B Tech EP Course structure (July 2018 onwards)

Course No	Course Name	L	T	P	C	Course No	Course Name	L	T	P	C
CH101	Chemistry	3	1	0	8	BT101	Biology	3	0	0	6
CH110	Chemistry Lab	0	0	3	3	CS101	Introduction to Computing	3	0	0	6
EE101	Electrical Sciences	3	1	0	8	CS110	Computing Laboratory	0	0	3	3
MA101	Mathematics–I	3	1	0	8	EE110	Basic Electronics Laboratory	0	0	3	3
ME111	Engineering Drawing	2	0	3	7	MA102	Mathematics-II	3	1	0	8
PH101	Physics-I	2	1	0	6	ME101	Engineering Mechanics	3	1	0	8
						PH102	Physics-II	2	1	0	6
PH110/ ME110	Physics Laboratory/Workshop	0	0	3	3	ME110/ PH110	Workshop/Physics Laboratory	0	0	3	3
		13	**4**	**9**	**43**			**14**	**3**	**9**	**43**
HS101	English Communication ♦	2	0	2	0	SA1xx	Students' Activity Course-I	0	0	2	0
Course No	Course Name	L	T	P	C	Course No	Course Name	L	T	P	C
PH201	Mathematical Physics	3	1	0	8	PH202	Electromagnetics	3	1	0	8
PH203	Classical Mechanics	2	1	0	6	PH204	Quantum Mechanics-I	2	1	0	6
PH205	Semiconductor Devices	3	0	0	6	PH206	Computational Physics	2	0	2	6
PH207	Heat and Thermodynamics	3	0	0	6	PH208	Digital Electronics & Microprocessors	3	0	0	6
PH209	Analog Electronics	2	1	0	6	PH210	General Physics Lab ♣	0	0	6	6
PH211	Electronics Lab-I	0	0	4	4						
EE220	Signals & Systems	3	1	0	8	HS1xx	HSS Elective-I, Level-I	3	0	0	6
		16	**4**	**4**	**44**			**13**	**2**	**8**	**38**
SA2xx	Students' Activity Course-II	0	0	2	0	SA3xx	Students' Activity Course-III	0	0	2	0
HS200	Sustainable Development Goals∗	2	0	0	0		Minor course -II	3	0	0	6
	Minor course-I	3	0	0	6						
Course No	Course Name	L	T	P	C	Course No	Course Name	L	T	P	C
PH301	Statistical Mechanics	3	1	0	8	PH302	Solid State Physics	3	0	0	6
PH303	Quantum Mechanics-II	2	1	0	6	PH304	Measurement Techniques	2	0	2	6
PH305	Engineering Optics	3	0	0	6	PH306	Lasers and Ultrafast Optics	3	0	0	6
PH307	Atomic and Molecular Spectroscopy	3	0	0	6	PH308	Nuclear Science and Engineering	3	0	0	6
PH309	Electronics Lab-II ♣	0	0	4	4	PH310	Advanced Physics Lab	0	0	6	6
						PH312	Mini Project	3	0	0	6
HS1xx	HSS Elective-II, Level-I	3	0	0	6	OExxx	Open Elective-I	3	0	0	6
		14	**2**	**4**	**36**			**17**	**0**	**8**	**42**
SA4xx	Students' Activity Course-IV	0	0	2	0		Minor course -IV	3	0	0	6
	Minor course -III	3	0	0	6						
Course No	Course Name	L	T	P	C	Course No	Course Name	L	T	P	C
PH411	Materials Science & Engineering**	3	0	0	6	PH4xx	Department Elective-I	3	0	0	6
PH413	Nanoelectronics & Nanophotonics**	3	0	0	6	PH4xx	Department Elective-II	3	0	0	6
PH415	Simulation Techniques in physical systems	2	1	0	6	PH4xx	Department Elective-III	3	0	0	6
PH421/ PH4xxx	Project-I/Department Elective	3	0	0	6	PH422/ PH4xxx	Project-II/ Department Elective	3	0	0	6
OExxx	Open Elective-II	3	0	0	6	OExxx	Open Elective-III	3	0	0	6
HS2XX	HSS Elective-I, Level-II	3	0	0	6	HS2XX	HSS Elective-II, Level-II	3	0	0	6
		17	**1**	**0**	**36**			**18**	**0**	**0**	**36**
	Minor course -V	3	0	0	6						

♦ *Only for students lagging language proficiency, to be graded as PP or NP.*

* *Compulsory course for all B.Tech. 3rd semester students, to be graded as PP or NP.*

** *In lieu of these courses, the students can opt for courses from other departments at levels 3 and 4.*

♣ *Only for 2018 batch, PH210 course is Electronics Lab-II and runs in 4th semester while PH309 course is General Physics Lab and runs in 5th semester.*

Total mandatory credits: 318

Summary of the curriculum

Description		Courses	Semester-wise credits								Total
			1	2	3	4	5	6	7	8	
Common Courses		15	43	43							**86**
Departmental Courses	Classroom	16			40	20	26	18			**104**
	Labs	4			4	6	4	6			**20**
	Mixed	2				6		6			**12**
Departmental Project/Electives		9						6	24	24	**54**
HSS Electives		4				6	6		6	6	**24**
Open Electives		3						6	6	6	**18**
		Total Credits	**43**	**43**	**44**	**38**	**36**	**42**	**36**	**36**	**318**

SEMESTER-3

PH-201 Mathematical Physics (3-1-0-8)

Complex Analysis: Functions, Derivatives, Cauchy-Riemann conditions, Analytic and harmonic functions, Contour integrals, Cauchy-Goursat Theorem, Cauchy integral formula, Taylor series, Laurent series, Singularities, Residue theorem and applications, conformal mapping and application.
Partial Differential Equations: Method of separation of variables, Laplace equation, Heat Equation, Wave equations in Cartesian and curvilinear coordinates, Green's function and its applications
Integral transformations: Laplace transformations and applications to differential equations, Fourier series, Fourier integrals; Fourier transforms, sine and cosine transforms; solution of PDE by Fourier transform.
Group Theory: Groups, subgroups, conjugacy classes, cosets, invariant subgroups, factor groups, kernels, continuous groups, Lie groups, generators, SO(2) and SO(3), SU(2), crystallographic point groups.

