ETERNAL UNIVERSITY

(ESTABLISHED UNDER HIMACHAL PRADESH GOVERNMENT ACT NO.3 OF 2009)

BARU SAHIB
HIMACHAL PRADESH

WORLD PEACE THROUGH VALUE BASED EDUCATION

AKAL COLLEGE OF BASIC SCIENCES

M. SC. PHYSICS SYLLABUS (REVISED)

(APPROVED VIDE ITEM 81/19/2023 IN THE 81st ACADEMIC COUNCIL MEETING HELD ON 22nd JUNE 2023)

(TO BE EFFECTIVE FROM THE ACADEMIC SESSION 2023-24 ONWARDS)

ETERNAL UNIVERSITY
BARU SAHIB

SYLLABUS

MASTER OF SCIENCE - PHYSICS

(TWO YEAR FULL TIME PROGRAMME)

(FOUR SEMESTER COURSE)

(Effective from session 2023-24 onwards)

DEPARTMENT OF PHYSICS

AKAL COLLEGE OF BASIC SCIENCES

PROGRAMME STRUCTURE
M.Sc. PHYSICS (Without Thesis)
(Effective from session 2023-24 onwards)

Semester	Course Code	Course	L	T	P	C
I	PHY-511	Mathematical Physics-I	3	0	0	3
	PHY-512	Classical Mechanics	3	0	0	3
	PHY-513	Condensed Matter Physics-I	3	0	0	3
	PHY-514	Quantum Mechanics-I	3	0	0	3
	PHY-515	Electronics-I	3	0	0	3
	PHY-516	Physics Laboratory-I	0	0	3	3
	PHY-517	Computational Physics Laboratory-I	0	0	2	2
		Sub Total	**15**	**0**	**5**	**20**
II	PHY-521	Mathematical Physics-II	3	0	0	3
	PHY-522	Condensed Matter Physics-II	3	0	0	3
	PHY-523	Quantum Mechanics-II	3	0	0	3
	PHY-524	Statistical Mechanics	3	0	0	3
	PHY-525	Electronics- II	3	0	0	3
	PHY-526	Physics Laboratory-II	0	0	3	3
	PHY-527	Computational Physics Laboratory-II	0	0	2	2
	PHY-528*	Project Seminar	1	0	0	1
		Sub Total	**16**	**0**	**5**	**21**
III	PHY-531	Nuclear and Particle Physics	3	0	0	3
	PHY-532	Atomic and Molecular Physics	3	0	0	3
	PHY-533	Materials Science	3	0	0	3
	PHY-534	Classical Electrodynamics	3	0	0	3
	PHY-535	Field Visit and Exploratory Physics	0	0	2	2
	PHY-536	Physics Laboratory-III	0	0	3	3
	RM-599	Research Methodology	3	1	0	4
		Sub Total	**15**	**1**	**5**	**21**
IV	**Elective Paper-I (Any One):**					
	PHY-541#	Science of Renewable Energy Sources	3	0	0	3
	PHY-542#	Opto-Electronics				
	PHY-543#	Particle Accelerator Physics				
	Elective Paper-II (Any one):					
	PHY-544#	Nano Physics	3	0	0	3
	PHY-545#	Advanced Computational Physics				
	PHY-546#	Nuclear Technology				
	Elective Paper-III (Any One):					
	PHY-547#	Medical Physics	3	0	0	3
	PHY-548#	Fibre optics and Non-linear Optics				
	PHY-549#	Astrophysics				
	PHY-550*	Project	0	0	10	10
	PHY-551*	Special Seminar	1	0	0	1
		Sub Total	**10**	**0**	**10**	**20**
Grand Total			**56**	**1**	**25**	**82**
Total Credits: 61+21*/#=82						

*** Marks will be given by the committee as per the specific proforma. Result will be satisfactory or non satisfactory.**

 # Compulsory Courses for students pursuing M.Sc. PHYSICS (Without Dissertation). Moreover, for students pursuing M.Sc. PHYSICS (With Dissertation) these are optional courses; any of them can be opted by the students. Result will be satisfactory or non satisfactory.

PROGRAMME STRUCTURE
M.Sc. PHYSICS (With Thesis)
(Effective from session 2023-24 onwards)

Semester	Course Code	Course	L	T	P	C
I	PHY-511	Mathematical Physics-I	3	0	0	3
	PHY-512	Classical Mechanics	3	0	0	3
	PHY-513	Condensed Matter Physics-I	3	0	0	3
	PHY-514	Quantum Mechanics-I	3	0	0	3
	PHY-515	Electronics-I	3	0	0	3
	PHY-516	Physics Laboratory-I	0	0	3	3
	PHY-517	Computational Physics Laboratory-I	0	0	2	2
		Sub Total	**15**	**0**	**5**	**20**
II	PHY-521	Mathematical Physics-II	3	0	0	3
	PHY-522	Condensed Matter Physics-II	3	0	0	3
	PHY-523	Quantum Mechanics-II	3	0	0	3
	PHY-524	Statistical Mechanics	3	0	0	3
	PHY-525	Electronics- II	3	0	0	3
	PHY-526	Physics Laboratory-II	0	0	3	3
	PHY-527	Computational Physics Laboratory-II	0	0	2	2
	PHY-591*	Synopsis Seminar	1	0	0	1
		Sub Total	**16**	**0**	**5**	**21**
III	PHY-531	Nuclear and Particle Physics	3	0	0	3
	PHY-532	Atomic and Molecular Physics	3	0	0	3
	PHY-533	Materials Science	3	0	0	3
	PHY-534	Classical Electrodynamics	3	0	0	3
	PHY-535	Field Visit and Exploratory Physics	0	0	2	2
	PHY-536	Physics Laboratory-III	0	0	3	3
	RM-599	Research Methodology	3	1	0	4
		Sub Total	**15**	**1**	**7**	**23**
IV	PHY-600*	Thesis (Experiments, Results Analysis, Thesis Submission)	0	0	20	20
		Sub Total	**0**	**0**	**20**	**20**
Grand Total			**46**	**1**	**35**	**82**
Total Credits: 61+21*=82						

*** Marks will be given by the committee as per the specific proforma. Result will be satisfactory or non satisfactory.**

 # Compulsory Courses for students pursuing M.Sc. PHYSICS (Without Dissertation). Moreover, for students pursuing M.Sc. PHYSICS (With Dissertation) these are optional courses; any of them can be opted by the students. Result will be satisfactory or non satisfactory.

TENTATIVE MARKS DISTRIBUTION FOR DIFFERENT CREDIT HOUR COURSES

CREDITS L+T+P*	THEORY			PRACTICALS		
	Total	Mid-Session	End Term	Total	Mid-Session	End Term
1+0+0 2+0+0 3+0+0 4+0+0 5+0+0 6+0+0 3+1+0	100	40 (30+10#)	60	-	-	-
0+0+1	0	0	0	100	50	50
1+0+1	50	20 (15+5#)	30	50	-	50
2+0+1	65	25 (20+5)	40	35	-	35
3+0+1	75	30 (25+5)	45	25	-	25
4+0+1	80	35 (30+5)	45	20		20
0+0+2	0	0	0	100	50	50
1+0+2	35	15 (10+5)	20	65	-	65
2+0+2	50	20 (15+5)	30	50		50
3+0+2	60	25 (20+5)	35	40		40
0+0+3	0	0	0	100	50	50

PHY-511 :: Mathematical Physics - I

(Semester I)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	Dimensional analysis, Vector algebra and vector calculus, Divergence and Curl of Vector Field, Line, Surface and Volume integrals, Gauss's Divergence Theorem, Stoke's & Green's Theorem, simple problems.	7
II	Delta and Gamma Functions: Dirac delta function, properties of delta function, Transformation of Gamma Function, Transformation of Beta Function, Relation between Beta and Gamma Functions, factorial notation and applications, Beta function.	9
III	Fourier and Laplace transforms; Fourier series and its properties, Euler's formulae, Fourier sine & cosine Transforms, Laplace transform, Properties of Laplace transforms, Inverse Laplace Transform, Laplace transform of derivatives, Faltung theorem, Inverse Laplace transformation.	12
IV	Linear algebra and matrices: Matrices, Various types of matrices, Rank of a matrix, Caley-Hamilton theorem, Eigen values and Eigen vectors, Diagonalisation of a matrix, Solution of linear equations. Tensors: Introduction, definitions, contraction, direct product. Quotient rule, Levi-Civita symbol, Non-cartesian tensors, metric tensor, covariant differentiation.	14

S.No.	Reference Books
1.	Mathematical Methods for Physicists: G Arfken, HJ Weber, Academic Press, San Diego, 7th ed., 2012.
2.	Matrices and Tensors in Physics: AW Joshi (Wiley Eastern, New Delhi), 2002.
3.	Mathematical Physics: PK Chattopadhyay, Wiley Eastern, New Delhi, 2004.
4.	Mathematical Methods in the Physical Sciences: M Boas, Wiley, New York, 3rd ed., 2007.
5.	Mathematical Physics, by HK Dass, S Chand & Co. Ltd., 2010.
6.	Mathematical Physics by BS Rajput, Pragati Prakashan, 2017.
7.	Mathematical Methods for Physics and Engineering: KF Riley, MP Hobson, SJ Bence, Cambridge University Press, Cambridge, 3rd ed., 2006.
8.	Introduction to Mathematical Physics: C Harper Prentice Hall of India, New Delhi, 2004.

PHY-512 :: Classical Mechanics

(Semester I)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	Lagrangian Formulation: Mechanics of a system of particles; constraints of motion, generalized coordinates, Principle of virtual work, D' Alembert's Principle, Kinetic energy in generalized coordinates, conservation laws and symmetry properties. Dissipative force (Rayleigh's dissipation function) Applications of Lagrangian formulation.	9
II	Variational Principles: Hamilton's principle and its deduction, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems. Hamiltonian Mechanics: Hamiltonian of s system, its equation of motion, Hamilton's equations from variational principle, canonical transformation, Poisson's brackets, Principle of least action	10
III	Hamilton-Jacobi Theory: Hamilton-Jacobi equations for principal and characteristic functions, Harmonic oscillator in H-J method, Action-angle variables for systems with one-degree of freedom. Central force motion: Two body Collisions - scattering in laboratory and Centre of mass frames	9
IV	Rigid Body Motion: Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top. Small Oscillations: Eigenvalue equation, Free vibrations, Normal Coordinates, Vibrations of a tri-atomic molecule.	14

S.No.	Reference Books
1.	Classical Mechanics: H Goldstein, C Poole, J Safko, Pearson Education Asia, NewDelhi, 3rd ed., 2002.
3.	Classical Mechanics: R Douglas Gregory, Cambridge University Press, 2006
4.	Mechanics: L D Landau, E M Lifshitz, 3rd ed., Pergamon, 1976
5.	Introduction to Classical Mechanics: RG Takwale, PS Puranik, Tata McGraw- Hill, 2018
6.	Classical Mechanics of Particles and Rigid Bodies: KC Gupta, Wiley Eastern, 1988
7.	Classical mechanics: NC Rana, McGraw-Hill Education, India Pvt Limited, 2001
8.	Classical Physics: G Aruldhas, PHI learning, 2008
9.	Classical Mechanics: JC Upadhyay, Himalaya Publishing House, 2022
10.	Classical Mechanics: HV Sharma, SL Gupta, V Kumar, Pragati Prakashan, 2012

