UNIVERSITY OF SARGODHA
Office of the Registrar

Ref: SU/Acad/23/415
Dated: 15.05.2023

The Additional Controller of Examinations.
University of Sargodha,
Sargodha.

Subject: **SYLLABI OF BS 5TH TERM / SEMESTER INTAKE**

Please refer to letter No. SU/CE/Secrecy-P.S/95 dated 06.04.2023 on the subject cited above.

2. This is to inform you that your kind letter has been analyzed thoroughly and Syllabi of various programs of BS 5th Term/Semester Intake w.e.f. Spring 2023 have been returned to the concerned departments with the relevant observations mentioned in your letter for rectification at the earliest.

3. In this regard, after removing the observations, following departments have updated and forwarded correct/vetted copies of Syllabi of BS 5th Semester Intake (**Annex-'A', 'B', 'C' & 'D'**) through the office of Director Academics.

i. Physics
ii. Economics
iii. Institute of Art & Design
iv. Sociology & Criminology

4. The same has also been forwarded through e-mail at controller.exam@uos.edu.pk as desired. The remaining Syllabi will be furnished to your kind office as and when received from quarter concerned.

5. Further necessary action may be taken accordingly.

15/05/23
Asif Mehmood
Deputy Registrar (Acad)

CC:
- Director Academics
- Director QEC
- Director Implementation
- Deputy Registrar (Affiliation)
- Deputy Registrar (Registration)
- Secretary to the Vice Chancellor
- P.A to Registrar

048 9230802 registrar@uosedu.pk www.uos.edu.pk University of Sargodha, University Road

SCHEME OF STUDIES & CURRICULUM

BS-PHYSICS

(5th Semester intake)

DEPARTMENT OF PHYSICS
UNIVERSITY OF SARGODHA
SARGODHA, PAKISTAN

Scheme of Studies is ok
15-05-2023

Forwarded for ula P.
15/5/23.

DR (Acad) 15/5

DEPARTMENT OF PHYSICS

Academic Programme Offered: BS Physics (5th Semester intake)
Programme Duration: 2 Years (4 Semesters)
Teaching System: Semester System/Term System
Start of Session: Spring 2023 & onward

Course Code	Course Title	Credit Hours
	Semester-I	
PHYS-6301	Methods of Mathematical Physics-I	3(3-0)
PHYS-6302	Classical Mechanics-I	3(3-0)
PHYS-6303	Electrodynamics-I	3(3-0)
PHYS-6304	Electronics	3(3-0)
PHYS-6305	Modern Physics Lab	3(0-3)
MATH-5124	Vectors and Tensors Analysis	3(3-0)
Total		**18**
	Semester-II	
PHYS-6306	Methods of Mathematical Physics-II	3(3-0)
PHYS-6307	Classical Mechanics–II	3(3-0)
PHYS-6308	Electrodynamics-II	3(3-0)
PHYS-6309	Quantum Mechanics-I	3(3-0)
PHYS-6310	Solid State Physics-I	3(3-0)
PHYS-6311	Electronics Lab	3(0-3)
Total		**18**
	Semester-III	
PHYS-6312	Statistical Mechanics	3(3-0)
PHYS-6313	Atomic Physics	3(3-0)
PHYS-6314	Plasma Physics	3(3-0)
PHYS-6315	Quantum Mechanics-II	3(3-0)
PHYS-6316	Solid State Physics-II	3(3-0)
PHYS-63xx	Optional Course[a]/Thesis[b]	3(3-0)
Total		**18**
	Semester-IV	
STAT-5125	Theory of Error Analysis	3(3-0)
PHYS-6317	Computational Physics	3(3-0)
PHYS-6318	Laser Physics	3(3-0)
PHYS-6319	Relativity and Cosmology	3(3-0)
PHYS-6320	Nuclear and Elementary Particle Physics	3(3-0)
PHYS-63xx	Optional Course[a]/Thesis[b]	3(3-0)
Total		**18**
		Total Credit Hours: 72

Optional Courses[a]		
PHYS-6321	Advanced Electronics	3(3-0)
PHYS-6322	Physical and Geometric al Optics	3(3-0)

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PHYS-6323	Physics of Nanotechnologies	3(3-0)
PHYS-6324	Methods of Experimental Physics	3(3-0)
PHYS-6325	Advanced Electronics LAB[c]	3(0-3)
PHYS-6326	Introduction to Quantum Computing	3(3-0)
PHYS-6327	Particle Physics	3(3-0)
PHYS-6328	Thesis	6

(a) Student may take two optional courses (Optional course-I in Semester III and Optional course-II in Semester IV) from courses offered at the department.
(b) A Thesis of 06 Cr Hrs can be opted if offered at the department.
(c) Advanced Electronics LAB can be opted only if Advanced Electronics is taken.

COURSE OUTLINE

Semester-I

PHYS-6301 Methods of Mathematical Physics-I Cr.H-3(3-0)

Functions of Complex Vairables: Calculys of Residues. Dispersion Relations. Method of Steepest Descents. Gamma Functions: Diagamma and Polygamma Functions. Stirling's Series. Beta Functions. Incomplete Gamma Functions. Strum-Liouville Theory (Orthogonal Functions): Hermite Operators, Completeness of Eigen Functions. Green's Functions-Eigen Function Expansion. Bessel Functions: Bessel Functions of first kind, Orthogonality. Neumann Functions, Hankel Functions, Modified Bessel Functions, Spherical Bessel Functions.

Recommended Books:

1. Arfken, G. B., Weber, H. J. & Harris, F. E. (2011). Mathematical methods for physicists (7th ed.). New York : Elsevier Science.
2. Kreyszig, E. (2011). Advanced engineering mathematics (10th ed.). New York: Wiley.
3. Spiegel, M. R., Lipschutz, S., Schiller, J. J. & Spellman, D. (2009). Schaum's outline of complex variables (2nd ed.). New York: McGraw Hill Professional.
4. Wong, C. W. (2013). Introduction to mathematical physics (2nd ed.). Oxford: Oxford University Press.
5. Kakani, S. L. & Hemrajani, C. (2010). Mathematical physics (2nd ed.). New Delhi: CBS Publishers.

