Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar

(Autonomous)

(Affiliated to Savitribai Phule Pune University, Pune)

Choice Based Credit System (CBCS)

Master of Science (M. Sc.)

Syllabus of

M. Sc. I Physics

Implemented from

Academic year 2021 -22

Ahmednagar Jilha Maratha Vidya Prasarak Samaj's

New Arts, Commerce and Science College, Ahmednagar (Autonomous)

Board of Studies (BOS) in Physics

Sr. No.	Name	Designation
1.	Prof. (Dr.) Avinash V. Mancharkar	Chairman, Head
2.	Dr. Ashok A. Jadhavar	Member
3.	Dr. Appasaheb Torane	Academic Council Nominee
4.	Dr. Vijay M. Mayekar	Academic Council Nominee
5.	Prof. (Dr.) Arun G. Banpurkar	Vice Chancellor Nominee
6.	Prof. (Dr.) Nandu B. Chaure	Meritorious Alumnus
7.	Dr. Vinay Hasabnis	Industry Expert
8.	Dr. Shrikrushna B. Gaikwad	Member (Co-opt)
9.	Mr. Dattatray K. Sonwane	Member (Co-opt)
10.	Mr. Dipak S. Shelar	Member (Co-opt)

1. Prologue/ Introduction of the programme:

The curriculum for the M. Sc. in Physics designed for the requirement of Choice Based Credit System (CBCS) following the University Grants Commission (UGC) and Savitribai Phule Pune University guidelines. As per the guidelines, we proposed structure including Core courses, Discipline specific elective courses, along with Discipline specific Special elective courses and general elective courses. In the CBCS pattern, continuous assessment of the students is an integral part. This continuous assessment carried out through systematic based on better understanding of the subject. During the curriculum designing, we have added the skill oriented courses to encourage students for achieving fruitful skills while completing their master degree in Physics. Curriculum designed to motivate students for the pursuing career in research and inculcate enough skills for becoming an entrepreneur.

2. Programme Outcomes (POs)

After successful completion of this program, they will train for essential skills and abilities required for the bright future. They will have the opportunity to master the following objectives.

I. To motivate students for participation in scientific events such as Conferences, Webinars and Seminars.

II. To motivate to visit national scientific institutes so that they will get status of the research in the field of physics.

III. To motivate students to pursue project work in nearby industries so that they can understood scientific and technological aspects of Physics in the industries.

IV. To enhanced knowledge through scientific problem solving using latest programming language, seminar presentation, participation in science exhibition, mini and major projects, etc.

V. To motivate students to peruse career in research and development science.

VI. To chance to conduct various experiments, this will help students to learn various concepts of Physics through experiments.

VII. To give experimental and computational hands on experience to develop ability to scientific problems.

VIII. To train students in get skills related to research, education and industry for bright future.

IX. To help students to build-up a progressive and successful career in Physics.

Program Structure and Course Titles

Sr. No.	Class	Semester	Course Code	Course Title	Credits
1.	M.Sc. I	I	MSC-PH 111 T	Mathematical Methods in Physics	04
2.			MSC-PH 112 T	Classical Mechanics	04
3.			MSC-PH 113 T	Electronics	02
4.			MSC-PH 114 P	Advanced numerical Skill Lab 1	02
5.			MSC-PH115 P	Electronics Lab 1	02
6.			MSC-PH116 P	Basics Physics Lab 1	02
7.			MSC-PH117 T (X)	Elective I Theory	02
8.			MSC-PH118 P (X)	Elective I Practical	02
9.			MSC-PH119 T (X)	General Elective I	02
10.		II	MSC-PH 211 T	Electrodynamics	04
11.			MSC-PH 212 T	Quantum Mechanics	04
12.			MSC-PH 213 T	Atoms and Molecules	02
13.			MSC-PH 214 P	Advanced numerical Skill Lab 2	02
14.			MSC-PH 215 P	Electronics Lab 2	02
15.			MSC-PH 216 P	Basics Physics Lab 2	02
16.			MSC-PH 217 T (X)	Elective II Theory	02
17.			MSC-PH 218 P (X)	Elective II Practical	02
18.			MSC-PH 219 T (X)	General Elective II	02
19.	M.Sc. II	III	MSC-PH 311 T	Statistical Mechanics	04
20.			MSC-PH 312 T	Solid State Physics	04
21.			MSC-PH 313 T	Experimental Techniques in Physics - I	02
22.			MSC-PH 314 P	Experimental Techniques Lab	02
23.			MSC-PH 315 P	Computational Lab 1	02
24.			MSC-PH 316 P	Project I	02
25.			MSC-PH 317 T (X)	Special Elective I Theory	02

26.			MSC-PH 318 P (X)	Special Elective I Practical	02
27.			MSC-PH 319 T (X)	General Elective III	02
28.		**IV**	MSC-PH 411 T	Nuclear Physics	04
29.			MSC-PH 412 T	Experimental Techniques in Physics-II	04
30.			MSC-PH 413 T	Astrophysics and Astronomy	02
31.			MSC-PH 414 P	Astronomy and Astrophysics Lab	02
32.			MSC-PH 415 P	Computational Lab 2	02
33.			MSC-PH 416 P	Project II	02
34.			MSC-PH 417 T (X)	Special Elective II Theory	02
35.			MSC-PH 418 P (X)	Special Elective II Practical	02
36.			MSC-PH 419 T	Problem solving using MATLAB Programming / C++	02

Group I: Discipline Specific Elective Courses for Semester I and II:

1. The Post Graduate Center will offer any two Electives from the following list as Elective I, Elective II irrespective of the sequence for semester I and II.
2. The Post Graduate Center will offer all Electives, i.e. Elective I, Elective II of 2-credit theory and 2-credit practical, as per availability of faculty and infrastructure.

Sr. No.	Title	Course Code	Course Title	Credits
1.	**Elective I, Elective II**	MSC-PH X17 T (A)	Physics of Nanomaterials	02
2.		MSC-PH X18 P (A)		02
3.		MSC-PH X17 T (B)	Communication Electronics	02
4.		MSC-PH X18 P (B)		02
5.		MSC-PH X17 T (C)	Physics of Thin Films	02
6.		MSC-PH X18 P (C)		02

Group II: General Elective Courses for Semester I and II:

1. The Post Graduate Center will offer any two General Electives from the following list as General Elective I, General Elective II irrespective of the sequence for semester I and II.
2. The Post Graduate Center will offer all general Electives, i.e. General Elective I, General Elective II of 2-credit theory, as per availability of faculty and infrastructure.

Sr. No.	Title	Course Code	Course Title	Credits
1.	**General Elective I, General Elective II**	MSC-PH X19 T (A)	Medical Physics	02
2.		MSC-PH X19 T (B)	Introduction to C++	02
3.		MSC-PH X19 T (C)	Advanced Characterization Techniques	02
4.		MSC-PH X19 T (D)	Biophysics	02
5.		MSC-PH X19 T (E)	Sensors and Transducer	02
6.		MSC-PH X19 T (F)	Digital Electronics	02

Group III: Discipline Specific Special Elective Courses for Semester III and IV

1. The Post Graduate Center will offer any one special Elective from the following list as Special Elective I, Special Elective II irrespective of the sequence for semester III and IV.
2. In semester III is Materials Science-I selected as Special Elective I then, Materials Science-II selected as Special Elective II in semester IV.
3. The Post Graduate Center will offer all Electives, i.e. Special Elective I, Special Elective II of 2-credit theory and 2-credit practical, as per availability of faculty and infrastructure.

Sr. No.	Title	Course Code	Course Title	Credits
1.	**Semester III Special Elective I**	MSC-PH316 T (A)	Energy Studies – I	02
2.		MSC-PH317 P (A)		02
3.		MSC-PH316 T (B)	Electronic Instrumentation – I	02
4.		MSC-PH317 P (B)		02
5.		MSC-PH316 T (C)	Nuclear Techniques – I	02

6.		MSC-PH317 P (C)		02
7.		MSC-PH316 T (D)	Material Science - I	02
8.		MSC-PH317 P (D)		02
9.	**Semester IV Special Elective II**	MSC-PH416 T (A)	Energy Studies – II	02
10.		MSC-PH417 P (A)		02
11.		MSC-PH416 T (B)	Electronic Instrumentation – II	02
12.		MSC-PH147 P (B)		02
13.		MSC-PH416 T (C)	Nuclear Techniques – II	02
14.		MSC-PH417 P (C)		02
15.		MSC-PH416 T (D)	Material Science - II	02
16.		MSC-PH417 P (D)		02

Group VI: General Elective Courses for Semester III :

1. The Post Graduate Center will offer only one General Electives from the following list as General Elective III for semester III for semester III.
2. The Post Graduate Center will offer General Electives III of 2-credit theory, as per availability of faculty and infrastructure.

