DEPARTMENT OF PHYSICS

JAGANNATH BAROOAH COLLEGE

(AUTONOMOUS)

Syllabus for

M.Sc. in Physics

Choice Based Credit System (CBCS)

Approved by the Board of Studies in Physics Meeting held on 18th May, 2019

1. Objectives of the Course:

The M.Sc. in Physics program offered by the Department of Physics, Jagannath Barooah College has been designed to give a solid background and deeper understanding of the core subjects of physics. The primary aim/objective of the course is to generate postgraduates equipped with advanced knowledge in fundamental aspects of all branches of Physics along with higher order critical, analytical and problem solving skills. In addition, the candidates will be trained to carry out both basic and/or applied research by harnessing and enhancing their ability think rigorously and independently on a particular problem in Physics having contemporary academic and/or industrial relevance. Further this program is also aimed at creating efficient manpower capable of teaching Physics at postgraduate and undergraduate level.

2. Course pattern

The Course in M.Sc. PHYSICS PROGRAMME is based on Choice Based Credit System (CBCS) and consists of two major types of courses as mentioned below.

1. **Credit Course:** These are Core or Elective Courses that are registered by a student during a semester to be taken into account for the credits earned by him/ her. There are five components of this type of course.
    a. **Core Course:** Core courses shall consist of those courses which a candidate must complete as compulsory requirement for the M.Sc. in Physics programme. Core courses will consist of components like Theory, Practical and Projects.
    b. **Elective Course:** The course is also offered by the parent department. It provides choice and flexibility within the department to choose a particular area of Physics. The student can choose his/her elective paper subject to certain criteria. The department will offer various elective papers subject to availability of sufficient infrastructure.
        i. Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
        ii. Dissertation/Project: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.
        iii. Open Elective (OE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called an Open Elective.
        P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Open Elective.
    c. **Ability Enhancement Courses (AEC):** The Ability Enhancement (AE) Courses are credit courses and are of two kinds as mentioned below.
        i. **Ability Enhancement Compulsory Courses (AECC)**: AECC courses are the courses based upon the content that leads to Knowledge enhancement.
        ii. **Skill Enhancement Courses (SEC):** SEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.
2. **Audit Course:** A student may take some courses which he/ she does not want to include in the list of courses that are to be taken into account for the credits earned by him/ her. Such courses are registered as Audit (non- credit) courses. The grades earned in the audit courses do not affect the performance score of the student.

SEMESTER WISE DISTRIBUTION OF MARKS:

SEMESTER-I:

5 Core Papers (100 Marks each)	:	500	
1 Open Elective - I	:	100	**600 Marks**
1 Audit Course	:	50#	

The grades earned in the audit courses do not affect the performance score of the student.

SEMESTER-II:

5 Core Papers (100 Marks each)	:	500	
1 Open Elective - I	:	100	**600 Marks**

SEMESTER-III:

1 Core Paper (100 Marks)	:	100	
3 DSE Papers (100 Marks each)	:	300	
Project – I	:	100	**550 Marks**
1 Ability Enhancement Compulsory Course	:	50	

SEMESTER-IV:

1 Core Papers (100 Marks)	:	100	
3 DSE Papers (100 Marks each)	:	300	**550 Marks**
Project – II & Dissertation	:	100	
1 Skill Enhancement Course	:	50	

Grand Total: **2300 Marks**

Total Credits: 90

Papers						
Semester	**Electives**		**Open Elective (3 credits each)**	**Ability Enhancement Course (2 credits each)**	**Audit Course (2 credit)**	**Total Credit**
	CORE (4 credits each) *6 credits	**Discipline Specific Elective**				
I	Mathematical Methods in Physics		OE I		Soft Skills	23
	Advanced Classical Mechanics					
	Quantum Mechanics					
	Atomic and Molecular Physics					
	Physics Laboratory-I (Quantum Mechanics/Optics/ Spectroscopy)					
II	Electromagnetic Theory and Electrodynamics		OE II			23
	Nuclear and Particle physics					
	Solid State Physics					
	Analog and Digital Electronics					
	Physics Laboratory-II (Solid State Physics/ Electronics/Optoelectronics/Nuclear Physics)					
III	Statistical Physics	DSE I		AEC I (AECC): (Computer Programming in C++, Python or Fortran)		22
		DSE II				
	Project –I*	DSE III				
IV	Numerical Methods and Computational Physics	DSE IV		AEC II (SEC): (Scientific and Technical Communication)		22
	Project –II*	DSE V				
		DSE VI				
Total Credit	56	24	6	4		90

Semester I

Sl. No.	Course Code	Course No.	Course Title	Contact hours (CH)/week			Credits (CR)	Durations in Exams	Marks*		Remarks
				Lecture	Tutorial	Practical			IA	Exam. Marks	
Core Course											
1	PHMC101		Mathematical Methods in Physics	3	1	0	4	3	20	80	
2	PHMC102		Advanced Classical Mechanics	4	0	0	4	3	20	80	
3	PHMC103		Quantum Mechanics	3	1	0	4	3	20	80	
4	PHMC104		Atomic and Molecular Physics	4	0	0	4	3	20	80	
5	PHMP101		Physics Laboratory-I (Quantum Mechanics/Optics/ Spectroscopy)	0	0	8	4	4	20	80	
Open Elective Course - I											
6			OE I	--	--	--	3	3	20	80	
Audit Course#											
7	PHMA101		Soft Skills	2	0	0	2		10	40	
Total credit and marks in their respective columns							**23**		**600**		#Credit/Marks of audit course not counted

PHMC: Physics Masters Core Course, PHMP: Physics Masters Core Practical Course, PHMG: Physics Masters Generic Elective Course, PHMS: Ability Enhancement Course, PHMA: Physics Masters Add On (Audit) Course, L: Lecture, T: Tutorial, P: Practical, IA: Internal Assessment

***Out of 100 Marks for each theory/practical paper 20 marks are allotted for internal assessments, 20 marks are allotted for internal continuous evaluation, and 60 marks are allotted for End Term College examination. Practical Examinations will be conducted at the end of each semester.**

Semester II

Sl. No.	Course Code	Course No.	Course Title	Contact hours (CH)/week			Credits (CR)	Durations in Exams	Marks*		Remarks
				Lecture	Tutorial	Practical			IA	Exam. Marks	
Core Course											
1	PHMC201		Electromagnetic Theory and Electrodynamics	4	0	0	4	3	20	80	
2	PHMC202		Nuclear and Particle physics	4	0	0	4	3	20	80	
3	PHMC203		Solid State Physics	4	0	0	4	3	20	80	
4	PHMC204		Analog and Digital Electronics	3	1	0	4	3	20	80	
5	PHMP201		Physics Laboratory-II (Electronics/Optoelectronics/Nuclear Physics)	0	0	8	4	3	20	80	
Open Elective Course - II											
6			OE I	--	--	--	3	3	20	80	
Total credit and marks in their respective columns							**23**		**600**		

PHMC: Physics Masters Core Course, PHMP: Physics Masters Core Practical Course, PHMG: Physics Masters Generic Elective Course, PHMS: Ability Enhancement Course, PHMA: Physics Masters Add On (Audit) Course, L: Lecture, T: Tutorial, P: Practical, IA: Internal Assessment

***Out of 100 Marks for each theory/practical paper 20 marks are allotted for internal assessments, 20 marks are allotted for internal continuous evaluation, and 60 marks are allotted for End Term College examination. Practical Examinations will be conducted at the end of each semester.**

Semester III

Sl. No.	Course Code	Course No.	Course Title	Contact hours (CH)/week			Credits (CR)	Durations in Exams	Marks*		Remarks
				Lecture	Tutorial	Practical			IA	Exam. Marks	
Core Course											
1	PHMC301		Numerical Methods and Computational Physics	2	2	0	4	3	20	80	
2	PHMP301		Project – I	0	0	8	4	-	20	80*	To be carried out under the guidance of a faculty member
Elective Course											
3			DSE I	3	1	0	4	3	20	80	
4			DSE II	3	1	0	4	3	20	80	
5			DSE III	0	0	8	4	4	20	80	
AEC – I: Ability Enhancement Compulsory Course											
6	PHMS301		Computer programming	2	0	0	2		10	40	
Total credit and marks in their respective columns							**22**		**550**		

PHMC: Physics Masters Core Course, PHMD: Physics Masters Discipline Specific Elective Course, PHME: Physics Masters DSE Practical Course, L: Lecture, T: Tutorial, P: Practical, IA: Internal Assessment.

***This course is aimed at giving research exposure to students by giving projects related to their chosen specialization (DSE course). At the end of 3rd semester, the student must submit give a progress report, a progress seminar and viva-voce examination.**

Semester IV

Sl. No.	Course Code	Course No.	Course Title	Contact hours (CH)/week			Credits (CR)	Durations in Exams	Marks*		Remarks
				Lecture	Tutorial	Practical			IA	Exam. Marks	
Core Course											
1	PHMC401		Statistical Physics	3	1	4	4	3	20	80	
2	PHMP404		Project – II	0	0	8	4	-	20	80*	To be carried out under the guidance of a faculty member.
Elective Course (any two)											
3			DSE IV	3	1	0	4	3	20	80	
4			DSE V	3	1	0	4	3	20	80	
5			DSE VI	0	0	8	4	4	20	80	
AEC II: Skill Enhancement Course											
6	PHMS401		Scientific and Technical Communication	2	0	0	2		10	40	
Total credit and marks in their respective columns							**22**		**550**		

PHMC: Physics Masters Core Course, PHMD: Physics Masters Discipline Specific Elective Course, PHME: Physics Masters DSE Practical Course, L: Lecture, T: Tutorial, P: Practical, IA: Internal Assessment.

***This course is aimed at giving research exposure to students by giving projects related to their chosen specialization (DSE course). At the end of 4th semester, the student must submit give the hardbound project report, a project seminar and viva-voce examination.**

Project (I & II): Students may choose any one of the following topics

1. Material science and Nanomaterials
2. Optoelectronic Instrumentation
3. Laser and Spectroscopy
4. Biophysics
5. Biophotonics
6. Computational Physics

Elective Courses

Semester III

DSE I: Any one course is to be chosen from the following courses

1. PHYD 301: Advanced Condensed Matter Physics
2. PHYD 302: Lasers and Nonlinear Optics
3. PHYD 303: Communication Electronics
4. PHYD 304: Quantum Field Theory

DSE II: Any one course is to be chosen from the following courses

5. PHYD 305: Physics of Thin Films
6. PHYD 306: Quantum Optics
7. PHYD 307: Digital Signal Processing
8. PHYD 308: High Energy Physics

DSE III: Any one course is to be chosen in line with DSE I and DSE II

9. PHYD 309: Advanced Condensed Matter Physics Laboratory I
10. PHYD 310: Advanced Optics & Photonics Laboratory II
11. PHYD 311: Advanced Electronics Laboratory I
12. PHYD 312: Advanced Mathematical Physics
    (To be taken in combination with PHYD 304, PHYD 308)

Semester IV

DSE IV: Any one course is to be chosen from the following courses

1. PHYD 401: Nanostructured Materials
2. PHYD 402: Advanced Laser Spectroscopy
3. PHYD 403: Microprocessors and Microelectronics
4. PHYD 404: Particle Physics

DSE V: Any one course is to be chosen from the following courses

5. PHYD 405: Organic Electronics and Optoelectronics
6. PHYD 406: Fiber Optics
7. PHYD 407: Microwaves, Antennas and Propagation
8. PHYD 408: Plasma Physics

