Savitribai Phule Pune University

(Formerly University of Pune)

M.Sc. in Physics

(Faculty of Science & Technology)

NEP-2020

To be implemented from Academic Year 2023-2024

Savitribai Phule Pune University, Pune

Syllabus for M.Sc. (Physics) (Pattern-2023)

To be implemented from Academic Year 2023-24

Salient Features of Revised Syllabi in Physics

As far as possible to promote:

1) Physics Education through Master Texts:

It helps in understanding the theoretical and mathematical development of the subject and to create interest in the subject.

2) Physics Education through Experimentation:

It helps in general to improve scientific attitude. So emphasis is given on the development of experimental skills, data analysis, calculations, and also on the limitations of the experimental method and data and, results obtained.

3) Physics Education through Problem Solving:

It helps in understanding the concepts of physics. It underline the strength of equations, formulae, graphs, mathematical tools to tackle the problems. So accordingly, we have introduced compulsory problem part in the question paper.

4) Physics Education through History and Philosophy:

It helps in understanding the conceptual development of the subject and thereby increase the interest in the subject. A topic on this is introduced in the Physics Course.

5) Physics Education through Awareness of Misconceptions:

It improves the scientific awareness among the students. A discussion on different subjects are encouraged.

6) Physics Education through Proto-research:

It creates interest in the subject and improves technological aspect. Accordingly, mini projects, hands-on activities, projects, models and demonstrations etc. is included in the syllabi.

7) Physics Education through Qualitative Overview:

It creates interest in the subject to continue to work in the field of science in general and physics in particular. Accordingly future directions and frontiers of the subject are included in the syllabi.

8) **Structure of Question paper:**

Existing structure shall continue.

9) **ATKT Rules:**

Existing rules shall apply.

10) **Structure of the Course:**

Semester	Course Type	Course Code	Course Name		Credits
I (Level 6.0)	**Major Core** **Theme :** Basic Physics	PHY 501 MJ	Mathematical Methods for Physics		2
		PHY 502 MJ	Statistical Physics		2
		PHY 503 MJ	Classical Physics		2
		PHY 504 MJ	Quantum Physics		4
		PHY 505 MJP	Basic Physics Laboratory-I (BPL-I)		4
		Total Major Core Credits			**14**
	Major Elective (any One)	**Major Elective (Select any One)**			4 (2T+2P)
		PHY 510 MJ	Industrial Electronics	2T	
		PHY 510 MJP	Industrial Electronics	2P	
		PHY 511 MJ	Computational Physics	2T	
		PHY 511 MJP	Computational Physics	2P	
		PHY 512 MJ	Space Weather and Technology	4T	
		PHY 513 MJ	Atmospheric Physics	2T	
		PHY 513 MJP	Atmospheric Physics	2P	
		PHY 514 MJ	Communication Physics	2T	
		PHY 514 MJ	Communication Physics	2P	
		Total Major Elective Credits			**04**
		PHY 541 MN	Research Methodology	2T	4
		PHY 541 MNP	Research Methodology	2P	
		Total Research Methodology Credits			**04**
	Total Credits Semester-I (Basic Physics)				**22**

Semester	Course Type	Course Code	Course Name		Credit
II (Level 6.0)	**Major Core** **Theme** : Light	PHY 551 MJ	Solid State Physics		4
		PHY 552 MJ	Electrodynamics		2
		PHY 553 MJ	Atomic and Molecular Physics		2
		PHY 554 MJ	Basic Electronics		2
		PHY 555 MJP	Basic Physics Laboratory-II (BPL-II)		4
			Total Major Core Credits		**14**
	Major Elective (any One)	**Major Elective (Select any One)**			4 (2T+2P)
		PHY 560 MJ	Fiber Optics and Photonics	2T	
		PHY 560 MJP	Fiber Optics and Photonics	2P	
		PHY 561 MJ	Experimental Techniques for Material Characterization	2T	
		PHY 561 MJP	Experimental Techniques for Material Characterization	2P	
		PHY 562 MJ	Industrial Physics	2T	
		PHY 562 MJP	Industrial Physics	2P	
		PHY 563 MJ	Semiconductor Technology	2T	
		PHY 563 MJP	Semiconductor Technology	2P	
		PHY 564 MJ	LASER Physics	2T	
		PHY 564 MJP	LASER Physics	2P	
			Total Major Elective Credits		**04**
		PHY 581 OJT	On Job Training	4T	**04**
			Total Credits Semester-II (Light)		**22**

Semester	Course Type	Course Code	Course Name		Credit
III (Level 6.5)	**Major Core** **Theme :** Radiation	PHY 601 MJ	Nuclear Physics		4
		Special Major Core Course-I : (Any One)			4
		PHY 602 MJ	Fundamental Physics of Thin Films		
		PHY 603 MJ	Fundamental Biophysics		
		PHY 604 MJ	Fundamental Astronomy and Astrophysics		
		PHY 605 MJ	Fundamental Energy Physics		
		PHY 606 MJ	Physics of Nanomaterials		2
		PHY 607 MJP	Special Major Core Laboratory-I (SMCL-I)		4
		PHY 608 RP	Research Project-I		4
			Total Major Core Credits		**18**
	Major Elective (any One)	**Major Elective (Select any One)**			4 (2T+2P)
		PHY 610 MJ	Physics of Diagnostic Instruments	2T	
		PHY 610 MJP	Physics of Diagnostic Instruments	2P	
		PHY 611 MJ	Radiation Physics	2T	
		PHY 611 MJP	Radiation Physics	2P	
		PHY 612 MJ	Physics of Data Science	2T	
		PHY 612 MJP	Physics of Data Science	2P	
		PHY 613 MJ	Basic Industrial Instrumentation	2T	
		PHY 613 MJP	Basic Industrial Instrumentation	2P	
			Total Major Elective Credits		**04**
			Total Credits Semester-III (Radiation)		**22**

Semester	Course Type	Course Code	Course Name		Credit
IV (Level 6.5)	**Major Core** **Theme:** Research	PHY 651 MJ	Advanced Functional Materials		4
		Special Major Core Course-I : (Any One)			4
		PHY 652 MJ	Advanced Physics of Thin Films		
		PHY 653 MJ	Advanced Biophysics		
		PHY 654 MJ	Advanced Astronomy and Astrophysics		
		PHY 655 MJ	Advanced Energy Physics		
		PHY 656 MJP	Special Major Core Laboratory-I (SMCL-II)		4
		PHY 657 RP	Research Project-II		6
		Total Major Core Credits			**18**
	Major Elective (any One)	**Major Elective (Select any One)**			4 (2T+2P)
		PHY 660 MJ	Energy Storage Devices	2T	
		PHY 660 MJP	Energy Storage Devices	2P	
		PHY 661 MJ	Data Interpretation and Analysis	2T	
		PHY 661 MJP	Data Interpretation and Analysis	2P	
		PHY 662 MJ	Ocean Physics	4T	
		PHY 663 MJ	Advance Industrial Instrumentation	2T	
		PHY 663 MJP	Advance Industrial Instrumentation	2P	
		Total Major Elective Credits			**04**
	Total Credits Semester-IV (Research)				**22**

Major Core

(Semester-I)

M.Sc. (Physics) (Sem-I)
PHY 501 MJ : Mathematical Methods in Physics

Lectures: 30 **(Credits-02)**

A) Course Objectives: This course aims to

1) To introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics.

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

B) Learning Course Outcomes (CO) : On completion of the course, the student will be able to,

- Understanding the mathematics in Physics
- Solve and understand complex problems.
- Apply the knowledge to solve problems in various branches of Physics and Electronics.

C) Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars
4) Use of Multimedia

D) Evaluation Strategies :

1) Descriptive written examinations
2) Assignments
3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Vector Space and Matrix Algebra**	**Lectures:12**
	Revision on Vector space: Vectors (dependent and independent), Vector space, Hilbert space, Dimension of vector space, Matrix representation, Similarity transformation, Eigen values and Eigen vectors, Inner product, Orthogonality, Introduction only to Gramm-Schmidt orthogonalization procedure, Self adjoint and unitary transformation, Eigen values and Eigen vectors of Hermitian and Unitary transformation, Diagonalization	**1 credit**
Module-2	**Fourier Series and Integral Transforms**	**Lectures:18**
	Fourier series: Definition, Dirichlet's Condition, Convergence, Fourier Integral and Fourier Transform, convolution theorem, Parseval's identity, Application to the solution of differential equations, Laplace transform and its properties, Fourier transform and Laplace transform of Dirac Delta function	**1 credit**

G) REFERENCES:

1. Mathematics for Physical Sciences by Mary Boas, John Wiley and Sons
2. Mathematical methods in Physics by B. D. Gupta
3. Mathematical methods in Physics by Satyaprakash
4. Linear algebra by Seymour Lipschutz, Schaum Outline Series McGraw Hill Edition
5. Mathematical Method for Physicists by Arfken and Weber, 6th Edition, Academic Press, N. Y.

M.Sc. (Physics) (Sem-I)
PHY 502 MJ : Statistical Physics

Lectures: 30 **(Credits-02)**

A) Course Objectives: This course aims to

- To introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in statistical mechanics and other fields of theoretical physics.
- To impart knowledge about various statistical tools employed to study physics problems

B) Learning Course Outcomes (CO) : On completion of the course, the student will be able to,

1) Understanding the Statistical in Physics 2) Solve and understand problems.
3) Apply the knowledge to solve problems in various branches of Physics.

C) Instructional design: **1)** Lecture method **2)** Tutorial method **3)** Use of Multimedia

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Classical Statistical Mechanics**	**L:12**
	Macroscopic and Microscopic states, Phase space, Statistical ensemble, Postulate of equal a priori probability, Behaviour of density of states, Lowville's theorem (Classical). Distribution of energy between systems in equilibrium, Sharpness of the probability distribution. Micro-canonical ensemble, Canonical ensemble, Applications of canonical ensembles (Paramagnetism, Molecule in an ideal gas, Law of atmosphere), Calculation of mean values and fluctuations in a canonical ensemble, Connection with thermodynamics, Grand-canonical ensemble, Physical interpretation of α, Chemical potential in the equilibrium state, Mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand partition function.	**1 credit**
Module-2	**Applications of Classical Statistical Mechanics, Ideal Bose and Fermi Systems**	**L:18**
	Classical partition functions and their properties, Calculations of thermodynamic quantities, Ideal monatomic gas, Gibbs paradox, Equipartition theorem and its Simple applications. i) Mean kinetic energy of a molecule in a gas ii) Brownian motion iii) Harmonic Oscillator iv) Specific heat of solid Symmetry of wave functions, Quantum distribution functions, Boltzmann limit of Boson and Fermion gases, **Ideal Bose gas:** Photon gas -i) Radiation pressure ii) Radiation density iii) Emissivity iv) Equilibrium number of photons in the cavity, Bose Einstein Condensation. **Ideal Fermi system**: Fermi energy, Mean energy of fermions at absolute zero	**1 credit**

G) REFERENCES:

1. Fundamentals of Statistical and Thermal Physics, F. Reif, McGraw-Hill International Edition (1985).
2. Fundamentals of Statistical Mechanics, B. B. Laud, New Age International Publication (2003).
3. Statistical Mechanics, R. K. Pathria, Butterworth Heinemann (2nd Edition).
4. Statistical Mechanics, K. Huang, John Willey and Sons (2nd Edition).
5. Statistical Mechanics, Satya Prakash and KedarNath Ram, Nath Publication (2008).
6. Statistical Mechanics by Loknathan and Gambhir.

M.Sc. (Physics) (Sem-I)
PHY 503 MJ : Classical Physics

Lectures: 30 **(Credits-02)**

A) Course Objectives: This course aims to introduce

1. To understand the Newtonian mechanics applications of Newton's laws of motion
2. To know the Lagrangian approach in classical mechanics and applications of Lagrangian formulation
3. To understand the Hamiltonian approach in classical mechanics and applications
4. To know about Variational principle and its applications

B) Learning Course Outcomes (CO) : After completion of the course, the student should be able to:

1. The students will introduce about the newton's laws of motion and knowledge about the applications of newton's laws of motion.
2. This paper enables the students to understand the Lagrangian approach in classical mechanics.
3. The students should be able to understand Hamiltonian formulation with applications
4. The paper also enables the students to know about Variational principle with applications.

C) Instructional design:

a. Lecture method
b. Tutorial method
c. Seminar/s on renewable energy project case studies

D) Evaluation Strategies :

a. Descriptive written examinations
b. Assignments
c. Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Constrained Motion, Lagrangian and Hamilton's formulation**	**Lect = 15**
	Revision of constrained Motion, Constraints and their Classification**,** Degrees of freedom, generalized coordinates, Virtual Displacement, Principle of Virtual Work, D'Alembert Principle, Configuration space, Lagrange's equation of motion, Theorem on total energy, Cyclic coordinates, Generalized momenta, Hamilton's function and Hamiltonian equation of motion, Phase space, Jacobi integrals and energy conservation, Lagrangian and Hamiltonian of relativistic particles and light rays, Problem Solving	**Credit-1**
Module-2	**Variational Principle, Canonical Transformations and Poisson's Bracket**	**Lect = 15**
	Variational principle, Euler's equation, Applications of Variational principle, Concept of symmetry. Introduction- Background and definition of Poisson's Brackets, Legendre transformations, Generating function, Conditions for canonical transformation, Poisson's bracket-definition, identities, Poisson's theorem, Jacobi identity, Invariance of Poisson Bracket under canonical transformation., Problem Solving	**Credit-1**

F) REFERENCES:

1. Classical mechanics by J.C. Upadhyaya, Himalaya Publishing House.
2. Classical mechanics by N.C. Rana and P.S. Jog, Tata Mc-Graw Hill Publishing Company limited, New Delhi.
3. Classical Mechanics by P.V. Panat, Narosa publishing Home, New Delhi.
4. Classical Mechanics by Kumar, Gupta, Sharma.
5. Classical Mechanics by H. Goldstein, Narosa Publishing Home, New Delhi.
6. Classical Mechanics by D. S. Mathur.
7. Introduction to Classical Mechanics by R. G. Takawale and P. S. Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.

M.Sc. (Physics) (Sem-I)
PHY 504 MJ : Quantum Physics

Lectures: 60 **(Credits-04)**

A) Course Objectives: This course aims to introduce the fundamentals of Quantum Mechanics and awareness about the use of Quantum Mechanics to the students. The primary objectives of the study are,

1) Utilize the postulates of quantum mechanics to describe quantum systems and determine their properties, including the results of measurements.
2) Use operator techniques to solve relevant problems.
3) Use the properties of angular momentum and spin to describe quantum systems such as the hydrogen atom and an electron in a magnetic field.
4) Use perturbation theory to find approximate solutions to more complex quantum mechanical systems.

B) Learning Course Outcomes (CO): Upon completion of the course, the student will be able to,

1) Understand various quantum mechanical features by solving various potentials: example, Finite and infinite well, Harmonic oscillator.
2) Learn Eigen values and Eigen functions of operators and computation of Clebsch–Gordan coefficients.
3) Application of Time-independent and time Dependent perturbation theory.
4) Apply the knowledge of Variational Methods for particle in box, Harmonic oscillator and Delta Function along with WKB approximation for classical Region and Tunneling.
5) Familiarizing students with the theoretical framework of non-relativistic quantum mechanics and its applications to simple problems.

C) Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars
4) Use of Multimedia
5) Creation of online resources

D) Evaluation Strategies:

1) Descriptive written examinations
2) Assignments
3) Seminars, Orals, and Viva

E) Course Contents:

Module-1	**Review and Mathematical Tools of Quantum Physics**	**Lectures 15**
	Origin of quantum theory, wave packets and uncertainty relations. Schrödinger wave equation, probability interpretation, Simple one-dimensional problems–wells, barriers and harmonic oscillator (One and three dimensional) **(Revision)** **a)** Postulates of quantum mechanics: Representation of states and dynamical variables, observables, self-adjoint operators, eigen	**Credit-1**

	functions and eigen values, degeneracy, Dirac delta function, Completeness and closure property, Physical interpretation of eigen values, eigen functions and expansion co-efficient, eigen values and eigen functions of momentum operator. **b)** Hilbert space, Dirac's bra and ket notation, dynamical variables and linear operators, projection operators, unit operator, unitary operator,	
Module-2	**Angular Momentum**	**Lectures 15**
	a) Eigen values and eigen functions of L^2 and L_z operators, ladder operators L_+ and L_-, Pauli theory of spins (Pauli's matrices), angular momentum as a generator of infinitesimal rotations, matrix representation of J in l_{jm}> basis. **b)** Addition of angular momenta, Computation of Clebsch-Gordon co-efficient in simple cases (J_1=1/2, J_2=1/2). **c)** Identical Particles-Two Particle systems.	**Credit-1**
Module-3	**Perturbation Theory**	**Lectures 15**
	a) Time-independent Perturbation theory: Non degenerate (up to 2nd order) and degenerate cases (two-fold degeneracy). **b)** Time-dependent Perturbation theory: Transition amplitude 1st and 2nd order, selection rules, constant perturbation (1st order).	**Credit-1**
Module-4	**Approximation Methods**	**Lectures 15**
	a) Variational method: Basic principles and applications to particle in box (1D), harmonic oscillator, Delta function **b)** WKB approximation: Qualitative development and condition for validity of this approximation, the Classical Region and Tunneling.	**Credit-1**

Reference books: -

1) D. J. Griffith, Introduction to Quantum Mechanics, Pearson Education, second edition (2005).
2) Nouredine Zettili, Quantum Mechanics Concepts and Applications, John Wiley & Sons Ltd, second edition (2009).
3) A Text-book of Quantum Mechanics- P.M.Mathews and K.Venkatesan Second Edition Tata McGraw Hill Education Pvt. Ltd. New Delhi.
4) Quantum mechanics by A.Ghatak and S.Lokanathan Kluwer Academic Publishers.
5) Quantum Mechanics by L.I.Schiff Third Edition.
6) Modern Quantum mechanics by J.J.Sakurai Second Edition.
7) Introductory Quantum mechanics by Granier, Springer Publication.
8) Introductory Quantum Mechanics, Liboff, 4th Edition, Pearson Education Ltd.
9) Advanced Quantum Mechanics by Satya Prakash.

M.Sc. (Physics) (Sem-I)

PHY 505 MJP : Basic Physics Laboratory-I (BPL-I)

Lectures: 60 **(Credits-04)**

List of Major Core Experiments (Any-12) :

Section-I (any-6):

1) **Legendre polynomials :**
Using the standard recurrence relation, confirm that the method works well for Legendre functions by comparing with standard tables for special functions. (Use forward recursion.)
2) **Bessel functions:**
Using the standard recurrence relation, Find first kind Bessel functions for (x) = 0, (x) = 0.1 X and the sum rule (x)+ 2 (x) = 1. (Use backward recursion)
3) **Monte-Carlo methods :**
Generate random numbers and find out the value of 'π'. Obtain your result correct up to five decimal positions.
4) **Lagrange interpolation method**:
Interpolate the value of a function at a point using Lagrange interpolation method.
5) **Clockwise Rotation of matrix:**
Rotate the elements of a n x n matrix in clockwise direction and display the matrices (n>=5).
6) **Anticlockwise Rotation of matrix:**
Rotate the elements of a n x n matrix in anticlockwise direction and display the matrices (n>=5).
7) **Inverse of a matrix:**
Find the inverse of an Xn matrix and display both matrices.
8) **Trapezoidal rule:**
Evaluate a given function f(x) using Trapezoidal rule correct up to given accuracy by successively halving the step size.
9) **Simpson rule:**
Evaluate a given function f(x) using Simpson rule correct up to given accuracy by successively halving the step size.
10) **Miller planes using Graphics:**
Write a program and display the Miller planes in the cubic lattice. Display the FCC, BCC and simple cubic lattice on the computer screen.

Section-II (any-2):

1) **Differential Equation**:
Find out the motion of a charged particle in a uniform magnetic field. The equation of motion of part icle with charge 'q' and mass 'm' in a uniform magnetic field B.
2) **Gauss-Elimination method:**
Circuit analysis using Kirchhoff's Laws. Write the relations for currents through various branches of a Whetstone's bridge. Find the current using Gauss elimination method.
3) **Euler method:**

Write the differential equation for charging /discharging of a capacitor C through a resistance 'R'. Solve this equation using Euler method and display your result in tabular as well as graphical form.

4) **Eigen Functions :**
Write a program to graphically display Eigen functions and probability density curves for particle in one dimensional rigid box.

5) **Runge-Kutta method:**
Write and the 1D-Time Independent Schrodinger's equation using Runge-Kutta method for different Harmonic Oscillator Potential.

