SYLLABUS

For

MASTERS PROGRAMME (M.Sc.)

In

PHYSICS
(BATCH 2021 and onwards)

Under

CHOICE BASED CREDIT SYSTEM (CBCS)

DEPARTMENT OF PHYSICS
ISLAMIC UNIVERSITY OF SCIENCE AND TECHNOLOGY,
AWANTIPORA, PULWAMA-192122

Approved in the Fourth Board of Studies (BoS) Meeting held on 18-11-2021

Programme Objectives

The Department of Physics is committed to impart quality education both in theoretical as well as experimental physics with special emphasis on 'learning by doing' to produce quality manpower for teaching and research. The objectives of the M.Sc. Physics programme are:

- To impart quality education in physics through well designed courses of fundamental interest and of technological importance.
- To enable the students to acquire deep knowledge in fundamental aspects of all branches of Physics.
- To assist the students in acquiring basic knowledge in the specialized thrust areas such as Condensed Matter Physics and Nanoscience, Electronics, High Energy Physics, Radiation Physics and Applications, Plasma Physics and Astrophysics and Advanced Nuclear Physics.
- To develop abilities and skills in students that encourage research and development activities and are useful in everyday life.
- To inculcate scientific bent of mind and attitude relevant to science such as concern for efficiency, accuracy and precision, objectivity, integrity, enquiry, effective communication, ethical responsibilities, Initiative and Inventiveness.
- Advanced and specialized training in physics that prepares a student for the job of researcher, teacher or hospital physicist, depending on the focus chosen.
- Learning of the most advanced experimental and modelling techniques of today's physics.
- Lot of practical works (exercises, laboratories, and personal or group projects).

Programme Outcomes

Upon a successful completion of M.Sc. Physics programme, a students will

- have acquired substantial knowledge of different areas in physics, basic knowledge in mathematics with advanced knowledge in some specialized areas of physics.
- be able to apply theoretical and/or experimental methods, including the use of numerical methods and simulations.
- have some research experience within a specific field of physics, through a supervised project (Master's dissertation).
- be familiar with contemporary research within various fields of physics and have the background and experience required to model, analyse, and solve advanced problems in physics.

Course Structure

Types of Courses:

- **C - Core Course**
- **E - Discipline Centric Elective Course**
- **0 - Open Elective Course**

SEMESTER I

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	P	T	Total	Int.	Ext.	Total	
Core Course (C)	PHY501C	Mathematical Methods in Physics I	3	0	1	04	30 + 20*	50	100	20
Core Course (C)	PHY502C	Quantum Mechanics I	3	0	1	04	30 + 20*	50	100	
Core Course (C)	PHY503C	Classical Mechanics	3	0	1	04	30 + 20*	50	100	
Core Course (C)	PHY504C	Lab I	0	4	0	04	30 + 20*	50	100	
Discipline Centric Elective Course (E)	PHY505E	Electronics	3	0	1	04	30 + 20*	50	100	
Discipline Centric Elective Course (E)	PHY506E	Percolation Theory	3	0	1	04	30 + 20*	50	100	

* Assignment/Attendance

No. of Core papers to be opted = 04 (12 credits Theory + 04 credit Lab)

No. of Discipline Centric Elective Papers to be opted = 01 (04 credit)

Total No. of credits = 20

SEMESTER II

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	P	T	Total	Int.	Ext.	Total	
Core Course (C)	PHY550C	Classical Electrodynamics	3	0	1	04	30 + 20*	50	100	24
Core Course (C)	PHY551C	Statistical Physics	3	0	1	04	30 + 20*	50	100	
Core Course (C)	PHY552C	Quantum Mechanics II	3	0	1	04	30 + 20*	50	100	
Core Course (C)	PHY553C	Lab II	0	4	0	04	30 + 20*	50	100	
Discipline Centric Elective Course (E)	PHY554E	Mathematical Methods in Physics II	3	0	1	04	30 + 20*	50	100	
Discipline Centric Elective Course (E)	PHY555E	Radiation Physics and Applications	2	0	0	02	15+10*	25	50	
Discipline Centric Elective Course (E)	PHY556E	Non – Linear Dynamics	2	0	0	02	15+10*	25	50	
Discipline Centric Elective Course (E)	PHY557E	Plasma Physics	2	0	0	02	15+10*	25	50	
Open Elective Course		To be chosen from the list of Open Elective Courses offered by other departments in the University	2	0	0	02	15+10*	25	50	

* Assignment/Attendance

No. of Core papers to be opted = 04 (12 credits Theory + 04 credit Lab)

No. of Discipline Centric Elective Papers to be opted = 02 (06 credit)

No. of Open Elective Papers to be opted = 01 (02 credits)

Total No. of credits = 24

SEMESTER III

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	P	T	Tot.	Int	Ext	Tot.	
Core Course (C)	PHY601C	Nuclear Physics	3	0	1	4	30+20*	50	100	24
Core Course (C)	PHY602C	Condensed Matter Physics	3	0	1	4	30+20*	50	100	
Core Course (C)	PHY603C	Particle Physics	3	0	1	4	30+20*	50	100	
Core Course (C)	PHY604C	Numerical Methods and Programming	3	0	1	4	30+20*	50	100	
Discipline Centric Elective Course (E)	PHY605E	Material Science	3	0	1	4	30+20*	50	100	
Discipline Centric Elective Course (E)	PHY606E	Group Theory	2	0	0	2	15+10*	25	50	
Discipline Centric Elective Course (E)	PHY607E	Astrophysics I	2	0	0	2	15+10*	25	50	
Discipline Centric Elective Course (E)	PHY608E	Optics	2	0	0	2	15+10*	25	50	
Discipline Centric Elective Course (E)	PHY609E	Experimental Techniques	2	0	0	2	15+10*	25	50	
Open Elective Course		To be chosen from a list of Open Elective Courses offered by other departments of the University	2	0	0	2	15+10*	25	50	

* Assignment/Attendance

No. of Core papers to be opted = 04 (16 credits)

No. of Discipline Centric Elective Papers to be opted = 02 (04 credit + 02 credits = 06 credits) or 03 (02 credits each = 06 credits)

No. of Open Elective Papers to be opted = 01 (02 credits)

Total No. of credits = 24

SEMESTER IV

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	P	T	Tot.	Int	Ext	Tot.	
Core Course (C)	PHY650C	Atomic, Molecular and Laser Physics	3	0	1	4	30+20*	50	100	24
Core Course (C)	PHY651C	Physics of Nanomaterials	3	0	1	4	30+20*	50	100	
Core Course (C)	PHY652C	Computational Lab	2	2	0	4	30+20*	50	100	
Core Course (C)	PHY653C	Project	0	0	0	4			100	
Discipline Centric Elective Course (E)	PHY654E	Superconductivity	2	0	0	2	15+10*	25	50	
Discipline Centric Elective Course (E)	PHY655E	Quantum Field Theory	2	0	0	2	15+10*	25	50	
Discipline Centric Elective Course (E)	PHY656E	Astrophysics II	2	0	0	2	15+10*	25	50	
Discipline Centric Elective Course (E)	PHY657E	Advanced Nuclear Physics	2	0	0	2	15+10*	25	50	
Discipline Centric Elective Course (E)	PHY658E	Research Methodology	2	0	0	2	15+10*	25	50	
Discipline Centric Elective Course (E)	PHY659E	Fourier Optics and Applications	2	0	0	2	15+10*	25	50	

* Assignment/Attendance

No. of Core papers to be opted = 04 (04 credits each)

No. of Discipline Centric Elective Papers to be opted = 04 (02 credits each)

Total No. of credits = 24

Total credit and marks distribution for the Four semesters.

Course Type	No. of Papers	Credits per paper	Total credits	Marks per paper	Total Marks
Core Course (Theory)	**13**	**04**	**52**	**100**	**1300**
Core Practical	**02**	**04**	**08**	**100**	**200**
Project core	**01**	**04**	**04**	**100**	**100**
Discipline Centric Elective	**02**	**04**	**08**	**100**	**200**
	08	**02**	**16**	**50**	**400**
Open Elective	**02**	**02**	**04**	**50**	**100**
TOTAL	**28**		**92**		**2300**

Open Elective Course (offered by Department of Physics for other Departments of the University)

Course Type	Course Code	Course Title	Credit Distribution				Marks Distribution			Total Credits
			L	P	T	Total	Int.	Ext.	Total	
ODD SEMESTERS										
Open Elective Course	PHY001	Physics and Technology	2	0	0	2	15+10	25	50	2
Open Elective Course	PHY002	History of Physics	2	0	0	2	15+10	25	50	2
EVEN SEMESTERS										
Open Elective Course	PHY050	Philosophical Foundations of Physics	2	0	0	2	15+10	25	50	2
Open Elective Course	PHY051	Physics and our World	2	0	0	2	15+10	25	50	2

The following courses in the Program are Value Added Courses:

Course Title	Course code	No. of credits
Percolation Theory	PHY506E	4
Radiation Physics and Applications	PHY555E	2
Non – Linear Dynamics	PHY556E	2
Numerical Methods and Programming	PHY604C	4
Material Science	PHY605E	4
Optics	PHY608E	2
Experimental Techniques	PHY609E	2
Atomic, Molecular and Laser Physics	PHY650C	4
Physics of Nanomaterials	PHY651C	4
Computational Lab	PHY652C	4

Semester First

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) I Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Mathematical Methods for Physicists - I**

Course Code: **PHY501C**

Credits: 04

Type of Course: Core (Theory)

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: (2. 5 Hours) 50%

Course Objectives

The purpose of the course is to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems of interest to physicists.

Course Outcome

On completion of the course, student will be able to:

- Develop understanding of the basic concepts underlying complex analysis and complex integration.
- Solve ordinary and partial differential equations of second order that are common in the physical sciences.
- Mathematical methods and techniques that deal with differential equations and their applications .
- Will be familiar with special functions like Bessel functions, Legendre functions , Laguerre and Hermite polynomials and their properties.
- Learning of the theory of probability, Random variables and probability distributions, Expectation values and variance. Various examples of probability distributions used in physics.
- Perform parameter testing techniques like least square fitting, chi square test.

PHY501C: Mathematical Methods in Physics -I **Credits: 04**
L 3 T 1 P 0

UNIT I

Functions of a complex variable, Analytic functions, Cauchy-Riemann relations, Conjugate and harmonic nature of the real and imaginary parts of an analytic function, Cauchy's theorem, Cauchy's integral formula, Taylor and Laurent expansions, classification of singularities, The Point at Infinity; Calculus of Residues, Residues at Infinity, residue theorem, Evaluation of definite integrals using Cauchy's residues.

UNIT II

Partial Differential Equations, Classes and Characteristics, Boundary Conditions, First-order, Separable variables, Solution of linear first-order ODEs; Separation of variables in Cartesian, Spherical Polar and Cylindrical Coordinates.

Singular points, Solution of Second order Differential Equations using Frobenius Method, Limitations of series approach; second solution, Linear independence of solutions.

UNIT III

Bessel functions of First kind, Orthogonality, Neuman Functions, Hankel Functions, Modified Bessel Functions, Spherical Bessel Function; Legendre Functions, Orthogonality, Associated Legendre Function, Spherical Harmonics, Hermite Functions; Laguerre Functions.

UNIT IV

Probability and Statistics: Introduction, Probability: Definition, Properties, Permutations and Combinations, Random Variable, Discrete Probability Distributions, Covariance and Correlations, Conditional Probability Distribution, Normal, Binomial and Poison – Distributions,

Statistical Hypothesis, Error Propagation, Confidence Interval, Fitting Curves to data, The Chi-Square Fitting, Examples.

Books Recommended:

1. Mathematical Methods for Physicists, G. B. Arfken and H. J. Weber, Academic Press, 7th ed.
2. Mathematical Methods for Students of Physics and Related Fields, Sadri Hassani, Springer, 2nd ed.
3. Advanced Engineering Mathematics, Michel D. Greenberg, Prentice Hall, 2nd ed.
4. Mathematical Methods for Physics and Engineering, K. F. Riley, M. P. Hobson and S. J. Bence, CUP, 3rd ed.,
5. Advanced Engineering Mathematics, E. Kreyszig, John Wiley, 10th ed.
6. Mathematical Physics, M. L. Boas, John Wiley, 3rd ed.,

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) I Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Quantum Mechanics I**

Course Code: **PHY502C**

Credits: 04

Type of Course: Core (Theory)

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: (2. 5 Hours) 50%

Course Objectives

To understand the behaviour of the physical world at the atomic level. Connect the historical development of quantum mechanics with previous knowledge and learn the basic properties of quantum world.

Course Outcomes

On completion of the course, student will be able to

- Understand the origin of quantum mechanics.
- Learn the various mathematical tools involving linear algebra.
- To learn the quantum mechanical algebra of angular momentum.
- To learn the concept of symmetry in the context of quantum mechanics.
- The time-dependent and time-independent Schrödinger equation for simple potentials like for instance the harmonic oscillator and hydrogen like atoms, as well as the interaction of an electron with the electromagnetic field.
- Quantum mechanical axioms and the matrix representation of quantum mechanics.