DSE VI: Any one course is to be chosen in line with DSE I and DSE II

9. PHYD 409: Advanced Condensed Matter Physics Laboratory II
10. PHYD 410: Advanced Optics & Photonics Laboratory II
11. PHYD 411: Advanced Electronics Laboratory II
12. PHYD 412: General Theory of Relativity and Cosmology
    (To be taken in combination with PHYD 404, PHYD 408)

DSE Courses for Semester III

Sl. No.	Course Code	Course No.	Course Title	Contact hours (CH)/week			Credits (CR)	Durations in Exams	Marks*		Remarks
				Lecture	Tutorial	Practical			IA	Exam. Marks	
DSE I (Any one course is to be chosen from the following courses)											
1	PHMD301		Advanced Condensed Matter Physics	4	0	0	4	3	20	80	
2	PHMP302		Lasers and Nonlinear Optics	4	0	0	4	3	20	80	
3	PHYD 303		Communication Electronics	4	0	0	4	3	20	80	
4	PHYD 304		Quantum Field Theory	4	0	0	4	3	20	80	
DSE II (Any one course is to be chosen from the following courses)											
5	PHYD 305		Physics of Thin Films	4	0	0	4	3	20	80	
6	PHYD 306		Quantum Optics	4	0	0	4	3	20	80	
7	PHYD 307		Digital Signal Processing	4	0	0	4	3	20	80	
8	PHYD 308		High Energy Physics	4	0	0	4	3	20	80	
DSE III (Any one course is to be chosen in line with DSE I and DSE II)											
9	PHYD 309		Advanced Condensed Matter Physics Laboratory I	0	0	8	4	4	20	80	
10	PHYD 310		Advanced Optics & Photonics Laboratory I	0	0	8	4	4	20	80	
11	PHYD 311		Advanced Electronics Laboratory I	0	0	8	4	4	20	80	
12	PHYD 312		Advanced Mathematical Physics – I	3	1	0	4	3	20	80	(To be taken in combination with PHYD 304, PHYD 308)

DSE Courses for Semester IV

Sl. No.	Course Code	Course No.	Course Title	Contact hours (CH)/week			Credits (CR)	Durations in Exams	Marks*		Remarks
				Lecture	Tutorial	Practical			IA	Exam. Marks	
DSE IV (Any one course is to be chosen from the following courses)											
1	PHMD 401		Nanostructured Materials	4	0	0	4	3	20	80	
2	PHMP 402		Advanced Optical Spectroscopy	4	0	0	4	3	20	80	
3	PHYD 403		Microprocessors and Microelectronics	4	0	0	4	3	20	80	
4	PHYD 404		Particle Physics	4	0	0	4	3	20	80	
DSE V (Any one course is to be chosen from the following courses)											
5	PHYD 405		Organic Electronics and Optoelectronics	4	0	0	4	3	20	80	
6	PHYD 406		Fiber Optics	4	0	0	4	3	20	80	
7	PHYD 407		Microwaves, Antennas and Propagation	4	0	0	4	3	20	80	
8	PHYD 408		Plasma Physics	4	0	0	4	3	20	80	
DSE VI (Any one course is to be chosen in line with DSE IV and DSE V)											
9	PHYD 409		Advanced Condensed Matter Physics Laboratory II	0	0	8	4	4	20	80	
10	PHYD 410		Advanced Optics & Photonics Laboratory II	0	0	8	4	4	20	80	
11	PHYD 411		Advanced Electronics Laboratory II	0	0	8	4	4	20	80	
12	PHYD 412		General Theory of Relativity and Cosmology	0	1	0	4	3	20	80	(To be taken in combination with PHYD 404, PHYD 408)

Proposed syllabus for

MSc in Physics

1st semester

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-I
COURSE TITLE: Mathematical Methods in Physics
Course Code: PHYC-101
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No of contact hours	Allotted marks
Unit 1	Linear Algebra: Vector Spaces, subspaces, linear independence, spans, basis, dimensions, linear transformations, image and kernel, rank and nullity, change of basis, similarity transformation, inner product spaces, orthonormal sets, Gram-Schmidt procedure, dual space, eigenvalues and eigenvectors, Hilbert space;	10	10
Unit 2	Complex variables: Complex algebra; graphical representation; analytical functions; Cauchy-Riemann conditions; complex integrations; Cauchy's theorem; Cauchy's integral formula; residue; Cauchy's residue theorem,	8	8
Unit 3	Legendre's Differential Equation: The Power series Solution –Legendre Functions of the first and second kind –Generating Function- Rodrigues Formula –Orthogonal Properties – Recurrence Relations. Beta and Gamma function –Properties – Relations between them. Bessel's Differential Equation: Power series Solution –Bessel Functions of First and Second kind- Generating Function –Orthogonal Properties –Recurrence Relations. Hermite Differential Equation: Power series Solution –Hermite polynomials -Generating Function-orthogonality –Recurrence relations -Rodrigues formula . Partial differential equations: Solutions for Laplace, wave and Helmholtz equations by method of separation of variables and Green's function method(Dirac-Delta functions) in Cartesian, Spherical and Cylindrical coordinates, other PDE in physics .	12	12
Unit 4	Integral transformations: Laplace transforms: solution of linear differential equations with constant Coefficients – Fourier integral. Fourier transforms: Fourier sine and cosine transforms – Convolution theorems – Applications. Fourier Transform : Infinite Fourier Sine and Cosine transforms –Properties of Fourier	10	10

	transforms-Derivative of Fourier transform – Fourier transform of a derivative-Fourier Sine and Cosine transform of derivatives-Finite Fourier transforms –Applications of Fourier Transforms.		
Unit 5	Matrices: Different kind of matrices, orthogonal matrices, Hermitian matrices, unitary matrices, diagonalisation of matrices, eigenvectors and eigenvalues. Tensors: Tensors, inner and outer products, contraction, symmetric and antisymmetric tensors, metric tensor, covariant and contravariant derivatives; Series: convergence, Taylor series, Laurent series, singularities, residue theorem, applications of residue theorem, conformal mapping and application;	10	10
Unit 6	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.	10	10

References Book:

1. Applied Mathematics for Engineers and Physicists –Lious A Pipes and Lawrance R. Rarvill.
2. Mathematical Physics – AK Ghatak, IC Goyal and SL Chua-Macmillan India Ltd.
3. Mathematical Physics – Satya Prakash
4. Sastry: Introductory Methods of Numerical Analysis.
5. An Introduction to Numerical Analysis by Kendall E. Atkinson.
6. Numerical Methods – E.Balaguruswamy, Tata McGraw – Hill publishing Company Limited.
7. Numerical Methods for Scientific and Engineering Computations – M.R.Jain, S.R.K Iyengar and R.K. Jain – PHI Publisher.

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-I
COURSE TITLE: Advanced Classical Mechanics
Course Code: PHYC-102
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No of contact hours	Allotted marks
Unit 1	D'Alembert's principle and Lagrange equation: Generalized coordinates, principle of virtual work, D'Alembert's principle, Lagrangian formulation and simple applications, Variational principle and Lagrange equation: Hamilton's principle, Lagrange equation from Hamilton's principle, Extension to non-Holonomic systems, Lagrange multipliers, symmetry and conservation laws	10	10
Unit 2	Central force problem: Two body problem in central force, Equations of motion, effective potential energy, nature of orbits, Virial theorem, Kepler's problem, condition for closure of orbits, scattering in a central force field, center of mass and laboratory frame	10	10
Unit 3	Rotating frame: Angular velocity, Lagrange equation of motion, inertial forces	6	6
Unit 4	Rigid body motion: kinetic energy, momentum of inertia tensor; angular momentum, Euler angles, heavy symmetrical top, Euler equations, stability conditions	8	8
Unit 5	Hamiltonian formulation: Legendre transformations, Hamilton's equations, symmetries and conservation laws in Hamiltonian picture, Hamilton's principle, canonical transformations, Poisson brackets, Hamilton-Jacobi theory, action-angle variables	10	10
Unit 6	Small-oscillations: Eigenvalue problem, frequencies of free vibrations and normal modes, forced vibrations, dissipation	8	8
Unit 7	Classical field theory: Lagrangian and Hamiltonian formulation of continuous system.	8	8

References Book:

1. N. C. Rana and P. S. Joag, *Classical Mechanics*, Tata Mcgraw Hill (2001).
2. L. Landau and E. Lifshitz, *Mechanics*, Oxford (1981).
3. S. N. Biswas, *Classical Mechanics*, Books and Allied (P) Ltd.,Kolkata (2004) .
4. F. Scheck, *Mechanics*, Springer (1994)
5. Upadhyaya, J. C., *Classical Mechanics*, (Himalayan Publishing House)
6. Goldstein, H., *Classical Mechanics*, (Narosa Publishing House)

7. Takawale, R. G., and Puranik, P. S., *Introduction to Classical Mechanics*, (Tata McGraw Hill)
8. Panat, P. V., *Classical Mechanics*, (Narosa Publishing House)
9. Gupta, S. L., Kumar, V. and Sarma, H. V., *Classical Mechanics*, (Pragati Prakashan)

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-I
COURSE TITLE: Quantum mechanics
Course Code: PHYC-103
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No of contact hours	Allotted marks
Unit 1	Recapitulation of Quantum and Schrodinger equation and its applications. Matrix formulation in quantum mechanics: linear and matrix algebra, Dirac bra and ket notation, matrix representations of vectors and operators, expectation values, Matrix representation of angular momentum, different representation in quantum mechanics, parity operation, Matrix theory of harmonic oscillator.	10	10
Unit 2	Theory of angular momentum: spherical harmonics, angular momentum operator, Eigen values of L_2, L_z, and commutation relations, addition of angular momentum, Clebsh Gordon coefficient, spin orbit interaction.	8	8
Unit 3	Perturbation Theory: Non-degenerate and Degenerate Cases and Applications. Zeeman and Stark effects Induced electric dipole moment of Hydrogen Real Hydrogen Atom, Schrodinger equation for a slowly varying potential, Variational Principle, WKB approximation, turning points, connection formulae, derivation of Bohr Sommerfeld quantization condition, applications of WKB. Time Dependent Perturbation Theory: Sinusoidal perturbation, Fermi's Golden Rule.	10	10
Unit 4	Scattering Theory: Scattering Cross-section, scattering amplitude, Partial waves, scattering by a central potential, partial wave analysis, the Born Approximation and its validity, Scattering for various kinds of potentials, applications. Laboratory and center of mass coordinate systems.	8	8
Unit 5	Symmetries and Conservation laws: Symmetry and conservation laws, Translation in space conservation of linear momentum, Translation in time- Conservation of energy, Rotation in -space Conservation of angular momentum, Space Inversion- parity conservation, Time reversal. Selection rules and conservation laws. Identical particle- symmetric and antisymmetric wave functions, spin and space wave function	12	12
Unit 6	Relativistic Quantum Mechanics: Klein-Gordon equation, Interpretation of Klein-Gordon equation, Particle in a Coulomb Feld, Dirac equation for a free particle, Dirac matrices, covariant form of Dirac equation, Probability density, Plane wave solution, Negative energy states, spin of Dirac particles	12	12

Reference Books:

1. Quantum Mechanics : Concepts and Applicaton by Nouredine Zetli
2. Quantum Mechanics by L.I. Schiff
3. Quantum Mechanics: Theory And Applicatons by A. K. Ghatak, S.Lokanathan,

4. The Principles of Quantum Mechanics by P. A. M. Dirac, Oxford University Press.
5. D. J. Griffiths, Introduction to Quantum Mechanics, Pearson Education (2005).
6. P. W. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill(1995).
7. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education (2002).
8. B. H. Bransden and C. J. Joachain, Quantum Mechanics, Pearson Education 2nd Ed. (2004)
9. R. L. Liboff, Introductory Quantum Mechanics, Pearson Education, 4th Ed. (2003).