6) **Fourier Analysis:**
Perform the Fourier analysis for Full wave rectifier

7) **Fourier Analysis:**
Perform the Fourier analysis for Square wave rectifier

Section-II (any-4):

1. To study basic operations used in MATLAB programming, Handling of 1D and 2D Arrays
2. To study various types of loops structures used in MATLAB programming
3. To plot 2D and 3D graphs using MATLAB commands
4. Using MATLAB, solve the time independent Schrodinger equation in one dimension for the particle in a box problem
5. Using MATLAB, Time Dependent Schrodinger equation in one dimension. Using Leapfrog method
6. Using MATLAB, calculate first and second derivative numerically showing how to write differential operator as a matrix
7. Using MATLAB, Matrix representation of differential operators, Solving for Eigenvectors & Eigenvalues of Infinite Square Well
8. Using MATLAB, calculate Probability Density as a function of time for a particle trapped in a double-well potential

Reference Books:

1) Schuam's Series, Programming in C.
2) Koonin S.E., Computational Physics, Benjamin/Cumming Pub .Co .(1986)
3) Pang T., An Introduction to Computational Physics, Cambridge
4) Kernighan B.W. and Ritchie D.M., The C Programming Language, Prentice Hall of India Pvt. Ltd., (1985).
5) Verma R.C., Ahluwalia P.K., and Sharma K.C., Computational Physics, New Age International Publishers (1999)
6) JalurIa Y., Computer Method for Engineering, Allyn and Bacon Inc. (1988)
7) Sastry S.S., Introductory Methods of Numerical Analysis, Prentice Hall of India Pvt. Ltd. (1990)
8) Kanti B. Datta, Mathamatical Methods for Science and Engineering Aided with MATLAB
9) Stephen J. Chapman, Essentials of MATLAB Programming
10) Rajkumar Bansal, Ashok Kumar Goel, Manoj Kumar Sharma, MATLAB and its Applications in Engineering
11) Mos Gilat, MATLAB: An Introduction with Application

Major Elective

(Semester-I)

M.Sc. (Physics) (Sem-I)
PHY 510 MJ (Elective): Industrial Electronics

Lectures: 30 **(Credits : 2)**

A) Course Objectives: This course aims to introduce IoT, IoT protocols, basics of communication and Aurdino knowledge

- To study the IoT and IoT protocols
- To study the basics of communication
- To study the basics of Aurdino and programming

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Understand IoT and IoT protocols.
- Understand Communication technology
- Understand Aurdino and programming

C) Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars
4) Use of Multimedia
5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations
2) Assignments
3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Fundamentals of IoT and Digital Communications**	**Lectures = 15**
	1.1 Definition and characteristics of IoT, Technical Building blocks of IoT, Devices, Communication Technologies, Physical design of IoT, IoT enabling technologies, IoT Issues and Challenges-Planning, Costs and Quality, Security and Privacy, Risks 1.2 MQTT, CoAP, XMPP and AMQT, IoT communication models, IoT Communication technologies: Bluetooth, BLE, Zigbee, Zwave, NFC, RFID, Zigbee etc. (Ref:1,2,3,4) 1.3 Basics of Digital Communication: Introduction, digital trans receiver, Information capacity, bits, bit rate, baud rate and m-ary coding. Ref: (5,6,7,8)	**Credit-1**
Module-2	**Industrial Electronics Automation**	**Lectures = 15**
	2.1 Introduction to Arduino : Introduction to microcontroller and microprocessors, role of embedded systems, open source embedded platforms, Introduction to Arduino IDE- features, IDE overview, fundamentals of embedded C Programming concepts: variables, functions,	**Credit-1**

	conditional statements, Concept of GPIO in Atmega 328 based Arduino board, digital input and output. 2.2 Peripheral Interface and Programming : Interfacing of Atmega328 based Arduino board with LED and LCD, serial communication using Arduino IDE, Concept of ADC in Atmega328 based Arduino board and different wave shape generation, interfacing of Atmega328 based Arduino board with temperature sensor (LM35), LVDT, strain gauge, Stepper motor. (Ref: 9,10,11)	

G) REFERENCES:

1) Internet of Things–A hands on approach, Arshdeep Bahga, Vijay Madisetti, Universities Press,
2) IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things, David Hanes, Cisco Press,
3) The Internet of Things: Applications to the Smart Grid and Building Automation, Olivier Hersent, Omar Elloumi and David Boswarthick, Wiley,
4) The Internet of Things –Key applications and Protocols, Olivier Hersent, David Boswarthick, Omar Elloumi ,Wiley, Electronic Communication Systems Fundamentals through advanced, Wayne Tomasi, Pearson Education Press
5) Wirelerss communications, Andrea Goldsmith, Cambridge University Press
6) Fundamentals of Wireless Communication, D. Tse and P. Viswanathan, Cambridge University Press.
7) Deshmukh Ajay : Microcontroller Theory and applications", Tata Mcgraw hill.
8) Barret Steven : Arduino Microcontroller processing for everyone" Morgan and Claypool Publishers.
9) Massimo Banzi : "Getting started with Arduino" Maker Media INC.
10) Brad Kendall : " Getting started with Arduino : Beginers Guide

M.Sc. (Physics) (Sem-I)

PHY 510 MJP (Elective): Industrial Electronics

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum-6) **(Lectures: 30) (2 Credits)**

1. To interface LED/buzzer to Arduino/Raspberry pi and write a program to make it ON or OFF
2. To interface digital sensor/push button to Arduino/Raspberry pi and write a program to make LED ON when button pressed or sensor detection
3. To interface motor to Arduino/Raspberry pi and write a program to turn ON motor when push button is pressed
4. To interface Bluetooth to Arduino/Raspberry pi and write a program to send sensor data to smartphone using Bluetooth
5. Seven segment display as a counter 0 to 9 using aurdino
6. Temperature sensor interfacing programming using aurdino
7. Thumbwheel switch interfacing as input using aurdino
8. LED blinking program using aurdino
9. Square and triangular generation using ADC of aurdino

G) REFERENCES:

11) Internet of Things–A hands on approach, Arshdeep Bahga, Vijay Madisetti, Universities Press,
12) IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things, David Hanes, Cisco Press,
13) The Internet of Things: Applications to the Smart Grid and Building Automation, Olivier Hersent, Omar Elloumi and David Boswarthick, Wiley,
14) The Internet of Things –Key applications and Protocols, Olivier Hersent, David Boswarthick, Omar Elloumi ,Wiley, Electronic Communication Systems Fundamentals through advanced, Wayne Tomasi, Pearson Education Press
15) Wirelerss communications, Andrea Goldsmith, Cambridge University Press
16) Fundamentals of Wireless Communication, D. Tse and P. Viswanathan, Cambridge University Press.
17) Deshmukh Ajay : Microcontroller Theory and applications", Tata Mcgraw hill.
18) Barret Steven : Arduino Microcontroller processing for everyone" Morgan and Claypool Publishers.
19) Massimo Banzi : "Getting started with Arduino" Maker Media INC.
20) Brad Kendall : " Getting started with Arduino : Beginers Guide

M.Sc. (Physics) (Sem-I)

PHY 511 MJ (Elective): Computational Physics

Lectures: 30 **(Credits : 2)**

A) Course Objectives: This course aims to familiarize the students with the numerical methods used in computation and programming using FORTRAN language to solve physics problems. The primary objectives of the course are

- To impart basic knowledge of computational physics in solving the physics problems.
- To use computer programming language for simulation and data analysis.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Apply basic knowledge of computational physics in solving the physics problems.
- Demonstrate concepts related to variables, I/O, arrays, procedures, modules, pointers in FORTRAN.
- Programme with the FORTRAN or any other high level language.
- Use various numerical methods in solving physics problems.
- Analyze the outcome of the algorithm/program graphically.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars 4) Use of Multimedia 5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Introduction to Fortran 90**	**Lectures = 15**
	Introduction to Fortran_90, Character sets, structure of statements, Structure of a Fortran Program, compiling, linking and executing the Fortran program. Constants & Variables, Arithmetic & Logical Expressions, Arithmetic & Logical operators. Input Output Statements, Conditional Statements, Looping, Functions & Subroutines, Defining and Manipulating Arrays & Strings. Pointers, Data Types & Modules, File Processing.	**Credit-1**
Module-2	**Numerical Methods**	**Lectures = 15**
	Numerical differentiation – Lagrange interpolation, Numerical integration by Simpson (1/3) rule and Weddle's rules, Numerical solution of differential equations by Taylor's Series, Euler Method, Newton-Raphson Method, Runge-Kutta methods, Guass elimination method, Gauss-Seidel iterative method, Monte Carlo simulations. Application of F90 to solve the problems based on these methods.	**Credit-1**

G) REFERENCES:

1) Programming in Fortran 90 and 95, V. Rajaram, Prentice-Hall of India (2013)
2) Computer Oriented Numerical Methods, V. Rajaraman, Prentice Hall of India (1993)
3) Numerical Methods for Scientist and Engineers, H. M. Antia, Tata McGraw Hill (1991)
4) Numerical Methods with Fortran IV case studies, Dorn & McCracken, John Wiley (1972)

M.Sc. (Physics) (Sem-I)

PHY 511 MJP (Elective): Computational Physics

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum-6) **(Lectures: 30) (2 Credits)**

Use Fortran 90 programming language to solve the following problems.

1) To find the largest or smallest of a given set of numbers.
2) To find the factorial of a number
3) Transpose of a square matrix using only one array.
4) To obtain the Fibonacci series
5) Find first order derivative at given x for a set of values with the help of Lagrange interpolation.
6) Evaluation of Bessel Functions.
7) To find roots of algebraic equation by Newton-Raphson Method.
8) To solve a Differential Equation by Runge Kutta method.
9) To solve roots of linear equation by Gaussian Elimination method/ Gauss-Seidel iterative method
10) Find out the value of 'π' using Monte-Carlo methods. Obtain your result correct up to five decimal positions.
11) Different equation: Write the differential equation for charging /discharging of a capacitor C through a resistance 'R'. Solve this equation using Euler method.
12) Linear fit / Fitting an exponential/ Fitting a trigonometric function.
13) To perform numerical integration of a function by Simpson's/ Weddle's Rule.
14) Trigonometric Functions Sin(x) and Cos(x) Using Series Method.

G) REFERENCES:

1) Programming in Fortran 90 and 95, V. Rajaram, Prentice-Hall of India (2013)
2) Computer Oriented Numerical Methods, V. Rajaraman, Prentice Hall of India (1993)
3) Numerical Methods for Scientist and Engineers, H. M. Antia, Tata McGraw Hill (1991)
4) Numerical Methods with Fortran IV case studies, Dorn & McCracken, John Wiley and Sons (1972)
5) Numerical Recipes in FORTRAN (2nd Edn.), W. H. Press, S. A. Teakalsky, W. T. Vellerling, B. P. Flannery, Cambridge University Press (1997)
6) Computational Physics - An introduction, R. C. Verma, P. K. Ahluwalia, K. C. Sharma, New Age International Publishers (2005).
7) Computational Physics – Fortran Version, S. E. Koonin, D. C. Meredith, Westview Press (1990).

M.Sc. (Physics) (Sem-I)

PHY 512 MJ (Elective): Space Weather and Technology

Lectures: 60 **(Credits : 4)**

A) Course Objectives:

This course aims to introduce the fundamentals of Space Technology and awareness about the use of Space Technology to the students. The aim of this course is to explore the physical processes, which occur in the space environment. The course will provide information on structure of upper atmosphere, ionosphere and magnetosphere, basic plasma phenomena, Sun, solar wind, and solar energetic particles, geomagnetic storms and explain some phenomena like Aurorae. This course provides information on how the space weather impacts human society.

The primary objectives of the study are,

1) To impart knowledge of basic concepts of Space Technology and their applications.
2) To introduce fundamental laws and principles in Space Technology and their applications.
3) To develop research skills, including advanced laboratory techniques, numerical techniques, computer algebra, and interfacing among the students.

B) Learning Outcomes: Upon completion of the course, the student will be able to,

- Understand Space Weather and Technology.
- Basics of atmospheric compositions, Solar and Plasma Physics, Sun and Cosmic rays.
- Apply the concept and use of knowledge of the Space Technology to real-life problems.
- Understanding of the Space Technology will create a scientific temperament.
- To Study the Implications of Space Weather On various Phenomenas.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars

D) Evaluation Strategies:

1) Descriptive written examinations **2)** Assignments **3)** Seminars, 4) Orals

E) Course Contents :

Module-1	**The Sun : Interior and Exterior**	**Lectures = 15**
	Brief Introduction of Plasma physics, Sun-Composition and Structure, Solar radiation, Solar atmosphere, Sunspots and solar rotation, Solar Cycle, Solar wind, Solar Flares and Coronal Mass Ejections. Origin of Cosmic rays. Propagation of Coronal Mass Ejections in the Interplanetary medium, Interaction of the Solar Wind with the Terrestrial Magnetic Field,	**Credit-1**
Module-2	**Magnetosphere : Structure and Properties**	**Lectures = 15**
	Introduction to Earth's magnetic field. Earth's Magnetosphere.The Bow Shock and the Magnetopause, The Magnetospheric Cavity, Magnetospheric Current Systems, The Ring Current, Field-Aligned Currents, Plasma Convection in the Magnetosphere, Magnetic Diffusion & Magnetic Reconnection, Convection Electric Field & High-Latitude Electrodynamics, Polar Cap Convection for Southward IMF and Ionospheric Convection	**Credit-1**

	Velocities, Aurorae, Magnetic Storms, Geomagnetic Activity Indices.	
Module-3	**Atmospheric Layers : Based on Thermal Structure and Ionisation**	**Lectures = 15**
	Composition and structure of stratosphere, mesosphere and thermosphere. The ionosphere - composition morphology and general properties. Coupling of different Atmospheric layers with magnetosphere, Gyration-Dominated Plasma Transport, Ambipolar Electric Field and Diffusion, Diffusive Equilibrium in the F2 Region, Sq Current and the Equatorial Electrojet	**Credit-1**
Module-4	**Application of Space Weather**	**Lectures = 15**
	Application to Space Weather ; for e.g. Satellite, GPS, Electric and Power Grid, Mobile Communication , Remote Sensing etc.	**Credit-1**

F) Reference Books:

1) Chen F. F., Introduction of Plasma Physics and Controlled Fusion, Plenum Press.
2) Gombosi T. I., Physics of the Space Environment, Cambridge University Press.
3) Kellenrode M-B, Space Physics, An Introduction to Plasmas and Particles in the Heliosphere and Magnetospheres, Springer.
4) Walker A. D. M., Magnetohydrodynamic Waves in Space, Institute of Physics Publishing.
5) Arvind Bhatnagar, Fundamentals of solar astronomy, William Livingston Arnab Rai Chowdhury, Nature's Third Cycle, Oxford University Press.
6) C. J. Schrijver and C. Zwaan, Solar and stellar magnetic activity, Cambridge University press
7) M. G. Kivelson and C.T. Russle, Introduction to Space Physics, Cambridge University Press
8) M. C. Kelley, The Earth's Ionosphere, Plasma Physics and Electrodynamics, Elsevier Press
9) Henry Rishbeth, Owen K. Garriott, Introduction to Ionospheric Physics (International Geophysics)
10) J. K. Hargreaves, Upper Atmosphere and Solar-terrestrial Relations: Introduction to the Aerospace Environment, Cambridge Press
11) Volker Bothmer and I. A. Dagliz, Space Weather: Physics and Effects, Springer.
12) J.K. Hargereaves, Solar Terrestrial Environment: Introduction to Geospace, Cambridge University
13) Margaret G. Kivelson and Christopher T. Russell, Introduction to Space Physics, Cambridge University
14) Kenneth Lang, Sun, earth and Sky, Springer Verlag.
15) Ronald Giovanelli,Secrets of the sun, Cambridge University Press.
16) Peter Taylor and Nancy Hendrickson, Kalmbach, Beginners guide to Sun, Publishing Company.
17) C.G. Andrews, J.R. Holton & C. Leovy, Middle Atmosphere Dynamics
18) G. Brasseur and S. Simon, Aeronomy of the Middle Atmosphere
19) C. O. Hines, I. Paghis, T. R. Hatz & J. A. Fejer, Physics of the Earth's Upper Atmosphere.

M.Sc. (Physics) (Sem-I)

PHY 513 MJ (Elective): Atmospheric Physics

Lectures: 30 **(Credits : 2)**

A) Course Objectives:

This course aims to introduce the fundamentals of Atmospheric Physics and awareness about the use of it to the students. The primary objectives of the study are,

1) To impart knowledge of basic concepts of Atmospheric Physics and their applications
2) To introduce fundamental laws and principles in various energy conversion of Physics and their applications.
3) To develop research skills, including advanced laboratory techniques, numerical techniques, computer algebra, and interfacing among the students.

B) Learning Outcomes: Upon completion of the course, the student will be able to,

1) Understand basic concepts and various atmospheric Phenomenos.
2) Basics of weather systems.
3) Apply the concept and use of knowledge of the LIDARS, SODARS, Weather RADARS, Wind Profiler, radio-acoustic sounding systems (RASS), Doppler radar, MST Radar, Microwave radiometer. Course to real-life problems.
4) Understanding the Physics of atmospheric dynamics will create a scientific temperament.
5) Students will have hand on experience intheory based on solar conversion systems and their applications, solar photovoltaics, solar thermal energy, geothermal energy, and emerging trends in atmospheric sciences.

C) Instructional design :

1) Lecture method
2) Tutorial method
3) Seminar/s on renewable energy project case studies

D) Evaluation Strategies :

1) Descriptive written examinations
2) Assignments
3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Atmospheric Dynamics**	**Lectures = 15**
	Kinematics of the Large-Scale Horizontal Flow, Elementary Kinematic Properties of the Flow, Vorticity and Divergence, Deformation, Streamlines versus Trajectories, Dynamics of Horizontal Flow, Apparent Forces, Real Forces, The Horizontal Equation of Motion, The Geostrophic Wind, The Effect of Friction, The Gradient Wind, The Thermal Wind, Suppression of Vertical Motions by Planetary Rotation, Conservation Law for Vorticity, Potential Vorticity, Primitive Equations, Pressure as a Vertical Coordinate, Hydrostatic Balance, The Thermodynamic Energy Equation, Inference of the Vertical Motion Field, Solution of the Primitive Equations, An Application of Primitive Equations, The	**Credit-1**

	Atmospheric General Circulation, The Kinetic Energy Cycle, The Atmosphere as a Heat Engine, Numerical Weather Prediction	
Module-2	**Atmospheric Observations**	**Lectures = 15**
	General principles of surface meteorological measurements, accuracy requirements. Conventional and self-recording measurements of pressure, temperature, humidity, wind speed and direction, sunshine duration, radiation, precipitation, visibility, clouds, soil temperature and soil moisture, evaporation. Measurement of sea surface temperature and other ocean parameters. Upper air pressure, temperature, humidity and wind measurements: pilot balloons, radiosonde, dropsonde, ozonesonde, radiometersondes, GPS sonde, Working principle and applications of LIDARS, SODARS, Weather RADARS, Wind Profiler, radio-acoustic sounding systems (RASS), Doppler radar, MST Radar, Microwave radiometer. satellite attitude and its control, types of orbits-polar and geostationary, earth- and sun synchronous, orbit optimization, viewing geometry, launch vehicles and space crafts. Meteorological satellites, multi-scanner radiometers and their applications in the observation of weather parameters.	**Credit-1**

Reference Books:

1) Introduction to Theoretical Meteorology by S.L. Hess,
2) Atmospheric Sciences: An introductory Survey by J.M. Wallace and P.V. Hobbs, Academic Press.
3) Guide to Meteorological Instruments and method of observation, WMO-8
4) Meteorological Instruments by W.E.K. Middleton and A.F. Spilhaus,
5) Instruments and Techniques for probing the atmospheric boundary layer by D.H. Lenchow.
6) Applications of Remote Sensing to Agrometeorology by F. Toselli, Kluwer

M.Sc. (Physics) (Sem-I)
PHY 513 MJP (Elective): Atmospheric Physics

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum-6) **(Lectures: 30) (2 Credits)**

1. Computation of CAPE and CINE with radiosonde data.
2. Computation of divergence and vorticity by finite difference technique.
3. Computation of vertical velocity using equation of continuity.
4. Analysis of upper air data; using ozonesondes
5. Use of various soft tools used in atmospheric sciences for data analysis
6. Use of various soft tools used in atmospheric sciences for plotting ex. GrADS/ MATLAB, etc.
7. Analysis of upper air data using ozonesondes
8. Humidity measurements using pilot balloons, radiosonde, ozonesonde, radiometersondes, etc.
9. Wind measurements using pilot balloons, radiosonde, ozonesonde, radiometersondes, etc.

Reference Books:

1) Introduction to Theoretical Meteorology By S.L.Hess,
2) Atmospheric Sciences: An introductory Survey By J.M. Wallace and P.V. Hobbs, Academic Press.
3) Guide to Meteorological Instruments and method of observation, WMO-8
4) Meteorological Instruments by W.E.K.Middleton and A.F. Spilhaus,
5) Instruments and Techniques for probing the atmospheric boundary layer, D.H. Lenchow.
6) Applications of Remote Sensing to Agrometeorology F.Toselli, Kluwer

M.Sc. (Physics) (Sem-I)

PHY 514 MJ (Elective): Communication Physics

Lectures: 30 **(Credits : 2)**

A) Course Objectives: This course aims to introduce fundamentals of Communication Electronics

- To study the basic concepts regarding Digital Communication
- To impart knowledge about Satellite Communication

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Understand Digital Communication.
- Identify Network organization.
- Satellite Communication and their significance
- Understanding the Communication Electronics to create a scientific temperament
- Apply the knowledge of Digital Communication systems.

C) Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars
4) Use of Multimedia

D) Evaluation Strategies :

1) Descriptive written examinations
2) Assignments
3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Digital Communication**	**Lectures = 15**
	Fundamentals of digital communication systems. Characteristics of data transmission system such as Band-Width requirement, speeds, SNR, cross talk, echo suppressors, distortion equalizer, Digital codes, Bardot code, binary code, ASCII code (EBCDIC), Hollerith code, Error detection, constant ratio codes, Redundant codes, parity check codes, Communication system using modem interfacing, Network organization.	**Credits = 01**
Module-2	**Satellite Communication**	**Lectures = 15**
	Introduction to radar systems, fundamental radar range equation, basic pulsed radar. Satellite frequencies, orbits (geostatic, equatorial/polar, synchronous) station keeping, satellite attitude, transmission path, path loss, noise considerations, satellite system.	**Credits = 01**

G) REFERENCES:

1) Electronic communications – Rooddy – Coolen (PHI) electronic
2) Communication Systems – George Keneddy (TMH)
3) Principles of Electronic Communication System – Louis Frenzel
4) Communication Electronics – Katre
5) Telecommunication switching systems & Network – T.Vishwanathan.(PHI)

M.Sc. (Physics) (Sem-I)

PHY 514 MJP (Elective): Communication Physics

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum-6) **(Lectures: 30) (2 Credits)**

1) Study of Pulse Amplitude Modulation
2) Study of Pulse Position Modulation
3) Study of Pulse Width Modulation
4) Study of Delta pulse Modulation
5) Study of Optical communication with Photo-transistor.
6) Study of Optical communication with IR-LED.
7) Study of Digital Multiplexing
8) Study of Directional characteristics of Dish antenna.