PHYS-6302 Classical Mechanics-I Cr.H-3(3-0)

Historical background of classical mechanics. Elementary scalar and vector operations. coordinates transformations and Properties of orthogonal matrix. Vector products and various vector identities. Velocity and acceleration in various coordinates. Gauss's theorem and Stokes theorem. Kinematics of particle motion. The Newtonian formulation of mechanics. Integration of Newton's equation of motion. Motion of the body in resistive medium. various problems involving Newton's Laws of motion. Conservation theorems. Simple Harmonic Oscillator. Harmonic Oscillation in two and three dimensions. Damped and forced Oscillator.

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Physical systems executing SHM. Non linear oscillations. Gravitation and Gravitational Potential, Poisson's Equations. Lines of force and Equi-potential surfaces.

Recommended Books:

1. Thornton, S. T. & Marion, J. B. (2012). Classical dynamics of particles and systems (5th ed.). New York: Thomson Brooks/Cole
2. Goldstein, H., Charles, P. P. & Safko J. L. (2001). Classical mechanics (3rd ed). Massachusetts: Addison Wesley Reading.
3. Taylor, J. R. (2005). Classical mechanics. California: University Science Books.
4. Tom, W. B. K. (2005). Classical dynamics (5th ed.). London: Imperial College Press.
5. Finn, J. M. (2010). Classical dynamics. Boston: Jones and Bartlett Publishers.

PHYS-6303 Electrodynamics-I Cr.H-3(3-0)

Differential/integral calculus: Orthogonal coordinate systems (cartesian/cylindrical/ spherical): Electrostatics in free space: Electrostatic force/field/potential/energy for discrete (a single point charge/a collection of point source charges) and continuous (line/surface/volume) charge distributions. Divergence/curl of E. Electrostatic boundary conditions (on E, V, and D). Conductors. Capacitors: Boundary value problems: Solutions of Laplace's equation for various symmetries (cartesian/ cylindrical/spherical). Method of Images for various symmetries: Electric monopole/ dipole/quadrupole/octopole etc.. Electric dipole moment for line/surface/volume charge: Electrostatics in matter: Polarization P. Bound surface/volume charge. Electric displacement D. Gauss's law for D & P–differential/integral forms and its uses/applications. Electric susceptibility/permittivity/relative permittivity: Electric line/surface/volume currents–I/K/J. Equation of continuity.

Recommended Books:

1. Griffiths, D. J. (2007). Introduction to electrodynamics (4th ed.). New York: Prentice Hall.
2. Cheng, D. K. (2013). Field and wave electromagnetics (2nd ed.). New York: Pearson.
3. Vanderlinde, J. (2005). Classical electromagnetic theory (2nd ed.). New York: Springer.
4. Zahn, M. (2003). Electromagnetic field theory: a problem solving approach (1st ed.). Florida: Krieger Publishing Co.
5. Fleisch, D. (2008). A student's guide to Maxwell's equations (1st ed.). Cambridge: Cambridge University Press.
6. Basic Laws of Electromagnetic, by E. Irodov, 1st Edition, CBS, India, (2001)

PHYS-6304 Electronics Cr.H-3(3-0)

Semiconductor Diode And Applications: Semiconductor Diode, Characteristics Curves, DC & AC resistance, Diode Equivalent circuit, Series and Parallel Diode configuration with DC load, Rectification, Half and Full wave rectifier circuit with and without filter circuit, Zener Diode, Light emitting diode. Bipolar Junction Transistor: Transistor and transistor operation, Transistor Configuratios (CB, CE,CC).Current amplification factors, Load line and Operating Conditios, DC biasing (voltage divider bias C-E amplifier).Design of voltage divider bias C-E amplifier, Transistor switching network, Field Effect Transistors: Introduction of FETs, Construction and basic operation JFET, Characteristics and parameter of JFETs, JFETs biasing (voltage divider bias), The metal oxide semiconductor FET(MOSFET), MOSFET parameters and characteristics, Low and High frequency response of FET amplifiers.

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Negative Feedback Amplifiers: Negative feedback amplifiers.General characteristics of Negative feedback amplifiers. Classification of negative feedback amplifiers. voltage series feedback amplifier. Integrated amplifier: The Differential amplifier (modes of operation. common mode rejection ratio). Operational Amplifier and its parameters. Op-amp configuration with negative feedback .Op-amp applications (voltage summing. voltage buffer. voltage comparators). Op- amp as differentiator and integrator. Oscillators: Oscillator Principles and conditions for oscillation. Oscillator with LC feedback circuits. Transistor RC phase shift oscillator. Crystal oscillators. UJT relaxation oscillator. Multivibrators. Schmitt trigger.

Recommended Books:

1. Boylestad. R. & Nashelsky. L. (2002). Electronic devices and circuit theory. New Jersey: Pearson Prentice Hall.
2. Floyd. T. L. (2007). Principles of electric circuits. New Jersey: Pearson Prentice Hall.
3. Halliday, D., Resnick, R. & Walker, J. (2014). Fundamental of physics (10th ed.). New York: Wiely.
4. Young. H. D., Freedman, R. A. & Ford, A. L. (2019). University physics (15th ed.). New York: Pearson.
5. Beiser. A. (2003). Concepts of modern physics (6th ed.). New York: McGraw-Hill Education.

PHYS-6305 Modern Physics LAB Cr.H-3(0-3)

The following practical are recommended for Modern Physics LAB. Minimum numbers of practical to be performed are six.

- To determine the Cauchy's constants using Spectrometer.
- Measurement of Wavelength of Mercury Light using Michelson Interferometer.
- To determine the charge to mass ratio (e/m) of electron by fine beam tube method.
- Determination of Speed of Light using Optical Fiber.
- To measure Plank's constant by studying photoelectric effect.
- Characteristics of G. M tube, Radiation Detection, shielding and analysis.
- Radio Frequency Measurements (Determination of dielectric constants of solids).
- The Frank-hertz experiment (Measurement of excitation potential of Hg).
- Determination of the charge on an electron (e) by Millikan's method.
- Determination of the Rydberg constant from the spectrum of hydrogen.
- To study the Zeeman effect for a line in the spectrum of helium.
- The measurement of the Hall effect in germanium and silicon.
- To determine the energy gap in silicon and Germanium.
- Characteristic Curves of a Solar Cell
- Diffraction Intensity due to multiple slits and grids

Recommended Books:

1. Mark. H. & Olsono. H.T. (2004). Experiments in modern physics. New York: McGraw-Hill
2. Melissinos. A.C. (2008). Experiments in modern physics. New York: Academic press.
3. Melissinos. A. C. & Napolitano. J. (2003). Experiments in modern physics. New York: Gulf Professional Publishing.
4. Shamos, M. H. (2012). Great experiments in physics: firsthand accounts from galileo to einstein. New York: Courier Corporation.