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-I
COURSE TITLE: Atomic and Molecular physics
Course Code: PHYC-104
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No of contact hours	Allotted marks
Unit 1	Review of one-electron and two-electron atoms: spectrum of hydrogen, helium and alkali atoms; Many electron atoms: central field approximation, Thomas-Fermi model, Slater determinant, Hartee-Fock and self-consistent field methods, Hund's rule, L-S and j-j coupling, Equivalent and nonequivalent electrons, Spectroscopic terms, Lande interval rule	12	12
Unit 2	Interaction of atoms with electric and magnetic field: Magnetic effects, Processional motion, Spin-orbit interaction, fine structure, Influence of external magnetic field: Zeeman and Paschen-back effects in one and two electron atom, g-factor	10	10
Unit 3	Line width and broadening: General factors influencing spectral line widths (collisional, Doppler Heisenberg), transition probability, population of states, Beer-Lambert law	8	8
Unit 4	Molecular Physics: Molecular symmetry, irreduciable representation Rotational Spectra of diatomic molecule, intensity of spectral lines, Effect of isotope substitutions, non-rigid rotator, Vibrational spectra of diatomic molecules, harmonic and anharmonic Vibrator-rotational spectra Pure rotational Raman spectra, linear and symmetric top molecules, vibrational Raman spectra, rotational fine structure, selection rule, overtone spectra	12	12
Unit 5	Electronic properties of molecules: Electronic spectra of diatomic molecules: Born-Oppenheimer approximation, Franck-Condon principle, Dissociation energy and dissociation products, rotational fine structures, pre-dissociation of molecules	10	10
Unit 6	Orbital theory of molecules: Molecular orbital theory, shape of molecular orbitals, classification of states, spectrum of hydrogen molecules	8	8

Reference Books:

1. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules,2nd Ed. Pearson (2008).
2. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed.,Tata McGraw (2004).

3. G. K. Woodgate, Elementary Atomic Structure, Clarendon Press (1989).
4. I. N. Levine, Quantum Chemistry, PHI (2009).
5. F. L. Pilar, Elementary Quantum Chemistry, McGraw Hill (1990).
6. H. E. White, Introduction to Atomic Spectra, Tata McGraw Hill (1934).
7. W. Demtroder, Atoms, Molecules and Photons, 2nd Ed., Springer (2010).
8. C. J. Foot, Atomic Physics, Oxford (2005).
9 Herberg, Introducton to Atomic Spectra.
10 K.Thyagarajan and A.K. Ghatak, Laser: Theory and Applicaton,.
11 B.B. Laud, Lasers and Non-linear Optics

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-I
COURSE TITLE: Physics Laboratory-I (Quantum Mechanics/Optics/ Spectroscopy)
Course Code: PHMP-101
Credits: 4 (0 -Theory, 4 Practical) No. of Class hours- 120
Total Practical Marks: 100 End Semester: 80 In Semester: 20

Course Objectives:
At the completion of this course, a student will be able to
1. Gather a broader knowledge on the experimental techniques of quantum mechanics, optics, and spectroscopy.
2. Understand the basic concepts in hands on mode through the following experiments.

Laboratory Experiments
1. Study of photoelectric effect and the determination of Planck's constant
2. To study tunnelling effect in a tunnel diode.
3. Diffraction at a slit and Heisenberg's uncertainty principle
    a. To measure the intensity distribution of the Fraunhofer diffraction pattern of a single slit (e.g. 0.1 mm). The heights of the maxima and the positions of the maxima and minima are calculated according to Kirchhoff's diffraction formula and compared with the measured values.
    b. To calculate the uncertainty of momentum from the diffraction patterns of single slits of differing widths and to confirm Heisenberg's uncertainty principle.
4. Quantum eraser experiment with polarization entangled photons.
5. Laser diffraction experiments
    a. Diffraction of light by single wire
        i. To determine the wavelength of laser light from a thin wire diffraction pattern.
        ii. Compare the thickness of the wire with the single-slit width that form the same diffraction pattern as wire and hence verify the Babinet's principle.
    b. Diffraction of light by Reflection Grating
        i. To measure the wavelength of laser light using a millimeter scale as grating
        ii. To find the groove spacing of CD (compact disc)
    c. Diffraction of light by circular aperture (Pinhole): to find the incident wavelength of light (for known pinhole size)/diameter of the pinhole (for known incident wavelength of light)
6. Experiments with Zeeman Effect Apparatus
    a. To observe the line triplet for the normal transverse Zeeman Effect
    b. Verification of the magnetic moment constant Bohr magnetron (μ)
7. Experiments with Franck Hertz Experiment Apparatus
    a. To measure the excitation potential of Argon using the Franck - Hertz method
    b. To verify that atomic systems have discrete energy levels by bombarding electrons and observing the difference in energy levels
8. Experiments with Hydrogen Spectra Balmer Series Apparatus
    a. To calculate and verify Hartmann's constants
    b. To study the emission of light from a hydrogen discharge source
    c. To learn the empirical formulas to characterize the pattern of spectral lines from hydrogen
9. Experiments with Constant Deviation Spectrometer

a. To measure the wavelength of absorption bands of $KMnO_4$ and calculate it's Hartmann's constant.
b. To find wavelength of prominent lines of the emission spectra of copper, iron and brass

Suggested References

1. *Lab Manual*, Physics Laboratory-I

Proposed syllabus for

MSc in Physics

2nd semester

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-II
COURSE TITLE: Electromagnetic Theory and Electrodynamics
Course Code: PHYC-201
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No of contact hours	Allotted marks
Unit 1	Review of Maxwell's Equations: Fundamental problem of electromagnetic theory. Scalar and vector potentials. Gauge transformations. Coulomb and Lorentz gauges. Poynting's theorem, Energy and momentum conservation; Electromagnetic waves: wave equation, propagation of electromagnetic waves in non-conducting medium, reflection and refraction at dielectric interface, total internal reflection, Brewster's angle, complex refractive index.	10	10
Unit 2	Electromagnetic waves in a medium: Frequency dependence of permittivity, permeability and conductivity, electrons in conductors and plasma; Electromagnetic waves in conducting medium: reflection and transmission; Wave Guides: waves between parallel conductors, TE and TM waves, rectangular and cylindrical wave guides, resonant cavities;	14	14
Unit 3	Scattering of electromagnetic waves: Rayleigh scattering, Mie scattering, colour of the sky and clouds.	8	8
Unit 4	Accelerated charge and radiation: Green function for relativistic wave equation. Radiation from localized oscillating charges. Near and far zone fields. Multipole expansion. Dipole and quadrupole radiation. Centrefed linear antenna. Radiation from an accelerated point charge. Lienard -Wiechert potentials. Power radiated by a point charge: Lienard's formula and its nonrelativistic limit (Larmor's formula). Angular distribution of power radiated by linearly and circularly accelerated charges.	14	14
Unit 5	Relativistic Electrodynamics and Plasma Physics: Review of Special Theory of Relativity (STR) and its application to electromagnetic theory: Conceptual basis of STR. Four-vectors, tensors. Lorentz transformation as 4-vector transformations. Transformation properties of electric and magnetic fields. E.M. field tensor. Covariance of Maxwell's equations in four tensor	14	14

	form.		

Reference Books:

1. Classical Electrodynamics by John David Jackson (3rct Ed.,Wiley,l998)
2. Introduction to Electrodynamics by David Griffiths (3rd Ed., Benjamin Cummings, 1999)
3. Principles of Electrodynamics by Melvin Schv-iartz (Dover Pub]ications, 1987)
4. Classical Electrodynamics by J. Schwinger, L.L. Deraad Jr, K.A. Milton, W-Y. Tsai and J.Norton (Westview Press, 1998)
5. Modern Problems in Classical Electrodynamics by Charles A. Brau (Oxford Univ. Press, 2003)
6. Electrodynamics: An introduction including quantum effects by H. J. W. Mueller-Kirsten (World Scientifie, 2004)
7. J. R. Reitz and F. J. Millford, Foundation of Electromagnetic Theory, Narosa (1986).
8. Puri, S. P., Classical Electrodynamics, 2nd edition, (Tata McGraw Hill Pub., 1997)
9. Electrodynamics of Continuous Media by L. D.Landau and E. M. Lifshitz & L. P. Pitaevskii (Oxford, 2005)

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-II
COURSE TITLE: Nuclear and particle physics
Course Code: PHYC-202
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No of contact hours	Allotted marks
Unit 1	Recapitulation of nuclear properties and nuclear forces, Yukawa hypothesis	6	6
Unit 2	Nuclear models: Thomas Fermi model, nuclear shell model, magnetic moments and spin parity of nuclei, the magic numbers; The collective model and application to even-even nuclei, their spectrum and selection rules for radiation.	8	8
Unit 3	Beta Decay**:** Fermi's theory of Beta decay, the Curie plot, mass of the neutrino, Fermi and Gamow Teller transitions, allowed and forbidden transitions. parity violation in beta decay and its experimental evidence	10	10
Unit 4	Nuclear reactions: conservation laws, energetics, isospin, reaction cross section, Rutherford scattering, nuclear scattering, optical model, compound nucleus, direct reactions, resonance reactions, neutron physics, fission and fusion reactors, Breit-Wigner dispersion formula	10	10
Unit 5	Particle accelerators and detectors: electrostatic accelerators, cyclotron, synchrotron, linear accelerators, colliding beam accelerators, ionization chamber, scintillation detectors, semiconductor detectors, their simple applications to material science and medicine	10	10
Unit 6	Elementary particles: Fundamental forces, properties mesons and baryons, symmetries and conservation laws, quark model, concept of colour charge, discrete symmetries, properties, of quarks and leptons, gauge symmetry in electrodynamics, particle interactions and Feynman diagrams.	8	8
Unit 7	Nuclear Astrophysics: Stellar structure, Nuclear burning stages, hydrogen and helium burning, core collapse, Chandrashekhar limit, supernova, white dwarf, neutron stars, pulsars and black holes; synthesis of nuclei in stars.	8	8

Reference Books:

1. K. S. Krane, Introductory Nuclear Physics, John Wiley (1988).
2. R. R. Roy and B. P. Nigam, Nuclear Physics: Theory and Experiment, New Age (1967).
3. A. Das and T. Ferbel, Introduction to nuclear and particle physics, John Wiley (1994).
4. M. A. Preston and R. K. Bhaduri, Structure of the nucleus, Addison-Wesley (1975).
5. I. S. Hughes, Elementary Particles, Cambridge (1991).

