Rayat Shikshan Sanstha's

R. B. Narayanrao Borawake College, Shrirampur

(Autonomous)

(Affiliated to Savitribai Phule Pune University, Pune)

Department of Physics

M.Sc. I (Physics) Syllabus as per NEP-2020

Implemented

From

Academic Year: 2023-24

Course Structure of M. Sc. I (Physics)

(Semester-I)

Year	Semester	Course Type	Course Code	Course Title	Theory/ Practical	Credits	No. of Lectures/ Practicals to be conducted	Page No.
1st	I	Major Core	PH-MJ-511T	Mathematical Methods in Physics	Theory	4	60L	4-5
			PH-MJ-512T	Classical Mechanics	Theory	4	60L	6-7
			PH-MJ-513T	Atoms and Molecules	Theory	2	30L	8-9
			PH-MJ-514P	Physics Laboratory I & II	Practical	4	12P	10-12
		Major Elective	PH-ME-515T	Theory Elective I	Theory	2	30L	13-15
			PH-ME-516P	Practical Elective I	Practical	2	6P	16-18
		Research Methodology	PH-RM-517T	Research Methodology	Theory	4	60L	19-20

Course Structure of M. Sc. I (Physics)

(Semester-II)

Year	Semester	Course Type	Course Code	Course Title	Theory/ Practical	Credits	No. of Lectures/ Practicals to be conducted	Page No.
1st	II	Major Core	PH-MJ-521T	Electrodynamics	Theory	4	60L	22-23
			PH-MJ-522T	Quantum Mechanics	Theory	4	60L	24-25
			PH-MJ-523T	Electronics	Theory	2	30L	26-27
			PH-MJ-524P	Physics Laboratory III & IV	Practical	4	12P	28-30
		Major Elective	PH-ME-525T	Theory Elective II	Theory	2	30L	31-33
			PH-ME-526P	Practical Elective II	Practical	2	6P	34-36
		OJT	PH-OJT-527	Field Project/On Job Training	--	4	-	-

Syllabus for M. Sc. I (Physics)

Semester I

DISCIPLINE SPECIFIC CORE COURSE (PH-MJ-511T):

Mathematical Methods in Physics

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-MJ-511T - Mathematical Methods in Physics	4	4	--

❖LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

1. Introduce students to the mathematical tools used in physics, such as differential equations, linear algebra, and complex analysis.
2. Develop students' ability to use these mathematical tools to solve problems in physics.
3. Provide students with a foundation in the mathematical concepts that is essential forfurther study in physics.

❖COURSE OUTCOMES:

After completion of this course student should be able to:

CO-1: Describe the fundamental concepts of Fourier, Laplace, and complex analysis.

CO-2: Apply mathematical tools, special functions on polynomials to solve physical problems andidentify mathematical concepts related to physics to generate solutions.

CO-3: Develop Fourier series and Fourier and Laplace transformations to resolvemathematical issues pertaining to the physical sciences.

CO-4: Discuss basic theory of Linear Algebra, Matrix algebra and special functions.

SYLLABUS OF PH-MJ-511T: Mathematical Methods in Physics [60 Hours]

Unit-I: Complex analysis [15 Hours]

1.1 Complex variable, Function of a complex variable, Limit of a function of a complex variable, Continuity, Differentiability,

1.2 Analytic functions, Cauchy-Riemann Equations,Harmonic Functions,

1.3 Complex Integration, Cauchy integral theorem, Cauchy integral formula,

1.4 Derivatives of analytic functions, Power Series, Taylor's theorem, Laurent's theorem,

1.5 Calculus of Residues, Cauchy's Residue theorem, Evaluation of real definite integrals.

Unit-II: Linear algebra [15 Hours]

2.1 Vector Spaces and Operators: Vector spaces and subspaces, Linear Spans, Linear dependence and independence, Basis and Dimensions.

2.2 Matrix algebra: Matrix representation of a linear operator, Change of basis, Polynomials of matrices, Characteristic polynomial, Cauchy Hamilton theorem, Diagonalization, Eigenvalues and Eigenvectors. Inner Product Spaces.

2.3 Orthogonality: Inner product spaces, Orthogonality, Orthogonal sets and basis, Gram-Schmidt orthogonalization process.

Unit-III: Special functions **[15 Hours]**

3.1 Legendre, Hermite and Laguerre function – Generating function, Recurrence relations and their differential equations,

3.2 Orthogonality properties, Bessels's function of first kind, Spherical Bessel function, Associated Legendre function, Spherical harmonics.

Unit-IV: Fourier series and integral transforms **[15 Hours]**

4.1 Fourier Series: Definition, Dirichlet's condition, Convergence, Parseval's identity, Fourier Integral and Fourier transform, Convolution theorem, Applications of Fourier Transform to solve differential equations

4.2 Laplace transforms and its properties, Applications of Laplace transform to solve differential equations, Laplace transform of Dirac Delta function.

❖ ESSENTIAL/RECOMMENDED READINGS:

1. Complex Variables and Applications – J.W.Brown, R.V.Churchill, 7th Edition, Mc-GrawHill.
2. Complex Variables – Schaum's Outlines Series, 2ndEdition, Tata McGraw-Hill Edition.
3. Higher Mathematical Physics- H.K. Dass & Dr. Rama Verma-S. Chand. & Co. Pvt. Ltd
4. Linear Algebra – Schaum's Outlines Series- 3rd Edition, Tata Mc-Graw Hill Edition.
5. Matrices and Tensors in Physics, A. W. Joshi, 3rdEdition, New Age International.
6. Mathematical Methods for Physicists – Arfken & Weber – 6th Edition-Academic Press,N.Y.
7. Mathematical Methods in the Physical Sciences – Mary Boas, John Wiley & Sons.
8. Fourier series - Seymour Lipschutz, Schaum's Outlines Series. Tata Mc-Graw Hill Edition
9. Laplace Transform - Seymour Lipschutz, Schaum's Outlines Series. Tata Mc-Graw HillEdition
10. Mathematical Methods in Physics – B. D. Gupta.