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MATH-5124 Vectors and Tensors Analysis Cr.H-3(3-0)

Vector Analysis: Gradient, Divergence and curl of point functions, Expansion formulae. Curvilinear coordinates. line, surface and volume integrals. Gauss's. Green's and Stoke's theorems. Proper and improper transformation, Cartesian Tensors: Summation convention. Transformation equations. Orthogonally conditions. Kronecker tensor and Levi-civita tensor. Tensors of different rank. Inner and outer products. Contraction. Quotient theorems. Symmetric and anti-symmetric tensors. Application to Vector Analysis.

Recommended Books:

1. Shah, N.A., (2015). Vector and Tensor Analysis.
2. Spiegel, M.R. (2016). An Introduction to Vector and tensor analysis. New York: McGraw Hill.
3.Young, E.C. (1993). Vector and tensor analysis. New York: Marcel Dekker.

Semester-II

PHYS-6306 Methods of Mathematical Physics-II Cr.H-3(3-0)

Legendre Functions: Generating Functinos. Recurrence Relations. Orthogonality. Associated Legendre Functions. Spherical Harmonics. Orbital Angular Momentum Operators. Legender Function of the second kind. Laguerre Functions. Hermite Functions. Chebyshev Polynomials. Fourier Series: Definition and general properties of Fourier series. Uses and Applications of Fourier Series. Gibbs Phenomenon. Discrete Fourier Transform. Integral Transforms: Development of Fourier Integral. Fourier Transforms and Inversion Theorem. Fourier Transforms of Derivatives. Convolution Theorem. Momentum Representation. Transfer Functions. Laplace Transform and its Application. Inverse Laplace Tranform.

Recommended Books:

1. Arfken, G. B., Weber, H. J. & Harris, F. E. (2011). Mathematical methods for physicists (7th ed.). New York : Elsevier Science.
2. Kreyszig, E. (2011). Advanced engineering mathematics (10th ed.). New York: Wiley.
3. Spiegel, M. R., Lipschutz, S., Schiller, J. J. & Spellman, D. (2009). Schaum's outline of complex variables (2nd ed.). New York: McGraw Hill Professional.
4. Wong, C. W. (2013). Introduction to mathematical physics (2nd ed.). Oxford: Oxford University Press.
5. Kakani, S. L. & Hemrajani, C. (2010). Mathematical physics (2nd ed.). New Delhi: CBS Publishers & Distributors.

PHYS-6307 Classical Mechanics -II Cr.H-3(3-0)

Limitations of Newtonian mechanics. Some methods in the calculus of variations. Euler's equation. The "second form" of Euler's equation. Generalized co-ordinates and constraints. D' Alembert's principle. Hamilton's principle. Lagrangian and Lagrange's equation. Hamiltonian of dynamical system. Hamilton's canonical equations. Poisson bracket and their properties. Central force motion and Two body problem. General solution of problems of motion in central force field. Kepler's laws of planetary motion. Applications of central force motion. Orbital Dynamics, Kinematics of system of particles. Collision between particles. Elastic collision in LAB and CM coordinate system. Rutherford's scattering formula. Rocket

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Motion. Dynamics of rigid body. Inertia tensor and principal axes of inertia. Moment of inertia for different body coordinate system. Eulerian angles and Euler's equation of motion for a rigid body. Motion of a symmetric top.

Recommended Books:

1. Thornton, S. T. & Marion, J. B. (2012). Classical dynamics of particles and systems (5th ed.). New York: Thomson Brooks/Cole
2. Goldstein, H., Charles, P. P. & Safko J. L. (2001). Classical mechanics. (3rd ed). Massachusetts: Addison Wesley Reading
3. Taylor, J. R. (2005). Classical mechanics. California: University Science Books.
4. Tom W. B. K. (2005). Classical dynamics (5th ed.). London: Imperial College Press.
5. Finn J. M. (2010). Classical dynamics. Boston: Jones and Bartlett Publishers.

PHYS-6308 Electrodynamics-II Cr.H-3(3-0)

Magnetostatics in free space: B for line/surface/volume currents. Divergence/curl of B. Magnetic vector/scalar potential–A/V_m for line/surface/volume currents. Magnetostatics boundary conditions (on B, A, and H): Magnetic monopole/dipole/quadrupole etc.. Magnetic dipole moment for line/surface/volume currents: Magnetostatics in matter: Magnetization M. Bound surface/volume currents. Auxiliary field H. Ampere's law for H & M–differential/integral forms and its uses/applications. Magnetic susceptibility/permeability/relative permeability; Electrodynamics: Faraday's law–differential and integral forms and its uses/applications. Mutual/self inductance. Magnetic energy for line/surface/volume currents, Poynting's theorem: Maxwell's equations in free space (static/non-static case). Maxwell's equations in matter: Electromagnetic waves in free space. Electromagnetic waves in matter.

Recommended Books:

1. Griffiths, D. J. (2007). Introduction to electrodynamics (4th ed.). New York: Prentice Hall.
2. Cheng, D. K. (2013). Field and wave electromagnetics (2nd ed.). New York: Pearson.
3. Vanderlinde, J. (2005). Classical electromagnetic theory (2nd ed.). New York: Springer.
4. Zahn, M. (2003). Electromagnetic field theory: a problem solving approach (1st ed.). Florida: Krieger Publishing Co.
5. Fleisch, D. (2008). A student's guide to Maxwell's equations (1st ed.). Cambridge: Cambridge University Press.

PHYS-6309 Quantum Mechanics-I Cr.H-3(3-0)

Review of Concepts of Classical Mechanics: Historical Review (Experiments and Theories). Wave Aspects of Particles. Hilbert Space and Wave Functions: Mathematical tools of Quantum Mechanics: The linear vector space. The Hilbert space. Dimensions and basis of a vector space. Square integrable wave functions. Dirac notation. Operators. Basic Postulates of Quantum Mechanics: The state of a system. Observables. Measurement in Quantum Mechanics, Time Evolution of the System's State (Time evolution operator. Stationary states: Time independent potentials). Time evolution of expectation values. Symmetries and Conservation Laws. General Properties of one Dimensional Schrödinger Equation: symmetric potentials and parity. Properties of one dimensional motion. Solution of Simple One Dimensional Systems: The free particle. The step potential. The potential barrier and well. The infinite square well potential. The finite square well potential and harmonic oscillator.

