TWO YEAR M.SC. PROGRAMME IN PHYSICS

Offered By

DEPARTMENT OF PHYSICS, IIT PATNA

Master of Science (Physics)

The Department of Physics would start a two year Master of Science (Physics) Program in 2016. This program is designed to cover a wide range of subjects within both theoretical and experimental physics. The students will have the access of modern laboratory and computational facilities and during the study they will have assignments involving the same. In project work and on the Master's Thesis the students will have the opportunity to apply their knowledge to forefront areas of the subject. It is expected and desired that a large fraction of M. Sc. passed out students would find their places for higher studies in various prestigious institutes/universities all over the world.

Admission Procedure:

The admission to the two year (Four Semester) M.Sc. (Physics) program will be through the Joint Admission Test (**JAM**) conducted by all IITs.

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Semester-wise Course Structure

SEMESTER I

Code	Course Name	L	T	P	C
PH421	Mathematical Physics	3	1	0	8
PH423	Classical Mechanics	3	1	0	8
PH425	Quantum Mechanics I	3	1	0	8
PH427	Numerical Techniques	2	0	2	6
HS513	Technical Communication	2	0	0	4
PH429	Electronics	2	1	0	6
PH430	Electronics Laboratory	0	0	6	6
		15	4	8	46

SEMESTER II

Code	Course Name	L	T	P	C
PH420	Quantum Mechanics II	2	1	0	6
PH422	Applied Optics	3	1	0	8
PH424	Statistical Physics	3	1	0	8
PH426	Electrodynamics	3	1	0	8
PH428	Computational Physics	2	0	3	7
PH440	General Physics Laboratory	0	0	6	6
		13	4	9	43

SEMESTER III

Code	Course Name	L	T	P	C
PH521	Atomic & Molecular Physics	3	1	0	8
PH523	Solid State Physics	3	1	0	8
PH525	Particle Physics	3	1	0	8
PH527	Measurement Techniques	2	0	2	6
PH6xx	Elective I	3	0	0	6
PH591	Project I	0	0	8	8
		14	3	10	44

SEMESTER IV

Code	Course Name	L	T	P	C
PH6xx	Elective II	3	0	0	6
PH6xx	Elective III	3	0	0	6
PH6xx	Elective IV	3	0	0	6
PH592	Project II	0	0	16	16
		9	0	16	34

Total Credit = 167

Electives:

PH601	Nanoscience	3	0	0	6
PH602	Quantum Optics & Quantum Information	3	0	0	6
PH603	Physics of Ultracold Atoms	3	0	0	6
PH604	Biophotonics	3	0	0	6
PH605	Introduction to Medical Physics	3	0	0	6
PH606	Magnetic Materials and Applications	3	0	0	6
PH607	Materials for Engineering Application	3	0	0	6
PH608	Atomic Collision Physics	3	0	0	6
PH609	Fourier Optics and Holography	3	0	0	6
PH610	Introductory Biophysics	3	0	0	6

DETAIL COURSE CONTENT

Course Name	**Mathematical Physics**
Course Number	PH421 (Core)
Course Credit	3 – 1 – 0 – 8
Prerequisite	None

Theory of Complex analysis, Complex integrals & applications: Geometrical representations of $w = f(z)$: Conformal Transformations; Schwarz– Christoffel Transformation; Solutions to Dirichlet and Newmann problems; Applications to fluid flow, electrostatics and heat flow; Integral Transforms of derivatives, Convolution; Partial Differential Equations; Special Functions: Neumann and Hankel functions, Spherical Bessel functions, Hermite, Laguerre, Hypergeometric and Confluent hypergeometric functions, Chebyshev polynomials; Integral Equations: Generating functions, Newmann series, Separable degenerate Kernels, Hilbert-Schmidt Theory; Sturm – Liouville Theorem – Orthogonal functions: Self adjoint DE, Hermitian operators, Gram – Schmidt Orthogonalization, Completeness of Eigenfunctions, Green's function – Eigen function Expansion; Group Theory: Definition, Subgroups and Classes, Group representations, Characters, Physical applications, Infinite groups, Irreducible representations of SU(2), SU(3) and O(3)

Textbooks:

1. George B. Arfken and Hans J. Weber, Mathematical methods for physicists, Academic Press Inc., 4^{th} Edition, 1995

2. I.A. Gradshteyn, I.M. Ryzhik, Sixth Edition, Academic Press, 2000.

3. M. Abramowitz and I. A. Stegan, Mandbook of Mathematical Functions, Dover Publications, INC., New York, 1965.

References:

1. E. Kreyszig, Advanced Engineering Mathematics, Wiley India, 8^{th} Edition, 2008.

Course Name	**Classical Mechanics**
Course Number	PH423 (Core)
Course Credit	3 – 1 – 0 – 8
Prerequisite	None

Review of Lagrangian and Hamiltonian formalisms in various systems, Legendre transforms, Principle of least action, Hamilton's canonical equations and their applications; Isometries, Noether theorem and conservation laws; Lagrangian and Hamiltonian for relativistic particle; Canonical transformations, Infinitesimal Canonical transformation, Integral invariant of Poincare; Lagrange and Poisson brackets and their applications; Liouville's theorem; Hamilton-Jacobi equation, Action and angle variable and their applications; Harmonic oscillator and Central Force problems including discussion of Normal modes and Scattering; Rigid body motion, Euler's equations and applications; State space, limit cycles and their stability, linearization near fixed points, bifurcation and routes to chaos.

Textbooks:

1. Classical Mechanics, H. Goldstein, C. P. Poole and J. Safko, Pearson Education; 3rd, International Economy Edition, 2011 (**ISBN-13:** 978-8131758915).
2. Classical Mechanics, J. R. Taylor, University Science Books, 2005 (**ISBN-**13: 978-1891389221).

References:

1. Classical Mechanics, L. D. Landau and E. M. Lifshitz, Course on Theoretical Physics, Vol.1, 3rd Edition, Butterworth-Heinemann (**ISBN**-13: 978-0750628969).
2. Classical Mechanics, N.C. Rana and P. S. Joag, McGraw Hill Education (India) Private Limited, 2001 (**ISBN-13:** 978-0074603154).
3. Introduction to Dynamics, I. Percival and D. Richards, Cambridge University Press, 1983 (**ISBN-13:** 978-0521174060).

Course Name	**Quantum Mechanics-I**
Course Number	PH425 (Core)
Course Credit	3 – 1 – 0 – 8
Prerequisite	None

Review of Basic Concepts: Experimental Background; Wave packet & its spreading; Coordinate and Momentum representations; Simultaneous eigenfunctions; Complete set of eigenfunctions; One-dimensional problems: Square well problem; Delta-function potential; Double-well; Application to molecular inversion; Kronig-Penney model.