G) REFERENCES:

1) Electronic communications – Rooddy – Coolen (PHI) electronic
2) Communication Systems – George Keneddy (TMH)
3) Principles of Electronic Communication System – Louis Frenzel
4) Communication Electronics – Katre
5) Telecommunication switching systems & Network – T.Vishwanathan.(PHI)

M.Sc. (Physics) (Sem-I)
PHY 541 MN : Research Methodology

Lectures: 30 **(Credits : 2)**

A) Course Objectives: This course aims to introduce fundamentals of Research in Science and Physics

- To study the basic concepts regarding research
- To impart knowledge about research

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Understand Research.
- Identify research problems.
- Understanding the research to solve research problems

C) Instructional design:

1) Lecture method, **2)** Tutorial method, **3)** Seminars, 4) Use of Multimedia

D) Evaluation Strategies :

1) Descriptive written examinations, **2)** Assignments, **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Research and Research Methods**	**Lectures = 15**
	Research : Meaning, Concept, Types, and Characteristics of Research, Scientific Inquiry, Interdisciplinary approach and its implications in various research area. **Research Methods :** Introduction to Various Scientific Methods, Characteristics of methods and their implications in research area. **Development of Research Proposal :** Research proposal and its elements, Formulation of research problem, Development of objectives and hypotheses.	**Credits = 01**
Module-2	**Data Collection, and its Analysis**	**Lectures = 15**
	Data Collection : Tools of Data collections, their types, attributes and uses, **Data Analysis :** Various Statistical tools for data analysis, Analysis of quantitative data and it presentation with tables, graphs, etc. **Report writing :** Writing and presentation of preliminary, main body and reference section of report	**Credits = 01**

F) References:

1) Research Methodology by C.R. Kothari

2) Research Methodology by V.V. Khanzode

3) Research Methodology and Statistical techniques by Santosh Gupta

4) Research Methodology, Sanay Prakashan by Bhise, Kulkarni, Gachande,

M.Sc. (Physics) (Sem-I)
PHY 541 MNP : Research Methodology
Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum-6) **(Lectures: 30) (2 Credits)**

1) Visit to any research center and prepare a research report.
2) Write research paper on any research experiments.
3) Write book review of any 2 reference books.
4) Write journal review of any 2 referred or peer review journal
5) Hands on training of any research method (Physical/Chemical/Hybrid) and write report.
6) Hands on training of any research instruments (Characteristics instruments) and write report.
7) Collect data from any journal and analyze it under supervisor instructions.
8) Collect data according to research methods and analyze it.
9) Take literature with working and advantages of any research method
10) Choose research problem and write various objectives of it.
11) Write any research proposal

F) References:

1) Research Methodology by C.R. Kothari

2) Research Methodology by V.V. Khanzode

3) Research Methodology and Statistical techniques by Santosh Gupta

4) Research Methodology, Sanay Prakashan by Bhise, Kulkarni, Gachande

5) Research Methodology by R. Cauvery

6) Research Methodology by Rao & Pasumarti

7) Research Methods by Agrawal & Rao

Major Core

(Semester-II)

M.Sc. (Physics) (Sem-II)
PHY 551 MJ : Solid State Physics

Lectures: 60 **(Credits-04)**

A) Course Objectives:

This course will investigate the structural and physical properties of materials by developing better understanding of crystal structure with particular emphasis on studying the electrical and magnetic behavior of solids. The course shows how various types of phenomena (resistivity, magnetism, superconductivity) are related. The main objectives of the course are to increase the students' understanding and knowledge of solid state physics and to improve their problem solving ability, including the design of experiments which examine principles in condensed matter physics.

B) Learning Course Outcomes (CO) :

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

1. Understand characteristic physical properties of different categories of solid materials, with an emphasis on the crystalline state.
2. How a wide spectrum of theoretical approaches to model the mechanical, thermal and electrical properties of solid materials.
3. Do quantitative calculations based on established theoretical models to describe the properties of materials.
4. Use of Fourier Transform methods, including reciprocal space, as an analytical tools to perform and analyze basic diffraction experiments to gain information about atomic scale structures.
5. Analyze solid-state problems using mathematical and numerical methods.
6. Account for the role of solid state physics for technology and society as well as links between solid state physics and other main branches of physics.

C) Instructional design:

1) Lecture method
2) Tutorial method
3) Seminars

D) Evaluation Strategies :

1) Descriptive written and/or subjective Multiple Choice Question based examination
2) Assignments/Tutorial sessions
3) Seminars/Orals//Viva/Classroom evaluation of students

E) Course Contents :

Module-1	Crystal Structure and Band Theory of Solids	Lectures = 15
	Introduction to Crystal structures, Reciprocal Space & Bragg's Diffraction, Brillouin Zone, Atomic form factor (scattering factor), Geometrical structure factor, Structure factor calculations for SC, BCC, FCC structure, Nearly free electron model, Motion of electron in 1-D according to band theory, Bloch theorem, Kronig-Penney model, Variation of Energy, Velocity and effective mass of electron,Tight binding approximation, Band structure, Numerical	**Credit-1**

Module-2	Magnetism	Lectures = 15
	Theory of diamagnetism and magnetic susceptibility using classical approach, Langevin theory of Paramagnetism, Quantum theory of Paramagnetism, Paramagnetic susceptibility of conduction electron, Hund's Rule and Magnetic properties of rare earth ions & iron group ions with graphical representation, Crystal field splitting, quenching of orbital angular momentum, Wiess molecular theory, Curie point, ferromagnetic domains, Anisotropy energy, Bloch wall. Antiferromagnetism and Ferrimagnetism, Numerical	**Credit-1**
Module-3	**Dielectric & Ferroelectrics**	**Lectures = 15**
	Electric Polarization, Macroscopic and local electric field, Dielectric Constant and Polarizability, Classical Theory of Electronic Polarizability, Debye Relaxation, Clausius – Mossotti relation, Ferroelectricity, structural phase transitions, ferroelectric crystals, Dielectric behaviour in $BaTiO_3$, Piezoelectricity, Numerical	**Credit-1**
Module-4	**Superconductivity**	**Lectures = 15**
	Properties of Superconductors: Meissner effect, Heat capacity, Energy gap, Isotope effect; Type I and II superconductors; Superconductor as perfect diamagnet, Thermodynamics of superconductivity; London equation and London penetration depth; BCS theory: Electgron-Electron interaction via Phonon, Cooper Pair, Bose-Einstein Condensate, High temperature superconductor e.g. $YBa_2Cu_3O_7$. Qualitative discussion of Josephson superconductor tunnelling, Numerical.	**Credit-1**

G) REFERENCES:

1. Introduction to Solid State Physics by C. Kittel, 8th edn, John Wiley & Sons. Inc., New York (1976).
2. Solid State Physics by S. O. Pillai. New Age International Publication.-2002
3. Solid State Physics by A. J. Dekker, MacMillan India Ltd. (1986).
4. Solid State Physics by N. W. Ashcroft and N. D. Mermin, HRW International edn. (1976).
5. Fundamentals of Solid State Physics, J. R. Christman, (John Wiley and Sons)
6. Solid State Physics, H. Ibach and H. Luth, (Springer-Verlag)
7. Solid State Physics, J.J. Quinn and K-Soo Yi (Springer)
8. Dielectrics in Electric Fields- Gorur Govinda Raju (CRC Press)
9. Introductory Solid State Physics, H. P. Myers, (Viva Books Pvt. Ltd.)
10. Elementary Solid State Physics by Ali Omar (Addison-Wesley Publishing Company)
11. Solid State Physics by M. A. Wahab (Narosa Publishing House)

M.Sc. (Physics) (Sem-II)

PHY 552 MJ : Electrodynamics

Lectures: 30 **(Credits-02)**

A) Course Objectives: This course aims to introduce fundamentals of Electrodynamics

- To study the basic concepts regarding Maxwell's equations
- To impart knowledge about Relativistic Mechanics and Covariance

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Understand time varying fields.
- Identify electromagnetic potentials, gauge transformations and Lorentz transformations.
- Inhomogeneous wave equations and their significance
- Understanding the electrodynamics to create a scientific temperament

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars 4) Use of Multimedia

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Multipole Expansions and Inhomogeneous Wave Equations**	**Lectures = 15**
	Multipole expansions for a localized charge distribution in free space, linear quadrapole potential and field, Time dependent fields, Faraday's law for stationary and moving media, Maxwell's displacement current, Differential and integral forms of Maxwell's equations. Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator, Hertz potential. (Ref: 1-4, 10)	**Credits = 01**
Module-2	**Relativistic Mechanics and Covariance**	**Lectures = 15**
	Experimental basis for special theory of relativity (Michelson – Morley experiment), Lorentz transformations, Relativistic velocity addition, Minkowski's space time diagram, Four vector potential, electromagnetic field tensor, Lorentz force on a charged particle.	**Credits = 01**

F) REFERENCES:

1) Introduction to Electrodynamics, (3rd Edition) by David J. Griffith, Publication: Prentice-Hall

2) Introduction to Electrodynamics, by A.Z. Capri and P.V. Panat, Narosa Publishing House

3) Classical Electricity and Magnetism, by Panofsky and Phillips, Addison Wesley

4) Foundations of Electromagnetic Theory by Reitz and Milford, World Student Series Edition

5) Classical Electrodynamics, by J. D. Jackson, 3rd Edition John Wiley

6) Electromagnetic Theory and Electrodynamics, by Satya Prakash, Kedar Nath and Co. Meerut

7) Special Theory of Relativity, by Robert Resnick

8) Electromagnetics by B.B. Laud, Willey Eastern

9) Matrices and Tensors in Physics, A.W. Joshi, 3rd Edition, New Age International

10) Electrodynamics by Kumar Gupta and Singh

M.Sc. (Physics) (Sem-II)

PHY 553 MJ : Atomic and Molecular Physics

Lectures: 30 **(Credits-02)**

A) Course Objectives:

1) To understand the basic physics concepts of atomic and molecular spectroscopy.
2) To impart knowledge about different spectroscopic techniques.

B) Learning Course Outcomes (CO) : After completion of the course, the student will be able to,

1) Understand the interaction of atoms in strong and weak magnetic field.
2) Identify the different bonding mechanisms in strong and weak magnetic field.
3) Understand different spectroscopic techniques and their significance

C) Instructional design:

1) Lecture method 2) Tutorial method **3)** Experiments

D) Evaluation Strategies :

1) Descriptive written examinations Assignments, 2) Seminars and Orals/Viva

E) Course Contents :

Module-1	**Atomic and Molecular spectroscopy**	**Lectures = 15**
	Revision of atomic models, Quantum number, Hunds rule, Lande g-factor, Gyrometric ratio, Zeeman effect- Normal and Anomalous, Paschen- Back effect, Stark effect. Molecule and Molecular Orbital method, Molecular Spectra – Rotational spectra of molecule and vibrational energy of diatomic molecules, Vibrational course structure, Frank – Condon principle, Dissociation, rotational fine structure of electronic vibration transitions.	**Credits = 01**
Module-2	**Spectroscopic Techniques**	**Lectures= 15**
	(a) ESR-Principles of ESR, ESR spectrometer, Hyperfine structure, Application of ESR (b) NMR-Nuclear Magnetron and resonance condition, NMR instrumentation, chemical shift, applications of NMR. (c) Microwave Spectroscopy: microwave spectrometer and its applications (d) IR and FTIR spectroscopy: Principle, IR spectrophotometer and its Applications (e) Raman spectroscopy: Theory of Raman scattering, Raman spectrometer and its Applications.	**Credits = 01**

G) REFERENCES:

1) Molecular structure and Spectroscopy G. Aruldhas. *Second Edition***.** PHI Learning Fundamentals of Molecular spectroscopy. Collin N. Banwell and Elaine M. McCash. *Fourth Edition.* McGraw Hill Education (India) Private Ltd

2) Quantum Physics – Robert Eiesberg and Robert Resnik**.** *Second Edition.* WILEY

3) Atomic and Molecular Spectra: Laser- Raj kumar, 2020th Edition, Knrn

4) Concepts of Modern Physics -Arthur Beiser, 6th Edition, McGraw Hill Education

M.Sc. (Physics) (Sem-II)
PHY 554 MJ : Basic Electronics

Lectures: 30 **(Credits-02)**

A) Course Objectives: This course aims to introduce knowledge of basic Electronics

1) To study the basic knowledge of basic electronics.
2) To impart knowledge about latest competent used in appliances.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to, 1) Understand power electronic devices and special function IC's 2) Apply the knowledge of course in industry

C) Instructional design:

1) Lecture method 2) Tutorial method 3) Seminars 4) Use of Multimedia 5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations 2) Assignments 3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Semiconductor Devices and its Applications**	**Lect = 15**
	1.1 SCR: Construction, working, Characteristics and applications as half wave and full wave rectifier 1.2 DIAC and TRIAC: Construction, working, characteristics and application as fan regulator 1.3 IC 723 Voltage Regulator: Block diagram and applications of IC 723 as Low and High voltage regulator. 1.4 DC-DC Converter and SMPS: Concept and Applications.	**Credits = 01**
Module-2	**Special Function ICs and their Applications**	**Lect = 15**
	2.1 Operational Amplifier: Function generator using two OPAMPS with variable controls, Multivibrators using OPAMPs, Precision rectifiers, Instrumentation amplifier using three OPAMPSs. 2.2 Timer IC 555: Applications as PAM, PWM, FM and FSK generator. 2.3 Voltage Controlled Oscillator (IC566): Block diagram and working. 2.4 Phase Locked Loop (IC565): Block diagram, working and applications as detector.	**Credits = 01**

F) REFERENCES:

1. Power Electronics Circuits, Devices and Applications by Muhammad H. Rashid, Pearsons Publications
2. Electronic Devices and Circuits: An Introduction by Allen Mottershed.
3. Solid State Electronic Devices, 6th Edition, by Ben G. Streetman.
4. Operational Amplifiers, 5th Edition by G.B. Clayton.
5. Linear Integrated Circuits, 4th edition by Roy Choudhari
6. Design with OPAMPS and Analog Integrated Circuits by Sergio Franco
7. Monolithic Integrated circuits by K. R. Botkar.
8. Electronic Principles by Albert Malvino.
9. Basic Electronics: Solid State – B.L. Theraja

M.Sc. (Physics) (Sem-II)

PHY 555 MJP : Basic Physics Laboratory-II (BPL-II)

Lectures: 60 **(Credits-04)**

List of Major Core Experiments (Any-12) :

1. To study Precision rectifier
2. To study Diode Pump Staircase generator using UJT
3. To study Feedback Power Supply
4. To study Voltage Control Oscillator using IC-566
5. To study Constant current Source using OP-AMP
6. To study DAC (Digital to Analogue Converter) using R-2R and Binary ladder
7. To study Voltage to Frequency / Frequency to voltage converter using OP-AMP
8. To study Optocoupler using OPAMPs and IC MCT-2E
9. To study Active filters using OP-AMP / IC- 8038 (L-P, H-P. Notch type)
10. To Study of Multiplexer and Demultiplexer
11. To Design, built and test oscillator - LC oscillator
12. To Design, built and test 8-bit ADC
13. To Design and built Function generator using IC-8038
14. To PLL application using IC565
15. To Study of errors in electrical measurement and results due to loading
16. To study Crystal Oscillator and Digital Clock
17. To determine the transition capacitance of a varactor diode and use it as a variable capacitor
18. To Measurement of efficiency of a power amplifier (IC810) and study of its frequency response.
19. To Study of noise performance of an amplifier

Additional Activities (*Any One*):

a) **Model Demonstrations :** Any 1-demonstrations equivalent to 2-experiments.
b) **Study tour:** Participate study tour (***Industry/Oganization/Research Institute/Research organization/ Small scale industry/University Department***) with study tour report equivalent to 2-experiments.
c) **Computer Aided Demonstrations :** Any 2-demonstrations equivalent to 2-experiments.

Note: *Students have to perform **12**-experiments or **1**-additional activities in addition to **10**-experiments mentioned above. Total laboratory work with additional activities should be equivalent to **12**-experiments**.***

Reference Books:

1. Malvino and Leach, Digital Principles, 6th Edition, Tata McGraw Hill Publication, Delhi
2. Clayton G.B., Operational Amplifier
3. Ramakant Gaikwad, OP-AMPS and Linear Integrated Circuits
4. Sonde B.S., Power Supplies, Tata Mc-Graw Hill Pub. Co. Ltd. (1974)
5. Sonde B.S., Data Converters, Tata Mc-Graw Hill Pub. Co. Ltd. (1974)
6. Miliman and Taub, Pulse, Digital and Switching Circuits
7. C. Fitchen and Franklin, Electronic Integrated Circuits and Systems, Van No strand Reinhold Company

Major Elective

(Semester-II)

M.Sc. (Physics) (Sem-II)
PHY 560 MJ (Elective): Fiber Optics and Photonics

Lectures: 30 **(Credits : 2)**

A) Course Objectives: This course aims to introduce to

1. Develop the understanding of elements of an optical fiber transmission link, block diagram, advantages of optical fiber communication,
2. Introduce basic concepts governing optical waveguides, fibres, and lasers.
3. Understanding and knowledge of optical communication technology and devices (including photonic integrated circuits, optical amplifiers, semiconductor lasers and optoelectronic),
4. Acquaint the students about important areas of photonics,
5. Foster a physical and quantitative understanding of key photonic devices
6. Develop an understanding of the use of photonics in sensing and communications applications.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1. Analyze fiber optics and optical detectors components associated with fiber optics systems,
2. Apply the skills necessary to solve practical and design problems for fiber optic communication systems.
3. Gain the knowledge about current status and future trends in development of photonic devices.
4. Characterize the performance of optical fibers based on understanding and mathematical description of their principle of operation

C) Instructional design:

1) Lecture method **2)** Tutorial method **3**) Use of Multimedia 4) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Optical Fiber : Fabrication Techniques and Losses**	**Lectures = 12**
	1.1 Fiber : 1.1.1 Optical Fiber and its Basic Structure, 1.1.2 Acceptance Angle and Acceptance Cone of a fiber 1.1.3 Numerical Aperture (General and Graded index fibre) 1.1.4 Modes of Propagation, Meridional and Skew Rays, 1.1.5 Classification of Fibers **1.2 Fabrication Techniques :** 1.2.1 Outside vapor-phase oxidation process, 1.2.2 Vapor axial deposition (VAD), 1.2.3 Modified chemical vapor deposition, 1.2.4 Plasma- activated chemical vapor deposition, **1.3 Fiber Losses:** 1.3.1 Materials or Impurity Losses, 1.3.2 Rayleigh Scattering Losses, 1.3.3 Absorption Loss, 1.3.4 Bending Losses, 1.3.5 Radiation Induced Losses,	

	1.3.6 Inherent Defect Losses **1.4 Applications of Fibers**	
Module-2	**Optical Fiber : Communication Systems and Measurements**	**Lectures = 10**
	2.1 Communication Systems: 2.1.1 Long-Haul Communication, 2.1.2 Coherent Optical Fibre Communication, 2.1.3 Principle of Coherent Detection. 2.1.4 Applications of OFC Technology **2.2 Measurements:** 2.2.1 Measurements of Numerical Aperture (NA), 2.2.2 Optical Time-Domain Reflectometer (OTDR), 2.2.3 Measurements of Dispersion Losses, 2.2.4 Measurements of Refractive Index, 2.2.5 Cut-Off Wavelength Measurement	
Module-5	**Photonics Technology**	**Lectures = 08**
	5.1 Introduction, 5.2 Components: Couplers-Directional Couplers, 5.3 Principle of Operation and Conservation of Energy, 5.4 Isolators and Circulators (Principle of Operation), 5.5 Grating: 5.5.1 Multiplexers and Filters Grating, 5.5.2 Bragg Grating; 5.5.3 Fiber Grating; 5.6 Fabry-Perot Filters	

G) REFERENCES:

1) Optical Fiber Communication, G. Keiser, Mc Graw Hill, 3rd Edition
2) Introduction to Fibre Optics, A. Ghatak and Thyagrajan, Cambridge University Press
3) Optical Fiber and Fiber Optic Communication Systems, S.K. Sarkar, S. Chand, New Delhi (2010)
4) Optical Fiber Communications: Principles and Practice, J. M. Senior, PHI, 2nd Ed (2007)
5) Fundamentals of Fiber Optics in Telecommunication and Sensor Systems, B. P. Pal, New Age International Publisher, New Delhi, 1st Edition (2006)
6) Deploying Optical Networking Components, Oil Held, Mccraw Hill (2001)
7) Optical Interconnection, C. Tocci, Hi Caulfield, Artech House (1999)

M.Sc. (Physics) (Sem-II)

PHY 560 MJP (Elective): Fiber Optics and Photonics

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum-6) **(Lectures: 30)** **(2 Credits)**

1) Study of electrical to optical and optical to electrical characteristics of given optical fiber.
2) Determination of the numerical aperture of given optical fiber.
3) Determination of the optical power loss in Attenuators.
4) Determination of the optical power splitting using coupler.
5) Estimation of the bending loss in a given optical fiber
6) Determination the power loss in optical fiber spool with OTDR.

G) REFERENCES:

1) Optical Fiber Communication, G. Keiser, Mc Graw Hill, 3rd Edition

2) Introduction to Fibre Optics, A. Ghatak and Thyagrajan, Cambridge University Press

3) Optical Fiber and Fiber Optic Communication Systems, S.K. Sarkar, S. Chand, New Delhi (2010)

4) Optical Fiber Communications: Principles and Practice, J. M. Senior, PHI, 2nd Ed (2007)

5) Fundamentals of Fiber Optics in Telecommunication and Sensor Systems, B. P. Pal, New Age International Publisher, New Delhi, 1st Edition (2006)

6) Deploying Optical Networking Components, Oil Held, Mccraw Hill (2001)

7) Optical Interconnection, C. Tocci, Hi Caulfield, Artech House (1999)

M.Sc. (Physics) (Sem-II)

PHY 561 MJ (Elective): Experimental Techniques for Material Characterization

Lectures: 30 **(Credits : 2)**

A) Course Objectives:

This course aims to introduce the fundamental understanding of characterization techniques which are commonly used for material analysis. This course develop and imparts the systematic steps for interpretation of data obtained from the characterization.

B) Learning Course Outcomes (CO) :

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

1) Identify and implement the specific characterization technique as per the requirement.
2) Relate and compare the data obtained from the characterization techniques.
3) Examine and interpret the details of the sample.