PHY502C: Quantum Mechanics I **Credits: 04**
L 3 T 1 P 0

UNIT I
Inadequacy of classical Physics, Wave particle duality-de Broglie hypothesis, The Schrodinger's equation and it's fundamental properties, Wave function and Operators, Statistical interpretation of wave function, Continuity equation in quantum mechanics, Expectation values, Ehrenfest theorem.
Solution of Schrodinger's equation for 1D problems (Free particle; Box (applications in β-carotene), Step, Barrier potentials and simple harmonic oscillator), stationary states and their properties. Dirac delta function and its properties.

UNIT II
Linear vector spaces: Basics, Inner Product spaces, Dual spaces and the Dirac notation, Subspaces, Linear Operators, Matrix elements of linear operators, Active and passive transformation, Eigen value problem, Functions of operators and related concepts, Generalisations to infinite dimensions, Heisenberg's uncertainty principle, Simple harmonic oscillator by operator method.
Postulates of quantum mechanics, Superposition principle, Time development of a quantum mechanical system: Schrodinger, Heisenberg and interaction pictures.

UNIT III
Angular Momentum: Orbital, Spin and total angular momentum operators, ladder operators L_+cand L_-, their Commutation relations, Eigen values of J^2 and J_z operators, Matrix representation of J in $|j,m\rangle$ basis, Computation of angular momentum matrices for simpler cases ($j = 1,\ 1/2$), Pauli spin matrices, Addition of angular momenta, Computation of Clebsch-Gordon (CG) coefficients for simple cases.

UNIT IV
Time independent Schrodinger's equation in spherical coordinates, Spherical Harmonics and their properties, Solution of Schrodinger equation for hydrogen atom. Charged particle in homogeneous magnetic field and Landau levels.
Unitary transformation and symmetry in Quantum Mechanics, Space and Time translations, Parity, Time reversal, Discrete symmetries, Symmetry and conservation laws, Symmetry and degeneracy.
Rotation operator and infinitesimal generators of rotation, Rotation of spherical harmonics — $\mathscr{D}$-matrix (elementary concept).

Books Recommended:

1. Quantum Mechanics, L. I. Schiff, McGraw Hill, 4^{th} edition.
2. Principles of Quantum Mechanics, R. Shankar, Springer, 2nd edition.
3. Modern Quantum Mechanics, J. J. Sakurai and J. J. Napolitano, Pearson Publications, 2nd edition.
4. Quantum Mechanics by L.D. Landau and E. M.Lifshitz, Elsevier, 3rd edition.
5. Quantum Mechanics Concepts and Applications by N. Zettili, John Wiley, 2nd edition.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) I Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Classical Mechanics**
Course Code: **PHY503C**
Credits: 04
Type of Course: Core (Theory)
Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)
End-Term Examination: (2.5 Hours) 50%

Course Objectives

The objective of this core course is to teach the students how complex classical systems could be studied using Lagrangian, Hamiltonian formulations, advanced technique of co-ordinate transformation – the canonical transformations, Poisson bracket and Hamilton-Jacobi theory. The students also study the mechanics of rigid-bodies and small oscillations. Besides, basic and advanced concepts of special theory of relativity are taught.

Course Outcomes

The completion of this core course will enable the students to:

- Write the Lagrangian and Hamiltonian for various classical systems.
- Derive Lagrange's and Hamilton's equations of motion using various principles and techniques and explain the relationship between symmetries and conservation laws.
- Comprehend and explain central force motion and Kepler's laws.
- Learn and solve the problems using canonical transformations, Poisson bracket and Hamilton-Jacobi theory.
- Understand the mechanics of rigid-bodies having large degrees of freedom and dig out the interesting dynamics using Euler-angles technique along with Euler's theorem and Euler equations.
- Understand and solve the problem of small oscillations using Lagrangian formalism.
- Develop the basic understanding of the special theory of relativity and learn to find Lagrangian and Hamiltonian of relativistic systems.

PHY503C: Classical Mechanics

Credits: 04
L 3 T 1 P 0

UNIT I

The Lagrangian Formalism**-** Constraints and their classifications, Generalized coordinates Virtual displacement, D'Alembert's principle and Lagrangian equations of motion with few examples.
Variational Principles and Lagrange's Equations: Hamilton's Principle, Calculus of variations, Derivation of Lagrange's Equations from Hamilton's Principle; Symmetry properties of space and time and Conservation Theorems.
The Central Force Problem: Reduction to the equivalent one-body problem, First Integrals, classification of orbits, The differential equation of the orbit, Kepler's problem and scattering by a central field. Rutherford scattering, The Virial Theorem.

UNIT II
Legendre Transformations and Hamilton Equations of motion, examples. Cyclic Coordinates and Conservation Theorems. Statement of Noether's Theorem, scaling laws. Physical significance of the Hamiltonian function. Hamiltonian formulation of Relativistic Mechanics. Derivation of Hamilton's Equations from Variational Principle, The Principle of Least Action.

UNIT III
The Equations of canonical transformations, properties and generating functions of four special types of canonical transformations, Examples of Canonical transformations, Poisson brackets (PB), Properties of Poisson brackets, Angular momentum and Poisson bracket relations. Equation of motion in the Poisson bracket notation. Invariance of P.B. under canonical transformations.
The Hamilton-Jacobi equation, example of the harmonic oscillator treated by the Hamilton-Jacobi method. Liouville's theorem.

UNIT IV
Review of Mechanics of rigid bodies; The Euler Angles, Euler's Theorem, The inertia tensor and the moment of Inertia, Euler equations of motion for a rigid body. Small Oscillations: General formalism, Eigen-value equation, normal coordinates and normal modes.
Special theory of Relativity: Introduction and postulates, Lorentz Transformation, Length Contraction, Time Dilation, Twin Paradox, four vectors, relativistic kinematics and mass energy equivalence. Lagrangian formulation of relativistic mechanics.

Books Recommended:

1. Classical Mechanics by H. Goldstein, Charles P. Poole, John Safko, 3rd Edition, Pearson.
2. Mechanics by Landau and Lifshitz, Butterworth-Heinemann
3. Classical Mechanics by R.D. Gregory, , Cambridge University Press
4. Classical Mechanics by N.C. Rana and P.S. Joag, Tata McGraw-Hill.
5. An introduction to Mechanics, D. Kleppner and R. Kolenkow, Tata McGraw-Hill.
6. Classical Mechanics by S. N. Biswas, Books and Allied Pvt. Ltd, 1998.
7. Classical Mechanics by J. C. Upadhaya, Himalaya Publishing House, Mumbai. 2006.
8. Classical Dynamics of particles and systems by S. T. Thornton and J. B.Marion, Cengage Learning, 2008.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) I Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title:	**LAB I**
Course Number:	**PHY504C**
Credits:	04
Type of Course:	Core (Practical)
Contact Hours:	4 Classes per week (8 Hours)
Internal assessment:	30% (Attendance/Viva)
End-Term Examination:	70% (Performance/viva)

Course Objectives

The main objective of the course is to train a students to realise the various physics concepts learnt in the class room in the laboratory and understand the various aspects of scientific measurement which include error analysis, data fitting and data interpretation.

Course Outcomes

- To gain practical knowledge by applying the experimental methods to correlate with the physics theory.
- To learn the usage of electrical and optical systems for various measurements.
- Apply the analytical techniques and graphical analysis to the experimental data.
- To develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.

PHY504C: Lab. I **Credits: 04**

L 0 T 0 P 4

A students will have to perform at least 10 experiments from the following list of experiments available. At least two experiments must be carried out from each category; General Lab, Solid State Physics & Electronics Lab and Optics Lab.

General Lab:

1) To determine the value of specific charge for an electron by Thomson's Method.
2) To study the characteristics and dead time of G.M. Counter.
3) To study Attenuation coefficient/ absorption coefficient, using GM Counter.
4) Study of Lissajous Figures using CRO.
5) To determine the Specific heat of solids.
6) To find the frequency of AC supply using an Electrical Vibrator (Melde's experiments).
7) To verify de-Broglie hypothesis using electron diffraction.

Solid State Physics & Electronics Lab:

8) To determine the band gap of semiconductor from temperature dependence of resistivity using Four Probe Method.
9) Study of Hall Effect.
   (a) Determination of Hall Voltage and $R_{H.}$
   (b) Determination of mobility of charge carriers and carrier concentration.
10) Design and study summer, inverting/non-inverting amplifier using operational amplifier (IC-741).
11) To study V-I characteristics of PN junction (Using breadboard).
12) To design and study the V-I characteristics of BJT (Using breadboard).
13) To design and study the characteristics of FET (Using breadboard).
14) Study of dielectric constant and determination of Curie temperature of Ferroelectric ceramics.
15) Verify Truth Tables of the various logic-gates using a digital electronic trainer
16) To study the characteristics of a photo-voltaic cell (Solar cell).
17) Design and study of RC filters (Active and Passive).

Optics Lab:

18) To verify the Malus Law (Cosine Square Law) for polarisation of light
19) To find the wavelength of sodium light by measuring the diameters of Newton's rings.
20) Precision measurement of wavelength of monochromatic light using Michelson interferometer.

Books Recommended:

1. C.L. Arora, Practical physics, S. Chand Publication.
2. B.L. Worsnop and H. T. Flint , Advanced Practical Physics, Asia Publishing House

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) I Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Electronics**
Course Code: **PHY505E**
Credits: 04
Type of Course: Discipline Centric Elective (Theory)
Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)
End-Term Examination: (2.5 Hours) 50%

Course Objective

To understand the basic concepts of Analog and Digital Electronics and apply it in experimental Physics and also for various Engineering Applications.

Course Outcome

On completion of the course, students will be able to:

- To understand material classification and semiconductor fundamentals.
- To understand the physics behind the functioning of the electronic devices like diodes and transistors.
- Understand the basic concepts of OP-AMP, its various parameters and oscillators.
- Understand fundamentals of digital electronics and its usage in practical applications.

<u>PHY505E: Electronics</u> **Credits: 04**
L 3 T 1 P 0

UNIT I

Need of Band theory of solids, Classification of materials, Occupational probability, Fermi level, Semiconducting Materials and properties, Conductivity in semiconductors, Direct and indirect band gap semiconductors, Variation of charge carrier concentrations and Fermi level with Doping and temperature in intrinsic semiconductors and extrinsic semiconductors, PN junction diode, diode equation, diode built in voltage, junction capacitance, Various types of PN junction diodes and their usage (LEDs, Photodetectors, Solar cells, Zener etc.) Semiconductor lasers, Fabrication of band gap

UNIT II

Fundamentals of operation of UJT and BJT, Configurations and modes of operation for BJT, Analysis of CE amplifier using h-parameters, The T-network equivalent circuit, constants of CB and CE amplifier using emitter, base, collector resistance, Biasing technique to BJT, stabilization factor, temperature stabilization, operating point, fixed bias, emitter feedback bias, voltage feedback bias. Field Effect Transistors (FET) and MOS-FET: Structure, Working, Derivations of the equations for I-V characteristics under different conditions.

UNIT III

Feedback Principle, Negative feedback, effect of negative feedback on input/output resistances, voltage gain, gain stabilization, band width, Oscillators: Oscillator operation, Phase shift Oscillator, Wien-bridge Oscillator, Hartley Oscillator. Block diagram of an operational amplifier – Characteristics of an ideal operational amplifier, Differential amplifier: voltage gain. Applications of op-amp, summing amplifier, inverting and non-inverting configurations, subtractor, difference summing amplifier, Integrator. Instrumentation amplifier.

UNIT IV

Number Systems, Boolean Algebra, Karnaugh map, Combinational Circuits like Adder, Subtrator, Encoder /Decoder, Mux/Demux, Comparators, Sequential Circuits like Flip Flops, Registers, Counters, Analog to Digital and Digital to analog converters, Microprocessor and microcontroller (basics).

Books Recommended:

1. Integrated Electronics, J. Millman and C. C. Halkias and C. D. Parikh, Tata McGraw Hill, 2nd ed.
2. Electronic Devices and Circuit Theory, R. L. Boylestad and L. Nashelsky, Pearson, 7th ed.
3. Solid State Electronic Devices, B. G. Streetman and S. K. Banerjee, PHI, 7th ed.
4. Digital Principles and Applications, D. P. Leach, A. P. Malvino and G. Saha, McGraw Hill, 8th ed.

5. Electronic Fundamentals and Applications, J. D. Ryder, PHI, 5th ed. Op-Amps and Linear Integrated Circuits, R. A. Gayakward, PHI, 4th ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) I Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Percolation Theory**

Course Code: **PHY506E**

Credits: 04

Type of Course: Discipline Centric Elective (Theory)

Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: (1. 25 Hours) 50%

Course Objectives

The aim of this course is to provide a challenging and stimulating introduction to the methods of percolation theory and its application to describe the phase transition phenomena in physics.