Hermitian & Unitary matrices, Linear vector spaces, Bra and ket vectors. Completeness, orthonormality, basis sets, change of basis; Generalized uncertainty relation; One dimensional harmonic oscillator by operator method, Time evolution operator, Schrödinger, Heisenberg and interaction pictures. Stern-Gerlach experiment, spin-1/2 system.

Three dimensional problems in Cartesian and spherical polar coordinates, spherical harmonics, 2-d & 3-d well, 3-d harmonic oscillator, degeneracy, Hydrogen atom.

Angular momentum algebra; Raising and lowering operators; Matrix representation of Angular momentum, spin-1/2 and finite rotations; Pauli matrices; Addition of angular momenta, Clebsch-Gordan coefficients.

Time independent perturbation theory, First and second order corrections to the energy eigenvalues; First order correction to the eigenvector; Degenerate perturbation theory; Application to one-electron system; Spin-orbit coupling (L-S and j-j), Zeeman effect and Stark effect; Helium atom.

Textbooks:

1. *Quantum Mechanics (Vol-I),* C. Cohen-Tannoudji, B. Diu, F. Laloẽ, John Wiley & Sons (Asia) (2005).
2. *Modern Quantum Mechanics*, J. J. Sakurai, Pearson Education (2002).
3. *Quantum Mechanics*, L. I. Schiff, McGraw-Hill (1968).

References:

1. *Principles of Quantum Mechanics*, R. Shankar, Springer (India) (2008).
2. *Quantum Physics*, S. Gasiorowicz, Wiley India (2007).
3. *Quantum Mechanics*, E. Merzbacher, John Wiley (Asia) (1999).
4. *Quantum Mechanics*, V.K. Thankappan, Wiley Eastern (1985).
5. *The Feynman Lectures on Physics, Vol.3*, R.P. Feynman, R.B. Leighton and M.Sands, Narosa Pub. House (1992).
6. *The Principles of Quantum Mechanics*, P.A.M. Dirac, Oxford University Press (1991).
7. *Quantum Mechanics -Nonrelativistic Theory*, L.D. Landau and E.M. Lifshitz, 3rd Edition, Pergamon (1981).
8. *Introduction to Quantum Mechanics*, D. J. Griffiths, Pearson Education (2005).
9. *Quantum Mechanics*, B. H. Bransden and C. J. Joachain, Pearson Education 2nd Ed. (2004)

Course Name	**Numerical Techniques**
Course Number	PH427 (Core)
Course Credit	2 – 0 – 2 – 6
Prerequisite	None

Algorithm, flowchart, structure of C program, Keywords, Identifiers, Basic data types and sizes, Constants, Variables, Operators, Loops, Arrays- concepts, declaration, definition, accessing elements, and functions, two-dimensional and multi-dimensional arrays, applications of arrays, Functions, pointers

Solution of linear algebraic equation: Gauss-Jordan elimination, LU and Cholesky decomposition; Interpolation and extrapolation: Polynomial, Rational functions, Application in two or more dimension; Numerical integration: Romberg, Gaussian Quadration and Orthogonal polynomials; Numerical differentiation of functions; Root finding and nonlinear sets of equations: Bisection, Secant, Regula-falsi method, Newton Raphson method, Roots of polynomial, Globally convergent method for nonlinear systems of equations; Minimization or maximization: Golden section search, Parabolic and Brent's method, Downhill simplex, Conjugate gradient method; Eigensystems: Jacobi transformation, Eigenvalue and eigenvector, Hermitian, Reduction to Hessenberg form; FFT in two or more dimensions; Least square method and non-linear models; Integration of ODE: Runge-Kutta and Predictor-Corrector method; Two point boundary value problems; Integral equation: Linear Regularization and Backus-Gilbert method; PDE: Flux-conservative method for initial value problem, Relaxation-method for boundary value problem

Textbooks:

1. Y. Kanetkar, Let us C, 13th edition, BPB publication 2013.
2. W. H. Press, S. A. Teukolsky, W T. Vetterling and B. P. Flannery, Numerical Recipes in C: The Art of Scientific Programming, 2nd Edition, Cambridge University Press, 1997

Reference:

1. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Edition, New Age International (P) Ltd. 2014
2. B. S. Grewal, Higher Engineering Mathematics, 43rd Edition, Khanna Publishers 2014
3. Let Us C, Yashavant P. Kanetkar, Infinity Science Press; 8th Revised edition edition, 1 January 2008.
4. Let Us C++, Yashavant P. Kanetkar, BPB, 14 March 2003.
5. Programming in ANSI C, Tata McGraw-Hill Education, 2008.
6. Programming with C (Schaum's Outlines Series), McGraw Hill Education (India) Private Limited; 3 edition, 27 July 2010.
7. The C++ Programming Language, Addison Wesley; 4 edition, 24 July 2013.

Course Name	**Electronics**
Course Number	PH429 (Core)
Course Credit	2 – 1 – 0 – 6
Prerequisite	None

Recap of Thevenin and Norton theorems; Ohmic and rectifying contacts, p-n junctions, Applications including Varactors, Zener diode, Schottky diode, switching diodes, Tunnel diode, Light emitting diodes, Semiconductor laser, Photodiodes, Solar cell, UJT, Gunn diode, IMPATT devices; Bipolar junction transistors, Operating point, Biasing, AC models, h-parameter analysis; Voltage amplifiers; Darlington pair; Field effect transistor action, JFET, Biasing in ohmic and active regions, MOSFETS; Thyristors and SCR crowbar;

Differential Amplifier, Instrumentation and operational amplifiers; Op-Amp Circuits: Characteristics of ideal and practical op-amp; inverting, noninverting and differential amplifier, Basic characteristics with detailed internal circuit of IC Op-Amp; Active filters; Nonlinear amplifiers using Op-Amps-log amplifier, anti-log amplifier, regenerative comparators; ADC and DAC circuits; Op-amp based self oscillator circuits- RC phase shift, Wien bridge, non-sinusoidal oscillators;

Regulated power supplies, shunt and series regulators; Monolithic linear regulators;

Logic functions and Digital circuits; Karnaugh maps; SOP and POS design of logic circuits; MUX as universal building block; RCA, CLA and BCD adder circuits; ADD-SHIFT and array multiplier circuits; RS, JK and MS-JK flip-flops; registers and counters

Textbooks:

1. Electronic Principles, A. P. Malvino and D. J. Bates, 7th Edition, McGraw Hill India Pvt. Ltd, 2014 (**ISBN-13:** 978-0-07-063424-4).
2. Digital Principles and Applications, D. P. Leach, A. P. Malvino, G. Saha, 8th Edition McGraw Hill India Pvt. Ltd, 2015 (**ISBN-13:** 978-93-3920-340-5).