C) Instructional design:

1) Lecture method
2) Tutorial method
3) Use of Multimedia
4) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations
2) Assignments
3) Seminars, Orals

E) Course Contents :

Module-1	**Structural and Compositional Characterization**	**Lect= 15**
	X-ray Diffraction, Bragg's diffraction condition, XRD instrumentation with filters, Derivation of Scherrer formula for size determination, Interpretation of XRD plot: Lattice parameters, Structure analysis, and strain effects. X-ray Photoelectron Spectroscopy (XPS) - Principle, instrumentation, working, analysis, carbon correction Scanning Electron Microscope (SEM) and Transmission Electron Microscopy (TEM): morphological study, crystalline nature and elemental analysis (EDS)	**Credit-1**
Module-2	**Optical and Electrical Characterization Techniques**	**Lect= 15**
	UV-Visible and Photoluminescence (PL)Spectroscopy- Principle, instrumentation, working, applications and analysis of spectra, Optical and electronics properties of semiconductors, Merits of Diffuse Reflectance Spectroscopy (DRS). Principle, instrumentation, working of Fourier Transform Infrared(FTIR) spectroscopy, Electron Spin Resonance(ESR) Resistivity by Four Probe method, Hall Effect Experiment	**Credit-1**

G) REFERENCES:

1) Elements of X-ray Diffraction: B. D. Cullity and S. R. Stock, Pearson, (**2014).**
2) An Introduction to Surface Analysis by XPS and AES: John F. Watts and John Wolstenholme, Wiley
3) Handbook of X-ray Photoelectron Spectroscopy: John F. Moulder, William F. Stickle, Peter E. Sobol and Kenneth D. Bomben, Perkin-Elmer
4) Fundamentals of Molecular Spectroscopy: C.N. Banwell, McGraw Hill
5) Instrumental Methods of Analysis: Willard ,Merritt, Dean and Settle
6) Nanotechnology Principles and Practices: Sulabha Kulkarni, Springer
7) Characterization of Materials, John B. Wachtman and Zwi. H. Kalman, Pub. Butterworth Heinemann (1992)
8) Instrumental Methods of Chemical analysis, G. Chatwal and S. Anand, Himalaya Publishing House.
9) Material Characterization, P.C. Angles
10) Transmission Electron Microscopy, D.B. Williams and C.B. Carter

M.Sc. (Physics) (Sem-II)

PHY 561 MJP (Elective): Experimental Techniques for Material Characterization

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum-6) **(Lectures: 30)** **(2 Credits)**

1) Determination of interplanar spacing (d) and particle size from XRD of the sample
2) Use of free softwares (QualX, Quanto, MAUD etc) to determine the crystal structure, phase and lattice parameters from the XRD data
3) Analysis of strain from X-ray diffraction of the sample
4) Determination of the band gap from the UV-Visible response and DRS of the sample
5) Analysis of XPS Survey scan of the sample
6) Determination of functional group present in the sample from FTIR response
7) Determination of Lande's 'g' factor from ESR curve
8) Carbon correction of the sample in XPS peak
9) Resistivity measurement by four probe method
10) To determine the Hall voltage developed across the sample material.
11) To calculate the Hall coefficient and the carrier concentration of the sample material.

G) REFERENCES:

11) Elements of X-ray Diffraction: B. D. Cullity and S. R. Stock, Pearson, (**2014).**
12) An Introduction to Surface Analysis by XPS and AES: John F. Watts and John Wolstenholme, Wiley
13) Handbook of X-ray Photoelectron Spectroscopy: John F. Moulder, William F. Stickle, Peter E. Sobol and Kenneth D. Bomben, Perkin-Elmer
14) Fundamentals of Molecular Spectroscopy: C.N. Banwell, McGraw Hill
15) Instrumental Methods of Analysis: Willard ,Merritt, Dean and Settle
16) Nanotechnology Principles and Practices: Sulabha Kulkarni, Springer
17) Characterization of Materials, John B. Wachtman and Zwi. H. Kalman, Pub. Butterworth Heinemann (1992)
18) Instrumental Methods of Chemical analysis, G. Chatwal and S. Anand, Himalaya Publishing House.
19) Material Characterization, P.C. Angles
20) Transmission Electron Microscopy, D.B. Williams and C.B. Carter

M.Sc. (Physics) (Sem-II)
PHY 562 MJ (Elective): Industrial Physics

Lectures: 30 **(Credits : 2)**

A) Course Objectives: This course aims to introduce an intellectual environment conducive for the study of Industrial Physics. Students will be:

1) Be employed in company.
2) Be employed and to teach in other tertiary institutions.
3) Work in Research Institutes or Laboratories.
4) Work in Telecommunications Companies.
5) Work in Radio and Television Houses.
6) Be gainfully employed in Instrumentation Laboratories of any Industry.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1) Teaching in order to maintain continuity in disseminating knowledge to future generation of physicists.
2) Working in various public establishments like Telecommunication, Meteorology Departments, Aviation Industries, Energy Centres, Survey Departments, Hospitals, Oil and Gas Industries, Mining and Steel Industries Solid Minerals Development, Electrical/Electronics Industries, and in the Raw Materials and Development Centers
3) Pursuing research in Industrial Physics in any chosen field.
4) Dovetailing into the engineering field in such areas as Electronics, Electrical Engineering, Computer/Information Technology, Materials/Metallurgy, etc., and; Working in both supervisory and advisory capacities in industries and other productive sectors of the economy.

C) Instructional design:

1) Lecture method
2) Tutorial method
3) Use of Multimedia
4) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations
2) Assignments
3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	Nuclear Physics and Vacuum Technology	Lectures = 06
	1.1 Nuclear Structure, Binding Energy and Various Models 1.2 Radioactivity, Radiation Detection and Monitoring Equipment 1.3 Particle Accelerators and Applications. 1.4 Radiation Protection in Medical Applications. 1.5 Industrial Vacuum Creating and Measurement (Pumps and Gauges) 1.6 Sealing Techniques in Vacuum 1.7 Materials in Vacuum Leak Detection	

Module-2	Physics and Technology	Lectures = 06
	3.1 Introduction to Solar cell and designing of Solar Panel 3.2 Introduction to Semiconductor devices and its Technology 3.3 Introduction to Electrical instruments used in Industries	
Module-4	**Safety Issues and Report Writing**	**Lectures = 03**
	4.1 Safety Issues in Industry and Safety Measures at Work 4.2 Basic Physical Principles that Govern Industrial Technology Output 4.3 Work Ethics and Industrial Working Conditions 4.4 Writing Scientific Working Reports	

G) REFERENCES:

1) Industrial Physics; Mechanics: Lewis Raymond Smith MaGraw-Hill book company , inc. (1922)

2) Engineering Physics: Marikani A., Prentice-Hall of India Pvt.Ltd

3) Nuclear Physics : Tayal D C, HPH, Bombay (1994)

4) Nuclear Physics : Patel S B, Wiley Eastern Ltd, New Delhi (1992)

M.Sc. (Physics) (Sem-II)
PHY 562 MJP (Elective): Industrial Physics

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum-6) **(Lectures: 30) (2 Credits)**

1. Study of different X ray photograph and MRI scan photographs in medicine
2. Study of NDT by acoustic method
3. Study of surface defects by liquid penetration method
4. Study of surface defects by liquid leak method
5. Study of surface defects by liquid spray method
6. Study of surface defects by using UV light and fluorescent liquid method
7. Study of designing of Solar cell and its study
8. Study various electrical instruments used in Industries
9. Study of semiconductor various devices used in Industries

G) REFERENCES:

1) Industrial Physics; Mechanics: Lewis Raymond Smith MaGraw-Hill book company , inc. (1922)
2) Engineering Physics: Marikani A., Prentice-Hall of India Pvt.Ltd
3) Nuclear Physics : Tayal D C, HPH, Bombay (1994)
4) Nuclear Physics : Patel S B, Wiley Eastern Ltd, New Delhi (1992)

M.Sc. (Physics) (Sem-II)
PHY 563 MJ (Elective): Semiconductor Technology

Lectures: 30 **(Credits : 2)**

A) Course Objectives:

This course aims to introduce physics of semiconductors

1) The course objective is to obtain practical knowledge in semiconductor physics and semiconductor devices and to identify types of semiconductors.
2) To study the basic concepts regarding properties and applications of semiconductors
3) To impart knowledge about identifying the types and its uses in semiconductor industries.

B) Learning Course Outcomes (CO) :

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

1) Use of knowledge in semiconductor physics and semiconductor devices to analyze and quantify complex problems in the field of nanotechnology
2) The course will enable students to understand and appreciate the properties, application and their significance of the semiconductor materials, which will eventually lead to a general framework of concepts applicable across a variety of semiconductor devices.
3) The course will enable students to understand and appreciate the synergy between quantum mechanics and semiconductor materials, which will eventually lead to a general framework of concepts applicable across a variety of semiconductor devices. The students will be able to comprehend the drift and diffusion mode of electrical transport through semiconductor devices.
4) Apply the knowledge to create new semiconducting materials to career prospects span science or mathematics education, a range of related scientific fields and industries, or the option to progress to further academic study.

C) Instructional design:

1) Lecture method
2) Tutorial method
3) Seminar/s
4) Use of Multimedia

D) Evaluation Strategies :

1) Descriptive written examinations
2) Assignments
3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Properties of Semiconductor and p-n Junctions**	**Lect =15**
	Energy bands in semiconductors, Types of semiconductors, Charge carriers, Intrinsic and extrinsic materials. Carrier concentration, Fermi Level, Electron and hole concentration equilibrium, Temperature dependence of carrier concentration, Compensation and charge neutrality. Conductivity and mobility, Effect of temperature, Doping and high electric field. Hall Effect. Optical absorption, carrier generation, Carrier life time, diffusion length and	**1 credit**

	photo conductivity, Direct and indirect recombination and trapping, Photoconductive devices. Diffusion of carriers, Einstein relation, Continuity equation, Carrier injection, Diffusion length. Haynes-Shockley experiment.	
Module-2	**Junction Transistor and Metal Insulator Semiconductor devices**	**Lect = 15**
	p-n junction and contact potential, Fermi levels, Space charge, Reverse and Forward bias, Zener and Avalanche breakdown. Capacitance of p-n junction, Schottky barriers; Schottky barrier height, C-V characteristics, current flow across Schottky barrier: thermionic emission, Rectifying contact and Ohmic contact, Thermal instability, Tunneling effect, Avalanche Multiplication.	**1 credit**

G) REFERENCES:

1. Physics of Semiconductor Devices – S.M. Sze –Third Edition (John Wiley)
2. An introduction to Semiconductor Devices—Donald A. Neaman –Third Edition (McGraw-Hill 2007)
3. Solid State Electronic Devices – B.G. Streetman and S.K. Banerjee (Pearson Education)
4. Fundamentals of Semiconductor Devices – J. Lindmayer and C.Y. Wrigley
5. Physics of Semiconductor Devices – Micheal Shur

M.Sc. (Physics) (Sem-II)

PHY 563 MJP (Elective): Semiconductor Technology

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum-6) **(Lectures: 30)** **(2 Credits)**

1. Study of optoelectronic properties of semiconductor devices (Solar cell)
2. Studies on the characterization of JFET (Output & transfer characteristic)
3. Studies on the characterization of MOSFET
4. Determination of band gap of semiconductor from temperature dependence of resistivity using four probe method
5. Study of Hall voltage as a function of probe current and magnetic field and determination of Hall coefficient and carrier concentration.
6. Opamp as a differential and subtraction application
7. Temperature and frequency dependent dielectric properties of the material.
8. Studies on the diode characteristics such as zener breakdown p-n junction diode etc

G) REFERENCES:

6. Physics of Semiconductor Devices – S.M. Sze –Third Edition (John Wiley)
7. An introduction to Semiconductor Devices—Donald A. Neaman –Third Edition (McGraw-Hill 2007)
8. Solid State Electronic Devices – B.G. Streetman and S.K. Banerjee (Pearson Education)
9. Fundamentals of Semiconductor Devices – J. Lindmayer and C.Y. Wrigley
10. Physics of Semiconductor Devices – Micheal Shur

M.Sc. (Physics) (Sem-II)
PHY 564 MJ (Elective): Laser Physics

Lectures: 30 **(Credits : 2)**

A) Course Objectives:

This course aims to introduce physics of Lasers

- The course objective is to obtain practical knowledge in Lasers physics and to identify types of Lasers.
- To study the basic concepts regarding properties and applications of lasers.
- To impart knowledge about identifying the types and its uses in industries.

B) Learning Course Outcomes (CO) :

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

- Use of knowledge in Laser physics and Laser devices to analyze and quantify complex problems in the field of nanotechnology
- The course will enable students to understand and appreciate the properties, application and their significance of the Lasers materials

C) Instructional design:

1) Lecture method, **2)** Tutorial method, **3)** Seminar/s 4) Use of Multimedia

D) Evaluation Strategies :

1) Descriptive written examinations, **2)** Assignments, **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Basic Principle of Lasers and its properties**	**Lect =15**
	Basic Principle : Absorption, spontaneous and stimulated emission, population inversion, Properties of Laser, Metastable state, Gain, Absorption coefficient, Einstein's coefficient Pumping methods : Pumping mechanisms (Two, Three and Four), Threshold pump power, g-parameters of laser cavity, stability curve, Gaussian beam and their properties. Line broadening mechanisms. Measurements of laser power, energy, wavelength, frequency, line width.	**Credit-1**
Module-2	**Types of Lasers and its Applications**	**Lect= 15**
	Principle, Construction, Energy level diagram and working : Solid State, Gas, Liquid, and Semiconductor Lasers with examples	**Credit-1**

G) REFERENCES:

1) Solid State Engineering Vol-I – W.Koechner Springer Verlag (1976).
2) Lasers Fundamentals – W.T. Silfvast.
3) Principles of Lasers – O.Svelto – Plenum, 1982
4) Laser Parameters - Heard
5) Laser and Non-Linear Optics – B.B. Laud (2nd Edition)
6) Lasers -- Nambiar
7) Introduction to Fiber Optics – A. Ghatak, K. Thyagarajan- Cambridge University Press
8) Principles of Laser and Their Applications – Callen O'Shea, Rhodes
9) Introduction to Laser Theory And Application – M.N. Avdhanulu, S. Chand Publication
10) Experiments with Laser – Sirohi

M.Sc. (Physics) (Sem-II)

PHY 564 MJP (Elective): Laser Physics

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum-6) **(Lectures: 30)** **(2 Credits)**

1) To determine wavelength of He-Ne laser using grating element.
2) To determine wavelength of He-Ne laser using measuring scale.
3) To determine spot size of laser using knife edge.
4) To determine divergence of laser beam.
5) To determine energy and power of laser beam.
6) To determine diameter of wire using laser.
7) To measure contamination in liquid sample using laser beam.
8) Use of laser in optical fiber communication.

G) REFERENCES:

1) Solid State Engineering Vol-I – W.Koechner Springer Verlag (1976).
2) Lasers Fundamentals – W.T. Silfvast.
3) Principles of Lasers – O.Svelto – Plenum, 1982
4) Laser Parameters - Heard
5) Laser and Non-Linear Optics – B.B. Laud (2nd Edition)
6) Lasers -- Nambiar
7) Introduction to Fiber Optics – A. Ghatak, K. Thyagarajan- Cambridge University Press
8) Principles of Laser and Their Applications – Callen O'Shea, Rhodes
9) An Introduction to Laser Theory And Application – M.N. Avdhanulu, S. Chand Publication
10) Experiments with Laser – Sirohi

M.Sc. (Physics) (Sem-II)
PHY 581 OJT : On Job Training

Lectures: 60 **(Credits : 4)**

On job training is one of the best ways to deliver type of specific and continuous learning. On job training is a form of training provided at the workplace. During the training, students are familiarized with the working environment and handling of instruments. Students get a hands-on experience using machinery, equipment, tools, materials, etc. Through hands-on teaching and coaching, students learn the practical skills and knowledge they need to perform their job.

Write a report on any-2 according to

a) Visit to any company or repairing center.
b) Study the various parts used.
c) Take a hand-on-training.
d) Attached training letter from authorized training center.
f) Write a report on this training
e) Evaluate the report by training supervisor and teachers.

Example: Choose any one for OJT

1) Refrigeration Manufacturing/Repairing:
2) AC Manufacturing/Repairing:
3) Solar Cell Manufacturing/Repairing:
4) Charging Battery Manufacturing/Repairing:
5) Wind Mill Manufacturing/Repairing:
6) Power Supply build and repairing:
7) TV Manufacturing/Repairing;
8) Four Stroke Engine Manufacturing/Repairing;
9) Hand watch Manufacturing/Repairing;
10) Any Instrument from Instrumentation facility;
11) CRO/Function generator/Multimeter Repairing;
12) Home appliances Manufacturing/Repairing:
13) Any industry of Physical Instruments or Electric Instruments Manufacturing/Repairing:

Major Core

(Semester-III)

M.Sc. (Physics) (Sem-III)
PHY 601 MJ : Nuclear Physics

Lectures: 60 **(Credits : 4)**

A) Course Objectives:

1. This course aims to introduce the structure and properties of atomic nuclei and elementary particles. It covers topics such as nuclear detectors, accelerators, nuclear decay, nuclear reactions, quarks, leptons, and the standard model of particle physics.
2. A course on nuclear physics focuses on the principles, methodologies, and applications of various nuclear techniques used in scientific research, industry, and medical fields. These techniques utilize nuclear processes, radiation, and nuclear instrumentation to investigate and analyze various phenomena.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Understand Nuclear Structure, Comprehend Nuclear Reactions, Learn Radioactivity and Decay, Explore Nuclear Energy, Nuclear Medicine, and Develop Computational and Analytical Skills.
- It focuses on the study of atomic nuclei, their properties, interactions, and the forces that govern them. It explores the fundamental structure and behavior of atomic nuclei, as well as the processes of nuclear reactions and the applications of nuclear phenomena..
- Nuclear physics is an active field of research with ongoing discoveries and advancements. You may be exposed to current research topics, emerging technologies, and recent developments in nuclear physics through lectures, literature reviews, or discussions
- Apply the knowledge of nuclear physics can be valuable for pursuing advanced research or specialized careers in nuclear / radiation areas.

C) Instructional design:

1) Lecture method 2) Tutorial method 3) Use of Multimedia 4) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations 2) Assignments 3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Nuclei: General Properties and Concepts**	**Lect = 15**
	Concept of Nucleus and Nuclear forces, Overview of Nuclear Mass & Binding Energy, Systematic of Nuclear Binding Energy, Measurement of Charge Radius- Electron Scattering Experiment, Concept of Mass Spectrograph, Nuclear spin, Magnetic Dipole Moments & Electric Quadrupole Moments of Nuclei , Basic theory of deuteron nucleus and problems, Radioactivity, Unit of Radioactivity, Alpha Decay: Velocity of Alpha Particles, Disintegration Energy, Range-Energy Relationship, Geiger-Nuttal Law, Beta Decay: Conditions for Spontaneous Emission of β^- & β^+ Particles, Selection Rules, Gamma Decay: Decay Scheme of ^{137}Cs &^{60}Co Nuclei, Internal Conversion, Internal Pair Creation,	**Credit-1**

Module-2	Radiation Detectors and Nuclear Models	Lect = 15
	Semiconductor Detectors: Si (Li) and Ge (Li) Detectors, High Purity Germanium Detector, NaI (Tl) Scintillation Detector. Geiger-Muller Counter, Bubble Chamber, Cloud Chamber, Spark Chamber. Nuclear Models: Liquid Drop Model- Semi Empirical Mass Formula, Shell Model-Square Well Potential, Harmonic Oscillator Potential, Spin-Orbit Coupling, Predictions of the Shell Model, Achievements & Failures of shell Model, Fermi Gas Model, Collective Model, Problems.	**Credit-1**
Module-3	**Reaction Dynamics, Nuclear Reactors and Accelerators**	**Lect = 15**
	Reaction Dynamics: Types of Nuclear Reactions, Conservation Laws in Nuclear Reactions, Q of Nuclear Reaction, Compound Nucleus Hypothesis, Fission and Fusion Reactions, Reactors: Fission Chain Reaction, Four Factor Formula, Multiplication Factor, General Properties and Concepts of Nuclear Reactors, Reactor Materials, Types of Reactors, List of Different Types of Reactors Developed in India, Accelerators: Van de Graff, Betatron, Microtron, Electron & Proton Synchrotron, Pelletron, Cyclotron, Light Hydron Collidor (LHC), Problems.	**Credit-1**
Module-4	**Nuclear Interactions and Particle Physics**	**Lect= 15**
	Nuclear Interactions: Low Energy Neutron-Proton Scattering, Scattering Length, Spin Dependence of n-p Interaction, Proton-Proton and Neutron-Neutron Scattering at Low Energies, Particle Physics: Classification of Elementary Particles, Mass Spectra and Decays of Elementary Particles- Leptons & Hadrons, Quantum Numbers, Conservation Laws, Quarks, Higgs Boson concept,	**Credit-1**

F) REFERENCES:

1. S.N. Ghoshal, Atomic and Nuclear Physics, S. Chand
2. S.B. Patel Nuclear Physics: An Introduction, New Age International, 1991
3. D.C. Tayal, Nuclear Physics, Himalaya Publishing House
4. G.F. Knoll, Radiation Detection and Measurement, 3rd Edition, Wiley India
5. S.S. Kapoor and V.S. Ramamurthy, Nuclear Radiation Detectors, Wiley Eastern Limited
6. K.S. Krane, Introductory Nuclear Physics, Wiley, India, 1988
7. B.L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill
8. Dunlap R.A. (2004). Introduction to the physics of nuclei & particles, Thomson Asia.
9. I. Kaplan, Nuclear Physics, 2nd Edition, Narosa, New Delhi, 1989
10. R.D. Evans, The Atomic Nucleus, Tata McGraw Hill
11. R.R. Roy, B.P. Nigam, Nuclear Physics-Theory and Experiment, Wiley Eastern Limited
12. Blatt and Weisskopf, Theoretical Nuclear Physics, New York, Wiley 12. S. Sharma, Atomic and Nuclear Physics, Pearson Education 2008
13. Griffith D. 1987 Introduction to Elementary Particles, John Wiley & Sons

M.Sc. (Physics) (Sem-III)

PHY 602 MJ (Special-I) : Fundamental Physics of Thin Films

Lectures: 60 **(Credits : 4)**

A) Course Objectives: This course aims to make the students to understand about the difference between bulk and thin film, the mechanical, optical, electrical and magnetic properties of thin film, the theories explaining the formation of thin film and the fabrication and advantages of thin film devices.

1) To study the basic concepts regarding to different types of growth mechanisms in the growth of thin films.
2) Understand the principle in measuring the thickness of thin films and to find a suitable method for measuring the thickness of thin films.
3) Understand and analyze the characteristics and properties of thin films using different instrumentation techniques.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Understand the principle, differences and similarities, advantages, and disadvantages of different thin film deposition techniques.
- Identify potential of thin film preparation method for future thin film application.
- Understand about different instrumentation techniques and to analyze thin film properties to apply for various applications.
- Understand, evaluate and use models for understanding nucleation and growth of thin films.
- Improve problems solving skills related to evaluation of different properties of thin films.