Sr. No.	Title	Course Code	Course Title	Credits
1.	**Semester III, General Elective III**	MSC-PH 319 T (A)	Experimental Techniques in Nuclear Physics	02
2.		MSC-PH 319 T (B)	Latex Language	02
3.		MSC-PH 319 T (C)	Research Paper Writing	02
4.		MSC-PH 319 T (D)	Physics Workshop Skill	02
5.		MSC-PH 319 T (E)	Scientific Research Instruments	02

Semester -I	Paper -I
Course Code: MSC-PH 111 T	**Title of the Course:** Mathematical Methods in Physics
Credits: 4	**Total Hours: 60 Hrs.**

Course Objectives	Course Outcomes
1. Provide a solid mathematical foundation for the budding Physicist eager to climb the ladder of self-learning. 2. Motivate students to use of mathematical methods to solve physics problems. 3. Provide students with basic skills necessary for the application of mathematical methods in physics. 4. Teach special functions and their recurrence relations.	1. Study various mathematical concepts used in the study of Physics 2. Understand basic theory of Complex algebra Analysis, Linear Algebra, Matrix algebra, 3. Understand Special functions, Fourier series and integral transforms. 4. Demonstrate quantitative problem solving skills in all the topics covered. 5. Fearlessly solve mathematical problems in physics.

Unit I: Complex Analysis (15 Hrs.)

Complex number, Complex function (polynomial, Exponential, Trigonometric complex function, Logarithm), Limit and Continuity, differentiation, Analytical function, Cauchy-Riemann condition, Line integrals, Cauchy integral formula, Derivative of analytical functions, Power Series, Taylor's theorem, Laurent's theorem, Calculus of residues, Evaluation of real definite integrals

Unit II: Vector Space and Matrix Algebra (15 Hrs.)

Revision on Vector space: Vectors (dependent and independent), Vector 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, Diagonalization

Unit III: Special Functions (15 Hrs.)

Bessel function, Legendre, Hermite, and Laguerre functions – Generating function, Recurrence relations and their differential equations, Orthogonality properties, Bessel's function of first kind, Associated Legendre function

Unit IV: Fourier series and Integral Transforms (15 Hrs.)

Fourier series: Definition, Dirichlet's Condition, Convergence, Fourier Integral and Fourier transform, convolution theorem, Parseval's identity, Fourier transform and Laplace transform of Dirac Delta function

Suggested Readings:

1. Complex Variables and Application- J. W. Brown, R. V. Churchill - McGraw Hill
2. Complex Variables – Seymour Lipschutz
3. Mathematics for Physical Sciences – Mary Boas, John Wiley and Sons
4. Mathematical methods in Physics- B. D. Gupta
5. Mathematical methods in Physics- Satyaprakash
6. Linear algebra – Seymour Lipschutz, Schaum Outline Series McGraw Hill Edition
7. Mathematical Method for Physicists, Arfken and Weber, 6th Edition, Academic Press, New York.
8. Mathematical methods in Physics- H. K. Dass
9. Mathematical Methods in Physics 2, By Prof. Auditya Sharma | IISER Bhopal https://onlinecourses.nptel.ac.in/noc21_ma48/preview
10. Mathematical Methods and its Applications Prof. P. N. Agrawal, Prof. S. K. Gupta, IITR, https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ma14/

Semester -I	Paper –II
Course Code: MSC-PH 112 T	**Title of the Course:** Classical Mechanics
Credits: 04	**Total Hours: 60 Hrs.**

Course Objectives	Course Outcomes
1. Teach fundamentals of classical mechanics. 2. Demonstrate knowledge and understanding of the various concepts in Classical mechanics. 3. Students enable to know constraints on a system, central, conservative and central-conservative forces. 4. Students enable to establish that Kepler's laws	1. Students learn to determine the motion of the system using Lagrangian and Hamiltonian formulation 2. Learn the conservation principles using mathematical derivations. 3. Understand that they follow from the fundamental equations of motion 4. Have a deep understanding of Newton's laws, Lagranagian dynamics 5. Students learn about motion of a particle under central force field.

Unit I: Lagrangian Dynamics (15 Hrs.)

Introduction, Basics Concepts: Coordinate systems, Degree of freedom, Constraints and Types, Generalized coordinates. Principle of Virtual work done, Lagrange's equation of motion using D'Alembert's principle, Lagrange Equation of motion in non-conservative force field. Lagrangian for a charged particle in moving electromagnetic field, Hamilton's Principle, Theorem of total energy, Symmetry and conservation laws (energy and momentum), Invariance under Galilean transformation.

Unit II: Hamiltonian Dynamics and Variational Principle (15 Hrs.)

Generalized momentum and cyclic coordinates, Conservation Theorems, Linear Momentum, Angular Momentum, Jacobi's Integral, Hamilton's Equations in different coordinate systems, Calculus of variations and Euler's Lagrange Equations, Variational principle and its applications to problems like shortest distance, brachistochrone, geodesics etc.

Unit III: Central force, rotating frame of reference and Small Oscillations (15 Hrs.)

One body equivalent problem, Equation of motion under central force field, Inverse square law of force. Kepler's Laws of Planetary motion and their deduction, Stability of orbit, Virial Theorem.

Rotating frames of reference, Coriolis force and examples, banking of rivers, Foucault's pendulum. Small oscillations. System of coupled oscillators. Normal modes and normal coordinates.

Unit IV: Canonical transformations and Poisson brackets (15 Hrs.)

Canonical Transformations, Legendre transformations, Generating function, Application of Canonical Transformations, Conditions for canonical transformation and problem.

Poisson Brackets, Lagrange Brackets, Relation between the Lagrange bracket and Poisson's Brackets, Jacobi-Poisson theorem, Jacobi identity, Invariance of Poisson Bracket under canonical transformation.

Suggested Readings:

1. Classical Mechanics by H. Goldstein, C. Poole and J. Safko
2. Classical Mechanics by J.C. Upadhhay
3. Classical Mechanics by N. C. Rana and P.S. Joag
4. Mechanics by L. D. Landau and E.M. Lifshitz
5. Classical Mechanics by J.R. Taylor
6. Classical Mechanics by P.V. Panat
7. Problems in classical mechanics, by N. L. Katkar
8. Introduction to Classical Mechanics Prof. Anurag Tripathi IIT Hyderabad, https://onlinecourses.nptel.ac.in/noc21_ph29/preview
9. Classical Mechanics: From Newtonian to Lagrangian Formulation Prof. Debamalya Banerjee, IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc21_ph32/preview

Semester -I	Paper –III
Course Code: MSC-PH 113 T	**Title of the Course:** Electronics
Credits: 2	**Total Hours: 30 Hrs.**

Course Objectives	Course Outcomes
1. This course will provide deep understanding of the special function IC's 2. Students will learn applications of special functions IC's 3. Students will learn the electronics behind the regulated power supply. 4. Students will understand the working of power supply and their uses.	1. Learn special function ICs like OPAMP, IC555 and their applications 2. Learn special function ICs like IC565 and IC 566 and their applications 3. Learn 3 pin regulators like IC 78XX/79XX, IC LM 317. 4. Understand basics of voltage regulator and foldback current limiting using IC 723. 5. Learn concept and applications of SMPS and DC - DC converter.

Unit I: Special Function ICs and their Applications (15 Hrs.)

Operational Amplifier: Function generator using two OPAMPS with variable controls, Astable and Monostable multivibrators using OPAMPs, Precision rectifiers (Half wave and Full wave), Instrumentation amplifier. Modulation: Need For Modulation, Classification, Applications as PAM, PWM, PPM using IC 555 / 741, FM and FSK generator, Voltage Controlled Oscillator (IC566): Block diagram and working, Phase Locked Loop (IC565): Block diagram and working and applications as FM detector, FSK detector, Frequency multiplier and Frequency Translator

Unit II: Regulated power supply (15 Hrs.)