Texts:

1. *J. Brown and R. V. Churchill, Complex Variables and Applications, McGraw-Hill, 8th Edition (2008)*
2. *G. B. Arfken, H. J. Weber and F. E. Harris, Mathematical Methods for Physicists, Seventh Edition, Academic Press (2012)*
3. *A. W. Joshi, Elements of Group Theory, New Age International Publishers; Fifth edition (2018)*

References:

1. *M. L. Boas, Mathematical Methods in Physical Sciences, John Wiley & Sons (2005)*
2. *P. Dennery and A. Krzywicki, Mathematics for Physicists, Dover Publications (1996)*
3. *I. N. Sneddon, Elements of Partial Differential Equations, McGraw Hill 5. T. Lawson, Linear Algebra, John Wiley & Sons (1996)*

PH-203 Classical Mechanics (2-1-0-6)

Principle of least action: Hamilton's principle, Generalized coordinates, Euler-Lagrange formulation of dynamical systems, Symmetry and conservation theorems

Two body central force problem: conservation of angular momentum and energy, motion in gravitational potential, equation for the orbit, stability of orbit

Rigid Body Dynamics: rigid body rotation about a fixed axis, moment of Inertia tensor, Eigen values and principal axis transformations; Euler angles, Euler equations of a rigid body, precession of heavy symmetrical top

Hamiltonian dynamics: Hamilton's equation of motion, Phase space diagram, Poison brackets, Infinitesimal transformations and symmetry generators, Hamilton-Jacobi equation and associated problems

Small oscillations: dynamical matrix, normal modes

Texts:

1. *N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw-Hill, New Delhi, 1991.*
2. *H. Goldstein, Classical Mechanics, Narosa, New Delhi, 1998.*

References:

1. *J. R. Taylor, Classical Mechanics, University Science Books, 2003.*
2. *L.D. Landau and E.M. Lifshitz, The Classical Theory of Fields, Elsevier, 2005.*

PH205: Semiconductor Devices (3-0-0-6)

Energy bands in solids and Charge carriers.

Semiconductors: Elemental and compound semiconductors, intrinsic and extrinsic materials, Direct and indirect band-gap semiconductors, Heavily doped semiconductors. Charge carrier in semiconductors: mobility, impurity band conduction, excess carriers in semiconductors. Semiconductor Bloch equation, transport properties.

P-N junctions: fabrication, static and dynamic behaviour of p-n junction diodes, Junction breakdown in p-n junctions, tunnel diode, Schottky diode. Bipolar Junction Transistor: fundamentals of BJT operation, BJT fabrication, carrier distribution and terminal current, generalized biasing, switches

Field Effect Transistors: JFET, MOSFET.

Metal Semiconductor junctions: Schottky effect, rectifying and Ohmic contacts. Integrated circuits, fabrication methods.

Optoelectronic Devices: photodiodes, light emitting diodes, semiconductor lasers, photovoltaic cells.

Texts:

1. *S. M. Sze, Physics of Semiconductor devices, 2nd Ed., John Wiley, 1982.*
2. *M. Shur, Introduction to Electronic Devices, John Wiley, 2000.*
3. *J. Singh, Semiconductor Devices - Basic Principles, John Wiley, 2001.*

References:

1. *M. S. Tyagi, Introduction to Semiconductor Materials and Devices, John Wiley, 2008.*
2. *B. G. Streetman, Solid State Electronic Devices, 5th Ed., PHI, 2001.*

PH-207 Heat and Thermodynamics (3-0-0-6)

Kinetic theory and Transport phenomena: Equation of state of a perfect gas, Maxwell velocity distribution, real gases and Vander Wall's equation, collisions, mean free path, viscosity and thermal conductivity, diffusion, Brownian motion.
Laws of thermodynamics and applications: Review of thermodynamic systems, state variables, intensive and extensive parameters, thermodynamic processes, Zeroth and first law of thermodynamics, State functions, internal energy and enthalpy, Joule Thomson effect, Carnot process and entropy, second law of thermodynamics, refrigerators and thermodynamic engines, Otto and diesel engines, TdS equations, Third law of thermodynamics
Thermodynamic potentials: Entropy and internal energy as thermodynamic potentials, Legendre transformation, Helmholtz and Gibbs potentials, enthalpy, grand potential, transformation of variables Maxwell relations.
Phase equilibria: Joule-Thomson expansion, Gibb's phase rule, Clausius-Clapeyron equation, phase equilibrium and Maxwell construction, first order phase transitions, critical point.