C) Instructional design:

1) Lecture method **2)** Tutorial method

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars and Orals

E) Course Contents :

Module-1	**Introduction & Mechanism of Thin Film Formation**	**Lect = 10**
	Introduction of thin and thick films, Nucleation and condensation of thin films, Frank-Van der Merwe model, Volmer-Weber model, Stranski-Krastanov model, Capillarity Theory of Nucleation, Statistical (Atomistic) Theory of Nucleation, Various stages of film formation mechanism. Influence of Individual Factors on Nucleation Process.	**Credit-1**
Module-2	**Methods of Thin Film Deposition**	**Lect = 20**
	Principle, Construction and Working of Physical deposition method, Thermal Evaporation methods: Resistive heating, Flash evaporation, Arc evaporation, Laser evaporation, Electron beam heating, Sputtering: Introduction to sputtering process and sputtering variants, glow discharge sputtering, Magnetic field assisted (Triode) sputtering, RF Sputtering, Ion beam sputtering, Influencing Factors on thin film nucleation and growth by physical methods. Chemical vapor deposition: Common CVD reactions,	**Credit-1**

	laser CVD, Photochemical CVD, Plasma enhanced CVD, Deposition Mechanism and preparation of compound thin film by Chemical Bath Deposition, Electrodeposition, Spray Pyrolysis, successive ionic layer adsorption reaction method (SILAR) method, Sol-gel method, Dip coating and Spin coating, Photolithography and Hydrothermal method.	
Module-3	**Thickness Measurements and Characterization of Thin Films**	**Lect = 15**
	Film Thickness measurements: Balance Methods: Microbalance Method, Vibrating Quartz Method; Electrical Methods: Electric Resistivity Measurement, Measurement of Capacitance, Measurement of Q-factor Change, Ionization Methods; Optical Methods: Method Based on Measurements of Light Absorption Coefficient, Interference Methods, Polarimetric (Ellipsometric) Method, Deposition Rate Monitoring Using Transfer of Momentum; Stylus Thickness measurment Method. Principle and Application of Fundamental Characterizations of Thin Films: UV-Visible Spectroscopy, Contact Angle Measurement, Photoluminnace, Electroluminance, X-ray diffraction, FTIR, Raman, scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), X-ray Energy Dispersive Analysis (EDX), Auger Electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS).	**Credit-1**
Module-4	**Properties of Thin Films**	**Lect = 15**
	Mechanical properties of thin films: Introduction to elasticity, plasticity and mechanical behavior, Electrical properties of thin films, Electrical Properties of Continuous and Discontinuous Metal Films, Electrical Properties of Semiconducting Thin Films, Optical properties of thin films: optical constants in thin films, Magnetic Properties and Superconductivity in Thin Films.	**Credit-1**

G) REFERENCES:

1. Hand book of Thin Film Technology by Maissel and Glang, (Mc Graw Hill)
2. Thin Film Phenomena by K.L. Chopra (Mc Graw Hill)
3. Material Science of Thin Films by M. Ohring (Academic Press)
4. Thin Film Process by J. L. Vossen and Kern (Academic Press)
5. Thin Film Fundamentals by A. Goswami, New Age International (2006)
6. Thin Films and its Applications By R.B. Bhise, V.H. Goswami, M.S. Shinde and M.D. Dhiware, Mahi Pblications, India (2023).
7. H.M. Pathan, and C.D. Lokhande (2004) Deposition of metal chalcogenide thin films by successive ionic layer adsorption and reaction (SILAR) method. Bulletin of Materials Science, 27, pp.85-111.
8. R.S. Mane and C.D. Lokhande (2000) Chemical deposition method for metal chalcogenide thin films. Materials Chemistry and physics, 65(1), pp.1-31.

M.Sc. (Physics) (Sem-III)

PHY 603 MJ (Special-I) : Fundamental Biophysics

Lectures: 60 **(Credits : 4)**

A) Course Objectives: This course aims to introduce Biophysics

3) To study the basic concepts regarding Cellular and Molecular Biology

4) To impart knowledge about Biophysical Techniques

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Understand Basic Structure of Cell
- Identify Biophysical Techniques
- Properties and their significance
- Working of Nervous System
- Apply the knowledge of Physics in Living things

C) Instructional design:

1) Lecture method 2) Seminars 3) Use of Multimedia 4) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations 2) Assignments 3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Basics of Biophysics**	**Lect = 15**
	Introduction to Biophysics,General organization of prokaryotic and eukaryotic organisms basic concepts and their detailed structure and functions, Cell, Animal and Plant Cell, Types of Cell and its composition, Prokaryotic cell wall, Eukaryotic cell wall, their functions, ribosomes, Physical and biological properties of protoplasm. Cytoskeleton – basic components, properties and functions in prokaryotic and eukaryotic cells.	**1Credit**
Module-2	**Properties of Lipid Membrane**	**Lect = 15**
	Cell surface charge, Resting membrane potential, Action potential, properties of action potential, Nernst-Plank equation, Hodgkin-Huxely equation, Hodking-Kartz experiment, Voltage clamp, Na+, K+ conductance, Membrane impedance and capacitance, Transmembrane potential, Zeta, stern and total electrochemical potential, Chemical synapse, post synaptic potential, Historical perspective of lipid model systems lipid monolayer. Liposomes: small and large unilamellar and multilamellar vesicles, planner lipid bilayer, Application of liposomes in biology and medicine.	**1Credit**
Module-3	**Molecular Biophysics**	**Lect = 15**
	Types of Protein structure (Primary,secondary and Tertiary), polypeptide chains, potential energy, hydrogen bonding, hydrophobic interactions, disulfide bonds & ways of pairing, Protein stability, chemical & surface denaturation, primary structure sequencing of polypeptide, α and β-helix, Ramchandran plot, protein folding & misfolding, Types of DNA, properties of	**1Credit**

	DNA & RNA, Nucleotide structure, Base pairing, Genetic code symmetry, Structure& function of water and carbohydrates	
Module-4	**Neuro-biophysics**	**Lect = 15**
	Neuron –structure and function, excitable membrane, Ion channels, Resting membrane potential, Depolarization, Hyper-polarization, Nernst equation, Goldman equation, Passive electrical prop. of neuron, Nerve conduction, Cell equivalent circuits, Synaptic Integration & transmission, Voltage clamp technique, coding of sensory information, MRI Technique, PET (Positron Emission Tomography) Technique,CT (Computed Tomography).	**1Credit**

G) REFERENCES:

1. Biophysics by G. R. Chatwal, Himalaya Publishing House, Mumbai, (**2011**)
2. Principles of neural science by E. R. Kandel& J. H. Schwatz, Elsevier, North Holland, (**1982)**
3. Neuron to Brain by S. W. Kuffler and J. G. Nichols, SinacuerAsso. Inc., (**1995)**
4. Biophysics by Mohan P. Arora, Himalaya Publishing House, (**2012)**
5. Biophysics An Introduction by Rodney Cotterill, Wiley, (**2014)**
6. Essentials of Biophysics by P. Narayanan, New Age International Publication, (**2005)**

M.Sc. (Physics) (Sem-III)

PHY 604 MJ (Special-I) : Fundamental Astronomy and Astrophysics

Lectures: 60 **(Credits : 4)**

A) Course Objectives: This course aims to introduce Astronomy and Astrophysics

5) To study the basic concepts regarding Astronomy and astrophysics

6) To impart knowledge about Astronomy and astrophysics

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Understand Astronomy.
- Identify cosmos.
- Stellar objects and their significance
- Solar system
- Apply the knowledge of space.

C) Instructional design:

1) Lecture method 2) Tutorial method 3) Use of Multimedia 4) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations 2) Assignments 3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Introduction to Astronomy and Astrophysics**	**Lect=15**
	Sky coordinates and motions: Earth Rotation - Sky coordinates - seasons - phases of the Moon- the Moon's orbit and eclipses - timekeeping (sidereal vs synodic period); Planetary motions - Kepler's Laws - Gravity; Light & Energy - Telescopes - Optics - Detectors; Planets: Formation of Solar System - planet types - planet atmospheres - extrasolar planets; Stars: Measuring stellar characteristics (temperature, distance, luminosity, mass, size) - HR diagram - stellar structure (equilibrium, nuclear reactions, energy transport) - stellar evolution; Galaxies: Our Milky Way -Galactic structure - Galactic rotation - Galaxy types - Galaxy formation; Cosmology: Expansion of the Universe - redshifts - supernovae - the Big Bang - history of the Universe - fate of the Universe.	
Module-2	**Planetary Sciences**	**Lect=15**
	Overview of Solar system - Dynamics: Two-body problem, Three-Body Problem (Lagrangian points) - Resonances - Tidal forces - Solar energy balance and transport: Radiative Equilibrium- Planetary Atmospheres: Structure, Composition, Atmospheric Escape - Planetary surfaces: Surface morphology - Impact cratering - Minor Bodies: Meteories, Asteroids, Comets, Minor planets, Trans-Neptunian Objects, Centaurs - Planetary rings - Planet formation: Evolution of protoplanetary disks, Growth of solid bodies, Formation of Terrestrial and Giant planets - Planetary Migration: - Extrasolar Planets: Detection techniques - Estimating planetary masses, sizes, orbital parameters -- Habitable zones:	

	factors influencing habitable zone – continuously habitable zone - Missions to study Planets and Extrasolar planets: Overview and Results	
Module-3	**Structure and Evolution of Stars**	**Lect=15**
	Mechanical, Thermal and Nuclear time scales – Hydrostatic equilibrium (Newtonian and Relativistic) – Polytropic Equation of State – Lane Emden Equation – Degenerte matter Equation of State – White Dwafs and Chandrasekhar limit – Virial Theorem – Radiative Equilibrium – Schwarzschild convection criterion – nuclear energy generation – stages of nuclear burning – full set of stellar structure equations – example solutions – HR diagram and the main sequence – Schonberg-Chandrasekhar limit – post- main sequence evolution – Hayashi tracks – Horizontal branch – giant and asymptotic giant branches – planetary nebula formation – supernovae – compact objects.	
Module-4	**Cosmology**	**Lect=15**
	Cosmology- Expansion and acceleration of the Universe-Cosmic Microwave Background- Large-scale structure- Dark matter in galaxies and clusters of galaxies- Geometry of the spacetime- Dynamical equations- Cosmological puzzles and inflation- Brief history of time- Standard model of cosmology- Beyond the standard model : curvature, dark energy & massive neutrinos	

G) REFERENCES:

1) BW Carroll & DA Ostlie, An Introduction to Modern Astrophysics, Latest Edition, Addison-Wesley.
2) Frank Shu, The Physical Universe, Latest Edition, University Science Books
3) Martin Harwit, Astrophysical Concepts, Latest Edition, Springer.
4) Fundamental Planetary Science: Jack Lissauer & Imke de Pater (Latest Edition) - Cambridge University Press
5) The Solar System: Therese Encrenaz and Jean-Pierre Bibring (Latest Edition) - Astronomy and Astrophysics Library, Springer
6) Cosmological Physics, Cambridge University Press, J . A. Peacock

M.Sc. (Physics) (Sem-III)

PHY 605 MJ (Special-I) : Fundamental Energy Physics

Lectures: 60 **(Credits : 4)**

A) Course Objectives: This course aims to introduce the fundamentals of renewable energy sources and awareness about the use of renewable energy to the students.

1) To study the basic concepts regarding fundamentals of renewable energy
2) To impart knowledge about importance of renewable energy

B) Learning Course Outcomes (CO): Upon completion of the course, the student will be able to,

1) Understand renewable and non-renewable sources of energy.
2) Basics of heat transfer and energy storage systems.
3) Apply the concept and use of knowledge of the renewable energy sources course to real-life problems.
4) Understanding the Physics of renewable energy sources will create a scientific temperament.
5) Students will have hand on experience in theory based on solar conversion systems and their applications, solar photovoltaic, solar thermal energy, geothermal energy, and emerging trends in renewable energy sources.

C) Instructional design:

1) Lecture method **2)** Tutorial method 3) Use of Multimedia 4) Creation of online resources

D) Evaluation Strategies:

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents:

Module-1	**Indian Energy Scenario and Energy Sources**	**L:15**
	Introduction: Role of energy in economic development and social transformation, Energy and gross domestic product (GDP), Gross National Product (GNP) and its dynamics. **Various types of energy sources:** Energy sources and overall energy demand, Availability of energy sources, Energy consumption in various sectors and its changing pattern, projected energy demands. Energy sources: Coal, Oil, Natural gas, Nuclear power, Hydro-electricity, Solar and other renewable sources, Depletion of energy sources and impact of exponential rise in energy consumption on economics of India and on international relations. **Energy Security:** Energy for security and security of energy, Energy consumption and its impact on environmental climatic change. **Future Energy Option:** Sustainable development, Energy crisis, Transition from carbon free technologies, Parameters of transition.	**Credit-1**
Module-2	**Solar Radiation and Its Measurement**	**L:15**
	Importance of Solar Energy: Nature of solar radiation, Sun as a fusion rector, spectral distribution of terrestrial and extra-terrestrial radiation, Estimation of extra-terrestrial solar radiation, Radiation on horizontal and titled surfaces.	**Credit-1**

	Nature of Solar Radiations - beam, diffuse, global radiation and their measurement by Pyranometer, Pyrheliometer, Sun shine recorder	
Module-3	**Basics of Heat Transfer**	**L: 15**
	Heat and Thermodynamics: Basic units, dimensions, Concept of heat, energy and work, Ideal gas flow, 1st and 2nd law of thermodynamics, Types of heat transfer. **Conductive heat transfer:** Fourier's law. Stefans-Boltzman relation and IR heat transfer between gray surfaces. Radiative heat transfer: sky radiation, radiation heat transfer coefficient **Convective heat transfer:** Natural and forced convection, natural convection between parallel plates, Non-dimensional numbers, conductive heat transfer coefficient, Heat transfer due to wind.	**Credit-1**
Module-4	**Energy Storage**	**L: 15**
	Types of energy storage systems: sensible and latent heat storage systems, Electric energy storage systems, Chemical energy storage systems, Heat exchanges, Hydro storage, solar pond as energy storage. **Solar Passive Systems and Green House:** Solar active and passive systems, Types of solar passive systems, designs aspects of solar passive systems, f-chart method. **Green House:** solar green House, design and control mechanism.	**Credit-1**

Reference Books:

1) Non-Conventional Energy Sources: G. D. Rai, Khanna Publishers (2011)
2) Renewable Energy Sources and Emerging Technologies: D. P. Kothari, K. C. Singal, and Rakesh Ranjan, Prentice Hall of India Pvt. Ltd. (2008)
3) Non-Conventional Energy Resources: B. H. Khan,Tata McGraw Hill Publication (2006)
4) World Energy Resources: Charles E. Brown, Springer Publication (2002)
5) Principles of Solar Energy Conversion: A. W. Culp, McGraw Hill Publication (2001)
6) Solar Energy-Fundamentals and Applications: H. P.Garg and J.Prakash, McGraw Hill (2000)
7) Renewable Energy Sources and Conversion Technology: N. K. Bansal, M. Kleeman, and S. N. Srinivas, Tata Energy Research Institute (TERI), New Delhi (1996)
8) Solar Cells: Operating Principles, Technology, and System Applications: Martin A. Green, Longman Higher Education (1982)
9) Principles of Solar Engineering: F. Kreith and J. F. Kreider, Mc Graw Hill (1978)
10) Solar Energy-Principles of Thermal Collection and Storage: S. P. Sukhatme, McGraw Hill (1976)

M.Sc. (Physics) (Sem-III)
PHY 606 MJ : Physics of Nanomaterials

Lectures: 30 **(Credits : 2)**

A) Course Objectives: This course aims to;

1) To equip the students for pursuing higher studies and employment in Physics and related areas.
2) Imagines developing thorough and in-depth knowledge in Physics of nanomaterials.
3) Understand the influence of dimensionality of the object at nanoscale on their properties
4) Size and shape controlled synthesis of nanomaterials and their future applications in industry
5) The program also acts as a bond between theoretical knowledge and its implementation in experimental scenario.
6) The program also introduces the students to the scientific research approach in defining problems, execution through analytical methods, systematic presentation of results keeping in mark with the research ethics through M. Sc dissertation

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to;

1) Define and explain fundamental ideas of size effect in materials science and explain the effects of quantum confinement on the electronic structure and corresponding physical and chemical properties of materials at nanoscale.
2) Choose appropriate synthesis technique to synthesize quantum nanostructures of desired size, shape and surface properties
3) Correlate properties of nanostructures with their size, shape and surface characteristics
4) Elaborate which properties can be used to application in solving problem of present and future community.
5) Study various applications of nanomaterials
6) Focus on the design and development of efficient innovative nanostructured materials prepared by various methodologies and physicochemical characterization for technological applications
7) Propose new applications of nanoscience and nanotechnology.
8) To define a research problem, translate ideas into working models, interpret the data collected draw the conclusions and report scientific data in the form of dissertation.
9) To disseminate scientific knowledge and scientific temper in the society to contribute towards greater human cause

C) Instructional design:

1) Lecture method **2)** Tutorial method **3**) Use of Multimedia 4) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Introductory Concepts for Nanomaterials and its Synthesis**	**Lect = 15**
	Introduction to Nanomaterials & Structures,Effect of Reduction of Dimension, Quantum size effect, Surface Effect and Interface Effect; Nucleation and Growth Phenomenon. Synthesis Methods: Top-down and bottom-up approach, Physical Vapour Deposition, Sputtering, Chemical vapor deposition, chemical bath deposition with capping techniques, mechanical	**Credit-1**

	milling, Sol-gel method, hydrothermal method and biological methods.	
Module-2	**Properties and applications of Nanomaterials**	**Lect = 15**
	Size and shape dependency of electronic, optical, photonic, mechanical, magnetic, catalytic properties. Applications of nanomaterials: Biomedical, Optoelectronic, Mechanical, Energy generation and storage, Nanocoatings and Nanocomposites Graphene, Carbon nanotubes and their Applications	**Credit-1**

G) REFERENCES:

1. Nanotechonolgy: Principal and Practices; by Sulbha Kulkarni; Capital Publication
2. Nanostructures and Nanoamaterials: Synthesis, Properties and Application; by Guozhong Cao; Imperical College Press, Londen
3. Nanoamaterials: Synthesis, Properties and Application; by A. S. Edstein and R.C. Commorta; Institute of Physics publishing Bristol and Philadephia
4. Introduction to Nanotechonology: by C. P. Poole, Jr. Frank J. Owens: Willey student Edition
5. Semiconductor Material and Device Characterization by D. K. Schroder
6. C. N. R. Rao, A. Muller, A. K. Cheetham (Eds), The chemistry of nanomaterials: Synthesis, properties and applications, Wiley VCH Verlag Gmbh & Co, Weinheim, 2004.

M.Sc. (Physics) (Sem-III)

PHY 607 MJP : Special Major Core Laboratory-I (SMCL-I)

Lectures: 60 **(Credits : 4)**

List of Major Core Experiments (any 12):

1) **Speed of Light :**
   To determine the speed of light using transit time of light pulse as a function of a reflecting mirror.
2) **Photoconductivity:**
   a. To plot the current voltage characteristics of a CdS photoresistor at constant irradiance.
   b. To measure the photocurrent as a function of irradiance at constant voltage.
3) **Faraday Effect:**
   Rotation of the Polarization Plane Φ As a Function of the Magnetic Field and Rotation of the Polarization Plane 2Φ as a Function of the Magnetic Field
4) **Dielectric constant:**
   a. To Measure the charge Q on a plate capacitor as a function of the applied voltage E.
   b. To determine the capacitance C as a function of areas A of plates.
   c. To determine the capacitance C with different dielectrics between the plates.
   d. To determine the capacitance C as a function of the distance d between the plates
5) **Specific Heat of Solids:**
   To determine the specific heat of copper, lead and glass at three different temperatures.
6) **Electron Spin Resonance:**
   To study the Electron Spin Resonance and to determine Lande's g-factor
7) **Frank-Hertz experiment:**
   To study the discrete energy levels using Frank-Hertz experiment
8) **Four Probe method:**
   To study Temperature variation and Band gap of Ge-semiconductor
9) To study Ionic Conductivity of NaCl
10) To study Fabry-Parot Etalon
11) To study Zeeman Effect
12) To study Stefan's constant - Black Body Radiation
13) To study absorption spectra of Iodine molecule and to determine its dissociation Energy using spectrometer
14) **Hall effect:**
    To determine charge concentration, conductivity of Ge-semiconductor
15) **G.M. counter:**
    To study characteristics of GM tube and determination of end point energy of β-ray source
16) **G.M. counter:**
    To Determination of dead time of GM tube by Double source method
17) **Millikan Oil Drop Apparatus:**
    To measure the rise and fall times of the oil droplets at different voltages having different charges.
    a. To determine the radii of droplets.

b. To determine the charge ‘e’ on the droplets

18) **Michelson’s Interferometer:**
To determine the wavelength of He-Ne LASER by using Michelson’s Interferometer apparatus.

19) **Skin depth :**
To study Skin depth in Al using electromagnetic radiation

20) **Gouy’s Method:**
To measurement of magnetic susceptibility of $MnSO_4$

21) **Thermionic emission:**
To determine work function of Tungsten filament

Additional Activities (*Any One*) :

a. **Model Demonstrations :** Any 1-demonstrations equivalent to 2-experiments.
b. **Study tour:** Participate study tour (***Industry/Oganization/Research Institute/Research organization/ Small scale industry/University Department***) with study tour report equivalent to 2-experiments.
c. **Computer Aided Demonstrations :** Any 2-demonstrations equivalent to 2-experiments.

Note: *Students have to perform **12**-experiments or **1**-additional activities in addition to **10**-experiments mentioned above. Total laboratory work with additional activities should be equivalent to **12**-experiments.*

Reference Books:

1. Pillai S.P., Solid State Physics, 3rd Edition, New age International Publisher.
2. Aruldas G., Molecular structure and Spectroscopy, Prentice-hall of India Pvt. Ltd., New Delhi.
3. Behekar D.R., Seman S.T., Gokhale V.M., and Kale P.G., Practical Physics, KitabMahal Publication Solid
4. State Laboratory Manual in Physics, Department of Physics, University of Pune, Pune-7 (1977)
5. Wersnop and Flint, Experimental Physics.
6. Singru R.M., Introduction to experimental Nuclear Physics, Wiley Eastern privateLtd., New Delhi.