Course Outcomes

On completion of this course, student will be able to:

- Understand the theory of random walks, diffusion equation and various theories regarding the Brownian motion.
- Understand various simulation techniques and their corresponding algorithms.
- Understand the application of percolation theory in the study of simple lattice models.
- Understand the basic concepts of fractals, scaling and renormalisation group theory.

<u>PHY506E: Percolation Theory</u> **Credits: 04**
L 3 T 1 P 0

UNIT I

Theory of random walks and simulation of random walks in one, two and three dimensions, Elementary idea sand simulations of self-avoiding walks, additive and multiplicative stochastic processes, Brownian motion and fractional Brownian motion.

UNIT II

Percolation theory and simulation by Hoshen-Kopelman algorithm; Application to simple lattice models in Physics.

UNIT III

Elementary ideas of: (a) Time-average and Molecular dynamics; Dynamical equations and physical potentials; Verlet algorithm (b) Ensemble average and Monte Carlo methods; Metropolis algorithm.

Introduction to the simulations of: (a) Ising model in magnetism (b) Bak-Tang-Wiesenfeld model in studies of self-organized criticality.

UNIT IV

Classification of problems; examples of optimization problems: traveling salesman problem (TSP) and satisfiability (k-SAT) problem; heuristic methods of solutions and simulated annealing technique.

Books Recommended:

1. Introduction to Percolation Theory, D. Stauffera and A. Aharony, Taylor and Francis, 2nd ed.
2. Numerical recipes in C: The Art of Scientific Computing, W. H. Press, B. P. Flannery, S. A. Teukolsky, W. T. Vetterling, CUP, 2nd ed.
3. Understanding Molecular Simulation, D. Frenkel and B. Smit, Elsevier, 2nd ed.
4. Equilibrium Statistical Physics, M. Plischke and B. Bergersen, World Scientific, 3rd ed.

Semester Second

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) II Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Classical Electrodynamics**
Course Code: **PHY550C**
Credits: 04
Type of Course: Core (Theory)
Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)
End-Term Examination: (2.5 Hours) 50%

Course Objectives

To develop understanding of the advanced concepts related to electrostatics, magnetostatics, electrodynamics and relativistic electrodynamics.

Course Outcomes

Completion of this core course will enable the students to:

- Find the electric field using Coulomb's law and Gauss' law for various charge distributions.
- Learn the relationship between electrostatic field and electrostatic potential.
- Solve the boundary value problem using various techniques.
- Solve the Poisson's and Laplace's equation.
- Use Biot-Savart law and Ampere's law to calculate magnetic fields.
- Explain Faraday's laws, Maxwell's equations and significance of displacement current.
- Understand the physics of gauge transformations and use of different gauges. Explain electromagnetic field energy and momentum.
- Use of Maxwell's equations to explain the behaviour of electromagnetic wave propagation in different media, phenomenon of refraction, reflection, interference, diffraction and polarization.
- Understand Dispersion phenomena, physics of transmission lines and wave guides.
- Understand the concept of retarded and Lienard-Wiechert potentials, and electrodynamics of a point charge.
- Learn the covariant form of Maxwell's equations, equation of continuity, transformation of fields and Lagrangian and Hamiltonian in presence of external magnetic field.

PHY550C: Classical Electrodynamics

Credits: 04
L 3 T 1 P 0

UNIT I

Electrostatics

Coulomb's law, Electric field, Gauss's law, applications of Gauss's law, Electric Potential, Poisson's equation and Laplace's equation, electrostatics potential energy. Formal solution of boundary-value problem using Green's function.

Boundary-value problems in Electrostatics: Method of Images, boundary conditions and uniqueness theorems, Solution of the Laplace equation in Cartesian, spherical and cylindrical coordinates. Solution of the Poisson equation. Multipole expansion.

UNIT II

Magnetostatics and Electrodynamics

Biot-Savart Law, Differential Equations of Magnetostatics, Ampere's law, Magnetic vector potential. Multipole expansion, Magnetization and Magnetic Field Intensity, Boundary conditions, The field produced by magnetized matter, Field of a magnetized object, Time dependent fields, Faraday's law, Energy in the magnetic Field, Maxwell's displacement current, Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, wave equations, gauge transformations, Coulomb and Lorentz Gauge, Maxwell's equations in terms of potentials. Poynting's theorem and Conservation of Energy and momentum.

UNIT III

Electromagnetic waves and Radiations

Electromagnetic waves in non-conducting media, Electromagnetic waves in free space, Dielectrics, and conductors, Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction, Dynamics of charged particles in static and uniform electromagnetic fields, Dispersion in plasma, Transmission lines and wave guides, Retarded potentials, Electric and Magnetic dipole radiation, Radiation from a point charge, moving charges and dipoles, Lienard-Wiechart potentials, fields of a point charge in motion, power radiated by a point charge.

UNIT III

Relativistic Electrodynamics

Four-Vectors in Electrodynamics, Invariance of Electric charge; Covariance of Electrodynamics, Four-Vector potential, Field Tensor, Covariant form of Maxwell's equation, Transformation of electric and magnetic fields under Lorentz transformations, invariants of electromagnetic field, , Lorentz force on a relativistic charged particle. Lagrangian and

Hamiltonian for a relativistic charge particle in external electromagnetic fields, Motion in-a static magnetic field, combined, uniform, static electric and magnetic fields.

Books Recommended:

1. Classical Electrodynamics, J. D. Jackson, John Wiley, 3rd ed.
2. Introduction to Electrodynamics, D. J. Griffiths, Pearson, 4th ed.
3. A. Das, Lectures on Electromagnetism, Hindustan Book Agency
4. Classical Electromagnetic Radiation, M. A. Heald and J. B. Marion, Suanders College Publishing.
5. R.P. Feynman, Feynman Lectures on Physics (Vol. II), Addison-Wesley
6. A. Zangwill, Modern Electrodynamics, Cambridge Univ. Press

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) II Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Statistical Physics**
Course Code: **PHY551C**
Credits: 04
Type of Course: Core (Theory)
Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)
End-Term Examination: (2.5 Hours) 50%

Course Objectives

To understand the theory and methods of statistical physics and thermodynamics. The aim of this course is to understand the basic as well as advanced concepts of both classical and quantum statistical physics.

Course Outcomes

On completion of this course, student will be able to:

- Understand the connection between statistics and thermodynamics.
- Understand different ensemble theories used to explain the behaviour of macroscopic systems.
- Understand the basic concepts of classical statistics and quantum statistics.
- Understand the statistical behaviour of ideal Bose and Fermi systems.
- Understand different types of phase transitions.

PHY551C: Statistical Physics **Credits: 04**
L 3 T 1 P 0

UNIT I

Statistical Basis of Thermodynamics: The Macroscopic and Microscopic States, Physical significance of the number Ω (N, V, E), The Classical Ideal Gas, Gibbs Paradox.
Ensemble Theory: Phase Space of a Classical System, Liouville's Theorem, Microcanonical Ensemble, Canonical and Grand Canonical Ensembles: Partition Function Calculations of Statistical Quantities, Energy and density fluctuations, Examples.

UNIT II

Formulation of Quantum Statistical mechanics: Density matrix, Statistics of Various Ensembles, System of Indistinguishable Particles, Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics, Properties of ideal Bose gases, Bose-Einstein condensation. Properties of ideal Fermi gas, Electron gas in metals.

UNIT III

The Method of Cluster Expansions: Cluster Expansion for a classical Gas, Virial Expansion of the Equation of state, Evaluation of Virial Coefficients, Exact Treatment of the Second Virial Coefficients, Cluster Expansion for a Quantum Mechanical System

UNIT IV

Phase Transitions: A dynamical Model of Phase Transition, Ising Model in the Zeroth Approximation, Random walk treatment, Brownian motion, diffusion equation.
Ising Model in the First Approximation, The Critical Exponents, Thermodynamic inequalities, Landau's Theory.

Books Recommended:

1. Statistical Mechanics, R.K. Pathria and P. D. Beale, Elsevier, 3rd ed.
2. Statistical Physics, F. Reif, McGraw Hill, Berkeley series, Vol. 5, 2nd ed.
3. Statistical Physics Part 1, L. D. Landau and E. M. Lifshitz, Elsevier, 3rd ed.
4. Statistical Mechanics, R.P. Feynman,Westview Press, 1st ed.
5. Statistical Mechanics, K. Huang, John Wiley, 2nd ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) II Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Quantum Mechanics II**
Course Code: **PHY552C**
Credits: 04
Type of Course: Core (Theory)
Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)
End-Term Examination: (2. 5 Hours) 50%

Course Objectives

The main objective of this course is to expose the students to the approximation methods in quantum mechanics such as the Variational Method, WKB approximation and perturbation theory. The other objectives are to teach scattering theory and the relativistic theory of quantum mechanics viz. Klein-Gordon equation and Dirac equation.

Course Outcomes

On completion of the course, student will be able to

- Understand the physics behind such technologies as Nuclear Magnetic Resonance Imaging, Lasers etc.
- Learn the quantum mechanics of scattering and its role to understand matter at subatomic level.
- To learn the quantum mechanics of identical particle systems.
- To learn the advanced concepts of relativistic quantum mechanics involving the Klein-Gordon and the Dirac equations.

PHY552C: Quantum Mechanics II **Credits: 04**
L 3 T 1 P 0

UNIT I

Time independent perturbation theory: Non-degenerate and Degenerate energy level, Applications: 1-D harmonic oscillator subjected to a perturbing potential in x and x^2. Variational Method, Applications: ground state of Helium atom. WKB approximation, the classical region, connection formulae.
Time dependent perturbation theory; Statement of the problem, Approximate solution of the Schrodinger equation, Transition probability, Constant perturbation, Harmonic perturbation, Adiabatic approximation, Transition to the continuum, The Fermi golden rule, Semi-classical theory of radiation, selection rules under dipole approximation.

UNIT II

The scattering experiment, Scattering cross-section, Asymptotic behaviour of wave function and scattering amplitude, Relation between scattering amplitude and scattering cross-section, Solution of Schrödinger equation for scattering (Lippmann-Schwinger equation), Born approximation, Scattering by a spherically symmetric potential, Cross-section for scattering in a screened coulomb potential, validity of Born's approximation.
Method of partial waves, Expansion of a plane wave in terms of partial waves, Scattering by a central potential, Optical theorem.

UNIT III

Many particle systems, systems of identical particles, exchange degeneracy, symmetrization postulate, construction of symmetric and anti-symmetric wave functions from unsymmetrized functions, Slater determinant, The Pauli Exclusion Principle and spin statistics connection, spin angular momentum, Density operator and density matrix.

UNIT IV

Klein-Gordon equation, charge and current densities for KG equation, Plane wave solution of KG equation, problems with KG equation, Dirac equation, Dirac matrices and their properties, plane wave solution of free particle Dirac equation, significance of negative energy solutions (Dirac's hole theory), spin angular momentum of the Dirac particle, Electron in electromagnetic field, Covariance of KG and Dirac equations.

Books Recommended

1. Quantum Mechanics, L. I. Schiff, McGraw Hill, 4th edition.
2. Principles of Quantum Mechanics, R. Shankar, Springer, 2nd edition.
3. Modern Quantum Mechanics, J. J. Sakurai and J. J. Napolitano, Pearson Publications, 2nd edition.
4. Quantum Mechanics by L.D. Landau and E. M.Lifshitz, Elsevier, 3rd edition.
5. Quantum Mechanics Concepts and Applications by N. Zettili, John Wiley, 2nd edition

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) II Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title:	**LAB II**
Course Number:	**PHY553C**
Credits:	04
Type of Course:	Core (Practical)
Contact Hours:	4 Classes per week (8 Hours)
Internal assessment:	30% (Attendance/Viva)
End-Term Examination:	70% (Performance/viva)

Course Objectives

The course is designed for the students of 2^{nd} semester to train them to handle some advanced level experiments. The main objective of the course is to teach the students how these experiments led to the discovery and advancement of modern physics.

Course Outcomes

- Students will perform advanced experiments specific to modern Physics, Solid State Physics & Electronics and Optics so as to gain practical knowledge in these areas of Physics.
- After completing the course, the students will be able to measure things like Bohr magnetron, nuclear magnetron, g-factors for atomic and molecular orbitals.
- Students would gain physical experience working with various advanced experimental setups like Millikan's Oil drop setup, Zeeman effect setup, Fabry Perot interferometer setup and other advanced electronics experiments.

PHY553C: LAB II **Credits: 04**

L 0 T 0 P 4

A students will have to perform at least 10 experiments from the following list of experiments available. At least two experiments must be carried out from each category; General Lab/Solid State Physics & Electronics Lab and Optics Lab.

General Lab:

1. To determine the charge of electron by Millikan's Oil Drop method.
2. To study the photoelectric effect.
3. To determine the value of e/m for an electron by long Solenoid helical method.
4. To determine the g-factor by the ESR Spectrometer.
5. To determine the g-factor by the NMR Spectrometer.
6. To study the Meissner effect.
7. To determine magnetic susceptibility of a paramagnetic/diamagnetic material using Quincke's tube method.
8. To study Poisson and Gaussian distributions using a GM counter.
9. To study the absorption of gamma rays using GM counter.
10. Frank-Hertz Experiment: To demonstrate the concept of quantisation of energy levels according to Bohr's model of atom.