Texts:

1. *W. Pauli, Thermodynamics and kinetic theory of gases, Dover Publications, 2010*
2. *M. W. Zeemansky and R. H. Dittman, Heat and thermodynamics, McGraw Hill, 1997*

References:

1. *F. W. Sears and G. L. Salinger, Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa, New Delhi, 1975.*
2. *C. Kittel and H. Kroemer, Thermal Physics, W. H. Freeman & Co., 1980.*
3. *F. Mandl, Statistical Physics, John Wiley, 1978.*
4. *W. Greiner, L. Neise and H. Stocker, Thermodynamics and Statistical Mechanics, Springer, 1995.*

PH-209 Analog Electronics (2-1-0-6)

BJT/FET circuits: BJT, enhancement and depletion MOSFET, Biasing, small signal models and small signal amplifiers of different configurations (CB, CE, CC, CS, CG, CD).
Feedback amplifiers: Four feedback topologies and their characteristics, practical feedback amplifiers
Power Amplifiers: Class A, B, AB, C and D output stages, direct and transformer coupled power amplifier circuits, power transistors.
Differential Amplifiers: BJT/MOSFET differential pair, common mode and differential input operations, large and small signal operation, common mode rejection ratio.
Operational Amplifiers (OpAmps): introduction to opamp, opamp characteristic parameters, offset parameters and their compensation, ideal opamp and its equivalent circuit.

OpAmp Circuits: Inverting and non-inverting amplifiers, arithmetic circuits, comparator, voltage / current converters, integrator and differentiator, logarithmic amplifier.
Active Filters and oscillators: low pass, high pass, band pass and band reject filter circuits; Oscillator principles, LC, phase shift, Wien bridge, voltage controlled oscillators, Schmitt trigger, pulse and square wave generation using Schmitt trigger.
D/A and A/D converters, IC 555, astable and monostable multivibrators.

Texts:

1. *S. Sedra and K. C. Smith, Microelectronic Circuits, Oxford University Press, 2008.*
2. *R. A. Gaykwad, Op-Amps and Linear Integrated Circuits, Prentice- Hall of India, 2002.*

References:

1. *J. Millman and C. C. Halkias, Integrated Electronics, Tata McGraw Hill, 1995.*
2. *R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, Pearson Education, 2007.*

PH211: Electronic Lab - I (0-0-4-4)

Amplifiers: single-stage and multi-stage amplifiers, frequency response, Fourier transform, various classes of amplifiers and their frequency response, various modulation schemes. Multivibrators and wave function generators, filters. Measurement of depletion layer capacitance and effect of temperature. Controller circuits.

References:

1. *P. B. Zbar and A. P. Malvino, Basic electronics: A text-lab manual, Tata McGraw Hill, 1983.*
2. *P. Horowitz and W. Hill, The Art of Electronics, Cambridge University Press, 1995.*
3. *R. A. Gayakwad, Op-Amps and Linear Integrated Circuits, Prentice Hall of India, 2002.*

SEMESTER-4

PH202: Electromagnetics (3-1-0-8)

Electrostatics: Green function, Dirichlet and Neumann boundary conditions, Green function for the sphere. Laplace Equation: Separation of variables in spherical and cylindrical coordinates and general solution (Legendre polynomials, Spherical harmonics, Bessel function, etc.). Multipole expansion.
Dielectrics: Boundary value problem, Clausius-Mossotti equation. Electrostatic energy. Anisotropy and susceptibility tensor.
Magnetism: Green function method for vector potential, Magnetic materials, Boundary value problems. Magnetic field in conductors.
Maxwell equations: Time varying fields, conservation laws, Plane waves, propagation in nonconducting and conducting media. Reflection and refraction, Fresnel relations. Kramers-Kronig relations. Gauge transformation and gauge conditions. Green function method for wave equation. Retarded potentials. Poynting theorem – for harmonic fields – in dispersive medium. Transformation properties of the EM field.
Wave guides & Cavities: Fields within a conductor. Rectangular and cylindrical geometries. Orthonormal modes. Energy flow and attenuation. Power loss and Q-value. Schumann resonances.
Radiation: Oscillating source. Electric dipole, magnetic dipole, and electric quadrupole fields. Centre-fed linear antenna. Multipole expansion and multipole radiation.
Scattering: Scattering of electromagnetic waves.

Texts:

1. *David Griffiths, Introduction to Electrodynamics, 4th Ed, Cambridge University Press, 2017*
2. *J. D. Jackson, Classical Electrodynamics, 3rd Ed., John Wiley, 2005.*

References:

1. *E. C. Jordan and K. G. Balmain, Electromagnetic Waves and Radiating Systems, 2nd Ed., Prentice Hall of India, 1995.*
2. *J. D. Kraus, Antennas, 2nd Ed., McGraw-Hill, 1988.*

PH-204 ***Quantum Mechanics-I*** *(2-1-0-6)*

Basic principles of quantum mechanics: Heisenberg Uncertainlty principle; Introduction to linear vector spaces: bra and ket vectors, completeness, orthonormality, basis vectors, Orthogonal, Hermitian and Unitary operators, change of basis, Eigenvalues and expectation values, position and momentum representation.

Postulates of Quantum Mechanics: Wave particle duality, wave function and its relation to the state vector, probability and probability current density, conservation of probability, equation of continuity, Schrödinger equation.

Simple potential problems: infinite potential well, step and barrier potentials, finite potential well and bound states; Linear harmonic oscillator, operator algebra of harmonic oscillator, coherent states and their properties.

Three dimensional problems: spherical harmonics, free particle in a spherical cavity, central potential, Three-dimensional harmonic oscillator, degeneracy, Hydrogen atom.