M.Sc. (Physics) (Sem-III)

PHY 608 RP : Research Project-I

Lectures: 60 **(Credits : 4)**

Guidelines: It is expected that,

1. The student does project work equivalent to about ten (12) laboratory experiments throughout the semester in the third semester.
2. One bears in mind that the project work is a practical course and it is intended to develop a set of skills pertaining to the laboratory work apart from the cognition of students. Therefore, the guides should not permit projects that involve no contribution on part of student.
3. The project must have a clear and strong link with the principles of basic physics and/or their applications.
4. The theme chosen should be such that it promotes better understanding of physics concepts and brings out the creativity in the students.
5. The evaluation of the project work must give due credit to the amount of the project work actually done by a student, skills shown by the student, understanding of the physics concepts involved and the final presentation at the time of viva voce.
6. It is also recommended that a **Teacher** will look after **Six (6)** projects at one time.
7. The student can perform an Experimental/Theoretical/Computational Project in Physics or interdisciplinary areas under the supervision of guide.
8. The student can learn the basics of the topic chosen for project, to learn how to do literature survey and set up the basic experimental/theoretical and computational techniques needed for the project.
9. The department encourage to students for projects both in experimental and theoretical areas of Physics in collaboration with other institutes and industry.

The Project work shall consist of the following Criterions.

1. Project work is **mandatory** for all the M.Sc. students.
2. All the M.Sc. students will be have to complete the Project work prescribed by the Board of Studies in Physics of Savitribai Phule Pune University during the IIIrd Semester.
3. The Project work shall consist of the following Criterions.
    - It is expected that students must finalize the Title of Project, Aim and objective, Significance, Literature survey, Materials required, Method and Application etc.
    - Introduction to foundations of Project Work.
    - Introduction of Project Research Methodology.
    - Study of Data Collection Methods.
    - Project Problem Writing and Presentation Skills.

Note: *At the time of project practical examination, the candidate must submit the certified project report by the project in-charge and HOD. A candidate will be allowed to appear for the Project practical examination only if the candidate submits a project completion report duly certified by the project in-charge and Head of the department.*

Evaluation weightage:

- Project-I: Semester End University Examination : 70 Marks
- Internal Examination: 30 Marks

Major Elective

(Semester-III)

M.Sc. (Physics) (Sem-III)

PHY 610 MJ (Elective): Physics of Diagnostic Instruments

Lectures: 30 **(Credits : 2)**

A) Course Objectives: This course aims to introduce Physics of diagnostic Instruments;

1) Explain the Physical principles behind the diagnostic Instruments.
2) It is concerned with the use of various imaging modalities to aid in the diagnosis of disease.
3) To provide knowledge on biological effects of ionizing radiation for all treatment equipments.
4) To create awareness of health hazards due to ionizing radiation and to impart knowledge on the radiation safety and Protection aspects in using radiation in health care.
5) To develop radiation oncology decision-making skills and in training radiation physicists in radiation therapy, radio-diagnosis and in nuclear medicine.
6) To give hands-on training to students on fundamental radiation detecting equipments.
7) To train the students to correlate the physical principles and the collected data.
8) The physics and theory behind the bio electric signal recording, Physiological assist devices, and Operation theater equipments and biotelemetry and their safety measures.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1) Get the hand on experience in calibration of various radiotherapy equipments and familiarize about health treatment.
2) Demonstrate understanding of radiological physics applied to medicine.
3) Apply confidently the concepts of radiation dosimetry in radiation therapy.
4) Select appropriate monitoring radiation instruments for survey and protection purpose.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3**) Use of Multimedia 4) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents : 2 credit

Module-1	**Biomedical Instrumentation**	**Lect=10**
	1.1 Biopotential Electrodes and Transducers 1.2 Blood Flow Measuring Techniques 1.3 Bioelectric Signals and their recording; a) Electrodcardiography (ECG) b) Electrodratinography (ERG) c) Electroencephalograph (EEG) d) Electromyograph (EMG) e) Electroneurograph (ENG)	
Module-2	**Radiotherapy Physics**	**Lect= 10**
	Concept and Principle of; a) Image Guided Radiotherapy (IGRT) b) Tomotherapy (TT) c) Stereotactic Body Radiotherapy (SBRT) d) Skin Electron Therapy (SET) e) High LET radiation therapy	

Module-3	Physics of Radiology Imaging	Lect=10
	Basic Principle and image analysis of; a) X-Ray, b) Computed Tomography (CT) Scanning c) Thermography, d) Magnetic Resonance Imaging (MRI), e) Ultrasound (USG).	

G) REFERENCES:

1) R. S. Khandpur. 1990, Handbook of Biomedical Instrumentation, Tata McGraw Hill, NewDelhi.
2) Geddes LA and Baker L.E. 1989, Principals of Applied Biomedical Instrumentation, 3rd Edition, John Wiley and sons, New york.
3) Farr. R. F and PJ Allisy-Roberts, 2006. Physics for Medical Imaging, 2nd Edition Saunders
4) David J. Dowsett; Patrick A. Kenny; Eugene Johnston R, 2006. The Physics of Diagnostic imaging, 2nd Edition, CRC Press.
5) FaizKhan. M, 2014. The Physics of Radiation Therapy, 5th Edition, Wolterskluwer
6) H. E. Johns, J. R. Cunningham, The Physics of Radiology, Charles C. Thomas, New York, 2002
7) Frank Herbert Attix, Introduction to Radiological Physics and Radiation Dosimetry, Wiley-VCH Verlag, 2007.

M.Sc. (Physics) (Sem-III)
PHY 610 MJP (Elective): Physics of Diagnostic Instruments
Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum 06) **(Credit-02)**

1. Quality assurance of a diagnostic X-ray machine.
2. Evaluation of characteristics of a radiographic image.
3. Dose output measurement of electron beams used in radiotherapy treatment
4. Protection survey of industrial radiography camera.
5. Design and study of ECG pattern of patient.
6. Design and study of ERG pattern of patient.
7. Design and study of EMG pattern of patient.
8. Design and study of MRI pattern of patient.
9. Design and study of CT pattern of patient.
10. Design and study of TT radiation therapy of patient.
11. Design and study of SET radiation therapy of patient.
12. Design and study of IGRT radiation therapy of patient.
13. Design and study of LET radiation therapy of patient.
14. Design and study of USG pattern of patient.

G) REFERENCES:

1) R. S. Khandpur. 1990, Handbook of Biomedical Instrumentation, Tata McGraw Hill, NewDelhi.

2) Geddes LA and Baker L.E. 1989, Principals of Applied Biomedical Instrumentation, 3rd Edition, John Wiley and sons, New york.

3) Farr. R. F and PJ Allisy-Roberts, 2006. Physics for Medical Imaging, 2nd Edition Saunders

4) David J. Dowsett; Patrick A. Kenny; Eugene Johnston R, 2006. The Physics of Diagnostic imaging, 2nd Edition, CRC Press.

5) FaizKhan. M, 2014. The Physics of Radiation Therapy, 5th Edition, Wolterskluwer

6) H. E. Johns, J. R. Cunningham, The Physics of Radiology, Charles C. Thomas, New York, 2002

7) Frank Herbert Attix, Introduction to Radiological Physics and Radiation Dosimetry, Wiley-VCH Verlag, 2007.

8) Donald T. Graham, Paul J. Cloke, Principles of Radiological Physics, Churchill Livingstone, 2003.

9) R. Hill, J. C. Bamber, G. R. terHaar, 2005. Physical Principles of Medical Ultrasonics, John Wiley & Sons.

10) H. Evans and J. P. Wood Cock, 1998. Doppler ultrasound Physics Instrumentation and Clinical applications, John Wiley, Chichester.

M.Sc. (Physics) (Sem-III)
PHY 611 MJ (Elective): Radiation Physics

Lectures: 30 **(Credits : 2)**

A) Course Objective: This course aims to introduce Radiation Physics and the candidate will be able to:

1. Apply physics knowledge to safely use ionizing radiation;
2. Detection and measurement of ionizing radiation; and
3. Study the concept of radiation hazards, protection, and the usefulness of radiation in various sectors.

B) Learning Course Outcomes:

1. Students acquire skills in operating different types of radiation detectors to detect and measure radiation levels in different places.
2. Students can use the knowledge in the applications of Radiation Physics in the fields like medical diagnostic tools, Food Processing, and Research sectors.
3. Students can work as advisers in the maintenance of radiation safety standards and following strict protocols at various places like Hospitals, Laboratories Industries, etc.

C) Instructional design:

1) Lecture method 2) Tutorial method 3) Study Tour/ Field Visit. 4) Projects

D) Evaluation Strategies

1) Descriptive Written Examinations 2) Assignments 3) Seminars, Orals, and Viva-Voce.

E) Course Contents:

Module-1	**Fundamentals of Radiation & Radiation Detectors**	**Lect = 15**
	Radiation Sources: Types of Radiation Sources, Ionizing Radiation Sources (γ, electron, neutron, and Charged Particles). *Radiation Exposure and Dose Equivalent*: Units & Definition for radiation exposure- Roentgen, Becquerel, Gray, Sievert, RAD, REM, KERMA, LET, Fluence, Radiation exposure, Absorbed Dose, Quality factor (Q). *Interaction of Radiation with Matter:* -Interaction of Gamma, Interaction of Neutrons, Interaction of Electrons. -Interaction of Heavy Charged Particles: Basic nature of Interaction E.g. Stopping Power, Bethe-Bloch Formula, Bragg Curve, Energy Straggling, Range, Penetration depth, etc. **Radiation Detectors**- Mode of Detector operation, Pulse Height Spectra, Counting Curves and Plateaus, Energy Resolution, Detector Efficiency, Dead Time. *Gas-Filled Radiation Detectors:* Ionization Chambers, and Geiger-Mueller Counters-basic detection mechanism. *Scintillation Detectors & Dosimeter:* Properties of ideal scintillator, Basic electronic blocks in scintillation detector setup, Advantages, Organic and inorganic scintillators. Thermoluminescence Dosimeter (TLD). Problems.	**Credit-1**

Module-2	Radiation Hazards, Safety, Protection, and Application	Lect = 15
	Radiation Protection Standards: International Commission on Radiological Protection (ICRP) and its recommendations, Dose Equivalent, Effective Dose Equivalent (H_E), Ambient and directional equivalent dose, Relative biological effective dose, Radiation and Tissue Weighting factors, etc. Radiation Associated Risk. *Principles of Protection and Regulation:* System of Radiological Protection, Methods of Radiation Control (Time, Distance, Shielding). Inverse square law, shielding requirements for electron, gamma/ x-rays, and neutron sources, Shielding materials for photon and neutron sources. *Regulations in India:* Atomic Energy Act and Rule (Overview only), AERB and its Regulatory Requirements, Safety codes, and Guides for handling radioactive sources. Use of Personal Monitoring Systems-TLD. Problems. ***Applications-*** *Radiation in Medical:* Radiology: X-ray Radiography: Principle, Working, and Uses. Computed Tomography (CT Scan): Principle and Working and Uses. Radiotherapy: Introduction and principle, Basic operation of Tele-Cobalt Therapy Machine and Medical Linear Accelerator & its Uses. Radioisotopes. *Radiation in Agricultural:* Food Preservation, Insect Disinfestation. *Radiation in Industry:* Nuclear Power Plants, Radiation Processing/Treatment, Luggage Scanners. *Radiation in Research:* Computational Simulation-Monte Carlo Codes, Use of Radioactive Materials in Research, Modification of Material Properties.	**Credit-1**

G) REFERENCES:

1) G. F. Knoll, Radiation Detection and Measurements (Wiley, New York, 1989)
2) Herman Cember, Introduction to Health Physics.
3) F. M. Khan, The Physics of Radiation Therapy, (6^{th} ed., Wolters Kluwer (India) Pvt. Ltd., New Delhi).
4) C. Leroy, P-G Rancoita, Principles of Radiation Interaction in Matter and Detection (World Scientific 2009).
5) K. Thayalan, Basic Radiological Physics (The Health Science Publisher).
6) Atomic Energy Act 1962.
7) AERB Radiation Protection Rules 2004.
8) Frank H. Attix., Introduction to Radiological Physics and Radiation dosimetry (Wiley, 1986)
9) Marilyn E. Noz., Radiation Protection and Health Science. (World Scientific, 2007).
10) Podgorsak Ervin B., Radiation Physics for Medical Physicists. (Springer, 2005).
11) Pandit B. Vidyasagar, Sagar S. Jagtap, Omprakash Yemul, Radiation in Medicine and Biology (1st Edition, Jenny Stanford Publishing).

M.Sc. (Physics) (Sem-III)

PHY 611 MJP (Elective): Radiation Physics

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum 06) **(Credit-02)**

1. Determination of Plateau and resolving time of a G.M. counter and its application in estimating the activity of a given source.
2. GM Counter- To determine the dead time using a single source.
3. GM counter – Statistics of counting.
4. Measurement of linear and mass attenuation coefficients for a gamma ray beam using GM counter.
5. Study of Inverse Square Law.
6. Study of thermo-luminescence spectrum.
7. Determination of K-40 half-life.
8. Measurement of linear and mass attenuation coefficients of an X-ray beam.
9. Study the different types of radioisotopes and their applications in the medical field.
10. Study use of isotopes in radiocarbon dating. Study of commercially available portable, handy radiation detectors.
11. Survey of various places to measure radiation levels
12. Field Visits to hospitals and other such locations for measuring radiation exposure.
13. Study of various shielding materials and their stopping power.
14. Study of protocols followed by various units to follow safety measures.
15. Visit diagnostic centers which employ radiation sources.
16. Visit to food industry using preservation techniques using nuclear radiation.
17. Visit to pharmaceutical industries producing radioactive compounds.

G) REFERENCES:

1. G. F. Knoll, Radiation Detection and Measurements (Wiley, New York, 1989)
2. Herman Cember, Introduction to Health Physics.
3. F. M. Khan, The Physics of Radiation Therapy, (6^{th} ed., Wolters Kluwer (India) Pvt. Ltd., New Delhi).
4. Leroy, P-G Rancoita, Principles of Radiation Interaction in Matter and Detection (World Scientific 2009).
5. K. Thayalan, Basic Radiological Physics (The Health Science Publisher).
6. Atomic Energy Act 1962.
7. AERB Radiation Protection Rules 2004.
8. Frank H. Attix., Introduction to Radiological Physics and Radiation dosimetry (Wiley, 1986)
9. Marilyn E. Noz., Radiation Protection and Health Science. (World Scientific, 2007).
10. Grupen C., Introduction to Radiation Protection. (Springer, 2008).
11. Podgorsak Ervin B., Radiation Physics for Medical Physicists. (Springer, 2005).
12. Pandit B. Vidyasagar, Sagar S. Jagtap, Omprakash Yemul, Radiation in Medicine and Biology (1st Edition, Jenny Stanford Publishing).
13. https://www.iaea.org/topics/food-irradiation

M.Sc. (Physics) (Sem-III)
PHY 612 MJ (Elective): Physics of Data Science

Lectures: 30 **(Credits : 2)**

A) Course Objectives:

This course aims to introduce data science.

- It teaches students how to work with structured or unstructured data using a number of tools, algorithms and software.
- To impart knowledge about Programming, Machine Learning, Artificial Intelligence, and Data Mining as the core data science subjects.
- Students focus on research-oriented topics, training, and research projects in the MSc course.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Apply the research-based knowledge to analyze and solve advanced problems in data science.
- Apply the knowledge of almost in all fields including healthcare and finance.
- Utilize the data science theories for societal and environmental concerns.
- Ability to understand the abstract concepts that lead to various data science theories in physics.
- Identify the need and scope of Interdisciplinary research.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars 4) Use of Multimedia
5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Introduction to Data Science**	**Lectures = 05**
	1.1 Definition 1.2 Defining goals 1.3 Retrieving data 1.4 Data preparation 1.5 Data exploration 1.6 Data modelling	
Module-2	**Machine Learning**	**Lectures = 05**
	2.1 Modeling Process 2.2 Training model 2.3 Validating model 2.4 Supervised learning algorithms 2.5 Unsupervised learning algorithms.	
Module-3	**Deep Learning**	**Lectures = 05**
	3.1 Deep Feedforward Networks 3.2 Regularization 3.3 Optimization of Deep Learning 3.4 Convolutional Networks 3.5 Recurrent and Recursive Nets	

Module-4	**Data Visualization**	**Lectures = 05**
	4.1 Introduction to data visualization 4.2 Data visualization options 4.3 Filters 4.4 MapReduce 4.5 Dashboard development tools	
Module-5	Python Programming	**Lectures = 10**
	5.1 Data structures like lists, dictionaries, tuples and sets. 5.2 Python coding with Conditionals, and Loops, 5.3 Python coding with Functions 5.4 Python coding with Modules 5.5 Python coding with Error Handling 5.6 Data Analysis and Data Visualization using Python packages	

G) REFERENCES:

1. Joel Grus, O'Reilly, Data Science from Scratch: First Principles with Python, 1st edition, 2015
2. Cathy O'Neil, Rachel Schutt, O'Reilly, Doing Data Science, Straight Talk from the Frontline, 1st edition, 2013
3. Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman,Mining of Massive Datasets, Cambridge University Press, 2nd edition, 2014
4. Davy Cielen, Arno D. B. Meysman, Mohamed Ali,Introducing Data Science, Manning Publications Co., 1st edition, 2016
5. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 1st edition, 2016

M.Sc. (Physics) (Sem-III)

PHY 612 MJP (Elective): Physics of Data Science

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum 6) 2 Credit

1. Demonstrate usage of branching and looping statements
2. Demonstrate Recursive functions
3. Demonstrate Lists
4. Demonstrate handling of missing data
5. Demonstrate hierarchical indexing
6. Demonstrate Scatter Plot
7. Demonstrate 3D plotting
8. Demonstrate usage of Pivot table
9. Demonstrate use of and query()
10. Demonstrate package and interface
11. Demonstrate the concept of function overloading and Constructor overloading

G) REFERENCES:

1) Joel Grus, O'Reilly, Data Science from Scratch: First Principles with Python, 1st edition, 2015

2) Cathy O'Neil, Rachel Schutt, O'Reilly, Doing Data Science, Straight Talk from the Frontline, 1st edition, 2013

3) Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 2nd edition, 2014

4) Davy Cielen, Arno D. B. Meysman, Mohamed Ali, Introducing Data Science, Manning Publications Co., 1st edition, 2016

5) Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 1st edition, 2016

M.Sc. (Physics) (Sem-III)

PHY 613 MJ (Elective): Basic Industrial Instrumentation

Lectures: 30 **(Credits : 2)**

A) Course Objectives:

1) The objective of the course is to introduce the fundamentals of Electronics Instruments and Measurement providing an in-depth understanding of Measurement errors, Signal conditioning elements and electronic sensors.
2) The objective of the course is to introduce the knowledge about data acquisition systems and transducers.
3) To address the underlying concepts and methods behind Electronics measurements.

B) Learning Course Outcomes (CO) :

1) On successful completion of the course student can learn about detailed aspects of Electronic instruments and measurements including error as well as in the field of Digital Instruments which all the areas in day to day life.
2) Students can learn about working information of transducers and sensors.
3) Students will get knowledge about the different data acquisition systems.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Measuring Instruments and Transducers (Sensors)**	**Lect=15**
	1.1 General configuration and functional description of measuring instruments, examples of instruments and their functional description. Static performance characteristics of measuring instruments such as accuracy resolution sensitivity, hysteresis, errors, their types (Static performance characteristics should only be mentioned without discussion since it has been discussed elsewhere in other core subject) **1.2 Dynamic characteristics:** Generalized mathematical model of measurement System, order of instruments: zero, first, second and higher order. Step, ramp and sinusoidal frequency response of first order instruments (thermistor & thermocouple only) **1.2a Displacement sensors** classification of displacement: linear, rotary and absolute time dependent, **Ref.1, 2 & 3.** (i) Resistive type: (Potentiometric linear and rotary (angular)), strain gauges- responding to dimensional changes and resistivity change namely electrical and semiconductor type. (ii) Capacitive type: linear and angular type, responding to change in distance.	**Credit-1**

	(iii) Inductive type: Responding to change in Mutual inductance (LVDT) (derivation of output of an LVDT not expected), Self inductance, Variable reluctance, Eddy current sensors. (iv) Hall effect sensors for displacement measurement. Ref.2 (v) Digital (optical) displacement sensors (rotary, linear and also absolute and incremental (introduction only)) Ref.2 (vi) Level measurements **1.2b Temperature Measurements:** Ref. 1,2,3,: Temperature scales, basis of temperature scales Transduction techniques: Liquid filled thermometer, Resistance type: Platinum resistance temperature sensor, and (PT 100) thermistors. Thermocouples – Seebeck effect, Peltier effect &Thompson effect, types of thermocouples: T, E, J, K, R, S, B types. With their ranges, thermocouple laws (construction of thermocouple probe not expected) Solid state temperature sensors AD-590, IC LM-35. (for both sensors introduction only from data sheets) optical pyrometers (total radiation and selective radiation type)	
Module-2	**Signal conditioning processing & Data acquisition**	**Lect=15**
	Signal conditioners: Signal conditioning of the inputs: Ratiometric conversion, Logarithmic compression. Instrumentation amplifier using three Op-Amps derivation of equation for output voltage, phase sensitive detection (for LVDT displacement sensors), Ref.2 basic bridge circuit for platinum resistance thermometer, Ref.2, Thermocouple amplifier with cold junction temperature compensation (Ref 2, Using solid state temperature sensor(AD-590 or LM-35 or thermistor or diode)) Data acquisition systems, Block diagram of generalized data acquisition system, single channel and multichannel data acquisition systems, microcontroller based data acquisition system. Ref.2 Data loggers, Ref. 2 & Ref. 4, general block diagram and increasing fuel efficiency of a petrol engine using microprocessor based data loggers, Sample and hold circuits. Ref. 5	**Credit-1**

G) REFERENCES:

1) Measurement Systems Applications and Design By E.O. Doebelin, 4th Edition, McGraw Hills Publishing Company
2) Instrumentation Devices and Systems, by C.S, Rangan, G.R. Sarma and V.S.V. Mani, 2nd Edition, TMH Publishing Company
3) Instrumentation, Measurement and Analysis By B.C. Nakra, K.K. Chaudhry, TMH Publishing Company
4) Electronic Instrumentation By H.S. Kalsi, 3rd Edition McGraw Hills Education
5) Design with Operational Amplifiers and Analog Integrated Circuits, 4th Edition By Sergio Franco McGraw Hills Publishing Company

M.Sc. (Physics) (Sem-III)

PHY 613 MJP (Elective): Basic Industrial Instrumentation

Lectures: 30 **(Credits : 2)**

List of Experiments (any 6)	2 Credit

1) To design, build and test absolute value circuits.
2) To design, build and test thermocouple amplifier having cold junction temperature compensation.
3) To design, build and test Instrumentation amplifier for load cell.
4) Study of IC 7107 as DPM and to design, build and test 3 &1/2 DPM for load cell.
5) To design, build and test displacement sensor using potentiometer, variable capacitor.
6) Study of accelerometer module.
7) To design build and test sample & hold amplifier.
8) To design, build and test bipolar DAC using binary weighted ladder and Op-amps. & IC
9) To design, build and test Log amplifier using Op-amps and diodes.
10) To Design, build and test phase sensitive detector.
11) Temperature characteristics of thermistors or strain gauge and applications
12) V/F converters as a basic concept of ADC
13) Characteristics and applications of photo electric devices.(photo diode led, photo transistor)
14) Study of data acquisition system.
15) Study of LVDT sensor.
16) To design, build and test Voltage to Frequency converters using OpAmps.
17) Study of Characteristics of Solar cell.

