Kavayitri Bahinabai Chaudhari
North Maharashtra University, Jalgaon

SYLLABUS

For

M. Sc. II Physics

(As per NEP-2020 Pattern)

For Affiliated Colleges

With Effect from

Academic Year 2024- 2025

Semester III & IV

Summary of Distribution of Credits
For
M.Sc. Physics

Sr. No	Type of course	Sem I	Sem II	Sem III	Sem IV
01	Discipline Specific Core	14 (03 T + 01 P)	14 (03 T + 01 P)	14 (03 T + 01 P)	12 (02 T + 01 P)
02	Discipline Specific Elective	04 (01 T)	04 (01 T)	04 (01 T)	04 (01 T)
03	Research Methodology	04 (01 T)	-	--	--
04	On Job Training/Internship	--	04	--	--
05	Research Project	--	--	04	06
06	Total Credits	22	22	22	22

Subject Type	Discipline Specific Core (T)	Practical (P)	Discipline Specific Elective	Research Methodology	On Job Training/ Internship	Research Project	Total
Credits	38	16	16	04	04	10	88

- T: Theory
- P: Practical

Semester-wise Course Structure, Course Code and Credit distribution of M. Sc. II PHYSICS Programme as per NEP-2020, for Affiliated Colleges, w.e.f – June 2024

SEMESTER – III, Level – 6.5

Course	Course Type	Course Code	Course Title	Credits	Teaching Hours/Week			Marks			
								Internal (CA)		External (UA)	
					T	P	Total	T	P	T	P
DSC-35	DSC	PHY-511	Atomic and Molecular Physics	4	4	--	4	40	--	60	--
DSC-36	DSC	PHY-512	Solid State Physics	4	4	--	4	40	--	60	--
DSC-37	DSC	PHY-513:	Materials Science and Technology	2	2	--	2	20	--	30	--
DSC-38	DSC	PHY-514:	Special Laboratory-V	4	--	8	8	--	40	--	60
DSE-7	DSE	PHY-515(A)	Battery Science and Technology	4	4	--	4	40	--	60	--
		PHY-515(B)	Electronics for Internet of Things (IOT)	4	4	--	4	40	--	60	--
		PHY-515(C)	Computational Methods by using 'C' Language	4	4	--	4	40	--	60	--
		PHY-515(D)	SWAYAM/NPTEL Live course	4	4	--	4	40	--	60	--
RP	RP	RP-516	Research Project	4	--	8	8	---	40	--	60
Total				**22**	**14**	**16**	**30**	**140**	**80**	**210**	**120**

Semester-wise Course Structure, Course Code and Credit distribution of M. Sc. II PHYSICS Programme as per NEP-2020, for Affiliated Colleges, w.e.f – June 2024

SEMESTER – IV, Level – 6.5

Course	Course Type	Course Code	Course Title	Credits	Teaching Hours/Week			Marks (Total 100)			
								Internal (CA)		External (UA)	
					T	P	Total	T	P	T	P
DSC-39	DSC	PHY-521	Nuclear Physics	4	4	--	4	40	--	60	--
DSC-40	DSC	PHY-522	Materials Characterization techniques	4	4	--	4	40	--	60	--
DSC-41	DSC	PHY-523	Special Laboratory-VI	4	--	8	8	--	40	--	60
DSE-8	DSE	PHY-524(A)	Fundamentals of Electric Vehicles: Science & Technology	4	4	--	4	40	--	60	--
		PHY-524(B)	Robotics and Applications	4	4	--	4	40	--	60	--
		PHY-524(C)	MATLAB	4	4	--	4	40	--	60	--
		PHY-524(D)	SWAYAM/NPTEL Live course	4	4	--	4	40	--	60	--
RP	RP	RP-525	Research Project	6	--	12	12	---	40	--	60
Total				**22**	**12**	**20**	**32**	**120**	**80**	**180**	**120**

*The SWAYAM/NPTEL Live Courses available for PHY-515D &, PHY-524D, should be announced by the Department at the beginning of the corresponding Semester.