6. F. Halzen and A. D. Martin, Quarks and Leptons, John Wiley (1984).
7. D. Perkins, Introduction to High Energy Pysics, Cambridge University Press; 4_{th} edition (2000)
8. A.Beiser, Concepts of Modern Physics
9. Bernard L Cohen, Concepts of Nuclear Physics.
10. D C Tayal, Nuclear Physics
11. E. Segre, Nuclei and Partcles

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-II
COURSE TITLE: Solid State Physics
Course Code: PHYC-203
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No of contact hours	Allotted marks
Unit 1	Basics of crystal structure: symmetry operations, Bravais lattices, Reciprocal lattice, Bragg and von Laue diffraction, Ewald Construction. Crystal binding: molecular crystals, repulsive interaction, cohesive energy, ionic metallic and covalent crystals	8	8
Unit 2	Free electron theory: Drude and Sommerfield's model of conductivity. Electrons in a Periodic Potential, Bloch Theorem in lattice and reciprocal space, origin of band gap in a weak periodic potential, Kronig-Penney Model, Band structures, Metal, Insulator Semiconductor, Concepts of Effective mass, light and heavy holes in semiconductor, optical properties of semiconductors.	12	12
Unit 3	Wannier functions, Tight binding model and Calculation of Band structure, Fermi Surfaces.	6	6
Unit 4	Lattice vibration and thermal properties: harmonic approximation, monatomic and diatomic lattices, Brillouin zone, phase and group velocities, density of states, acoustic and optical modes, quantization of linear chain, phonons, crystal momentum, determination of dispersion relations, Debye model of specific heat, anharmonic effects, thermal expansion, thermal conductivity; Free electron theory: Fermi gas, specific heat, Ohm's law, magneto-resistance, thermal conductivity Wiedemann-Franz law	14	14
Unit 5	Special class of Dielectrics & Polarizability, Ferroelectric, Piezoelectric. Magnetism: Diamagnetism, Paramagnetism, Hunds Rule, Curie's Law, Cooling by Diamagnetism, Pauli Paramagnetism, Curie's weiss Law, Ferromagnetism and Antiferromagnetic ordering, Domains.	10	10
Unit 6	Superconductivity: Basic Phenomenology, Meissner effect, London penetration depth, coherence length, Flux quantization, Type I, Type II, BCS theory, Energy gap, Josephson effect & SQUID.	10	10

Reference Books:

1. Kittel, C., *Introduction to Solid State physics* 7th Edition (Wiley, Eastern Ltd., 1996)
2. Burns, G., *Solid State Physics* (Academic press, 1995)
3. Dekker, A. J., *Solid State Physics* (Macmillan India Ltd., 2003)
4. Ashcroft, N. W. & Mermin, N. D., *Solid State Physics* (Saunders, 1976)
5. Ibach, H. & Luth, H., *Solid State Physics*, (Springer-Verlag)
6. Patterson, J. D., *Introduction to the Theory of Solid State Physics*, (Addison-Wesley, 1971)

7. Ghatak, A.K. and Kothari, L.S., *Introduction to Lattice Dynamics*, (Addison-Wesley, 1972)
8. Hall, H.E. and Hook J.R., *Solid State Physics*, 2nd Edition, (Wiley, 1991)

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-II
COURSE TITLE: Analog and Digital Electronics
Course Code: PHYC-205
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	**Topic**	**No of contact hours**	**Allotted marks**
Unit 1	Op Amp non-linear applications: Voltage limiters, comparators, zero detector, Schmitt trigger, voltage to frequency and frequency to voltage converter, small-signal diodes, sample-and-hold circuits and signal generators: oscillators-square-wave, Wien bridge, phase shift.	12	12
Unit 2	Frequency response of an op-amp and active filter: Gain and phase shift vs. frequency, Bode plots, compensated frequency response, slew rate, active filter, first and second order low pass and high pass, Butterworth filter, band reject filter.	10	10
Unit 3	Digital Electronics: Review of Boolean algebra, gates, transistor switching times, INHIBIT (ENABLE) operation, De Morgan's laws, gate assemblies, binary adders.	10	10
Unit 4	Combinatorial digital systems: arithmetic functions, decoder/demultiplexer, data selector/multiplexer, encoder, ROM and applications.	10	10
Unit 5	Sequential digital systems: flip-flops, shift registers and counters, random access memory (RAM), dynamic MOS circuits, MOS shift registers, MOS Read Only Memory, D/A and A/D systems, digital-to-analog converters, analog-to-digital converters, character generators.	10	10
Unit 6	Microprocessor: Architecture and Laboratory.	8	8

Reference Books:

1. Kumar, A., *Fundamentals of Digital Electronics* (PHI Learning Pvt. Ltd., 2003)
2. Gayakward, R.A., *Op-Amps and Linear Integrated Circuits*, 3rd Edition, (PHI, 2001).
3. Gaonkar R.S., *Microprocessor Architecture, Programming, and Applications with the 8085*, 5th Edition, (Prentice Hall, 2002).
4. Malvino A.P.and Leach D.J., *Digital Principles and Applications,* (Tata McGraw Hill 1994).
5. Milliman, J. & Halkias, C.C., *Integrated Electronics,* (Tata McGraw Hill, 2003).
6. Tocci R.J., *Digital Systems,* (Pearson/Prentice Hall, 2004).
7. Bartee T.C., *Digital Computer Fundamentals,* (Tata McGraw Hill Publishing Company, 1985).

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-II
COURSE TITLE: Physics Laboratory-II (Solid State Physics/Electronics/Nuclear Physics)
Course Code: PHMP-201
Credits: 4 (0 -Theory, 4 - Practical) **No. of Class hours- 120**
Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Course Objectives:
At the completion of this course, a student will be able to
1. Gather a broader knowledge on the experimental techniques of solid-state physics, electronics, and nuclear Physics.
2. Understand the basic concepts in hands on mode through the following experiments.

Laboratory experiments

1. To measure the resistivity of a material using two probe method.
2. Experiments using Four Probe Set up:
    a. Study the variation of resistivity of a semiconductor with temperature and hence to determine the Band Gap
    b. To study conductivity of thin film by four probe method.
3. To measure the dielectric constant and loss using microwave bench.
4. Electron spin resonance spectrometer:
    a. To find out the Lande' g – factor of 2,2-Diphenyl-1-picrylhydrazyl sample using ESR spectrometer.
    b. To observe the E.S.R. signal of given sample (DPPH) and to measure its full width at half maximum (FWHM).
5. To study solar cell characteristics.
    a. To plot the I - V characteristic curve of a solar cell
    b. To evaluate fill factor of the solar cell
6. To Study the Photo-Diode Characteristics.
7. To use Op-Amp as Square, Ramp Generator and Wien Bridge Oscillator.
8. Design and study of a triangular wave generator
9. Design and study of sample and hold circuits
10. GM counter:
    a. Determine the resolving time of the GM counting system.
    b. Study and determine the statistical distribution low that governs nuclear decay.
    c. Determine the characteristics of a GM tube to study the variations of count rate with applied voltage and thereby determine the plateau, the operating voltage and the slope of the plateau.
    d. Determine the dead time of the GM tube using a single source.
11. Gamma ray absorption-half thickness in lead for ^{60}Co gamma-rays.
12. Beta ray absorption- end point energy of beta particles.

Suggested References

1. *Lab Manual*, Physics Laboratory-I

Proposed syllabus for

MSc in Physics

3rd semester

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Numerical Methods and Computational Physics
Course Code: PHYC-302
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No of contact hours	Allotted marks
Unit 1	Solution of Linear Algebraic Equations: Gaussian Elimination (forward elimination & back substitution method), Gauss-Jordan Elimination method, Iterative methods: Jacobi methods & Gauss-Seidel methods, Comparison of direct and iterative methods.	12	12
Unit 2	Root-finding Methods: Bisection method, successive bisection method, Regula falsi method, Newton-Raphson method, Secant method, method of Successive approximations.	10	12
Unit 3	Interpolation – Lagrange and Newton interpolation method, least square curve fitting Numerical differentiation and integration - Simpson's rule, trapezoidal rule, Gaussian Quadrature method, Gauss-Laguerre, Gauss-Hermite methods, Newton-cotes Integration formula	12	12
Unit 4	Numerical methods for ordinary differential equations - Euler's method, Runge-Kutta method (second & fourth order)	10	10
Unit 5	Simulations: A system and its model; The basic nature of simulation; The simulation of continuous and discrete systems - suitable examples; Stochastic simulation - generation of random numbers with different probability distributions; Monte Carlo methods, Molecular diffusion and Brownian motion as random walk problems and their Monte-Carlo simulation	16	14

Reference Books:

1. Hildebrand, F. B. Introduction to Numerical Analysis. New York: McGraw-Hill, pp. 327-330, 1956
2. Sastry: Introductory Methods of Numerical Analysis
3. An Introduction to Numerical Analysis by Kendall E. Atkinson
4. Byron S. Gottfried. Schaum's outline of Theory and Problems of Programming with C. New Delhi: Tata McGraw-Hill,1991.
5. Suresh Chandra. Application of Numerical Techniques with C. New Delhi: Narosa Publishing House, 2006.
6. Brain W. Kernighan and Dennis. M. Ritchie. The C Programming Language. 2nd ed. New Delhi: Prentice-Hall of India, 1988.
7. E. Balagurusamy. Numerical Methods. New Delhi: Tata McGraw-Hill, 1999.

8. A.K. Ghattak, T.C. Goyal and S.J. Chua. Mathematical Physics. New Delhi: Macmillan, 1995.
9. Numerical Methods for Scientific and Engineering Computations – M.R.Jain, S.R.K Iyengar and R.K. Jain – PHI Publisher
10. Narsingh Deo, *System Simulation with Digital Computers*, (Prentice Hall, 1979)
11. Abramowitz, M. and Stegun, I. A. (Eds.). Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables, 9th printing. New York: Dover, p. 890, 1972

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Project – I
Course Code: PHYP-301
Credits: (0 -Theory, 4-Practical) **No. of Class hours - 120**
Total Theory Marks: 100 **End Semester: 80** **In Semester: 20**

Preamble: This course is aimed at giving research exposure to students by giving small projects to them in physics related areas

Course outline: Each student will be given a project which they have to complete during their first semester

Modules: This course will be based on preliminary research topics both in theory and experiment. The teachers who will act as supervisors for the projects will float projects and any one of them will be allocated to the student. At the semester end, the student will submit Project Report in the form of Dissertation which will be examined by the examiners. The examination shall consist of (a) presentation and (comprehensive viva-voce).

Textbooks: As advised by the faculty member

References: As advised by the faculty member

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Advanced Condensed Matter Physics
Course Code: PHYD-301
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Course Contents:

Unit No.	**Topic**	**No. of contact hours**	**Allotted marks**
Unit I	Review of free electron theory, Bloch theorem, Fermi energy, and Fermi surface. Tight binding Model, Wannier orbitals, density of states. Electron motion in 2-dimension, quantum Hall effect.	10	10
Unit II	Born-Oppenheimer approximation, second quantization for Fermions and Bosons. Effects of electron-electron interactions - Hartree-Fock approximation, exchange and correlation effects. Fermi liquid theory, elementary excitations, quasiparticles.	12	12
Unit III	Dielectric function of electron systems, electrostatic screening, random phase approximation, plasma oscillations, optical properties of metals and insulators, electron-electron and electron-phonon interaction, excitons, polaritons, fluctuation-dissipation theorem.	12	12
Unit IV	Metal-Insulator transition, Mott insulators, Hubbard model, spin and charge density waves, electrons in a magnetic field, Landau levels, integer.	10	10
Unit V	Defects and Interfaces: Surface crystallography, Surface electronic structure, magnetoresistance, Heterostructures, point defects, dislocations, Burger vectors, dislocation and crystal growth.	8	8
Unit VI	Soft Matter: Time and length scales, Colloids, polymers, liquid crystals and ionic soft matter, phase transition in soft matter systems.	8	8

Reference Books:

1. Kittel C, Solid State Physics, Wiley, 2004.
2. Ashcroft N. W., Mermin N. D., Solid State Physics, Saunders, 1976.
3. R. A. L. Jones, Soft Condensed Matter, Oxford University Press 2002.
4. Sander M. Leonard, Advanced Condensed Matter Physics, Cambridge Univ. Press, 2009.
5. Snoke W. David, Solid State Physics: Essential Concepts, Pearson, 2009.
6. M. Doi, Soft Matter Physics, Oxford University Press, 2014.