Concept of Voltage Regulator using discrete components. Types of power supplies: series and shunt regulators, CVCC, SMPS. Three pin regulators. (IC 78XX/79XX, IC LM 317). Basic low and high voltage regulator and foldback current limiting using IC 723.Concept and applications of DC - DC converter.

Suggested Readings:

1. Power Electronics Circuits, Devices and Applications, 3rd Edition 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

Semester -I	Paper -IV
Course Code: MSC-PH 114 P	**Title of the Course:** Advanced Numerical skills Lab I
Credits: 2	**Total Number of Hours: 60 Hrs. (10 Practical)**

Course Objectives	Course Outcomes
1. Give depth in knowledge of the core courses in physics. 2. Inculcate theoretical sense of the science. 3. Develop logic for problem solving 4. Motivate students for solving problems with programming.	1) Learn scientific concepts using various programming languages. 2) Able to solve numerical problem. 3) Get quantitative problem solving skills MMP, CM and electronics. 4) Get logic development skills

- Following practicals must performed using C/**C++/MATLAB/MAXIMA/Wolfram Cloud** or any other equivalent software.

Sr. No.	Title of Experiment
1.	Program for addition two complex numbers.
2.	Program to Compute Sine and Cosine Series using Taylor series.
3.	Program for finding Eigen value and corresponding Eigen vector
4.	Program to find the basis and dimension of the given matrix.
5.	Numerical Laplace Transforms and Inverse Transforms
6.	Draw trajectory of the small oscillations of a simple pendulum
7.	Draw phase space trajectory of the forced damped pendulum.
8.	The trajectory of a charged particle in a constant magnetic field.
9.	Exponential/ Linear peak fitting of the given data.
10.	Solve first order differential equation.
11.	Draw various hkl planes using C programming.

12.	Evaluation of trigonometric functions e.g. sin θ, Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate 1/x2+2 numerically and check with computer integration.
13.	Incorporates the solution to the Foucault pendulum using MATLAB
14.	Plot the solution of a body of mass m under the action of central force using MATLAB
15.	Program to implement various Logic Gates
16.	Program to implement half adder and full adder
17.	Programs to convert decimal to binary conversion, binary to octal conversion.

- ❖ Industrial visit report / Conference poster Presentation /Conference oral presentation / Project competition or any other activity equivalent to **Two** practicals.

Suggested Readings:

1. Computational Physics, A Practical Introduction to Computational Physics and Scientific Computing (using C++), Konstantinos N. Anagnostopoulos
2. Classical Mechanics with MATLAB Applications Javier E. Hasbun
3. Mathematical Methods for Physics: Using MATLAB and Maple
4. Computational Physics: With Worked Out Examples in FORTRAN and MATLAB Book by Michael Bestehorn
5. https://www.programiz.com/c-programming: Learn C Programming. The definitive guide
6. http://web-ext.u-aizu.ac.jp/course/prog1/ (in Japanese) : University of Aizu, "Programming C" course home page.
7. https://www.geeksforgeeks.org/program-to-implement-logic-gates/
8. https://www.tutorialride.com/cpp-conversion-programs/12-c-programs-and-code-examples-on-conversions.htm
9. https://mantechnogyan.blogspot.com/2020/01/program-in-c-for-half-adder.html

Semester -I	Paper -V
Course Code: MSC-PH 115 P	**Title of the Course:** Electronics Lab 1
Credits: 2	**Total Number of Hours: 60 Hrs. (10 Practicals)**

Course Objectives	Course Outcomes
1. To give knowledge of some basic electronic components and circuits. 2. Give hands on skill for circuit designing. 3. Inculcate experimental sense of the various circuits. 4. Develop skill to find out the error in the designed circuit. 5. Motivate students for circuit design.	1. Have hands-on practice of the theory course and its applications. 2. Design a circuit for the required output-using breadboard and PCB. 3. Understand working of various Electronic circuits. 4. Understand how to use the basic test and measuring instruments to test the circuits

Sr. No.	Title of Experiment
1.	DAC (Digital to Analogue Converter) using R-2R and Binary ladder
2.	Active filters using OP-AMP
3.	Crystal Oscillator
4.	Foldback Current Power Supply
5.	Constant Current Source using OPAMP
6.	Precision Rectifier : Half wave, Full wave
7.	OPAMP Logarithmic Amplifier
8.	Mono-stable and Astable Multivibrator using IC555
9.	Low/High voltage power supply using IC-723
10.	Inverting and non-inverting Amplifier using IC741
11.	Function generator using IC-8038
12.	Adder/Subtractor using IC- 741
13.	Integrator/Differentor using IC 741
14.	OPAMP as comparator

- Industrial visit report / Conference poster Presentation /Conference oral presentation / Project competition or any other activity equivalent to **Two** practicals.

Semester -I	Paper -VI
Course Code: MSC-PH 116 P	**Title of the Course:** Basic Physics Lab 1
Credits: 2	**Total Number of Hours: 60 Hrs. (10 Experiments)**

Course Objectives	Course Outcomes
1. To give knowledge of some basic of laboratory experiments. 2. Give hands on skill for physics lab work. 3. Inculcate experimental cultural in students. 4. Develop skill to find out the possible errors during practical. 5. Motivate students for experiment design.	1. Understand the physics concept with the help of actual experiments. 2. Handle scientific instruments during the practical. 3. Have hands-on practice of the basic physics theory and its applications. 4. Able to analyze their result and analyze them. 5. Able to analyze the error in their measurement.

Sr. No.	Title of Experiment
1.	Electron Spin Resonance: To study the Electron Spin Resonance and to determine Lande's g-factor
2.	Frank-Hertz experiment: To study the discrete energy levels using Frank-Hertz experiment
3.	G.M. counter: Counting statistics, Characteristics of GM tube and determination of end point energy of β-ray source
4.	G.M. counter: Determination of dead time of GM tube by Double source method
5.	Skin depth : Skin depth in Al using electromagnetic radiation
6.	Thermionic emission: To determine work function of Tungsten filament
7.	Hall effect: To determine charge concentration, conductivity of Ge-semiconductor
8.	Four Probe method: Temperature variation and Band gap of Ge-semiconductor

9.	Ionic Conductivity of NaCl
10.	Photoconductivity: Plot the current voltage characteristics of a CdS photo-resistor at constant irradiance and measure the photocurrent as a function of irradiance at constant voltage.
11.	Zeeman Effect
12.	Stefan's constant – Black Body Radiation
13.	Determine e/m ratio.
14.	Speed of Light: To determine the speed of light using transit time of light pulse as a function of a reflecting mirror.

- Industrial visit report / Conference poster Presentation /Conference oral presentation / Project competition or any other activity equivalent to **Two** practicals.

Semester –II	Paper -I
Course Code: MSC-PH 211 T	**Title of the Course:** Electrodynamics
Credits: 4	**Total Hours: 60 Hrs.**

Course Objectives	Course Outcomes
1. Teach electrodynamics concept to the student with the help of real life applications 2. Teach some mathematical tools which can be used to solve problems. 3. Motivate students to gain the deeper meaning of the Maxwell equations. 4. Motivate students for critical thinking in the electrodynamics course.	1. Understand the relation between various fields in electrostatics, magnetostatics and electrodynamics, 2. Explain propagation of electromagnetic waves in various environments; 3. Apply Maxwell's Equations to solve some of the real life problems 4. Use the mathematical tools, methodologies and scientific language

Unit I: Introduction to Electrodynamics (7 Hrs.)

Coulomb's law, Gauss's law, Poisson's equation and Laplace's equation, Electrostatic potential energy, boundary value problems (method of images, separation of variables), Green's functions. Maxwell's equations, The Pointing vector, The Maxwellian stress tensor, Lorentz Transformations, The field equations and the field tensor, Maxwell equations in covariant notation.

Unit I: Multipole Expansions (10 Hrs.)

Multipole expansions for a localized charge distribution in free space, linear quadrapole potential and field, static electric and magnetic fields in material media, Faraday's law for stationary and moving media, Maxwell's displacement current.

Unit III: Energy, Force, Momentum Relations, and Electromagnetic Wave Equations (13 Hrs.)

Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Plane waves, Spherical waves, Phase and group velocities, Poynting's theorem and vector, electromagnetic energy and momentum. Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries, skin depth.

Unit IV: Magntostatics Inhomogeneous Wave Equations (15 Hrs.)