Angular momentum: Commutation relations, spin angular momentum, Pauli matrices, raising and lowering operators, L-S coupling, Total angular momentum, addition of angular momentum, Clebsch-Gordon coefficients; The spin-orbit coupling and its consequences, charged particle in a uniform magnetic field.

Texts

1. *R. Shankar, Principles of Quantum Mechanics, Springer (India) (2008).*
2. *D. J. Griffiths, Introduction to Quantum Mechanics, 2nd Ed., Pearson Education (2005)*
3. *P. W. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill (1995).*

References:

1. *J. Sakurai, Modern Quantum Mechanics, Pearson Education (2002).*
2. *F. Schwabl, Quantum Mechanics, Narosa (1998).*
3. *L. Schiff, Quantum Mechanics, Mcgraw-Hill (1968).*
4. *E. Merzbacher, Quantum Mechanics, John Wiley (Asia) (1999).*
5. *Ajit Kumar, Fundamentals of Quantum Mechanics, Cambridge University Press (2018).*

PH206: Computational Physics (2-0-2-6)

Solutions of Algebraic and Transcendental Equations: Bisection methods, Interpolation methods, Iterative methods.
Matrices: System of linear equations, Gauss and Gauss-Jordan elimination, Matrix Inversion, LU decomposition, Eigen value and eigenvector problems, Power and Jacobi method, application to physics problems;
Interpolation: Newton's divided difference method; Linear and nonlinear least squares fitting;
Numerical Differentiation; Numerical integration: Newton–Cotes formulae, Gauss Quadrature;
Ordinary and Partial Differential Equations: Euler, Runge-Kutta and finite difference methods; solution to initial and boundary value problems, Finite difference solutions to hyperbolic, parabolic and elliptic partial differential equations, application to physics problems;
Monte Carlo Simulation: Markov process and Markov chain, random numbers, simple and importance sampling, Metropolis algorithm, 2D-Ising model.

Texts:

1. *S. S. M. Wong, Computational Methods in Physics and Engineering, World Scientific, 2nd Edition, 1997.*
2. *T. Pang, An Introduction to Computational Physics, Cambridge University Press, 2nd Edition, 2006.*

References:

1. *R. H. Landau, M. J. Paez and C. C. Bordeianu,* Computational Physics: Problem Solving with Computer, *Wiley-VCH, 2nd Edition, 2007.*
2. *D. Frenkel and B. Smit,* Understanding Molecular Simulation, *Academic Press, 1996.*
3. *M. E. J. Newman and G. T. Barkema,* Monte Carlo Methods in Statistical Physics, *Clarendon Press, Oxford, 2001.*
4. *M. P. Allen and D. J. Tildesley,* Computer Simulation of Liquids, *Clarendon Press, Oxford, 1991.*
5. *W. H. Press, S. A. Teukolsky, W. T. Verlling and B. P. Flannery,* Numerical Recipes in C/Fortran, *Cambridge, 1998.*

PH-208 Digital Electronics and Microprocessor (3-0-0-6)

Digital Electronics:

Data processing circuits: multiplexers, demultiplexers, encoders, decoders, parity checkers, magnitude comparator, half and full adders, subtractor, adder-cum-subtractor, programmable logic arrays, memory (ROM, RAM, Flash).

Flip Flops: RS, clocked RS, D-type, JK and JK-master slave flip flops; truth tables, input/output waveforms.

Registers and Counters: Serial in - serial out, serial in – parallel out (shift) registers, asynchronous (ripple) and synchronous counters, MOD counters, decade counter.

Microprocessor:

INTEL 8085 Architecture: Bus organization, 8085 microprocessor pin diagram, internal architecture block diagram, MPU design, instruction fetch, decode and execution, machine cycles and bus timing for various operations (opcode fetch, read, write).

INTEL 8085 Instructions: Data transfer group (between registers, registers and memory, registers and I/O devices), Arithmetic group (addition, subtraction, increment, decrement, complement), Logical operation group (AND, OR, NOT, XOR, rotate, compare), Branching operation group (unconditional / conditional jumps), flags, 16 bit arithmetic, Control group – Programming exercises

Stack and Subroutine: stack memory structure, stack access commands, conditional call / return, restart instructions.

Interrupts: 8085 interrupts, restart instruction, vector interrupts, m/c group (EI, DI, SIM, RIM)

Counters and Time Delays: time delay using register/register pair/looping, hexadecimal counter

Memory and I/O Interfacing: memory interfacing – memory structure, address decoding, interfacing circuits, read/write operations, interfacing I/O devices, machine cycles.

Peripherals: 8155 programmable peripheral interface, 8255 general purpose programmable device and 8279 programmable keyboard/display interface

Serial I/O and data communication, evolution of INTEL microprocessors

Texts:

1. *D. P. Leach, A. P. Malvino and G Saha, Digital Principles and Applications, Tata McGraw Hill, 2007.*
2. *R. S. Gaonkar, Microprocessor Architecture, Programming, and Applications with the 8085, 6th Ed., Penram International/ Prentice Hall, 2002.*
3. *N. K. Srinath, 8085 Microprocessor Programming and Interfacing, Prentice Hall of India, 2005*

References:

1. *D. V. Hall, Microprocessors and Interfacing, Tata McGraw-Hill, 1995.*
2. *W. Kleitz, Microprocessor and Microcontroller Fundamentals: the 8085 and 8051 Hardware and Software, Prentice Hall, 1997.*
3. *J. Uffenbeck, Microcomputers and Microprocessors: the 8080, 8085, and Z80 Programming, Interfacing, and Troubleshooting, Prentice Hall, 1999.*
4. *J. F. Wakerly, Digital Design - Principles and Practices, 3rd Ed., Prentice Hall of India, 2005.*

PH210: General Physics Lab (0-0-6-6)

Experiments based on general physics, optics, and condensed matter physics.

