz group.

Recommended Books

1. *Mathematical Methods for Physicists (7^{th} Edition) by G. B. Arfken, H. J. Weber and F. E. Harris, Academic Press (2012)*
2. *A Guide to Mathematical Methods for Physicists by M. Petrini, G. Pradisi and A. Zaffaroni, World Scientific Press (2017)*
3. *Mathematical physics: A modern introduction to its foundations by S. Hassani, Sadri, Springer (2013)*
4. *Dennery, Philippe, and André Krzywicki, Mathematics for physicists, Dover Publications (2012).*
5. *Mathematical methods for physics and engineering by K. F. Riley, M. P. Hobson, and S. J. Bence (3rd Edition), Cambrige (1999)*
6. *Mathematical Methods for Physicists: A Concise Introduction by T. L. Chow, Cambridge (2000)*
7. *Contemporary Abstract Algebra by J. A. Gallian (8th Edition), Cengage Learning (2013)*

Phys 3402	**SOLID STATE PHYSICS-II**	**(CR3)**
Preq.	**Phys 3401**	

Objectives
To equip students with fundamental concepts of solid state physics and its applications.

Syllabus
Free Electron Fermi Gas: Energy levels in one dimension, effect of temperature on the Fermi-Dirac distribution, free electron gas in three dimensions, heat capacity of the electron gas, experimental electrical resistivity of metals, motion in magnetic fields, Hall effect, thermal conductivity of metals, ratio of thermal to electrical conductivity. Energy Bands: Nearly free electron model, origin of the energy gap, magnitude of the energy gap, Bloch functions, wave equation of an electron in a periodic potential, crystal momentum of an electron, solution of the central equation, empty lattice approximation, approximate solution near a zone boundary, number of orbital in a band, metals and insulators. Homogeneous Semiconductors: Band gap, equation of motion, effective mass, physical interpretation of the effective mass, effective masses in semiconductors, silicon and germanium,

intrinsic carrier concentration, intrinsic mobility, impurity conductivity, donor states, acceptor states, thermal ionization of donors and acceptors.

Recommended Books

1. *Introduction to Solid State Physics by C. Kittel (8^{th} Edition), Johan Wiley (2012)*
2. *Elementary Solid State Physics by M. A. Omar, Addison-Wesley (1987)*
3. *Solid State Physics by Neil W. Ashcroft & M. David Mermin, Holt-Sanders (1976)*
4. *Solid State Physics by J.R.Hook & H.E Hall (2^{nd} Edition), Johan Wiley (2013)*
5. *Solid State Physics by Blakemore, Cambridge (1991)*

Phys 3301	**QUANTUM MECHANICS –I**	**(CR3)**
Preq.	**BSc (Two Years)**	

Objectives

This course offers a systematic introduction to fundamental non-relativistic quantum mechanics.

Syllabus

From classical mechanics to quantum mechanics, mathematical tools, Hilbert Space, dimension, bases, orthonormal set, Dirac notation, operators on Hilbert space, Hermition and unitary operators, representation in discrete bases, representation in continuous bases, position and momentum representation, postulates of quantum mechanics, the generalised uncertainty principle, evolution of state, Schrodinger equation and solutions, quantum simple harmonic oscillator, Hermite polynomials, Schrödinger's equation in three dimensions, central potentials and introduction to hydrogenic systems,energy eigenvalues and energy eigenstates, matrix representatio of various operators, angular momentum and spherical harmonics, spherical harmonics, matrix representation of angular momentum, spin angular momentom and Pauli matrices, eigenfunctions of angular momentum, Hydrogen atom and Laguerre polynomials, transformations of states and operators, spatial translations, rotations, translations around, rotation of diatomic molecules, orbital angular momentum, wavefunctions for orbital angular momentum eigenstates, spin SO(3), SU(2) and their representations, the Stern-Gerlach experiment, precession in a magnetic field, composite systems, the tensor product of Hilbert spaces, addition of angular momenta, spin-orbit coupling.

Recommended Books

1. *Introduction to Quantum Mechanics by D. J. Griffiths and D. F. Schroeter(3rd Ed),Cambridge, (2018)*
2. *Introductory Quantum Mechanics by R. Liboff (4^{th} Edition), Addison-Wesley (2002)*
3. *Quantum Mechanics: Concepts and Applications by N. Zettili (2^{nd} Edition), Wiley (2009)*
4. *Modern Quantum Mechanics by J. J. Sakuri and Jim J. Napolitano (2^{nd} Edition), Pearson (2010)*
5. *An Introduction Quantum Mechanics by W. Greiner, Addison Wesley (1980)*

Phys 3504	**COMPUTATIONAL PHYSICS-II**	**(CR3)**
Preq.	**Phys 3502**	

Objectives

To make students understand how to program with MATLAB or PYTHON or MATHEMATICA in solving physical problems with numerical methods.

Syllabus

Advanced simulation techniques, problem solving using simulation, projectile motion, simple pendulum, motion of falling objects, motion in single and multi dimensions, programming techniques in quantum mechanics, statistical mechanics and nuclear physics, numerical solutions to Schrodinger's equations, normalization of wave function, orthogonality of eigenfunctions, certain calculations quantum mechanics, interpolation and extrapolation, Numerical integration, Monte Carlo methods, metropolis algorithm, some finite element methods, applications in statistical physics, Laplace transformation, solution of linear algebraic equations, sorting and curve fitting, special functions, Hermite polynomials and quantum harmonic oscillator etc. Stochastic methods, random number generation and Monte Carlo integration, random walk, Fourier transform spectral methods, orthogonal functions, wavelet analysis, Gaussian quadrature, problems in electrodynamics, solution of Laplace equation.