PHY-513 :: Condensed Matter Physics - I

(Semester I)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	Structure, elastic properties and lattice dynamics: Bragg Law, Reciprocal lattice vectors, structure factor, form factor, Forces between atoms: ionic bonding, cohesive energy of ionic crystal, evaluation of Madelung constant of NaCl structure, elementary idea of covalent bonding, metallic bonding, hydrogen bonding, Van der Waals bonding; Elastic strain and stress components, Elastic compliance and stiffness constants, Elastic constants of cubic crystals. Discussion on dispersion relations for linear mono-atomic and diatomic chains.	12
II	Thermal Properties: Phonon, lattice specific heat, Einstein and Debye model of density of states, Debye T^3 law; Drude model of electrical and thermal conductivity.	8
III	Energy Band Theory: Electrons in a periodic potential: Bloch theorem, Kronig-Penney model, Nearly free electron model; calculation of energy bands using tight binding method; Semiconductor Crystals, equation of motion of electron and hole in an energy band, effective mass and its physical interpretation, effective mass in semiconductors, Band theory of pure and doped semiconductors; elementary idea of semiconductor superlattices.	12
IV	Transport Theory: Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magnetoresistance.	10

S.No.	Reference Books
1.	Introduction to Solid State Physics: C Kittel, Wiley, New York, 8th ed., 2005.
2.	Quantum Theory of Solids: C Kittel, Wiley, New York, 1987.
3.	Principles of the Theory of Solids: J Ziman, Cambridge University Press, 1972.
4.	Solid State Physics: H Ibach, H Luth, Springer Berlin, 3rd ed., 2002.
5.	Solid State Theory: Walter A Harrison, Tata McGraw-Hill, New Delhi, 1970.
6.	Materials Science: MS Vijaya, G Rangarajan, Tata McGraw-Hill, New Delhi, 2003.
7.	Solid State Physics: RK Puri, VK Babbar, S Chand & Company, New Delhi, 2004.

PHY-514 :: Quantum Mechanics - I

(Semester I)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	Mathematical Tools of Quantum Mechanics: Hilbert spaces, Vector spaces and wave functions, Dirac's bra and ket notation, Schwarz inequality, Orthonormal basis; Operators: Projection operator, Hermitian and Unitary operators; Commutators and Heisenberg uncertainty principle, Eigenvalues and Eigenvectors of an operator, matrix mechanics, Harmonic oscillator in matrix mechanics; Postulates of quantum mechanics, Time development of states and operators, Ehrenfest's theorem, Difference between Schrödinger, Heisenberg and Interaction pictures; Problems related to particle in a box and tunneling through a barrier.	15
II	Angular Momentum: Angular part of the Schrödinger equation for a spherically symmetric potential; spherical harmonics; orbital angular momentum, spin angular momentum, total angular momentum operators; eigenvalues and eigenvectors of L^2, L_z, S^2, S_z, J^2 and J_z, addition of angular momenta, C.G. coefficients, hydrogen atom, Stern-Gerlach experiment.	12
III	Time Independent Perturbation: Non-Degenerate and degenerate perturbation theory and its applications, Variational method and WKB approximation with applications to the ground states of harmonic oscillator and other simple systems.	8
IV	Time Dependent Perturbation: General expression for the probability of transition from one state to another, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light.	7

S.No.	Reference Books
1.	Quantum Mechanics: Concepts and Applications: Nouredine Zettili, Wiley, India, 2nd ed., 2016.
2.	A Text book of Quantum Mechanics, PM Mathews, K Venkatesan, Tata McGraw Hill, NewDelhi, 2nd ed., 2004.
3.	Modern Quantum Mechanics: JJ Sakurai, Addison Wesley, Reading, 2004.
4.	Quantum Mechanics: VK Thankappan, New Age, New Delhi, 2004.
5.	Quantum Mechanics: JL Powell, B Crasemann, Narosa, New Delhi, 1995.
6.	Quantum Physics: S Gasiorowicz, Wiley, New York, 3rd ed. 2003.
7.	Quantum Mechanics: MP Khanna, Har Anand, New Delhi, 2006.
8.	Introduction to Quantum Mechanics: David J. Griffiths, Pearson, 2nd ed., 2014.

PHY-515 :: Electronics - I

(Semester I)

L+T+P	:	**3+0+0**	Mid- Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	Circuit Analysis: Lumped circuits, Ohm's Law, KCL, KVL, Thevenin theorem, and Norton theorem, Mesh and Node analysis: Admittance, Impedance, Hybrid and Transmission matrices for two-port networks. Star-Delta Transformation, Superposition theorem, Reciprocity theorem, Maximum power transfer theorem.	11
II	Feedback Amplifiers: Classification of Feedback amplifiers, Properties of negative Feedback amplifiers. Semiconductor Devices and applications: Direct and indirect semiconductors, Varactor diode, Zener diode, MOSFET, FET as switch, Photoconductors, Light emitting diodes, Semiconductor laser, Photodiodes, Solar cell, UJT, Liquid crystal displays.	10
III	Analog Circuits: OP AMP: IC configuration, Differential amplifiers, CMMR, PSRR, inverting, non-inverting and differential amplifier, Basic characteristics with detailed internal circuit of IC Op-amp, Logarithmic and anti-logarithmic amplifiers, Current-to-voltage and Voltage-to-current converter, Electronic circuits - Phase shift oscillator, Wien-bridge oscillator, Transfer function: LP, HP, BP and BS active and passive filters.	11
IV	Communication systems (Broad aspects): Review of analog modulation techniques, Analog pulse modulation techniques; PAM, PTM (PWM, PPM), Sampling theorem, Pulse code modulation (PCM), DM, ADM, DPCM, Introduction to Satellite Communication and cellular mobile communication.	10

S.No.	Reference Books
1.	Semiconductor Devices - Physics and Technology: SM Sze, John Wiley, 2002.
2.	Solid State Electronic Devices: Ben Streetman, Sanjay Banerjee, Prentice Hall India, 6th ed., 2005.
3.	Electronic Principles: AP Malvino, Tata McGraw, New Delhi, 7th ed., 2009.
4.	Linear and Non-linear Circuits: Chua, Desoer, Kuh, Tata McGraw, 1987.
5.	Applications of Laplace Transforms: Leonard R Geis, Prentice Hall, New Jersey, 1989.
6.	Circuit theory Fundamentals and Applications: Aram Budak, Prentice-Hall, 1987.
7.	Integrated Electronics: Millman and Halkias, Tata McGraw Hill, 1991.
8.	Electronic Devices and Circuits Theory: Boylested and Nashelsky, Pearson Education, 10th ed., 2009.
9.	OPAMPS and Linear Integrated circuits: Ramakant A Gayakwad, Prentice Hall, 1992.
10.	Operational amplifiers and Linear Integrated circuits: RF Coughlin, FF Driscoll, PrenticeHall of India, New Delhi, 2000.
11.	The Elements of Fibre Optics: SL Wymer, Regents/Prentice Hall, 1993.
12.	Modern Electronic Communication: Gary M Miller, Jeffrey S Beasley, Prentice Hall, 8th ed., 2004.
13.	Communication Systems: Simon Haykin, John Wiley and Sons, 2001.
14.	Digital Signal Transmission: CC Bissell, D.A. Chapman, Cambridge University, 1992.

PHY-516 :: Physics Laboratory - I

(Semester I)

L+T+P	:	**0+0+3**	**Relative weightage**		
Credits	:	**3**	Mid-Sessional Practical Exam	:	**50**
Contact hours	:	**84**	End-semester Practical Exam	:	**50**

S.No.	Practical Description
1.	To determine the value of low resistance by using Kelvin double bridge.
2.	To determine the coefficient of self-inductance of a coil by Anderson bridge.
3.	To determine the capacitance of a capacitor using Schering bridge method.
4.	To find the capacitance of a capacitor using flashing and quenching of argon lamp.
5.	To find the moment of inertia of a flywheel.
6.	To verify the truth tables of half adder and full adder circuits.
7.	To determine the velocity of ultrasonic waves in a given liquid.
8.	To find the acceleration due to gravity by using bar pendulum.
9.	To study the zener diode characteristics.
10.	To determine the radius of curvature of plane convex lens.
11.	To study the Cathode Ray Oscilloscope and its various applications.
12.	To study of characteristics of semi-conductor devices (UJT, FET).
13.	To study the characteristics of a regulated power supply and voltage multiplier circuits.
14.	To study the integrating and differentiating circuits.
15.	To study the clipping and clamping circuits.
16.	To study the tunnel diode characteristics.
17.	To study the frequency response of an operational amplifier & to use operational amplifier for different mathematical operations.
18.	To study the oscillator circuits.
19.	To design and study the Op-Amp: Characteristics and parameter measurements.
20.	To study Op-Amp as an active filter, its frequency response and basic mathematical operations.
21.	To study the multi vibrators (a) a stable (b) bi-stable (c) mono-stable.
22.	To design (i) Low pass filter (ii) High pass filter (iii) All-pass filter (iv) Band pass filter (v) Band-reject filter using Op-Amps.
23.	To determine the value of Plank's constant using a photo-electric cell.
24.	To determine the value of Cauchy's Constant for the material of given prism using a mercury vapor lamp.
25.	To determine the value of e/m for electron by helical method.
26.	To determine the wavelength and difference in wavelengths of sodium lines using Michelson Interferometer.
27.	To Determine the thickness of mica sheet using Michelson Interferometer.
28.	To determine the Hall voltage, Hall coefficient and the carrier concentration of a given semi-conductor.
29.	To study the series and parallel L.C.R. circuit and find its Q factor for different resistances.
30.	To verify the statement: Power dissipation in the side bands in amplitude modulation is directly proportional to the square of the modulation.

PHY-517 :: Computational Physics Laboratory - I

(Semester I)

L+T+P	:	**0+0+2**	**Relative weightage**		
Credits	:	**2**	Mid-Sessional Practical Exam	:	**50**
Contact hours	:	**56**	End-semester Practical Exam	:	**50**

S.No.	Practical Description
1.	Find standard deviation, mean, variance, moments etc. of at least 25 entries.
2.	Choose a set of 10 values and find the least squared fitted curve.
3.	Generation of waves on superposition like stationary waves and beats
4.	Fourier analysis of square waves.
5.	To find the roots of quadratic equations.
6.	Wave packet and uncertainty principle
7.	Find y for a given x by fitting a set of 9 values with the help of cubic spline fitting technique.
8.	Find first order derivative at given x for a set of 10 values with the help of Lagrange interpolation.
9.	To generate random numbers between (i) 1 and 0, (ii) 1 and 100.
10.	Perform numerical integration on 1-D function using Simpson and Weddle rules.
11.	To find determinant of a matrix - its eigenvalues and eigenvectors
12.	Use Monte Carlo techniques to simulate phenomenon of Nuclear Radioactivity. Modify your program to a case when the daughter nuclei are also unstable.
13.	Statistical and error analysis of (a) given data (b) error estimation in computation.
14.	Operations on a matrix “inversion”
15.	Operations on a matrix “solution of simultaneous equations”
16.	Plotting and interpolation of a function.
17.	Operations on a matrix “diagonalisation (3x3 matrix)”
18.	Finding the value of Pi using monte carlo method
19.	Numerical differentiation and integration of simple functions.