Inhomogeneous wave equations, Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator, Hertz potential and its use in computation of radiation fields

Unit IV: Relativistic Mechanics and Covariance (15 Hrs.)

Experimental basis for special theory of relativity (Michelson – Morley experiment), Ether Hypothesis, Lorentz transformations, Relativistic velocity addition, Minkowski's space time diagram, Four vector potential, electromagnetic field tensor, Lorentz force on a charged particle.

Suggested Readings:

1. Introduction to Electrodynamics, (3rd Edition) by David J. Griffith, Publication: Prentice-Hall of India, New Delhi
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 JohnWiley
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
11. Electrodymanics, By Dr. Amol Dighe, IIT Bombay, https://nptel.ac.in/courses/115/101/115101004/
12. Electromagnetism, is Dr. Nirmal Ganguli, IISER Bhopal, https://nptel.ac.in/courses/115/106/115106122/
13. Introduction to Electromagnetic Theory, Prof. Manoj Harbola, IIT Kanpur, https://nptel.ac.in/courses/115/104/115104088/

Semester –II	Paper -II
Course Code: MSC-PH 212 T	**Title of the Course:** Quantum Mechanics
Credits: 4	**Total Hours: 60 Hrs.**

Course Objectives	Course Outcomes
1. Offers a systematic introduction to fundamental quantum mechanics. 2. Teach historical aspects of development of quantum mechanics. 3. Teach idea of wave function, uncertainty relations, probability, eigenvalues, etc. 4. Given mathematical tool to solve Schrodinger equation for simple potentials 5. Motivate to use approximation method for complex systems.	1. Understand and explain the differences between classical and quantum mechanics. 2. Understand the central concepts and principles in quantum mechanics. 3. Understand use of linear algebra including elementary concepts in statistics, such as expectation values and variance. 4. Solve the complex systems by approximation method.

Unit I: Revision and General Formalism (15 Hrs.)

Limitations of classical Physics, wave packets and uncertainty relations, Schrodinger wave equation and probability interpretation. Simple 1dimensional problems wells, barriers and harmonic oscillator (One dimension) Postulates of Quantum Mechanics. Representation of states and dynamical variables, observables, self adjoint operators, Eigen functions and Eigen values, degeneracy, Dirac delta function. Completeness and closure property, Physical interpretation of Eigen values, Eigen functions and expansion coefficients, Eigen values and Eigen functions of momentum operator.

Unit II: Representation of States – Dirac notation (15 Hrs.)

Hilbert space, Dirac's bra and ket notation, dynamical variables and linear operators, projection operators, unit operator, unitary operator, matrix representation of an operator, change of basis, unitary transformation. Eigen values and Eigen functions of simple harmonic oscillator by operator method.

Unit III: Angular Momentum (15 Hrs.)

Eigen values and Eigen functions of L2 and Lz operators, ladder operators L+ and L–, Pauli theory of spins (Pauli's matrices), matrix representation of J in |jm> basis. Addition of angular momenta, Computation of Clebsch-Gordon coefficients in simple cases (J1=1/2, J2=1/2).

Unit IV: Approximation Methods (15 Hrs.)

Time-independent Perturbation theory: Non degenerate, Zeeman effect, Time dependent Perturbation theory: Two level system, Emission and Absorption of radiation, Spontaneous emission, Fermi's golden rule, Harmonic perturbation, Introduction to WKB approximation, The classical region, Tunneling.

Suggested Readings:

1. Introduction to Quantum Mechanics, David Griffith, 1st Edition, Prentice Hall, 1995.
2. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, 1st Edition, Wiley Publication, 2009.
3. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, R. Eisberg and R. Resnick, 2nd Edition, Wiley Publication, 2006.
4. A Text-book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Edition, McGraw Hill, 2017.
5. Quantum mechanics by A. Ghatak and S. Lokanathan
6. Quantum Mechanics by L.I. Schiff
7. Modern Quantum mechanics by J. J. Sakurai Principles of Quantum Mechanics, IInd Edition, R. Shankar (Plenum, 1994)
8. Quantum Mechanics and Applications by Prof. Ajoy Ghatak, Department of Physics, IIT Delhi, http://www.nptelvideos.in/2012/11/quantum-mechanics-and-applications.html
9. Quantum Physics by Prof. V. Balakrishnan, Department if Physics, IIT Madras, https://nptel.ac.in/courses/122/106/122106034/
10. Quantum Mechanics by Prof. P. Ramadevi, Department of Physics, IIT Bombay, https://nptel.ac.in/courses/115/101/115101107/

Semester –II	Paper -III
Course Code: MSC-PH 213 T	**Title of the Course:** Atoms and Molecules
Credits: 2	**Total Hours: 30 Hrs.**

Course Objectives	Course Outcomes
1. Offers a systematic introduction to various atomic and molecular models. 2. Teach formation of molecules and various bonds. 3. Give mathematical tool to analyses of Atoms and molecules. 4. Motivate to learn various spectroscopic techniques. 5. Teach analysis of molecules with examples.	1. Understand structure of atom using various models. 2. Learn the physics behind the molecule formation. 3. Understand working of molecule spectroscopy works and various applications. 4. Study real life use of resonance spectroscopy.

Unit I: Atoms and Molecules (15 Hrs.)

Atomic models, Hydrogen atom, Quantum numbers, Pauli's exclusion principle, electron configuration, Hund's rule, origin of spectral lines, selection rules, One electron spectra, Coupling schemes, two electron spectra, Atoms in Electromagnetic field: Zeeman effect- Normal and Anomalous, Paschen- Back effect, Stark effect (weak field)

Bonding mechanism in molecules, Molecular orbital methods, Valence band method, Molecular Spectra – Rotational and vibrational spectra for diatomic molecules, Electronics spectra of diatomic molecules, Dissociation energy and dissociation products, electronic angular momentum in diatomic molecules, Problems

Unit III: Spectroscopy (15 Hrs.)

Introduction to spectroscopy, types of spectroscopy.

a) Infrared spectroscopy: IR spectrophotometer and instrumentation, sample handling techniques, FTIR spectroscopy and analysis of HCl spectrum
b) Raman spectroscopy: Theory of Raman scattering, Rotational Raman spectra, sample handling techniques, Fourier transform Raman spectrometer, Raman Analysis of diamond
c) ESR- Principles of ESR, ESR spectrometer, hyperfine structure
d) NMR-Magnetic properties of nucleus, resonance condition, NMR instrumentation, relaxation process, chemical shift, applications of NMR.

Suggested Readings:

1. Fundamentals of Molecular spectroscopy. Collin N. Banwell and Elaine M. McCash
2. Molecular structure and Spectroscopy G. Aruldhas
3. Quantum Physics – Robert Eiesberg and Robert Resnik
4. Perspectives of Modern Physics: Arthur Beiser, McGraw Hill.
5. Introduction to Atomic Spectra: H. E. White. McGraw Hill.
6. Fundamentals of Molecular Spectroscopy: C. N. Banwell & E. M. McCash (TMH). (4^{th} Ed.)
7. Quantum Chemistry of Atoms and Molecules by Prof. Anindya Datta, Department of Chemistry, IIT Bombay, https://nptel.ac.in/courses/104/101/104101124/
8. Atomic and Molecular Physics. Prof. Amal Kumar Das, Department of Physics, IIT Khargapur, https://nptel.ac.in/courses/115/105/115105100/
9. Fundamental of Spectroscopy by Prof. Dr. Sayan Bagchi,Physical and Materials Chemistry Division, NCL, Pune and Prof. Dr. Anirban Hazra, Department of Chemistry, IISER – Pune, https://nptel.ac.in/courses/104/106/104106122/
10. Principles and Applications of NMR Spectroscopy by Prof. H. S. Atreya, IISC, Banglore, https://nptel.ac.in/courses/104/108/104108078/

Semester -II	Paper -IV
Course Code: MSC-PH 214 P	**Title of the Course:** Advanced Numerical Skills Lab 2
Credits: 2	**Total Hours: 60 Hrs. (10 Practical)**

Course Objectives	Course Outcomes
1. Give depth in knowledge of the core courses in physics 2. Encourage students to solve the physics problem using various programming software. 3. Develop logic creating capabilities in students. 4. Inculcate theoretical sense of the science.	1. Learn scientific concepts using various programming languages. 2. Able to solve numerical problem using C++, Matlab, etc. 3. Get quantitative problem solving skills core courses of physics. 4. Earn logic development skills