References:

1. *R. A. Dunlop, Experimental Physics, Oxford University Press, 1988.*
2. *A. C. Melissinos, Experiments in Modern Physics, Academic Press, 1996.*

* Only for 2018 batch, PH210 course is Electronics Lab-II and runs in 4th semester while PH309 course is General Physics Lab and runs in 5th semester.

Semester - 5

PH-301 Statistical Mechanics (3-1-0-8)

Probability concept: One dimensional random walk problem and any other relevant examples; Different probability distributions: Binomial, Gaussian and Poisson distributions and their region of validity.
Concepts of ensemble and microstates (Quantum and Classical): Phase space, phase cell; Counting of microstates for some examples (using both quantum and classical concepts); Postulate of equal a priori probability; Liouville's theorem; Ergodic hypothesis; Boltzmann H-theorem. Different types of interactions: Thermal interaction, mechanical interaction, Diffusion.
Ensembles: Microcanonical ensemble; Canonical ensemble; Grand canonical ensemble. Equipartition and virial theorems. Gibbs paradox. [10]
Quantum Statistics: quantum mechanical ensemble theory for all ensembles, Wave function for quantum many body system (Bosons and Fermions).
Quantum gases: Ideal Bose gas, Bose-Einstein condensation, black body radiation, phonons; Ideal Fermi gas, Pauli paramagnetism, thermionic emissions, white dwarf. [10]
Critical Phenomena: Van der Waals equations of state and phase transition, critical exponents, Landau model, one dimensional Ising model and its solution by transfer matrix method..

Text books:

1. *Federic Reif, ``Fundamentals of Statistical and thermal physics.'', Sarat Book Distributors, 2010*
2. *R. K. Pathria, ``Statistical mechanics.'', 3rd Ed, Elsevier, 2011.*
3. *Nigel Goldenfeld, ``Lectures on phase transitions and the renormalization group.'', Sarat Book House, 2005.*

Refs:

1. *Kerson Haung, `` Statistical mechanics.'', John Wiley, Asia, 2000*
2. *L. D. Landau and E. M. Lifshitz, ``Statistical Physics I.'', Pergamon, 1980*
3. *M. Toda, R.K. Kubo and N. Saito, ``Statistical Physics I.'', Springer-Verlag Berlin and Heidelberg GmbH & Co. K; 2nd ed, 1998 edition*
4. *H. Eugene Stanley, ``Introduction to Phase transitions and critical phenomena.''*
5. *W. Greiner, L Neise, and H. Stocker, ``Thermodynamics and Statistical Mechanics.''*

PH-303 Quantum Mechanics-II (2-1-0-6)

Approximation methods for stationary states: time-independent perturbation theory, the variation method and the Wentzel–Kramers–Brillouin (WKB) method.
Time Dependent Perturbation Theory: the Schrodinger and the Heisenberg pictures, Heisenberg equations of motion, the interaction picture; two-level systems, sinusoidal perturbation, Fermi's Golden Rule; the adiabatic and sudden approximation.
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.
Scattering Theory: Born approximation, scattering cross-section, partial wave analysis, phase shifts.
Foundations of Quantum mechanics: EPR paradox; Bell's theorem, the no-clone theorem, Schrodinger's Cat.

Texts and References:

1. *R. Shankar, Principles of Quantum Mechanics, Springer (India) (2008).*
2. *D. J. Griffiths, Introduction to Quantum Mechanics, 2nd Ed., Pearson Education (2005).*
3. *J. J. Sakurai, Modern Quantum Mechanics, Pearson Education (2002).*

References:

1. *E. Merzbacher, Quantum Mechanics, John Wiley (Asia) (1999).*
2. *Ajit Kumar, Fundamentals of Quantum Mechanics, Cambridge University Press (2018).*
3. *L.D. Landau and E. M. Lifshitz, Quantum Mechanics, Pergamon, New York (1974).*
4. *B.H.Bransden and C.J.Joachain, Quantum Mechanics, Pearson (2000)*

PH305: Engineering Optics (3-0-0-6)

Geometrical optics: Matrix formulation for lens, mirrors and combinations under paraxial approximation, image formation; brief introduction to primary monochromatic aberrations and chromatic aberrations.

Diffraction: Fresnel and Fraunhoffer diffraction: rectangular and circular aperture; Lens as a Fourier transforming tool, spatial frequency filtering and Image processing; working principle of holography.

Interference: Two and Multiple beam interference, Michelson and Fabry-Perot interferometer; line width and coherence; multilayer thin films as antireflection coatings.

Polarization: Linear and elliptically polarized light, Poincare representation; Jones vector: polarisers and retarders; production of polarized light: polarization by reflection, scattering, and selective absorption; birefringence, anisotropic media, optics of liquid crystals; optical activity, principles of magneto-optics, electro-optics and acousto-optics.