DISCIPLINE SPECIFIC CORE COURSE (PH-MJ-512T):

Classical Mechanics

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-MJ-512T - Classical Mechanics	4	4	--

❖ LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

1. Develop a deep understanding of the fundamental laws of motion, such as Newton's lawsof motion and conservation laws.
2. Develop the mathematical and analytical skills necessary to solve problems in classical mechanics.
3. Communicate effectively about classical mechanics concepts and principles.

❖ COURSE OUTCOMES:

After completion of this course student should be able to:

CO-1: Describe the various techniques used to solve motion equations.
CO-2: Solve mechanical problems, use a variety of mathematical methods and tools.
CO-3: Discuss and give examples of constraints and methods of eliminating them.
CO-4: Set up Lagrangian and Hamiltonian formulation.
CO-5: Introduction to Canonical transformations and Poisson brackets.

SYLLABUS OF PH-MJ-512T: Classical Mechanics **[60 Hours]**

Unit-I: Analytical Dynamics (Lagrangian and Hamiltonian Dynamics) **[15 Hours]**

1.1 Newtonian mechanics, Disadvantage of Newtonian mechanics,
1.2 Principle of virtual work, D'Alembert's Principle,
1.3 Types of constraints, Generalized co-ordinates, Degrees of freedom,
1.4 Variational principle and its applications,
1.5 Lagrangian and Hamiltonian equations of motion
1.6 Hamiltonian for a charged particle,
1.7 Properties of kinetic energy function,
1.8 Time-dependence of total energy (theorem on total energy)

Unit-II: Canonical transformations and Poisson brackets **[15 Hours]**

2.1 Symmetry and conservation laws (energy and momentum), Gauge function for Lagrangian, Invariance under Galilean transformation
2.2 Legendre transformations, Generating function,
2.3 Conditions for canonical transformation and problem. Definition, Identities,
2.4 Poisson theorem, Jacobi-Poisson theorem, Jacobi identity (statement only),

2.5 Invariance of Poisson Bracket under canonical transformation.

Unit-III: Central Forces and Non-inertial Frames of Reference [15 Hours]

3.1 Lagrangian formulation of motion under central force,
3.1 Kepler problem, Inverse square law and orbital equation,
3.1 Stability of orbits, Motion of satellites,
3.1 Rotating frames of reference, Coriolis force, banking of rivers, Foucault's pendulum and tides.

Unit-IV: Rigid Body Dynamics and Small Oscillations [15 Hours]

4.1 Moment of inertia tensor, Euler angles, Angular momentum and torque in Euler's angle, Euler equation of motion for rigid body motion,
4.2 Symmetric top, General theory of small oscillations,
4.3 Lagrangian for small oscillations, Secular equation and eigen value equation,
4.4 System of coupled oscillators, Normal modes and normal coordinates, Vibrations of linear triatomic molecule.

❖ **ESSENTIAL/RECOMMENDED READINGS:**

1 Classical Mechanics: H. Goldstein, C. Poole and J. Safko, Addison-Wesley.
2 Classical Mechanics: N.C. Rana and P.S. Joag, Tata McGraw-Hill Education.
3 Classical Mechanics: J.R. Taylor, University Science Books.
4 Classical Mechanics: P.V. Panat, Narosa Publishing House.
5 Classical Mechanics: Y.R. Waghmare, Prentice-Hall of India.

DISCIPLINE SPECIFIC CORE COURSE (PH-MJ-513T):

Atomic and Molecular Physics

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-MJ-513T - Atomic and Molecular Physics	2	2	--

❖ LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

1. Understand the fundamental principles of atomic and molecular physics, such as the Schrödinger equation, the uncertainty principle, and the Bornrule.
2. Apply these principles to solve problems involving atoms, molecules, and other quantum systems.
3. Develop a deep understanding of the nature of matter and energy at the atomic and molecularlevels.
4. Communicate effectively about atomic and molecular physics concepts and principles.

❖ COURSE OUTCOMES:

After completion of this course student should be able to:

CO1: Describe the theories explaining the structure of atoms and the origin of observed spectra.

CO2: Calculate quantities associated with different types of spectra exhibited by atoms, molecules and solids, heat capacities using different models and structural properties.

CO3: Get familiar with ESR, NMR and X-ray diffraction techniques.

CO4: Analyze spectra and identify the effect of magnetic and electric fields on it.

SYLLABUS OF PH-MJ-513T: Atomic and Molecular Physics [30 Hours]

Unit-I: Atoms and Molecules [15 Hours]

1.1. Revision (Atomic structure and atomic spectra, quantum numbers, Pauli's exclusion principle, electron configuration, Terms for equivalent and non-equivalent electrons, Hand's rules, Origin of spectral lines, selection rules, spectra of one electron atoms, spectra of two electron atoms.)