Sr. No.	Title of Experiment
1.	Some electric field lines of the electric field of two opposite charges calculated.
2.	Solving the 2D Poisson's equation in MATLAB
3.	Solving Laplace equation using MATLAB
4.	Draw electromagnetic filed using Maxwell's Equation
5.	Solve one dimensional wave equation in MATLAB
6.	Solve one dimensional harmonic oscillator
7.	Solve particle in one dimensional box
8.	Compute energy Eigen values and Eigen functions of a particle in infinite square wll with V(-x)=V(x)
9.	Find determinant of 2x2 matrix
10.	Calculation of Eigen values of 3 dimensional subspace

11.	Program to solve the differential equations for a sliding block using Newton's equation.
12.	Study basic operations used in MATLAB programming, Handling of 1D and 2D Arrays
13.	Study various types of loops structures used in MATLAB programming
14.	Plot 2D and 3D graphs using MATLAB commands
15.	Using MATLAB, solve the time independent Schrodinger equation in one dimension for the particle in a box problem
16.	Using MATLAB, Time Dependent Schrodinger equation in one dimension. Using Leapfrog method
17.	Using MATLAB, calculate first and second derivative numerically showing how to write differential operator as a matrix
18.	Using MATLAB, Matrix representation of differential operators, Solving for Eigenvectors &Eigenvalues of Infinite Square Well
19.	Evaluation of Bessel Functions.
20.	To find the standard deviation, mean, variance, moments etc. of at least 25 entries
21.	Plot various geometry like circle, straight line, ellipse, parabola, etc

- Industrial visit report / Conference poster Presentation /Conference oral presentation / Project competition or any other activity equivalent to **Two** practicals.

Semester -II	Paper -V
Course Code: MSC-PH 215 P	**Title of the Course:** Electronics Lab 2
Credits: 2	**Total Number of Hours: 60 Hrs. (10 Practicals)**

Course Objectives	Course Outcomes
1. To give knowledge of some basic electronic components and circuits. 2. Give hands on skill for circuit designing. 3. Inculcate experimental sense of the various circuits. 4. Develop skill to find out the error in the designed circuit. 5. Motivate students for circuit design.	1. Have hands-on practice of the theory course and its applications. 2. Design a circuit for the required output-using breadboard and PCB. 3. Understand working of various Electronic circuits. 4. Understand how to use the basic test and measuring instruments to test the circuits

Sr. No.	Title of Experiment
1.	Function generator using IC-741
2.	Optocoupler using ICMCT-2E
3.	Voltage Control oscillator using IC-566
4.	Voltage to frequency/ Frequency to Voltage converter using OPAMP
5.	SMPS
6.	DC to DC Converter
7.	Phase locked loop (PLL) applications using IC-565
8.	Active Filters using IC-8038
9.	Study of Multiplexer and Demultiplexer
10.	Study of noise performance of an amplifier
11.	Analog to digital converter
12.	Monostable and Astable multivibrator using IC741
13.	Study of counter
14.	Study of shift registers

- Industrial visit report / Conference poster Presentation /Conference oral presentation / Project competition or any other activity equivalent to **Two** practicals.

Semester -II	Paper -VI
Course Code: MSC-PH 216 P	**Title of the Course:** Basics Physics Lab 2
Credits: 2	**Total Number of Hours: 60 Hrs. (10 Practicals)**

Course Objectives	Course Outcomes
1. To give knowledge of some basic of laboratory experiments. 2. Give hands on skill for physics lab work. 3. Inculcate experimental cultural in students. 4. Develop skill to find out the possible errors during practical. 5. Motivate students for experiment design.	1. Understand the physics concept with the help of actual experiments. 2. Handle scientific instruments during the practical. 3. Have hands-on practice of the basic physics theory and its applications. 4. Able to analyze their result and analyze them. 5. Able to analyze the error in their measurement.

Sr. No.	Title of Experiment
1.	To study absorption spectra of Iodine molecule and to determine its dissociation Energy using spectrometer
2.	Michelson's Interferometer: To determine the wavelength of He-Ne LASER by using Michelson's Interferometer apparatus.
3.	Fabry-Parot Etalon
4.	Gouy's Method: Measurement of magnetic susceptibility of $MnSO_4$
5.	Specific Heat of Solids: To determine the specific heat of copper, lead and glass at three different temperatures.
6.	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
7.	Faraday Effect: Rotation of The Polarization Plane Φ As A Function of The Magnetic Field and Rotatin of The Polarization Plane 2Φ As A Function Of The

	Magnetic Field
8.	Study of Compton scattering.
9.	Measurement of de Broglie wavelength (λ) and interplanar distance (d) using electron-diffraction method
10.	Clausius – Mossotti equation using sugar solution (Determination of Polarization.)
11.	Comparison of resolving limit of optical instruments with human eye.(Pg. 300-301, A world view of Physics by Prof. D.P. Khandelwal et al. South Asian Publishers pvt. Ltd. New Delhi, 1999)
12.	Study of electromagnetic damping (Pg. 320, A world view of Physics by Prof. D.P. Khandelwal et al. South Asian Publishers pvt. Ltd.New Delhi, 1999)
13.	Rydberg's constant using constant deviation prism.
14.	Study of dielectric constant and Curie temperature measurement of ferroelectric ceramics.

- Industrial visit report / Conference poster Presentation /Conference oral presentation / Project competition or any other activity equivalent to **Two** practicals.

Group I: Discipline Specific Elective Courses for Semester I and II:

Semester – I/II	**Paper – VII**
Course Code: MSC-PHX17 T (A)	**Title of the Course:** Physics of Nanomaterials
Credits: 2	**Total Hours: 30 Hrs.**

Course Objectives	Course Outcomes
1. Provide in depth knowledge of scientific and technological aspects of nanoscience. 2. Explain the nanoscale paradigm in terms of dimensions. 3. Make aware of various types of nanostructures and their basic properties. 4. Train students in skills related to research, education, industry and market of nanotechnology. 5. Create foundation for research and development in nanoscience and technology.	1. The student will develop a fundamental knowledge of nanomaterials. 2. Learn about the Synthesis and Fabrication techniques for nanomaterials. 3. Understand physics behind nucleation theory, surface energy and stabilization 4. Understanding the characterization techniques used to analyze various properties like optical, structural, morphological, etc. for synthesized nanomaterials

Unit I: Introduction to Nanomaterials and synthesis techniques (15 Hrs.)

Introduction to Nanomaterials And Structures, Features of Nanosystems, Characteristic Length Scales of Materials and Their Properties, Effect of Reduction of Dimension, Density of States, Synthesis Methods: Top-Down and Bottom-Up Approach, Physical Vapor Deposition, Chemical Bath Deposition, Hydrothermal Method, Sol Gel Method, Biological Method.

Unit II: Properties and Application of Nanomaterials (15 Hrs.)

Properties And Application of Nanomaterials, Mechanical Properties, Size and Shape Dependence of Mechanical, Magnetic and Catalytic Properties, Thermal Electrical and Optical Properties, Magnetic Properties, Graphene, Carbon Nanotubes and Their Applications, Mechanical and Biomedical Applications, Optoelectronic Application, Thin Film Chemical Sensors, Biosensors, Solar Cells, Drug Deliveries and Optoelectronic Devices.