Reference:

1. Electronic Devices and Circuit Theory, R. L. Boylestad and L. Nashelsky, 11th Edition, Prentice Hall, 2012 (**ISBN-13:** 978-0132622264).

Course Name	**Electronics Laboratory**
Course Number	PH430 (Lab)
Course Credit	0 – 0 – 6 – 6
Prerequisite	None

Introduction to passive and active electronic components and use of instruments including Oscilloscope, Digital storage oscilloscope, Multimeters, Wave-form generators; Use of printed circuit boards, soldering and breadboards;

Analog and Digital electronics experiments including (ten of the following):

1. To study the forward and reverse characteristics of p-n junction diode;
2. To study the IV characteristics of a solar cell in dark and ambient light;
3. To study the characteristics of a light emitting diode;
4. To design and study the characteristics of a CE Amplifier using BJTs;
5. To study the frequency response of an operational amplifier and to use operational amplifier for different mathematical operations;
6. To study the characteristics of a regulated power supply and voltage multiplier circuits;
7. To design a rectangular/triangular waveform generator using Comparators and IC8038;
8. To study Hartley and Wien-Bridge oscillators;
9. Design and study of an ECL OR-NOR circuit;
10. Design and study of an active band pass filter/notch filter;
11. Design and study of an active phase sifter;
12. Design and study of a current/voltage controlled oscillator;
13. Design and study of a RC phase shift oscillator;
14. Design and study of a astable multivibrator;
15. Design and study of timing circuits using 555 timer IC LM555.
16. To study characteristics of an RS, JK and MS-JK flipflops;
17. Implementation of ADC/DAC;
18. Implementation of mathematical operations using Microprocessor

TEXT BOOKS:

3. Electronic Principles, A. P. Malvino and D. J. Bates, 7th Edition, McGraw Hill India Pvt. Ltd, 2014 (**ISBN-13:** 978-0-07-063424-4).
4. Digital Principles and Applications, D. P. Leach, A. P. Malvino, G. Saha, 8th Edition McGraw Hill India Pvt. Ltd, 2015 (**ISBN-13:** 978-93-3920-340-5).

REFERENCE BOOKS:

2. Electronic Devices and Circuit Theory, R. L. Boylestad and L. Nashelsky, 11th Edition, Prentice Hall, 2012 (**ISBN-13:** 978-0132622264).

Course Name	**Quantum Mechanics-II**
Course Number	PH420 (Core)
Course Credit	2 – 1 – 0 – 6
Prerequisite	Quantum Mechanics-I

WKB Approximation, Bohr-Sommerfeld quantization condition; Time dependent perturbation theory, interaction picture; Constant and harmonic perturbations Fermi's Golden rule;

Scattering theory: Laboratory and centre of mass frames, differential and total scattering cross-sections, scattering amplitude; Born approximation, Greens functions, scattering for different kinds of potentials; Partial wave analysis;

Special topics in radiation theory: semi-classical treatment of interaction of radiation with matter, Einstein's coefficients, spontaneous and stimulated emission and absorption, application to lasers;

Symmetries in quantum mechanics: Conservation laws and degeneracy associated with symmetries; Continuous symmetries, space and time translations, rotations; Rotation group, Wigner-Eckart theorem; Discrete symmetries; parity and time reversal.

Relativistic quantum mechanics, Klein-Gordon equation, Interpretation of negative energy states and concept of antiparticles; Dirac equation, covariant form, adjoint equation; Plane wave solution and momentum space, spinors; Spin and magnetic moment of the electron.

Textbooks:

1. *Quantum Mechanics (Vol-II)*, C. Cohen-Tannoudji, John Wiley & Sons (Asia) (2005).
2. *Advanced Quantum Mechanics*, J. J. Sakurai, Pearson Education (2007).
3. *Principles of Quantum Mechanics*, R. Shankar, Springer (India) (2008).

References:

1. *Quantum Mechanics*, L. I. Schiff, McGraw-Hill (1968).
2. *Quantum Mechanics*, E. Merzbacher, John Wiley (Asia) (1999).
3. *Quantum Mechanics*, V.K. Thankappan, Wiley Eastern (1985).
4. *The Feynman Lectures on Physics, Vol.3*, R.P. Feynman, R.B. Leighton and M.Sands, Narosa Pub. House (1992).
5. *The Principles of Quantum Mechanics*, P.A.M. Dirac, Oxford University Press (1991).
6. *Quantum Mechanics -Nonrelativistic Theory*, L.D.Landau and E.M. Lifshitz, 3rd Edition, Pergamon (1981).
7. *Quantum Mechanics*, B. H. Bransden and C. J. Joachain, Pearson Education 2nd Ed. (2004)

Course Name	**Applied Optics**
Course Number	PH422 (Core)
Course Credit	3 – 1 – 0 – 8
Prerequisite	None

Laser fundamentals, Experimental realization of single-mode lasers, Intensity and wavelength stabilization techniques, Tunable lasers and their applications, Pulsed lasers and their applications, Industrial and Medical applications of lasers, Non linear optical mixing techniques, Generation of super continuum lasers, Basics of holography, Applications of Holography, Holographic Optical Elements, Digital holography, Optical Information Security, Introduction to Fiber optics, Types of optical fibers, Single and Multimode fibers, Losses in optical fibers, Fiber optic devices, Optical receivers, Basics of non linear fiber optics, Pulse propagation in fiber optics, Group velocity dispersion, Solitons in optical fibers, Application of fiber optic devices for optical communication.

Textbooks:

1. W. Demtroder, *Laser Spectroscopy, Volume 1, Basic Principles*, Fourth edition, Springer, 2008.
2. W. T. Silvfast, *Laser Fundamentals*, Cambridge University Press, 2008.
3. Robert W. Boyd, *Nonlinear Optics*, Second edition, Academic press, 2003.

Reference:

1. B. E. A. Saleh and M. C. Teich, *Fundamentals of Photonics*, John Wiley & Sons (1991).
2. F.J. Duarte, Tunable Laser applications, Second addition, CRC press, 2008.
3. Robert R. Alfano, The Supercontinuum Laser Source, Springer Science + Business media, LLC.
4. P. Hariharan, *Optical Holography: Principles, Techniques, and Applications*, 2nd ed., Cambridge University Press, 1996.
5. Joseph Rosen, *Holography, Research & Technologies*, InTech, 2011.
6. U. Schnars and W. Jueptner, *Digital Holography*, Springer, 2005.
7. A.K. Ghatak and Thyagarajan, *An Introduction to fiber optics*, Cambridge University Press, 1998.
8. John Crisp and Barry Elliot, *Introduction to fiber optics*, Third edition, Elsevier, 2005.
9. G.P Agrawal, *Non Linear Fiber optics, fourth edition*, Elsevier, 2007.
10. G. Keiser, *Optical fiber communications, Fourth edition*, Tata McGraw Hill, 2008.
11. G.P Agrawal, *Fiber optics communication, Third edition*, Wiley, 2002.