S.No.	Reference Books
1.	Computational Physics: A Guide For Beginners Looking To Speed Up Their Computation:Muhammad Bilal Alli, The MathWorks, Inc., 2018.
2.	A First Course in Computational Physics: Paul L. DeVries, Javier E. Hasbun, 2nd ed., 2010
3.	Computational Physics, Nicholas J. Giordano, Hisao Nakanishi, Prentice Hall 2nd ed., 2005
4.	Numerical Mathematical Analysis: JB Scarborough, Oxford & IBH Book Co., 6th ed., 1979.
5.	A first course in Computational Physics: PL DeVries, Wiley, 2nd ed., 2011.
6.	Computer Applications in Physics: S Chandra, Narosa, 2nd ed., 2005.
7.	Computational Physics: RC Verma, PK Ahluwalia, KC Sharma, New Age, 2000.
8.	Object Oriented Programming with C++: Balagurusamy, Tata McGraw Hill, 4th ed., 2008.

PHY-521 :: Mathematical Physics - II

(Semester II)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	Elements of Probability: Definition of probability, Theorem of totalprobability, Random variables, Poisson Law, Constants of some important distributions: Binomial, Normal and Poisson distributions.	8
II	Differential Equations: Linear Equations with variable Coefficients: Equations of the second order, series solutions of Linear Differential Equation of second order.	8
III	Special functions: Basic properties (recurrence and orthogonality relations, series expansion) of Bessel, Legendre, Hermite and Laguerre functions.	8
IV	Complex Variables: Introduction, Cauchy Riemann conditions. Cauchy's Integral theorem, Cauchy's Integral formula, Taylor & Laurent series; Zeros and singular points, poles, residues and evaluation of integrals. Dispersion relation. Numerical Techniques: Finite differences, Interpolation, Differentiation, integration by trapezoid and Simpson's rule, Runge-Kutta method.	16

S.No.	Reference Books
1.	Special Functions: ED Rainville, MacMillan, New York, 1960.
2.	Mathematical Methods for Physicists: G Arfken, HJ Weber, Academic Press, San Diego, 6th ed., 2005.
3.	Mathematical Methods for Physicists: G Arfken, HJ Weber, Academic Press, San Diego, 7th ed., 2012.
4.	Mathematical Physics: PK Chattopadhyay, Wiley Eastern, New Delhi, 2004.
5.	Mathematical Physics: AK Ghatak, IC Goyal, SJ Chua, MacMillan, India, Delhi, 1986.
6.	Mathematical Methods in the Physical Sciences: M Boas , Wiley, New York, 3rd ed., 2007.
7.	Mathematical Physics: PK Chatopadhyay, Wiley Eastern, New Delhi, 2011.
8.	Introduction to Mathematical Physics : C Harper, Prentice Hall of India, New Delhi, 2006.

PHY-522 :: Condensed Matter Physics - II

(Semester II)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	Magnetism: Dia- and para-magnetism in materials, magnetism in rare earth ions and transition metal ions, Pauli paramagnetism, Exchange interaction - Weiss theory, Heisenberg Hamiltonian; Ferro-, ferri- and antiferromagnetism; spin waves, Bloch $T^{3/2}$ law.	8
II	Dielectric and optical properties of materials: Polarization mechanisms, Clausius-Mosotti relation; sources of polarizability, frequency dependence of polarizability, piezo, pyro- and ferro-electricity, reflectivity in terms of dielectric constant, absorption, interband and intraband transitions, excitons, photoconductivity, luminescence.	12
III	Superconductivity: Experimental Survey, thermodynamics of superconducting transitions, origin of energy gap, iosotope effect, London equation, London penetration depth, coherence length, BCS theory of superconductivity; flux quantization, Josephson junctions, Josephson superconducting tunneling; High T_c superconductors.	12
IV	Defects and Disorders in Solids: Point defects, line defects, dislocations, Burgers vector and circuit; Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order; Quasi crystals.	10

S.No.	Reference Books
1.	Introduction to Solid State Physics: C Kittel, Wiley, New York, 2005.
2.	Quantum Theory of Solids: C Kittel, Wiley New York, 1987.
3.	Materials Science: MS Vijaya, G Rangarajan, Tata McGraw-Hill, New Delhi, 2003.
4.	Solid State Physics: R.K. Puri, V.K. Babbar, S. Chand & Company, New Delhi, 2004.
5.	Principles of the Theory of Solids : J Ziman, Cambridge University Press, 1972.
6.	Solid State Physics: H Ibach, H Luth, Springer, Berlin, 3rd ed., 2002.
7.	A Quantum Approach to Solids: PL Taylor, Prentice-Hall, Englewood Cliffs, 1970.
8.	Intermediate Quantum Theory of Solids: AOE Animalu, East-West Press, New Delhi,1991.
9.	Solid State Physics: Ashcroft, Mermin, Reinhert & Winston, Berlin, 1976.
10.	Liquid Crystals: S Chandrasekhar, Cambridge University, 2nd ed., 1992.
11.	The Liquid Crystal Phases-Physics & Technology: TJ Sluckin, Contemporary Physics, Taylor& Francis, 2000.

PHY-523 :: Quantum Mechanics - II

(Semester II)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	Scattering Theory: Scattering cross-section and scattering amplitude, Born approximation and its application to Yukawa potential and square well potential, Partial wave analysis, optical theorem, phase shift, low energy scattering, Scattering of identical particles.	11
II	Relativistic wave equation: Generalization of the Schrodinger equation, Klein- Gordon Equation, plane wave solutions, charge and current densities, interaction with electromagnetic fields, Hydrogen-like atom (to show it does not yield physical spectrum), non-relativistic limit.	11
III	Relativistic Dirac Equation: Dirac relativistic Hamiltonian, probability density, Dirac's alpha, beta matrices and their properties, non-relativistic limit of Dirac equation. Covariance of Dirac equation, Gama matrices and their properties, plane wave solution, energy spectrum of hydrogen atom, electron spin and magnetic moment, hole interpretation and the concept of positron, spin-orbit coupling, elementary idea of hyperfine structure of hydrogen atom and Lamb shift.	15
IV	Elementary idea of quantization of fields, second quantization, quantum electrodynamics, Feynman diagrams and their applications.	5

S.No.	Reference Books
1.	Quantum Mechanics: MP Khanna, Har Anand, New Delhi, 2006.
2.	Advanced Quantum Mechanics: Satya Prakash, Arihant, Meerut, 2012
3.	Advanced Quantum Mechanics: JJ Sakurai, Addison-Wesley, Reading, 2004.
4.	Lectures on Quantum Field Theory: A Das, World Scientific, 2008.
5.	A Text book of Quantum Mechanics: PM Mathews, K Venkatesan, Tata McGraw Hill, New Delhi, 2004.
6.	Quantum Mechanics: VK Thankappan, New Age, New Delhi, 2004.
7.	Relativistic Quantum Mechanics J. D. Bjorken and S. D. Drell, (McGraw Hill).
8.	Quantum Field Theory: H Mandl, G Shaw, Wiley, New York, 2010.
9.	A first book of Quantum Field Theory: A Lahiri, P Pal, Narosa Publishers, New Delhi, 2nd ed. 2005.

PHY-524 :: Statistical Mechanics

(Semester II)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	The Statistical Basis of Thermodynamics: Laws of thermodynamics, the macroscopic, microscopic states, Thermodynamic potentials, chemical potential, black body radiation and Plank's distribution law, Gibbs paradox, Phase space, Liouville's theorem.	7
II	Maxwell relations, chemical potential, phase equilibria. Phase space, micro- and macro-states. Micro-canonical, canonical, grand-canonical ensembles, density and energy fluctuations, partition functions and its application to classical ideal gas, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble.	12
III	Quantum Statistics of Ideal Systems: Quantum states and phase space, Ideal Bose systems: basic concepts and thermodynamic behavior of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems: thermodynamic behavior of an ideal Fermi gas, discussion of heat capacity of a free-electron gas at low temperatures, Pauli paramagnetism.	12
IV	Elements of Phase First- and second-order phase transitions. Diamagnetism, paramagnetism, and ferromagnetism, Ising model. Fluctuations: Thermodynamic fluctuations, random walk and Brownian motion, introduction to non-equilibrium processes, diffusion equation	11

S.No.	Reference Books
1.	Statistical Mechanics: RK Pathria, PD Beale, Butterworth-Heinemann, Oxford, 3rd ed., 2011.
2.	Statistical Mechanics: K Huang, Wiley Eastern, New Delhi, 1987.
3.	Statistical Mechanics: BK. Agarwal, M Eisner, Wiley Eastern, New Delhi, 2nd ed., 2011.
4.	Elementary Statistical Physics: C Kittel , Wiley, New York, 2004.
5.	Statistical Mechanics: SK Sinha, Tata McGraw Hill, New Delhi, 1990.

PHY-525 :: Electronics - II

(Semester II)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	Digital circuits: Boolean algebra, de Morgans theorem, Karnaugh maps. don't care condition, Data processing circuits: Multiplexers, Demultiplexers, Arithmetic building blocks, Encoders, Decoders, Parity generators, Code convertors, Comparator, Decoders/derivers for display devices.	7
II	Sequential circuits: Flip-Flops RS, JK, D, clocked, master-slave JK flip-flops, Shift registers, Asynchronous and Synchronous counters, Counter design and applications. A/D Converters: Successive approximation, Counter-type, Dual slope, accuracy and resolution, D/A converter using resistive network, accuracy and resolution.	11
III	Digital logic families: RTL, DTL, TTL, ECL, CMOS, MOS, Tri-state logic - switching and propagation delay, fan out and fan in, CMOS, 555 Timer and its application as astable and bistable multi-vibrator. Schmitt trigger. IC technologies MSI, LSI, VLSI, and ULSI. Semiconductor Memories: ROM, PROM and EPROM, RAM, Static and Dynamic Random Access Memories (SRAM and DRAM), content addressable memory, Other advanced memories.	16
IV	Microprocessors: Microprocessor & Micro controller, Introduction to 8086. 8051 Microcontroller: Architecture (Block diagram and pin description), PSW, RAM, ROM, memory interfacing.	8

S.No.	Reference Books
1.	Digital Principles and Applications: Malvino, Leach, Tata McGraw Hill, 2010.
2.	Microelectronics: Millman, Grabel, Tata McGraw Hill, 1999.
3.	A text book of digital electronics, RS Sedha, S. Chand Publishers, 2004.
4.	Integrated Electronics: Millman, Halkias, Tata McGraw Hill, 2010.
5.	Semiconductor Devices- Physics and Technology: SM Sze, John Wiley, 2007.
6.	Digital Computer Electronics: Albert P Malvino, Jerald A Brown, Tata-McGraw Hill, 3rd ed.
7.	Microprocessor Architecture, Programming and Applications with 8085: RS Gaonkar, Prentice Hall, 2002.