Suggested Readings:

1. Nanotechnology: Principal and Practices; by Sulbha Kulkarni; Capital Publication
2. Nanostructures and Nanomaterials: Synthesis, Properties and Application; by Guozhong Cao; Imperical College Press, Londen
3. Nanomaterials: Synthesis, Properties and Application; by A. S. Edstein and R.C. Commorta; Institute of Physics publishing Bristol and Philadephia
4. Introduction to Nanotechnology: by C. P. Poole, Jr. Frank J. Owens: Willey student Edition
5. Timp, G., Nanotechnology, Springer-Verlag (1999).
6. Nanostructures and Nanomaterials:Characterization and Properties by Dr. Anandh Subramaniam, and Dr. Kantesh Balani Department of Materials andMetallurgical Engineering IIT Kanpur, https://nptel.ac.in/courses/118/104/118104008/
7. Nanomaterials and their Properties, By Prof. Krishanu Biswas, IIT Kanpur, https://onlinecourses.nptel.ac.in/noc21_mm38/preview

Semester – I/II	Paper - VIII
Course Code: MSC-PHX18 P (A)	**Title of the Course:** Physics of Nanomaterials
Credits: 2	**Total Hours: 60 Hrs. (10 Practicals)**

Course Objectives	Course Outcomes
1. Provide in depth knowledge of scientific and technological aspects of nanoscience. 2. Explain the nanoscale paradigm in terms of dimensions. 3. Make aware of various types of nanostructures and their basic properties. 4. Hands on training in skills related to research, education, industry and market of nanotechnology. 5. Create foundation for research and development in nanoscience and technology.	1. Hands on training for nanomaterials for various synthesis techniques. 2. Understand the basics of characterization techniques used for nanomaterials. 3. Understand various types of nanostructures and their basic properties 4. Learn the approaches for characterization of nanomaterials. 5. Learn to analyze the various properties like optical, structural properties of the synthesized nanomaterials. 6. Choose career in the nanotechnology field for the development of science.

Sr. No.	Title of Experiment
1.	Synthesis of nanomaterial by sol gel method
2.	Synthesis of nanomaterial by hydrothermal method
3.	Synthesis of nanomaterial by chemical bath deposition
4.	Synthesis of nanomaterial by biological method
5.	Determination of average crystallite size of nanoparticles from X ray diffraction technique (software related Practical)
6.	Study of optical properties of nanoparticles
7.	Microwave assisted synthesis of nanomaterials
8.	Optical Verification of nanoparticles

9.	Synthesis metal nanoparticles like Silver, gold, etc.
10.	Synthesis of Nanoparticles by Physical Vapor Deposition.
11.	Morphological study of synthesized nanoparticles.
12.	Study of magnetic nanoparticles using hysteresis.
13.	Study FTIR analysis of synthesized Nano materials
14.	Study Morphological study of the synthesized nanomaterials.
15.	Study of Raman Spectra of the synthesized nanoparticles.
16.	Synthesis of silver nanoparticles using plant extract
17.	Preparation of CdSe by Successive Ionic Layer, Adsorption and Reaction(SILAR) method.
18.	Determine oxidation and reduction potential of nanomaterials.

- Industrial visit report / Conference poster Presentation /Conference oral presentation / Project competition or any other activity equivalent to **Two** practicals.

Semester – I/II	Paper – VII
Course Code: MSC-PHX17 T (B)	**Title of the Course:** Communication Electronics
Credits: 2	**Total Hours: 30 Hrs.**

Course Objectives	Course Outcomes
1. Provide in depth knowledge of communication technology 2. Explain the physics and electronics behind the communication technology. 3. Train in skills related to industry and market of communication field. 4. Create foundation for communication technology.	1. The student will develop a fundamental knowledge of communication media. 2. Learn Digital Communication Systems. 3. Learn about Telephone, Facsimile and Satellite Communication systems 4. Understand the importance communication electronics and their applications.

Unit I: Digital Communication (15 Hrs.)

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, Baudot code, binary code, ASCII code (EBCDIC), hollerith code, error detection, constant ratio codes, Redundant codes, parity check codes, Communication system using modern interfacing, interconnection of Data circuit to telephone loops, Network organization.

Unit II: Telephone, Facsimile and Satellite Communication (15 Hrs.)

Wire telephone, telephone subscriber's loop circuit, transmission bridges, four wire terminating set, Two–wire repeaters and Four-wire transmission. Facsimile transmission, reception, Transmission of facsimile telegraph.

Introduction to radar systems, fundamental radar range equation, basic pulsed radar. Satellite frequencies, orbits (geostatics, equatorial/polar, synchronous) station keeping, satellite attitude, transmission path, path loss, noise considerations.

Suggested Readings:

1. Electronic communications – Rooddy – Coolen (PHI) electronic
2. Communication Systems – George Keneddy (TMH)
3. Telecommunication switching systems & Network – T.Vishwanathan.(PHI)
4. Mobile Cellular Tele communication System – C.Y.Lee
5. Communication Electronics – Fresnel
6. Communication Electronics – Katre

Semester – I/II	Paper - VIII
Course Code: MSC-PHX18 P (B)	**Title of the Course:** Communication Electronics
Credits: 2	**Total Hours: 60 Hrs. (10 Practicals)**

Course Objectives	Course Outcomes
1. Provide in hands on skills of communication technology 2. Explain the physics and electronics behind the communication technology through experiments. 3. Training in skills related to industry and market of communication field through actual experiment. 4. Motivate students to design communication experiments in communication technology	1. The student will design a experiments with a fundamental knowledge of communication media. 2. Learn Digital Communication Systems through experiments. 3. Learn about Telephone, Facsimile and Satellite Communication systems 4. Understand the importance communication electronics and their applications.

Sr. No.	Title of Experiment
1.	Generation of AM Signal and measurement of Modulation Index.
2.	Generation of FM Signal.
3.	Directional characteristics of Dish antenna.
4.	Digital Multiplexing
5.	Study of cordless telephone
6.	Study of PAM, PPM, PWM
7.	Study of 3-way intercom system.
8.	FM Detector using PLL
9.	Design ,build and test Frequency Shift Keying(FSK)
10.	Delta pulse Modulation
11.	Optical communication with LED and Photo-transistor.

12.	Design of AM transmitter and receiver.
13.	Design of FM transmitter and receiver.
14.	Study of Satellite communication system.
15.	Study of Facsimile communication system.
16.	Study of Telephone communication system.

- Industrial visit report / Conference poster Presentation /Conference oral presentation / Project competition or any other activity equivalent to **Two** practicals.

Semester – I/II	Paper – VII
Course Code: MSC-PHX17 T (C)	**Title of the Course:** Physics of Thin Films
Credits: 2	**Total Hours: 30 Hrs.**

Course Objectives	Course Outcomes
1. Explain the importance of thin films in technology through examples. 2. Provide historical background of the physics of thin films 3. Explain various methods of thin film deposition. 4. Motivate students to learn physics behind the thin film technology through experiments. 5. Explain the properties dependent applications of thin films.	1. The student will synthesized thin films using various deposition techniques. 2. Able to analyze the various properties of the deposited thin films. 3. Able to choose proper material for specific application based on the properties. 4. Learn about the Synthesis and Fabrication techniques thin films. 5. Understand the importance of thin films and their applications in real life

Unit I: Introduction to Thin Films and Deposition Techniques (15 Hrs.)

Comparison of thin and thick films, Theory of growth of thin films: Nucleation, Condensation, Capillarity model, Atomistic model, comparison of models, various stages of film growth Physical Vapour Deposition, Chemical Vapour Deposition, Molecular Beam Epitaxy, Sputtering, Spray pyrolysis, Dip coating and Spin coating, Photolithography, Electron –beam deposition, Pulsed Laser Ablation

Unit II: Characterization of properties of Thin Film and Applications. (15 Hrs.)

Optical properties: - absorption coefficient, band gap, Anti reflection, refractive index Mechanical properties: - film thickness, residual stresses, elastic and plastic properties, deformation, Electrical properties: - IV graph, CV graph, Structural properties: - Various structures, hkl planes, crystallite size, Morphological properties.

Applications: - Resistors, capacitors, Junction devices (Metal semiconductor junction), Solar cells, ICs, Optical coating, Thin film sensors (gas and humidity), Thin films for information storage, electro acoustics and telecommunication.