Text Books:

1. *F. A. Jenkins and H. E. White, Fundamentals of Optics, 4^{th} Edition, McGraw Hill, 2011*
2. *B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, 2^{nd} Edition, Wiley, 2007.*
3. *J W Goodman, Introduction to Fourier Optics, 3rd edition, Robert and Company, 2005*
4. *Max Born and Emil Wolf, Principles of optics, 7th edition, Cambridge University Press, 1999*

PH307: Atomic and Molecular Spectroscopy (3-0-0-6)

Review of single electron systems;
Multi-electron atoms: central-field and Hartree – Fock approximations, Thomas Fermi model, angular momentum, LS and JJ coupling, Pauli exclusion principle, alkali spectra, Helium atom, complex atoms;
Interaction with Electric and Magnetic Fields: Zeeman effect, Paschen-Back effect and Stark effect.
Rotational spectra of diatomic molecules, infra-red spectra, diatomic vibrating rotator, vibration rotation spectra;
electronic spectra of diatomic molecules, vibrational coarse structure, Franck- Condon principle, dissociation energy, rotational fine structure;
Spectroscopic Techniques: Interferometers and spectrometers, FTIR, Raman, NMR and ESR spectroscopy.

Texts:

1. *B H Bransden and C J Joachaim, Physics of atoms and molecules, 2nd Ed., Pearson Education, 2007.*
2. *A N Banwell and E M McCash, Fundamentals of molecular spectroscopy, 4th Ed., Tata McGraw Hill, 1995.*

References:

1. *H E White, Introduction to atomic spectra, 1st Ed., McGraw Hill, 1934.*
2. *H. Haken and H. C. Wolf, The Physics of Atoms and Quanta: Introduction to experiment and theory, 7th Ed., Springer, 2010.*
3. *S. Svanberg, Atomic and molecular spectroscopy: basic aspects and practical applications,4th Ed., Springer, 2004.*
4. *W. Demtroder, Laser Spectroscopy, 4th Ed., Springer, 2008.*

PH309: Electronics Lab - II (0-0-4-4)

Experiments using Small Scale Integration and Medium Scale Integration digital integrated circuits: logic gates, flip-flops, counters, multiplexers, de-multiplexers, shift registers, seven segment decoders, monostable multi-vibrators, latches, memories, etc. Assembly language programming for 8085 microprocessor, interfacing 8085 microprocessor with memory and I/O devices, 8085 microprocessor kit based interfacing experiments using peripheral programmable interface such as LED and 7-segment display, Temperature controller, stepper motor control, A/D and D/A converters, etc.

References:

1. *P. B. Zbar and A. P. Malvino, Basic electronics: A text-lab manual, Tata McGraw Hill, 1983.*
2. *A. P. Malvino and D. P Leach, Digital Principles and Applications. McGraw-Hill, 1996.*
3. *R. S. Gaonkar, Microprocessor Architecture, programming & application with 8085, Penram international/Prentice Hall, 5th Edition 1999*

* Only for 2018 batch, PH210 course is Electronics Lab-II and runs in 4th semester while PH309 course is General Physics Lab and runs in 5th semester.

Semester - 6

PH302: Solid State Physics (3-0-0-6)

Free Electron Theory: Drude Model, Widemann-Franz law, Thermal Conductivity, Sommerfeld model, specific heat .

Lattice vibration and thermal properties: Einstein and Debye theory of specific heat, lattice vibrations in harmonic approximation, dispersion relations in monatomic and diatomic chains, optical and acoustic modes, concept of Brillouin zone, phonons, crystal momentum, dispersion relations in three dimensional systems, anharmonic effects, thermal expansion.

Crystal structures: Symmetry operations, Bravais lattice, reciprocal lattice, Brillouin zone, Miller indices, Bragg and Laue diffractions, structure factor.

Electronic properties: Electrons in a periodic potential, Nearly free electron model, Bloch's theorem, Kronig-Penny model, Tight binding model, band theory, effective mass, concept of hole, classification of metal, insulator and semiconductor, semiconductors: intrinsic and extrinsic semiconductors, mobility and electrical conductivity, Hall effect, statistics of semiconductors.

Magnetic properties: Classical and quantum models of diamagnetism, quantum theory of Paramagnetism, Hund's rule, crystal field effect, Curie law, concepts of Ferro, Ferri and anti-ferromagnetism, Heisenberg model and exchange interaction, spin waves and magnon dispersions.

Superconductivity: Meissner effect, London equations, BCS ground state, flux quantization in superconducting ring, type-II superconductors, Josephson tunnelling, high temperature superconductors.

Texts:

1. *C. Kittel, Introduction to Solid State Physics, John Wiley & Sons, 2005.*

References:

1. *N.W. Ashcroft and N.D. Mermin, Solid State Physics, HBC Publication, 1976.*
2. *J. R. Christman, Fundamentals of Solid State Physics, John Wiley & Sons, 1988.*
3. *A.J. Dekker, Solid State Physics, Mcmillan, 1986.*

PH304: Measurement Techniques (2-0-2-6)

Sensors: Resistive, capacitative, inductive, electromagnetic, thermoelectric, elastic, piezoelectric, piezoresistive, photosensitive and electrochemical sensors; interfacing sensors and data acquisition using serial and parallel ports.

Low Pressure: Rotary, sorption, oil diffusion, turbo molecular, getter and cryo pumps; Mcleod, thermoelectric (thermocouple, thermister and pirani), penning, hot cathode and Bayard Alpert gauges; partial pressure measurement; leak detection; gas flow through pipes and apertures; effective pump speed; vacuum components.

Low Temperature: Gas liquifiers; Cryo-fluid baths; liquid He cryostat design; closed cycle He refrigerator; low temperature measurement.

Analytical Instruments: X-ray diffractometer; Spectrophotometers; FT-IR; DSC; lock-in amplifier; spectrum analyser, fluorescence and Raman spectrometer, scanning electron microscope, atomic force microscope, interferometers.