Recommended Books

1. *Introduction to Computational Physics, by T. Pang, Cambridge (2010)*
2. *Numerical methods for Physics, A. L.Garcia,Createspace,(2017)*
3. *Computational Methods in Physics, Chemistry and Biology by P. Harrison, Wiley, (2001).*
4. *More Physics with MATLAB, by D. Green, World Scientific, (2015)*
5. *Computational Physics by H. J. Gardner, World Scientific, Singapore (1997).*
6. *Numerical Recipes: The Art of Scientific Computing by W. H. Press, B. P. Flannery, Saul A. Teukolsky, and William T. Vetterling Cambridge University Press, (1988).*
7. *Mathematica for Physics: R. L. Zimmerman Addison Wesley Publishing Company, (1994.)*

Phys 3702	**ELECTRONICS-II**	**(CR3)**
Preq.	**Phys 3701**	

Objectives

To be capable of designing rectifiers, amplifiers, oscillators, and multivibrators and to design circuits.

Syllabus

Cascade amplifier, The Amplifier pass band, the frequency plot (Bode plot), Low frequency analysis, Low frequency limit, the un-bypassed emitter resistor, high frequency equivalent circuit and analysis, The Miller Effect, high frequency limit of transistor, bandwidth of a cascade amplifier. Feedback Amplifiers, Positive and Negative feedback, Principle of feedback amplifier, stabilization of gain by negative feedback, Bandwidth improvement, Reduction of nonlinear distortion, control of amplifier output and input resistance, current series feedback circuit, voltage shunt feedback circuit. Oscillator operation and feedback principles, the oscillatory circuit and frequency stability, oscillators with LC, RC feedback circuits, Power Amplifiers, differential Amplifier Circuit, Common mode rejection ratio, operational amplifier (Op-Amp), Inverting and Non-inverting configuration, Op-Amp Applications, Basic types of Multivibrators, Astable Multivibrator, Mono-stable Multivibrator, Bi-stable Multivibrator, Flip-flop. Binary systems, octal and hexadecimal numbers and their conversions, complements, arithmetic addition and subtraction, binary codes "BCD", Excess-3", "Gray code", "ASCII characters code", boolean algebra and logic gates, basic theorems and properties of boolean algebra, boolean functions, canonical and standard forms, digital logic gates, digital logic functions, gate-level minimization, Karnaugh-map, product of sum and sum of products simplifications, NAND and NOR implementation.

Recommended Books

1. *Electronic Devices (Conventional Current Version), by T. L. Floyd, Pearson, 10th Edition, (2017)*

2. *Electronics Fundamentals: Circuits, Devices and Applications, by Thomas L. Floyd , David M. Buchla, Prentice Hall, 8th Edition, (2009)*
3. *Electronic Principles, by A. P. Malvino, D. J. Bates, McGraw-Hill, 8th Edition, (2015)*
4. *Solid State Electronic Devices, by B. Streetman and S.K. Banerjee, Pearson, 7th edition, (2015)*
5. *Grob's Basic Electronics, by M. E Schultz, McGraw-Hill Education, 12th edition, (201)5*
6. *Electronic Devices and Circuit Theory, by R. L. Boylestad, L. Nashelsky, Pearson, 11th edition, (2012)*
7. *Introductory Electronic Devices and Circuits (Conventional Flow Version), by R. T. Paynter, Prentice Hall, 7th edition, (2005)*
8. *Digital Fundamentals, by T. L. Floyd, Pearson, 11th Edition, (2014)*

Phys 4302	**QUANTUM MECHANICS-II**	**(CR3)**
Preq.	**Phys 3301**	

Objectives
The second course provides a basis for further concepts of quantum mechanics.

Syllabus
Elements of Matrix Mechanics, matrix representation, Identical particles, many particle systems, and second quantization: indistinguishability of identical particles, systems of identical particles, quantum dynamics of identical particle systems, angular momenta and spin *1/2* boson operators, exchange degeneracy, symmetrization postulates, constructing symmetric and anti-symmetric wavefunctions, system of identical noninteracting particles, Exclusion principle approximate methods for stationary states, time independent perturbation theory for non degenerate levels and for degenerate levels, fine structure and anamolous Zeeman effect, the variational method, the WKB approximation, bound states for potential well with no rigid wall, bound states for potential well with one rigid wall, tunneling with potential barrier, time dependent perturbation theory, pictures of quantum mechanics, Schrodinger, Heisenberg and interaction picture, transition probability and Fermi Golden Rule, interaction of atoms with radiation, the theory of scattering, scattering experiments and cross sections, scattering amplitudes, potential scattering, the method of partial waves, the Bom approximation.