Abbreviations:

DSC: Discipline Specific Core Course**, DSE:** Discipline Specific Elective**, T:** Theory Course**, P:** Practical course**, RP:** Research Project **; CA:** College Assessment**; UA:** University Assessment**.**

• One credit means: One hour of theory or Two hours of laboratory work for duration of a semester (13-15 weeks) resulting in the award of one credit.

Program at a Glance

Name of the program (Degree)	: M. Sc. Physics
Faculty	: Science and Technology
Duration of the Program	: Two years (four semesters)
Pattern	: As per NEP-2020
Medium of Instruction and Examination	: English
Examination Pattern	: **For Course with 4 Credits:** University Assessment (UA) – 60 marks College Assessment (CA) – 40 marks **For Course with 2 Credits:** University Assessment (UA) – 30 marks College Assessment (CA) – 20 marks
Passing standards	: 40% marks in UA and CA separately.
Evaluation mode	: CGPA
Total Credits of the program	: 88 (Distribution of credits as given in structure)

Program Objectives

1. To impart sound theoretical and practical knowledge of the different core and applied subjects.
2. To understand the concepts of classical and quantum theories.
3. To train the students to employ modern techniques, equipment, and software for the application of that subject in different areas.
4. To train the students to utilize the knowledge and skills gained to deal with real-life situations and problems.
5. To impart knowledge of basic concepts in Material Science.
6. To provide the knowledge and methodology necessary for solving problems in Physics.
7. The course also involves the related experiments based on the theory.
8. To develop problem solving skills, better understanding of research methods and analysis of the results through research project.

M.Sc. Program Outcomes

Upon successful completion of the M.Sc. program, student will be able to:

PO1	Understand the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
PO2	Administer the skills in handling scientific instruments, planning and performing laboratory experiments.
PO3	Analyze the given scientific experimental data critically and systematically to draw the objective conclusions.
PO4	Develop various skills such as communication, managerial, leadership, entrepreneurship, teamwork etc.. Express ideas and views clearly and effectively.
PO5	Model and formulate the problems and find solutions based on the knowledge acquired.
PO6	Adopt interdisciplinary approach in providing better solutions and new ideas.
PO7	It will provide the exposure to develop research culture amongst the students.

Semester – III

Course Code: PHY-511

Course Title: Atomic and Molecular Physics

Course Code: PHY-511	Course Category: Core
Course Title: Atomic and Molecular Physics	Type : Theory
Total Contact Hour : 60 (4/week)	Course Hour :04
College Assessment (CA) Marks : 40	University Assessment (UA) Marks :60

Course Objectives:

- Learn atomic and molecular spectroscopy.
- To learn related experiments based on theory and gain problem solving skills in atomic and molecular physics.

Course Outcomes:

- Describe the atomic spectra of one and two valance electron atoms.
- Explain the change in behavior of atoms in external applied electric and magnetic field.
- To correlate rotational, vibrational, electronic and rotation-vibration spectra of the molecules.

Course Content:

Unit 1: Atomic Model for Two Valence Electron (14 H, 14M)

Basics of Atomic structure, Vector atom model- its need/importance, Various coupling schemes: LL, SS, LS and jj, Pauli's exclusion principle, Coupling principle, factors for LS coupling, Lande's interval rule, JJ branching rule, selection rules, magnetic moment of atom, Lande g factor, Zeeman effect, intensity rules, calculation of Zeeman pattern, Paschen Back effect-LS and jj coupling, Breit's scheme for derivation of spectral terms, Stark effect.

Unit 2: Complex Spectra & Hyperfine Structure (12 H, 12M)

Displacement law, alternation law of multiplicities, vector model for more valance electrons, Lande's interval rule, inverted terms, Hund's rule, Introduction, hyperfine structure and Lande's interval rule, nuclear interaction with one valance electron, hyperfine structure of two or more electrons, Zeeman effect in hyperfine structure, Back Gouldsmit effect in hyperfine structure.