Laboratory Component: physical parameter measurement using different sensors; low pressure generation and measurement; calibration of secondary gauges; cryostat design; CCR operation; data collection from analytical instruments in the department.

Texts:

1. *A. D. Helfrick and W. D. Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice-Hall of India, 1996.*
2. *J. P. Bentley, Principles of Measurement Systems, Longman, 2000.*

References:

1. *G. K. White, Experimental Techniques in Low Temperature Physics, Clarendon, 1993.*
2. *Roth, Vacuum Technology, Elsevier, 1990.*
3. *D. A. Skoog, F. J. Holler and T. A. Nieman, Principles of Instrumental Analysis, Saunders Coll. Publ., 1998.*

PH306: Lasers and Ultrafast Optics (3-0-0-6)

Laser Physics: The Einstein coefficients, light amplification, the threshold condition, laser rate equations, line broadening mechanisms, cavity modes, optical resonator, quality factor, mode selection, Introduction to gas lasers, solid state lasers, and semiconductor lasers.
Ultrafast optics: Introduction to ultrashort pulses (nano-, pico-, femto-, attosecond pulses): generation and propagation; principles of mode locking; pulse compression; laser amplifiers; interferometric autocorrelation; ultrafast measurement techniques: time resolved measurement, electro-optic sampling.
Applications: Nonlinear optical susceptibilities, second harmonic generation, self-focusing;, Step index and graded index optical fibers, attenuation and dispersion, brief introduction to fiber optic communications; Optical solitons, working principle: terahertz spectroscopy, laser ablation, multiphoton absorption.

Texts:

1. *W. T. Silfvast, Laser Fundamentals, 2nd Ed., Cambridge University Press, 2004.*
2. *B.E.A. Saleh and M.C.Teich, Fundamentals of Photonics, 2nd Ed., Wiley, 2007.*
3. *Ultrafast Optics - Andrew Weiner (John Wiley & Sons).*
4. *Ultrashort Laser Pulse Phenomena - J.-C. Diels and W. Rudolph (Academic Press).*
5. *O. Svelto and D. C. Hanna, Principles of Lasers, Springer, 1998.*
6. *R.W. Boyd, Nonlinear Optics, 3rd Ed., Academic Press, 2007.*
7. *A. Ghatak and K. Thyagarajan, Optical Electronics, Cambridge University Press, 2009.*

PH308: Nuclear Science and Engineering (3-0-0-6)

Review of nuclear physics: general nuclear properties, models of nuclear structure, nuclear reactions, nuclear decays and fundamental interactions;

Nuclear radiation: radioactivity, radiation dosimetry, dosimetry units and measurement; radiation protection and control; applications of radiation: medical applications, industrial radiography, neutron activation analysis, instrument sterilization, nuclear dating;

Nuclear fission: nuclear energy, fission products, fissile materials, chain reactions, moderators, neutron thermalization, reactor physics, criticality & design; nuclear power engineering; energy transport and conversion in reactor systems, nuclear reactor safety;

Nuclear fusion: controlled fusion, nuclear fusion reactions, fusion reactor concepts, magnetic confinement, tokamak, inertial confinement by lasers;

Nuclear waste management: components and material flow sheets for nuclear fuel cycle, waste characteristics, sources of radioactive wastes, compositions, radioactivity and heat generation; waste treatment and disposal technologies; safety assessment of waste disposal;

Particle accelerators and detectors: interactions of charged particles, gamma rays and neutrons with matter, electrostatic accelerators, cyclotron, synchrotron, linear accelerators, colliding beam accelerators, gas-filler counters, scintillation detectors, and semiconductor based particle detectors.

Texts:

1. *K. S. Krane, Introductory Nuclear Physics, John Wiley, 1987.*
2. *R. J. Blin-Stoyle, Nuclear and Particle Physics, Springer, 1991.*

References:

1. *J. K. Shultis and R. E. Faw, Fundamentals of Nuclear Science and Engineering, Marcel Dekker, 2007.*
2. *J. E. Turner, Atoms, Radiation, and Radiation Protection, Wiley-VCH, 2007.*
3. *R. L. Murray, Nuclear Energy, 6th Ed., Butterworth-Heinemann, 2008.*
4. *J. J. Duderstadt and L. J. Hamilton, Nuclear Reactor Analysis, Wiley, 1976.*
5. *D. H. Perkins, Introduction to High Energy Physics, Cambridge University Press, 2000.*
6. *J. R. Lamarsh and A. J. Baratta, Introduction to Nuclear Engineering, Prentice Hall, (2001*
7. *G. Chmielewski, C. M. Kang, C. S. Kang, and J. L. Vujic, Radiation Technology: Introduction to Industrial and Environmental Applications, Seoul National University Press, 2006.*

PH310: Advanced Physics Lab (0-0-6-6)

Experiments based on modern optics, lasers, solid state physics, microwave, nuclear physics and advanced measurement techniques.