Solid State Physics & Electronics Lab:

11. **(a)** To study the characteristics of a PN junction with varying temperature and to find the energy band gap of semiconductor.
    (b) To measure the capacitance of the junction.
    (c) Determination of Reverse Saturation of current I_0 and Material Constant.
12. To study the different hybrid parameters of transistor.
13. Study of RC-coupled amplifier.
14. Study of forward and reverse bias Photodiode Characteristics.
15. Realization of Fourier series.
16. Study of Hysteresis loop of Magnetic Materials; To verify B-H curve and to find out the values of coercivity, retentivity and saturation magnetization of experimental materials.
17. Design and study of Integrator and differentiator using operational amplifier (IC-741).
18. Study of regulated and stabilized power supply.

Optics Lab:

19. To study Zeeman Effect and to measure the value of Bohr Magnetron.
20. To measure the attenuation or propagation loss in an optical fibre using He-Ne laser source.
21. Fabry-Perot Interferometer.

Books Recommended:

1. C.L. Arora, Practical physics, S. Chand Publication.
2. B.L. Worsnop and H. T. Flint , Advanced Practical Physics, Asia Publishing House

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) II Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Mathematical Methods for Physicists - II**
Course Code: **PHY554E**
Credits: 04
Type of Course: Core (Theory)
Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)
End-Term Examination: (2. 5 Hours) 50%

Course Objectives

To impart knowledge about various mathematical tools employed to study physics problems.

Course Outcome

After successfully completing the course, student will be able to

- Learn the fundamentals and applications of Fourier series, Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems. They are also expected to learn the Laplace transform, the inverse Laplace transforms, their properties and their applications in solving physical problems.
- Develops ability to solve mathematical problems involving tensors.
- Solve linear differential equations with inhomogeneous term by the method of Green's function.
- Give an account of the foundations of calculus of variations and of its applications in physics.

PHY554E: Mathematical Methods in Physics II **Credits: 04**
L 3 T 1 P 0

UNIT I
Fourier Series: Definition, Properties, Convergence, Application of Fourier series, Fourier Integral and Fourier transform and inverse Fourier transform, Convolution theorem, Parseval's theorem, Laplace transform and its properties, inverse Laplace transforms, solution of differential equations using Laplace transforms, Fourier transform & Laplace transform of distributions: Gaussian and Poisson Distributions.

UNIT II
Tensor Analysis: Occurrence of tensors in physics, Notation and conventions, Tensors and their Ranks, Contravariant, covariant and mixed tensors, Addition and subtraction of tensors, Inner and Outer Product, Contraction, symmetric and anti-symmetric tensors, The Kronecker Delta, Quotient law, Conjugate symmetric tensors of second rank. The metric tensor, Contravariant metric tensor, Associate tensors Cartesian tensors: rotation and translation, Isotropic tensors. Examples: Moment of Inertia, dielectric susceptibility, stress and strain-Hooke's law.

UNIT III
Introduction and motivation, Green's Functions in One Dimension: Calculation of Green's Functions for simple differential operators, Green's Function for the Laplacian, Green's Functions for Second order Linear Differential Operators (SOLDOs), Adjoint and Self Adjoint Operators, Self-Adjoint SOLDOs, Green's function for regular S-L problems via Eigen function expansion, Dirac delta function and the Green's function, Generalized Green's identity, Green's function for non S-A BVPs, Existence of a zero Eigen value – modified Green's function.

UNIT IV
Variational Calculus: Introduction of variational calculus, Euler Equation (for one variable), Examples: Shortest path between two points on a plane, optical path near a black hole, Alternate forms of Euler Equations, More General Variations (Several dependant variables), Hamilton's principle, Examples: Moving Particle in Cartesian and cylindrical coordinates, Hamilton's equations. Geodesics.

Books Recommended:

1. Mathematical Methods for Physicists (7th Ed.), G. B. Arfken and H. J. Weber, Academic Press
2. Mathematical Methods for Students of Physics and Related Fields, Sadri Hassani, Springer, 2nd ed.
3. Matrices and Tensors in Physics 4th Edition, A. W. Joshi, New age international publishers.
4. Advanced Engineering Mathematics, Michel D. Greenberg, Prentice Hall, 2nd ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) II Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Radiation Physics and Applications**

Course Code: **PHY555E**

Credits: 02

Type of Course: Discipline Centric Elective (Theory)

Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)

End- Term Examination: (1. 25 hours) 50%

Course Objectives

To understand the basic concepts of radiation physics and its application in the medical science. Also, the aim is to make students familiarize with the construction of various radiotherapy units and their working principle.

Course Outcomes

On completion of this course, student will be able to

- Understand the basic principles of radiation physics and various radiotherapy units.
- Understand the basic physics of the electromagnetic and particulate forms of ionizing & non ionizing radiation.
- Understand the distinctions between the units of radiation quantity, exposure and dose.
- Understand the basic concepts of dosimetry.

PHY555E Radiation Physics and Applications

Credits: 02
L 2 P 0 T 0

Unit I:

Ionizing and Non-Ionizing Radiation

Electromagnetic spectrum: Introduction, Interaction of electromagnetic radiation with matter, Thomson scattering, Rayleigh scattering, Compton scattering, Photoelectric absorption, Pair production, Cerenkov radiation-mass-energy attenuation and absorption coefficient.

Radiation quantities and units, Radiometry, particle flux and fluence, energy flux and fluence, Linear and mass attenuation coefficients, Mass energy transfer and mass energy absorption coefficients, Stopping power, LET, Radiation chemical yield, W value, Dosimetry, Energy imparted, Measurement of Absorbed Dose, Definition of absorbed dose, relationship between kerma, exposure, and absorbed dose, Brag-Gray Cavity.

Unit II:

Radiotherapy Units

Introduction, Considerations in the design of high energy beams, General Introduction to Tele, Bracy and Internal Therapy, Betatrons, The Linear Accelerators, Medical Linacs, Isotope Machines, Typical Cobalt 60 Units, The cyclotron, Particles for radiotherapy.

Recommended Books:

1. The Physics of Radiology, Harold Elford Johns, J.R. Cunningham, 4th edition.
2. The Physics of Radiation Therapy, Faiz M. Khan, J. P. Gibbons, Fifth Edition
3. Basic Physics of Radiation Therapy, J. Selman, Third Edition.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) II Semester
Department of Physics
Islamic University of Science and Technology

Course Title: Non-Linear Dynamics

Course Code: PHY556E

Credits: 02

Type of Course: Discipline Centric Elective (E)

Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (45 minutes) and 20% assignments/attendance)

End-Term Examination: (1. 25 Hours) 50%

Course Objectives

It is an applied mathematics course designed to provide an introduction to the theory and basic concepts of Nonlinear Dynamics and Chaos. The course concentrates on simple models of dynamical systems, their relevance to natural phenomena.

Course Outcomes

- To enable a student to study the non-linear and chaotic physical systems.
- The tools learnt here can also be used in other disciplines like weather forecasting, forecasting market behaviour etc.

PHY556E: Non-Linear Dynamics **Credits: 02**
L 2 T 0 P 0

UNIT I

Physics of nonlinear systems, dynamical equations and constants of motion, phase space, fixed points, stability analysis, bifurcations and their classification, Poincaré section and iterative maps

UNIT II

Integrability, Liouville's theorem, action-angle variables, introduction to perturbation techniques, concepts of chaos and stochasticity. Solitons and Korteweg de Vries Equation. **Solitons and completely integrable systems**: Sine-Gordon Equation, Lattice with Exponential interaction: Toda potential, Nonlinear Schrondinger Equation.

Books Recommended:

1. Nonlinear Dynamics and Chaos, Steven H Strogatz, Westview Press, 2nd ed.
2. Introduction to Dynamical Systems, George Simmons, McGraw Hill, 1st ed.
3. Chaos in Dynamical Systems, Edward Ott, CUP, 2nd ed.
4. Perspectives of Nonlinear Dynamics (Vol. I and II), E.A. Jackson, CUP, Revised ed.
5. Hamiltonian Systems: Chaos and Quantization, A.M. Ozorio de Almeida, CUP, 1st ed.
6. Chaos and Integrability in Nonlinear Dynamics, M. Tabor, John Wiley, 1st ed.
7. Mathematical Methods of Classical Mechanics, V. Arnold, Springer, 2nd ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) II Semester
Department of Physics
Islamic University of Science and Technology

Course Title: Plasma Physics

Course Code: PHY557E

Credits: 02

Type of Course: Discipline Centric Elective (E)

Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (45 minutes) and 20% assignments/attendance)

End-Term Examination: (1. 25 Hours) 50%

Course Objectives

The purpose of this course is to make students understand the physics of plasma. This course will convey how our understanding of plasma physics extends to a description of a huge diversity of systems over varying scales of space, time, density, and temperature

Course Outcomes

On successful completion of this course the students:

- may have an opportunity for employability in plasma research and application industry.

PHY557E: Plasma Physics **Credits: 02**
L 2 T 0 P 0

UNIT I

Plasma as a fourth state of matter, definition and elementary concepts, concept of temperature, Debye Shielding and Debye length, Plasma Parameters and criteria for plasma, plasma frequency, important applications of plasma physics: Controlled Thermonuclear fusion, The magnetohydrodynamic generator, Plasma Propulsions and other plasma devices.
Production of plasma in laboratory: DC discharge, RF discharge and photo-ionization.

UNIT II

Single particle motion in uniform E and B fields, single particle motion in non-uniform E and B fields, motion in time varying electromagnetic fields, Adiabatic invariants, guiding and center drifts, tokamak confinement.
Plasmas as fluids, the fluid equation of motion, equation of continuity and state, fluid drifts.

Books Recommended:

1. Introduction to plasma Physics and Controlled Fusion, F. F. Chen, Springer, 2nd ed.
2. Fundamentals of Plasma Physics, J. A. Bittencourt, Springer, 3rd ed.
3. Principles of Plasma Physics, N. A. Krall, and A. W. Trivelpiece, Mc Graw Hill.
4. Space Plasma Physics, A. C. Das, Narosa Publishing House.

Semester Third

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) III Semester
Department of Physics
Islamic University of Science and Technology

Course Title: Nuclear Physics
Course Code: PHY601C
Credits: 04
Type of Course: Core
Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)
End-Term Examination: (2.5 Hours) 50%

Course Objectives

The purpose of this course is to

- make students understand the concept of Nuclear Physics.
- give them the knowledge of various Nuclear Models.
- make them understand about the working of various detectors and accelerators used for research purposes.

Course Outcomes

On successful completion of the course the students will be able to:

- Join as a Nuclear Scientist in the reputed Labs. of the country.
- carry out research in Experimental/ Theoretical Nuclear Physics from any leading University/research institute.
- Pursue their carrier in Radiation Physics.

PHY601C: Nuclear Physics **Credits: 04**
L 3 T 1 P 0

UNIT I

Mass, Charge and Constituents of the nucleus, Nuclear size and the distribution of nucleons, what holds a nucleus together, Parity and statistics, Characteristics of nuclear force, nucleon-nucleon potential.

Simple theory of two nucleon system –Deuteron problem, Spin states of two nucleon system, Isotopic Spin, Effect of Pauli's exclusion principle, Magnetic dipole moment and electric quadrupole moment of Deuteron, Yukawa meson theory, The Tensor forces.

UNIT II

Liquid drop model, Weizsacker's semi-empirical mass formula and its applications, Evidence for Magic Numbers, prediction of energy levels in an infinite square well potential, Shell model: Shell structure, spin-orbit interaction, prediction of ground state spin, parity and magnetic moment of odd-A nuclei, Collective model.

UNIT III

Kinds of nuclear reactions, Kinematics of nuclear reactions, standard Q-equation and its solution, Threshold Energy, nuclear reaction cross-section, Differential cross-section, Compound reaction mechanism, nuclear fission and fusion, laws of successive disintegration, Alpha Decay: Gamow's Theory, Beta Decay: Fermi's theory of beta decay, selection rules

UNIT IV

Interaction of charged particles and electromagnetic radiation with matter, Energy loss and stopping power, Bethe-Bloch formula, Energy loss of fast electrons: Bremstrahlung and Cerenkov Radiation. Detectors: Scintillation Detectors-NaI(Tl), HpGe Clover detector, Gas detectors (GM-Counter), Particle accelerators: Linacs, elementary idea of Tandem accelerator, Pelletron accelerator.