PHY-526 :: Physics Laboratory - II

(Semester II)

L+T+P	:	**0+0+3**	**Relative weightage**		
Credits	:	**3**	Mid-Sessional Practical Exam	:	**50**
Contact hours	:	**84**	End-semester Practical Exam	:	**50**

S.No.	Practical Description
1.	To determine the wavelength of He-Ne laser using diffraction grating
2.	To determine the Hall voltage, Hall coefficient and the carrier concentration of a given semi-conductor.
3.	To study temperature-dependence of conductivity of a given semiconductor crystal using four probe method.
4.	To study the intensity of photovoltaic cell and verify inverse square law.
5.	To compare the luminous intensities of two lights using photovoltaic cell.
6.	To determine the band gap of a semiconductor by Four Probe Method.
7.	To study the temperature dependence of a ceramic capacitor: Verification of Curie-Weiss law for the electrical susceptibility of a ferroelectric material.
8.	To study the characteristics of a LED and determine activation energy.
9.	To find the angle of minimum deviation of sodium light by prism using spectrometer.
10.	To study the single slit interference by He-Ne laser.
11.	To study the V-I characteristics of PN junction diode
12.	To obtain the different waveforms using cathode ray oscilloscope (CRO)
13.	To study logic gates and flip flop circuits using on a bread-board.
14.	To determine the wavelength of sodium light by Newton's ring.
15.	To study the characteristics and dead time of a GM Counter.
16.	To study Poisson and Gaussian distributions using a GM Counter.
17.	To determine the electric charge of an electron using Millikan drop experiment.
18.	To study the molecular susceptibility of a given salt by Quincke's method.
19.	To study the variation of modulus of rigidity and internal friction of a specimen rod with temperature.
20.	To determine specific heat of graphite or solids (metals and alloys) at different temperatures.
21.	To determine Ionization potential of mercury/neon using a gas filled diode.
22.	To determine the wave velocity and attenuation in solids by pulse method.
23.	To study solar cell characteristics.
24.	To trace the B-H curve of a given material and to determine its magnetic parameters.
25.	Determination of magneto resistance of an extrinsic semiconductor.
26.	To study the modulation and demodulation of AM wave.
27.	To study the modulation and demodulation of FM wave.
28.	To study hybrid parameters of a transistor and design an amplifier.
29.	To configure various shift registers and digital counters. Configure seven segment displays and drivers.
30.	To study the use of timer IC 555 in astable and monostable modes.

PHY-527 :: Computational Physics Laboratory - II

(Semester II)

L+T+P	:	**0+0+2**	**Relative weightage**		
Credits	:	**2**	Mid-Sessional Practical Exam	:	**50**
Contact hours	:	**56**	End-Semester Practical Exam	:	**50**

S.No.	Practical Description
1.	Particle motion in infinitely deep square well potential.
2.	Plotting of radial eigen function of harmonic oscillator.
3.	Scattering states in step potential and tunneling effect.
4.	Semi classical quantization of molecular vibration.
5.	Fast Fourier transforms of some simple functions.
6.	Scattering by a central potential.
7.	Study of Ising model using Monte Carlo method
8.	Solution of ordinary differential equation and application to order and Chaos in two dimensional motion.
9.	Structure of white dwarf stars.
10.	Simulation of an order disorder phase transition for a three states potts model
11.	Boundary value and eigen-value problems. (a) Stationary solution of one dimensional Schrodinger equation (b) atomic structure in HF approximation.
12.	Special functions and Gaussian Quadrature: (a) partial wave solution of quantum scattering (b) Born and eikonal approximation in quantum scattering.
13.	Write a program to study graphically the EM oscillations in a LCR circuit (use Runge- Kutta Method). Show the variation of (i) Charge vs Time, (ii) Current vs Time
14.	Study graphically the path of a projectile with and without air drag using FN method. Find the horizontal and maximum height in either case. Write your comments on the findings.
15.	Study the motion of an artificial satellite.
16.	Study graphically the motion of falling spherical body under various effects of medium (viscous drag, buoyancy and air drag) using Euler method.
17.	Study the motion of (a) 1-D harmonic oscillator (without and with damping effects). (b) Two coupled harmonic oscillators. Draw graphs showing the relations: (i) Velocity vs Time, (ii) Acceleration vs Time (iii) Position vs Time, also compare the numerical and analytical results.
18.	To obtain the energy eigenvalues of a quantum oscillator using the Runge-Kutta method.
19.	Study the motion of a charged particle in: (a) Uniform electric field, (b) Uniform Magnetic field, (c) in combined uniform E and M fields. Draw graphs in each case.
20.	To study phase trajectory of a Chaotic Pendulum
21.	To study convection in fluids using Lorenz system

S.No.	Reference Books
1.	Computational Physics: A Guide For Beginners Looking To Speed Up Their Computation: Muhammad Bilal Alli, The MathWorks, Inc., 2018.
2.	A First Course in Computational Physics: Paul L. DeVries, Javier E. Hasbun, 2nd ed., 2010
3.	Computational Physics, Nicholas J. Giordano, Hisao Nakanishi, Prentice Hall 2nd ed., 2005
4.	Numerical Mathematical Analysis: JB Scarborough, Oxford & IBH Book Co., 6th ed., 1979.
5.	A first course in Computational Physics: PL DeVries, Wiley, 2nd ed., 2011.
6.	Computer Applications in Physics: S Chandra, Narosa, 2nd ed., 2005.
7.	Computational Physics: RC Verma, PK Ahluwalia, KC Sharma, New Age, 2000.
8.	Object Oriented Programming with C++: Balagurusamy, Tata McGraw Hill, 4th ed., 2008.

PHY-528 :: Project Seminar

(Semester II)

(Applicable to those students who have not opted for Thesis)

L+T+P	:	**1+0+0**	Write-up	:	**25**
Credits	:	**1**	Viva-voce	:	**25**
Contact hours	:	**14**	Presentation	:	**50**

Description

The advisor will be allocated to the students in the start of second semester by the Dean of the college. Students will be assigned the project work by their respective advisor. Students have to make a PowerPoint presentation on the topic assigned to them which will be notified by the office of the Dean. The students will be evaluated by advisory committee members and faculty of the discipline and then average marks will be awarded to the student. The criteria of seminar evaluation proforma are given below:

S.No.	Evaluation Criteria	Max Marks
1.	Originality and creativity	15
2.	Organization and logical presentation of ideas	25
3.	Presentation (Oral presentation and delivery)	25
4.	Knowledge and familiarity with subject matter	15
5.	Quality and neatness of slides, charts and graphs	10
6.	Response to the questions/queries	10
Total		**100**

Satisfactory grade will be awarded on securing minimum 60 marks out of 100. Four copies of the project work outline duly approved by the departmental committee will be submitted by the student in the office of Dean for its final approval before the start of the third semester.

Suggested Journals

S.No.	Name of the research journal/database	Publisher	Website
1.	Journal of Applied Physics	AIP	http://scitation.aip.org/content/aip/journal/jap
2.	Applied Physics Letters	AIP	http://scitation.aip.org/content/aip/journal/apl
3.	Physical Review B	APS	https://journals.aps.org/prb/
4.	Physical Review Letters	APS	http://journals.aps.org/prl/
5.	Journal of Magnetism and Magnetic Materials	Elsevier	http://www.journals.elsevier.com/journal-of-magnetism-and-magnetic-materials/
6.	Journal of Alloys and Compounds	Elsevier	http://www.journals.elsevier.com/journal-of-alloys-and-compounds/
7.	Current Applied Physics	Elsevier	http://www.journals.elsevier.com/current-applied-physics/
8.	Journal of Materials Science and Technology	Elsevier	https://www.sciencedirect.com/journal/journal-of-materials-science-and-technology
9.	Journal of Superconductivity and Novel Magnetism	Springer	http://www.springer.com/materials/journal/10948
10.	Journal of Applied Physics	AIP	http://scitation.aip.org/content/aip/journal/jap

Databases

Elsevier/Science Direct, Springer Link, AIP, APS, Google Scholar, Research Gate.

It is recommended that students should consider journals listed in Q1 and Q2 in the JCR report (Clarivate Analytics).

PHY-591 :: Synopsis Seminar

(Semester II)

(Applicable to those students who have opted for Thesis)

L+T+P	:	**1+0+0**	Write-up	:	**25**
Credits	:	**1**	Viva-voce	:	**25**
Contact hours	:	**14**	Presentation	:	**50**

Description

The Major Advisor will be allocated to the students in the start of second semester by the Dean of the college. Students will be assigned the research topic by their respective advisor. Students have to make a PowerPoint presentation on the research topic assigned to them which will be notified by the office of the Dean. The students will be evaluated by advisory committee members and faculty of the department/college and then average marks will be awarded to the student. The criteria of seminar evaluation proforma are given below:

S.No.	Evaluation Criteria	Max Marks
1.	Originality and creativity	15
2.	Organization and logical presentation of ideas	25
3.	Presentation (Oral presentation and delivery)	25
4.	Knowledge and familiarity with subject matter	15
5.	Quality and neatness of slides, charts and graphs	10
6.	Response to the questions/queries	10
Total		**100**

Satisfactory grade will be awarded on securing minimum 60 marks out of 100. Four copies of the synopsis duly approved by the advisory committee will be submitted by the student in the office of Dean for its final approval before the start of the third semester.

Suggested Journals

S.No.	Name of the research journal/database	Publisher	Website
1.	Journal of Applied Physics	AIP	http://scitation.aip.org/content/aip/journal/jap
2.	Applied Physics Letters	AIP	http://scitation.aip.org/content/aip/journal/apl
3.	Physical Review B	APS	https://journals.aps.org/prb/
4.	Physical Review Letters	APS	http://journals.aps.org/prl/
5.	Journal of Magnetism and Magnetic Materials	Elsevier	http://www.journals.elsevier.com/journal-of-magnetism-and-magnetic-materials/
6.	Journal of Alloys and Compounds	Elsevier	http://www.journals.elsevier.com/journal-of-alloys-and-compounds/
7.	Current Applied Physics	Elsevier	http://www.journals.elsevier.com/current-applied-physics/
8.	Journal of Materials Science and Technology	Elsevier	https://www.sciencedirect.com/journal/journal-of-materials-science-and-technology
9.	Journal of Superconductivity and Novel Magnetism	Springer	http://www.springer.com/materials/journal/10948
10.	Journal of Applied Physics	AIP	http://scitation.aip.org/content/aip/journal/jap

Databases

Elsevier/Science Direct, Springer Link, AIP, APS, Google Scholar, Research Gate.

It is recommended that students should consider journals listed in Q1 and Q2 in the JCR report (Clarivate Analytics).