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Lasers and Nonlinear Optics
Course Code: PHYD-302
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	**Fundamentals of Lasers**: Absorption, Spontaneous emission and Stimulated emission, Einstein coefficients and their significance, Lasing mechanisms, Laser oscillator, Laser characteristics, Principles for operation of Lasers, modes and mode selection, Temporal & Spatial Coherence, comparison of laser with conventional sources of light, Laser Line width and Line broadening mechanisms, Gaussian Beams and optical resonators.	10	10
Unit 2	**Types of Lasers**: Rate equations, CW lasers, and Pulsed Lasers, Gas lasers, solid state lasers, semiconductor lasers, Dye Lasers and Fiber lasers, Spectral coverage with current Laser technologies.	8	8
Unit 3	**Generation of short and Ultrashort pulses**: Q-Switching, Mode locking, Chirping and Pulse compression, YAG Lasers, State-of–art-lasers (Ti: Sapphire Lasers and Fiber Lasers).	8	8
Unit 4	**Nonlinear Optics**: Optics & Wave propagation in anisotropic medium, Electromagnetic Waves in Nonlinear Media, Phenomenological theory of nonlinearities, Nonlinear polarization, Nonlinear susceptibility, Wave equation.	10	10
Unit 5	**Nonlinear processes:** Second Order Nonlinear Optics: Electro-Optic and Acousto-optic effects, Acousto-optic Modulators, Harmonic generation, Phase Matching, Parametric Effects, Photorefractive Effect. Third-order Nonlinear Optics: Wave Mixing; Nonlinear Refraction and Absorption, Multiphoton Processes, Self-focusing, Self-phase-modulation, Photon Echo, Optical Switching and Solitons. Stimulated Scattering: Rayleigh, Brillouin, and Raman Processes.	15	14

Reference Books:

1. Laser fundamentals- W. T .Silfvast, 2nd edition, Cambridge University Press (2008) (Text).
2. Lasers: Fundamentals and Applications, K. Thyagarajan and Ajoy Ghatak, Springer, 2nd edition (2011)
3. Principles of Lasers, Orazio Svelto and David C. Hanna, Springer, Fifth Edition (2010)
4. Nonlinear optics- Robert W Boyd, Academic Press, Elsevier, Inc (Third Edition) (2008), (Text)
5. Lasers and Nonlinear optics- B B Laud, Wiley Eastern 3rd Edition, (2004)

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Communication Electronics
Course Code: PHYP-303
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	**Topic**	**No. of Lectures**	**Allotted marks**
Unit 1	Introduction to digital communications, sampling techniques, quantization, ESD, PSD, autocorrelation function, orthogonality.	10	10
Unit 2	Pulse modulation: PAM, PCM, DPCM, delta modulation, ADM.	8	8
Unit 3	Data transmission: FSK. PSK, DPSK, Mary modulation systems, error probability calculations.	8	10
Unit 4	Random process: PSD of random process, transmission of random process through linear systems, optimum filtering.	8	10
Unit 5	Behaviour of digital communication system in presence of noise: optimum threshold detection, OBR, carrier systems ASK, FSK, PSK and DPSK, spread spectrum systems, Optimum signal detection: Gaussian random process, optimum receiver, nonwhite channel noise.	14	12
Unit 6	Error control coding: block and convolution codes, combined modulation and coding, examples of typical communication systems: Modems, local area networks, computer communication, microwave, satellite, optical, cellular mobile etc.	12	10

Reference Books:

1. Lathi, B. P., *Modern Analog and Digital Communication Systems*, (Oxford University Press, 2009).
2. Haykins, S., *Communication systems*, 3rd edition, (Wiley India Pvt Ltd., 2006).
3. Gallager, R. G., *Principles of Digital Communication*, (Cambridge University Press, 2008).
4. Rao, P. R., *Digital Communication*, (Tata McGraw-Hill ***Publishing*** Co., 2007).
5. Sklar, B., *Digital Communications: Fundamentals & Applications*, 2nd edition, (Pearson
1. Education, 2009).
6. Proakis, J. G. and Salehi, M., *Communication Systems Engineering*, (McGraw-Hill Higher
2. Education, 2007).

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Quantum Field Theory
Course Code: PHYD-304
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Introduction to Fields: Lagrangian and Hamiltonian formulation of continuous systems, introduction to relativistic field theories, four-vector notations. Klein-Gordon equation, relativistic free scalar fields, Dirac equation, antiparticles, free Dirac fields, covariant formulation of Dirac equation and its gamma matrices and their algebra including trace calculations.	20	20
Unit 2	Quantization of Fields: Quantization of scalar fields (complex and real), Dirac fields and vector fields.	10	10
Unit 3	Conservation Laws and Associated Symmetries: Noether's theorem, discrete symmetries: C, P and T symmetries of free scalar, charged scalar, Maxwell and Dirac fields.	15	15
Unit 4	Interaction Among Fields: Interaction picture, S-matrix, wick's theorem, Feynman rules, Feynman diagrams for elementary processes, lowest order calculations for Compton scattering, Bremsstrahlung, Bhabha and Moller scatterings, renormalization.	15	15

Reference Books:

1. Lahiri, A., and Pal, P. B., Quantum Field Theory, (Narosa Publishing House, 2017)
2. Ryder, L. H., Quantum Field Theory, (Cambridge University Press, 1996)
3. Halzen, F., and Martin, A. D., Quarks and Leptons: An Introductory Course in Modern Particle Physics, (John Wiley and Sons, 2008).
4. Peskin, M. E., and Schroeder, D. V., Introduction to Quantum Field Theory, (Addison Wesley, 1995)
5. Weinberg, S., The Quantum Theory of Fields (Vol. I, II, III), (Cambridge University Press, 2005)
6. Mandl, F., and Shaw, G., Quantum Field Theory (John Wiley and Sons, 2010)
7. Huang, K., Quarks, Leptons and Gauge Field, (World Scientific, 1992)
8. Aitchison, I. J. R., and Hey, A. J. G., Gauge Theories in Particle Physics, (Adam Hillier, 2004)
9. Chang, S. J., Introduction to Quantum Field Theory, (World Scientific, 1990)

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Physics of Thin Films
Course Code: PHYD-305
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Vacuum Science and Technology: Vacuum pumps, gauges, vacuum seals and motion and electrical feedthroughs UHV materials and technology	12	12
Unit 2	Thin film deposition techniques: Physical vacuum deposition, e-beam, MBE, sputtering, laser ablation, chemical - CVD MOCVD, electrochemical deposition, plasma assisted techniques.	15	15
Unit 3	Nucleation & Growth: capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & mechanisms, amorphous thin films, Epitaxy–homo, hetero and coherent epitaxial layers, lattice misfit and imperfections, epitaxy of compound semiconductors.	15	15
Unit 4	Film Formation and Structure: Capillarity Theory, Atomistic Nucleation Processes, Cluster Coalescence and Depletion, Experimental Studies of Nucleation and Growth, Grain Structure of Films and Coatings	8	8
Unit 5	Structural, optical, electrical and mechanical characterization of films, metallic, semiconducting and insulation films, non-crystalline films	6	6
Unit 6	Applications of thin films	4	4

Reference books

1. Ohring, M., The materials science of Thin films, Academic Press Ltd, 2nd Edition, 2002
2. Vacuum Technology: A. Roth-North Holland Pub. Co., 1976
3. Handbook of thin film technology, L. I. Maissel and R. Glang. (McGraw-Hill), 1970.
4. 2. Thin film phenomena, K. L. Chopra (McGraw-Hill), 1969.
5. Thin films Solar Cells, K. L. Chopra, S. R. Das (Plenum Press), 1983.
6. Physics of Thin Films, Lckertova Plenum, 1977.
7. Thin Films : Trends and New Applications, Vol. 2 H. Hoffmann, (Elsevier), 1989.

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Quantum Optics
Course Code: PHYD-306
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Concept of density matrix and its properties: Quantization of EMF, Field quantisation, Fock/Number states, Expansion in number states, Coherent States, Displacement operator, Squeezed States, Squeezing operator, Correlation and characteristic functions. Coherence properties of EMF: First order optical coherence, Coherent field, Photon correlation measurements, Hanbury Brown-Twiss experiments	20	20
Unit 2	Photon counting measurements, Classification light by photon statistics, Photon bunching, Photon antibunching, Squeezed light: Generation and application of squeezed light, Resonant light atom interactions, Two level atom approximation, Rabi oscillations	14	14
Unit 3	EPR argument, experimental studies , Bell's inequalities in quantum optics , nondemolition measurements, quantum coherence, Entanglement and interferometric measurements.	14	14
Unit 4	Deflection of atoms by light, Kapitza- Dirac effect, Optical Stern-Gerlach experiment, Interaction between Atoms and quantized fields- dressed fields, Jaynes - Cummings model.	12	12

Reference Books

1. Quantum Optics -D F Walls, G J Milburn Springer Verlag, 2nd edition (2008) (Text). 2. Quantum Optics an Introduction - Mark Fox Oxford University press Press (2004) (Text)
2. Introductory Quantum Optics Christopher Gerry and Peter L knight, Cambridge University Press
3. Optical Coherence and quantum optics, Leonard Mandel, Emil Wolf, Cambridge University Press, 2nd Edition (2013
4. Fundamentals of Quantum Optics- John R Klauder and ECG Sudarshan, Dover publication (2006)
5. Quantum Optics- Werner Vogel, Dirk-Gunnar Welsch, Wiley VCH,3rd edition(2006)

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Digital Signal Processing
Course Code: PHYD-307
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Discrete time signal and systems, sampling of signals in time and frequency domain, z-transform, discrete cosine transform, Hilbert transform, Fourier transform, DFT, FFTs, convolution,	20	20
Unit 2	Digital filters: structures of Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters, Linear phase filter, windowing method, standard and multi band, constrained least square filtering, arbitrary response filter design, IIR filter design, in frequency domain, Butterworth, Chebyshev type I and type II, elliptical, Bessel	14	14
Unit 3	Spectral analysis: Welch's method, multilayer method, Yule-Walker method, covariance methods, MUSIC and eigenvector analysis method	14	14
Unit 4	Applications in real time problems like extraction of voice from noisy environment, filtering the signal using digital filters etc.	12	12

Reference Books:

1. Proakis, J. G. and Manolakis, D. G., Digital Signal Processing: Principles, Algorithms, and Applications, 3rd edition, (Prentice Hall, 1996).
2. Mitra, S. K., Digital Signal Processing: A Computer Based Approach, (McGraw-Hill, 2001).
3. Lyons, R. G., Understanding DSP, 3rd edition, (Pearson Education, International, 2010).
4. Hayes, M. H., Digital Signal Processing, Schaum's Outline Series, (McGraw-Hill, 1999).
5. Oppenheim, A. V. and Schafer, R. W., Digital Signal Processing, (Macmillan Publishing Company, New York, 1993).
6. Porat, B., A course in Digital Signal Processing, (John Wiley & Sons, 1996).
3. Soliman, S. S. and Srinath, M. D., Continuous and Discrete Signals and Systems, (Prentice Hall, 1998).
7. Sharma, S., Signals and Systems, (Katson Books, 2010).