G) REFERENCES:

1) Measurement Systems Applications and Design By E.O. Doebelin, 4th Edition, McGraw Hills Publishing Company
2) Instrumentation Devices and Systems, by C.S, Rangan, G.R. Sarma and V.S.V. Mani, 2nd Edition, TMH Publishing Company
3) Instrumentation, Measurement and Analysis By B.C. Nakra, K.K. Chaudhry, TMH Publishing Company
4) Electronic Instrumentation By H.S. Kalsi, 3rd Edition McGraw Hills Education
5) Design with Operational Amplifiers and Analog Integrated Circuits, 4th Edition By Sergio Franco McGraw Hills Publishing Company

Major Core

(Semester-IV)

M.Sc. (Physics) (Sem-IV)
PHY 651 MJ : Advanced Function Materials

Lectures: 60 **(Credits : 4)**

A) Course Objectives: This course aims to introduce various advance functional materials

- To study the basic concepts regarding materials used in various applications
- To impart knowledge about materials used in research

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1. Understand the fundamental principles and concepts of advanced functional materials.
2. Explore the synthesis and fabrication techniques employed in the development of advanced functional materials.
3. Study the characterization methods and tools used to analyze various properties of advanced functional materials.
4. Examine the various applications of advanced functional materials in different fields.
5. Investigate the advancements and recent developments in the field of advanced functional materials, including emerging materials and cutting-edge research.
6. Develop critical thinking and problem-solving skills by exploring case studies and research articles related to advanced functional materials.
7. Foster an understanding of the ethical, environmental, and safety considerations associated with the production, use, and disposal of advanced functional materials.
8. Promote teamwork and collaboration through group projects and discussions focused on designing and optimizing functional materials for specific applications.
9. Enhance communication skills by presenting research findings, writing technical reports, and engaging in scientific discussions related to advanced functional materials.
10. Foster a mindset of innovation and creativity by encouraging students to explore and propose novel applications or advancements in the field of advanced functional materials.

C) Instructional design:

1) Lecture method **2)** Tutorial method 3) Use of Multimedia 4) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Polymer based Advanced Functional Materials**	**L = 15**
	1. Conducting Polymers (PANI) 2. Shape Memory Polymers (Polyethylene based) 3. Biodegradable polymers for Drug Delivery 4. Self-Healing Polymers 5. Polymer Nanocomposites (Polymer matrix composites with nanoparticles (e.g., carbon nanotubes, graphene) 6. Conductive Polymers for Organic Electronics 7. Stimuli-Responsive Polymers 8. Polymeric Membranes for Separation	
Module-2	**Environmental based advanced functional materials**	**L = 15**
	1. Photocatalytic Materials (TiO_2, ZnO)	

	2. Adsorbents for Pollutant Removal (Activated Carbon, Zeolites) 3. Sustainable Energy Materials (Pervoskite Solar Cells, Organic Photovoltaics) 4. Green Composites (Natural Fibre reinforced composite) 5. Waste Derived Nanomaterials (Carbon Based)	
Module-3	**Energy Storage based advanced functional Materials**	**L = 15**
	1. Lithium-ion Battery Materials ($LiFePO_4$) 2. Supercapacitor Materials [Transition metal oxides (e.g., RuO_2, MnO_2) Carbon nanotubes and graphene-based materials] 3. Fuel Cell Materials: [Anode and cathode materials (e.g., hydrogen storage alloys, perovskites)] 4. Sodium-ion Battery Materials [$NaFePO_4$] 5. Hydrogen Storage Materials [Metal hydrides (e.g., MgH_2, $TiFeH_2$)]	
Module-4	**Smart Functional Materials**	**L = 15**
	1. Magnetostrictive Materials [Galfenol (iron-gallium alloy)] 2. Magnetorheological fluids [tungsten oxide (WO_3) or molybdenum oxide (MoO_3)] 3. Hybrid pH-responsive nanoparticles [Mesoporous silica nanoparticles] 4. Photochromic nanoparticles [Spiropyran-doped silica nanoparticles] **5.** Smart window coatings [$Ge_{20}Te_{80}$]	

G) REFERENCES:

1. https://pubs.rsc.org/en/content/articlehtml/2021/ra/d0ra07800j
2. https://www.sciencedirect.com/science/article/pii/S1369702107700470
3. Biodegradable Polymers as Drug Delivery Systems
4. https://www.sciencedirect.com/science/article/abs/pii/S0014305719305920
5. https://www.nature.com/articles/s41578-020-0202-4
6. https://onlinelibrary.wiley.com/doi/full/10.1002/app.52816
7. https://link.springer.com/book/10.1007/978-3-319-32778-5
8. Polymer Nanocomposites: www.mdpi.com/journal/nanomaterials E
9. Principles of polymerization, G.Odian, Wiley – Interscience (1981)
10. High performance polymers, their origin and development, by Seymour R. B. and Kirshenbaum G. S. Elservier
11. https://link.springer.com/chapter/10.1007/978-3-642-58559-3_9
12. Polymeric Membranes for Water Purification and Gas Separation
13. https://pubs.acs.org/doi/10.1021/acsaem.8b01345
14. https://www.sciencedirect.com/book/9780128190005/current-developments-in-photocatalysis-and-photocatalytic-materials
15. https://link.springer.com/book/10.1007/978-3-030-16800-1
16. https://link.springer.com/article/10.1007/s10311-020-01075-w
17. https://doi.org/10.1016/S1369-7021(03)00331-6
18. https://iopscience.iop.org/article/10.1088/0964-1726/20/4/043001
19. https://iopscience.iop.org/article/10.1088/1361-648X/ac4ceb
20. https://pubs.acs.org/doi/10.1021/acsami.7b16787

M.Sc. (Physics) (Sem-IV)

PHY 652 MJ (Special-II) : Advanced Physics for Thin Films

Lectures: 60 **(Credits : 4)**

A) Course Objectives: This course equips students with a comprehensive understanding of thin film technology and its diverse applications, preparing them for careers in research, industry, and development of advanced materials and devices. This course aims to make the students to understand working devices of thin films in different sectros.

B) Learning Course Outcomes (CO) :

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

- Familiar with different materials used in thin film applications, such as semiconductors, metals, oxides, and polymers.
- Understand applications of thin films in electronic devices like transistors, integrated circuits, and sensors.
- Understand the role of thin films in optoelectronic devices like solar cells, light-emitting diodes (LEDs), and displays.
- Understand use of thin films in surface engineering applications, such as protective coatings, corrosion resistance, and wear resistance.
- Understand use of thin films in medical devices, biotechnology, and biomaterials, including bio-sensors, and tissue engineering.
- Understand the role of thin films in magnetic storage devices, magnetic sensors, and superconducting applications.

C) Instructional design:

1) Lecture method **2)** Tutorial method

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals and Viva.

E) Course Contents :

Module-1	**Thin films in Optoelectronic Industry**	**L = 15**
	Photon Detectors: Photoconductive Detectors, Photoemissive Detectors Photovoltaic Devices: General Analysis of Solar Cells, Thin Film Solar Cells, thin film solar cell generations, construction, working and update of CdTe, CIGS, CZTS, DSSC, pervoskite thin film Solar cells. Thin film Applications in Imaging; Electrophotography (Xerography and Electrofax); Thin Film Displays: Electroluminescent (EL) Displays, Electrochromic Displays; Optoelectronic Information Storage Devices.	**Credit-1**
Module-2	**Thin films in Microelectronic Industry**	**L = 15**
	Electrical Behavior of Metal Films, Dielectric Behavior of Insulator Films, Electrical thin film components: Resistors, Capacitors, Inductors, Thin Film Transistor (TFT), Diodes, Integrated Circuits, Microwave Integrated Circuits (MICs), Surface Acoustic Wave	**Credit-1**

	(SAW) Devices: Transducer, Delay Line, Band-Pass Filter, Pulse-Compression Filters, Amplifier; Charge-Coupled Devices (CCDs); Thin Film Strain Gauges.	
Module-3	**Magnetic, Thermal and Energy Storage Thin Film Devices**	**L = 15**
	Uniaxial Anisotropy in Magnetic Thin Films, Domains and Domain Walls, Switching in Thin Films, Thin Film Applications in Magnetic Devices: Computer Memories, Domain-Motion Devices, Magnetic Heads and Displays, microwave devices. Bolometers and Thermometers, Thermocouples and Thermopiles, Pyroelectric Detectors, Absorption-Edge Thermal Detectors, Thermal Imaging, Photothermal devices Thin Film Storage Devices: Batteries, Supercapacitors, Fuel Cells, Lithium-ion Capacitors, Thin film Piezoelectric Nanogenerators.	**Credit-1**
Module-4	**Quantum and Surface Engineering Applications**	**L = 15**
	Superconductivity in Thin Films, Superconductive Tunneling Devices, Switching Devices, Cryotron Amplifiers, superconducting quantum interference device (SQUID), Specialty Coatings: corrosion-resistant coatings, thermal barrier coatings, and anti-fouling coatings; Radiation-Shielding Materials; Radar-absorbing materials (RAM) and radar-reflective materials (RRM) coatings, Infrared (IR) Sensor, Chemical and Biological Sensors, Acoustic Sensors, Radiation Sensors, Pressure and Strain Sensors, Optical Sensors, Gas Sensors. Self-Healing thin films and their applications, Biomaterial thin films and its application in biomedical sector, Importance of antimicrobial materials, Silver thin films for antimicrobial application.	**Credit-1**

G) REFERENCES:

1) Thin Film Device Applications by K. L. Chopra and I. Kaur. Plenum Press, New York.
2) Handbook of Deposition Technologies for Films and Coatings Science Application and Technology by Peter M. Martin, 2nd Edition (2005).
3) Thin Film Coatings Properties, Deposition, and Applications by Frederick Madaraka Mwema, Tien-Chien Jen, Lin Zhu, CRC Press (2022).
4) Thin Films - Deposition Methods and Applications by Dongfang Yang, IntechOpen (2023),
5) W.F. Lai, (2023) Design and application of self-healable polymeric films and coatings for smart food packaging. npj Science of Food, 7(1), p.11.
6) Thin Film Coatings for Biomaterials and Biomedical Applications by Hans J Griesser, Elsevier (2016)
7) Advanced antimicrobial materials and applications by M.I. Ahamed and R. Prasad, Singapore: Springer (2021).
8) Thin Films and its Applications By R. B. Bhise, V. H. Goswami, M. S. Shinde and M.D. Dhiware, Mahi Pblications, India (2023).

M.Sc. (Physics) (Sem-IV)

PHY 653 MJ (Special-II) : Advanced Biophysics

Lectures: 60 **(Credits : 4)**

A) Course Objectives: This course aims to introduce Techniques in Biophysics

1) To study the basic concepts regarding Spectroscopy
2) To impart knowledge about Biophysical Techniques

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1) Understand Spectroscopy
2) Identify Biophysical Methods
3) Properties and their significance
4) Working of Types of Microscope
5) Apply the knowledge of Statistics in Biophysics

C) Instructional design:

1) Lecture method 2) Use of Multimedia 3) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations 2) Assignments 3) Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Spectroscopy**	**Lect = 15**
	Principle, instruments and application of spectroscopic instruments: **UV Visible:** absorption of light, radiation sources, sample holders, monochromators, radiation detectors, single and double beam instruments, colorimeter. **IR spectroscopy:** Rotational and vibration spectra, Instrumental features, applications. Raman Effect, strokes and anti-strokes lines, advantages, applications. **CD/ORD** principles and applications. **Fluorescence:** Fluorescence and phosphorescence, bioluminescence and chemiluminiscence phenomenon, quenching, energy transfer, and applications. **Atomic absorption spectroscopy:** Principle and instrumentations. **Mass Spectroscopy:** Principal, Instrumentation, Working, Time of Flight, Applications.	
Module-2	**Microscopy**	**Lect = 15**
	Principle, instrumentation and application of microscopy, image formation, magnification, resolving power, Optimum resolution, image defects, different types of Microscopy: Confocal microscopy, Dark field, Phase contrast, polarization microscopy, Interference microscopy, Fluorescence microscopy, Electron microscopy: Electron guns, Electron lens, electrostatic focusing, magnetic focusing, SEM, STEM.	
Module-3	**Techniques and Methods in Biophysics**	**Lect = 12**
	Centrifugation (Density Gradient), Chromatography (GC & HPLC), Raman spectroscopy for biomolecules, NMR and ESR (Electron spin reversal) spectroscopy for proteins, X –Ray Crystallography, MALDI-TOF, Atomic Absorption Spectroscopy (AAS), Flow Cytometry, Scanning Tunneling Microscopy.	

Module-4	Radiation Biophysics	Lect = 10
	Ionizing radiation, Interaction of radiation with cells & biological systems, measurement of radiation (Dosimetry), radioactive isotopes and medical applications, Biological effects of radiation, radiation protection & therapy Laser radiation & cell-tissue interactions, Lasers and phototherapy	
Module-5	**Biostatistics**	**Lect = 8**
	Statistical methods, Sampling methods, Measures of central tendency, Test of statistical Significance, Chi-Square Test, Regression Analysis, Analysis of Variance (ANOVA)	

G) REFERENCES:

1. Essentials of Biophysics by P. Narayanan, New Age International Publication, (**2005)**
2. Biophysics by G. R. Chatwal, Himalaya Publishing House, Mumbai, (**2011**)
3. Principles of neural science by E. R. Kandel& J. H. Schwatz, Elsevier, North Holland, (**1982)**
4. Neuron to Brain by S. W. Kuffler and J. G. Nichols, SinacuerAsso. Inc., (**1995)**
5. Biophysics; An Introduction by Rodney Cotterill, Wiley, (**2014)**
6. Biophysics by Mohan P. Arora, Himalaya Publishing House, (**2012)**

M.Sc. (Physics) (Sem-IV)

PHY 654 MJ (Special-II) : Advanced Astronomy and Astrophysics

Lectures: 60 **(Credits : 4)**

A) Course Objectives :

1. To provide a broad overview of modern physical cosmology.
2. To make clear the connections between basic physical ideas and modern cosmology.
3. To apply the fundamental physics laws to understand the physics of stellar structure.

B) Learning Outcomes: Upon completion of the course, the student will be able to,

1) Carry out calculations in using common astrophysical units
2) Describe and explain the physics of detectors and telescopes including geometric optics
3) Explain how astronomical distances are measured
4) Use the basic laws of physics to explain the global properties and basic evolution of stars
5) Derive Kepler's Laws and apply them with Newton's laws and theorems to a range of astrophysical objects including extrasolar planets
6) Describe the structure of the Milky Way and other galaxies
7) Describe the fundamental constituents of the Universe: baryons, dark matter and dark energy, and the observational evidence for their presence
8) Describe and explain the evolution of our Universe, including the evidence for the Big Bang.
9) Use the equations which describe the evolution of the Universe to derive properties of the Universe.

C) Instructional design :

1) Lecture method **2)** Tutorial method **3)** Seminar/s on renewable energy project case studies

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Astronomical Tools and Techniques**	**L = 15**
	Telescopes and Detectors – optical, infrared, radio, x-rays, gamma-rays, neutrinos and cosmic rays; Gravitational radiation; Detection of dark matter and Dark Energy Astronomy from Space; Imaging – focal plane imagers, PSF and deconvolution, interferometry Photometry, Spectroscopy, Polarimetry, Astrometry; Solar telescopes; Surveys, Astronomical databases, Virtual Observatory	**Credit-1**
Module-2	**Radiation processes**	**L = 15**
	Introduction; the electromagnetic spectrum; multi-wavelength view of astrophysical objects; cgs system; energy equivalence (slides). Definition of flux, brightness, luminosity, pressure, energy density, Emission and absorption coefficients; radiative transfer equation and its solutions; optical depth; mean free path, Thermal emission; black body; Kirchhoff law; Planck function, Stars as black bodies (slides); Einstein coefficients, Lasers/masers; scattering; random walk; extinction, Maxwell's equations; Poynting flux; electromagnetic waves in vacuum, Electromagnetic potentials; retarded	**Credit-1**

	potentials, Velocity and radiation fields, Larmor's formula; dipole approximation; Thomson scattering. Special relativity; Lorentz transformations, Four-momentum, covariant dynamics; Emission from relativistic particles; beaming.	
Module-3	Computational Astrophysics	**L = 15**
	Overview of numerical computation - Simple problems: data sorting, root finding etc. - Numerical solutions of algebraic equations - Numerical integration, interpolation/extrapolation - Numerical differentiation - Ordinary differential equations - Partial differential equations - Statistics, Leastsquares fitting - Data crunching, dealing large data set - Fourier transform - Advanced Applications in Astrophysics: N-Body Methods, Hydrodynamics - Monte Carlo Methods	**Credit-1**
Module-4	**Mathematical Techniques for Astrophysics**	**L = 15**
	Vector space and matrices, linear independence, bases dimensionality, Inner product, tensors, transformations of, parallel transport, linear transformation matrices, inverse, orthogonal and unitary matrices, independent element of a matrix, Eigen values and Eigen vectors, diagonalization, complete orthonormal sets to functions, series, convergence tests; complex Variables, Cauchy- Riemann condition, analytic functions, Cauchy's theorem, Cauchy integral formula, Laurent series, singularities, residue theorem, contour integration, evaluation of definite integrals. Differential equations, second order linear ODEs with variable coefficients, Solution by series expansion, non-homogeneous differential equations and solution by the method of Green's functions with applications. Eigenvalue methods, up to Strum-Liouville systems. Special functions, Legendre, Bessel, Hermite and Laguerre functions with their physical application	**Credit-1**

F) Reference Books:

1) Roy, A.E., & Clarke, D., Astronomy Principles and Practice, 4th ed., Institute of Physics, 2003.
2) Kitchin, C.R.: Astrophysical Techniques, 4th ed., Institute of Physics, 2003.
3) Smart, W.M., Spherical Astronomy, 6th ed., Cambridge University Press, 1977.
4) Tools of the Astronomers - C. R. Miczaika and W. M. Sinton:
5) G.B. Rybicki and A.P. Lightman, Radiative Processes in Astrophysics, Wiley.
6) F.H. Shu, The Physics of Astrophysics vol I: Radiative Processes, University Science Books.
7) W.H. Tucker, Radiation Processes in Astrophysics.
8) Mathematical Methods for Physicists : G.Arfken & H.G.Weber
9) Advanced Engineering Mathematics : E.Kresjig
10) Fourier Transform and Its Applications : R.N.Bracewell

M.Sc. (Physics) (Sem-IV)

PHY 655 MJ (Special-II) : Advanced Energy Physics

Lectures: 60 **(Credits : 4)**

A) Course Objectives: This course aims to introduce the Applications of renewable energy sources and awareness about the use of renewable energy to the students.

1) To study the basic concepts regarding conversion of renewable energy in to other form.
2) To impart knowledge about utilization of renewable energy

B) Learning Course Outcomes (CO): Upon completion of the course, the student will be able to,

- Understand conversion of renewable energy in to other form of energy.
- Basics of utilization of solar energy.
- Apply the concept and use of knowledge of the renewable energy sources in day today life.
- Understanding the Physics of renewable energy sources will create a awareness.
- Students will have hand on experience in theory based on solar conversion systems and their applications, solar photovoltaic, solar thermal energy, geothermal energy, and emerging trends in renewable energy sources.

C) Instructional design:

1) Lecture method **2)** Tutorial method 3) Use of Multimedia 4) Creation of online resources

D) Evaluation Strategies:

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents:

Module-1	**Photo thermal Applications of Solar Energy**	**L:15**
	Selective coatings: Ideal characteristics of selective coating for various applications, Types of selective coatings, materials and techniques for selective coatings, Effect of selective coating on the efficiency of solar collectors. **Solar Thermal Devices and Systems:** Different types of collectors, Flat plate collector (Basic principle, construction, Energy balance equation of steady state, Testing, Methods to reduce losses), Solar cookers, Domestic hot water system, Solar dryers, solar pond, Solar still, Solar furnace, Solar refrigeration, Solar concentrators and system based on use of solar concentrators.	
Module-2	**Solar Photovoltaic (SPV)**	**L: 15**
	Solar photovoltaic (SPV) Conversion: Basic principles, Types of solar cell materials, Fabrication of solar photovoltaic cells, solar cell parameters and characteristics, Modules. Block diagram of general SPV conversion system and their characteristics, Different configurations, Application (such as street light, water pumps, Radio / TV, Small capacity power generation) **Solar photovoltaic (SPV) Systems Designing:** Load estimation, selection of inverters, battery sizing, and array sizing.	
Module-3	**Wind and Bio Energy**	**L: 15**
	Wind Energy: Introduction, Basic principle of wind energy conversion, Extraction of maximum power from wind and its dependence on various parameters.	