PHY-531 :: Nuclear and Particle Physics

(Semester III)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model. Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations.	8
II	Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions. Compound nucleus formation and direct reactions, Compound. Nuclear Reaction: Types of nuclear reactions, wave function and scattered waves, differential cross-sections, scattered potential, partial waves, total differential cross-sections and Optical theorem. Berit-Wigner formula, Inverse reactions (Reciprocity Theorem).	16
III	Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.	8
IV	Elements of Quantization and Feynman rules. Standard Model of Particle Physics: SU(3) x SU(2) x U(1) gauge theory, Coupling to Higgs and Matter fields of 3 generations. Gauge boson and fermion mass generation via spontaneous symmetry breaking, CKM matrix. QCD and quark model: Asymptotic freedom and Infrared slavery, confinement hypothesis.	10

S.No.	Reference Books
1.	Nuclear Physics: DC Tayal, Himalaya Publishing House, 1997.
2.	Nuclear Physics: Experimental and Theoretical, HS Hans, New Academic Science, 2011.
3.	Basic Ideas and Concepts in Nuclear Physics: K Hyde, Institute of Physics, 2004.
4.	Concepts of Nuclear Physics: BL Cohen, Tata McGraw Hill, 2004.
5.	An Introduction to High Energy Physics: DH Perkins, Cambridge Press, 4th ed., 2000.
6.	An Introduction to Elementary Particles: D Griffiths, Wiley, 2008.
7.	Introduction to Particle Physics: MP Khanna, Prentice-Hall of India, New Delhi, 2004.
8.	Particle Physics and introduction to Field Theory: TD Lee, Harwood Academic, 1988.
9.	First Book of Quantum Field Theory, A Lahiri, P Pal , Narosa, New Delhi, 2nd ed., 2007.
10.	Nuclear Physics-Problem-Based Approach Including MATLAB: H M Agrawal, PHI LearningPvt. Ltd., 2016.

PHY-532 :: Atomic and Molecular Physics
(Semester-III)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	Molecular Quantum Mechanics: Quantum states of an electron in an atom. Electron spin. Hydrogen molecular ion, hydrogen molecule, Relativistic corrections for energy levels of hydrogen atom, Hyperfine structure and isotope shift, width of spectrum lines, LS and JJ couplings.	**10**
II	Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules; Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation	**13**
III	Atomic and Molecular Spectroscopy: Fine and hyperfine structure of atoms, electronic, vibrational and rotational spectra for diatomic molecules, role of symmetry, selection rules, term schemes, applications to electronic and vibrational problems.	**7**
IV	Interaction of Atoms with Radiation: Atoms in an electromagnetic field, absorption and induced emission, spontaneous emission and line-width, Einstein A and B coefficients, density matrix formalism, two-level atoms in a radiation field. Lasers: spontaneous and stimulated emission, Einstein A and B coefficients, Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.	**12**

S.No.	Reference Books
1.	Fundamental of molecular spectroscopy: C.N. Banwell, Elaine M. McGraw- Hill, 1994
2.	Atoms, Molecules and Photons-An Introduction to Atomic-, Molecular- and Quantum Physics: W. Demtroder, Springer, 2010
3.	Atoms and Molecules-An Introduction for Students of Physical Chemistry: M. Karplus and R.N. Porter, 1970
4.	Molecular Quantum Mechanics: P.W. Atkins and R.S. Friedman, OUP Oxford, 2011.
5.	Elementary Particles: IS Hughes, Cambridge University, 3rd ed., 1991.
6.	Understanding Properties of Atoms, Molecules and Materials: Pranab Sarkar, Sankar Prasad Bhattacharyya, CRC Press, 2022.
7.	Atomic and Molecular Spectra-Laser: Raj Kumar, Kedar Nath Ram Nath, Meerut, 2012.

PHY-533 :: Materials Science

(Semester III)

L+T+P	:	**3+0+0**	Mid- Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-semester exam	:	**60**

Unit	Contents	Lectures
I	Materials Crystal Structure: crystalline and noncrystalline materials, lattice, unit cells, Bravais lattices, Indices of crystal directions and planes, packing factor, radius ratio, zones and zone axes, crystal geometry, symmetry classes and point groups, space groups, glide planes and screw axes, space group notations, systematic absences, phase transition in materials.	11
II	Classification of Materials: Alloys and composites, polymer, ceramics, semiconductors, liquid crystals, quasi crystals, solar energy materials, luminescent and optoelectronic materials, high T_c superconductors.	6
III	Materials Preparation Techniques: Zone refining, epitaxy, melt-spinning and quenching, sol-gel, solid-state reaction techniques, different technique of thin film preparations and their basic principles, synthesis of nanomaterials: Top down and bottom up approaches of synthesis of nano-structured materials (nanorods, nanotubes/wire and quantum dots), polymer processing technique.	12
IV	Materials Characterization Techniques: X-ray Diffraction (XRD), Raman Spectroscopy, X-ray Photoelectron Spectroscopy (XPS), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Inferred (IR) Spectroscopy, Ultraviolet-Visible (UV-Vis) Spectroscopy, Dielectric Spectroscopy, Vibrating Sample Magnetometry (VSM).	13

S.No.	Reference Books
1.	Materials science and Engineering: V. Raghavan, Prentice-Hall Pvt. Ltd. New Delhi, 5th ed., 2004
	Materials Science & Engineering- An Introduction: W D Callister, John Wiley & Sons, 2010.
2.	The Materials Science of Thin Films: M. Ohring, Academic Pres, 1992.
3.	Elements of X-ray diffraction: BD Cullity, Addison-Wesley Publishing Co., 1978.
4.	Elements of crystallography: LV Azaroff, McGraw-Hill Companies, 1968.
5.	Engineering Materials- Properties and Selection: Kenneth G. Budinski, Michael K. Budinski Prentice-Hall of India Pvt. Ltd., 2002.
6.	Materials Characterization Techniques: Sam Zhang, Lin Li, Ashok Kumar, CRC Press, 2008.
7.	Materials Science: MS Vijaya, G Rangarajan, McGraw Hill Education, 2004.

PHY-534 :: Classical Electrodynamics

(Semester III)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	Coulomb's law, Concept of fields, Poisson and Laplace equations, formal solution for potential with Green's functions, boundary value problems; Dielectrics, polarization of a medium; Biot-Savart law, vector potential, Faraday's law of induction; energy densities of electric and magnetic fields.	8
II	Maxwell's equations in vacuum. Vector and Scalar potentials in electrodynamics, gauge invariance and gauge fixing, Coulomb and Lorenz gauges. Displacement current. Electromagnetic energy and momentum. Conservation laws. Inhomogeneous wave equation and its solutions using Green's function method. (Brief discussion).	12
III	Boundary value problems: Uniqueness theorem, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green's (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Magnetostatic boundary value problems.	8
IV	Plane waves in a dielectric medium, reflection and refraction at dielectric interfaces. Frequency dispersion in dielectrics and metals. Dielectric constant and anomalous dispersion. Wave propagation in one dimension, group velocity; EM Field of a localized oscillating source. Fields and radiation in dipole and quadrupole approximations. Antenna; Radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula.	14

S.No.	Reference Books
1.	Classical Electrodynamics: SP Puri , Narosa Publishing House, 2011.
2.	Classical Electrodynamics: JD Jackson, New Age, New Delhi, 2009.
3.	Classical Electromagnetic Radiation: JB Marion, MA. Heald, Saunders College Publishing House, 3rd ed., 1995.
4.	Introduction to Electrodynamics: DJ Griffiths, Prentice Hall India, New Delhi, 4th ed., 2012.
5.	Electromagnetic Fields: Ronald K Wangsness ,John Wiley and Sons, 2nd ed., 1986.
6.	Electromagnetic Field Theory Fundamentals: Bhag Singh Guru, HR Hiziroglu, Cambridge University Press, 2nd ed., 2004.
7.	Introduction to Electrodynamics: AZ Capri, PV Panat, Narosa Publishing House, 2010.

PHY-535 :: Field Visit and Exploratory Physics

(Semester III)

L+T+P	:	**0+0+2**	**Relative weightage**		
Credits	:	**2**	Mid-Sessional Practical Exam	:	**50**
Contact hours	:	**56**	End-Semester Practical Exam	:	**50**

S.No.	Practical Description
1.	Visit to the traditional/conventional technologies to explore new innovative ideas
2.	Visit to see the solar photovoltaic technologies and understanding the working of the same
3.	Visit to see the solar thermal technologies and understanding the working of the same
4.	Noble Prize winners in Physics and explore their discoveries
5.	Model making of any Physics related topic
6.	Observance of scientific days related to Physics
7.	Study of contribution of Sir CV Raman
8.	Study of contribution of Indian Physicist
9.	Collection of Physics related news in newspapers
10.	Science centre visit
11.	Online website search of organizations related to the Physics
12.	Organize and/or participate in Physics Quiz
13.	Database of National fellowships and examinations for Physics students
14.	Physics job opportunities through printed and electronic media
15.	Social outreach for basic physics awareness (to schools)
16.	Educational tour to institutions, industries, diagnostic labs
17.	Registration for SWAYAM course
18.	Study of patents granted in the field of Physics and associated applied sciences
19.	To attend scientific seminar/conferences delivered by renowned experts
20.	Exercise of various questions asked in last few years in CSIR-NET/ GATE/ SET Examinations

PHY-536 :: Physics Laboratory - III

(Semester III)

L+T+P	:	**0+0+3**	**Relative weightage**		
Credits	:	**3**	Mid-Sessional Practical Exam	:	**50**
Contact hours	:	**84**	End-Semester Practical Exam	:	**50**

S.No.	Practical Description
1.	To determine the resistivity of semiconductor using four probe method.
2.	To study temperature-dependence of conductivity of a given semiconductor crystal using four probe method.
3.	To determine the Hall voltage, Hall coefficient and the carrier concentration of a given semi-conductor.
4.	To determine the band gap of a semiconductor by four probe method.
5.	To find out the specific rotation of unknown solution using Polarimeter.
6.	To study the temperature dependence of a ceramic capacitor: Verification of Curie-Weiss law for the electrical susceptibility of a ferroelectric material.
7.	To study the characteristics of a LED and determine activation energy.
8.	To determine the surface of water by using a travelling microscope.
9.	To study the characteristics and dead time of a GM Counter.
10.	To find the linear magnifying power of a telescope by linear scale method.
11.	To determine the electric charge of an electron using Millikan drop experiment.
12.	To Study the variation of modulus of rigidity and internal friction of a specimen rod with temperature.
13.	To determine the refractive index of the material of the prism for the given wavelength of the light.
14.	To study the basic characteristics an applications of the operational amplifiers.
15.	To determine the dielectric constant of a liquid by dipole meter.
16.	To determine the wavelength of sodium light using a plane diffraction grating.
17.	To trace the B-H curve of a given material and to determine its magnetic parameters.
18.	To determine magneto resistance of an extrinsic semiconductor.
19.	To design a rectangular/triangular waveform generator using Comparators.
20.	To study the Hybrid parameters of a transistor and design an amplifier.
21.	To study logic gates and flip flop circuits using on a bread-board.
22.	To determine the standing wave ratio and reflection coefficient.
23.	To study Fraunhoffer diffraction (single slit, double slit, circular aperture).
24.	To determine thickness of a thin wire by diffraction using laser beam.
25.	To determine the numerical aperture of an optical fiber.
26.	To study the characteristics of lumped transmission line.
27.	To measure the thread angle, pitch and diameter of screw using laser beam.
28.	To measure the wave length of laser light with transmission grating.
29.	To study of polarization using laser beam (measurement of state of polarization of light wave, measurement of Brewster's angle of glass plate, verification of Malus's law).
30.	To study the solar water heating or solar drying system.