Books Recommended:

1. Introductory Nuclear Physics, S. M. Wong, John Wiley, 2^{nd} ed.
2. Introductory Nuclear Physics, K. S. Krane, John Wiley, 2^{nd} ed.
3. Introductory Nuclear Physics, D. Halliday, John Wiley, 2^{nd} ed.
4. Concepts of Nuclear Physics, Bernard L Cohen, Mc Graw Hill.
5. Atomic and Nuclear Physics, S. N. Ghosal, S. Chand, 2^{nd} ed.
6. Introduction to Nuclear Physics, H. A. Enge, Addison-Wesley.
7. Introductory Nuclear Physics, P. E. Hodgson, and E. Gadoili, OUP, illustrated ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) III Semester
Department of Physics
Islamic University of Science and Technology

Course Title: **Condensed Matter Physics**

Course Code: **PHY602C**

Credits: **04**

Type of Course: Core (Theory)

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: (2. 5 Hours) 50%

Course Objectives

To learn some of the basic properties of the condensed phase of matter especially solids

Course outcomes

Students will have achieved the ability to:

- Differentiate between different Lattice types and explain the concepts of reciprocal lattice and crystal diffraction.
- Predict electrical and thermal properties of solids and explain their origin.
- Explain the concept of energy bands and effect of the same on electrical properties.
- Have an understanding of the magnetic properties of condensed matter.
- Have an understanding of the elastic properties of solids and lattice vibrations.

PHY602C: Condensed Matter Physics **Credits: 04**

L 3 T 1 P 0

UNIT I **Lectures 16**

Introduction to crystal structure, Symmetry operations, Miller indices, closed packed structures, Common crystal structures, Quasi crystals, Reciprocal lattice, Brillouin zones, X-ray diffraction by a crystal and their equivalence, Laue equations, Edwald construction, Brillouin interpretation, Crystal and atomic structure factors, Experimental methods of structure analysis: Types of probe beam, the Laue, rotating crystal and powder methods. Imperfections: Point defects, Colour Centres, Shear strength of crystals, Dislocations, Illustration of types of dislocation, Burger's vector, Role of dislocation in crystal growth, Low angle grain boundaries, Whiskers.

UNIT II **Lectures 16**

Free electron gas model: Electrical conductivity and Ohm's law, Density of states, Fermi energy, effective mass, Limitations of the free electron gas model, Band theory of solids: Electrons in periodic potentials, Bloch's Theorem, Kronig-Penney model, Nearly free electron model, Tight-binding model: density of states, examples of band structures. Fermi surfaces of metals and semiconductors. Semiconductors: Band gap, concept of hole; equations of motion of charge carriers in electric and magnetic fields, effective mass, physical basis, cyclotron resonances (Ge, Si); mobility, intrinsic and extrinsic conductivity, Hall effect, Quantum Hall effect (qualitative idea only).

UNIT III **Lectures 16**

Origin of magnetism, Classical theory of diamagnetism and paramagnetism, Curie law, Ferromagnetism, Weiss Theory of Ferromagnetism and Curie-Weiss law, Exchange interaction of free electrons, Band model of Ferromagnetism, super exchange, double exchange, Hubbard model, Antiferromagnetism, Neel temperature, Quantum theory of magnetic susceptibility, van Vleck paramagnetism, Pauli-paramagnetism, Exchange interaction (two electron system), Heisenberg model (spin Hamiltonian)

UNIT IV **Lectures 16**

Classical theory of lattice dynamics: Vibrations of crystals with monatomic basis and Two atomic basis, Dispersion relation, Group velocity, Acoustical and optical modes; Phonons: Quantization of lattice vibration, Phonon-momentum. General Theory of harmonic approximation for a three-dimensional crystal, normal modes of real crystals, dispersion curve Theory of neutron-phonon scattering. Thermal properties: heat capacity, Normal modes, Debye and Einstein models, lattice thermal conductivity of solids- Umklapp process.

Books Recommended:

1. Introduction to Solid State Physics, C. Kittel, John Wiley, 7th ed.
2. Solid State Physics, N. W. Ashcroft, and N. D. Mermin, Saunders College, 2nd ed.
3. Solid State Physics, S. O. Pillai, New Age Sci., 6th ed.
4. Solid State Physics, M. A. Wahab, Narosa Pub., 3rd ed.
5. Elements of Solid State Physics, J. P. Srivastava, PHI, 3rd ed.
6. Solid State Physics: An Introduction to the Theory, James Patterson and Bernard Bailay, Springer, 2nd ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) III Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Particle Physics**
Course Code: **PHY603C**
Credits: 04
Type of Course: Core (Theory)
Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)
End-Term Examination: (2.5 Hours) 50%

Course objective

The objective of this core course is to understand the nature of particles and their interactions at fundamental level. Further to study the physics of collisions of particles and nuclei at relativistic energies, concept of origin of the universe and quark gluon plasma.

Course outcome

Upon the completion of the above course, the student will be able to:

- Learn about the basic interactions and their mediating quanta.
- Classify the particles; learn about various particle quantum numbers and the role of symmetries in their interactions.
- Understand Quark Model of hadrons and be able to calculate the charge and magnetic moment of particles.
- Study of weak interactions in detail and CP violation.
- Understand the various scattering processes including deep inelastic scattering.
- Have an idea of Standard Model.
- Solve the particle flavor oscillation based on semi-quantum mechanical approach for neutrino and K-mesons.
- Apply concept of relativistic kinematics in solving related problems.
- Explain the mechanism and features of particle production in hadronic and ion collisions.

PHY603C: Particle Physics **Credits: 04**

L 3 T 1 P 0

UNIT I

Basic interactions and their mediating quanta, types of particles - fermions and bosons, leptons and hadrons, particles and antiparticles, resonances, Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.), conservation rules, Gellmann-Nishijima Relation. Quark model , C, P, and T invariance and CPT theorem. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction, parity of Pions, Helicity.

UNIT II

Weak Interactions: Classification, lepton universality, Nuclear β - decay: Fermi theory, Inverse β - decay: neutrino interactions, parity conservation in β - decay, Helicity of the neutrino, the V – A interaction, Conservation of weak currents, Pion and muon decay, Neutral weak currents, Cabibbo theory, Neutral K mesons, $K_L – K_s$ mass difference and CP violation in the neutral kaon system.

UNIT III

Quark model of hadrons: Combining quarks into baryons and Mesons -SU(2), SU(3) isospin symmetry. Mass formula for baryons and mesons. Calculation of charge and magnetic moments of baryons.

Lepton and quark scattering: Electron-positron annihilation ($e^+e^- \rightarrow \mu^+\mu^-$), electron-proton scattering, deep inelastic scattering.

UNIT IV

Review of Lorentz transformations for energy and momentum, four-vectors and invariants, Laboratory and Centre-of-momentum systems, calculation of energy, momentum and angle of particles produced in nuclear reactions in Lab and centre-of-momentum frames and their transformations. Rapidity and pseudorapidity variables. Lab. and CM-rapidity, Maximum and minimum rapidities, Pseudorapidity distribution in projectile, target and central fragmentation regions.

Ultra-relativistic nucleus-nucleus collisions: Glauber model of nucleus-nucleus collision, participant-spectator model, Bjorken estimate of the initial energy density, hadron structure and quark confinement, hydrodynamics of Quark-Gluon Plasma and phase diagram, possible signatures of Quark-Gluon Plasma formation.

Books Recommended:

1. Introduction to Elementary Particles, D. J. Griffiths, John Wiley, 4th ed.
2. Introduction to High Energy Physics, D. H. Perkins, Addison Wesley, 4th ed.
3. Particle Physics, B. R. Martin and G. Shaw, John Wiley, 3rd ed.
4. Quarks and Leptons, F. Halzen and B. R. Martin, John Wiley.
5. An Introduction to Quarks and Partons, F. E. Close, Academic Press, 1st ed.
6. Relativistics Kinematics, R. Hagedorn, Benjamin.
7. Introduction to High Energy Heavy Ion Collisions, C. Y. Wong, World Scientific.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) III Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Numerical Methods and Programming**
Course Code: **PHY604C**
Credits: 04
Type of Course: Core (Theory)
Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)
End-Term Examination: (2.5 Hours) 50%

Course objective

- The course will expose a student to the numerical techniques used to solve scientific problems which include solution to algebraic and transcendental equations, interpolation, numerical differentiation and integration.
- The course is designed to provide complete knowledge of C language so that the numerical techniques learnt above could be encoded in C.

Course outcome

Upon the completion of the above course, the student will be able to:

- Use numerical techniques to solve problems in science and engineering.
- Students will be able to develop logic that will help them to write programs in C. Also by learning the basic programming constructs, they can easily switch over to any other language in future.
- Able to implement the algorithms and draw flowcharts for solving Mathematical and Engineering problems.

PHY604C: Numerical Methods and Programming **Credits: 04**

L 3 T 1 P 0

UNIT I

Introduction to numerical analysis, Some mathematical preliminaries, Approximation Methods and Errors: Truncation and round-off errors, accuracy and precision. Roots of Equations: Bracketing Methods (false position, bisection) Iteration Methods (Newton- Raphson and Secant), Convergence of solutions.

Interpolation, Errors in Polynomial Interpolation, Finite differences (forward, backward and central differences), symbolic relations and separation of symbols, Detection of Errors by use of difference tables, Differences of a polynomial, Newton's formulae for interpolation.

UNIT II

Numerical differentiation, Errors in numerical differentiation, Cubic Spline Method, Differentiation formulae with Function values, Maximum and minimum values of a tabulated function.

Numerical Integration: Trapezoidal rule, Simpson's 1/3 and 3/8 rule.

Numerical solution of ODEs: Solution by Taylor's series, Picard's Method of successive approximations, Euler's Method, Error Estimates for the Euler's Method, Modified Euler's Method, Runge Kutta methods: Second and Fourth order.

UNIT III

Introduction to programming: Computer software, classification, compilers and interpreters, programming languages. C programming: Programme Characteristics, structure of C program, C character set, identifiers and key words, Data types, Constants, Variables, input\output statements in C, operators in C, Functions: function definition, function call, return statements, Programming exercises.

UNIT IV

Decision control and looping statements: conditional branching statements(if-statement, if – else statement, switch case), Iterative statements (while, do-while, for loop), nested loops, goto statement. Arrays: One and two dimensional arrays, deceleration, accessing array elements. Strings: reading writing strings, string operations, array of strings. Pointers: Pointer declaration, Operation on pointers, Pointers and one-dimensional arrays, Arrays of pointers, User defined data types: Structure, Union and Enumerated data types.

Developing algorithms and Computer programs in C-Language based on numerical methods.

Books Recommended:

1. Introductory Methods of Numerical Analysis, S. S. Sastry, PHI, 3rd ed.
2. Numerical Mathematical Analysis, J. B. Scarborough, The John Hopkins University Press, 6th ed.
3. An Introduction to Numerical Analysis, K. E. Atkinson, John Wiley.
4. Programming in ANSI C by E. Balaguruswamy. 6th ed.
5. Numerical Methods, E. Balaguruswamy, Tata McGraw Hill (1999)

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) III Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Materials Science**

Course Code: **PHY605E**

Credits : 04

Type of Course: Core (Theory)

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: (2. 5 Hours) 50%

Course Objective

The objective of this course is to learn about novel materials and provide fundamental understanding of physical properties of materials.

Course Outcome

After the completion of this course, the student will be able to:

- Learn about various types of materials and their important physical properties like Elastic Properties, Compressive, Shear, and Torsional Deformation. Hardness of Ceramic materials.
- To know about novel materials like Electro strictive materials - shape memory alloys - rheological fluids - CCD device. LED materials and their applications.
- Understand the thermodynamics of Materials, electrochemical equilibria and surface thermodynamics, solution theory and equilibrium diagrams.

PHY605E: Material Science **Credits: 04**
L 3 T 1 P 0

UNIT I

Classification of Materials, Advanced Materials, Atomic Structure, Bonding Forces and Energies, Primary Interatomic Bonds, Secondary Bonding or Van der Waals Bonding, Diffusion- Importance and Mechanism, Diffusion in ionic and polymeric materials. Mechanical Properties: - Stress-strain Behaviour, Elastic Properties, Compressive, Shear, and Torsional Deformation. Hardness of Ceramic materials.

Fundamentals of Fracture, Principles of Fracture Mechanics, Cyclic Stresses, The *S–N* Curve, Fatigue in Polymeric Materials, Crack Propagation.

UNIT II

Metallic glasses - preparation, properties and applications - SMART materials -piezoelectric, magnetostrictive, Electrostrictive materials - shape memory alloys - rheological fluids - CCD device materials and applications - solar cell materials (single crystalline, amorphous and thin films) - surface acoustic wave and sonar transducer materials and applications - introduction to nanophase materials and their properties

UNIT III

Basic ideas about classification of magnetic materials- ferrite structure and uses - dilute magnetic semiconductor (DMS) materials**-** magnetic bubbles - magnetoresistance - GMR materials, magnetic recording.

LED materials - superluminescent LED materials - liquid crystals – properties and structure - liquid crystal displays-comparison between LED and LC displays**.** Optics-nanophosphors and photonic crystals Mechanics

UNIT III

Electronics and Electromagnetics-ceramic capacitors. Thermodynamics of Materials-electrochemical equilibria and surface thermodynamics, solution theory and equilibrium diagrams. phase transformations, and the development of microstructure. fluid and heat transport; morphological instabilities; gas-solid, liquid-solid, and solid-solid reactions. energy generation and storage (e.g. automobile engines, lithium batteries), emerging technologies (e.g. photonic and biomedical devices), and the environmental impact of chemical processing (e.g. recycling glass, metal, and plastic).