Course Name	**Statistical Physics**
Course Number	PH424 (Core)
Course Credit	3 – 1 – 0 – 8
Prerequisite	None

Review on relativistic quantum mechanics, Conservation laws, Parity charge conjugation and time reversal, CPT-theorem, Permutation Symmetry, Isospin, G-parity, Strange particles, Unitary symmetry in 2-dimensions, Lie algebra of SU(2), SU(2) Representations, Unitary symmetry in 3-dimensions, Lie Algebra for U(n), SU(n), Representations of SU(3), Quark model of Hadrons SU(6), Applications of Quark model, Structure of Hadrons, The Quark Parton Model, The weak interactions, Current from weak interactions, nonleptonic weak interaction, CP-Violation, CP-Violation in K-decays, Gauge invariance, The standard model, Charm and heavier flavours, Introduction to Grand Unified Theories, Beyond GUT model, Basics of supersymmetry.

Textbooks:

1. M.P. Khanna, *Introduction to Particle Physics*, Prentice Hall of India, 1999.
2. David Griffiths, Introduction to Elementary Particles, John Wiley, 1987.

References:

1. B.R. Martin and G. Shaw, *Particle Physics*, Third edition, Wiley, 2008.
2. G. Kane, Modern Elementary Particle Physics, Addison-Wesley, 1987
3. Abraham Seiden, Particle Physics: A Comprehensive Introduction, 1st Edition, Pearson Education Inc. 2005

Course Name	**Electrodynamics**
Course Number	PH426 (Core)
Course Credit	3 – 1 – 0 – 8
Prerequisite	None

Classical electrodynamics: Maxwell equations, pointing macroscopic electromagnetism, conservation laws, plane electromagnetic waves and propagation in non conducting medium and insulator, magneto hydrodynamic waves, wave guides, resonant cavities and optical fibers, Radiation systems, multiple fields and radiation scattering and diffraction dynamics of relativistic particles and electromagnetic fields, radiation by moving charge, Bremstrahlung , method of virtual quanta, radiation damping.

Basics in Quantum electrodynamics: Electromagnetic field in quantum theory, wave equation for particles with spin zero, helicity states of a particle, wave equation for particles with spin ½, four dimensional spinors, Dirac equation in the spinor representation, Dirac equation for an electron in an external filed.

Textbook

1- Classical Electrodynamics, Jackson, John David, Willey, 1999
2- Quantum Electrodynamics, Greiner, Walter, Reinhardt, Joachim, Springer, 2009

References:

1- Quantum Electrodynamics, Iwo Białynicki-Birula, Zofia Białynicka-Birula, Elsevier, 1975.
2- Classical and Quantum Electrodynamics and the B(3) Field, Myron Wyn Evans, L. B. Crowell, world scientific, 2001.
3- Course of Theoretical Physics: Vol. 8, Electrodynamics of Continuous Media, Lev Davidovich Landau, Evgenij M. Lifshitz, L.P. Pitaevskii, 15th 1984 by Butterworth-Heinemann (first published 1984).
4- Classical Electrodynamics, Walter Greiner, D. Allan Bromley, Sven Soff, springer, 1998
5- Quantum Electrodynamics, Richard P. Feynman lecture
6- Principles of Electrodynamics, Melvin Schwartz McGraw-Hill Book Company, New York, 1972.

Course Name	**Computational Physics**
Course Number	PH428 (Core)
Course Credit	2 – 0 – 3 – 7
Prerequisite	None

Recapitulation of numerical techniques and errors of computation (rounding, truncation); Classical molecular dynamics simulations, Verlet algorithm, predictor corrector method, Continuous systems, hydrodynamic equations, particle in a cell and lattice Boltzmann methods; Schrodinger equation in a basis: numerical implementation of Numerov method, matrix methods and variational techniques; applications of basis functions for atomic, molecular, solid-state and nuclear calculations; Elements of Density functional theories; Monte Carlo simulations, Metropolis, critical slowing down and block algorithms with applications to classical and quantum lattice models; Tractable and intractable problems; P, NP and NP complete problems with examples; Shor and Grover algorithms; Quantum parallelism;

Textbooks:

1. Tao Pang, *An Introduction to Computationl Physics* (Cambridge Univ Press, 2nd Edition, 2006).
2. Steven E. Kooning and Dawn C. Meredith, *Computational Physics* (Westview Press, 1990).

References:

1. J. M. Thijssen, *Computational Physics* (Cambridge University Press, 2nd Edition, 2007).
2. Rubin H. Landau, Manuel José Páez Mejía, Cristian C. Bordeianu, *A Survey of Computational Physics: Introductory Computational Science*, Volume 1 (Princeton University Press, 2008).

Course Name	**General Physics Laboratory**
Course Number	PH440 (Lab)
Course Credit	0 – 0 – 6 – 6
Prerequisite	None

1. Anomalous Zeeman effect experiment
2. Quinck’s tube method for the measurement of paramagnetic susceptibility of liquid
3. Magnetic susceptibility of paramagnetic solid using Gouy’s method
4. B-H loop measurement
5. Study of dielectric constant
6. Michelson Interferometer
7. Kerr Effect
8. Study of a He-Ne laser cavity
9. Balmer’s series of Hydrogen
10. Holography and interferometry
11. Study of Faraday Effect
12. Zeeman effect experiment
13. Study of NMR
14. Hall effect of Metals
15. Mach-Zehnder interferometer
16. Study of Electron Spin Resonance
17. Rutherford Scattering using Geiger-Muller counter tube
18. Pockels effect and electro-optic modulation
19. Measurement of magnetoresistance of semiconductors
20. Resistivity measurement of a thin film using four probe and Van der Pauw methods
21. Positron annihilation
22. X- ray diffraction by telexometer
23. Spectrum analysis with a CCD spectrometer
24. Optical fiber study
25. Optical filtration-Fourier optics
26. Construction of T and π equivalent of two port network.
27. Quantum Entanglement Setup
28. Mossbauer Spectroscopy

Course Name	**Atomic and Molecular Physics**
Course Number	PH521 (Core)
Course Credit	3 – 1 – 0 – 8
Prerequisite	None

One electron atoms , Schrodinger equation for one-electron atoms, Interaction of one electron atoms with electromagnetic radiation, Transition rates, The dipole approximation, The Einstein coefficients, Selection rules, Spectrum of one electron atoms, Line intensities and the life time of the excited states, Line shapes and widths, Fine structure and Hyperfine structure, The Lamb Shift, Zeeman and Stark effect, Many electron systems: central field approximation, Thomas Fermi model, Hartree- Fock method and the SCF, L-S coupling and j-j coupling, Introduction to the Density functional theory, Interaction of many electron atoms with electromagnetic radiation, Molecular structure, Born -Oppenheimer approximation, The rotation and vibration of diatomic molecules, Electronic structure of diatomic molecule, Rotational and Vibrational Spectra of diatomic molecules, Electronic spectra of diatomic molecules, The Franck-Condon principle.