RM-599 :: Research Methodology

(Semester III)

L+T+P	:	**3+1+0**	Mid-Sessional exam	:	**30**
Credits	:	**4**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42+14**	End-Semester exam	:	**60**

Unit*	Contents	Lectures + Tutorials
I	Research: need, importance, types of research -fundamental v/s applied and impact of research. Research prioritization – objectives, process of research. Qualitative and quantitative research. Ethics with respect to science and research. Committee on Publication Ethics (COPE).Violation of publication ethics, authorship and contributor ship. Identification of publication misconduct, complaints and appeals.	10+3
II	Qualities of a good research worker. Research as career, current status and future prospects of research. Process of selecting research problem; survey of literature; allied and critical literature, research infrastructure. Good Laboratory Practices (GLPs). Sampling design; types of sampling & their advantages/disadvantages, recording of observations; measurement and scaling techniques.	11+4
III	Measures of central tendencies and relationships, sources and collection of primary & secondary data, storage and analysis of data. Pie chart, histogram and figures plotting. Formulation and types of hypotheses& their testing. Chi (χ^2) test, Z - test, t- test, F-test. Correlation, rank correlation and regression analysis, ANOVA- test of significance and error analysis. Absolute error, relative error, percentage error.	8+3
IV	Computer and informatics: Introduction, word processing, Excel, PowerPoint presentation. Information resources and various databases. Introduction to statistical software(s). LATEX. Impact factor and indexing data base. Different search engines in Library for research articles. Web of science, web browsing. Scopus organization of reference material using endnote; bibliography. Scientific misconduct: Falsification, fabrication and plagiarism (FFP), IPR and patent application. Entrepreneurship.	6+2
V	Selecting research problem and preparation of synopsis as per guidelines of university. Research paper and thesis writing. Compilation and presentation of results, writing & publication of research paper. Multidisciplinary and multi-institutional research; writing research proposal for external funding. Demonstration of departmental research activities through pictures, charts, research project reports and instrumentation. PG scholarship funding agencies Govt. of India. Post Doctoral Fellowships (PDFs).	7+2

***Unit -I, II, III, IV: Common for all streams; Unit- V: Offered by Concerned Department**

S.No.	Reference Books
1.	An Outline of Statistical Theory: DD Gupta, AM Moon, MK Gupta. (Vol. I/II).
2.	Statistical Methods: SP Gupta, Sultan Chand Publications.
3.	Research Methodology-Methods and Techniques: C R Kothari, New Age International, 2nd ed., 2004.
4.	Research Methodology: A Step by Step Guide for Beginners: R Kumar, Pearson Education, 2nd ed., 2005.
5.	Research Methodology in the Medical and Biological Sciences: P Laake, H Benestad, B Olsen, Elsevier, 1st ed., 2007.
6.	Research Methodology: C Murthy, Vrinda Publications, 1st ed., 2009.
7.	Research Methodology For Biological Sciences: N Gurumani, MJP Publishers, 1st ed.,2013.
8.	Methods in Social Research: C.R. Kothari, K.F. Hatt.
9.	Handbook of Sampling. Kumar Pranesh, Daroga Singh, Padam Singh. IASRI Publications.
10.	Sharma Jai Narain. Research Methodology. Deep & Deep Publications.
11.	Materials science and Engineering: V Raghavan, Prentice-Hall of India Pvt. Ltd., New Delhi, 5th ed., 2004.
12.	Nanotechnology: Principles and Practices: SK. Kulkarni, Springer: Capital Publishing company, 3rd ed., 2007.

PHY-600 :: Thesis
(Semester IV)

L+T+P : **0+0+20**
Credits : **20**
Contact hours : **560**

Description

Semester IV is only for Thesis work. There will be no compulsory theory or practical courses in this semester. **However, any of among the *Compulsory Courses* offered to the students pursuing M.Sc. PHYSICS (Without Thesis); can be opted by the students *as Optional Courses*. Students will receive "Satisfactory" result on obtaining ≥ 60% marks in these courses. Result will be satisfactory or non satisfactory.**

Students are required to start working on their thesis during semester III and will finish the assigned research work in semester IV. Students will work on a research topic assigned to them by their Major Advisor with a purpose to develop a collective approach to study, analyze and solve the problem. Students are required to submit their thesis in hard-bound form at the end of the semester.

Thesis will be forwarded by the Dean of the College to one of the external expert/examiner out of the panel of experts submitted by the major advisor. The suggestions made by the external expert will be incorporated in the thesis by the student and five hard copies will be submitted in the office of Dean. Thereafter, the Dean of the College will arrange internal viva-voce examination to be conducted by the advisory committee of the student under the chairmanship of the Dean. Result of viva-voce in **Satisfactory** or **Unsatisfactory** form will be submitted along with necessary documents to the Controller of Examinations office for declaration of the semester result.

Suggested Journals

S.No.	Name of the research journal/database	Publisher	Website
1.	Journal of Applied Physics	AIP	http://scitation.aip.org/content/aip/journal/jap
2.	Applied Physics Letters	AIP	http://scitation.aip.org/content/aip/journal/apl
3.	Journal of Applied Physics	AIP	http://scitation.aip.org/content/aip/journal/jap
4.	Physical Review B	APS	https://journals.aps.org/prb/
5.	Physical Review Letters	APS	http://journals.aps.org/prl/
6.	Journal of Magnetism and Magnetic Materials	Elsevier	http://www.journals.elsevier.com/journal-of-magnetism-and-magnetic-materials/
7.	Journal of Alloys and Compounds	Elsevier	http://www.journals.elsevier.com/journal-of-alloys-and-compounds/
8.	Current Applied Physics	Elsevier	http://www.journals.elsevier.com/current-applied-physics/
9.	Journal of Materials Science and Technology	Elsevier	https://www.sciencedirect.com/journal/journal-of-materials-science-and-technology
10.	Journal of Superconductivity and Novel Magnetism	Springer	http://www.springer.com/materials/journal/10948

Databases

Elsevier/Science Direct, Springer Link, AIP, APS, Google Scholar, Research Gate.
It is recommended that students should consider journals listed in Q1 and Q2 in the JCR report (Clarivate Analytics).

PHY-541 :: Science of Renewable Energy Sources

(Semester IV)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	Introduction: Classification of Energy Sources, Production alternatives and reserves of energy sources in the world and in India; need of renewable energy sources, energy security and energy conservation, Energy and its environmental impacts, Distributed generation.	7
II	Solar Energy: Solar thermal and solar photovoltaic technologies and their applications; solar radiation outside the earth's atmosphere and at the earth's surface, solar radiation geometry, solar collectors, solar distillation, fundamentals of photovoltaic energy conversion. Direct and indirect transition semi-conductors, types of solar cells, p-n junction solar cell, current density, open circuit voltage and short circuit current, Fill factor, power conversion efficiency, description of single crystal, polycrystalline and amorphous silicon solar cells, dye sensitized solar cells, Perovskite solar cells, Elementary ideas of Tandem solar cells.	14
III	Hydrogen Energy: Environmental considerations, solar hydrogen through photo electrolysis and photocatalysis, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, new storage modes, safety factors, use of hydrogen as fuel in vehicles and electrical power generation, hydride batteries.	12
IV	Other sources: Wind energy, wave energy, ocean thermal energy conversion (OTEC).	9

S.No.	Reference Books
1.	Solar Energy: SP Sukhatme, Tata McGraw-Hill, New Delhi, 2008.
2.	Non Conventional Energy Sources: GD Rai, Khanna Publishers, 4th ed., 2005.
3.	Non-Conventional Energy Resources: B H Khan, McGraw-Hill Education (India) Pvt Limited, 2006.
4.	Solar Cell Devices: Fonash, Academic Press, New York, 2010.
5.	Fundamentals of Solar Cells, Photovoltaic Solar Energy: Fahrenbruch, Bube, Springer, Berlin, 1983.
6.	Photo electrochemical Solar Cells (Advances in Solar Cell Materials and Storage (ASCMS)): N D Sankir, M Sankir, Wiley-Scrivener, 2019.
7.	Handbook of Hydrogen Energy: S A Sherif, D Yogi Goswami, E K (Lee) Stefanakos, Aldo Steinfeld, CRC Press, 2014.
8.	Hydrogen Storage- Preparation, Applications and Technology: H Shao, Nova, 2018.

PHY-542 :: Optoelectronics

(Semester IV)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits:	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	Injection luminescence: Recombination processes, the spectrum of recombination radiations, Direct and Indirect band gap Semiconductors, The Internal Quantum Efficiency, The External Quantum Efficiency.	8
II	The basic principles of laser actions: spontaneous and stimulated emission and absorption, the condition for the laser action, Types of laser, Semiconductor lasers; Theory of Laser action in Semiconductors , condition for gain, The threshold conditions for oscillations, rates of spontaneous and stimulated emission , effect of refractive index, calculation of the gain coefficients , relation of the gain coefficient to current density, Semiconductor Injection Laser :Efficiency, Stripe geometry LED materials, commercial LED materials, LED construction, Response time of LED's, LED derive circuitry.	12
III	Optical Detectors: Introduction, Device types, Optical Detection. Principles, Absorption, quantum efficiency, Responsivity, Long wavelength cut off, Photoconductive Detectors, Characteristics of particular photoconductive materials. Solar cell, Holography and its applications, Liquid crystal displays The Optical Fiber , Multimode and Single Mode Fibers, Glass Fibers, Plastic Optical Fibers, Fiber-Optic Bundle, Fabrication of Optical Fibers, Preform fabrication, Fiber Fabrication, Free Space Optics, Nanophotonics.	12
IV	Junction Detectors: detectors performance parameters Semiconductors p-i-n diodes, General Principle, quantum efficiency, Materials and design for p-i-n photodiodes. Impulse & frequency response of p-i-n photodiodes. Avalanche photodiodes detectors. The multiplication process. Avalanche photodiodes (APD) design, APD bandwidth, phototransistors	10

S.No.	Reference Books
1.	Optical communication systems: John Gowar, Prentice Hall, New Delhi, 1987.
2.	Optoelectronics and Photonics-Principles and Practices: S. O. Kasap, Prentice Hall, 2001.
3.	Optical fibre communications-Principles and practice: John M Senior, Prentice HallI, 1985.
4.	Optoelectronics-An Introduction: J Wilson, JFB Hawkes, Prentice Hall, 3rd ed., 1998.
5.	Physics of the semiconductor devices: SM Sze, Wiley Eastern Ltd., 2nd ed.1983.
6.	Fiber Optics and Lasers–The Two Revolutions: Ajoy Ghatak, K Thyagarajan, Laxmi Publications Private, 2016.
7.	Fiber optics communication system: G. P. Agrawal, John Wiley & Sons, 2011.
8.	Nanophotonics: P. N. Prasad, John Wiley & Sons, 2004.