Books Recommended:

1. Materials Science and Engineering, An Introduction, 9th edition, by William D Callister, William D Callister Jr., David G Rethwisch, (2007) John Wiley & Sons, Inc.
2. Engineering Materials Science, 1st Edition, by Milton Ohring, (1995) Academic Press.
3. Modern Ceramic Engineering - Properties Processing and Use in Design, D. W. Richerson, 3rd Edition, (2006) CRC Press.
4. Textbook of Polymer Science, F. Billmeyer, (1994) Wiley Interscience.
5. Smart materials and structures, Mukesh V Gandhi and Brian S. Thompson, (1992), Chapman & Hall, London.
6. Introduction to Materials Science for Engineers. J. Shackelford, (2004) 6th edition. Upper Saddle River, NJ: Pearson

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) III Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Group Theory**
Course Code: **PHY606E**
Credits: 02
Type of Course: Discipline Centric Elective (Theory)
Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)
Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)
End-Term Examination: (1. 25 Hours) 50%

Course Objectives

To train a student in the advanced tools of mathematical physics involving group theoretical concepts required in such fields as condensed matter physics, quantum field theories, particle physics and quantum mechanics.

Course Outcomes

On completion of the course, student will be able to

- To learn the continuous group theory.
- Use group theoretical concepts in understanding physical problems.
- Use of group theory in understanding concepts line quark model and isospin.

PHY606E: Group Theory **Credits: 02**

L 2 T 0 P 0

UNIT I

Group theory in physics, Definition and examples of groups, Cyclic groups, Subgroup and Lagrange's theorem, Conjugacy classes, Invariant subgroups, Cosets and Factor groups. Group homomorphism and isomorphism.

Group representation with examples, Equivalence of representations and reducibility, Groups acting on a vector space, Linear transformation and G-module, Scalar product and the Unitary representation, Maschke's theorem.

Schur's lemmas, Fundamental Orthogonality theorem, Orthogonality of characters, Decomposition of reducible representations, Regular representation, Construction of Character Table.

Applications of discrete group theory: Raising of degeneracy.

UNIT II

Review of linear vector space, Continuous groups, connectedness and compactness, Topological and the Lie groups, Infinitesimal generators, Rotation groups: $SO(2)$, $SO(3)$ and their irreducible representations. The group $O(n)$.
The special unitary groups $SU(2)$ and $SU(3)$, Homomorphism of SU(2) on SO(3), Lie algebra and representation of a Lie group.

Applications of continuous group theory: elementary particles in Nuclear and Particle Physics (Isospin symmetry and Quark model).

Books Recommended

1. Group Theory and it's Applications to physical problems, M. Hammermesh, Dover publications, reprint 2017.
2. Group Theory in Physics, Wu-Ki Tung, World Scientific, Reprint 2010.
3. Elements of Group Theory for Physicists, A. W. Joshi, New Age International Publishers, 5th edition.
4. Groups, Representations and Physics, H. F. Jones, Taylor and Frances Group, 2nd edition.
5. Group Theory for Physicists with Applications, P. Ramadevi and V. Dubey, Cambridge University Press, 2019.
6. Mathematical Physics, P. K. Chattopadhyay, New Age International Publishers, 2nd edition.
   Mathematical Methods for Physicists, Arfken, Weber and Harris, Academic Press, 7th edition.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) III Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Astrophysics I**
Course Code: **PHY607E**
Credits : 02
Type of Course: Discipline Centric Elective (Theory)
Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)
Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)
End- Term Examination: (1.25 Hours) 50%

Course Objectives

To familiarize and expose students to various fields, basic principles and theories of astronomy and astrophysics. The aim of this particular course is to provide knowledge of formation, evolution, classification of stars in particular.

Course Outcomes

On completion of this course, student will be able to:

- Understand the basic concepts in astronomy and astrophysics
- Understand the various physical processes in stars.
- Understand the stellar evolution and in-depth understanding of binary stars.

PHY607E: Astrophysics I **Credits: 02**
L 2 T 0 P 0

UNIT I

The stellar system, Evolution of the Stars, Observational properties of stars (stellar Magnitudes and Colors, Brightness and distance, Luminosity, temperature), Spectral Classification, H-R Diagram and main sequence stars, Boltzmann & Saha Ionization Formula, Equation of Stellar Structure (Hydrostatic Equilibrium, Mass &Temperature Distribution and Energy Transport in Stellar Interiors). Polytropic Model: Lane Emden equation, Virial theorem.

UNIT II

Binary Stars: Classification, Mass determination, White-Dwarf, Classes of White Dwarf Stars, The Physics of degenerate Matter, The condition for degeneracy, Electron Degeneracy Pressure, The Chandrasekhar Limit, The Mass-Volume Relation, Neutron Stars, black holes, Thermodynamics of black holes.

Books Recommended:

1. An Introduction to Modern Astrophysics, B. W. Carroll and D. A. Ostlie, Addison-Wesley Publishing Co., ISBN 0-321-44284-9.
2. The Physical Universe: An Introduction to Astronomy, Frank H. Shu, Mill Valley : University Science Books, ISBN 0-935702-05-9.
3. An Introduction to Astrophysics, Baidyanath Basu, PHI Learning Pvt. Ltd ISBN 9788120340718
4. Theoretical Astrophysics, Volume II: Stars and Stellar Systems, T. Padmanabhan, Cambridge University Press, ISBN: 0521562414

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) III Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Optics**
Course Code: **PHY608E**
Credits: 02
Type of Course: Discipline Centric Elective (Theory)
Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)
Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)
End-Term Examination: (1.25 Hours) 50%

Course Objective

To understand the basic concepts of lights, its properties and few applications

Course Outcome

On completion of the course, the student will be able to:

- Understand mathematical framework to analyze the light waves.
- learn the interaction of light with matter and few applications.
- understand polarization.
- Explain theoretical background of interference and diffraction

PHY608E: Optics **Credits: 02**

L 2 T 0 P 0

UNIT I

Three-dimensional differential wave equation, Plane, Spherical, and cylindrical waves, Electromagnetic waves, The Poynting Vector, Radiation pressure and momentum, Light in bulk matter, Dispersion, Propagation of light: Rayleigh Scattering, Fermat's principle, Electromagnetic approach to reflection and refraction, Fresnel equations, Aperture and Field Stops, Relative Aperture and f-Number, Fiber optics, Optical systems, Wavefront shaping

UNIT II

Aberrations: coma, astigmatism. Polarization: The nature of polarized light, Polarizers, Birefringence, Scattering and polarization, Retarders, Optical activity, Induced optical effects-optical modulators, Kerr and Pockels effect, Liquid crystals, The Stokes parameters, The Jones vectors, Interference: Wave front splitting interferometers, Amplitude Splitting interferometers, Multiple beam interferometer. Diffraction: Kirchhoff's diffraction theory, regimes of diffraction, Fresnel and Fraunhofer diffraction, single and multiple slit diffraction. Basics of Coherence theory

Books Recommended:

1. Optics, E. Hecht and A. R. Ganesan, Pearson, 4th ed.
2. Optics, A. Ghatak, McGraw Hill, 7th ed.
3. Introduction to Modern Optics, G. R. Fowles, Dover Pub., 2nd ed.
4. Lasers and Non-Linear Optics, B. B. Laud, New Age Pub., 3rd ed.
5. Optical Electronics, A. Ghatak and K. Thyagarajan, Cambridge University Press, 1989
6. Optics Principles and Applications, K. K. Sharma, Academic Press, 2006.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) III Semester
Department of Physics
Islamic University of Science and Technology

Course Title: Experimental Techniques
Course Code: PHY609E
Credits: 02
Type of Course: Discipline Centric Elective (E)
Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)
Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)
End-Term Examination: (1. 25 Hours) 50%

Course Objectives

The purpose of Experimental Techniques is to

- guide students about the data analysis.
- give them the knowledge of various software's.
- make them understand that how to obtain the deterministic data.
- make them aware about the research facilities that is being used currently across the world.

Course Outcomes

On successful completion of the course the students will be able to:

- Join as a data scientist in any industry, which relies on data analysis and data evaluation.
- carry out research from any leading University/ research institute.

PHY609E: Experimental Techniques **Credits: 02**
L 2 T 0 P 0

UNIT I

Measurement concepts and Error analysis, Propagation of error, Plotting of Graphs using ORIGIN software. Least square fitting (Linear and non-linear), chi-square test. Transducers (temperature, magnetic fields, vibration, optical and surface barrier detector)

UNIT II

General properties of detectors: Sensitivity, energy resolution and fano factor, detector efficiency and dead time.

Vacuum Techniques: Basic idea of conductance, pumping speed, mechanical pump, diffusion pump. Gauges: Penning and Pirani.

Measurement and Control: Signal conditioning and recovery, impedance matching, shielding and grounding.

Books Recommended:

1. Introduction to Experimental Nuclear Physics, R. M. Singura, John Wiley Eastern.
2. Elements of X-Ray Diffraction, B. D. Cullity, and S. R. Stock, Pearson, 3rd ed.
3. Core Level Spectroscopy of Solids, F. De Groot, CRC Press, 1st Ed.
4. Instrumentation Measurement Analysis, B. C. Nakra and B. C. Chudhary, McGraw Hill, 4th ed.
5. The Art of Experimental Physics, D. W. Preston and E. R. Dietz, John Wiley, 1st ed.
6. Probability and Statistics in Experimental Physics, B. P. Roe, Springer, 1st ed.
7. Introduction to Nuclear Physics, V. K. Mittal, R. C. Verma, and S. C. Gupta, PHI, 3rd ed.

Semester Fourth

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) IV Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Atomic, Molecular and Laser Physics**
Course Code: **PHY650C**
Credits: 04
Type of Course: Core (Theory)
Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)
Internal assessment: 50% (30% Exam (1.5 Hours) and 20% assignments/attendance)
End-Term Examination: (2.5 Hours) 50%

Course Objective

To develop basic theoretical knowledge in Atomic, Molecular and Laser Physics

Course Outcome

On completion of the course, students will be able to:

- Understand quantum states of atoms.
- know atomic spectra of atom.
- explain the various types of spectra of di-atomic molecules.
- understand the Physics of Lasers.
- understand various types of Lasers, their working and applications.

PHY650C: Atomic, Molecular and Laser Physics **Credits: 04**
L 3 T 1 P 0

UNIT I

Atomic Structure and Atomic Spectra: Bohr model of atom and its limitations, Relativistic correction, Revision of quantum numbers, Quantum states of an electron in an atom, Pauli exclusion principle, electronic Configuration, Spin and orbital angular momenta, Stern-Gerlach experiment, behaviour of a magnetic dipole in an external magnetic field, space quantization of atoms.

UNIT II

Spin-orbit interaction, Lamb shift, Fine spectra, Fine spectra of hydrogenic atoms, hyperfine structure. Coupling of orbital and spin angular momenta of many electron atoms, LS and JJ coupling schemes, Breit Scheme, Lande interval rule. Spectroscopic notation and multiplicity of energy states. Normal and anomalous Zeeman effect. Paschen Back effect, Stark effect.

UNIT III

Molecular Spectra, Born-Oppenheimer Approximation, Rotational, Vibrational, Rotational Vibrational and Electronic energy and spectra of Di-atomic molecules, Selection rules, Frank Condon principle, Raman spectra, Intensity of bands in absorption and emission. Isotopic effect, Resonance: ESR and NMR. Mossbauer Effect.

UNIT IV

Basic of Laser, Boltzmann equation, Spontaneous and Stimulated transitions, Einstein coefficients, Population inversion. Transition rates, Light matter interaction, Pumping schemes, Two level, The three level and four level systems, Line broadening mechanism. Shape and width of spectral lines. Optical resonators: Quality factor. Losses inside the cavity. Threshold conditions. Schawlow-Townes condition. Transverse and longitudinal modes, He-Ne laser, Ruby laser, CO2 laser, Dye lasers

Books Recommended:

1. Fundamentals of Molecular Spectroscopy, C. N. Banwell, McGraw Hill, 4th ed.
2. Introduction to Atomic Spectra, H. E. White, McGraw Hill.
3. Lasers: Fundamentals and Applications, K. Thyagarajan and A. Ghatak, Springer, 2nd ed.
4. Physics of Atoms and Molecules, B. H. Bransden and C. J., Joachain, PHI, 2nd ed.
5. Atoms, Molecules and Photons, W. Demtroder, Springer.
6. Molecular Spectra & Molecular Structure-I, Diatomic Molecules, G. Herzberg, Krieger Pub., 2nd ed.
7. Principles of Lasers, O. Svelto, Springer, 5th ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) 4th Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Physics of Nano-materials**

Course Code: **PHY651C**

Credits: 04

Type of Course: Core (Theory)

Contact Hours: 4 hours per week (Total: 52 lecture + 12 tutorials)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: (2. 5 Hours) 50%

Course Objectives

To Understand

- the influence of dimensionality of the object at nanoscale on different properties;
- Different techniques of controlled synthesis and characterization of nanomaterials and their future applications.