Textbooks:

1. B.H. Bransden and C.J. Joachain, *Physics of atoms and molecules*, Longman Scietific and Technical, 1983.
2. Gordon W and F. Drake , *Springer handbook of atomic, molecular, and optical physics*, Springer, 2006.
3. W. Demtroder, *Atoms, Molecules and Photons*, Springer, 2010.
4. H. Haken and H.C. Wolf, *Physics of Atoms and Quanta*, Springer, 2005.

References

1. Ira N. Levine, Quantum Chemistry, 6th Edition, PHI Learning Private Limited, New Delhi 2009
2. John P. Lowe and Kirk A. Peterson, Quantum Chemistry, 3rd Edition, Academic Press 2009
3. Peter Atkins and Ronald Friedman, 4th Edition, Oxford University Press 2012
4. Collin N. Banwell and Elain M. Mc Cash, Fundamentals of Molecular Spectroscopy, Fourth edition, Tata Mc Graw Hills, 2008

Course Name	**Solid State Physics**
Course Number	PH523 (Core)
Course Credit	3 – 1 – 0 – 8
Prerequisite	None

Crystal physics: Symmetry operations; Bravais lattices; Point and space groups; Miller indices and reciprocal lattice; Structure determination; diffraction; X-ray, electron and neutron; Crystal binding; Defects in crystals; Point and line defects.

Lattice vibration and thermal properties: Einstein and Debye models; continuous solid; linear lattice; acoustic and optical modes; dispersion relation; attenuation; density of states; phonons and quantization; Brillouin zones; thermal conductivity of metals and insulators.

Electronic & Magnetic properties: Free electron theory of metals; electrons in a periodic potential; Bloch equation; Kronig-Penny model; band theory; Semiconductor physics; Quantum Hall effect. Dielectric Response. Magnetic properties;

Superconductivity: General properties of superconductors, Meissner effect; London equations; coherence length; type-I and type-II superconductors.

Noncrystalline Solids: Glasses, Amorphous ferromagnets, Amorphous Semiconductors

Quasicrystals: Stable quasicrystal, metastable quasicrystal

Text Books:

1. C. Kittel, *Introduction to Solid State Physics*, Wiley India (2009).
2. M. A. Omar, *Elementary Solid State Physics*, Addison-Wesley (2009).

References:

1. A. J. Dekker, *Solid State Physics*, Macmillan (2009).
2. N. W. Ashcroft and N. D. Mermin, *Solid State Physics*, HBC Publ. (1976).
3. H. P. Myers, *Introduction to Solid State Physics*, Taylor and Francis (1997).
4. Richard Zallen, The Physics of Amorphous Solids, John Wiley and Sons Inc.,(1983)

Course Name	**Particle Physics**
Course Number	PH525 (Core)
Course Credit	3 – 1 – 0 – 8
Prerequisite	None

Review on Canonical and Grand Canonical Ensemble: Ideal Gases, Equation of state for ideal quantum gas, Einstein's derivation of Planck's Law: Maser and Laser ; Partition function Z: Translational, Rotational and Vibrational; Application of *Z*: Vapour pressure, Real gas and van der Waal gas; Ideal Bose-Einstein (BE) gas: BE distribution and condensation, Thermodynamic properties, Phase space distribution function and Liouville theorem, Ergodicity and H-theorem; Liquid He, Two fluid model of liquid He II, Superfluid phases of ^{3}He; Ideal Fermi-Dirac (FD) gas: FD distribution and degeneracy, Equation of state of FD gas, Landau Diamagnetism, De-Haas van Alfen Effect, Quantized Hall effect, Pauli Paramagnetism, Magnetic properties of imperfect gas, Thermionic emission; Transport theory: Transport processes and distribution functions, Boltzmann equation in absence of collision, Calculation of electrical conductivity (σ) and coefficient of viscosity (η), Boltzmann Differential Transport (BTE) equation, Scattering cross-section and symmetry properties, Reformulation of BTE, Approximation methods for solving BTE, Evaluation of σ and η.

Textbooks

1. F.Reif, Fundamentals of Statistical and Thermal Physics (Levant Books, 2010).
2. K.Huang, Introduction to Statistical Physics (Chapman and Hall/CRC, 2nd Edition, 2009).
3. R. K. Pathria and Paul D. Beale, Statistical Mechanics (Elsevier, 3rd Edition, 2011).

References:

1. F. Mandl, Statistical Physics (Wiley-Blackwell, ELBS Edition, 1988).
2. D. Chandler, Introduction to Modern Statistical Physics (Oxford University Press, 1987).
3. M.Pilschke and B.Bergerson, Equilibrium Statistical Physics, (World Scientific, 1994)
4. B. P. Agarwal ad M. Eisner, Statistical Mechanics, (Wiley Eastern Limited, 1988)
5. Carolyne M. van Vliet, Equilibrium and Non-equilibrium Statistical Mechanics, (World Scientific, 2008).

Course Name	**Measurement Techniques**
Course Number	PH527 (Core)
Course Credit	2 – 0 – 2 – 6
Prerequisite	None

Basics of measurement: uncertainty in measurements, Comparison of measured & accepted values and Two measured values, Checking relationships with a graph, Fractional uncertainties, multiplying two measured numbers, Propagation of uncertainties;

Low level DC measurement of voltage, current and resistance, C-V and Impedance spectroscopy; Deep Level Transient Spectroscopy, Hall effect and Time of Flight methods for charge carriers; Magnetic Response using SQUID magnetometer and VSM;

UV-VIS-NIR spectro-photometer & Ellipsometry, FTIR, Raman spectroscopy; Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM); X-ray diffraction (XRD) and grazing angle XRD;

Textbooks:

1. John R. Taylor, An Introduction to Error Analysis, (University Science Books, 2nd Edition, 1997).

2. Milton Ohring, Materials Science of Thin Films, (Academic Press, 2nd Edition,2006).

Course Name	**Nanoscience**
Course Number	PH601 (Elective)
Course Credit	3 – 0 – 0 – 6
Prerequisite	PH403

Background to Nanoscience, length scales and size effects in smaller systems-pre quantum, review of quantum and statistical mechanics, quantum wells, quantum wires and quantum dots, band structure and density of states, inter band transitions; Electrical transport in nanostructures – Quantum confinement, Coulomb blockade and Conductance quantization, conduction mechanisms – Thermionic effect, Schottky and Poole-Frenkel effect, Arrhenius type thermally activated conduction, variable range hopping conduction and Polaron conduction; Synthesis -Top –down and bottom-up approach, characterization of nanostructures; Semiconductor quantum dots, self assembled monolayers, Metal nanoparticles, core-shell nanoparticles, nano-shells, new nanostructures -carbon (fullerenes, CNTs, graphene, nanodiamond), BN nanotubes; Nanotribology and Nanorheology, stiction, van der Waal's and Casimir forces; Applications in Nanobiology, Nano sensors, Nanoelectronics, Nanomedicines, Molecular nanomachines.