PHY-543 :: Particle Accelerator Physics

(Semester IV)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits:	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	Charged Particle Dynamics: Particle motion in electric and magnetic fields, Beam transport system, Beam pulsing and bunching techniques, micro beams, Particle and ion sources, secondary beams, Measurement of beam parameters.	8
II	Radiofrequency Accelerators: Linear accelerators - Resonance acceleration and phase stability, electron and proton Linacs. Circular accelerators- Cyclotron, Frequency Modulated Synchrocyclotron, AVF Cyclotron, Alternating-gradient accelerators.	10
III	Electrostatic and Heavy Ion Accelerators : Van de Graaff voltage generator, Cockcroft Walton voltage generator, insulating column, voltage measurement, Acceleration of heavy ions, Tandem electrostatic accelerator, Production of heavy negative ions, Pelletron and Tandetron, Cluster beams, Superconducting Heavy Ion Linear Accelerators.	10
IV	Synchrotron Radiation Sources: Electromagnetic radiation from relativistic electron beams, Electron synchrotron, dipole magnet, multipole wiggler, noncoherent and coherent, Undulator, Characteristics of synchrotron radiation. Radioactive ion beams: Production of Radioactive ion beams, Polarized beams, Proton synchrotron, Colliding accelerators. Applications: Use of accelerators for AMS and Ion-beam Analysis Techniques.	14

S.No.	Reference Books
1.	Particle Accelerator Physics, Vol I and II: HJ Wiedman, Springer Verlag, 1998.
2.	Particle Accelerators, MS Livingston, JP Blewel, McGraw-Hill Book Press, 1962.
3.	Nuclear Spectroscopy and Reactions Part-A: Ed J Cerny, Academic Press, 1974.
4.	Theory of Resonance Linear Accelerators: IM. Kapchenkey, Harwood Academic Publishers, 1985.

PHY-544 :: Nano Physics

(Semester IV)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits:	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	Types of Nanomaterials and Their Properties: Clusters, Types of Clusters; Metal Nanocluster, Magic number, Theoretical modeling of Nanoparticles, Geometric structures, Electronic structure, Reactivity, Fluctuations, Magnetic Clusters, Bulk to nanotransitions, Semiconductor Nanoparticles, Excitons, Optical Properties of Semiconductor Nanoparticles.	10
II	Nanomagnetism: Types of Magnetic Materials, Effect of Bulk nanostructuring of Magnetic properties, Dynamics of nanomagnets; Nanopore Containment of magnetic particles, Nanocarbon ferromagnets, Giant and colossal Magnetoresistance, Ferrofluids; Mechanical Properties of Nanomaterials; Structural Properties; Melting of Nanoparticles. Nanoelectronics: Single electron Tunneling Spintronics: Giant Magnetoresistance (GMR).	10
III	Quantum Wells, Wires, and Dots: Introduction; Preparation of Quantum Nanostructures; Size and Dimensionality effects: size effect, conduction electrons and dimensionality, Fermi gas and Density of States, Potential wells, Partial confinement, properties dependent and density of states.	7
IV	Synthesis of Nanomaterials (Bottomup Approach): Sol-gel method, Hydrothermal Synthesis, Thin film growth (Physical vapour deposition (PVD) and Chemical vapour deposition (CVD) Techniques). Synthesis of Nanomaterials (Top down Approach): Ball milling, Lithography. Some special Nanomaterials: Carbon Nanomaterials, Porous materials, Aerogels, Zeolites, Porosity through templates, Core shell particles, Metamaterials, Metal Nanocluster Composite Glasses, Multiferroics, Nanostructured Multilayers.	15

S.No.	Reference Books
1.	Nanotechnology: Principles and Practices: Sulabha K Kulkarni, Springer: Capital Publishing company, 3rd ed., 2014.
2.	Introduction to nanotechnology: Charles P PooleJr., Frank J Owens, John Wiley and Sons,2003.
3.	Nanoscience and Nanotechnology: M S Ramachandra Rao, Shubra Singh, Wiley India, 2013.
4.	Nanostructured Materials: Wei, Ying, Y Jackie, Academic Press Inc. New York, 2001.
5.	Nanotechnology- Molecularly Designed Materials: GM Chow, KE Gonsalves, American Chemical Society, 1996.
6.	Nanoparticles and Nanostructured Films–Preparation, Characterization and Application: JHFendler, Wiley, 1998.
7.	Physics of Low-Dimension Semiconductors: JH Davies, Cambridge Univ. Press, 1998.

PHY-545 :: Advanced Computational Physics

(Semester IV)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits:	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	Concepts of deterministic and stochastic simulation methods, limitations of simulational physics, percolation, percolation threshold, cluster labeling, critical exponents, fractal dimension, regular fractals and self similarity, fractal growth processes. One particle system moving in a spring potential.	6
II	Monte Carlo Method (Stochastic Methods): Random walk on one, two and three dimensional lattices, self-avoiding walk, micro-canonical ensemble monte carlo method (Case Study: one dimensional ideal gas, Ising Model, heat flow), Canonical ensemble monte carlo method (Metropolis method, classical ideal gas, ising model, hard rods), isothermal-isobaric ensemble monte carlo method, grand-canonical ensemble monte carlo method.	8
III	Molecular Dynamics (Deterministic Methods): Molecular Dynamics as deterministic simulation, integration schemes (euler, predictor corrector, verlet), calculating thermodynamic quantities, organization of simulation, micro-cannonical ensemble molecular dynamics (case study: monoatomic particle system interacting via lennard jones potential), canonical ensemble molecular dynamics (case study: isokinetic simulation of a system of monoatomic particle system using lennard jones potential), isothermic-isobaric ensemble molecular dynamics (case study: simulation of a system of monoatomic particle system using lennard jones potential at constant temperature and constant pressure). Brief discussion of Anderson scheme and Nose scheme.	12
IV	Symbolic Computing: Symbolic Computing Systems, Basic symbolic mathematics, computer calculus, Linear systems, Non-linear systems, Differential equations, Computer graphics, Dynamics of a flying sphere. Basics of Mathematica: numerical computations, algebraic computations, calculus, graphics, Procedural programming High Performance Computing: The basic concept, High performance computing systems Parallelism and Parallel computing, Data parallel programming, Distributed computing and message passing, Some current applications. Computing Hardware Basics: Memory and CPU, Components: Memory Hierarchy, The Central Processing unit, CPU Design: RISC, CPU Design; Vector Processing, Virtual Memory, Programming for virtual memory, Programming for Data Cache.	16

S.No.	Reference Books
1.	Computer Simulation Methods in Theoretical Physics: Heermann, Springer Verlag, 1990.
2.	Computational Physics: SE Koonin, Addison Wesley, New York., 1986.
3.	An Introduction to Computational Physics: T Pang, Cambridge, University Press, 2006.
4.	Computational Physics: RH Landau, MJ Paez, John Wiley & Sons, 1997.
5.	The Art of Molecular Dynamics Simulation: DC Rapaport, Cambridge University Press, 2004.
6.	A First Course in Scientific Computing: Symbolic, Graphic, and Numeric Modeling Using Maple, Java, Mathematica, and Fortran90: R H Landau, Princeton University Press, 2005.
7.	Monte Carlo methods in statistical physics & The Monte Carlo method in condensed matter physics: K Binder, Springer, 1992.
8.	An Introduction to Computer Simulation Methods, Applications to Physical Systems: Harvey Gould, Jan Tobochnik, 3rd ed., 2017.
9.	Understanding Molecular Simulations: Frankel, Smit, Elsevier, 2nd ed., 2002.
10.	An Introduction to Computer Simulation Methods: Application to Physical Systems: H Gould, JTobochnik, W Christian, Pearson 3rd ed., 2006.
11.	Numerical Recipes: WH Press, BP Flannery, SA Teukolsky, WT Vetterling, Cambridge University Press, 1st or 2nd eds., (Fortran, C or C++ only), 1986.
12.	Mathematica-A System for Doing Mathematics by Computer: S Wolfram, Addison Wesley, 1991.

PHY-546 :: Nuclear Technology

(Semester IV)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits:	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	The interaction of radiation with matter: Introduction, Heavy charged particle interactions, electron interactions. Gamma rays interactions:- photoelectric effect, Compton scattering, pair production and attenuation. Neutrons interactions: moderation, nuclear reaction and elastic and inelastic scattering.	9
II	Detectors and Instrumentation: Introduction, Gas detectors: ionization chamber, proportional counter, and Geiger-Mueller counter. Scintillation counters. Semiconductor Detectors, Neutrons detectors Biological Effects of radiation: Initial interactions, Dose, dose rate and dose distribution, Damage to critical tissue, Human exposure to radiation and Risk assessment,	9
III	Industrial and Analytical Applications: Industrial uses: Tracing, Gauging, material modification sterilization, food preservation. Neutron activation analysis, Rutherford backscattering, particle induced X-ray Emission Accelerator Mass spectroscopy, Nuclear Medicine: Projection Imaging: X-Radiography and the Gamma Camera, Computed Tomography, Positron Emission Tomography (PET), Magnetic resonance Imaging (MRI), Radiation Therapy., Mossbauer Spectroscopy: Resonant absorption of gamma rays, the Mossbauer effect, Application: nano material spectroscopy and nuclear spectroscopy.	12
IV	Nuclear Energy Power from Fission: Characteristic of fission, The chain Reaction in a thermal fission reactor, the reactor, reactor operation, commercial thermal reactions, the breeder reactor, accelerator driven systems, Power from Fusion: Thermonuclear reaction and energy production, Fusion in hot medium, progress towards fusion power, fusion in early universe, stellar burning The pp chains, Beyond hydrogen burning, and nucleo-synthesis: Production of light elements (up to Fe), Production of the heavy elements – supernovae.	12

S.No.	Reference Books
1.	Nuclear Physics-Principles and Applications: Lilley, 2001.
2.	Introductory Nuclear Physics: Krane Kenneth S., John Wiley & Sons, India, 2008.
3.	Techniques for Nuclear and Particle Physics Experiments: William R. Leo, Springer, 1987.
4.	Nuclear Energy-An Introduction to the Concepts, Systems, and Applications of Nuclear Processes: Raymond L. Murray and Keith E. Holbert, Elsevier Inc., 8th ed., 2020.
5.	Astrophysics I (Stars): Richard L. Bowers, Terry Deeming, Jones and Bartlett, 1984.
6.	Nuclear Methods of Dating: Roth, Poty, Springer, 1990.
7.	The Physics of Medical Imaging: Webb, CRC Press, 1988.