Unit 3: Pure Rotational Structure (12H, 12M)

Rotation of linear system (classical and quantum mechanical), rigid rotator, rotational energy levels and their populations, interaction of rotation with rotating molecules, rotational spectra of rigid rotators, selection rules for linear molecules, determination of moment of inertia and bond length from rotational spectra, isotope effect on rotational spectra, relative intensities of spectral lines.

Unit 4: Pure Vibrational Spectra **(6 H, 6 M)**

Vibrations of two particles connected by spring (classical), Harmonic oscillators, vibrational energies of diatomic molecules, interaction of radiation with vibrating molecules, an-harmonic oscillator, deduction of molecular properties from vibrational spectra of diatomic molecules.

Unit 5: Rotation and Vibration Spectra **(6 H, 6 M)**

Diatomic vibrating rotator coupling of rotation and vibration , rotation-vibration spectra, selection rules and transition for vibrating rotator, intensities in rotation and vibration spectrum, parallel and perpendicular bands of linear molecules, Isotope effect-vibration.

Unit 6 : Electronic Spectra of Diatomic Molecules **(10 H, 10 M)**

Electronic energy curves, potential energy curves - stable and unstable molecular states, vibration structure of electronic transitions, general formula, rotational structure of electronic spectra, the branches of band, band head formation and shading of bands: Fortrat diagram, intensities in electronic bands-Vibrational structure-Frank Condon principle.

Reference Books:

1. Introduction to atomic and nuclear physics, by H. E. White, Van Norstrand Reinhold (east-West Press)
2. Introduction to atomic spectra, by H. E. White, Mc. Graw hill, International Edition
3. Atoms and Molecules: An introduction for students of Physical chemistry by Martin Karplus and Richard N. Porter, W. A.Benjamin Inc. New York
4. Atomic physics, by Christopher J. Foot., Oxford Master Series in atomic, optical and laser Physics
5. Molecular structure and spectroscopy, by G. Aruldhas, PHI learning Pvt. Ltd. New Delhi
6. Fundamentals of Molecular Spectroscopy by Colin Banwell, McGraw-Hill Publishing Company
7. Atomic and Nuclear Physics, S Chand, Dr. N. Subramanyam Brijlal, revised by Jivan Seshan 2013.

Course Code: PHY-512

Course Title: Solid State Physics

Course Code: PHY-512	Course Category: Core
Course Title: Solid State Physics	Type : Theory
Total Contact Hour : 60 (4/week)	Course Hour :04
College Assessment (CA) Marks : 40	University Assessment (UA) Marks :60

Course Objectives:

- To study the band theory of solids.
- To understand the lattice vibration and concept of phonon.
- To understand the concepts of classical and quantum theory of magnetism.
- To study and understand the concept of dielectric parameters and polarization.
- To understand the basic principle of superconductivity and its theories.

Course Outcomes:

- Understand the origin of different properties of solids.
- Apply the ideas learnt to explain the electric and magnetic phenomena observed.
- Understand to categorize the Type I and Type II superconductors.
- Understand the concept of Curie temperature of ferroelectric materials.

Course Content:

Unit 1: Band Theory of Solids: (10 H, 10 M)

Nearly free electron model, Bloch theorem (with proof), Kronig Penny model, Motion of electrons in 1-D according to band theory, Distinction between metals, insulators and intrinsic semiconductor, origin of energy gap, Effective mass of an electron.

Unit 2: Lattice Vibrations and Phonons (8 H, 8 M)

Concept of lattice vibration, Elastic waves in an infinite and finite one dimensional array of identical atoms, Lattice vibrations of diatomic lattice, Optical and Acoustic modes of vibrations, Quantization of lattice Vibrations: Phonons.

Unit 3: Theory of Dielectrics, Piezoelectricity and Ferroelectrics: (12 H, 12 M)

Polarization of dielectric, Dielectric constant, Local electric field, Polarizability, Clausius Mosotti relation, Dipolar polarizability, Calculation of Ionic & Electronic polarizability, Total polarizability, Piezoelectricity, Ferro electricity, Theories of Ferro electricity: Dielectric behavior above Tc, Spontaneous polarization below Tc and Ferroelectric Hysteresis, Applications of ferroelectrics.