1.2. Fine structure and hyperfine structure,

1.3. Normal Zeeman Effect and Anomalous Zeeman effect, Paschen- Back effect.

1.4. Molecular Spectra: Rotational and vibrational spectra for diatomic molecules,

1.5. Electronics spectra of diatomic molecules, vibration course structure, vibrational analysis of band structure,

1.6. Frank – Condon principle, rotational fine structure of electronic vibration transitions, electronic angular momentum in diatomic molecules.

Unit-II: Resonance Spectroscopy **[7 Hours]**

2.1 ESR: Principles of ESR, ESR spectrometer,

2.2 NMR: Magnetic properties of nucleus, resonance condition, NMR instrumentation, applications of NMR.

Unit-III: Spectroscopic Techniques **[8 Hours]**

3.1 Microwave Spectroscopy,

3.2 Infrared spectroscopy,

3.3 Raman spectroscopy

3.4 Fourier transform Ramanspectrometer

❖ ESSENTIAL/RECOMMENDED 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

DISCIPLINE SPECIFIC CORE COURSE (PH-MJ-514P):

Physics Lab-I

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-MJ-514P - Physics Lab-I & II	**2**	**--**	**2**

Section I:

❖ **LEARNING OBJECTIVES:**

The learning objectives of this course are as follows:

1. Apply the principles of electronics to the design and construction of real-world electronic devices.
2. Develop the ability to troubleshoot and repair electronic circuits.
3. Develop the practical skills necessary to design, build, and test electronic circuits.
4. Use electronic test equipment, such as oscilloscopes, multimeters, and signal generators.

❖ **COURSE OUTCOMES:**

After completion of this course student should be able to:

CO-1: Design skills of electronic circuits.
CO-2: Handling of electronic instruments.
CO-3: Explain internal block diagram and working of the ICs.
CO-4: Illustrate the use of dedicated ICs in different circuits.
CO-5: Explain working of circuits using operational amplifiers, timers.

SYLLABUS OF PH-MJ-514P: Physics Laboratory-I

Student has to perform any 12 Experiments:

1. Diode Pump Staircase generator using UJT
2. Fold back Power Supply
3. Crystal Oscillator & Digital Clock
4. Voltage Control Oscillator using IC-566
5. Function generator using IC -8038
6. Optocoupler using OPAMPs and IC MCT-2E
7. Constant current Source using OP-AMP
8. Active filters using OP-AMP (L-P, H-P type)
9. Active filters using IC- 8038 (L-P, H-P type)
10. Precision rectifier
11. PLL application using IC565
12. Voltage to Frequency / Frequency to voltage converter using OP-AMP
13. Schmitt trigger using IC-741

14. Integrator and Differentiator using IC-741.

❖ ESSENTIAL/RECOMMENDED READINGS:

1. Signetic Manual Power Supplies: B.S. Sonde
2. Digital Principles: Malvino (6th Edition, Tata McGraw Hill Publication Co. Ltd. Delhi)
3. Operational Amplifier: G.B. Clayton
4. OP-AMPS and Linear Integrated Circuits: Ramakant Gaikwad
5. Data Converters: B.S. Sonde, Tata Mc-Graw Hill Pub. Co. Ltd. (1974)
6. Pulse, Digital and Switching Circuits: Miliman and Taub
7. Electronic Integrated Circuits and Systems: Franklin, C. Fitchen (Van No strand Reinhold Company)
8. Digital Principles and Applications: Leach and Malvino, Tata Mc-Graw Hill Pub.Co. Ltd. N. Delhi (5th Edition, 2002)

Section II:

❖ LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

1. Apply the principles of electronics to the design and construction of real-world electronic devices.
2. Develop the ability to troubleshoot and repair electronic circuits.
3. Develop the practical skills necessary to design, build, and test electronic circuits.
4. Use electronic test equipment, such as oscilloscopes, multimeters, and signal generators.

❖COURSE OUTCOMES:

After completion of this course student should be able to:

CO-1: Design skills of electronic circuits.
CO-2: Handling of electronic instruments.
CO-3: Explain internal block diagram and working of the ICs.
CO-4: Illustrate the use of dedicated ICs in different circuits.
CO-5: Explain working of circuits using operational amplifiers, timers.

SYLLABUS OF PH-MJ-514P: Physics Laboratory-II

Student has to perform any 12 Experiments:

1 Millikan Oil Drop Apparatus:

i. To measure the rise and fall times of the oil droplets at different voltages having different charges to determine the radii of droplets.

ii. To measure the rise and fall times of the oil droplets at different voltages having different charges to determine the charge 'e' on the droplets.

2 Michelson's Interferometer:

To determine the wavelength of He-Ne LASER by using Michelson's Interferometer apparatus.

3 Specific Heat of Solids:

To determine the specific heat of copper, lead and glass at three different temperatures.

4 Electron Spin Resonance:

i.To study the Electron Spin Resonance

ii. To determine Lande's g-factor

5 Frank-Hertz experiment:

To study the discrete energy levels using Frank-Hertz experiment.

6 G.M. counter:

Counting statistics

Characteristics of GM tube

Determination of end point energy of β-ray source.

Determination of dead time of GM tube by Double source method

7 Skin depth:

Skin depth in Al using electromagnetic radiation.