Recommended Books
1. *Introduction to Quantum Mechanics by D.J. Griffiths (2nd Edition), Addison-Wesley (2004)*
2. *Introductory Quantum Mechanics by R. Liboff (4th Edition), Addison-Wesley (2002)*
3. *Quantum Mechanics: Concepts and Applications by N. Zettili (2nd Edition), John Wiley (2009)*
4. *Modern Quantum Mechanics by J. J. Sakuri and Jim J. Napolitano (2nd Edition), Pearson (2010)*
5. *An Introduction Quantum Mechanics by W.Greiner, Addison Wesley (1980)*

Phys 4403	**STATISTICAL PHYSICS**	**(CR3)**
Preq.	**Phys 3301, 3402**	

Objectives
This course will develop basic knowledge of statistical mechanics at the undergraduate level and to use this knowledge to describe macroscopic systems, thermodynamic potentials and ensembles.

Syllabus

Concepts in classical laws of thermodynamics and their application, postulates of statistical mechanics, statistical interpretation of thermodynamics, Phase space description of physical systems, macrosystems and macrosystems, ensembles, entropy in statistical mechanics, microcanonical ensemble, canonical ensemble, the methods of statistical mechanics are used to develop the statistics for Bose-Einstein, Fermi-Dirac statistics and photon gases; frequency spectrum of a black body and Planck's radiation law, Liouville's theorem, equality of probability for the perfect gas, energy distribution of conduction electrons in metals, Quantization effects in molecular gases; phonons, photons; density matrix formulation, Identical Particles, Degenerate quantum gases; Fermi liquids; Bose-Einstein condensation; superfluidity, selected topics from low temperature physics and electrical and thermal properties of matter.

Recommended Books

1. *Statistical Mechanics, by K. Huang, Pearson, (2008)*
2. *Statistical Mechanics, by R. K. Pathria and P. D. Beale, Academic Press, (3rd Ed.), (2011)*
3. *Quantum Statistical Thermodynamics, by K. N. Huang, Springer, (2018)*
4. *Fundamentals of Statistical and Thermal Physics, by F. Reif, Waveland, (2008)*
5. *Statistical Physics of Particles, by M. Kardar, (2007)*
6. *Elementary Statistical Physics by C. Kittle John Wiley (1958)*

Phys 4201	**CLASSICAL ELECTRODYNAMICS-I**	**(CR3)**
Preq.	**BSc (Two Years)**	

Objectives

This course gives understanding of the basic concepts of classical electrodynamics.

Syllabus

The basic concepts (Electric charge, Coulomb's law, the electric field, the electrostatic potential, Gauss's law, application of Gauss's law etc) , the electric dipole, multipole expansion of electric fields, Dirac delta function, Poisson's equation, Laplace's equation, Laplace's equation in one independent variable, solution to Laplace's equation, conducting sphere in a uniform electric filed, electrostatic images, Polarization in dielectrics, field outside a dielectric medium, the electric field inside a dielectric, Gauss's law in a dielectric: the electric displacement, electric susceptibility and dielectric constant, point charge in a dielectric fluid, boundary conditions on the field vectors, boundary-value problems involving dielectrics, method of images for problems involving dielectrics, Potential energy of a group of point charges, electrostatic energy of a charge distribution, energy density of an electrostatic field, related problems, Electric Current and Magnetostatics: Nature of the current, current density: equation of continuity, Ohm's law: conductivity, steady currents in continuous media, approach to electrostatic equilibrium, the definition of magnetic induction, forces on current-carrying conductors, the law of Biot and Savart, elementary applications of the Biot and Savart law, Ampere's circuital law, the magnetic vector potential, the magnetic field of a distant circuit, the magnetic scalar potential, magnetic flux.

Recommended Books

1. *Foundation of Electromagnetic Theory by J. R. Reitz, F. J. Milford and R. W. Christy (4thEdition), Addison-Wesley (2009)*
2. *Introduction to Electrodynamics, D. J. Griffiths (4th Edition), Prentice Hall (2013).*
3. *Classical Electrodynamics, J. D. Jackson, third edition, Wiley (2012)*
4. *Elements of Electromagnetics by M. N. O. Sadiku (5thEdition), Oxford (2009).*

Phys 4303	**NUCLEAR PHYSICS-I**	**(CR3)**
Preq.	**Phys 3301**	

Objectives
To describes the fundamental principles and concepts of Nuclear physics.

Syllabus
Basic Properties of Nucleus, nuclear size, mass, radius, binding energy and semi-empirical mass formula, Applications of semi-empirical mass formula, nuclear spin, magnetic dipole moment, electric quadrupole moment, parity, isobaric spin and nuclear statistics, nuclear level, nature of nuclear force between nucleons, the deuteron, Radioactive decay, radioactive decay law, quantum theory of radioactive decay, Basic alpha decay processes, quantum theory of alpha decay and explanation of observed phenomena, angular momentum and parity in alpha decay, alpha decay spectroscopy, measurement of β-ray energies, Fermi theory of β-decay, angular momentum and parity selection rules, neutrino hypothesis, double beta decay, parity violation in beta decay, theory of gamma decay, multipolarity of gamma-rays, angular momentum and parity selection rules, Nuclear forces, Properties of the nuclear force, Nuclear Potential, Yukawa's theory of nuclear forces, Nuclear Models: Liquid drop model, Shell model, collective model.