Course Outcomes

On completion of the course, student will be able to

- Understand the size dependent effects on various properties of solids.
- To get the various interesting features of Nanostructures
- To know about the importance of Carbon Nanotubes (CNTs)
- Understand different properties of Nanostructures with the help of different characterization techniques.

PHY651C: Physics of Nano-materials **Credits: 04**

L 3 T 1 P 0

UNIT I

Idea of band structure in solids, Solutions of the Schrodinger equation for free particle, particle in a finite well, Density of states, Variation of density of states with energy and Size of crystal.

Nanoscience & Nanotechnology, Size dependence of properties, Surface energy and Melting point (quasi melting) of nanoparticles, quantum confinement in 0D, 1D and 2D, Quantum well, Quantum wire and Quantum dots. Heterostructures and Multiple Quantum Wells.

UNIT II

Bulk to nano transition – Semiconducting nanoparticles, Conductance formula for nanostructures, Quantized conductance. Ballistic transport, Diffusive transport, Coulomb blockade, Superparamagnetism.

Key issue in the synthesis of Nanomaterials, Top down and Bottom up approaches: Photo and Electron beam lithography, Ball Milling, Chemical Vapor Deposition, Sol gel (hydrothermal and solvothermal synthesis), Biological Synthesis.

UNIT III.

Carbon nanotubes (CNT)- Synthesis: Laser Deposition, Arc Method, Solar Method. Homogeneous and heterogeneous Synthesis, Properties and Applications of CNTs, Fullerenes, Graphene: Band Structure and Electronic properties.

MEMS and NEMS. Introduction to molecular electronics, Nanocomposites, Fuel cells – Chemical sensors - Mechanical reinforcement, Ferrofluids.

UNIT IV.

Structural analysis: X-ray Diffraction (XRD), Microscopic techniques: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM),

Scanning probe techniques: Scanning Tunnelling Microscopy (STM), Atomic Force Microscopy (AFM), Spectroscopy techniques: X-ray Absorption (XAS). X-ray Photoelectron spectroscopy (XPS). Photoluminescence Emission (PL) and Excitation (PLE) spectroscopy; Infrared (IR) and Raman spectroscopy.

Books Recommended:

1. Nanotechnology: An Introduction, Jeremy Ramsden, Elsevier, 1st ed.
2. Nanoscience and Nanotechnology, M. S. R. Rao and S. Singh, John Wiley, Ist ed.
3. Introduction to Nanotechnology, C. P. Poole Jr. and F.J. Owens, John Wiley.
4. Nanostructured Materials: Processing, Properties and Applications, C. C. Koch, Taylor & Francis, 2nd ed.
5. Quantum Wells, Wires and Dots, P. Harrison, John Wiley, 3rd ed.
6. Introduction to Nanoscience and Nanotechnology, G. L. Hornyak, H. F. Tibbals, J. Dutta, J. J. Moore, CRC Press, 2nd ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) 4^{th} Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Computational Lab**

Course Code: **PHY652C**

Credits: 04

Type of Course: Core (2 Theory & 2 Practical)

Contact Hours: 6 hours per week (Total: 2 Hour Theory + 4 Hour Practical)

Internal assessment: 50% (30% Exam (1.5 Hour) and 20% assignments/attendance)

End-Term Examination: (2. 5 Hours) 50%

Course Objectives

The aim of this course is to train students in Fortran language and to enable them to write Fortran programs for solving various mathematical and physics problems numerically.

Course Outcomes

On completion of this course, student will be able to:

- Understand the importance and development of programming languages and their importance in the present world.
- Understand how to write an algorithm and draw the corresponding flowchart.
- Understand the basic format of a Fortran program.
- Understand the use of function and subroutine in a Fortran program.
- Write Fortran programs for various numerical methods used to solve various differential problems.

PHY652C: Computational Lab **Credits: 04**

L 2 T 0 P 2

UNIT I

Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) Lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

UNIT II

Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

UNIT III

Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DOWHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

UNIT IV

Preparing flow chart, writing and running the following programmes:

- Sin(x) series and Cos(x) series
- Exp(x) and Exp(-x) series
- Fibonacci Series
- Addition and multiplication of matrices
- Inverse of a matrix
- Trapezoidal Rule,
- Simpson’s 1/3 Rule
- Newton-Raphson Method
- Runge Kutta second order and Fourth order Method

Books Recommended:

1. Computer programming in FORTRAN 77 and 90, V. Rajaraman, PHI, 4th ed.
2. Numerical Recipes in FORTRAN 77, W. H. Press and S. A. Teukolsky, CUP, 2nd ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) I Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Project**

Course Code: **PHY653C**

Credits: 04

Type of Course: Core (Project)

Contact Hours: 8 hours per week

Internal assessment: (No internal assessment)

End-Term Examination: 100% (Dissertation defence and Viva)

Course Objective

Dissertation involves project work with the intention of exposing the student to research /development. It involves open ended learning based on student ability and initiative, exposure to scientific writing and inculcation of ethical practices in research and communication.

Course Outcome

- Exposure to research methodology.
- Picking up skills relevant to dissertation/project.
- Development of creative ability and intellectual initiative.
- Developing the ability for scientific writing.
- Becoming conversant with ethical practices in acknowledging other sources.

<u>PHY653C: Project</u> **Credits: 04**

Each student has to undergo through the project work with a faculty member (Supervisor) from the department. The project work involves choosing a specific problem (experimental/theoretical), carrying literature survey, analysing and working out the calculations and preparing a dissertation report to be submitted to the department at the end of the semester for evaluation and viva-voce examination.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) IV Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Superconductivity**
Course Code: **PHY654E**
Credits: 02
Type of Course: Discipline Centric Elective (Theory)
Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)
Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)
End-Term Examination: (1. 25 Hours) 50%

Course Objectives

To predict the effect of temperature change on the electrical resistivity superconductors.

Course Outcomes

Students will have achieved the ability to:

- Describe the historical background of superconductor
- Explain their properties
- Apply basic theory and concepts of superconductivity
- Analyse and evaluate superconducting applications
- Describe the advantages and disadvantages of superconductor
- Describe their function and uses in daily life.

PHY654E: Superconductivity **Credits: 02**
L 2 T 0 P 0

UNIT I

The superconducting state, Basic properties of the superconducting state: Zero resistance, Critical temperature, The Meissner effect (Perfect diamagnetism), Flux quantization, Isotope effect, Critical magnetic fields, Type-I and Type-II superconductors, Critical Current, Penetration depth, Coherence length, Thermodynamics of transition, First and Second order transitions, Entropy, specific heat, Energy gap, The Josephson effects.

UNIT II

Models and theories: Two fluid model, London equations, Ginzburg-Landau theory, main results of Bardeen Cooper and Schrieffer (BCS) theory: Instability of the Fermi Surface in the presence of attractive Interaction between electrons, Electron distribution in the ground state of a Superconductor, Critical temperature, Energy gap, Origin of the attractive interaction. Introduction to High T_C superconductivity. Applications: SQUIDS, Magnetic Shielding, Power Transmission, Energy Storage devices, and Medical Applications, Topological superconductivity (qualitative idea only).

Books Recommended:

1. Introduction to Superconductivity, C. Rose-Innes and E. H. Rhederick, Pregamon Press, 2nd ed.
2. Handbook of superconductivity, C. P. Poole Jr., Academic Press, 1st ed.
3. Room Temperature Superconductivity, Andrei Mourachkine, CISP, 1st ed.
4. High Temperature Superconductivity, Jeffrey W. Lynn, Springer.
5. Superconductivity Today, T. V. Ramakrishnan and C. N. R. Rao, Universities Press, 2nd ed.
6. Introduction to Superconductivity, M. Tinkham , Dover Pub., 2nd ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) IV Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title**: Quantum Field Theory**

Course Code: **PHY655E**

Credits: 02

Type of Course: Discipline Centric Elective (Theory)

Contact Hours: 2 hours per week (Total: 32 lecture)

Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)

End-Term Examination: (1.5 Hours) 50%

Course Objectives

Quantum Field Theory (QFT) is a mathematical framework which combines the concepts in classical field theory, special relativity, and quantum mechanics. Objective of the course is to develop basic understanding of the field concept and obtain its quantized version.

Course Outcomes

On completion of this elective course, students will learn:

- The concept of second quantitation.
- Quantization of Lagrangian field theory.
- Quantization of Klein-Gordon field.
- Quantization of Dirac field.
- Gauge Quantization.
- Using Feynman diagrams to calculate amplitude/ reaction cross section for few QED processes.

PHY655E: Quantum Field Theory Credits: 02
L 2 T 0 P 0

UNIT I

The classical electromagnetic field and its quantization, Classical Lagrangian field theory, Quantized Lagrangian field theory, symmetries and conservation laws- Noether's theorem. The real and complex scalar fields.

UNIT II

Canonical quantization and particle interpretation: The Real Klein-Gordon field. The complex Klein-Gordon field. Covariant commutation relations, the meson propagator. The Dirac field: Number representation for Fermions, Dirac equation, second quantization. The Feynman Propagator. The electromagnetic field. Lorentz gauge quantization. Radiation gauge quantization. The Feynman diagrams and rules in QED with simple examples

Books Recommended:

1. Quantum Field Theory, F. Mandal and G. Shaw, John Wiley, 2nd ed.
2. Quantum Field Theory, L. H. Ryder, CUP, 2nd ed.
3. Lectures on Quantum Field Theory by Ashok Das, World Scientific.
4. A Modern Introduction to Quantum Field Theory, M. Maggiore, Cambridge University Press.
5. Field theory, A Modern Primer, P. Ramond, Addison-Wesley.
6. Relativistic Quantum Fields, J. D. Bjorken and S. D. Drell, McGraw Hill, 1st ed.
7. *An Introduction to Quantum Field Theory,* **M.E. Peskin and D.V. Schroeder,** Levant.
8. The Quantum Theory of Fields, Vol I, S. Weinberg, CUP.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) IV Semester
Department of Physics
Islamic University of Science and Technology, Awantipora

Course Title: **Astrophysics II**
Course Code: **PHY656E**
Credits : 02
Type of Course: Discipline Centric Elective (Theory)
Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)
Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)
End- Term Examination: (1.25 Hours) 50%

Course Objectives

To familiarize and expose students to various fields, basic principles and theories of astronomy and astrophysics. The aim of this particular course is to understand various aspects of our own galaxy. Also, this course will focus on Cosmology which is the study of large-scale structure of the universe.

Course Outcomes

On completion of this course, student will be able to:

- Understand the formation and evolution of our own Galaxy-The Milky Way.
- Understand the origin and evolution of our universe as whole and various models which have been proposed.
- Understand basic concepts about dark matter, dark energy and expansion of universe.

PHY656E: Astrophysics II **Credits: 02**
L 2 T 0 P 0

UNIT I

Our Galaxy: The Milky Way, Shape of Size of the Milky Way, Differential Rotation of the galaxy, The local Standard of rest, Local differential motions, Crude estimates of the mass of the Galaxy, Determination of Rotation parameters in the Solar neighbourhood, Spiral Structure: The nature of the spiral arms, Magnetic field in the Galaxy.

UNIT II

Cosmology: Newtonian Cosmology, The Einstein universe, The expanding universe, Redshift, Hubble's law, Cosmic Microwave Background Radiation (CMBR), Simplifying assumptions of cosmology, The Einstein field equations in cosmology, The Friedmann models, The solution of Friedmann's equations, Alternatives to Friedmann cosmologies, The steady state theory, Observable parameters of the steady state theory, Dark Matter and Dark Energy

Books Recommended:

1. The Physical Universe: An Introduction to Astronomy, Frank H. Shu, Mill Valley: University Science Books, ISBN 0-935702-05-9.
2. An Introduction to Astrophysics, Baidyanath Basu, PHI Learning Pvt. Ltd ISBN 9788120340718
3. Introduction to Cosmology, 3rd Edition, J. V. Narlikar, Cambridge University Press, ISBN 0-521-41250.
4. Theoretical Astrophysics, Volume III: Galaxies and Cosmology, T. Padmanabhan, Cambridge University Press, ISBN: 0521562422

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) IV Semester
Department of Physics
Islamic University of Science and Technology

Course Title: **Advanced Nuclear Physics**

Course Code: **PHY657E**

Credits: 02

Type of Course: Discipline Centric Elective (Theory)

Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)

End-Term Examination: (1. 25 Hours) 50%

Course Objectives

To understand the advanced concepts of nuclear physics in order to enable a student to take up research in nuclear theory. The other objective involves to impart the knowledge of some important theoretical tools such as the rotation of spherical harmonics.

Course Outcomes

On completion of the course, student will be able to

- Understand the quantum mechanics of a 3D harmonic oscillator, both isotropic as well as anisotropic.
- Parametrisation of a 3D surface and its rotation in terms of spherical harmonics.
- The student will learn the Nilsson model of nucleus.
- The student will learn the Particle Rotor Model of nucleus.