Suggested Readings:

1. Hand book of Thin Film Technology: Maissel and Glang, (Mc Graw Hill)
2. Thin Film Phenomena: K. L. Chopra, (Mc Graw Hill)
3. Material Science of Thin Films: M. Ohring, (Academic Press)

4. Thin Film Process: J. L. Vossen and Kern, (Academic Press)
5. Vacuum Technology (2nd revised edition), A. Roth, (North Hollad)
6. Fundamentals of Materials Processing (Part- II), Prof. Shashank Shekhar and Prof. Anshu Gaur, Department of Materials Science and Engineering, Indian Institute of Technology, Kanpur, https://nptel.ac.in/courses/113/104/113104075/
7. Chemical Engineering Principle of C V D Processes, Professor R. Nagrajan, Department of Chemical Engineering, Indian Institute of Technology Madras, https://nptel.ac.in/courses/103/106/103106115/
8. Materials Characterization Fundamentals of Optical microscopy, Dr. S. Sankaran, Associate Professor, Department of Metallurgical and Materials Engineering, IIT Madras, https://nptel.ac.in/courses/113/106/113106034/
9. Fundamental of X-ray diffraction and transmission microscopy, , Dr. S. Sankaran, Associate Professor, Department of Metallurgical and Materials Engineering, IIT Madras, https://nptel.ac.in/courses/113/106/113106069/

Semester – I/II	Paper - VIII
Course Code: MSC-PHX18 P (C)	**Title of the Course:** Physics of Thin Films
Credits: 2	**Total Hours: 60 Hrs. (10 Practicals)**

Course Objectives	Course Outcomes
1. Explain the importance of thin films in technology through experiments. 2. Hands on training various methods of thin film deposition. 3. Motivate students to learn physics behind the thin film technology. 4. Explain the properties dependent applications of thin films.	1. Hands on training for synthesis of thin films by various synthesis techniques. 2. Understand the basics of characterization techniques used for thin films. 3. Learn the approaches for characterization of thin films. 4. Learn to analyze the various properties like optical, structural properties of the synthesized thin films.

Sr. No.	Title of Experiment
1.	Deposition of metallic thin films by vacuum evaporation method
2.	Deposition of thin films by spray pyrolysis method and thickness measurement by gravimetric method
3.	Thin film formation by Electro-chemical deposition technique
4.	Deposition of thin films by spin coating method and resistance measurement
5.	Deposition of thin film by dip coating method
6.	Deposition of thin film by chemical bath deposition method and thickness measurement
7.	Thickness measurement of thin film by Tolansky method.
8.	Measurement of resistance of thin film by two probe method with variation in temperature
9.	Study of oxidation laws.

10.	Development of microstructures by photolithography.
11.	Measurement of reflectivity and transferability of thin films by using He-Ne laser and Determination of refractive index of a transparent film by Abe's method.
12.	Pattern generation by photolithography
13.	Deposition of thin films by SILAR method.
14.	Determine band gap of deposited thin film by Tauc plot.
15.	Determine thickness of thin film using Swanpoel Method.

- Industrial visit report / Conference poster Presentation /Conference oral presentation / Project competition or any other activity equivalent to **Two** practicals.

Group II: General Elective Courses for Semester I and II

Semester – I/II	**Paper - IX**
Course Code: MSC-PH X19 T (A)	**Title of the Course:** Medical Physics
Credits: 2	**Total Hours: 30 Hrs.**

Course Objectives	Course Outcomes
1. Explain the importance Medical physics and applications 2. Motivate students to learn physics behind the medical applications. 3. Teach signal processing and measurements. 4. Explain amplifiers used in medical physics.	1. Students will acquire basic knowledge of biomedical instrumentation. 2. Students learn handling and operations of different equipment's like ECG, Oxymeter, and Glucometer. 3. Students will be able to record the different health parameters using it. 4. Student will also able to analyze and interpret the recorded data.

Unit I: Introduction to Medical Physics and Sensors (15 Hrs.)

Terminology of medical instrumentation, Physiological system of body, Sources of bioelectric signals, Origin of bioelectric signals, Analysis of ECG pattern, Nernst equation, Various types of bioelectric signals, Basic medical instrumentation system, Electrode-electrolyte interface, Polarizable and non-polarizable electrodes, Electrodes for ECG, EEG, EMG, Resistive sensor, Capacitive sensor, Inductive sensor, Piezoelectric sensor, Temperature sensor.

Unit II: Amplifiers and Signal Processing and measurements (15 Hrs.)

Introduction, Basic amplifier requirements, The Differential amplifier, Common mode rejection, Instrumentation amplifier, Isolation amplifier, Pateint safety, Cardiac monitor, Direct measurements of blood pressure, Indirect measurements of BP, Heart sounds, Phonocardiography, Ultrasonic blood flow meter, Laser Doppler blood flow meter.

Suggested Readings:

1. Handbook of Biomedical Instrumentation, R.S. Khandpur
2. Medical Instrumentation application design, John G Webster, Houghon Mifflin Co.
3. Clinical Biophysics, P. Narayanan
4. Introduction to biomedical equipment technology J. Carr and John M. Brown
5. Introduction to Biomedical Electronics, Joseph DfuBovy, Mc Graw Hill.

Semester – I/II	Paper - IX
Course Code: MSC-PH X19 T (B)	**Title of the Course:** Introduction to C++
Credits: 2	**Total Hours: 30 Hrs.**

Course Objectives	Course Outcomes
1. Explain the importance C++ programming and their applications. 2. Motivate students to learn programming languages. 3. Motivate students to use of C++ language in physics. 4. Encourage students for logic development.	1. Understanding about object oriented programming. 2. Gain knowledge about the capability to store information together in an object. 3. Understand the capability of a class to rely upon another class. 4. Learn how to store one object inside another object 5. Learn use of one method can be used in variety of different ways

Unit I: Introduction to C++ **(15 Hrs.)**

Evolution of Programming methodologies, Introduction to OOP and its basic features, Basic components of a C++, Program and program structure, Compiling and Executing C++ Program. Selection control statements in C++. Data types, Expression and control statements Iteration statements in C++, Introduction to Arrays, Multidimensional Arrays, Strings and String related Library Functions. Functions, Passing Data to Functions, Scope and Visibility of variables in Functions, Structures in C++.

Unit II: Programming using C++ **(15 Hrs.)**

Creating classes and Abstraction: Classes objects, data members, member functions, this Pointer, Friends, Friend Functions, Friend Classes, Friend Scope, and Static Functions. Constructors and Destructors, Static variables and Functions in class. Operator Overloading in C++, Overloading Unary Operators, Overloading binary operators. Files and streams in C++: Character, String input, and output to files, Command Line Arguments and Printer Output. Standard input and output operations: C++ iostream hierarchy, Standard Input/output Stream Library, Organization Elements of the iostream Library, Programming using Streams, Basic Stream Concepts.

Suggested Readings:

1) C++ common knowledge: essential intermediate programming/ C++ (Computer program language) , Dewhurst, Stephen C. Addison-Wesley, Upper Saddle River, N. J.: 2005.
2) C++ programming cookbook Herb Schildt's C++ programming cookbook / C++ (Computer program language), Schildt, Herbert. McGraw-Hill, New York: c2008.

3) Problem solving with C++: The object of programming/ C++ (Computer program language) Savitch, Walter. Pearson Addison Wesley, Boston: 2005. Fifth Edition (International ed.)
4) Programming in C++, Prof. Partha Pratim DasDepartment of Computer Science and Engineering, Indian Institute of Technology, Kharagpur, https://nptel.ac.in/courses/106/105/106105151/
5) An Introduction to Programming through C++ , Professor Abhiram G. Ranade, Department of Computer Science and Engineering, Indian Institute of Technology Bombay, https://nptel.ac.in/courses/106/101/106101208/

Semester – I/II	Paper - IX
Course Code: MSC-PH X19 T (C)	**Title of the Course:** Advanced Characterization Techniques
Credits: 2	**Total Hours: 30**

Course Objectives	Course Outcomes
1. Explain various characterization techniques. 2. Explain the importance characterization techniques in recent trends of science. 3. Teach basics of characterization techniques. 4. Motivate students to use of characterization techniques in the material science.	1. Learn basics of characterization techniques and their uses. 2. Learn use of characterization techniques in industrial and scientific applications. 3. Able to analyze data with characterization methods for defects and characterization of industrial components.

Unit I: Advanced Characterization Techniques - I (15 Hrs.)

Introduction: X-Ray, their production &properties Review of basic diffraction theory; Properties of neutron radiation; neutron sources; Small angle neutron scattering; Examples.

Advanced Surface Characterization Techniques: XPS, AES & SIMS; Importance of surface, characterization techniques; Physical principles of XPS, Photoelectric effects.

Unit II: Advanced Characterization Techniques - II (15 Hrs.)

Advanced Spectroscopic Techniques: Introduction; Electromagnetic spectroscopy; UV-Visible Spectroscopy; Photo-luminescence spectroscopy; Infrared spectroscopy; Raman

Advanced Microscopic Techniques: Introduction; Electron-materials interactions; TEM, SEM, AFM.