8 Gouy's Method:

Measurement of magnetic susceptibility of $MnSO_4$

❖ **ESSENTIAL/RECOMMENDED READINGS:**

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

MAJOR ELECTIVE COURSE (PH-ME-515T):

Theory Elective- I

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-ME-515T - Theory Elective- I	2	2	--

Elective Option A

PH-ME-515(A) T

Computational Physics

❖ **LEARNING OBJECTIVES:**

The learning objectives of this course are as follows:

1. This course aims to familiarize the students with the numerical methods used in computation and programming using FORTRAN language to solve physics problems.
2. To impart basic knowledge of computational physics in solving the physics problems.
3. To use computer programming language for simulation and data analysis

❖ **COURSE OUTCOMES:**

Upon completion of the course, the student should be able to:

CO1: Apply basic knowledge of computational physics in solving the physics problems.
CO2: Demonstrate concepts related to variables, I/O, arrays, procedures, modules, pointers in FORTRAN.
CO3: Programmed with the FORTRAN or any other high-level language.
CO4: Use various numerical methods in solving physics problems.
CO5: Analyze the outcome of the algorithm/program graphically.

SYLLABUS OF PH-ME-515(A)T: Computational Physics [30 Hours]

Unit-I: Introduction to Fortran 90 [15 Hours]

1.1.Introduction to Fortran_90, Character sets, structure of statements, Structure of a
1.2 Fortran Program, compiling, linking and executing the Fortran program.
1.3 Constants & Variables, Arithmetic & Logical Expressions, Arithmetic & Logical
1.4 operators. Input Output Statements, Conditional Statements, Looping, Functions & Subroutines, Defining and Manipulating Arrays & Strings. Pointers,
1.5 Data Types & Modules, File Processing.

Unit-II: Numerical Methods **[15 Hours]**

2.1 Numerical differentiation – Lagrange interpolation, Numerical integration by Simpson (1/3) rule and Weddle's rules,

2.2 Numerical solution of differential equations by Taylor's Series, Euler method, Newton Raphson Method, Runge-Kutta methods, Guasse limination method, Gauss-Seidel iterative method, Monte Carlo simulations.

2.3 Application of F90 to solve the problems based on these methods.

❖ ESSENTIAL/RECOMMENDED READINGS:

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 Wile

<u>Elective Option B</u>

PH-ME-515(B)T

Industrial Electronics

❖ LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

1. To study the IoT and IoT protocols
2. To study the basics of communication
3. To study the basics of Aurdino and programming.

❖ COURSE OUTCOMES:

Upon completion of the course, the student should be able to:

CO1: Understand IoT and IoT protocols.

CO2: Understand Communication technology

CO3: Understand Aurdino and programming

SYLLABUS OF PH-ME-515(B)T: Industrial Electronics **[30 Hours]**

Unit-1 Fundamentals of IoT and Digital Communications **[15 Hours]**

1.1 Definition and characteristics of IoT,

1.2 Technical Building blocksof IoT, Devices,

1.3 Communication Technologies, Physical design ofIoT,

1.4 IoT enabling technologies,

1.5 IoT Issues and Challenges-Planning, Costs and Quality,Security and Privacy, Risks MQTT, CoAP, XMPP and AMQT, IoT communication models,

1.6 IoT Communication technologies: Bluetooth, BLE, Zigbee, Zwave, NFC, RFID, Zigbee etc.

Unit-2 Industrial Electronics Automation Lectures [15 Hours]

2.1 Introduction to Arduino: Introduction to microcontroller and microprocessors, role of embedded systems, open source embedded platforms,

2.2 Introduction to Arduino IDE- features, IDE overview,

2.3 fundamentals of embedded C Programming concepts: variables, functions

❖ ESSENTIAL/RECOMMENDED READINGS:

1) Internet of Things–A hands on approach, Arshdeep Bahga, Vijay Madisetti, Universitie 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

MAJOR ELECTIVE COURSE (PH-ME-516P):

Practical Elective-I

Course Code & Title	Credits	Credit Distribution of the Course	
		Lecture	Practical
PH-ME-516P - Practical Elective-I	2	--	2

<u>**Elective Option A**</u>

PH-ME-516(A)P

Computational Physics (Practical)

❖ **LEARNING OBJECTIVES:**

The learning objectives of this course are as follows:

1. This course aims to familiarize the students with the numerical methods used in computation and programming using FORTRAN language to solve physics problems.
2. To impart basic knowledge of computational physics in solving the physics problems.
3. To use computer programming language for simulation and data analysis

❖ **COURSE OUTCOMES:**

Upon completion of the course, the student should be able to:

CO1: Apply basic knowledge of computational physics in solving the physics problems.

CO2: Demonstrate concepts related to variables, I/O, arrays, procedures, modules, pointers in FORTRAN.

CO3: Programmed with the FORTRAN or any other high-level language.

CO4: Use various numerical methods in solving physics problems.

CO5: Analyze the outcome of the algorithm/program graphically.

SYLLABUS OF PH-ME-516(A)P: Computational Physics (Practical)

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.

❖ ESSENTIAL/RECOMMENDED READINGS:

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.
6. Vellerling, B. P. Flannery, Cambridge University Press (1997)
7. Computational Physics - An introduction, R. C. Verma, P. K. Ahluwalia, K. C.
8. Sharma, New Age International Publishers (2005).

<u>Elective Option B</u>

PH-ME-516(B)P

Industrial Electronics (Practical)

❖ LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

1. To study the IoT and IoT protocols
2. To study the basics of communication
3. To study the basics of Aurdino and programming.

❖ COURSE OUTCOMES:

Upon completion of the course, the student should be able to:

CO1: Understand IoT and IoT protocols.