Unit 4: Magnetism **(15 H, 15 M)**

Origin of magnetic moments, Classification of magnetic materials, Langevin's classical theory of diamagnetism, Langevin's classical theory of Para magnetism, Weiss theory of Para magnetism, Paramagnetic susceptibility of conduction electron, Ferromagnetic domains, ferromagnetic Hysteresis, Exchange energy, Anisotropy energy, Bloch wall, Weiss theory of ferromagnetism, Two sub-lattice model of Anti ferromagnetism, Neel's model of ferrimagnetism.

Unit 5: Superconductivity **(15 H, 15 M)**

Basic concept, Occurrence, Meissner effect, Critical field, Type-I and type-II superconductors, Heat capacity, Energy gap, Microwave and IR properties, Critical currents, Thermodynamics of superconducting transitions, London equation, Coherence length, London penetration depth, BCS theory of superconductivity, High Tc superconducting materials, Qualitative discussion of Josephson superconductor tunneling (a.c. & d.c.).

Reference Books:

1. Fundamentals of Solid State Physics: B.S.Saxena ,R.C.Gupta&P.N.Saxena, PragatiPrakashan, Meerut 11thEd.

2. Solid State Physics : R. L. Katiyar, Campus Books International, New Delhi . 2009.

3. Solid State Physics : R. L. Singhal, KedarnathRamnathPrakashan, Meerut.

4. Solid State Physics : S.L. Gupta & V. Kumar, K. Nath& Co. Meerut.

5. Solid State Physics: A.J. Dekkar, McMillan students Ed.

6. Introduction to Solid State Physics: C. Kittle, Wiley Eastern Ltd; 7th Ed.

7. Solid State Physics: C. M. Kachhava, Tata McGraw Hill Eds.

8. Solid State Physics: R. K. Puri and V. K. Babbar.

9. Elementary Solid State Physics: M. Ali Omar.

10. Solid State Physics, by Ashcroft and Mermin, Published in 1976 by Saunders College Publishing

11. Solid State Physics, structure and properties of materials third edition by M A Wahab, 2015

12. Solid State Physics , 10th Edition By S. O. Pillai, 2022

Course Code: PHY-513
Course Title: Material Science

Course Code : PHY-513	Course Category: Core
Course Title: Material Science	Type : Theory
Total Contact Hour : 30 (2/week)	Course Hour :02
College Assessment (CA) Marks : 20	University Assessment (UA) Marks :30

Course Objectives:

- To impart knowledge of basic concepts in Material Science.
- To provide the knowledge and methodology necessary for solving problems in Physics.
- The course also involves the related experiments based on the theory.
- To learn basics of Materials Science including different types of materials and their applications.
- To learn basics of solar energy materials.

Course Outcomes:

- Understand different types of materials and their applications
- Apply the knowledge of processing of metals and alloys

Course Content:

Unit 1: Phases in Alloys and Phase Transformations: (8 H, 8 M)

Introduction, Iron-Carbon phase diagram and different phases of the system. Phase transformations in steel during heating and transformation of austenite during cooling. Transformation rate effects and TTT diagrams, Microstructure and Property Changes in Fe-C Alloys.

Unit 2: Applications and Processing of Metals and Alloys: (16 H, 16 M)

Types of metals and alloys: Ferrousmaterials -A Steels: Low carbon steels, Medium carbon steels, High carbon steels, Stainless steels. Cast irons: Gray cast iron, White cast iron, Nodular (or ductile) cast iron, Malleable cast iron. Non-ferrous materials: Aluminium alloys, Copper alloys, Magnesium alloys, Titanium alloys, Refractory metals, Noble metals, free cutting steel, structural steel, high speed steel, ball, bearing steel. Cu-alloys: Brasses and Bronzes- Properties and applications, Cu-Ni – alloys. Thermal processing of metals and alloys: Annealing processes: Process annealing, Stress relief, Full annealing, Normalizing. Quenching and Tempering processes. Case Hardening: Induction hardening, Flame hardening, Laser hardening, Carburizing, Cyaniding.