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Recommended Books:

1. Liboff, R. L. (2002). Introductory quantum mechanics (4th ed.). New York: Addison Wesley Publishing Company.
2. Zettili, N. (2009). Quantum mechanics: concepts and applications (2nd ed.). New York: Wiley.
3. Townsend, J. S. (2012). A modern approach to quantum mechanics (2nd ed.). New York: University Science Books.
4. Robinett, R. W. (2006). Quantum mechanics, classical results, modern systems and visualized examples (2nd ed.). Oxford: Oxford University Press.
5. Gasiorowicz, S. (2003). Quantum physics (3rd ed.). New York: Wiley.
6. Griffiths, D. J. (2018). Introduction to quantum mechanics (3rd ed.). Cambridge: Cambridge University Press.

PHYS-6310 Solid State Physics-I Cr.H-3(3-0)

Crystal structure in 2D and 3D, fundamental types of lattices, index system for crystal planes, simple crystal structures, X-ray diffraction, Braggs law, reciprocal lattice, Diffraction of waves by crystals, scattered wave amplitude, Brillouin zones, crystal binding and elastic constants, Classification of Solids, ionic crystals, covalent crystals, Ionic Radii, II-VI and III-V compounds, Molecular crystals, metals, Cohesive energy, The Lenard Jones Potential, Density, Cohesive energy and Bulk Modulus of crystalline solids, The Madelung constant, Cohesion in Covalent crystals, elastic waves in cubic crystals, Vibration of crystals with monatomic basis, two atoms per primitive basis, quantization of elastic waves, normal vibration modes and phonon, phonon momentum, inelastic scattering by phonons, Phonon heat capacity, lattice heat capacity, Einstein and Debye models, Sommerfeld model of free electron theory, Energy levels in one dimension, free electron gas in three dimension, DC and AC electrical conductivity of metals

Recommended Books:

1. Kittle, C. (2005). Introduction to solid state physics (8th ed.). New Jersey: Wiley
2. Wahab, M. A. (2017). Solid states physics: structure and properties of materials (3rd ed.). Oxford: Alpha Science International
3. Szwachi, N. G. & Szwacka, T. (2016). Basic elements of crystallography (2nd ed.). Singapore: Pan Stanford Publishing.
4. Simon, S. H. (2013). The oxford solid state basics (1st ed.). Oxford: Oxford University Press.
5. Blakemroe, J. S. (2012). Solid state physics (2nd ed.). Cambridge: Cambridge University Press.

PHYS-6311 Electronics LAB Cr.H-3(0-3)

The following practicals are recommended for Electronics LAB. Minimum number of practicals to be performed is six.

- To construct from discrete components OR, AND, NOT, NAND, NOR exclusive OR Circuits and verify their truth tables.
- Design a fixed and self bias and voltage divider bias transistor To construct a single stage CE transistor voltage amplifier and study gain, input impedance, output impedance, and half power points by sine/square wave testing and effect of bias on the output and measurement of distortion

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- To construct and study the wave forms at the base and collector of the transistors of a free running a multivibarator.To construct and study of the height, duration and time period of the output pulses in a monostable and Bistabale multivibrators with reference to the input Trigger
- To study of RC integrators and differentiators.
- Design an inverting and non-investing D.C. amplifier. measurement of parameters of a given IC operational amplifier.
- Design and study the application of operational amplifier (current to voltage converter. instrumentation amplifier. buffer. voltage clamp. integrator. and differentiator. Low and high pass filter half-wave rectifier etc.)
- To construct a phase shift or Wein bridge oscillator and measure its frequency by 741.555timer

Recommended Books:

1. Robert, L. B. & Nashelsky, L. (2005). Electronic devices and circuit theory (9th ed.). New Jersey: Prentice Hall.
2. Mitchel, E. S. (2003). Grob's basic electronics (13th ed.). New York: McGraw-Hill Education.

Semester-III

PHYS-6312 Statistical Mechanics Cr.H-3(3-0)

Review of thermodynamics:_Mathematical formulation of first and second law of thermodynamics. Maxwell's relation. Reduction of derivatives. General conditions of equilibrium. Partition Function:_Partition Function. Relations of partition function with thermodynamical variables, examples (collection of simple harmonic oscillators. Half spin paramagnet. Basic Principles of statistical Mechanics:_Microscopic and macroscopic states. Phase Space, Ensemles,Liouvillie theorem, Formation of Microcanonical, Canonical and Grand canonical partition function. Maxwell distribution of molecular speed: Probability of the particle in quantum state. Density of states in k-space.single particle density of states in energy. Maxwell-Boltzman Distribution Function. Validity of Maxwell-Boltzman statistics. Evaluation of constants α and β. Maxwell Speed distribution function. Theory of ideal Fermi System: Fermi-Dirac Distribution Function. Examples of the Fermi system (free electron theory of metals. Electrons in stars. electrons in white dwarf stars). Theory of Bose System: Bos-Einstein Distribution Function. Black body radiation. the photon gas. ideal bose gas model of liquid helium. Einstein's model of vibration in a solids. Debye's model of vibration in a solids.

Advanced Topics: Fluctuations. Bose-Einstein Condensation. Introduction to density matrix approach

Recommended Books:

1. Reif, F. (2009) Fundamentals of Statistical and Thermal Physics. New York McGraw Hill.
2. Garg. S. C. Bansal, R.M., Ghosh, C.K., (2012) Thermal Physics. (2nd ed) New Delhi McGraw Hill.
3. Agarwal. B.K., Melvin, E. (2012) Statistical Mechanics. (3rd ed.) New Delhi. New Age International.
4. Pathria, R. K. (2011) Statistical Mechanics. UK: Elsevier Ltd.
5. Sinha S. K. (2007). Introduction to statistical mechanics. Oxford Alpha Science International.

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PHYS-6313 Atomic Physics Cr.H-3(3-0)

The Thomson model. The Rutherford model. Alpha-Particle Scattering. Electron orbits. Sommerfeld model. Atomic Spectra of hydrogen atom. Nuclear Motion and Reduced Mass. The Correspondence principle. The Frank-Hertz and Stern-Gerlach Experiments. Quantum Theory of the Hydrogen Atom. Quantum numbers. Total Quantum numbers. Orbital Quantum number. Magnetic Quantum Number. Spin-orbit interaction. Exclusion principle. Electron configuration in many electron-atoms. Hund's rules. Coupling of angular momenta. LS-coupling. jj-coupling. Origin of Spectral lines. Selection Rules. One electron Spectra. Two-electron Spectra. Relative intensities in a multiplet. X-ray spectra. Atoms in Magnetic and Electric fields: Space quantization. Magnetic moment and Bohr Magneton. Zeeman Effect. Paschen-Back effect. Stark effect.