CO2: Understand Communication technology

CO3: Understand Aurdino and programming

SYLLABUS OF PH-ME-516(B)P: Industrial Electronics (Practical)

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

❖ ESSENTIAL/RECOMMENDED READINGS:

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,
4. Olivier Hersent, Omar Elloumi and David Boswarthick, Wiley

RESEARCH METHODOLOGY COURSE (PH-RM-517T): Research Methodology

Course Code & Title	Credits	Credit Distribution of the Course	
		Lecture	Practical
PH-RM-517T - Research Methodology	4	4	--

❖ LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

1. They should also be familiar with the different types of research designs, such as experimental, quasi-experimental, and correlational designs.
2. Students should be able to identify a research problem, develop a research question or hypothesis, design a study, collect data, analyze data, and interpret results.

❖ COURSE OUTCOMES:

After completion of this course student should able to:

CO-1: Define research and identify the different types of research.

CO-2: Understand the research process, from problem identification to data analysis and interpretation.

CO-3: Collect data using a variety of methods, including surveys, interviews and observations

CO-4: Analyze data using statistical software.

CO-5: Interpret data and draw conclusions.

CO-6: Communicate research findings in a clear and concise way.

SYLLABUS OF PH-RM-517T: Research Methodology [30Hours]

Unit-I: Introduction to Research Methodology [15 Hours]

1.1 Definition of Research, Qualities of Researcher, Components of Research Problem

1.2 Various Steps in Scientific Research: Hypotheses, Research Purposes, Research Design, Literature Searching.

Unit-II: Design and Planning of Experiments, Time Scheduling [15 Hours]

2.1 Aims and Objectives, expected outcome, Methodology to be adapted,

2.2 Planning of experiments for achieving the aims and objectives,

2.3 Importance of reproducibility of research work.

2.4 DATA COLLECTION: Sources of Data: Primary Data, Secondary Data; Sampling Merits and Demerits of Experiments, Procedure and Control Observations, Sampling Errors - Type-I Error - Type-II Error.

Unit-III: Statistical Analysis and Fitting of Data [15 Hours]

3.1 Introduction to Statistics – Probability Theories - Conditional Probability,
3.2 Poisson Distribution, Binomial Distribution and Properties of Normal Distributions,
3.3 Estimates of Means and Proportions; Chi-Square Test, Association of Attributes - t-Test Standard deviation - Co-efficient of variations. Correlation and Regression Analysis.
3.4 Introduction to statistical packages, plotting of graphs.

Unit-IV: Scientific Report Writing [15 Hours]

4.1 Structure and Components of Research Report,
4.2 Types of Report: research Papers, thesis. Research Project Reports, Pictures and Graphs, citation styles.

❖ ESSENTIAL/RECOMMENDED READINGS:

1) "How to write and Publish" by Robert A. Day and Barbara Gastel, (Cambridge University Press).
2) "Survival skills for Scientists" by Federico Rosei and Tudor Johnson, (Imperial College Press).
3) "How to Research" by Loraine Blaxter, Christina Hughes and Malcum Tight, (Viva Books).
4) "Probability and Statistics for Engineers and Scientists" by Sheldon Ross, (Elsevier Academic Press)
5) "The Craft of Scientific Writing" by Michael Alley, (Springer).

Syllabus for M. Sc. I (Physics)

Semester II

DISCIPLINE SPECIFIC CORE COURSE (PH-MJ-521T):

Electrodynamics

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-MJ-521T - Electrodynamics	4	4	--

❖ **LEARNING OBJECTIVES:**

The learning objectives of this course are as follows:

1. Understand the fundamental laws of electromagnetism, such as Coulomb's law, Gauss'slaw, and Faraday's law.
2. Apply these laws to solve problems involving electric and magnetic fields, such as themotion of charged particles and the propagation of electromagnetic waves.
3. Develop a deep understanding of the nature of electricity and magnetism.
4. Communicate effectively about electrodynamics concepts and principles.

❖ **COURSE OUTCOMES:**

After completion of this course student should be able to:

CO-1: Understand the basic concepts of electrostatics, magnetostatics, and electromagnetic waves.

CO-2: Understand the basic concepts of electrostatics, magnetostatics, and electromagnetic waves.

CO-3: Analyze the behavior of electromagnetic waves in different media.

CO-4: Determine charged particle dynamics and radiation from localized time varying electromagnetic sources.

CO-5: Compose relative problems in electrodynamics and resolve them through the fundamental equations.

SYLLABUS OF PH-MJ-521T: Electrodynamics [60Hours]

Unit-1: Electrostatics and Dielectrics: [15 Hours]

1.1 Electrostatics: Coulomb’s law, Gauss’s law and its applications,

1.2 Laplace equations in two and three dimensions, multipole expansions for a localized charge distribution in free space,

1.3 Linear quadrupole potential and field, energy in electrostatic fields.

1.4 Dielectrics: linear dielectrics, polarisation, electric displacement, Gauss’s law in dielectric materials, boundary conditions at the interface of two dielectrics.

Unit-II: Magnetostatics and Electrodynamics: Magnetostatics: [15 Hours]

2.1 Magnetic forces,

2.2 The Biot-Savart’s law and Ampere’s law and its applications,

2.3 Magnetic vector potential, magnetostatics boundary conditions, magnetic fields inside matter.

2.4 Electrodynamics: Electromotive force, Faraday's law of electromagnetic induction, energy in Magnetic fields, Maxwell's correction to Amperes law, differential and integral forms of Maxwell's equations

Unit-III: Electromagnetic Waves and its Propagation: [15 Hours]

3.1 Poynting's theorem,

3.2 Electromagnetic wave equations, Electromagnetic plane waves in free space, non-conducting and conducting media,

3.3 Polarisation on reflection and refraction of electromagnetic waves,

3.4 Fresnels equations, Brewster's law, skin effect and skin depth.

Unit-IV: Electromagnetic Potentials and Fields: [15 Hours]