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: High Energy Physics
Course Code: PHYD-308
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	**Topic**	**No. of Lectures**	**Allotted marks**
Unit 1	Introduction: Colliders, Detectors, Klein-Gordon Equation, Dirac Equation, Antiparticles	8	8
Unit 2	Gauge Field Theory: Particle Interactions, S-Martrix, Cross Sections	8	8
Unit 3	Quantum Electrodynamics (QED): Feynman Rules, Elementary processes, Higher-order Corrections, Lamb Shift, Renormalization	12	12
Unit 4	Quantum Chromodynamics (QCD): Structure of Hadrons, Parton Model, Bjorken Scaling, Quarks, QCD, Aymptotic Freedom, Confinement, Chiral Symmetry, Feynman Rules, Elementary Processes, Renormalization	12	12
Unit 5	Weak Interactions: V-A Theory, Weak Mixing Angles, CP violation	6	6
Unit 6	The Standard Model: Electroweak Interactions, SU(2) x U(1) Gauge Symmetry, Spontaneous Symmetry Breaking, Higgs Mechanism, Renormalizability, Collider Experiments, Neutrinos. Beyond the Standard Model: Supersymmetry, Grand Unified Theories, Ideas in String Theory.	14	14

Reference Books:

1. Francis Halzen and Alan D. Martin: Quarks and Leptons: An Introductory course in Modern Particle Physics; John Wiley & Sons (1984)
2. M.E. Peskin and D.V. Schroeder: An Introduction to Quantum Field Theory; Westview Press (1995)
3. D.H. Perkins: Introduction to high energy physics-4th Edn.; Cambridge University Press (2000).
4. C. Itzykson and J.B. Zuber: Quantum Field Theory; McGraw Hill (1986).
5. Ta-Pei Cheng and Ling-Fong Li: Gauge Theory of Elementary Particle Physics; Oxford
6. University Press (1992)
7. T. Muta: Foundations of Quantum Chromodynamics; World Scientific (1987)

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Advanced Condensed Matter Physics Laboratory
Course Code: PHYD-309
Credits: 4 (0 -Theory, 4 Practical) **No. of Class hours- 120**
Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Course Objectives:
At the completion of this course, a student will be able to
1. Gather a broader knowledge on the experimental techniques of condensed matter Physics
2. Understand the basic concepts in hands on mode through the basic solid state physics experiments.

List of Experiments:
1. To determine the magnetic susceptibility of a material by using Gouy's method.
2. To identify the lattice and to determine its lattice constant by using X-ray diffraction (laboratory simulation).
3. Study of temperature dependent Hall effect of the supplied semiconductor.
4. Measurement of resistivity and determination of hall co-effiecients in semiconductor samples by using Van der Pauw Set-Up.
5. Measurement of magnetoresistance: To measure magnetoresistance of a thin (0.5 mm) sample of p-doped (or n-doped) Germanium as a function of magnetic field for 3 different sample current.
6. Study of magnetic hysteresis: To plot magnetic hysteresis loop of a feromanetic rod.
7. Measurement of dielectric constant: To measure dielectric constant of a ferroelectric material as a function of temperature and to observe ferroelectric to paraelectric transition.
8. To prepare and measure the thickness of a thin film.

Suggested References
1. *Lab Manual*, Advanced Condensed Matter Physics Lab

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Advanced Optics and Photonics Laboratory I
Course Code: PHYD-310
Credits: 4 (0 -Theory, 4 Practical) **No. of Class hours- 120**
Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Course Objectives:
At the completion of this course, a student will be able to

1. Gather a broader knowledge on the experimental techniques of laser technology and nonlinear optics Physics
2. Understand the basic concepts in hands on mode through the basic advanced optics and photonic experiments.

List of Experiments:

1. Characteristics of laser beam
   - (a) To study the polarization nature of laser beam and find the polarization extinction ratio of the laser beam
   - (b) To measure the divergence of the laser beam
   - (c) To measure the divergence of laser beam using a lens of known focal length
   - (d) To study the Gaussian nature of laser beam
   - (e) To measure the diameter (beam spot size) of the laser beam
2. Experiments with Fabry-Perrot Interferometer
   - d. To find the wavelength of monochromatic light, small difference in wavelength, etc.
   - e. To determine the spacing between the plates of Fabry-Perot etalon from the fringe Pattern
3. To determine particle size of lycopodium using laser beam diffraction
4. Verification of Beer-Lambert law and determination of absorption co-efficient.
5. To measure intensity dependent nonlinear susceptibilities of materials by using Z-scan technique
6. Second harmonic generation
   - (a) Second harmonic generation of light - frequency doubling in Urea and KDP crystals
   - (b) Comparison of SHG efficiency of urea and KDP crystals using a CCD spectrometer

Suggested References

1. *Lab Manual*, Advanced Optics and Photonics Laboratory I

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Advanced Electronics Laboratory
Course Code: PHYP-311
Credits: 4 (0 -Theory, 4 Practical) **No. of Class hours- 120**
Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Course Objectives:
At the completion of this course, a student will be able to
3. Gather a broader knowledge on the experimental techniques of electronics.
4. Understand the basic concepts in hands on mode through the advanced electronics experiments.

List of Experiments:
1. Design a Frequency modulation circuit using IC 555. Observe the components of the FM modulated spectrum for different modulation index. Compare the same with the theoretical value. Estimate the bandwidth required for the FM modulated signal.
2. Design a FM demodulation circuit using PLL. Estimate the free running signal and the lock range. Use the circuit for demodulating a FM modulation system.
3. To study the Signal Generation Applications of Operation Amplifier – 741.
4. To study different LC oscillator circuits, e.g., Hartley Oscillator, Tuned Output Oscillator, Colpitts Oscillator, and Clapps Oscillator, using operational amplifiers type-741
5. To study the operation and characteristics of a stepper motor with an 8085 based µP-Kit and user software EPROM.
6. Study of synchro transmitter-receiver pair with calibrated dials. Receiver also used as control transformer.
7. Study of microprocessor based linear digital control system.
8. Use of virtual instrumentation for signal acquisition and analysis (Labview and DAQ)

Suggested References
1. *Lab Manual*, Advanced Electronics Laboratory – I

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-III
COURSE TITLE: Advanced Mathematical Physics
Course Code: PHYD-312
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	**Nonlinear Dynamics:** Overview: Significance of nonlinearity; one-dimensional flows: flows on the line and the circle, fixed points and stability, existence and uniqueness, impossibility of oscillation, potentials; bifurcations: saddle-node bifurcation, transcritical bifurcation, pitchfork bifurcation, imperfect bifurcations and catastrophes, ghosts and bottlenecks, applications to physical problems; two-dimensional flows: linear systems, classification of linear system; phase plane: phase portraits, fixed points and linearization; chaos: strange attractors, chaos on a strange attractor, Lorentz map, Logistic map, Henon map, Liapunov exponent; Fractals: countable and uncountable sets, self-similarity, dimension of self-similar fractals, applications to physical problems.	20	20
Unit 2	**Topology**: Overview: topology and geometry in physics, maps, linear maps, images and kernels, dual vector space; topological spaces: definition and types, compactness, connectedness; homeomorphisms and topological invariants; Nielsen-Olensen vortex, topological excitations; homology and homotopy groups; fibre, vector and principal bundles; anomaly, abelian and non-abelian anomaly; some examples and applications.	20	18
Unit 3	**Differential Geometry**: Manifolds: definition, calculus of manifolds; Killing vectors: definition, Killing vector fields, conformal Killing vector fields; non-coordinate bases, differential forms, duality transformation; sub manifolds; complex manifolds: definition, calculus on complex manifolds, complexifications, complex differential forms; Hermitian manifolds: definition, Hermitian differential geometry, Kahler form, torsion and curvature; Kahler manifolds: definition, Kahler geometry, Kahler differential geometry; moduli space; matter fields and covariant derivatives; some examples and applications.	20	22

Reference books

1. Nonlinear Dynamics and Chaos, S. H. Strogatz,Perseus Books Publishing.

2. Stability, Instability and Chaos: An Introduction to the Theory of Nonlinear Differential Equations, P. Glendinning, Cambridge University Press.
3. Introduction to Applied Nonlinear Dynamical Syatem and Choas, Stephen Wiggins, Springer.
4. Geometry, Topology and Physics, M. Nakahara, IOP Publishing.
5. Calculus on Manifolds, M. Spivak, Addition-Wesley Publishing.
6. Topology, Geometry and Gauge Fields, G. L. Naber, Springer.
7. Topology and Geometry in Physics, E. Bick and F. D. Steffen (Eds.), Springer.

Proposed syllabus for

MSc in Physics

4th semester

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Statistical Physics
Course Code: PHYC-401
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No of contact hours	Allotted marks
Unit 1	Review of Statistical Physics, Phase space, ergodicity and Liouville theorem, Macrostates, microstates and fundamental postulate of equilibrium statistical mechanics, Micro canonical, Canonical and Grand canonical ensembles. Concept of ensemble average, Equation of state, specific heat and entropy of a classical ideal gas using microcanonical ensemble. Entropy of mixing, Gibb's paradox, Sakura Tetrode Equation. Energy and Density fluctuations; Equivalence of various ensembles, Virial and equipartition theorems	15	15
Unit 2	Partition function: Definition and significance. Application to an ideal diatomic gas. Classical harmonic oscillator, magnetic dipoles in a magnetic field.	8	8
Unit 3	Inadequacy of classical theory, Quantum mechanical ensemble theory, density matrix, Ensembles in quantum statistical mechanics. Partition functions with examples including: (i) an electron in a magnetic field (ii) Free particle in a box (iii) Linear Harmonic oscillator. Ensembles of ideal Boltzmann, Bose-Einstein and Fermi gas. Identical particles and symmetry requirement, difficulty with Maxwell-Boltzmann statistics, quantum distribution functions, Bose-Einstein and Fermi-Dirac statistics. Grand partition function for ideal Bose and Fermi gas.	12	12
Unit 4	Ideal Bose System: Thermodynamic behavior of ideal Bose gas, Bose-Einstein condensation (Experimental evidences), Liquid Helium: two fluid hydrodynamics, Second sound, Theories of Landau and Feynman (qualitative only). Thermodynamics of Black body radiation – Stephan Boltzmann law, Wein's Displacement Law. Ideal Fermi System: Thermodynamic behavior of an ideal Fermi Gas, Degenerate Fermi Gas, Pauli Paramagnetism.	10	10
Unit 5	Fluctuations, Gaussian distribution, Brownian motion (Langevin's Theorem). Approach to	15	15

	equilibrium: Fokker -Planck Equation. Fluctuation-dissipation theorem. Phase Transitions: Phenomenology —First and Second order phase transitions, elementary idea of critical phenomena, Universality of critical exponents, scaling of thermodynamic functions. Elementary ideas of Mean field theories, Exact solutions --Ising model in 1- dimension.		

Reference books:

1. R. K. Pathria and P. D. Beale, Statistical Mechanics, 3rd ed. Butterworth-Heinemann (2011).
2. S. R. A. Salinas, Introduction to Statistical Physics, Springer (2004).
3. W. Greiner, L Neise, and H. Stocker, Thermodynamics and Statistical Mechanics, Springer (1994).
4. K. Huang, Statistical Mechanics, John Wiley Asia (2000).
5. L. D. Landau and E. M. Lifshitz, Statistical Physics, Pergamon (1980).

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Project – II
Course Code: PHYP-301
Credits: (0 -Theory, 4-Practical) **No. of Class hours - 120**
Total Theory Marks: 100 **End Semester: 80** **In Semester: 20**

Preamble: This course is aimed at giving research exposure to students by giving small projects to them in physics related areas

Course outline: Each student will be given a project which they have to complete during their first semester

Modules: This course will be based on preliminary research topics both in theory and experiment. The teachers who will act as supervisors for the projects will float projects and any one of them will be allocated to the student. At the semester end, the student will submit Project Report in the form of Dissertation which will be examined by the examiners. The examination shall consist of (a) presentation and (comprehensive viva-voce).