Recommended Books:

1. Foot, C. J., Atomic Physics. (Oxford University Press. (2005))
2. Krane, K.S., Modern Physics, (John Wiley & Sons. (2019))
3. Brandsen, B. H. and Joachain, C. J., Physics of atoms and molecules, 2nd edition. (Pearson Education (2003))
4. Beiser, A., Perspective of Modern Physics. (McGraw-Hill. (1981))
5. White, H.E., Introduction to Atomic Spectra. (McGraw-Hill. (1999))
6. Haken, H. and Wolf, H. C., Atomic and Quantum Physics. 2nd edition (Springer. (2012)
7. Thorne, A. P., Spectrophysics, 2nd edition. (Chapman and Hall. (2012).

PHYS-6314 Plasma Physics Cr.H-3(3-0)

Introduction. Occurrance of plasma. Concept of temperature. Debye shielding. The plasma parameter. Criteria for plasma. Applications of plasma physics. Single-particle motion in electromegnatic field. Uniform and nonuniform E and B fields. Time-variant E and B fields. Fluid description of plasma. Wave propagation in plasma. Derivation of dispersion relations for simple electrostatic and electromagnetic modes. Low temperature plasmas and their applications. Magnetic fusion plasmas. Laser produced plasmas. inertial confinement fusion. X-ray lasers and Particle accelerators.

Recommended Books:

1. Chen, F. F., Introduction to plasma Physics and Controlled Fusion, 3rd edition (Springer. (2016)).
2. Bittencourt, J. A., Fundamentals of Plasma Physics, 3rd edition (Springer-Verlag. (2004)).
3. Bellan, P. M., Fundamentals of Plasma Physics. 1st (CUP. (2006)).
4. Glasston, R. J., Introduction to Plasma Physics. 1st (Taylor & Francis. (2019)).

PHYS-6315 Quantum Mechanics-II Cr.H-3(3-0)

Orbital angular momentum. The eigenvalues and eigen-functions of L^2 and L_z. Matrix representation of angular, momentum operators. Addition of angular momenta. spin-angular momentum. Schrödinger Equation in Three Dimensions (3D problems in Cartesian and Spherical coordinates). The free particle solution, box potential problem, The Harmonic Oscillators: Isotropic and Anisotropic Harmonic Oscillator. the Hydrogen atom. Approximate Methods (Time independent perturbation theory for non degenerate and

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degenerate levels. the variational method. The WKB approximation. Time dependent perturbation theory). Identical Particles (Many Particles Systems. Systems of Identical Particles. The Pauli Exclusion Principle).

Recommended Books:

1. Liboff. R. L. (2002). Introductory quantum mechanics (4th ed.). New York: Addison Wesley Publishing Company.
2. Zettili. N. (2009). Quantum mechanics: concepts and applications (2nd ed.). New York: Wiley.
3. Townsend. J. S. (2012). A modern approach to quantum mechanics (2nd ed.). New York: University Science Books.
4. Robinett, R. W. (2006). Quantum mechanics. classical results. modern systems and visualized examples (2nd ed.). Oxford: Oxford University Press.
5. Gasiorowicz. S. (2003). Quantum physics (3rd ed.). New York: Wiley.
6. Griffiths. D. J. (2018). Introduction to quantum mechanics (3rd ed.). Cambridge: Cambridge University Press.

PHYS-6316 Solid State Physics-II Cr.H-3(3-0)

Solid state problem. free electron approximation. density of states. Fermi Dirac distribution. k-space. concept of Fermi energy and the Fermi surface. free electron description of Heat capacity. electrical conductivity of metals. Hall effect. Nearly free electron model. origin of the energy gap. . Bloch functions. Concept of hole. reduced. periodic & extended zone schemes. motion of electrons in a periodic potential. crystal momentum. effective mass. physical interpretation of the effective mass. Kronig-Penney model. Calculation of band structure. Tight-Binding method. Semiconductors. intrinsic and extrinsic semiconductors. intrinsic carrier concentration. mobility. impurity conductivity donor states. acceptor states. thermal ionization of donors and acceptors. simple description of pn-junction and rectification. Transistors. Semiconductors heterostructures and outline of solid state lasers. Optical properties of solids. Diamagnetism and Paramagnetism. Larmor Diamagnetism. Pauli Paramagnetism. Conduction electrons Diamagnetism. introduction to superconductivity.

Recommended Books:

1. Pillai. S. O. (2005) Solid States Physics. Revised (6th Edition) New Delhi: New Age International Limited.
2. Wahab. M. A. (2017). Solid states physics: structure and properties of materials (3rd ed.). Oxford: Alpha Science International
3. Ibach. H. & Luth. H.. (2009) Solid States Physics. 4th Edition. New Yark City Springer.
4. Ashcroft. N. W. and Mermin. N. D. (2003) Solid state physics. 1st Edition. Hong Kong (CBS Publishing Asia.
5. H. P. Myers . (2002) Introductory Solid States Physics. 2nd Edition, (Boca Raton: CRC Press.

Semester-IV

STAT-5125 Theory of Error Analysis Cr.H-3(3-0)

Preliminary Description of Error Analysis. How to Report and Use Uncertainties. Discrepancy. Comparison of Measured and Accepted Values. Comparison of Two Measured Numbers. Checking Relationships with a Graph. Significant Figures and Fractional Uncertainties. Multiplying Two Measured Numbers. Propagation of Uncertainties. The Square-Root Rule. Independent Uncertainties in a Sum. Arbitrary Functions of One Variable. General Formula for Error Propagation. Statistical

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Analysis of Random Uncertainties, Random and Systematic Errors, The Mean and Standard Deviation, Standard Deviation of the Mean, probability concepts, Probabilities in Dice Throwing, The Normal Distribution and its properties, Binomial Distribution and its Properties, The Poisson Distribution and its Properties, The Chi-Squared Test for a Distribution, Degrees of Freedom and Reduced Chi Squared, Probabilities for Chi Squared, Limiting Distributions, Justification of the Mean as Best Estimate, Justification of Addition in Quadrature, Acceptability of a Measured Answer, Rejection of Data, Chauvenet's Criterion, Weighted Averages, Covariance and Correlation, Covariance in Error Propagation, Coefficient of Linear Correlation, Least-Squares Fitting, Calculation of the Constants A and B and their uncertainty, Least-Squares fits to other cruves