Unit 3: Solar Energy materials: (6 H, 6 M)

Solar energy spectrum, photovoltaic conversion materials: Si, GaAs, CdS, $CuInSe_2$, fabrication of CdS/Cu^2S cell, introduction to organic solar cells.

Suggested readings:/Reference Books:

1. Material Sciences and Process by S. K. Hajara-Chaudhari, Indian Book Distributing Co.
2. Introduction to engineering materials: B. K. Agrawal, Tata McGraw-Hill Pub.
3. Material Science and Engineering, A first course : V. Raghavan, Prentice Hall Of India.
4. Introduction to Materials Science: H. B. Lal, Dominant Publishers, New Delhi.
5. Composite Material Science and Engineering, Springer, 2001. By Krishnan K. Chawla.
6. Material Science and Engineering: R. K. Rajput , S. K. Kataria& Sons, New Delhi,2002.
7. Solid State Physics-Structure and Properties of Materials: M. A. Wahab, Narosa Publishing.
8. Material Science and Engineering- An introduction W. D. Callister Jr sixth edition.
9. Foundations of Material Science and Engineering- William F. Smith.
10. Mechanical Metallurgy, Third Edition, G. E. Dieter McGraw-Hill, New York, 1986.
11. Introduction of Dislocations, D. Hull, Third Edition, Butterworth-Heinemann, Woburn, U.K.
12. Introduction to Ceramics, Second Edition W. D. Kingery, H. K. Bowen, and D. R. Uhlmann.
13. Introduction to Material Science and Engineering, by L. H. Van Vlack

Course Code: PHY-514
Course Title: Special Laboratory - V

Course Code: PHY-514	**Course Category: Core**
Course Title: Special Laboratory - V	**Type : Practical**
Total Contact Hour : 60 (8/week)	**Course Hour : 08**
College Assessment (CA) Marks : 40	**University Assessment (UA) Marks :60**

Course Objectives:

- To gain practical knowledge of applying experimental methods to test/validate Physics theory.
- To learn the usage of various instruments for measurements.
- Learn to analyse and interpret the data obtained from measurements
- To get the knowledge of experiments based on the materials science.

Course Outcomes:

- Develop and conduct appropriate scientific experimentation
- Analyze and interpret data and use scientific judgment to draw conclusions.
- Integrate new knowledge as needed using appropriate experimentation strategies.

SECTION A:

1. Determination of Curie temperature of given magnetic material.
2. Determination of e/m ratio of an electron.
3. Determination of Susceptibility: Gouy's Method.
4. Measurement of waves by Ultrasonic Interferometer.
5. Determination of the band gap of a semiconductor by four probe method
6. Measurement of wavelength using engraved scale.
7. Verification of Brewster's law using laser.
8. To measure thermoelectric power of semiconductor.
9. Charge on electron using spectrometer.
10. To study absorption spectrum of Iodine vapor.

SECTION B:

1. To determine the dielectric Constant of $BaTiO_3$.
2. To study the Phase diagram of Pb-Sn alloy.
3. To study the Hysteresis loop for Ni material.
4. Measurement of Heat Capacity of different metals.
5. Thin film coating using thermal evaporation/SILAR/spin coatingmethod.
6. Deposition of thin film and its thickness measurement by Gravimetric method.
7. Synthesis of CdS thin film by chemical bath deposition (CBD) method
8. Electrical conductivity measurements in thick films.
9. To study various crystals structures by using XRD data. (Related free software can be used)
10. Determination of Fermi Energy of Copper
11. To study hysteresis of soft and hard ferrites.
12. Determination of Hall Coefficient and mobility (Hall Effect).

Section C: List of Experiments from Elective Course PHY 515 (A)

1. Building a Battery with Vinegar and record its voltage and current.
2. Making batteries and testing their performance by changing the Electrolyte and Electrodes.
3. The assembly and testing of a rechargeable 3 V lithium-ion battery.
4. Evaluate Charge-discharge Characteristics of a Secondary Battery
5. Battery lasts longer testing of three given batteries
6. Hands-on experiments to measure battery capacity, voltage, and energy density using various testing equipment.