4.1 Scalar and vector potentials, Coulomb gauge and Lorentz gauge,

4.2 Gauge transformations, Wave equations in terms of electromagnetic potentials,

4.3 The d'Alembertian operator, Hertz potential and its use in computation of radiation fields, Lienard Wiechert potentials, Fields of moving point charge

❖ ESSENTIAL/RECOMMENDED READINGS:

1. Introduction to Electrodynamics, D. J. Griffiths (Prentice Hall, India)
2. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat, (Narosa Publishing House).
3. Classical Electricity & Magnetism, W.K.H. Panofsky and Phillips, (Addison-Wesley)
4. Foundations of Electromagnetic Theory, J. R. Reitz, F. J. Milford and R. W. Christy, (Pearson)
5. Classical Electrodynamics, by J. D. Jackson, (John Wiley)
6. Electromagnetic Theory and Electrodynamics, Satya Prakash, KedarNath Ram Nath, (Meerut)
7. Electromagnetics, B. B. Laud, (Willey Eastern)
8. Classical Theory of Fields, L.D. Landau and E.M. Lifshitz, (Addison-Wesley)
9. Feynman Lectures, Volume II, R.P. Feynman, Leighton, and Sands, (Narosa)
10. Berkley Series, Volume II, E.M. Purcell (Mc-Graw Hill)

DISCIPLINE SPECIFIC CORE COURSE (PH-MJ-522T): Quantum Mechanics

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-MJ-522T - Quantum Mechanics	4	4	--

❖ LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

1. Understand the fundamental principles of quantum mechanics, such as wave-particle duality,the uncertainty principle, and the Schrödinger equation.
2. Apply these principles to solve problems involving atoms, molecules, and other quantum systems.
3. Develop a deep understanding of the nature of matter and energy at the atomic and subatomic levels.
4. Communicate effectively about quantum mechanics concepts and principles.

❖ COURSE OUTCOMES:

After completion of this course student should be able to:

CO-1: Understand the basic concepts of wave-particle duality, the uncertainty principle, and the Schrödinger equation.

CO-2: Apply the Schrödinger equation to solve problems involving the motion of electrons in atomsand molecules.

CO-3: Understand the nature of light, including its wave-particle duality and its interaction with matter.

SYLLABUS OF PH-MJ-522T: Quantum Mechanics **[60 Hours]**

Module 1: Revision and General Formalism **[15 Hours]**

1.1 Wave packets and uncertainty relations,

1.2 Schrodinger wave equation and probability interpretation, Simple onedimensional problems wells and harmonic oscillator (One dimension)

1.3 Postulates of Quantum Mechanics, Physical interpretation of eigen values, eigen functions

1.4 Eigen values and eigen functions of momentum operator.

Module 2: Representation of States – Dirac Notation **[15 Hours]**

2.1 Hilbert space, Dirac's bra and ket notation, dynamical variables and linear operators, projection operators, unit operator, unitary operator,

2.2 matrix representation of an operator, change of basis, unitary transformation.

2.3 Eigen values and eigen functions of simple harmonic oscillator by operator method.

Module 3: Angular Momentum [15 Hours]

3.1 Eigen values and eigen functions of L2 and Lz operators,

3.2 Ladder operators L+ and L–, Pauli theory of spins (Pauli's matrices), matrix representation of J in |jm> basis.

3.3 Addition of angular momenta, Computation of Clebsch-Gordon coefficients in simple cases (J1=1/2, J2=1/2)

Module 4: Approximation Methods and Symmetry in Quantum Mechanics [15 Hours]

4.1 Time-independent Perturbation theory: Non degenerate, Zeeman effect,Time

4.2 Dependent Perturbation theory: Transition amplitude 1st and 2nd order, Fermi's golden rule

4.3 Harmonic perturbation, Introduction to WKB approximation,

4.4 Variational method Symmetry Parity, Identical particles, symmetric and antisymmetric wave functions, Slater determinant.

❖ ESSENTIAL/RECOMMENDED READINGS:

1. A Text-book of Quantum Mechanics by P.M.Mathews and K.Venkatesan.
2. Quantum mechanics by A. Ghatak and S. Lokanathan
3. Quantum Mechanics by Kumar Gupta Sharma
4. Quantum Physics by R. Eisberg and R. Resnick
5. Introduction to Quantum Mechanics by by David J. Griffiths
6. Introductory Quantum mechanics by Granier, Springer Publication.
7. Introductory Quantum Mechanics, Li Boff, 4th Edition, Pearson Education Ltd

DISCIPLINE SPECIFIC CORE COURSE (PH-MJ-523T):

Electronics

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-MJ-523T - Electronics	2	2	--

❖ LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

1. Understand power electronic devices and special function IC's
2. Apply the knowledge of course in industry

❖ COURSE OBJECTIVES:

After completion of the course, the student should be able to:

CO-1: List special and general-purpose integrated circuit chips.
CO-2: Explain internal block diagram and working of the ICs.
CO-3: Illustrate the use of dedicated ICs in different circuits.
CO-4: Explain working of circuits using operational amplifiers, timers, PLLs and SMPS.
CO-5: Design different circuits for dedicated applications

SYLLABUS OF PH-MJ-523T: Electronics **[30 Hours]**

Unit-I: Applications of special function ICs **[10 Hours]**

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 IC723 as Low and High voltage regulator.
1.4 DC-DC Converter and SMPS: Concept and Applications.
1.5 Study of Timer IC 555: Block diagram, Study of VCO IC 566 and its applications. Study of PLL IC 565: Block diagram

Unit-II: A. Digital Logic circuits I: Combinational Logic **[10 Hours]**

2.1 Review of Boolean identities and its use to minimize Boolean expressions. Minimization of Boolean expressions using Karnaugh map (up to 4 variables).
2.2 Digital Logic circuits II: Sequential Logic: Review of synchronous, asynchronous and combinational counters (4-bit).
2.3 Decade counter IC 7490 with applications.