PHY-547 :: Medical Physics

(Semester IV)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits:	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	The interaction of radiation with matter: Introduction, Heavy charged particle interactions, electron interactions. Gamma rays interactions: - photoelectric effect, Compton scattering, pair production and attenuation. Neutrons interactions: - moderation, nuclear reaction and elastic and inelastic scattering.	8
II	Biological Effects of radiation: Initial interactions, Dose, dose rate and dose distribution, Damage to critical tissue, Human exposure to radiation and Risk assessment.	7
III	Nuclear Medicine: Projection Imaging: X-Radiography and the Gamma Camera, Computed Tomography, Positron Emission Tomography (PET), Magnetic resonance Imaging (MRI), Radiation Therapy. Mossbauer Spectroscopy: Resonant absorption of gamma rays, the Mossbauer effect, Application: nano material spectroscopy and nuclear spectroscopy.	15
IV	Nuclear Energy Power from Fission: Characteristic of fission, The chain Reaction in a thermal fission reactor, the reactor, reactor operation, commercial thermal reactions, the breeder reactor, accelerator driven systems Power from Fusion: Thermonuclear reaction and energy production, Fusion in hot medium, progress towards fusion power, fusion in early universe, stellar burning.	12

S.No.	Reference Books
1.	Nuclear Physics– Principles and Applications. Good general text covering most of the course, Lilley, 2006.
2.	Farr's Physics for Medical Imaging, Alim Yucel-Finn, Fergus Mckiddie & Rachal Griffiths, Elsevier Health Sciences, 2023.
3.	Techniques for Nuclear and Particle Physics Experiments. A lot of practical detail, William RLeo, Springer, 1994.
4.	Nuclear Methods of Dating. For radiocarbon and geological dating, Roth & Poty, Springer 2010.
5.	The Future of Fusion Energy, Jason patisi, Justin Ball, World Scientific 2019.

PHY-548 :: Fiber Optics and Non-Linear Optics

(Semester IV)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits:	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	Optical fibre and its properties: Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and bandwidth, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types. Fiber fabrication and cable design: Fibre fabrication, mass production of fiber, comparison of the processes, fiber drawing process, coatings, cable design requirements, typical cable design, testing.	14
II	Optics of anisotropic media: Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and Poynting vector S, the indicatrix, uniaxial crystals, index surfaces, other surfaces related to the uniaxial indicatrix, Huygenian constructions, retardation, biaxial crystals, intensity through polarizer/waveplate/ polarizer combinations.	11
III	Electro-optic and acousto-otpic effects and modulation of light beams: Introduction to the electro-optic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a longitudinal acoustic wave in isotropic medium, calculation of LM for a shear wave in lithium niobate, Raman-Nath diffraction, Raman-Nath acousto-optic modulator.	11
IV	Non-linear optics/processes: Introduction, anharmonic potentials and nonlinear polarization, non-linear susceptibilities and mixing coefficients, parametric and other nonlinear processes, macroscopic and microscopic susceptibilities.	6

S.No.	Reference Books
1.	The Elements of Fibre Optics: SL Wymer, Meardon, Regents/Prentice Hall, 1993.
2.	Lasers and Electro-Optics: CC Davis, Cambridge University Press, 1996.
3.	Optical Electronics: Gathak, Thyagarajan, Cambridge Univ. Press, 1989.
4.	The Elements of Non-linear Optics: PN Butcher, D Cotter, Cambridge University Press,1991.

PHY-549 :: Astrophysics

(Semester IV)

L+T+P	:	**3+0+0**	Mid-Sessional exam	:	**30**
Credits	:	**3**	Quiz +Assignment + Attnd	:	**10**
Contact hours	:	**42**	End-Semester exam	:	**60**

Unit	Contents	Lectures
I	Introduction: Basic concepts of celestial sphere, Co-ordinate systems; Alt-azimuth, Equatorial, Right Ascension, Ecliptic, Basic stellar properties; Luminosity, apparent and absolute magnitude, photo visual and photographic magnitude system, estimation of distance using parallax method and Cepheid variables, stellar masses in binary system. Spectral classification of stars, Origin of emission and absorption spectra, Doppler effect and its applications, Mass-Luminosity relation; free electron scattering and bound-free scattering, HR diagram. Basic concepts of astronomical observations in γ-rays, X-rays, UV, visible, infra-red, radio waves.	12
II	Interstellar medium and molecular clouds: Structure of our galaxy, Globular clusters, velocity distribution of stars, origin of 21-cm radiation and interstellar gas, fine structure of Carbon, Origin of spiral arms and its basic features, Interstellar dust and theory of extinction of stellar light, molecules and molecular clouds, the galactic magnetic field, the active starforming molecular clouds.	9
III	Stellar evolution and nucleo synthesis: Pre-main sequence collapse, origin of the solarsystem, Jean's criteria, Shedding excess of angular momentum and magnetic field, T Tauriphase, Quasi-hydrostatic equilibrium, Virial theorem, Radiative and convective heat transfer, the sun on the main sequence, rates of nuclear energy generation, the standard solarmodel, evolution of low, intermediate and high mass stars on HR diagram, late stageevolution of stars, red giant phase, white dwarf, supernova (type Ia, Ib/c, II), neutron star,black hole, stellar nucleo-synthesis, hydrostatic and explosive nucleo-synthesis, sprocess, rprocess, the galactic chemical evolution.	12
IV	Cosmology: Simple extragalactic observations, Olber's paradox, Hubble's constant and its implications, the steady state universe, Evolution of the Big Bang, hadron era, lepton era, primordial nucleosynthesis, the radiation era, the matter era, time evolution of the future universe.	9

S.No.	Reference Books
1.	Physics of stellar evolution and cosmology: HS. Goldberg, MD Scadron, Gordon and Breach,1986.
2.	Astronomy: Principles and Practice: AE Roy, D Clarke, Adam Hilger, 2003.
3.	Theoretical Astrophysics (Vol. I, II, III): T Padmanabhan, Cambridge University Press, 2005.

PHY-550 :: Project
(Semester IV)

L+T+P : **0+0+10**
Credits : **10**
Contact hours : **280**

Description

Objectives:
This course is designed to provide practical exposure to the students about ongoing research in basic and applied areas of Physics and different research techniques and methods. It will impart skills on planning, performing, analyzing and, data interpretation of experiments. Students will also acquire proficiency in reading research articles, preparing PowerPoint presentations and giving oral presentations.

Guidelines:

1. In the second semester, student will be given an orientation about the aim and objectives of the project work. The student will develop the outline of the project work for approval by Advisor, HoD of respective department and the Dean of the college.
2. The student will perform the assigned project work in the fourth semester under the supervision of the assigned Advisor.
3. The student will prepare the final project work report and will submit to the Dean of the College through HoD of department.
4. The student will make a presentation at Department/College level and present before the Evaluation Committee comprising of faculty members of the department and/or other allied departments of the college.
5. The student will submit five hard copies of the report in spiral-bound / comb-bound form along with the soft copy to the Advisor.

The final result of student either as **Satisfactory** or **Unsatisfactory** will be submitted to the office of Controller of Examinations by the Advisor. Satisfactory grade will be awarded on securing minimum 60% marks as per evaluation criteria mentioned below:

Marks given by Advisor: 40 marks

S/N	Particulars	Marks
(a)	Attendance	**10**
(b)	Experimental work performance	**10**
(c)	Data presentation and quality	**10**
(d)	Data analysis and interpretation	**10**

Marks given by Evaluation Committee: 60 marks

S/N	Particulars	Marks
(e)	Evaluation of submitted project report	**30**
(f)	Presentation of project report	**20**
(g)	Response to the questions	**10**

Note: To get satisfactory grade in the Project Work course, the student must obtain minimum 60% marks.

Suggested Journals

S.No.	Name of the research journal/database	Publisher	Website
1.	Journal of Applied Physics	AIP	http://scitation.aip.org/content/aip/journal/jap
2.	Applied Physics Letters	AIP	http://scitation.aip.org/content/aip/journal/apl
3.	Journal of Applied Physics	AIP	http://scitation.aip.org/content/aip/journal/jap

4.	Physical Review B	APS	https://journals.aps.org/prb/
5.	Physical Review Letters	APS	http://journals.aps.org/prl/
6.	Journal of Magnetism and Magnetic Materials	Elsevier	http://www.journals.elsevier.com/journal-of-magnetism-and-magnetic-materials/
7.	Journal of Alloys and Compounds	Elsevier	http://www.journals.elsevier.com/journal-of-alloys-and-compounds/
8.	Current Applied Physics	Elsevier	http://www.journals.elsevier.com/current-applied-physics/
9.	Journal of Materials Science and Technology	Elsevier	https://www.sciencedirect.com/journal/journal-of-materials-science-and-technology
10.	Journal of Superconductivity and Novel Magnetism	Springer	http://www.springer.com/materials/journal/10948

Databases

Elsevier/Science Direct, Springer Link, AIP, APS, Google Scholar, Research Gate.

It is recommended that students should consider journals listed in Q1 and Q2 in the JCR report (Clarivate Analytics).

PHY-551 :: Special Seminar

(Semester IV)

L:T:P:	:	**1+0+0**	Write-up	:	**25**
Credits:	:	**1**	Viva-voce	:	**25**
Contact hours	:	**14**	Presentation	:	**50**

Description

Students have to make a PowerPoint presentation on the topic assigned to them which will be notified by the office of the Dean. The students will be evaluated by advisory committee members and faculty of the discipline and then average marks will be awarded to the student. The criteria of seminar evaluation proforma are given below:

S.No.	Evaluation Criteria	Max Marks
1.	Originality and creativity	15
2.	Organization and logical presentation of ideas	25
3.	Presentation (Oral presentation and delivery)	25
4.	Knowledge and familiarity with subject matter	15
5.	Quality and neatness of slides, charts and graphs	10
6.	Response to the questions/queries	10
Total		**100**

Satisfactory grade will be awarded on securing minimum 60 marks out of 100.

Suggested Journals

S.No.	Name of the research journal/database	Publisher	Website
1.	Journal of Applied Physics	AIP	http://scitation.aip.org/content/aip/journal/jap
2.	Applied Physics Letters	AIP	http://scitation.aip.org/content/aip/journal/apl
3.	Journal of Applied Physics	AIP	http://scitation.aip.org/content/aip/journal/jap
4.	Physical Review B	APS	https://journals.aps.org/prb/
5.	Physical Review Letters	APS	http://journals.aps.org/prl/
6.	Journal of Magnetism and Magnetic Materials	Elsevier	http://www.journals.elsevier.com/journal-of-magnetism-and-magnetic-materials/
7.	Journal of Alloys and Compounds	Elsevier	http://www.journals.elsevier.com/journal-of-alloys-and-compounds/
8.	Current Applied Physics	Elsevier	http://www.journals.elsevier.com/current-applied-physics/
9.	Journal of Materials Science and Technology	Elsevier	https://www.sciencedirect.com/journal/journal-of-materials-science-and-technology
10.	Journal of Superconductivity and Novel Magnetism	Springer	http://www.springer.com/materials/journal/10948

Databases

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