SECTION C: List of Experiments from Elective Course PHY 515 (B)

1. Voice Controlled Home Automation with Arduino and Bluetooth.
2. Bluetooth based Smart Phone Controlled Robot Car using Arduino.
3. Fingerprint Door Lock system using Arduino and Smart phone.
4. IoT Based Heart Rate Monitor using Arduino and ESP.
5. Magnet detector using Arudino

SECTION C: List of Experiments from Elective Course PHY 515 (C)

1. Draw a flowchart and write a program to find the root of the equation f(x)=0 by Bisection Method.
2. Draw a flowchart and write a program to solve given differential equation using Euler'ssimple method.
3. Draw a flowchart and write a program for finding the inverse of a given matrix./transpose of a matrix.
4. Implement strlen ( ), Strcat ( ), Strcpy ( ), Strcmp ( ) using pointers.
5. Write a menu driven program to create, list, modify and calculate the student record details.

SECTION C: List of Experiments from Elective Course PHY 515 (D)

Take list of experiments related to the SWAYAM/NPTEL Live course selected by respective college.

(**Note:-***Perform at list 10 experiments total –

- Select 5 experiments from Section: A list
- Select 3 experiments from Section: B list. And
- Select 2 Experiments from Section: C according to respective elective course from **PHY -515 (A/B/C/D)**selected by the College

More experiments can be added to this list with prior permission of Chairman BOS Physics)

Course Code: PHY-515(A)
Course Title: Battery Science and Technology

Course Code: PHY-515(A)	Course Category: Elective
Course Title : Battery Science and Technology	**Type : Theory**
Total Contact Hour : 60(4/week)	**Course Hour :04**
College Assessment (CA) Marks : 40	**University Assessment (UA) Marks :60**

Course Objectives:

- Understand batteries basic chemistry.
- Understand the need of energy storage systems; select the right battery technology for chosen application.
- Identify the advantages and disadvantages of using alternative battery types.
- Understand the figure of merits, energy and power density limits of each electrical energy storage component type.
- Learn about a variety of applications such as automotive and grid-energy storage systems.

Course Outcomes:

- Student will understand various parts of the battery and their functions.
- Understand the discharging and charging process of a lithium-ion battery.
- Understand components of a lithium-ion battery cell and battery packs and know about the purpose of each one.
- To Analyze dynamic behavior of lithium-ion cells and cells in a battery pack.
- Understand - how battery energy storage systems are used for everyday purposes: road, water and air transport vehicles, portable and stationary use.

Course Content:

Unit 01: Fundamentals of Battery and Battery Technologies (15 H, 15 M)

Basics of energy storage: Different types of ESS (electro-chemical, thermal, mechanical); Energy storage technologies (pumped hydro, compressed air, electrical, flow batteries, lead acid, advanced lead Carbon, Lithium-ion, flywheels, electrochemical capacitors, etc.);

Revision of Electrochemical aspects of battery, Primary and secondary batteries, electrochemical series, materials for battery applications, anode material, cathode materials, electrolytes, separators etc.

Construction and working of lead-acid battery, construction and working of lithium ion battery: Cell mechanical structure, Resistance and polarization, Electrode design, Charging and Discharging

- Battery structure and functions (anode, cathode, membrane, electrolyte, battery pack)

- Battery structures (cylindrical, button, prismatic, pouch)
- Terms in the use of battery technology- Cell, module, BMS, J/B, battery pack, C-rate, charging efficiency, energy density, power density (gravimetric Wh/kg and volumetric Wh/m3), internal resistance, self-discharge & storage, cycle life & factors affecting it.
- Different battery chemistries and differentiation between them: Lead-acid (PbA), Nickel-Cadmium (Ni-Cd), Nickel-Metal Hydride (Ni-MH), Lithium-ion (Li-Ion), Sodium-Sulfur (Na-S), Redox Flow Battery (RFB), Future technologies overview (Zn-air, Li-S, Li-air)

Unit 02: Lithium-Ion Battery Fundamentals and Applications (15 H, 15 M)

Lithium Based Battery Chemistry: Characteristics of Li, Advantages of Li based battery chemistry, Hazards involved, Li compounds for battery, Energy levels for electrolyte stability.
Lithium-ion Battery Pack Assembly: Cell performance testing overview, Series and parallel connections, Cell to cell connections, Cell module assembly, Material for battery packs, Guidelines for pack assembly, Testing of battery pack.