Recommended Books:

1. Hughes, I. & Hase, T. (2010). Measurements and their uncertainties: a practical guide to modern error analysis (1st ed.). New York: Oxford University Press.
2. Bevington, P. (2003). Data reduction and error analysis for physical science (3rd ed.). New York: McGraw Hill
3. James, F. (2006). Statistical methods in experimental physics (2nd ed.). New York: World Scientific Publishing Company.
4. An introduction to Error Analysis by John R.Taylor, Universiy Science Books, California, 1982.
5. Mueller-kirsten, H.J. (2009). Basics of statistical physics: a bachelor degree introduction. London: World Scientific Publishing Company

PHYS-6317 Computational Physics Cr.H-3(3-0)

Preparatory Concepts: A brief introduction of the computer package MATLAB®. Numerical Techniques: Numerical Solutions of equations, Interpolation and Extrapolation, Numerical integration and differentiation and solution of differential equations. Modeling & Simulations: Basic concepts of modeling and simulation, relation between modeling and simulation. Case Study: Some systems of interest for physicists such as Motion of Falling objects, Kepler's problems, Oscillatory motion, many particle systems, Dynamic systems, Wave phenomena, Field of static charges and current, Diffusion, Populations genetics etc (only one).

Recommended Books:

1. Peter, A. S. (1992). Introduction to Numerical Methods. 2nd edition.(Macmillan Pub Ltd.
2. Amos G.(2011) MATLAB® An Introduction with Applications, 4th edition, New Yark Wiley.
3. Pinter C & Dejong.M., (1991). Introduction to Computational Physics. (2nd ed) Massachusetts: Addison-Wesley

PHYS-6318 Laser Physics Cr.H-3(3-0)

Introduction to Lasers, Properties of laser beam. Electromagnetic waves and photons, Energy levels, Transition and spectral lines, Spontaneous and Stimulated emission, Stimulated Absorption, Line shape function, Black-Body Radiation, Relation between Einstein A and B Coefficients, Conditions for large stimulated emissions, Gain coefficient, Threshold Gain coefficient, Line-broadening mechanism, The metastable level, Population inversion, The three and four-level system, Rate equations, Optical resonators, Conditions for steady state oscillation in a two mirror Resonator, Cavity resonance frequencies, Longitudinal and Transverse modes in a cavity, Pumping Process, Pulsed vs Continuous emission, Threshold condition and output power, Optimum output coupling, Laser tuning, Oscillation and pulsations in lasers, Q-Switching and mode-locking methods, Phase velocity, Group

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Velocity. Dispersion and Pulse Width, Non-linear crystals, Laser Systems (Solid state lasers. Ruby Laser, Nd:YAG and Nd:Glass lasers, Semiconductor lasers: Homojunction lasers. Double Hetrostructure lasers, Gass Lasers: Helium Neon laser. CO_2 laser. Nitrogen laser and Excimer laser. Free-Electro and X-ray lasers). Laser Applications.

Recommended Books:

1. Silfvast. W. T. (2008). Laser Fundamentals. New Yark Cambridge University press.
2. Milonni. P. W. and Eberly. J. (2010). Laser Physics. New Jersey John Wiley & Sons. Inc.
3. Hecht. J. (2018). Understanding lasers. New Jersey. Wiley-IEEE Press.
4. Hooker. S. and Webb. C. (2010). Laser Physics. Oxford University Press.
5. Svelto. O. (2010). Principles of lasers. New Yark Springer.
6. Avadhanulu. M. N. and Hemne. P. S. (2001). An Introduction to Lasers-Theory and applications. New Dehli S. Chand publishing.

PHYS-6319 Relativity and Cosmology Cr.H-3(3-0)

Galilean Transformations. Existence of Ether, Michelson-Morley Experiment. Stellar Aberration, Einstein's Postulates of Special Relativity. Lorentz Transformations. Relativity of Simultaneity, Time Dilation (Twins Paradox). Length Contraction (Ladder Paradox). Velocity Transformation and Velocity Addition. Relativistic Mechanics. Minkowski Spacetime. Line Element. Four-Vectors. Force Equation in relativity. Rest Mass. Conservation of Energy and Momentum. Elements of Tensor Calculus. Manifolds and Coordinates. Curves and Surfaces. Geodesics. Parallel Transport. Riemann Tensor. Metric Tensor, Christoffel Symbols. Principles of General Relativity. Equation of Geodesics. Einstein's Field Equations. Cosmology. Newtonian Cosmology. Cosmological Redshift. Hubble's Law. The Big Bang. Expansion Rate.

Recommended Books:

1. Cheng. T (2015). A college course on relativity and cosmology (1st ed) Oxford. Oxford University Press.
2. Forshaw, J. R. and Smith, A. G. (2009) Dynamics and Relativity (1st ed) Oxford University Press.
3. McMohan, D. (2006). Relativity Demystified (1st ed) New Yark Mc Graw-Hill.
4. McComb. W. D. (1999) Dynamics and Relativity (2nd ed) Oxford. Oxford University Press.
5. Narlikar. J. V. (2002) Introduction to Cosmology (3rd ed) Cambridge. Cambridge University Press.

PHYS-6320 Nuclear and Elementary Particle Physics Cr.H-3(3-0)

Nuclear Physics: Basic properties of Nucleus: Size and mass of the nucleus. Nuclear spin. magnetic dipole moment. electric quadropole moment. parity and statistics. Detectors. Passage of charged particle through matter. ionization chamber. proportional counter. scintillation counter. semi-conductor detector. bubble chamber. Particle Accelerators: Linear accelerator. Van de Graff. Betatron. synchrocyclotron. Nuclear Forces. Yukawa theory. proton-proton and neutron-proton scattering. charge independence of nuclear force. Conservation laws of nuclear reaction. Q-value of nuclear reaction. threshold energy. transmutation by photons, proton, deuterons and alpha particles. excited states of nucleus. energy levels, level width, Cross section from nuclear reactions. compound nucleus theory of nuclear reactions, limitation of compound nucleus theory, direct reactions, theory of fission and spontaneous fission. nuclear chain reaction and applications. Thermonuclear Reactions. Fusion and thermonuclear process. energy released in nuclear fusion. formation of heavy

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elements. semi-carbon nitrogen cycle controlled nuclear fusion.