	Wind Mills: Types of wind mills, Vertical axis and Horizontal axis wind mills their performance, Merits and Demerits, Limitations of wind energy conversions. **Bio Energy:** Biomass, Generation and utilization, Property of biomass, Physical, Chemical and biological conversion of biomass into useful form of energy. Gasification, Biomass gasifier and types. **Biogas:** Introduction, Generation of biogas, Aerobic and anaerobic bio conversion process. Digesters and their designs, Pyrolysis and gasification, Fermentation process. **Bio fuels:** Types of bio fuels, Production processes, Bio fuel applications, Ethanol as a bio fuel.	
Module-4	**Hydrogen and Geothermal Energy**	**L: 15**
	Hydrogen Fuel: Importance of Hydrogen as a future fuel, Sources of Hydrogen, Fuel of vehicles. **Hydrogen production:** Production of Hydrogen by various methods, Direct electrolysis of water, Direct thermal decomposition of water, Biological and biochemical methods of hydrogen production. **Hydrogen storage:** Gaseous, Cryogenic and Metal hydride. **Utilization of hydrogen:** Fuel cell– Principle, construction and applications. **Geothermal energy**: Geothermal energy as a renewable source of energy, Origin of geothermal resources, Types of geothermal resources, Basics of a geothermal electric power plant, Geothermal heat pump, Heating and cooling using a heat pump, Benefits of geothermal heat pumps, Global status of power generation from geothermal resources, Identification of geothermal resources in India	

F) Reference Books:

1. Non-Conventional Energy Sources: G. D. Rai, Khanna Publishers (2011)
2. Renewable Energy Sources and Emerging Technologies: D. P. Kothari, K. C. Singal, and Rakesh Ranjan, Prentice Hall of India Pvt. Ltd. (2008)
3. Non-Conventional Energy Resources: B. H. Khan, Tata McGraw Hill Publication (2006)
4. World Energy Resources: Charles E. Brown, Springer Publication (2002)
5. Principles of Solar Energy Conversion: A. W. Culp, McGraw Hill Publication (2001)
6. Solar Energy-Fundamentals and Applications: H. P. Garg and J. Prakash, McGraw Hill (2000)
7. Renewable Energy Sources and Conversion Technology: N. K. Bansal, M. Kleeman, and S. N. Srinivas, Tata Energy Research Institute (TERI), New Delhi (1996)
8. Solar Cells: Operating Principles, Technology, and System Applications: Martin A. Green, Longman Higher Education (1982)
9. Principles of Solar Engineering: F. Kreith and J. F. Kreider, McGraw Hill (1978)
10. Solar Energy-Principles of Thermal Collection and Storage: S. P. Sukhatme, McGraw Hill (1976)

M.Sc. (Physics) (Sem-IV)

PHY 656 MJP : Special Major Core Laboratory-II (SMCL-II)

Lectures: 60 **(Credits : 4)**

List of Major Core Experiments (Any-12) :

Section-I (Any-6):

1. To determine the magnetic susceptibility of FeCl3
2. Average grain size by SEM
3. Density of ceramic material using XRD
4. Study of creep behaviour for binary Sn-Pb alloy
5. Humidity measurement
6. To determine specific heat of graphite
7. Temperature dependent resistivity measurement of a material
8. To determine the dipole moment of a given liquid
9. Determination of Band gap of given material by UV-Visible-IR spectroscopy.
10. Determination of interatomic bond length in diatomic molecules by studying Rotational vibrational IR spectra.
11. Study of Beer and Lamberts law in absorption spectroscopy by using UV-Vis spectroscopy.
12. Study of Hystersis of hard and soft ferrites 8. Determination of resonance frequency of ferroelectric element
13. Study of Thermogravimatric analysis
14. Hysteresis loop tracing from VSM and determination of magnetic moment
15. Study of microstructure of copper

Section-II (Any-2):

1. Deposition of thin films by spray pyrolysis method and measure thickness
2. Thin film formation by Electro-chemical deposition technique and measure thickness
3. Deposition of thin films by spin coating method and measure thickness
4. Deposition of thin film by chemical bath method and measure thickness
5. Measurement of resistance of thin film by two probe method with variation in temperature
6. Measurement of reflectivity and transferability of thin films by using He-Ne laser.

Section-III (Any-2):

1. Study of Optical Properties of selective coatings.
2. Study of Series and Parallel Combination of Solar Photovoltaic panels.
3. Study of Solar Collector (Efficiency).
4. Determine the I-V and P-V characteristics of series and parallel combination of PV modules.
5. Determine the I-V and P-V characteristics of PV module with varying intensity of solar radiation.
6. Study of Solar Dryer.
7. Study of Parabolic Type Solar Cooker.
8. Determination of overall heat Loss Coefficient in Flat Plate Collector
9. Study of Solar Still.
10. Determination of Energy content in wind using anemometer.

Section-III (Any-2):

1. ECG Recording and analysis.
2. Measurement of sound intensity using SPL
3. Measurement of Viscosity of blood.
4. Measurement of Heart Rate, Pulse rate, respiration rate, and BP using Multipara.
5. Blood analysis, Absorption spectra of Blood using Spectrophotometer.
6. Study of UV-Visible for characterization of Biomaterial
7. Study of FTIR for characterization of Biomaterial
8. Measurement of physical parameter using embedded system

Additional Activities (*Any One*):

- **Model Demonstrations :** Any 1-demonstrations equivalent to 2-experiments.
- **Study tour:** Participate study tour (***Industry/Oganization/Research Institute/Research organization/ Small scale industry/University Department***) with study tour report equivalent to 2-experiments.
- **Computer Aided Demonstrations :** Any 2-demonstrations equivalent to 2-experiments.

Note: *Students have to perform **12**-experiments or **1**-additional activities in addition to **10**-experiments mentioned above. Total laboratory work with additional activities should be equivalent to **12**-experiments.*

Reference Books:

1. Materials Science and Engineering by V. Raghvan
2. Elements of Materials Science and Engineering (5th edition) by Lawrence H. Van Vlack, Addison - Wesley Publishing Co.
3. Materials Science by Kodgire and Kodgire
4. Introduction to Materials Science for Engineers (6th edition) by J.F. Shaekelford and M.K. Murlidhara - Pearson Education
5. Medical instrumentation: Application and design (Third edition) by John G.Webster, Willey India Education
6. Solar Energy Utilization by G.D.Rai, 9Khanna Publishers) 1995
7. Energy technology by S.Rao and B.B. Parulekar (Khanna Publishers) 1995
8. Solar Thermal Engineering by J.A. Duffie (Academic Press)
9. Thin Film Solar Cells by K.L. Chopra and S.R.Das (Plenum Press) 1983
10. Thin Film Phenomena by K. L. Chopra, (Mc Graw Hill)
11. Material Science of Thin Films by M. Ohring, (Academic Press)
12. Thin Film Process by J. L. Vossen and Kern, (Academic Press)
13. Solar Hydrogen Energy Systems by T. Ohta (Pergamon Press) 1979
14. Solar Photovoltaics by C.S. Solanki
15. Climatological and Solar data for India by Seshadri. (Sarita Prakashan) 1969
16. Renewable Energy Sources and Conversion Technology by N.K. Bansal, M. Kleeman and S.N. Sreinivas 9 Tata Energy Research Institute, New Delhi) 1996
17. Fundamentals of Solar Cells by F.A. Faherenbruch and R.H. Bube 9Academic Press).
18. Medical Physics by John R. Cameron, J. G. Skofronick, John Wiley and Sons, International Publications
19. Clinical Biophysics: Principles and Techniques by P. Narayanan

M.Sc. (Physics) (Sem-III)
PHY 657 RP : Research Project-II

Lectures: 90 **(Credits : 6)**

Guidelines: It is expected that,

1. The student does work equivalent to about 12 laboratory experiments throughout the semesters in the third year.
2. One bears in mind that the project work is a practical course and it is intended to develop a set of skills pertaining to the laboratory work apart from the cognition of students. Therefore, the guides should not permit projects that involve no contribution on part of student.
3. The project must have a clear and strong link with the principles of basic physics and/or their applications.
4. The theme chosen should be such that it promotes better understanding of physics concepts and brings out the creativity in the students.
5. The evaluation of the project work must give due credit to the amount of the project work actually done by a student, skills shown by the student, understanding of the physics concepts involved and the presentation of the final report at the time of viva voce.
6. The viva voce should be conducted at the time of evaluation of project work at least for twenty minutes per student. Extra care must be taken in the evaluation of projects done in a pair or group. Delegation of the work done by individuals must be sought from the students in such cases.
7. Any ready-made material used in the report (such as downloaded pages from the web) must be clearly referred to and acknowledged.
8. It is also recommended that a **Teacher** will look after **six (6)** projects at one time.
9. Any non-adherence to this norm should attract a penalty by way of deduction in the marks awarded to a student.

The Project work shall consist of the following Criterions.

1) Working model (Experimental or Concept based simulation/Demonstration Related to Physics).
2) Understanding of the project.
3) Experimental Details.
4) Data collection and Data Analysis.
5) Innovation.
6) Outcomes/Result.
7) Conclusion.

Note: *At the time of project practical examination, the candidate must submit the certified project report by the project in-charge and HOD. A candidate will be allowed to appear for the Project practical examination only if the candidate submits a project completion report duly certified by the project in-charge and Head of the department.*

Evaluation weightage:

- Semester End University Examination : 70 Marks
- Internal Examination : 30 Marks

Major Elective

(Semester-IV)

M.Sc. (Physics) (Sem-IV)
PHY 660 MJ (Elective): Energy Storage Devices

Lectures: 30 **(Credits : 2)**

A) Course Objectives:

1. To study details of various energy storage systems along with applications
2. Enabling to identify the optimal solutions to a particular energy storage application/utility
3. Focus and develop future energy devices through research

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1. Understand the necessity and usage of different energy storage schemes for different purposes.
2. Have a technological overview of various energy storage schemes.
3. Understand the operational mechanisms of each energy storage system.
4. Understand preliminary thermodynamics and electrochemistry.
5. Characterize and analyze electrochemical energy storages.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Energy Storage Systems**	**Lects = 06**
	Scope of energy storage, Needs and opportunities in energy storage, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market.	
Module-3	**Electrochemical Energy Storage System**	**Lects = 12**
	(a) Batteries: Working principle of battery, Primary and secondary (flow) batteries, Battery performance evaluation methods, Major battery chemistries and their voltages- Li-ion battery, Metal hydride battery and lead-acid battery. (b) Supercapacitors: Working principle of supercapacitor, Types of supercapacitors, Cycling and performance characteristics, Difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors (c) Fuel cell: Operational principle of a fuel cell, Types of fuel cells, Hybrid fuel cell-battery systems, Hybrid fuel cell-supercapacitor systems.	
Module-4	**Battery Design for Transportation**	**Lects = 12**
	Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced Battery-Assisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles.	

G) REFERENCES:

1) Electric & Hybrid Vehicles by G. Pistoia, Elsevier B. V.

M.Sc. (Physics) (Sem-IV)

PHY 660 MJP (Elective): Energy Storage Devices

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum 6) **Credit-2**

1) Construction of Battery Device.
2) Construction of Supercapacitor Device.
3) Study of charging and discharging of battery.
4) Study of rechargeable battery componants using standard commercial battery.
5) Study of cyclic voltammetry for supercapacitor.
6) Study of Lithium-Ion Batteries
7) Study of charger for Electric Vehicles
8) Study of lead-acid battery

G) REFERENCES:

1) Lithium-Ion Batteries: Basics and Applications edited by Reiner Korthauer, Springer-Verlag GmbH Germany (2018) ; ISBN 978-3-662-53069-6 ISBN 978-3-662-53071-9 (eBook) https://doi.org/10.1007 /978-3-662-53071-9.

2) Fundamentals of Energy Storage by J. Jensen and B. Sorenson, Wiley-Interscience, New York,

3) Energy Storage - Technologies and Applications by Ahmed Faheem Zobaa, InTech.

4) Handbook of battery materials by C. Daniel, J. O. Besenhard,Wiley VCH Verlag GmbH & Co.

5) Electric & Hybrid Vehicles by G. Pistoia, Elsevier B. V.

6) Thermal energy storage: Systems and Applications by Dincer I. and Rosen M. A., Wiley pub.

7) Energy Storage: Fundmentals, Materials and Applications, by Huggins R. A., Springer

8) Fuel cell Fundamentals by R. O'Hayre, S. Cha, W. Colella and F. B. Prinz, Wiley Pub.

9) Chemical and Electrochemical Energy System by R. Narayan and B. Viswanathan, University Press.

10) Battery Systems Engineering by C. D. Rahn and C. Wang, Wiley Pub.

11) Electrochemical Energy Storage for Renewable sources and grid balancing by P. T. Moseley and J. Garche,Elsevier Science

12) Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications by B. E. Conway

M.Sc. (Physics) (Sem-IV)

PHY 661 MJ (Elective): Data Interpretation and Analysis

Lectures: 30 **(Credits : 2)**

A) Course Objectives: To be confident in data handling and analysis

1. Understand the importance of data interpretation and analysis in decision-making processes.
2. Develop skills to collect, organize, and clean data for analysis.
3. Apply statistical techniques to analyze data and draw meaningful conclusions.
4. Utilize data visualization tools to present data effectively.
5. Interpret and communicate the results of data analysis to stakeholders.
6. Explore real-world applications of data interpretation and analysis in different domains.

Course Description :

This course introduces students to the fundamental concepts and techniques of data interpretation and analysis. Students will learn how to collect, organize, analyze, and interpret data to make informed decisions. The course will cover various statistical methods, data visualization techniques, and data analysis tools.

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

1. Understand the importance of data interpretation and analysis in decision-making processes.
2. Demonstrate knowledge of different types of data and data sources.
3. Collect, organize, and clean data for analysis.
4. Apply statistical techniques to analyze data and draw meaningful conclusions.
5. Utilize data visualization tools to present data effectively.
6. Interpret and communicate the results of data analysis to stakeholders.
7. Critically evaluate data analysis methods and approaches.
8. Continuously update knowledge and skills in the field of data interpretation and analysis.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars on renewable energy project case studies 4) Use of Multimedia 5) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Data Collection and Preparation**	**L = 04**
	○ Introduction ○ Types of data and data sources ○ Designing data collection methods ○ Data cleaning and pre-processing ○ Handling missing data and outliers	
Module-2	**Data Analysis**	**L = 05**
	○ Descriptive statistics ○ Data visualization techniques (e.g., charts, graphs, and plots) ○ Analysis of variance (ANOVA) ○ Multivariate analysis ○ Time series analysis	

	○ Cluster analysis ○ Factor analysis	
Module-3	**Data Visualization**	**L = 03**
	○ Principles of effective data visualization ○ Tools for data visualization (e.g., Tableau, R, Python libraries) ○ Creating meaningful visualizations	
Module-4	**Interpretation and Communication of Results**	**L = 03**
	○ Interpreting statistical findings ○ Presenting data analysis results ○ Communicating insights to stakeholders	

G) REFERENCES:

1. "A Practical Guide to Scientific Data Analysis" by David J. Livingstone.
2. "Data Analytics Made Accessible" by Dr. Anil Maheshwari

M.Sc. (Physics) (Sem-IV)

PHY 661 MJP (Elective): Data Interpretation and Analysis

Lectures: 30 **(Credits : 2)**

Experimental List: (Minimum 6) **Credit 2**

1. Apply ethical considerations in data interpretation and analysis.
2. Analyze real-world datasets and identify patterns and trends.
3. Solve complex problems using data interpretation and analysis techniques.
4. Demonstrate proficiency in using data analysis software and tools.
5. Collaborate effectively in a team to analyze and interpret data.
6. Apply data interpretation and analysis skills in a project.
7. Apply data interpretation and analysis skills in a case study.
8. Use ANOVA software to analyze any data

G) REFERENCES:

3. "A Practical Guide to Scientific Data Analysis" by David J. Livingstone.
4. "Data Analytics Made Accessible" by Dr. Anil Maheshwari

M.Sc. (Physics) (Sem-IV)
PHY 662 MJ (Elective): Ocean Physics

Lectures: 60 **(Credits : 4)**

A) Course Objectives: This course aims to introduce principles of Ocean Physics and study the physical behavior of the ocean.

- To study the basic concepts regarding Ocean.
- To impart knowledge about Physics of Ocean

B) Learning Course Outcomes (CO) : Upon completion of the course, the student will be able to,

- Understand the fundamentals of the Quantitative Physics of the Sea.
- Identify Physical Parameters of Ocean.
- Understand underwater acoustics. It is relevant because it is the only known form of signaling that can carry information through large distances in the sea-a fact of much interest to submarine warfare, to the study of marine life, and to charting the ocean depths.
- Study of optics of the sea. It has been stimulated by the need to understand absorption or emission of infrared, visible, and ultraviolet radiation, which in turn are relevant to the life cycle of flora and fauna and to the interchange of heat and water vapor between the sea and the atmosphere.
- Apply the knowledge of oceanography.

C) Instructional design:

1) Lecture method **2)** Tutorial method 3) Use of Multimedia 4) Creation of online resources

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Physical Oceanography and Forcing Functions**	**L = 10**
	1.1 Introduction 1.2 Evolution of Modern Physical Oceanography 1.3 Forcing Functions On and In the Sea 1.4 Wind Stress 1.5 Pressure Forcing 1.6 Waves : Tsunamis	
Module-2	**Optics of the Sea**	**L= 10**
	2.1 Introduction 2.2 Optical Fields and Parameters 2.3 Surface Illumination: Sun, Sky, and Artificial 2.4 Surface Interactions: Reflection, Scattering, and Refraction 2.5 Radiative Transfer Beneath the Sea	

	2.6 Ocean Color; Underwater Imaging 2.7 Remote Sensing of Optical Parameters	
Module-3	**Acoustical Oceanography**	**L = 10**
	3.1 Introduction 3.2 Characteristics of Sound in the Sea 3.3 The Acoustic Wave Equation 3.4 The Speed of Sound 3.5 Mechanical Properties of Acoustic Waves	

F) REFERENCES:

1) **Principles of Ocean Physics:** J. R. Apel, International Geophysics Series, Volume 38, Academic Press, London (1999).
2) **The Oceans Their Physics, Chemistry, and General Biology:** H. U. Sverdrup, Martin W. Johnson, Prentice-Hall, New York (1942)
3) **Introduction To Physical Oceanography:** Robert H. Stewart, Texas A & M University (1997)
4) **The Oceanic Optics Book:** Curtis D. Mobley, The Oceanic Optics Book, International Ocean Colour Coordinating Group (IOCCG), Dartmouth, NS, Canada (2022)
5) **Introduction to Oceanography:** Paul Webb, Pressbooks, University of California-Santa Cruz, French (2020).

M.Sc. (Physics) (Sem-IV)

PHY 663 MJ (Elective): Advance Industrial Instruments

Lectures: 30 **(Credits : 2)**

A) Course Objectives:

1) The objective of the course is to introduce the fundamentals of Electronics Instruments and Measurement providing an in-depth understanding of process control system, discrete process control and their elements.
2) The objective of the course is to introduce the knowledge about analog controllers and their principles

B) Learning Course Outcomes (CO)

1) On successful completion of the course students will learn different process control systems.
2) Students will able to use MATLAB skills in problem solving.

C) Instructional design:

1) Lecture method **2)** Tutorial method **3)** Seminars

D) Evaluation Strategies :

1) Descriptive written examinations **2)** Assignments **3)** Seminars, Orals, and Viva

E) Course Contents :

Module-1	**Introduction to Process Control**	**Lectures = 15**
	Introduction to Control systems: Process control block diagram, Control system Evaluation, Control system Objectives, Stability, Regulation, Transient Regulation, Evaluation Criteria, Damped response, Cyclic response, Sensor time response, References: 1 **Discrete Process Control:** Introduction, definitions of discrete state process control characteristics of the systems , relay, controllers and ladder diagrams (ladder programs for elevator and automatic bottle filling machine only) PLC's,	
Module-2	**Principles of Analog Controllers**	**Lectures = 15**
	Discontinuous Controller Modes Two Position Neutral Zone (Examples) Applications, Continuous controller modes: Proportional Control Mode, Integral Control Mode, Derivative Control Mode, Composite Control, P-I Control, P-D Control Mode, Three Mode Controller (P-I-D controllers). **An Introduction to MATLAB programming:** Introduction to MATLAB, Arrays in MATLAB, Mathematical Operations with Arrays	

G) REFERENCES:

1) Process Control Instrumentation Technology, Curtis D. Johnson, 8th Edition, Prentice Hall India Pvt. Ltd.
2) Computer Based Industrial Controls by K. Kant PHI Publications
3) Matlab an Introduction and Applications by Amos Gilat, Wiley Students Edition
4) MATLAB an introduction with applications Book by Rao A Dukkipati New Age International Publication

M.Sc. (Physics) (Sem-IV)

PHY 663 MJP (Elective): Advance Industrial Instruments

Lectures: 30 **(Credits : 2)**

List of Experiments (any 6)	**2 Credit**

1) 0Pronblems based on basic commands in MATLAB
2) 2D and 3D problems using MATLAB.
3) Given that at T = 300K, the electron concentration in silicon is 1.52 x 10^{10} electrons /cm^3 and Eg = 1.1 eV at 300 K. (a) Find the constant A of Equation (b) Use MATLAB to plot the electron concentration versus temperature T= 300 K.The average number of carriers (mobile electrons or holes) that exist in an intrinsic semiconductor material may be found from the mass-action law: ni =$AT^{1.5}$exp (-Eg/kT) where T is the absolute temperature in 0 K, k is Boltzmann's constant k = 1.38x10^{-23} J/K, Eg is the width of the forbidden gap in eV. Eg is 1.21 and 1.1eV for Si at 0 K and 300 K, respectively. It is given as Eg = Ec – Ev. A is a constant dependent on a given material and it is given as A = $(2/h^3)$ $(2\pi m0k)^{3/2}$ $(m^*_n m^*_p/m_0.m)^{3/4}$ h is Planck's constant h = 6.62 x 10^{-34} Js, mo is the rest mass of an electron m_n^* is the effective mass of an electron in a material, m_p^* is effective mass of a hole in a material
4) Problem 5.3 Page No. 163 Ref 2 V^{th} Edition, electric field at a point due to a charge is a vector E. The magnitude of E is given by Coulomb's law $E = (q/4\pi\varepsilon_0 r^2)$, where q is magnitude of the charge, r is the distance between the charge and the point, and ε0 is the permittivity constant $(8.8542\times10^{-12}C^2 /Nm^2)$. The electric field E at any point is obtained by superposition of the electric field of each charge. An electric dipole with q = 12 × 10^{-19} C is created. Write a MATLAB program to determine and plot the magnitude of the electric field along the x-axis from x = – 8 cm to x = 8 cm.
5) Ladder programming using Trilogy Ladder Programming software. (This software is available free of cost on web https://i-trilogi.software.informer.com/6.2/) or any other ladder programming software.
6) To design, build and test two position controller using Op-Amps.
7) To design build and test 4 - 20 mA current loop (voltage to current converter for input voltage range 0-1 Volt or any other suitable range and corresponding output current 4 to 20 mA)
8) Practical based on PLC's (cards) available in the market.
9) To Design, build and test Proportional, differential and integral controller circuits

G) REFERENCES:

1) Process Control Instrumentation Technology, Curtis D. Johnson, 8th Edition, Prentice Hall India Pvt. Ltd.

2) Computer Based Industrial Controls by K. Kant PHI Publications

3) Matlab an Introduction and Applications by Amos Gilat, Wiley Students Edition

4) MATLAB an introduction with applications Book by Rao A Dukkipati New Age International Publication

5) Semiconductor device fundamentals By R F Pierret Pearson Education India Publication and other Physics problem related Books Following is an example(s) problem(s).