Recommended Books
1. *Introductory Nuclear Physics by K. Krane, Wiley (1980)*
2. *Nuclear and Particle Physics by E. E. Burcham, and M. Jobes, Longman (1995)*
3. *Nuclear and Particle Physics by R. B. Martin, Wiley (2006)*
4. *Nuclear Physics by I. Kaplan, Addison-Wesley (1980).*
5. *Nuclear Physics in a nutshell, by C .A. Bertulani, Princeton, (2007).*
6. *Nuclear Physics by A. Kamal, Springer, (2014)*
7. *Foundations of Nuclear and Particle Physics, T. W, Donnelly and J. A. Formaggio, Cambridge (2017)*
8. *Nuclear Physics: Principles and Applications by J. Lilley, Wiley (2013)*

Phys 4404	**SOLID STATE PHYSICS-III**	**(CR3)**
Preq.	**Phys 3402**	

Objectives
The course will provides some valuable introduction of quantum theory of solids.

Syllabus
Screening of the electron-phonon interaction, ionic crystals, the production and propagation of polarons, mirco-scopic theory of frequency-dependent dielectric constants, band gap sensitive optical properties of semiconductors, interaction of conduction electrons and their impact on conductivity, transport phenomenon, Boltzmann transport equation, relaxation time and conductivity equation in Boltzmann transport equation, solids in external magnetic fields: Free electron approximation in magnetic field and the formation of Landau levels, Landau diamagnetism in free electrons, Optical reflectance spectroscopy, Exitonic transitions, Types of excitons (Frenkle and Mott-Wannier Excitions), Excition Condensation into the Electron-hole drops, Raman measurements of inelastic scattering in crystals, stokes and anti-stokes scattering, X-ray induced emission spectra in crystals, Electron energy loss spectroscopy.

Recommended Books
1. *Quantum Theory of the Solid by J. Callaway, 2nd Edition, Elsevier Science, (2013)*
2. *Solid-State Physics: Introduction to the Theory by James D. Patterson, Bernard C. Bailey, 3rd Springer International Publishing (2018)*

3. *Introduction to Solid State Physics, 8th Edition, by C. Kittle, (2012).*
4. *Solid State Physics by N. W. Ashcroft and D. Mermin, Cengage, (2011).*
5. *Solid State Physics: An introduction by P. Hofmann, 2nd Edition, Wiley-VCH, (2015)*

Phys 4202	CLASSICAL ELECTRODYNAMICS-II	(CR3)
Preq.	Phys 4201	

Objectives
The second course provides some further topics of classical electrodyamics.

Syllabus
Magnetization, the magnetic field produced by magnetized material, magnetic scalar potential and magnetic pole density, sources of the magnetic field: magnetic intensity, magnetic susceptibility, permittivity and hysteresis, boundary conditions on the field vectors, boundary-value problems involving magnetic materials, related problems, Electromagnetic induction, the generalization of Ampere's law, energy density in the magnetic field, electromagnetic energy, the wave equation, monochromatic waves, boundary conditions, the wave equation with sources, vector and scalar potentials, gauge transformations (Lorentz gauge, coulombs gauge), pressure of radiations, retarded scalar and vector potentials, covariant formulation of electrodynamics, transformation laws of electro magnetic fields, related problems, Propagation of Electromagnetic Waves, plane monochromatic waves in non-conducting media, polarization of waves, energy density, plane monochromatic waves in conducting media, Reflection and refraction at the boundary of two non-conducting media: normal incidence, reflection and refraction at the boundary of two non-conducting media: oblique incidence, complex Fresnel coefficients: reflection from a conducting plane, waveguides, transverse electric and transverse magnetic waves, parallel-plate waveguide, dielectric waveguides, radiation from an oscillating dipole, related problems, Plasma Physics**:,** electrical neutrality in a plasma, particle orbits and drift motion in a plasma, magnetic mirrors, the hydromagnetic equations, plasma oscillations and wave motion.

Recommended Books
1. *Foundation of Electromagnetic Theory by J. R. Reitz, F. J. Milford and R. W. Christy (4thEdition), Addison-Wesley (2009)*
2. *Introduction to Electrodynamics, D. J. Griffiths (4th Edition), Prentice Hall (2013).*
3. *Classical Electrodynamics, J. D. Jackson, third edition, Wiley (2012)*
4. *Elements of Electromagnetics by M. N. O. Sadiku (5thEdition), Oxford (2009).*

Phys 4304	NUCLEAR PHYSICS-II	(CR3)
Preq.	Phys 4303	

Objectives
This part deals with some additional topics of nuclear physics.

Syllabus
Nuclear Reactions, types of nuclear reactions and conservation laws, Coulomb scattering, nuclear scattering, Q-value of nuclear reaction, threshold energy, transmutation by photons, protons, deutrons and alpha particles, Cross section from nuclear reactions, compound nucleus theory of nuclear reactions, limitations of compound nucleus theory, direct reactions, Neutron Physics, Neutron sources, radioactive sources, photon neutron sources, charged particle sources, reactor as a neutron source, slowing down of neutron, neutron detectors, neutron capture, interference and diffraction with neutrons, Nuclear fission, Description of fission reaction, Mass distribution of fission fragments,

Average number of neutrons released, Fission cross section, Chain reaction, Controlled fission reactions, Fission reactors. Nulclear Fusion, Basic fusion processes, Energy released in nuclear fusion, Solar fusion, p-p cycle, CNO cycle, controlled nuclear fusion, D-D and D-T reactions, accelerators, electrostatic accelerators, cyclotrons, synchrotrons, linear accelerators, colliding-beam accelerators.