Unit-III: Data Converters **[10 Hours]**

3.1 Digital to Analog converters: Binary weighted and R-2R ladder type

3.2 Analog to Digital converters: Single slope, Dual slope, Flash (Simultaneous) type, Counterramp type, Continuous type and Successive approximation type.

❖ ESSENTIAL/RECOMMENDED READINGS:

1. Operational Amplifiers: G. B. Clayton (5th edition).
2. OPAMPS and Linear Integrated Circuits: Ramakant Gayakwad, Prentice Hall.
3. Linear Integrated Circuits: D. Roy Choudhary, Shail Jain.
4. Electronic Principles: A. P. Malvino, TMH.
5. Power Supplies: B. S. Sonde SMPS, Inverters, Converters: Gottlieb
6. Digital Principles and Applications: Leach and Malvino.
7. Digital Electronics: R. P. Jain 8. Data Converters: B. S. Sonde

DISCIPLINE SPECIFIC CORE COURSE (PH-MJ-524P):

Physics Lab-III

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-MJ-524P - Physics Lab-III & IV	**2**	**--**	**2**

Section I:

❖ **LEARNING OBJECTIVES:**

The learning objectives of this course are as follows:

1. Apply the principles of electronics to the design and construction of real-world electronic devices.
2. Develop the ability to troubleshoot and repair electronic circuits.
3. Develop the practical skills necessary to design, build, and test electronic circuits.
4. Use electronic test equipment, such as oscilloscopes, multimeters, and signal generators.

❖ **COURSE OUTCOMES:**

After completion of this course the student should be able to:

CO-1: Design skills of electronic circuits.

CO-2: Handling of electronic instruments.

CO-3: Explain internal block diagram and working of the ICs.

CO-4: Illustrate the use of dedicated ICs in different circuits.

CO-5: Explain working of circuits using operational amplifiers, timers.

SYLLABUS OF PH-MJ-524P: Physics Lab-III

Student has to perform Any 12 Experiments:

1. Verification of logic gates
2. DAC (Digital to Analogue Converter) using R-2R and Binary ladder
3. Study of Multiplexer
4. Study of Demultiplexer
5. Design, built and test oscillator – LC oscillator
6. 8-bit ADC
7. OP-AMP: logarithmic amplifier
8. Study of errors in electrical measurement and results due to loading
9. Study of LVDT
10. Design half and full adder
11. Instrumentation amplifier using three OP-AMPs
12. Shift registers

❖ ESSENTIAL/RECOMMENDED READINGS:

1. Signetic Manual
2. Power Supplies: B.S. Sonde
3. Digital Principles: Malvino (6th Edition, Tata McGraw Hill Publication Co. Ltd. Delhi)
4. Operational Amplifier: G.B. Clayton
5. OP-AMPS and Linear Integrated Circuits: Ramakant Gaikwad
6. Data Converters: B.S. Sonde, Tata Mc-Graw Hill Pub. Co. Ltd. (1974)
7. Pulse, Digital and Switching Circuits: Miliman and Taub
8. Electronic Integrated Circuits and Systems: Franklin, C. Fitchen (Van No strand Reinhold Company)
9. Digital Principles and Applications: Leach and Malvino, Tata Mc-Graw Hill Pub. Co. Ltd. N. Delhi (5th Edition, 2002)

Section II:

❖ LEARNING OBJECTIVES:

The learning objectives of this course are as follows:

1. Understand the principles of physics through hands-on experiments.
2. Develop problem-solving skills.
3. Communicate effectively about physics concepts and principles.

❖ COURSE OUTCOMES:

After completion of this course student should be able to:

CO-1: Tabulate the appropriate experimental data accurately and keep systematic record of general laboratory experiments.

CO-2: Discuss the results, findings using the physical scientific framework and learn experimental tools.

CO-3: Interpret professional quality of textual and graphical presentations of laboratory data and computational results.

CO-4: Analyze various experimental results by developing analytical abilities to address real applications.

CO-5: Develop the skills related to betterment in education and research.

SYLLABUS OF PH-MJ-524P: Physics Lab-IV

1. **Thermionic emission:**
   To determine work function of Tungsten filament.
2. **Hall effect:**
   To determine charge concentration, conductivity of Ge-semiconductor
3. **Four Probe method:**
   Temperature variation and Band gap of Ge-semiconductor

Ionic Conductivity of NaCl
Fabry-Parot Etalon
Zeeman Effect

4. **Stefan's constant – Black Body Radiation**
   To study absorption spectra of Iodine molecule and to determine its dissociation Energy using spectrometer
5. 'μ' by total internal reflection of light.
6. Study of X-ray spectra.
7. Surface of a liquid by a Fergusson method.
8. Fly wheel.
9. Electromagnetic Pendulum
10. To determine refractive index of liquid using hollow prism.
11. Study of dielectric constant and determination of Curie temperature of dielectric ceramics.
12. GM Counter: Determination of Dead Time of GM Tube by double source method.