References:

1. *C. Isenberg and S. Chomet (eds.), Physics experiment and projects for students, Vols. I, II and III, Hemisphere Publishing Corporation, 1998.*
2. *G. L. Squires, Practical Physics, Cambridge University Press, 1999.*

Semester - 7

PH411: Materials Science & Engineering (3-0-0-6)

Classification of engineering materials; equilibrium and kinetics; structure of crystalline and non- crystalline solids; imperfections in solids; phase diagrams: phase rule, phases, binary phase diagram and eutectic, eutectoid and peritectic systems, microstructural changes, the lever rule, examples and application of phase diagram; phase transformation: time scale of phase changes, nucleation and growth, transformation in steel, precipitation processes, solidification and crystallization, re-crystallization and grain growth; diffusion in solids: Fick's laws and their applications, Kirkendall effect, atomistic model of diffusion; Mechanical properties of metals: elastic, anelastic and viscoelastic behaviours, plastic deformation and creep in crystalline materials, hardness, mechanical testing of metals; failure: fracture, fatigue and creep; thermal processing of metal alloys: annealing processes, heat treatment of steels, precipitation hardening; oxidation and corrosion, oxidation resistant materials, protection against corrosion; electrical and optical properties of the materials; ceramics, polymers and composite materials, selection and design consideration; environmental issues in material science.

Texts:

1. *V. Raghavan, Material Science and Engineering: A First Course, 6th Ed, Prentice-Hall of India, 2015.*
2. *W.D. Callister (Jr.), D. J. Rethwisch, Materials Science and Engineering : An Introduction, 10th Ed., John Wiley & Sons Inc., 2003.*
3. *William Smith , Principles of Materials Science and Engineering, 3rd Ed, McGraw-Hill series in materials science and engineering, 2003.*

References:

1. *J. B. Wachtman, Z. H. Kalman, Characterization of Materials, Illustrated Ed., Butterworth-Heinemann, 1993.*
2. *L.H. Van Vlack, Elements of Materials Science and Engineering, 6th Ed., Pearson India, 2002.*

PH413: Nano Electronics and Nano photonics (3-0-0-6)

Nanoelectronics: energy levels, density of states, band structure, coulomb blockade; electron phase correlation, single electron tunnelling; electron transport in nanostructures, electrons in quantum well; quantum wire, quantum dot; resonant tunnelling devices, field-effect transistor, single electron transfer devices; nanoelectromechanical system and sensors.

Nanophotonics: nanoscale field interaction, nanoconfinement; near field microscopy; plasmonics, nonlinear optical phenomena; nanoscale dynamics, quantum well laser; photonic crystal and waveguide; nanophotonics for biotechnology.

Nanofabrication and nanocharacterization: top-down and bottom-up growth method; nanolithography; electron microscopy, scanning probe techniques.

Texts:

1. *G.L. Hornyak, J. J. Moore, H. F. Tibbals, J. Dutta, Fundamental to Nanotechnology, CRC Press, 2018.*
2. *J. J Ramsden, Nanotechnology: An Introduction; 2nd Edition, Elsevier, 2016.*
3. *J. W. Haus, Fundamentals and Applications of Nanophotonics, Woodhead Publishing, 2016.*

References:

1. *X. Zhao, M. Lu, Nanophotonics in Biomedical Engineering, Springer Singapore, 2020.*
2. *L. H. Madkour, Nanoelectronic Materials: Fundamentals and Applications, Springer, 2019.*
3. *H. V. Demir, S. V. Gaponenko, Applied Nanophotonics, Cambridge University Press, 2018.*
4. *A. McGurn, Nanophotonics, Springer, 2018.*
5. *S. M. Bhagyaraj, O. S. Oluwafemi, N. Kalarikkal, S. Thomas, Characterization of Nanomaterials: Advances and Key Technologies, Woodhead Publishing, 2018.*
6. *E. L. Wolf, Quantum Nanoelectronics: An introduction to Electronic Nanotechnology and Quantum Computing, John Wiley & Sons, 2015.*
7. *S. K. Sharma, D. S. Verma, L. U. Khan, S. Kumar, S. B. Khan, Handbook of Materials Characterization, Springer, 2018.*
8. *V. V. Mitin, V. A. Kochelap, M. A. Stroscio, Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications, Cambridge University Press, 2008.*
9. *S. Zhang, L. Li, A. Kumar, Materials Characterization Techniques, CRC Press, 2008.*

PH415: Simulation techniques in physical systems (2-1-0-6)

Introduction to simulation methods, necessity of simulation, physical problems.

Monte Carlo (MC) simulation: Ensemble theory, thermodynamic quantities, fluctuations; Markov process and Markov chain; Random number generator, MC estimates of statistical average, simple and importance sampling; Ergodic principle; Metropolis algorithm, calculations of thermodynamic quantities; Applications.

Molecular dynamics (MD) simulation: Interatomic potentials, periodic boundary conditions, equations of motion, time integration of atomic trajectories, conservation laws; initialisation of simulation, controlling the parameters; equilibriation, calculations of thermodynamic properties; simulation of molecular systems, MD simulation in canonical and iso-thermal isobaric ensemble; calculation of structural and dynamic properties; time correlation functions; Error estimation.

Texts:

1. *D. Frenkel and B. Smit, Understanding Molecular Simulation, Academic Press 1996*
2. *R.Y. Rubinstein and D.P. Kroese, Simulation and Monte Carlo method, John Wiley and Sons Inc. 2008*
3. *J. M. Yeomans, Statistical Mechanics of Phase transitions, Clarendon Press, Oxford, 1992*

References:

1. *M.P. Allen and D. J. Tildesley, Computer Simulation of Liquids, Clarendon Press, Oxford 1991*
2. *J. M. Haile, Molecular dynamics simulation: elementary methods, John- Wiley & Sons Inc. 1997*
3. *D. P. Landau and K. Binder, A Guide to Monte Carlo Simulations in Statistical Physics, Cambridge 2000*
4. *M. E .J. Newman and G. T. Barkema, Monte Carlo Methods in Statistical Physics, Clarendon press 1999*