Recommended Books

1. *Introductory Nuclear Physics by K. Krane, Wiley (1980)*
2. *Nuclear and Particle Physics by E. E. Burcham, and M. Jobes, Longman (1995)*
3. *Nuclear and Particle Physics by R. B. Martin, Wiley (2006)*
4. *Nuclear Physics by I. Kaplan, Addison-Wesley (1980).*
5. *Nuclear Physics in a nutshell, by C. A. Bertulani, Princeton, (2007).*
6. *Nuclear Physics by A. Kamal, Springer, (2014)*
7. *Foundations of Nuclear and Particle Physics, T. W, Donnelly and J. A. Formaggio, Cambridge (2017)*
8. *Nuclear Physics: Principles and Applications by J. Lilley, Wiley (2013)*

Phys 4102	**RELATIVITY AND COSMOLOGY**	**(CR3)**
Preq.	**Phys 3503**	

Objectives

The purpose of this course is to introduce the field of general relativity and cosmology.

Syllabus

Einstein's postulates of special relativity, Lorentz transformations, structure of spacetime, Minkowski spacetime tensors, the light-cone, line element, four-vectors, relativity of simultaneity, velocity transformation and velocity addition. Force equation in relativity, rest mass, kinetic and total energy, conservation of energy and momentum. Covariant form of Maxwell's equations, four vector potential and field strength tensor. Elements of Tesnsor Calculus, Manifolds and coordinates, curves and surfaces, tensor fields, geodesics, Riemann tensor, Bianchi identity, metric tensor, Ricci tensor, Einstein's tensor. General Relativity, Principles of general relativity, weak and strong equivalence principle, equation of geodesics deviation, Einstein's field equations, tests of general theory of relativity, Cosmology, Newtonian cosmology, cosmological redshift, luminosity and redshift relation, Hubble's law, microwave background, the Big Bang, Friedmann models and cosmological constant, FRW metric.

Recommended Books

1. *Dynamics and Relativity by W. D. McComb, Oxford (1999)*
2. *Introduction to Cosmology by J. V. Narlikar, Cambridge (2002).*
3. *Introduction to Cosmology by B. Narlikar, Cambridge (2016).*
4. *Special Relativity: For the Enthusiastic, CreateSpace, (2017).*
5. *Introduction to General Relativity,C. Bambi, Springer, (2018)*
6. *Introducing Einstein's Relativity, by R. D'Inverno, Oxford (1992).*

OPTIONAL COURCES

Phys 4305	**INTRODUCTORY PARTICLE PHYSICS**	**(CR3)**
Preq.	**Phys 3301**	

Objectives

This course will provide an introductory survey of modern particle physics.

Syllabus

Particle Classification, Quantum numbers, leptons, quarks, hadrons, baryons, mesons, strange particles, the eightfold way, the fundamental interactions: Primitive vertices for EM, strong and weak interactions, Feynman Diagrams, The electromagnetic coupling, the strong coupling, the weak coupling, Vacuum Polarization, Symmetry Transformation and Conservation Laws, Translation in space, Rotation in space, The group SU (2), isospin, extended Pauli principle, consequence of isospin conservation, Systems of identical particles, Parity, Charge conjugation, Time reversal, G parity, CPT theorem, polarization and photon spin, gauge invariance and Maxwell's equations, angular momentum, parity and C-parity of photons,. The quark model, The group SU (3) and its representations, notion of colour, quarks, hadrons (baryons, mesons in quark model).

Recommended Books

1. *Introduction to Elementary Particles by D. Griffiths (2nd Edition), Wiley, (2008).*
2. *Nuclear and Particle Physics by E. E. Burcham, and M. Jobes, Longman, (1995).*
3. *Nuclear and Particle Physics by R. B. Martin, Wiley, (2006)*
4. *Concepts of Particle Physics by K. Gottfried, and F. Weisskopt, Vol. 1, Oxford, (1986).*
5. *Nuclear and Particle Physics by W. S. C. Williams, Oxford, (1995).*
6. *A Modern Introduction to Particle Physics by Fayyazudding and Riazuddin, World Scientific, (1992)*
7. *Quarks and Leptons by F. Halzen and A. D. Martin, Wiley, (1984).*

Phys 4306	**RELATIVISTIC QUANTUM MECHANICS**	**(CR3)**
Preq.	**Phys 3301**	

Objectives

To provides an understanding of the effects of special relativity in quantum mechanics.

Syllabus

The Klein-Gordan Equation, Non relativistic quantum mechanics, Lorentz covariance and 4 vector notation, the Klein Gordon equation, the Feynman-Stuckelberg interpretation of $E < 0$ solutions, non relativistic perturbation theory (brief review), rules for scattering amplitudes in the Feynman-Stukelberg approach, the Dirac Equation: Covariant form of the Dirac Equation, Dirac γ-matrices, conserved current and the adjoint equation, free particle spinors, anti particles, normalization of spinors and the completeness relations, bilinear covariants, zero mass fermion, Weyl and Majorana spinors, Weyl equation, Weyl and Majorana representation of the Dirac equation, the two-component neutrino, V-A interaction, Fermi interaction, unitary and anti-unitary symmetries, CPT symmetries, Dirac particles in external fields, brief introduction to QED: Feynman Rules in QED, Invariant amplitude, Invariant variables.