Elementary Particle Physics: Introduction. Fundamental Interactions. Classification of elementary particles, Parameters of elementary particles, The massless bosons. The leptons. The mesons, The baryons, The eight fold way, Quarks, colour, charm.

Recommended Books:

1. Krane. S. (2008) Introductory Nuclear Physics.(3rd edition) New Jersy. Wiley.
2. Wong. S. M. (2004) Introductory Nuclear Physics.(2nd edition) Weinheim Wisley.
3. Chatwa. G. (2007) Nuclear Physics. (2nd ed) New Delhi. Dominant Publisher and Distribution).
4. Wiedemann. H. Particle Accelerator Physics. 2nd edition.(Springer.(2007)).
5. Bernardeau. F.Grojean. C. & Dalibard J. (2007)). Particle Physics and Cosmology.Amsterdam Elsevier Science

DETAILS OF OPTIONAL COURSES

PHYS-6321 Advanced Electronics Cr.H-3(3-0)

Number Systems and Operations (Number systems their introversion) Codes (BCD.Excess-3. Gray) error detection and correction codes, Parity codes, Seven-segment Display Code Logic Gates and Related Devices. Logic Families- significance and types, Boolean Algebra and Simplification Techniques. Combitional Logic Design. Flip-Flops . Sequential Logic Circuits (Registers and application of shift register). Ripple Counters. Synchronous Counter. Microprocessors

Introduction to Microprocessors. Inside a Microprocessor. Arithmetic Logic Unit (ALU). Register File. Control Unit. Basic Microprocessor Instructions. Data Transfer Instructions. Arithmetic Instructions. Logic Instructions. Discussion on 8085/8088. 8086 processor family. Intel Microprocessor hierarchy. Microcontrollers. Introduction to the Microcontroller. Applications. Inside the Microcontroller. Central Processing Unit (CPU). Random Access Memory (RAM). Read Only Memory (ROM). Special-Function Registers. Peripheral Components. Microcontroller Architecture. Architecture to Access Memory. Eight-Bit Microcontrollers.-Bit Microcontrollers . 32-Bit Microcontrollers. Interfacing (Peripheral Devices with a Microcontroller. LEDs. Electromechanical Relay. Keyboards Seven-Segment Displays). Modulation. Modulation: the power spectrum in AM. the diode modulator for AM, detection of AM signals. AVC. The SSB system of modulation. the frequency spectrum. bandwidth , generation of FM and AM. The superhetrodyne receiver. a radar system. Radio communication, Production of radio transmitter block diagram. Propagation of radio waves system Formation of ionosphere layers and their variations.

Recommended Books:

1. Mano. M .M (2017) Digital Logic and Computer Design. (5th ed) New Delhi Pearson.
2. Tokheim. R. L. (2013). Digital Electronics: Principles and Applications. (8th ed). Boston MacGraw-Hill education.
3. Floyd. T. L. (2014). Digital Fundamental. (11th ed). New Jersey. Prentice Hall Pearson.
4. Morris. M. Michael. M. and Ciletti. D. (2013). Digital Design. (5th ed).Upper Saddle River Prentice Hall Pearson.
5. Kummer A.A (2016) Fundamental of Digital circuits (4th ed) New Delhi PHI Learning.
6. Boslestad R. & Nashelsky L. (2002) Electronics Device and circuits theory. Jersey. Pearson Prentice Hall

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PHYS-6322 Physical and Geometrical Optics Cr.H-3(3-0)

Light - A historical perspective. Production and measurement of light. Geometrical Optics. The thick lens. Cylindrical lenses and astigmatism. Aberration theory. Controlling light through optical system, Optical instruments. Light as waves, Interference phenomena. Interference applications, Polarized light, Fraunhofer diffraction. Fiber otics. Non-linear Optics.

Recommended Books:

1. Pedrotti. F. L., Pedrotti. L. S. and Pedrotti. L.M.. (2008). Introduction to Optics. (3rd ed). New Delhi. Pearson Education.
2. Eugene H. and Ganesan. A. R. (2012). Optics.(4th ed). New Delhi Pearson Education.
3. Garbovskiy. Y. A. and Glushchenko. A. V.. (2017). A Practical Guide to Experimental Geometrical Optics. New Yark Cambridge University Press.
4. Freenan. M. H. and Hull. C. C. (2013). Optics. (11th ed). Berlin : Elsevier
5. Sharma K. K (2006) Optics.Principales and applications. New Yark: Elsevier.

PHYS-6323 Physics of Nanotechnologies Cr.H-3(3-0)

Introduction: The Importance of Nanoscale, Moore's law, Nanotechnology/Top down and bottom up approaches of nanofabrication, Advances in Nanotechnology, Advantages of nanotechnology, Future prospects in nanoscience and nanotechnology. Societal impact of nanotechnology. Two Dimensional Nanomaterials Growth: Thin film growth. Epitaxial growth modes. Thin film growth techniques: Pulsed laser deposition (PLD). Molecular beam epitaxy (MBE). Sputter deposition. Chemical vapour deposition (CVD). Electron beam evaporation (EBE) etc. Zero & One Dimensional Nanostructures Fabrication Techniques: Lithography : Mask lithography: Optical lithography. Nanoimprint. Maskless lithography: Scanning electron beam lithography. Focussed ion beam lithography. Nanostructures characterization techniques: Surface analysis by microscopy techniques : Optical microscopy (Conventional light microscopy. Fluorescence microscopy etc.). Electron microscopy (Scanning electron microscopy. Transmission electron microscopy. Focus ion beam microscopy etc.). Scanning probe microscopy (Scanning tunneling microscopy. Atomic force microscopy. Near-field scanning optical microscopy). Elemental Composition/Structural analysis: Electron techniques (Reflection high energy electron diffraction. Low energy electron diffraction. Auger electron spectroscopy etc.) and X-ray techniques (X-ray diffraction. X-ray reflectivity, X-ray photoelectron spectroscopy etc.).

Recommended Books:

1. Wolf. E . L (2015) Nanophysics and Nanotechnology. An introduction to modern concepts in nanoscience. New York: John Wily & Sons.
2. Wiesendanger. R. (2013). Scanning probe microscopy: analytical methods. New York: Springer Science & Business Media.
3. Goldstein J. I, Newbury, D. E . Michael. J. R Ritchie. N.W Scott. J . H & Joy. D. C (2017). Scanning electron microscopy and x-ray micro analysis . New York: Springer.