Text Books:

1. Nano – The Essentials, by T. Pradeep, McGraw-Hill Education (2014).
2. Introduction to Nanoscience, by G. L. Hornyak, J. Dutta, H. F. Tibbals, A. Rao, CRC Press (2008).
3. Introduction to Nanoscience and Technology, by K. K. Chattopadhyay, A. N. Banerjee , PHI Learning Private Ltd., (2009)

References:

1. Introductory Nanoscience, by Masuro Kuno, Garland Science (2011).
2. Introduction to Nanotechnology, by Poole and Owen, Wiley Indian Edition (2010).
3. Nanophysics and Nanotechnology, by Edward L. Wolf, Wiley-VCH (2006).
4. Nanotechnology, by Lynn E. Foster, Pearson (2011).
5. Quantum Mechanics, by J. J. Sakurai.
6. Statistical Mechanics, by Kerson Huang.
7. Fundamentals and Applications of Nanomaterials, by Z. Guo and Li Tan.
8. Nanoelectronics and Information technology, by Rainer Waser, Wiley-VCH (2005).

Course Name	**Quantum Optics & Quantum Information**
Course Number	PH602 (Elective)
Course Credit	3 – 0 – 0 – 6
Prerequisite	Quantum Mechanics-I and II

Basic Concepts in Quantum Optics; Quantization of free electromagnetic field; Fock or number states, Quadratures of the fields, Coherent & Squeezed states, Photon added & substracted coherent state, Schrödinger cat state and the cat paradox; Q-representation and Wigner- Weyle distribution; First & second order Coherence, Correlation function; Hanbury Brown-Twiss experiments, Atom-field interaction; Laser without inversion, Quantum theory of laser-density operator approach; Atom optics;
Open quantum system, Master equation; Cavity quantum electrodynamics (cavity-QED), Jaynes-Cummings model, dispersive atom-field interaction in a cavity; Laser Cooling;

Quantum bits (Qubits), Bloch sphere, Quantum gates (single & two qubit); Quantum Entanglement, Bell's Inequality; Quantum Algorithms; Principles of Teleportation;
Examples of Quantum information processing in physical systems: cavity-QED, Ultracold neutral atoms etc.; Current research and development in Quantum Optics & Quantum Information

Textbooks:

1. *Quantum optics*, M.O.Scully & M. Suhail Zubairy, Cambridge Univ. Press, New York (2008).
2. *Quantum Optics*, Girish S. Agarwal, Cambridge Univ. Press, New York (2013).
3. *Quantum Computation & Quantum Information*, M. A. Nielsen & I. L. Chuang, Cambridge Univ. Press, UK (2000).

References:

1. *Quantum Optics: An Introduction*, Mark Fox, Oxford Univ. Press, New York (2014).
2. *The Quantum theory of light*, Rodney Loudon, Oxford Univ. Press, New York (2000).
3. *Quantum Optics*, Klauder & Sudarshan

Course Name	**Physics of Ultracold Atoms**
Course Number	PH603 (Elective)
Course Credit	3 – 0 – 0 – 6
Prerequisite	None

Introduction to ultracold atoms and Bose-Einstein condensate (BEC), critical temperature Basic Scattering theory; Second quantization, Mean field theory, Gross-Pitaevskii equation; 1D nonlinear Schrödinger equation; weak, strong and higher order interactions; BEC in a trap, trap engineering and condensate density; Bright & dark Solitons, exact solution; Applications & future technologies: BEC optical lattices; Faraday waves, phase transition, BEC in a chip, atomic beam splitter, atom lasers, Negative temperature etc.

Alkali metal gases, Introduction to laser cooling, Velocity dependent force, Optical Molasses, Magneto optical trapping (MOT), Limitations of MOT, Different types of trapping, Magnetic and optical trapping, Evaporative cooling techniques in magnetic and optical trap, Applications in quasi-one dimension, Achieving Bose-Einstein Condensates in pure magnetic and optical traps, Hybrid trapping potentials; Various applications in experiments.

Textbooks:

1. C. J. Pethick & H. Smith, *Bose-Einstein Condensation in Dilute Gases*, Cambridge Univ. Press, Cambridge , 2008.
2. A. Griffin, D. W. Snoke & S. Stringari, *Bose-Einstein Condensation*, Cambridge Univ. Press, Cambridge, 1995.
3. Robert W. Boyd, *Nonlinear Optics*, Second edition, Academic press, 2003.

References:

1. Scully, M. O., and M. S. Zubairy. *Quantum Optics.* Cambridge University Press, 1997.
2. Harold J. Metcalf, Peter van der Straten, *Laser Cooling and Trapping*, Springer, 1999.
3. Lambropoulos. P, Petrosyan. D, *Fundamentals of Quantum Optics and Quantum Information*, Springer 2007.
4. M. Lewenstein, A. Sanpera, and V. Ahufinger, Ultracold Atoms in Optical Lattices, Oxford University Press, 2012.

Course Name	**Biophotonics**
Course Number	PH604 (Elective)
Course Credit	3 – 0 – 0 – 6
Prerequisite	None

Fundamentals of light matter interaction [absorption, fluorescence, phosphorescence, Raman scattering, Mie-scattering, Second harmonic generation (SHG) and two photon absorption], Introduction to biological cells, viruses, protein molecules

Optical imaging of cells (using various optical microscopes):
Optical microscopy, Bio-imaging with confocal fluorescence microscope, evanescent wave microscope, SHG and two photon microscopes, Different techniques to achieve super resolution with optical microscopes.

Biodetection in real time (using optical biosensors):
Importance of biodetection in real time, detection of bioanalytes (viruses/protein molecules) using evanescent based fiber-optic biosensor, photonic crystal biosensor and whispering gallery mode biosensor.