Recommended Books

1. *Quarks and Leptons by F. Halzen, and A. D. Martin, Wiley, (1984).*
2. *Introduction to Elementary Particles by Griffiths, D., 2nd Edition, Wiley, (2008).*
3. *Relatvistic Quantum Mechanics by J. D. Bjorken, and S. D. Drell, McGraw-Hill, (1964)*
4. *Quantum Mechanics by Riazuddin and Fayyazuddin, World Scientific(1990).*

Phys 4405	**TOPICS IN SOLID STATE PHYSICS**	**(CR3)**
Preq.	**Phys 3402**	

Objectives

To study selected topics in solid state physics such as quantum theory of magnetism and superconductivity.

Syllabus

Diamagnetic and paramagnetic solids, magnetic susceptibilities of diamagnetic and paramagnetic substances, Quantum theory of paramagnetism, Pauli paramagnetism of conduction electrons, Types of superconductors, BCS theory, magnetic field induced superconducting to normal state transitions, parameters evidencing the superconducting phase transitions, free energy change during superconducting transition, London relations and coherence length of superconductor, Quantized flux due to cooper pairs flowing in a ring, calculation of the sustaining time of supercurrents, fabrication of junctions for Josephson effects, principle and theory of SQUIDS, high-temperature superconductors, electric polarization, calculation of macroscopic electric field, dielectric constant and polarizability, phase transitions in ferroelectric crystals, Landau description of the order of phase transitions, differentiation of anti-ferroelectric, piezoelectric and ferro-elastic materials. Quantization of free electron orbits in a magnetic field, De Haas-van Alphen effect, the quantum Hall effect, Quantum dots, Quantum dot crystals, Kondo effect, Epitaxial hetero- and quantum structures, Coulomb blockade.

Recommended Books

1. *Quantum Theory of the Solid by J. Callaway, 2nd Edition, Elsevier, (2013)*
2. *Solid-State Physics: Introduction to the Theory by J. D. Patterson, B. C. Bailey (3rdEdition), Springer (2018)*
3. *Introduction to Solid State Physics by C. Kittle (8th Edition), Wiley (2012)*
4. *Solid State Physics by N. W. Ashcroft and N. D. Mermin, Cengage (2011)*
5. *Solid State Physics: An introduction by P. Hofmann (2nd Edition), Wiley-VCH (2015)*

Phys 4406	**ADVANCED SOLID STATE PHYSICS**	**(CR3)**
Preq.	**Phys 3402**	

Objectives

This course will provide an introduction of magnetic phenomena in solids.

Syllabus

Ferromagnetism and Antiferromagnetism: Ferromagnetic order, Curie point and the exchange integral, temperature dependence of the saturation magnetization, saturation magnetization at absolute zero, magnons, ferromagnetic magnons, quantization of spin waves, thermal excitation of magnons, neutron magnetic scattering, ferromagnetic order, Curie temperature and susceptibility of ferrimagnets, antiferromagnetic order, susceptibility below Neel temperature, antiferromagnetic magnons, ferromagnetic domains, anisotropy energies, transition region between magnetic domains, origin of domains, hysteresis curve, single domain particles, superparamagnetism, magnetic force microscopy. Magnetic resonance: Magnetic resonance phenomenon's in magnetism, nuclear magnetic resonance (NMR), equations of motion, line width, motional narrowing, hyperfine splitting, nuclear quadrupole resonance, ferromagnetic resonance (FMR), shape effects in FMR, spin wave resonance, antiferromagnetic resonance, electron paramagnetic resonance, exchange narrowing, zero-field splitting.

Recommended Books

1. *Introduction to Solid State Physics by C. Kittle, 8th Edition (2012).*
2. *Magnetic Materials: Fundamentals and Applications by N. A. Spaldin, 2nd Ed. (2011).*
3. *Quantum Theory of the Solid State by J. Callaway, 2nd Edition (1991).*
4. *Introduction to Magnetic Materials by B. D. Cullity & C.D. Graham, 2nd Ed. (2008).*

Phys 4308	QUANTUM INFORMATION THEORY	(CR3)
Preq.	Phys 3301	

Objectives
To understand the fundamental concepts of quantum information, communication, computation, and physical protocols for quantum computation

Syllabus
Review of Quantum Mechanics and overview of Quantum information: Postulates of quantum mechanics, quantum states and observables, Dirac notation, projective measurements, density operator, pure and mixed states, entanglement, tensor products, no-cloning theorem, mixed states from pure states in a larger Hilbert space, Schmidt decomposition, generalized measurements, (CP maps, POVMs), qualitative overview of Quantum Information. Quantum Communication: Dense coding, teleportation, entanglement swapping, instantaneous transfer of information, quantum key distribution. Entanglement and its Quantification: Inseparability of EPR pairs, Bell inequality for pure and mixed states, entanglement witnesses, Peres- Horodecki criterion, properties of entanglement measures, pure and mixed state entanglement, relative entropy as entanglement measure, entanglement and thermodynamics, measuring entanglement. Quantum Information: Classical information theory (data compression, Shannon entropy, von Neumann entropy), fidelity, Helstrom's measurement and discrimination, quantum data compression, entropy and information, relative entropy and its statistical interpretation, conditional entropy, Holevo bound, capacity of a quantum channel, relative entropy and thermodynamics, entropy and erasure, Landauer's erasure.