PHYS-6324 Methods of Experimental Physics Cr.H-3(3-0)

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Introduction to vacuum physics: Importance. Ranges and applications of vacuum. Molecular description of gases: Kinetic molecular theory of gases. Continuum and molecular states of gases, Mean free path. Molecular number density. Impingement rate. Fundamental concepts of vacuum physics: Surfaces processes. Scattering of a molecule from a surface. Adsorption and desorption. Outgassing. Sputtering. Gas flow and pumping: Continuum and molecular flow of gases. Conductance and pumping speed. Pumping process & pumping equation. Pump down time. Ultimate pressure. Vacuum pumps: Primary. Secondary and Ultra-high vacuum pumps. Vacuum gauges: Primary. Secondary and Ultra-high vacuum gauges. Sensor technology: Fundamental sensor performance characteristics. Classification of sensors. Temperature. Optical, Magnetic, Pressure, Fluid flow sensors, Metal detectors

Recommended Books:

1. Chambers. A. (2004) Modern Vacuum Physics (1st ed). London: CRC Press.
2. Fraden. J. (2010). A Handbook of Modern Sensors-Physics. Design and Applications (4th ed.) New York: Springer.
3. Hoffman. D. M Thomas J. H. & Singh. B (1997) Handbook of Vacuum Science and Technology. London: Elsevier.
4. Yoshimura. N. (2007) Vacuum Technology-Practice for Scientific Instruments. New York: Springer.

PHYS-6325 Advanced Electronics LAB Cr.H-3(0-3)

The following practicals are recommended for Modern Physics LAB. Minimum number of practicals to be performed is six.

- using IC's construct and study RS. JK (Master slave). T and D flip-flops.
- Design and study of a half and full adder with different Boolean expression using IC's.
- Design and study different combinational circuit(BCD adder.7-segment decoder.comparater encoder. multiplexer circuits)
- To study combinational lock and led sequencer circuits
- Synchronous and asynchronous BCD counters. memory shift register with IC's.
- Design and Study of decoder. encoder. multiplexer circuits and compare the input output waveforms.
- To construct and understand an operation of arithmetic logic unit and study of different arithmetic logic operations.

The following practical are recommended for advanced electronics lab using 8051microcontroller and 8086 microprocessor.

1. Programmable peripheral interface
2. Graphical/Character LCD
3. ADC and DAC
4 External Interrupt and Timers
5 2-Dimensional Key Board
6 LED and SSD display controls

Recommended Books:

1. Floyd. T. L. (2014) Digital Fundamental (11th ed). New Jersey: Prentice Hall Pearson.

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2. Mono, M. M. and Ciletti, M. D. (2013). Digital Design, (5th ed). Upper Saddle River: Prentice Hall Pearson.
3. Mono, M. M. (2017) Digital Logic and Computer Design, (5th ed). New Delhi. Pearson.
4. Tokheim, R. L. (2013) Digital Electronics: Principles and Applications. (8th ed). OH. MacGraw-Hill Education.
5. Kumar, A. A (2016). Fundamentals of Digital Circuits. (4th ed) New Delhi: PHI Learning.
6. Robert, L. B. & Nashelsky, L. (2005). Electronic Devices and circuits theory (9th ed.) New Jersey: Prentice Hall.
7. Mitchel, E. S (2003) Grob's basic electronics (13th ed.) New York MacGraw-Hill Education.

PHYS-6326 Introduction to Quantum Computing Cr.H-3(3-0)

Computer technology and historical background: Basic principles and postulates of quantum mechanics: Quantum states, evolution, quantum measurement, superposition, quantization from bits to qubits, operator function, density matrix, Schrodinger equation, Schmidt decomposition, EPR and Bell's inequality; Quantum Computation: Quantum Circuits, Single qubit operation, Controlled operations, Measurement, Universal quantum gates, Single qubit and CNOT gates: Breaking unbreakable codes: Code making, Trapdoor function, One time pad, RSA cryptography, Code breaking on classical and quantum computers, Schor's algorithm: Quantum Cryptography: Uncertainty principle, Polarization and Spin basis, BB84, BB90, and Ekert protocols, Quantum cryptography with and without eavesdropping, Experimental realization: Quantum Search Algorithm.

Recommended Books:

1. Nielson, M. A. & Chuang, I. L. (2000). Quantum Computation and Quantum Information. (2nd ed.) Cambridge: Cambridge University Press.
2. McMahon, D. (2007), Quantum Computing explained,(1st ed.) New York John Wiley & Sons.
3. Bouwmester, P.,Ekert,A. & Zeilinger,A. (2000) The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, Quantum Computation. Berlin: Springer Verlag.
4. Williams, C . P (2011) Exploration in Quantum Computation, (2nd ed.) Berlin: Springer Verlag.
5. Brylinsky, A. K. & Chen, G. (2002) Mathematics of Quantum Computation. London: Chapman & Hall/CRC.

PHYS-6327 Particle Physics Cr.H-3(3-0)

Particle Classification, Quantum numbers, leptons, hadrons, baryons, mesons, quarks, The Fundamental Interactions, The electromagnetic coupling, the strong coupling, the weak coupling, Symmetry Transformation and Conservation Laws, Translation in space, rotation in space, the group SU (2), systems of identical particles, parity, iso-spin charge conjugation, time reversal, G parity, CPT theorem, The Electromagnetic Field, Gauge invariance and Maxwell's equations, polarization ad photon spin, angular momentum, parity and C parity of photon, Hadron Spectroscopy, Formation experiment, partial wave formalism and the optical theorem, the Breit-Wigner resonance formula, baryon resonances, phase space considerations, production experiments, The Quark Model, The group SU (3), quarks, hadrons baryons, mesons in quark model, heave meson spectroscopy, the quarkonium model, The Standard Model (qualitative treatment only), Unification of weak and electromagnetic interactions Glashow-Salam-Weinberg Model.

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Recommended Books:

1. Griffiths, D.(2008) Introduction to Elementary Particles (2nd ed.) Weinheim: Wiley.
2. Riazuddin and Fayyazuddin (2012). Quantum Mechanics.(2nd ed.) Singapore: World Scientific.
3. Povh. B. Rith. K & Scholz. C. (2006) Particles and nuclei: an introduction to the physical concepts (5th ed.) Berlin: Springer.

PHYS-6328 **Thesis** **Cr.H-6**

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