❖ **ESSENTIAL/RECOMMENDED READINGS:**

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

MAJOR ELECTIVE COURSE (PH-ME-525T):

Theory Elective- II

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-ME-525T - Theory Elective- II	**2**	**2**	**--**

<u>Elective Option A</u>

PH-ME-525(A) T

Experimental Techniques for Material Characterization

❖ **LEARNING OBJECTIVES:**

1. The learning objectives of this course are as follows:
2. Identify and implement the specific characterization technique as per the requirement.
3. Relate and compare the data obtained from the characterization techniques.
4. Examine and interpret the details of the sample.

❖ **COURSE OUTCOMES:**

After completion of this course student should be able to:

CO1: This course aims to introduce the fundamental understanding of characterization techniques which are commonly used for material analysis.

CO2: This course develops and imparts the systematic steps for interpretation of data obtained from the characterization.

SYLLABUS OF PH-ME-525(A)T:

Experimental Techniques for Material Characterization [30 Hours]

Unit I: Structural and Compositional Characterization [15 Hours]

1.1 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.

1.2 X-ray Photoelectron Spectroscopy (XPS) - Principle, instrumentation, working, analysis, carbon correction,

1.3 Scanning Electron Microscope (SEM) and Transmission Electron Microscopy (TEM): morphological study, Field Effect Scanning Electron Microscope (FE-SEM), crystalline nature and elemental analysis (EDS)

Unit II: Optical and Electrical Characterization Techniques [15 Hours]

2.1 UV-Visible and Photoluminescence (PL) Spectroscopy- Principle, instrumentation, working, applications and analysis of spectra,

2.2 Optical and electronics properties of semiconductors,

2.3 Merits of Diffuse Reflectance Spectroscopy (DRS).
2.4 Principle, instrumentation, working of Fourier Transform Infrared (FTIR) spectroscopy, Principle, instrumentation, working of Fourier Transform,
2.5 Raman (FT Raman) spectroscopy,
2.6 Resistivity by Four Probe method, Hall Effect Experiment

❖ **ESSENTIAL/RECOMMENDED READINGS:**

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.

Elective Option B

PH-ME-525(B)T

Laser Physics

❖ **LEARNING OBJECTIVES:**

The learning objectives of this course are as follows:

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

❖ **COURSE OUTCOMES:**

After completion of this course student should be able to:

CO1: Use of knowledge in Laser physics and Laser devices to analyze and quantify complex problems in the field of nanotechnology

CO2: The course will enable students to understand and appreciate the properties, application and their significance of the Lasers materials.

SYLLABUS OF PH-ME-525(B)T: Laser Physics **[30 Hours]**

Unit-I Basic Principle of Lasers and its properties **[15 Hours]**

1.1 Basic Principle: Absorption, spontaneous and stimulated emission, population inversion,
1.2 Properties of Laser, Metastable state, Gain, Absorption coefficient, Einstein's coefficient
1.3 Pumping methods: Pumping mechanisms (Two, Three and Four),

1.4 Threshold pump power, g-parameters of laser cavity, stability curve,
1.5 Gaussian beam and their properties.
1.6 Line broadening mechanisms. Measurements of laser power, energy, wavelength, frequency, line width.

Unit-II Types of Lasers and its Applications [15 Hours]

2.1 Principle, Construction, Energy level diagram and working: Solid State, Gas, Liquid, and Semiconductor Laser

❖ ESSENTIAL/RECOMMENDED READINGS:

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

MAJOR ELECTIVE COURSE (PH-ME-526P):

Practical Elective- II

Course Code & Title	Credits	Credit Distribution of the Course	
		Theory	Practical
PH-ME-526P - Practical Elective- II	2	--	2

Elective Option A

PH-ME-526(A)P

Experimental Techniques for Material Characterization (Practical)

❖ **LEARNING OBJECTIVES:**

The learning objectives of this course are as follows:

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.

❖ **COURSE OUTCOMES:**

After completion of this course student should be able to:

CO1: This course aims to introduce the fundamental understanding of characterization techniques which are commonly used for material analysis.

CO2: This course develops and imparts the systematic steps for interpretation of data obtained from the characterization.

SYLLABUS OF PH-ME-526(A)P:

Experimental Techniques for Material Characterization

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,
3. phase and lattice parameters from the XRD data
4. Analysis of strain from X-ray diffraction of the sample
5. Determination of the band gap from the UV-Visible response and DRS of the sample
6. Analysis of XPS Survey scan of the sample
7. Determination of functional group present in the sample from FTIR response
8. Determination of Lande's 'g' factor from ESR curve
9. Carbon correction of the sample in XPS peak
10. Resistivity measurement by four probe method
11. To determine the Hall voltage developed across the sample material.
12. To calculate the Hall coefficient and the carrier concentration of the sample material.

❖ **ESSENTIAL/RECOMMENDED READINGS:**

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

Elective Option B

PH-ME-526(B)P

Laser Physics (Practical)

❖ **LEARNING OBJECTIVES:**

The learning objectives of this course are as follows:

1. To study the basic concepts regarding properties and applications of lasers.
2. To impart knowledge about identifying the types and its uses in industries.

❖ **COURSE OUTCOMES:**

After completion of this course student should be able to:

CO1: Use of knowledge in Laser physics and Laser devices to analyze and quantify complex problems in the field of nanotechnology

CO2: The course will enable students to understand and appreciate the properties, application and their significance of the Lasers materials.

SYLLABUS OF PH-ME-526(B)P: Laser Physics Practical

Experimental List:

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.

❖ **ESSENTIAL/RECOMMENDED READINGS:**

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