Recommended Books

1. *Introduction to Quantum Information Science by V. Vedral, Oxford (2007)*
2. *Quantum Computation and Quantum Information by M. Nielsen and I. Chuang (10th Edition), Cambridge (2010)*
3. *Problems and Solutions in Quantum Computing and Quantum Information by W. Steeb and Y. Hardy (3rd Edition), World Scientific Publishing (2011)*

Phys 4703	INTRODUCTION TO PHOTONICS	(CR3)
Preq.	Phys 3402	

Objectives
To study the application of light, studying the photonic devices including detectors.

Syllabus
Guided Wave Optics: Planar slab waveguides, Rectangular channel waveguides, Single and multi-mode optical fibers, waveguide modes and field distributions, waveguide dispersion, pulse propagation Gaussian Beam Propagation: ABCD matrices for transformation of Gaussian beams, applications to simple resonators Electromagnetic Propagation in Anisotropic Media: Reflection and transmission at anisotropic interfaces, Jones Calculus, retardation plates, polarizers Electro-optics and Acousto-optics: Linear electro-optic effect, Longitudinal and transverse modulators, amplitude and phase modulation, Mach-Zehnder modulators, Coupled mode theory, Optical coupling between waveguides, Directional couplers, Photoelastic effect, Acousto-optic interaction and Bragg diffraction, Acousto-optic modulators, deflectors and scanners Optoelectronics: p-n junctions, semiconductor devices: laser amplifiers, injection lasers, photoconductors, photodiodes, photodetector noise.

Recommended Books

1. *Fundamentals of Photonics by B. E. A. Saleh and M. C. Teich (2nd Edition), John Wiley (2007)*
2. *Photonic Devices by J-M. Liu, Cambridge (2009)*
3. *Photonics: Optical Electronics in Modern Communications by A. Yariv and P. Yeh, Oxford (2006)*
4. *Optics by E. Hecht (4thEdition), Addison-Wesley (2001)*

Phys 4309	**QUANTUM SOLID STATE MAGNETISM**	**(CR3)**
Preq.	**Phys 3402**	

Objective

Learn the modern theoretical foundations used to describe and study collective magnetic phenomena in the Solid State.

Syllabus

Magnetic response and correlation functions, analytic properties, fluctuation-dissipation theorem, experimental methods to measure static and dynamic correlations, magnetic response and correlations in metals, diamagnetism and paramagnetism, magnetic ground states: ferromagnetism, spin density waves, excitations in metals, spin waves, experimental examples, magnetic response and correlations of magnetic ions in crystals: quantum numbers and effective Hamiltonians, application of group theory to classifying ionic states, experimental case studies, magnetic response and correlations in magnetic insulators, effective Hamiltonians, magnetic order and propagation vector formalism., the use of group theory to classify magnetic structures, determination of magnetic structures from diffraction data, excitations: spin wave theory and beyond, Triplons, measuring spin wave spectra.

Recommended Books

1. *Quamtum Theory of Magnetism, by W. Nolting, Springer, (2009)*
2. *Quantum Theory of Magnetism, by R. M. White, Springer, (2006)*
3. *Quantum Magnetism, by U. Schollwöck and J. Richter, Springer, (2004)*
4. *Introduction to Magnetic Materials by B. D. Cullity & C. D. Graham, 2nd Ed. (2008).*

Phys 4310	**QUNTUM ELECTRONICS**	**(CR3)**
Preq.	**Phys 3402, 3702**	

Objective

Develop a basis for understanding the quantum mechanical aspects of modern electronics (lasers, quantized Hall effect, field effect transistors, optical tweezers, etc.)

Syllabus

Time-independent Schrodinger equation, quantum mechanical tunneling, bound states and scattering transmission electron microscopy, the energy spectrum of diatomic and aromatic molecules, the band structure of one-dimensional crystalline and disordered solids, the scattering time for electron transport in a crystal, the quantized and fractional Hall effect in a two-dimensional electron gas, perturbation theory and field quantization, two-state lasers, light pressure forces on atoms, quantization of LC circuits, Casimir forces, field effect transisters, optical tweezers, quantum devices, single electron transister,
Spontaneous and stimulated transitions, Einstein coefficients, coherence of stimulated emission Light-matter interaction, transition probability Spectral line shape, inhomogeneous and homogeneous broa

dening Absorption and amplification, gain medium, saturation Laser oscillations, feedback, lasing th reshold, resonant conditions interaction of electromagnetic radiations with resonant atomic transitions, density matrix treatment, Rabi oscillations.

Recommended Books

1. *Quantum Theory Of The Optical And Electronic Properties Of Semiconductors (5Th Edition), H. Haug and S. W. Koch, World Scientific, (2009)*
2. *Quantum Electronics, by A. Yariv,Wiley, (2013)*
3. *Principles of Quantum Electronics, D. Marcuse, Academic Press, (2012).*

Phys 4310	**ASTROPHYSICS**	**(CR3)**
Preq.	**Phys 3402, 3702**	

Objective

To give an introduction to theory of star formation and to understand large scale structure of the universe.