Förster resonance energy transfer (FRET) to study protein - protein interactions

Super continuum sources for Biophotonic applications

Optical trapping and manipulation for biomedical applications

Advanced photodynamic therapy (APT)
Nanoplasmonic biophotonics:
Introduction to Nanoplasmonics, Applications of nanoplasmonics in optical trapping, biosensing, APT, and Raman scattering of nanometer sized bioanalytes

Textbooks:

1. X. Shen and R. V. Wijk, *Biophotonics*, Springer, USA, 2005
2. P. N. Prasad, *Introduction to Biophotonics*, Wiley-Interscience, New Jersey, 2003
3. X. Shen and R. V. Wijk, *Biophotonics*, Springer, USA, 2005
4. L. Pavesi and P. M. Fauchet, *Biophotonics*, Springer, Berlin, 2008
5. B. D. Bartolo and J. Collins, *Bio-photonics: Spectroscopy, imaging, sensing and manipulation*, Springer, Netherlands, 2009

References:

1. R. K. Wang and V. V. Tuchin, *Advanced Biophotonics*, CRC press, New York, 2014

Course Name	**Introduction to Medical Physics**
Course Number	PH605 (Elective)
Course Credit	3 – 0 – 0 – 6
Prerequisite	None

Breathing and Metabolism: Breathing, Human Elevation limits, Oxygen transfer in the brain, Photo synthesis, Oxygen transfer in the body, Network theory of the human breathing apparatus, Transport phenomena at the cell membrane, Dielectric measurement of exocytosis processes, Diffusion and scale qualities

Biomechanics and fluid dynamics of the circulatory system: Bone structures, Ski binding, Elasticity of the vertebrae, Lifting a patient, Bones of uniform strength, Lifting weights, The blood as a power fluid, Branching, Bypass, Flow coefficients, Narrowing of the aorta, Blood pressure in the aorta, pulsatile blood flow.

The Senses, Electric currents, Fields and Potential: Information processing, Glasses, Optical illusions, Retina implantation, threshold of vision of the human eye, Visual angle and resolution, Sound propagation, Threshold of hearing, Nerve stimulation, Electrical model of a cell membrane, Measurement of cell membrane potentials.

The physics of Diagnostics and Therapy: X-ray diagnostics and Computer tomography, Ultrasound, Nuclear magnetic resonance, Magnetic Resonance Imaging, Nuclear diagnostics and positron emission tomography, Temperature measurement system, Blood Pressure measurement, ECG, ECHO.

Radiation medicine and protection: Pair production in radiation therapy, Compton scattering, Radiation damage from potassium, Lethal energy dose, Fatal does equivalents, Laser therapy

Textbooks:

1- Medical physics, W. A. Worthoff, H. G. Krojanski, D. Suter, DE DRUYTER, 2014,
2- Medical Physics and Biomedical Engineering, B. H. Brown, R. H. Smallwood, D. C. Barber, P. V. Lawford and D. R. house, Taylor & Francis, Newyork, 1999.

References:

1- The Essential Physics of Medical Imaging, Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt, Jr., and John M. Boone, Wolters Kluwer | Lippincott, Williams & Wilkins, 2011. Third Edition, Philadelphia:,
2- Medical Physics, Martin Hollins, Nelson Thornes Ltd. 2001.
3- The Physics of Radiology, H. E. Jones, J. R. Cunningham, Charles C. Thomas, New York, 2002.
4- Radiation oncology physics : A Handbook for teachers and students, E.B. Podgorsak, IAEA publications, 2005.
5- Handbook of Bio Medical Engineering, Jacob Kline, Academic press Inc., Sandiego, Oxford University Press, 2004.
6- Smart Biosensor Technology, G. K. Knoff, A. S. Bassi, CRC Press, 2006.
7- Physics of Diagnostic Radiology, Thomas S Curry, IV Edition, Lippincott Williams & Wilkins, 1990.
8- The Essential Physics for Medical Imaging, Jerrold T Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., John M. Boome, Lippincott Williams & Wilkins, , 2 nd Edition –2012.
9- Medical Physics: Imaging, Jean A. Pope, Heinemann Publishers, 2012.
10- Nanobiotechnology: concepts, applications and perspectives, Niemeyor, christober M. Mirkin, , Kluwer publications , USA, 2004.
11- Physical Principles of Medical Ultrasonics, C. R. Hill, J. C. Bamber, G. R. ter Haar, John Wiley & Sons, 2005.
12- Diagnostic Ultrasonic principles and use of Instrument, W. M. McDicken, 2nd edition, John Wiley and Sons, New York, 1992.

Course Name	**Magnetic Materials and Applications**
Course Number	PH606
Course Credit	3 – 0 – 0 – 6
Prerequisite	None

Atomic magnetism, diamagnetism and paramagnetism, Hund's rule, Solid state magnetism, 3d transition metals and 4f rare earths, Magnetic interactions, direct exchange and indirect exchange, Magnetic order, Ferromagnetism, Ferrimagnetism, Antiferromagnetism, Spin glasses; Magneto-crystalline anisotropy, Shape anisotropy, Induced magnetic anisotropy, Stress anisotropy, Magnetic surface and interface anisotropy; Magnetic Domain structures and magnetization dynamics, Domain walls, Closure domains, closure domains, damping processes, ferromagnetic resonance; Magnetoresistivity, Anisotropic Magnetoresistance (AMR), Giant Magnetoresistance (GMR), Colossal Magnetoresistance (CMR), Tunneling Magnetoresistance (TMR), Spin polarization, Andreev reflection, Point contact Andreev reflection (PCAR) spectroscopy, BTK theory; Soft Magnetic Materials , Eddy currents, losses in electrical machines, applications in Transformers, Flux-gate magnetometers, recording heads, magnetic shielding, anti-theft systems; Hard Magnetic Materials, Permanent Magnets, operation and stability, applications in motors, loudspeakers, hard drives, wigglers, undulators; Magnetism in reduced dimensions, Atoms, Clusters, Nano-particles, Nanoscale wires, Thin films, Multilayers, Superparamagnetism, Exchange bias, Interlayer exchange coupling (non-magnetic spacer, AFM spacer), Spin engineering, Spin valves.

Textbook

1. Magnetic Materials: Fundamentals and Applications, Nicola A. Spaldin, 2nd Edition, Cambridge University Press.

Reference Books

1. Magnetism and Magnetic Materials, J.M. D. Coey, 1st Edition, Cambridge University Press (2010).
2. Principles of Magnetism and Magnetic Materials, K. H. J. Buschow and F. R. de Boer, Kluwer Academic Publisher, New York (2004).