Suggested Readings:

1) Materials Characterization Techniques Sam Zhang, Lin Li, Ashok Kumar;CRC press,(2008)
2) Transmission Electron Microscopy; D.B. Williams and C.B. Carter,Plenum Press (2004)
3) Modern ESCAThe Principles and Practice of X-Ray Photoelectron Spectroscopy, Terry L.Barr, CRC press, (1994)
4) Scanning Electron Microscopy and X-ray Microanalysis by Joseph Goldstein, Dale E. Newbury, David C. Joy, and Charles E.;Springer Science (2003)

5) Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series) A.K. Tyagi, Mainak Roy,S.K.Kulshreshtha and S.Banerjee;, Volumes 49 – 51 (2009)
6) Encyclopedia of Materials Characterization Editors: c.r. Brundle, C.A.Evens, Jr,S. Wilson, Butterworth-Heinmann, Boston (1992)
7) Advanced Characterization techniques by Dr. Krishanu Biswas Department of Materials and Metallurgical Engineering, IIT, Kanpur https://nptel.ac.in/courses/113/104/113104004/
8) Materials Characterization, Fundamentals of Optical microscopy, Dr. S. Sankaran Associate Professor, Department of Metallurgical and Materials Engineering IIT Madras, https://nptel.ac.in/courses/113/106/113106034/

Semester – I/II	Paper - IX
Course Code: MSC-PH X19 T (D)	**Title of the Course:** Biophysics
Credits: 2	**Total Hours: 30 Hrs.**

Course Objectives	Course Outcomes
1. Learn the chemical structure of the major classes of biomolecules. 2. Explain the physicochemical principles of molecular interactions. 3. Explain the physical principles and applications of important biophysical techniques. 4. Explain basic techniques of signal processing, data analysis, and data fitting when using biophysical or other techniques	1. Students will acquire basic knowledge of biophysics. 2. Students learn handling and operations of different equipment's like ECG, PET, NMR, CT scan, etc. 3. Students learn basic physics behind this different equipment.

Unit I: Introduction to Biophysics (15 Hrs.)

History of Biophysics, Concept of Biophysics, Surface tension, Viscosity, adsorption, diffusion, osmosis, Biostatistics and Biometry.

Cell: Animal and plant cell, types of cell, Functional aspects of cell membrane, cytoplasm, nucleus, mitochondria and chloroplast,

Introduction to Protein Structure, Secondary and Tertiary Structure of Proteins, amino acid structure, Protein Denaturation, Genetic code- symmetry, DNA structure,

Unit II: Biophysics Instrumentation and Radiation Biophysics (15 Hrs.)

Basic principle, Construction and working of colorimeter, spectrophotometer, PH meter and Centrifuge measurement. ECG (Electrocardiography), Electron Microscope: SEM, TEM

Definition, Units of Radioactivity and radiation doses, Types of radiation (Ionizing and non-ionizing), radio immune assays. Applications: Positron Emission Tomography (PET), NMR, MRI, Ultrasonography, CT scan.

Suggested Readings:

1. Introduction to Biophysics - by P. Narayanan.New Age P.
2. Medical Instrumentation - by Khandpur, TMH
3. Laboratory Manuals of Biophysics Instruments - by P.B. Vidyasagar
4. Biophysics -by Vatsala Piramal, Dominant Publisher and Distributors, New Delhi-110002

5. Textbook of Biophysics - by R.N. Roy
6. Physics of biomedical systems, Prof. M. Mitra, Department of Physics, IIT Bombay, https://nptel.ac.in/courses/115/101/115101121/
7. Biophysics Chemistry by Dr. P. Chowdhary, Department of Chemistry, IIT Delhi, https://nptel.ac.in/courses/104/102/104102009/#

Semester – I/II	Paper - IX
Course Code: MSC-PH X19 T (E)	**Title of the Course:** Sensors and Transducer
Credits: 2	**Total Hours: 30 Hrs.**

Course Objectives	Course Outcomes
1. Learn the chemical structure of the major classes of biomolecules. 2. Explain the physicochemical principles of molecular interactions. 3. Explain the physical principles and applications of important biophysical techniques. 4. Explain basic techniques of signal processing, data analysis, and data fitting when using biophysical or other techniques	1. Learn concepts in common methods for converting a physical parameter into an electrical quantity 2. Choose proper sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc 3. Learn use of different type of sensors for real life applications.

Unit I: Mechanical, Electromechanical and Capacitive sensor (15 Hrs.)

Definition, principle of sensing & transduction, classification. Resistive (potentiometric type): Forms, material, resolution, accuracy, sensitivity. Strain gauge: Theory, type, materials, design consideration, sensitivity, gauge factor, variation with temperature, adhesive, rosettes. LVDT: Construction, material, output input relationship, I/O curve, discussion.

Variable distance-parallel plate type, variable area- parallel plate, serrated plate/teeth type and cylindrical type, variable dielectric constant type, calculation of sensitivity. Stretched diaphragm type: microphone, response characteristics.

Unit II: Thermal, magnetic and Radiative sensors (15 Hrs.)

Material expansion type: solid, liquid, gas & vapor Resistance change type: RTD materials, tip sensitive & stem sensitive type. Thermo emf sensor: types, thermoelectric power, general consideration, Junction semiconductor type IC and PTAT type.

Sensor based on Villari effect for assessment of force, torque, proximity, Wiedemann effect for yoke coil sensors, Thomson effect, Hall effect, and Hall drive, performance characteristics. Radiation sensors: LDR.

Suggested Readings:

1) R Sensor & transducers, D. Patranabis, 2nd edition, PHI
2) Instrument transducers, H.K.P. Neubert, Oxford University press.
3) Measurement systems: application & design, E.A.Doebelin, Mc Graw Hill

4) Sensor & transducers, D. Patranabis, 2nd edition, PHI
5) Instrument transducers, H.K.P. Neubert, Oxford University press.
6) Measurement systems: application & design, E.A.Doebelin, Mc Graw Hill
7) Sensors and Actuators by Dr. H. J. Pandya, Department of Electronics System Engneering, IISC, Bengaluru, https://nptel.ac.in/courses/108/108/108108147/
8) Industrial Instrumentation by Prof. A. Barua, Department of Electrical Engineering, IIT Khargapur, https://nptel.ac.in/courses/108/105/108105064/

Semester -I	Paper – IX
Course Code: MSC-PH X19 T (F)	**Title of the Course:** Digital Electronics
Credits: 2	**Total Hours: 30 Hrs.**

Course Objectives	Course Outcomes
1. Learn the digital logic circuits and Boolean algebra.. 2. Explain use of Karanaugh Map to design 4-variable logic circuits. 3. Explain Digital to Analog converters like Binary weighted and R-2R ladder 4. Explain analog to Digital converters: Single slope, Dual slope, etc.	1. Learn basics of Digital Electronics and Boolean algebra. 2. Understand Both Combinational and Sequential digital Logic Circuits. 3. Understand various D/A data convertor types. 4. Understand various A/D data convertor types.

Unit I: Digital Logic Circuits **(15 Hrs.)**

Combinational Logic: Review of Boolean identities and its use to minimize Boolean expressions. Use of Karanaugh Map to design 4-variable logic circuits like BCD to 7-segment decoder, Binary-to-Gray and Gray-to-Binary code converter. Sequential Logic: bit serial, parallel and combinational counter. Study of IC 7490 with applications as MOD counters (01 to 99)Study of IC 7495 and its use as SISO, SIPO, PIPO and PISO.UP-DOWN counters, Ring counter and their applications..

Unit II: Data Converters **(15 Hrs.)**

Digital to Analog converters: Binary weighted and R-2R ladder type with practical circuit (Using Input switches, Level amplifiers, Control gates and Buffer amplifier), Analog to Digital converters: Single slope, Dual slope, Flash (Simultaneous) type, Counter ramp type, Continuous type and Successive approximation type**.**

Suggested Readings:

1. Digital Electronics by R.P. Jain
2. Digital Principles and Applications by Leach and Malvino
3. Digital Electronics: An Introduction to Theory and Practice by W.H. Gothmann
4. Digital Electronics by T. L. Floyd
5. Digital Electronic Circuits by Prof. Goutam Saha, Department of E and EC Engineering, Indian Institute of Technology, Kharagpur, https://nptel.ac.in/courses/108/105/108105132/
6. Digital Circuits and Systems, Prof. S. Srinivasan, Department of Electrical Engineering, Indian Institute of Technology Madras, https://nptel.ac.in/courses/117/106/117106086/