Syllabus

Astronomy as an observational science, measuring time, angle, and distance, luminosity, brightness and telescope, temperature, colour and spectral properties of stars, basic physics of stars, The interstellar medium and the birth of stars; protostars and evolution to the main sequence; star clusters, The death of stars - white dwarfs, the late evolution of massive stars, supernovae and supernova remnants Neutron stars, pulsars and black holes, Galaxies: the Milky Way galaxy, rotation curves and dark matter, other galaxies and the Hubble classification scheme, Galaxies: active galaxies, galaxy environments and large scale structure, galaxy clusters and dark matter, galaxy formation, Cosmology: Hubble's law, the Big Bang, the cosmic microwave background, Expanding Universe, Hubbles law, red shift, Big Bang and Inflation, Cosmic Microwave Background, Nucleosynthesis, Dark Matter and Dark Energy.

Recommended Books

1. *An Introduction to Modern Astrophysics by B. W. Carroll and D. A. Ostlie, (2nd Edition), Cambridge (2017)*
2. *Introduction to Astrophysics: The Stars by J. Dufay and O. Gingerich, Dover (2012)*
3. *An Introduction to Stellar Astrophysics by F. LeBlanc (1st Edition), Wiley (2010)*

Phys 4310	**MEDICAL PHYSICS**	**(CR3)**
Preq.	**Phys 3402, 3702**	

Objective

To give an introduction to various applications of physics in medical sciences and heatj care sector.

Syllabus

Interactions of lonising Radiation with Matter: Introduction; Beta-rays, range-energy relationship, mechanism of energy loos, lonization and excitation, Bremsstrahlung, Alpha-rays, Rang-energy relation – ship, Energy transfer, Gamma-rays, exponential absorption, interaction mechanisms, Pair production, Compton scattering, photoelectric absorption, photodisintegration, Combined effect, Neutrons, Production classification, interaction, Scattering, Absorption. Radiotherapy, development of radiotherapy, Radiotherapeutic aims, External beam therapy, Brachytherapy, Unsealed source therapy, Requirements for accuracy and precision, Quality assurance, The role of medical physics. Medical Imaging, Diagnostic X-rays, Production of X-rays, Absorption of x-ray to other planes, Partial volume effect, Artifacts, Contrast agents in conventional radiography and CT, Diagnostic Ultrasound, Doppler effect, Radionuclide imaging, positron emission tomography (PET), Magnetic resonance imaging (MRI), Contrast agents for MRI.

Recommended Books

1. *Introduction to Health Physics by H. Cember. 3rd Ed. McGraw Hill, (1996).*
2. *Diagnostic Imaging, by Peter Armstrong and Martin L. 4th Ed., Blackwell, (1998).*
3. *Radiologic Science of Technologists by S. C. Bushong, 5th Ed. Mosby, (1993).*
4. *Fundamentals of Radiation Dosimetry, by J. R. Greening, 2nd Ed. Adam Hilger, (1985).*
5. *Radiation Detection and Measurement, by Knol G.F., 2nd Ed. Willey, (1980).*
6. *Physics of Medical Imaging, by Edwin G. A. Aird, Heinemann, (1988).*

LABORATORY COURSES

Phys 3605L	PHYSICS LAB-I	(CR3)
Preq.	BSc (Two Years) Physics Lab	

Objectives

To give students training in perfoerming experiments that led to great discoveries in physics.

Syllabus

Measurement of wavelengths of laser light by using Michelson interferometer, The determination of Cauchy's constants using spectrometer, To determine e/m of an electron using a fine beam tube, To measure Planck's constant by studying photoelectric effect, To measure the critical potential of mercury by Frank-Hertz method, To study some aspects of Ferromagnetism by drawing B. H. curve. (a)To determine the characteristic of G. M. tube and measure the range and maximum energy of β particles. (b) Measurement of half-life of a radioactive source (c) Characteristics of G.M. counter and study of fluctuations in random process.

Recommended Books

1. *Physics laboratory experiments by J. D. Wilson, Cengage Learning (2014)*
2. *General Physics Laboratory I Experiments by K. Clara Castoldi, Kendall Hunt, 2015*
3. *Physics Lab Experiments by M. French, Mercury Learning & Information, (2016)*
4. *Experiments And Demonstrations In Physics: Bar-ilan Physics Laboratory by Kraftmakher Yaakov, World Scientific (2014)*

Phys 3606L	PHYSICS LAB-II	(CR3)
Preq.	BSc (Two Years) Physics Lab	

Objectives

To enable students in performing experiments related to advanced topics in electronics and semiconductor physics.

Syllabus

Constructing a power supply by using Bridge rectifier and study its output without and with a capacitor filter, Designing a full-wave rectifier and study its output with a π-filter, Designing a regulated power supply using Zener diode and study its regulation. Desining clipper and clamping circuits and study the output waveshapes, Designing differentiator and integrator circuits and study output waveshapes, Designing a CE amplifier and study its frequency response. Determining its low- and upper-limit frequencies and also the bandwidth. Designing an emitter amplifier and determine its input and output impedance. Designing an RC phase-shift oscillator and determine its frequency by

Lissajous figures. Designing an astable multivibrator and determine its frequency. To construct from discrete components OR, AND, NOT, NAND, NOR Circuits and verify their truth tables.

Recommended Books

1. *Physics laboratory experiments by J. D. Wilson, Cengage Learning (2014)*
2. *General Physics Laboratory I Experiments by Kapila Clara Castoldi, Kendall Hunt, 2015*
3. *Physics Lab Experiments by M. French, Mercury Learning , (2016)*
4. *Experiments And Demonstrations In Physics: Bar-ilan Physics Laboratory by Kraftmakher Yaakov, World Scientific (2014).*