Course Name	**Materials for Engineering Applications**
Course Number	PH607
Course Credit	3 – 0 – 0 – 6
Prerequisite	None

Orientation: Why materials? Functionality driven material (re)search; Extraction, synthesis, processing, and characterization of materials.
Structural Materials: Introduction to Alloys, Ceramics, Polymers and Composites; Preparation, Processing and Applications; Elastic and Plastic deformation, Residual stress, Hardness, Fracture, Fatigue, strengthening and forming, fracture resistance, fatigue life, creep resistance
Optical Materials: Introduction to optical materials; Interaction of light with electrons in materials; Applications as dielectric coatings, electro-optical devices, optical recording, optical communications.
Magnetic Materials: Properties and processing of magnetic materials; Field, Induction, Magnetization and Hysteresis; Applications as Permanent magnets, Magnetic recording and sensing.
Electronic Materials: Si as material for microelectronics and photovoltaic, preparation, processing and applications; III-V and II-VI semiconductors and optoelectronic applications; Thermoelectric materials, figure of merit, thermoelectric generators and refrigerators; Superconducting Materials and properties, applications including magnets, magneto-encephalography, Josephson junction, SQUID; Conducting Polymers, synthesis and applications; Ferroelectric materials, piezoelectricity and applications; Shape memory alloys and applications.
Energy storage materials: Batteries, principles of electrochemistry; Primary and secondary (rechargeable) batteries and materials; Fuels cells; Ultracapacitors.
Biomaterials: Requirements like absence of toxicity, corrosion resistance, biocompatibility; Metal, ceramic and polymer biomaterials; bio-resorbable and bio-erodible polymers; Applications as implants, and prosthesis.
Nanomaterials: A brief introduction to mechanical, optical, electronic and magnetic properties; Applications (including self healing structural materials, nano-photonic materials, nano-electronic materials, etc) and Safety concerns.

Textbook

1. Materials Science for Engineering Students, Traugott Fischer, Academic Press, 2009.

Reference Books

1. The Structure and Properties of Materials, J.W. Morris, Jr., McGraw Hill, 2005.
2. Principles of Electrical Engineering Materials and Devices, S. O. Kasap, McGraw-Hill, 2005.

Course name	**Atomic collision physics**
Course Number	PH608 (Elective)
Course credit	3-0-0-6
Prerequisite	Quantum Mechanics I and II

Quantum collisions: Optical theorem, Method of Partial wave, Phase shift analysis, Resonances, Integral equation of potential scattering; Lippman-Schwinger equation, Coulomb scattering.

Occupation number representation: creation, destruction and number operators, Many-particle Hamiltonian in occupation number representation, The Hartree-Fock method and the free electron gas, Exchange, statistical and Fermi-Dirac correlations, Time dependence and Dirac picture of quantum mechanics, Dyson's perturbation expansion for the evolution operator.

Feynman Graphs: Creation and destruction operator in the interaction picture, First order Feynman diagrams, Second and higher order Feynman diagrams.

Resonances in Quantum scattering: Scattering of partial wave, Resonances in quantum collisions, Breit-Wigner formalism, Fano parameterization of Breit-Wigner formula, Resonance life time, Time delay in scattering and photoionization.

Textbooks:

1. Quantum Collision Theory, C. J. Joachain, Elsevier (1984).
2. Many-electron Theory, S. Raimes, North-Holland Publishing Company (1972).
3. Quantum Theory of Many-Particle Systems, A. L. Fetter and J. D. Walecka, Dover Books (2003).

References:

1. Atomic Collisions and Spectra, U. Fano and A. R. P. Rau, Academic press (1986).
2. Relativistic Quantum Theory of Atoms and Molecules, I. P. Grant, Springer (2007).
3. Quantum Theory of Scattering, T. Wu and T. Ohumura, Prentice Hall (1962).
4. Atomic Structure Theory, W. R. Johnson, Springer (2007).

Course name	**Fourier Optics and Holography**
Course Number	PH609 (Elective)
Course credit	3-0-0-6
Prerequisite	Applied Optics

Signals and systems, Fourier transform (FT), FT theorems, sampling theorem, Space-bandwidth product; Review of diffraction theory: Fresnel-Kirchhoff formulation, FT properties of lenses; Coherent and incoherent imaging. Basics of holography, in-line and off-axis holography, plane and volume holograms, diffraction efficiency; Recording medium for holograms; Applications of holography: display, microscopy; memories, interferometry, Non-destructive testing of engineering objects, Digital Holography, Digital holographic microscope, 3D display, etc.; Analog optical information processing: Abbe-Porter experiment, phase contrast microscopy and other simple applications; Coherent image processing: Vander Lugt filter; joint-transform correlator; optical image encryption.

Texts:

1. J. W. Goodman, *Introduction to Fourier Optics*, 3^{rd} ed. 2005
2. M. Born and E. Wolf, *Principles of Optics*, 7^{th} ed., Cambridge University Press, 1999
3. P. Hariharan, *Optical Holography: Principles, Techniques, and Applications*, 2^{nd} ed., Cambridge University Press (1996).
4. B. E. A. Saleh and M. C. Teich, *Fundamentals of Photonics*, John Wiley & Sons (1991).

References:

1. E. G. Steward, *Fourier Optics: An Introduction*, 2^{nd} ed., Dover Publications (2004).
2. Robert K. Tyson, Principles and Applications of Fourier Optics, IOP Publishing, Bristol, UK, 2014
3. U. Schnars and W. Jueptner, *Digital Holography*, Springer, 2005.
4. Joseph Rosen, *Holography, Research & Technologies*, InTech, 2011.

Course name	**Introductory Biophysics**
Course Number	PH610 (Elective)
Course credit	3-0-0-6
Prerequisite	None

Review of basic concepts in thermodynamics and statistical mechanics: Entropy, Free energy, Random walk in biology, Introduction to force, time and energy at mesoscopic scales. Hydrophobicity, Ficks law of diffusion, Rigidity and elasticity

Bio-macromolecules: Nucleic acid structure and properties, Protein structure, Ramachandran's plot, Protein folding problem, Levinthal Paradox, enzyme kinetics, Membrane structure and Ion channels, Central Dogma, Gene Expression, Genetic code.

Molecular Recognition: Thermodynamics of Binding, Allostery and Cooperatively, Specificity of macromolecular recognition, Protein-Nucleic acid Interaction, Protein-Protein Interaction.

Experimental methods for structure-function relation in biopolymers: Transient absorption and fluorescence, FRET, FCS, Forced spectroscopic technique (optical tweezers, AFM and Magnetic trap).

Text Books:

(1) Biophysical Chemistry; Cantor and Schimmel I, II and III. **ISBN-13**: 978-0716711902, ISBN-13: 978-0716711889 and ISBN-13: 978-0716711926
(2) The Physics of Living process; A mesoscopic approach. T. A. Waigh **ISBN**: 978-1-118-44994-3
(3) Molecular Biophysics, Structure in motion. M. Daune. **ISBN-13:** 978-0198577829

References:

1. Molecular Driving Forces; Statistical Thermodynamics in Biology, Chemistry, Physics and Nanoscience. Ken A Dill and Sarina Bromberg. ISBN- 0815320515
2. John Kuriyan, BoyanaKonford, and David Wemmer "The Molecules of Life: Physical and Chemical Principles" (Garland Science)
3. "Random Walks in Biology" by Howard C. Berg (published by Princeton University Press)

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