Textbooks: As advised by the faculty member

References: As advised by the faculty member

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Nanostructured Materials
Course Code: PHYD-401
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	**Quantum confinement and its consequences:** Electronic states in semiconductor, Concepts of 2D nanostructures (quantum wells), 1D nanostructures (quantum wires) 0D nanostructures (quantum dots), Quantum mechanical treatment of quantum wells, wires and dots, Variation of electronic structure with size of semiconductor nanostructures, Widening of band gap, Effective mass approximation theory and other models for determination of electronic structures in semiconductor nanostructures, Strong and weak confinement in semiconductor nanostructures.	16	16
Unit 2	**Dielectric and optical properties:** Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons: Excitons in direct and indirect band gap semiconductor nanocrystals. Optical properties of semiconductor nanostructures, Phonons in nanostructures.	14	14
Unit 3	**Nanostructured materials:** Metallic nanostructures- Surface Plasmons, permittivity and permeability based on Lorentz oscillator model, Properties of metallic nanoparticles, surface plasmon resonance, stability of metal nanoparticles. Carbon nanostructures- Carbon nanomaterial, Fullerene, Carbon cluster, Carbon nanotubes, SWCNT, MWCNT, graphine, application of carbon nanotube. Magnetic nanostructures- magnetism in small and nanoparticles, superparamagnetism, introduction to spintronics, spin valve, magnetic tunnel junction, memory elements.	12	12
Unit 4	**Nanostructure Synthesis and Characterization:** Top-down and bottom-up approaches, natural occurrence, chemical methods, chemical vapour deposition, physical vapour deposition, magnetron sputtering, pulsed laser deposition, molecular beam epitaxy, lithography, mechanical alloying, biosynthesis, nanomanipulation. X-ray diffraction, crystallite size and strain, X-ray line profile analysis - size and strain broadening, electron microscopy, atomic probe microscopy, magnetometry, absorption and luminescence spectroscopy, X-ray photoelectron spectroscopy.	10	10
Unit 5	**Applications of nanomaterials and challenges:** Application nanostructured material in electronics, photonics, biotechnology, nano-electromechanical systems,	8	8

	nanocatalysis, nanocompsties and fibers, challenges of nanotechnology.		

Reference books:

1. Nanomaterials: Synthesis, properties and Applications, Ed. A. S. Edelstein and R.C.Cammarata, IOP (UK, 1996). Characterization of nanophase materials: Ed. Z.L.Wang, Willey-VCH (New York, 2002).
2. Introduction to nanotechnology, Charles P. Poole and Frank J. Owens (Wiley-Interscience, May 2003).
3. Naostructured Materials, Ed. Jackie Yi-Ru Ying (Academic Press, Dec 2001).
4. Nanotechnology: Basic Science and emerging technologies, Ed. Michael Wilson, K.Kannangara, G. Smith, M. Simmons, and C. Crane (CRC Press, June 2002).

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Advanced Laser Spectroscopy
Course Code: PHYD-402
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Interaction of radiation with matter, electronic transitions, radiative processes, energy diagram, internal conversion, conical intersection, Frank Condon principle, Kasha's rule, structure determination and solvent effect; basic photometric quantities, widths and profiles of spectral lines, overview of spectroscopic instrumentations-detection of light, interferometers, photo emissive detectors,	10	10
Unit 2	Application and advantages of Lasers in spectroscopy, time resolved laser spectroscopy, homodyne and hetrodyne techniques, measurement of ultra-short pulses, pump and probe techniques	8	8
Unit 3	Laser induced absorption and fluorescence spectroscopy, Stokes Shift, fluorescence experiments, quenching, lifetime and quantum yield, fluorescence anisotropy, applications	10	10
Unit 4	Infrared Spectroscopy: Steady-state and time-resolved Infrared spectroscopy: from overview to potential applications	10	10
Unit 5	Raman Spectroscopy: Spontaneous Raman Spectroscopy, Resonance-enhanced Raman Spectroscopy, Stimulated Raman spectroscopy, hyper Raman and coherent anti Stokes Raman spectroscopy, applications	12	12
Unit 6	Principles and applications of photon correlation spectroscopy, Frequency Comb Spectroscopy, Photoacoustic Spectroscopy, Laser-induced Breakdown Spectroscopy, and their applications	10	10

Reference books:

1. W. Demtroder, Laser Spectroscopy Basic Concepts and Instruments, Springer (1996).
2. M. S. Feld and V. S. Lethokov, Non linear laser Spectroscopy, Springer (1980).
3. S. Stenholm, Foundations of laser spectroscopy, Wiley (1999).
4. V. I. Balykin and V. S. Lethokov, Atom Optics with Laser Light, Harwood Academic Publishers (1995).

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Microprocessors and Microcomputers
Course Code: PHYP-403
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Microprocessor & Architecture: Internal Microprocessor Architecture, Real mode and protected modes of memory addressing, memory paging. Addressing mode: Data addressing modes. Program memory addressing modes, Stack-memory addressing modes. Instruction set: Data movement instructions, Arithmetic and Logic Instructions, Program control instructions. Assembler details.	16	16
Unit 2	Programming the microprocessor: Modular programming, using the keyboard and video display, Data conversions. Disk files. Examples programs.	8	8
Unit 3	Hardware specifications: Pin-outs and the Pin functions, clock-generator (8284A), bus buffering and latching, Bus timing. Ready and wait state. Minimum mode versus maximum mode.	8	8
Unit 4	Memory Interface: Memory devices, address decoding, 8088 and 80188 (8-bit) memory interface, 8086, 80186, and 80386 (16-bit) memory interface, 80386DX and 80486 (32-bit) memory interface, Dynamic RAM.	8	8
Unit 5	Basic I/O interface: Introduction to I/O interface, I/O port address decoding, 8255, 8279, 8254, 16550, ADC and DAC. Interrupts: Basic interrupt processing, Hardware interrupts. Expanding the interrupt structure, 8259A PIC	10	10
Unit 6	Direct memory access: Basic DMA operation, 8237 DMA controller, shared Bus operation, Disk memory systems, video displays	10	10

Reference books:

1. Barry B. Brey, "The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and pentium pro processor architecture, programming, and interfacing" Fourth Edition, PHI, 1999
2. Douglas V. Hall, "Microprocessors and Interfacing. Programming and Hardware", Second Edition, McGraw Hill International Edition, 1992.
3. Muhammad Ali Maxidi and Janice Gillispie Mazidi, ""The 80x86 IBM PC and Compatible Computers (VOlumes I a& II), second edition, Prentice-Hall International, 1998.

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Particle Physics
Course Code: PHYD-404
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Introduction: Elementary particles, fundamental interactions (strengths and ranges), natural units. Conservation rules in fundamental interaction.	6	6
Unit 2	Quark Model: Quark model of mesons and baryons (quarks, gluons and colors), eightfold way of classification, symmetry groups: SU(2), SU(3), discovery of heavy quarks.	12	12
Unit 3	Parton Model: Probing charge distributions with electrons, form factors, e-p scattering, proton form factors, deep inelastic scattering, structure functions, partons, Bjorken scaling, QCD – dual role of gluons.	12	12
Unit 4	Weak Interactions: Introduction to neutrinos (postulation and discovery), V-A theory, nuclear beta decay, neutrino-quark scattering, Cabibbo angle, weak mixing angle, neutrino oscillations, CP violation.	10	10
Unit 5	Gauge theory: Local and global gauge theory, non-abelian gauge theory, spontaneous symmetry breaking, Higgs Mechanism, Goldstone theorem.	10	10
Unit 6	Statistical Tools and Data Analysis: Bayes' theorem, probability distribution functions, Monte-Carlo method, statistical tests: significance and power of a test, maximum likelihood method, examples of data analysis using the above tools in accelerator and neutrino experiments.	10	10

Reference books:

1. Halzen, F., and Martin, A. D., Quarks and Leptons: An Introductory Course in Modern Particle Physics, (John Wiley and Sons, 2008)
2. Griffiths, D., Introduction of Elementary Particles, (John Wiley and Sons, 1987)
3. Lyons, L., Statistics for Nuclear and Particle Physicists, (Cambridge University Press, 1989)
4. Mandl, F., and Shaw, G., Quantum Field Theory (John Wiley and Sons, 2010)
5. Huang, K., Quarks, Leptons and Gauge Field, (World Scientific, 1992)
6. Aitchison, I. J. R., and Hey, A. J. G., Gauge Theories in Particle Physics, (Adam Hillier, 2004)
7. Cowan, G., Statistical Data Analysis, (Oxford Science Publications, Clarendon Press, 1998)
8. Sakurai, J. J., Invariance principle and elementary particles, (Princeton Univ. press, 2016)

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Organic Electronics and Optoelectronics
Course Code: PHYD-405
Credits: 4 (4 - Theory, 0 - Practical) No. of Class hours - 60
Total Theory Marks: 100 End Semester: 60 In Semester: 40

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Organic molecules, covalent bond-sigma and pi bonds, electronic structures of atoms and molecules, energy levels, organic films, organic solids, excited states of aggregated films, excitons and exciton diffusion	10	10
Unit 2	Conducting polymers, oligomers, semiconducting small organic molecules and their properties. Charge transport and optical processes in organic films.	10	10
Unit 3	Organic light emitting diodes (OLED), fabrication techniques, performance, way to perceive colors, conventional, transparent, inverted and flexible OLEDs, OLED based flexible display technology	10	10
Unit 4	Organic thin films transistors (OTFT), fabrication techniques, performance, applications, single molecule switch and memory element, organic nanotube transistors, OTFT based display technology	12	12
Unit 5	Organic laser, optically pumped lasing structures, applications. Organic multilayer photodetectors, organic photovoltaic cells.	10	10
Unit 6	Organic spintronics-spin transport through organic films, spin valves, applications.	8	8

Reference books:

1. F. So, Organic Electronics: Materials, Processing, Devices and Applications, CRC Press, 2010.
2. H. Klauk, Organic Electronics: Materials, Manufacturing and Applications, Wiley-VCH, 2006.
3. G. Meller and T. Grasser, Organic Electronics, Springer, 2010.
4. W. Brutting, Physics of Organic Semiconductors, Wiley-VCH, 2005.
5. J. Kalinowski, Organic Light-Emitting Diodes: Principles, Characteristics, and Processes, Marcel Dekker, 2005.
6. Z. Bao and J. Locklin, Organic Field Effect Transistors, CRC Press, 2007.
7. F. C. Krebs, Polymer Photovoltaics: A Practical Approach, SPIE Press, 2008.
8. Z. V. Vardeny, Organic Spintronics, CRC Press, 2010.

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Fiber Optics
Course Code: PHYD-406
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Optical waveguides, numerical aperture, Modes in planar waveguides, Goos-Hanchen effect, evanescent field. Cylindrical fibers. Step index and graded index fibers, single mode and multimode fibers, cut of wavelengths, Integrated Optics, channel waveguides, electro optic waveguides, i/p and o/p couplers, e-o and m -o modulators applications of integrated optics - lenses, grating, spectrum analysers.	16	16
Unit 2	Transmission characteristics of optical fiber, attenuation, absorption and scattering losses, nonlinear losses, wavelengths for communication, bend losses, dispersion effects in optical fibers- material, waveguide dispersions, modal birefringence and polarization maintaining fibers. Nonlinear effects in optical fibers - Self phase modulation, cross phase modulation, stimulated Raman scattering, stimulated Brillouin scattering.	14	14
Unit 3	Optical fiber measurements – Attenuation, loss dispersion band width, refractive index profile. OTDR. Testing of optical fiber systems, eye pattern techniques. Fabrication and characterization of silica, polymer fibers and photonic crystal fibers. Erbium doped fibers. Fiber components – couplers, connectors, Packaging, Splicers, Cable, Fiber joints, fiber polishing, Industrial, medical and technological applications of optical fiber	15	15
Unit 4	Fiber optic sensors – advantages of fiber optic sensors. Intensity modulation and interference type sensors, intrinsic: and extrinsic fiber sensors. Wavelength modulated sensors. Fiber Bragg grating and fiber long period grating sensors. Distributed fiber optic sensors. Polarization modulation type sensors. Sagnac and fiber gyro, temperature, pressure, force and chemical sensors.	15	15

Reference books:

1. Fundamentals of Fibre Optics-B. P. Pal, Wiley Eastern, (1994)
2. Understanding Fiber optics- J. Hecht, Pearson Edu. Inc (2006)
3. An introduction to Fiber Optics, Ghatak and Thyagarajan, Cambridge University Press 1998.
4. Fibre optic sensors - principles and applications - B.D.Gupta, New India Publishing, (2006).