PHY657E: Advanced Nuclear Physics **Credits: 02**
L 2 T 0 P 0

UNIT I

Three-dimensional isotropic harmonic oscillator (wave-functions in cartesian, spherical and cylindrical coordinates), LS coupling.

Parametrisation of surface deformation, Types of multipole deformations, Quadrupole deformation, Two level mixing, Rotation of spherical harmonics, $\mathscr{D}$-matrix and it's properties.

UNIT II

Review of spherical shell model, Nilsson Model; The potential, Nilsson model (Qualitative treatment).

Nilsson model (exact treatment), solution of hypergeometric function, The asymptotic quantum numbers.

Particle-Rotor mode: Hamiltonian, wave-function and transition matrix elements.

Books Recommended:

1. Peter Ring and Peter Schuck, The Nuclear many-Body Problem, Text & Monographs in Physics, Springer-VerlagNew-York.
2. M.K. Pal, Theory of Nuclear Structure (Affiliated East - West, Madras,1982).
3. Greiner and Maruhn, Nuclear Models, Springer International (Reprint 2010).
4. Atomic and Nuclear Physics, S. N. Ghosal, S. Chand, 2nd ed.
5. Introduction to Nuclear Physics, H. A. Enge, Addison-Wesley.
6. Introductory Nuclear Physics, P. E. Hodgson, and E. Gadoili, OUP, illustrated ed.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) IV Semester
Department of Physics
Islamic University of Science and Technology

Course Title: Research Methodology

Course Code: PHY658E

Credits: 02

Type of Course: Discipline Centric Elective (E)

Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)

End-Term Examination: (1. 25 Hours) 50%

Course Objectives

The purpose of this course is to

- make students understand how to carry out the scientific research.
- give them the knowledge of Scientific writing and presentation.

Course Outcomes

On successful completion of this course the students:

- will be able to learn various tools to carry out the research work.
- should be familiar with ethical issues in educational *research*.

PHY658E: Research Methodology **Credits: 02**
L 2 T 0 P 0

UNIT I

What is science? Scientific reasoning, Scientific Temper, Scientific Method, Scientific measurement, The Criteria for Good Measurement.

Introduction to Research, Types of research: exploratory, conclusive, modeling and algorithmic, Identification of research problems, formulation of a problem, Data collection: data analysis, interpretation of results and validation of results.

UNIT II

Scientific Writing: Goals and Objectives, Structure of documents, importance of clear title, abstract or summary, Introduction, Methods, Results and Discussion, Illustrations and aids

Numbers and statistics, Tables and Figures, Language and grammar, writing proposals andinstructions, making presentations, Formatting documents, Drafts and revisions, Editing,Writing popular science / journal article, Science fiction.

Books Recommended:

1. Research Methodology: An introduction for science and engineering students, Stuart Milville & Wayne Goddard, McGraw Hill International.
2. Research Methodology: Methods & Techniques, C.R. Kothari New Age International Publishers, New Delhi.
3. Research Methodology, N. Thanulingon , Himalaya Publishing House, New Delhi
4. Research Methodology, R. Pannerselvam Prentice Hall of India Pvt. Ltd
5. The Craft of Scientific Writing (3rd Edition), Michael Alley, Springer, New York, 1996.
6. Science and Technical Writing – A Manual of Style (2nd Edition), Philip Reubens (General editor), Routledge, New York, 2001.
9. Writing Remedies – Practical Exercises for Technical Writing Edmond H. Weiss, Universities Press (India) Ltd., Hyderabad, 2000.
8. Effective Technical Communication, M. Ashraf Rizvi, Tata Mc Graw – Hill, New Delhi, 2005.

Syllabus with Course Objectives and Course Outcomes
M. Sc (Physics) IV Semester
Department of Physics
Islamic University of Science and Technology

Course Title: **Fourier Optics and Applications**

Course Code: **PHY659E**

Credits: 02

Type of Course: Discipline Centric Elective (E)

Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)

End-Term Examination: (1. 25 Hours) 50%

Course Objective

To develop understanding of the optical systems using Fourier analysis

Course Outcome

On completion of course, the student will be able to:

- Understand the fundamentals of signal sampling.
- Understand Fourier domain analysis of diffraction theory
- To know frequency response of optical systems under coherent and incoherent illumination.
- To understand working of various imaging system

PHY659E: Fourier Optics and Applications **Credits: 02**
L 2 T 0 P 0

Unit I

Signals and systems, Fourier Transform(FT), Sampling theorem; Diffraction theory; Fresnel-Kirchhoff formulation and angular spectrum method, brief discussion of Fresnel and Fraunhofer diffraction, FT Properties of lenses and Image formation by a lens; Frequency response of a diffraction-limited system under coherent and incoherent illumination, OTF-effects of aberration and apodization.

Unit II

Comparison of coherent and incoherent imaging, Analog optical information processing: Abbe-Porter experiment, phase contrast microscopy, Image restoration: Inverse and Wiener Filters; Coherent image processing: Vander Lugt filter; Joint-transform correlator; Synthetic Aperture Radar. Basics of holography, in-line and off-axis holography; Super-resolution: Structured Illumination microscopy; Ghost Imaging

Books Recommended:

1. GOODMAN, J. W. (1996). Introduction to Fourier optics. New York, McGraw-Hill.
2. KHARE, Kedar (2016). Fourier Optics and Computational Imaging. John Wiley and Sons.

Syllabus for Open Elective Courses (offered by Department of Physics for other Departments of the University)

Course Title: **Physics and Technology**
Course Number: **PHY001**
Credits: **02**
Type of Course: **Open Elective (Theory)**
Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)

End-Term Examination: (1. 25 Hours) 50%

Course Objectives

- This course being open elective in nature is designed for the students from other departments to let them know the significance of the subject of Physics in connection with the advancements made in the present-day technology. This course contains some basic and important concepts of physics that will make the students acquainted and will infuse in them the technological importance of the subject.

Course Outcomes

- The students will gain the knowledge of the technological advancements made in physics and also the concepts underlying this technological advancement.

- The students will especially from the engineering background will come to know about the research or job opportunities in the field of physics.

PHY001: Physics and Technology Credits: 02
L 2 P 0 T 0

UNIT I

Industrial physics, Vacuum tube technology, Semiconductor technology, Wireless communication, Nuclear fission, Nuclear reactors, Nuclear fusion and Source of energy in Sun, ITER, Concept of Plasma and Bose-Einstein Condensate, Super conductivity and its Applications, SQUID.

UNIT II

Transistor and microwave technology, the laser, quantum optics, optical fibres, idea of quantum computers and Super computers, Technology development at CERN: particle accelerators. Nanotechnology, Novel materials, idea of Solar technology.

Books Recommended:

1. Radiation Detection and Measurement, G. F. Knoll, John Wiley, 2nd ed.
2. Introduction to Nanotechnology, Charles P. Poole Jr. and Frank J. Owens, John Wiley.
3. Plasma Physics and Controlled Fusion, F. F. Chen, Springer, 2nd ed.
4. Superconductivity, C. P. Poole Jr., H. A. Farach, R.J. Creswick and R. Prozorov, Academic Press, 2nd ed.
5. Feynman Lectures on Physics Vol.I, II & III, Narosa Publishing House.

Course Title: **Philosophical Foundations of Physics**
Course Number: **PHY050**
Credits: 02
Type of Course: Open Elective (Theory)
Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)

End-Term Examination: (1. 25 Hours) 50%

Course Objectives

- This course is designed for the students from the other departments especially Humanities who are interested in the philosophical aspect of physics.

Course Outcomes

- The students will gain the knowledge of the important concepts like determinism, unification and their philosophical interpretation.

- The students will learn some important concepts in quantum mechanics like its probabilistic interpretation, Copenhagen interpretation besides the incompleteness and the philosophical interpretation of quantum mechanics.

PHY050: Philosophical Foundations of Physics **Credits: 02**
L 2 P 0 T 0

UNIT I

Classical Physics and Determinism, defining the object, subjectivity, Aristotelian space-time, Newtonian mechanics and space-time, The Leibnitz-Clarke Debate, Space as metaphor, Concept of Ether, Unification of Electricity and Magnetism: Maxwell's equations.

Special Relativity: Simultaneity and Relativity of time, Unification of Space and time (Four-dimensional space-time), time as metaphor, unification of mass and energy ($E = mc^2$).

UNIT II

The Epistemology of Physics: Probabilistic interpretation of Quantum Mechanics, why interpretation? Uncertainties, Copenhagen interpretation: Reduction of wave function, Principle of Complementarity, Rudiments of Quantum Dialect, The role of Probabilities, The logic of Quantum world, Incompleteness of Quantum Mechanics and EPR experiment.

Process of measurement: The Decoherence effect, Quantum Physics and Realism. The religious Interpretation of Science, Physics as Metaphor.

Books Recommended:

1. Physics as Metaphor, R. S. Jones, Wildwood House, 1982.
2. Quantum Philosophy, R.Omnes, University Press, 1999.
3. Doubt and Certainty, Tony Rothman and George Sudarshan, CUP, 1998.
4. Probabilities of Quantum World, D. Danin, Mir Publishers Moscow, 1983

Course Title: **History of Physics**
Course Number: **PHY002**
Credits: 02
Type of Course: Open Elective (Theory)
Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)

End-Term Examination: (1. 25 Hours) 50%

Course Objectives

- This course is an open elective designed for the students from the other departments to make them aware of the developments, discoveries, crisis, opportunities etc. in physics.

Course Outcomes

- The students will gain the knowledge of how the important theories and laws came into being.

- The students will also learn how political leadership and different ideologies affected the development of physics.

PHY002: History of Physics **Credits: 02**
L 2 T 0 P 0

UNIT I

Galilean and Newtonian Physics, law of inertia, laws of motion, Early history of thermodynamics and kinetic theory of gases, Concept of ether and Michelson Morley experiment, Electricity and Magnetism unified.
History of Atom- Aristotle to Bohr Development of quantum theory of light, Theory of Relativity (General and Special)-How I (Einstein) created it?
Development of quantum mechanics-Schrödinger and Heisenberg picture, crisis in quantum theory, discovery of spin

UNIT II

Physics under political leadership: In the shadow of Nazism and Mussolini, Physics Dialectical Materialism and Stalinism, Physics in the great depression, Nuclear bomb and death of two cities.
Rise of Nuclear and Particle Physics, Engineering Physics and Quantum Electronics, Physics in crisis.
Concept of Unification and String Theory.

Books Recommended:

1. History of Physics, S. R. Weart and Melba Phillips, AIP publication, 1985.
2. Quantum Generations A History of Physics in The Twentieth Century, Helge Kragh, Universities Press.
3. Physics as Metaphor, R. S. Jones, Wildwood House, 1982.
4. Probabilities of Quantum World, D. Danin, Mir Publishers Moscow, 1983.

Course Title: **Physics and Our World**
Course Number: **PHY051**
Credits: 02
Type of Course: Open Elective (Theory)
Contact Hours: 2 hours per week (Total: 26 lecture + 6 tutorials)

Internal assessment: 50% (30% Exam (45 Minutes) and 20% assignments/attendance)

End-Term Examination: (1. 25 Hours) 50%

Course Objectives

- This course is designed to make understand, the general undergraduate and masters students about the world around us ranging from the size of atom to the size of galaxies through the concepts of Physics. It includes very fundamental and useful concepts that will be helpful for a general student to have better understanding of the world around us.

Course Outcomes

- The students will grasp the ideas about the various length scales on which matter exists in nature.
- The students will learn about some basic phenomena like formation of day and night, change in seasons and other important phenomena of nature that we experience in day to day life.
- The students will have an elementary idea of space-time through the introduction of special theory of relativity besides the laws of thermodynamics and concept of entropy.
- The concept of matter and energy, elementary particles and unification of forces will be learnt.
- Idea about different sources of energy will be learnt.

PHY051: Physics & Our World **Credits: 02**

L 2 T 0 P 0

UNIT I

A discussion on length scales and dimensions, Galaxies, The solar system and the planet earth, Rotation and revolution of the earth, Seasons, Calendars in history and the recording of time. Development of laws of motion. The relationship between space and time: A brief account of the theory of relativity, cosmological principle, Laws of thermodynamics and probabilistic interpretation of entropy.

UNIT II

Concept of Matter and Energy, From Atoms to Elementary particles: a brief overview, Fundamental forces in nature, Unification of fundamental forces. Equivalence of matter and energy, Energy from nucleons, Renewable and Non-Renewable sources of energy.

Books Recommended:

1. The Evolution of Physics, A. Einstein, and L. Infeld, Touchstone, 1967.
2. Relativity The Special and The General Theory, Pigeon Books India.
3. The Ascent of Man, J. Bronowski, RHUK, 2011.
4. Cosmos, Carl Sagan, Random House, 1980.
5. In search of Schrodinger's Cat, J. Gribbin, Random House, 1984.
6. Brief History of Time, S. Hawking, Bantam, 1989.