5. Fibre Optic Communication Systems, 3rd Edition - G.P. Agrawal, John Wiley and Sons, (2002)

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Microwaves, Antennas and Propagation
Course Code: PHYD-407
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Review of Maxwell's equations: Electromagnetic radiation, plane waves in dielectric and conducting media, reflection and refraction of waves. Transmission lines, smith chart and its applications, rectangular wave guide, rectangular cavity, modes in waveguides and cavities, dielectric filled wave guides, dielectric slab guide, surface guided waves, non-resonant dielectric guide, modal expansion of fields and its applications.	12	12
Unit 2	Microwave generation and amplification, avalanche effect devices: Read diode, IMPATT diode, klystron: velocity modulation process, bunching process, output power and beam loading, reflex klystron: power output and efficiency, traveling wave tubes, magnetron.	10	10
Unit 3	Microwave waveguide components: attenuators, phase shifters, matched loads, detectors and mounts, slotted-sections, E-plane tee, H-plane tee, hybrid tees, directional couplers, tuners, circulators and isolators, quarter wavelength transformer, multi section transformer matching section.	10	10
Unit 4	Lumped planar components: capacitor, inductor and balun; power dividers, directional couplers, analysis of these components using the S-parameters, microwave planar filters, planar non reciprocal devices, signal generators: fixed frequency, sweep frequency and synthesized frequency oscillators, frequency meters, VSWR meters, measurements of frequency, attenuation, VSWR and impedance.	10	10
Unit 5	Antenna characteristics: radiation patterns, directive gain, side lobe, back lobe, polarization, copolarization and cross polarization level, frequency reuse, beam width, input impedance, bandwidth, efficiency, antenna types: wire, loop and helix antennas, aperture antenna-slot, waveguide and horn antenna, parabolic reflector antenna.	10	10
Unit 6	Microwave integrated circuits (idea only): different planar transmission lines, characteristics of microwave integrated circuits, microstrip antenna: rectangular and circular patch, feed for microstrip antennas: probe feed, microstrip line feed, aperture feed, electromagnetically fed microstrip patch.	8	8

Reference books:
1. Rizzi, P. A., Microwave Engineering, (Prentice-Hall, 1999).
2. Pozar, D. M., Microwave Engineering, 3rd edition, (Wiley India Pvt. Limited, 2009).

3. Liao, S. Y., Microwave Devices and Circuits, 3rd edition, (Prentice-Hall of India, 2000).
4. Collin, R. E, Foundations for Microwave Engineering, (McGraw-Hill, 1992).
5. Griffiths, D. J., Introduction to Electrodynamics, (Prentice-Hall, 2009).
6. Jackson, J. D., Classical Electrodynamics, 3rd edition, (John Wiley & Sons, 1998).

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Plasma Physics
Course Code: PHYD-408
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Definition of plasma, Concept of temperature, Debye shielding, plasma parameters, criterion for plasma, Classification of Plasma, Applications of Plasma Physics.	15	15
Unit 2	Motion of charged particles in electromagnetic fields uniform E and B fields, non-uniform fields, diffusion across magnetic fields, varying E and B fields, Adiabatic invariants, Magnetic mirror	16	16
Unit 3	Plasma as fluids: Introduction, relation of plasma physics to ordinary electromagnetics, Fluid equation of motion, Fluid drifts perpendicular and parallel to B, Plasma approximation. Plasma confinement	14	14
Unit 4	Wave phenomena in plasma: phase and group velocities, plasma oscillation, electron plasma waves, ion-acoustic waves, propagation parallel and perpendicular to the magnetic field, propagation through ionosphere and magnetosphere; Space and Astrophysical Plasma, Van Allen Belts	15	15

Reference books:

1. Introduction to plasma physics, F. F. Chen, Springer.
2. Fundamentals of plasma physics, R. A. Bittencourt, Springer-Verlag NY Inc.
3. Principles of plasma diagnostics, I. H. Hutchinson, Cambridge University Press.

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Advanced Condensed Matter Physics Laboratory II
Course Code: PHYD-409
Credits: 4 (0 -Theory, 4 Practical) **No. of Class hours- 120**
Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Course Objectives:
At the completion of this course, a student will be able to
1. Gather a broader knowledge on the experimental techniques of condensed matter Physics
2. Understand the basic concepts in hands on mode through the basic solid state physics experiments.

List of Experiments:
1. Familiarization with ORIGIN Graphing and Analysis Software for analysis of absorption & photoluminescence spectra and X-ray diffraction patterns (Demonstration)
2. Production and measurement of low pressure using high vacuum pumping system (Demonstration)
3. Preparation of particles of different sizes by chemical method. (e.g.CdS, ZnS, Au,Ag etc.) (Demonstration)
4. To record and analyse UV-Vis absorption spectra of chemically synthesized CdS/ZnS nanostructures. Examine possible quantum confinement effect.
5. To analyse X-ray diffraction pattern of a given material to determine the crystal structure and estimate the particle using the Debye-Scherrer method.
6. To analyse the FTIR spectra of a given material to find the chemical bonds.
7. To study V-I characteristics of given Laser diode and LED
8. To study P-I characteristics of given Laser diode and LED
9. To study V-I and response characteristics of photo diode
10. To calculate the peak wavelength of LEDs
11. To calculate the spectral bandwidth of LEDs - FWHM
12. To analyze emission spectrum of laser and study the peak wavelength and FWHM

Suggested References
1. *Lab Manual*, Advanced Condensed Matter Physics Laboratory II

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Advanced Optics & Photonics Laboratory II
Course Code: PHYD-410
Credits: 4 (0 -Theory, 4 Practical) **No. of Class hours- 120**
Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Course Objectives:
At the completion of this course, a student will be able to
1. Gather a broader knowledge on the experimental techniques of optics and photonics.
2. Understand the basic concepts in hands on mode through the advanced optics and photonics experiments.

List of Experiments:
1. To determine the focal length of liquid lens.
2. To construct a Grating-Based Spectrometer (Wavelength-Dispersive Elements: 600 lines/mm and 1200 lines/mm Reflective Gratings)
3. To construct a Prism-Based Spectrometer (Wavelength-Dispersive Element: Equilateral Prism).
4. To determine the spectral composition of the white LED or other given light sources
5. To study polarization by quarter wave plate - elliptical and circular polarization.
6. To study polarization by half wave plate - change of polarization axis.
7. To construct laser beam expander
8. To construct optical beam collimator
9. To construct simple and compound microscopes
10. Numerical aperture measurement of multi-mode fiber
11. Measurement of bending loss in multi-mode fiber
12. Relative measurement of splice loss in multi-mode fiber
13. Numerical aperture measurement of single mode fiber
14. Calculation of normalized frequency or V-number of single mode fiber
15. Calculation of mode field diameter of single mode fiber.

Suggested References
1. *Lab Manual*, Advanced Optics & Photonics Laboratory II

Proposed syllabus for MSc in Physics 3rd semester:

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: Advanced Electronics Laboratory II
Course Code: PHYP-411
Credits: 4 (0 -Theory, 4-Practical) **No. of Class hours-120**
Total Practical Marks: 100 **End Semester: 80** **In Semester: 20**

Course Objectives:
At the completion of this course, a student will be able to
1. Gather a broader knowledge on the experimental techniques of electronics
2. Understand the basic concepts in hands on mode through the advanced electronics experiments.

List of Experiments:
1. Write a program using 8085 Microprocessor for Decimal, Hexadecimal addition and subtraction of two Numbers.
2. Write a program using 8085 Microprocessor for addition and subtraction of two BCD numbers.
3. To perform multiplication and division of two 8 bit numbers using 8085.
4. To find the largest and smallest number in an array of data using 8085 instruction set.
5. To write a program to arrange an array of data in ascending and descending order.
6. To convert given Hexadecimal number into its equivalent ASCII number and vice versa using 8085 instruction set.
7. To write a program to initiate 8251 and to check the transmission and reception of character.
8. To interface 8253 programmable interval timer to 8085 and verify the operation of 8253 in six different modes.
9. To interface DAC with 8085 to demonstrate the generation of square, saw tooth and triangular wave.
10. Serial communication between two 8085 through RS-232 C port.
11. To study mode characteristics of reflex klystron and hence to determine mode number, transit time electronic tuning range (ETR) and electronic tuning sensitivity (ETS)
12. To study I-V characteristics of Gunn Diode and depth of modulation of modulation of PIN diode
13. To measure the frequency generated by source and wavelength in rectangular waveguide for TE_{10} mode.
14. To measure voltage standing wave ratio (VSWR) and Reflection coefficient

Suggested References
1. *Lab Manual*, Advanced Electronics Laboratory II

Detailed Syllabus for Core Course
M.Sc. Physics

Semester-IV
COURSE TITLE: General Theory of Relativity and Cosmology
Course Code: PHYD-412
Credits: 4 (4 - Theory, 0 - Practical) **No. of Class hours - 60**
Total Theory Marks: 100 **End Semester: 60** **In Semester: 40**

Unit No.	Topic	No. of Lectures	Allotted marks
Unit 1	Tensor Analysis: Covariant and contravariant tensors, quotient rule, metric tensor. Christoffel symbol, covariant derivative of contravariant and covariant tensors, equations of geodesics, Rhemmann-christeffel tensor, Ricci tensor, scalar curvature, Einstein tensor.	14	14
Unit 2	Elements of General Theory of Relativity: Principle of equivalence, Principle of General Congruence. Einstein Field Equation, low velocity and weak field approximation of Einstein field equation, Gravitational waves.	12	12
Unit 3	Solution of EFE: Static and Schwarzschild solution of Einstein equation, exterior and interior solutions, Schwarzschild singularity & concept of black hole. Planetary orbits: advance of perihelion of mercury; bending of light: gravitational lensing and microlens, gravitational red shift.	12	12
Unit 4	Large-scale structure of universe: Cosmological principle, elements of Newtonian cosmology; Cosmological Models: Friedman-Robertson-Walker (FRW) metric, Hubble's law, Einstein universe, De-Sitter universe. Idea of dark matter and dark energy; Early Universe: The big bang theory, steady state theory, Cosmic Microwave Background Radiation, decoupling of matter and radiation. Inflation.	14	14
Unit 5	Idea of quantum gravity and quantum cosmology. Idea of Hawking radiation. Gravitational Waves.	8	8

Reference books:

1. Misner, C., Thorne, K. S. and Wheelar, J. A., Gravitation (Freeman, 2003).
2. Kenyon, I.R., General Relativity (Oxford University Press, 1990).
3. Weinberg, S., Gravitation and Cosmology (Wiley, New York, 1972).
4. Ryden B., Introduction to Cosmology (Cambridge University Press, 2016)
5. Schneider P., Extragalactic Astronomy and Cosmology: An Introduction (Springer, 2010)
6. Narliker, J. V., Introduction to Cosmology (Cambridge University Press, 2002).