Unit 03: Configurations and Applications of Lithium-ion Battery Systems (15 H, 15 M)

Applications of Li-ion battery:i. Battery Requirements- Electrical Requirements, Thermal Requirements, Mechanical Requirements. ii. Automotive Applications- Drive Cycles, SLI (starting, lighting and ignition) batteries, Start-Stop (Micro) Hybrids, Power Assist Hybrids, Plug-In Hybrids, BEVs.
Introduction to Battery Management System (BMS): Need for BMS, Overview of BMS building blocks: components, fuse, current sensing, thermistors, main switch, balancer, etc.
Applications of Energy Storage Systems: Applications for various Energy Storage technologies, Stationary solar and Other Renewable Energy Systems, Ancillary services, Residential storage, Commercial storage, e-Mobility

Unit 04: Current Research Update on Energy Storage Technologies & Applications - Where the Future Is Going (15 H, 15 M)

Future technological development, Energy storage technologies to pursue instead of LIBs, Long duration energy storage, Hydrogen and movements toward zero carbon, All solid-state batteries, Ongoing energy market disruptions and projections for future storage deployments, Optimizing storage as a resource in the short- and long-term, Opportunities and risks – how to move forward

Reference Books:

1. Lithium-Ion Batteries Basics and Applications by Reiner Korthauer, Springer.
2. Lithium-Ion Batteries Science and Technologies by Ralph J. Brodd (auth.), Masaki Yoshio, Ralph J. Brodd, Akiya Kozawa (eds.), Springer.
3. Lithium-ion Batteries Fundamentals and Applications by Wu, Yuping, CRC Press, Taylor and Francis.
4. Handbook of lithium-ion battery pack design chemistry, components, types and terminology by Warner, John T, Elsevier.
5. Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles by San Ping Jiang, Wiley.
6. Lithium ion rechargeable batteries by edited by Kazunori Ozawa, Wiley.

Course Code: PHY–515 (B)
Course Title: Electronics for Internet of Things (IOT)

Course Code: PHY-515(B)	**Course Category: Elective**
Course Title: Electronics for Internet of Things (IOT)	**Type : Theory**
Total Contact Hour : 60(4/week)	**Course Hour :04**
College Assessment (CA) Marks : 40	**University Assessment (UA) Marks :60**

Course Objectives:
- To understand the basics of Internet of things and protocols.
- To study characteristics of IoT based Components.
- To get an idea of some application areas where IoT is applicable.
- To study the Logical Design of IoT using Python.
- To understand the concepts of Web of Things

Course Outcomes:
- Understand the Architecture and various protocols of IoT.
- Identify new models for strategic market interaction.
- Establish the interface of the IoT based system.
- Understand the logical designing using Python.
- Understand the architecture standardization for WoT.
- Familiarize with the IoT based system for automation in industry.

Course Content:

Unit 1: Introduction to Internet of Things **(12 H, 12 M)**

Definition and characteristics of IoT, Internet of Things: Vision, Emerging Trends, Technical Building Blocks, Physical design of IoT, Things in IoT, IoT Communication APIs, IoT enabling technologies, Wireless Sensor Networks, IoT levels and deployment templates, IoT Issues , challenges and applications.

Unit 2: IoT Physical Devices and Endpoints **(12 H, 12 M)**

Basic building blocks of an IoT device, horizontal and verticals of IoT applications, four pillars of IoT, M2M: The internet of devices, RFID: The internet of objects, WSN: The internet of transducer, SCADA: Choosing platform for IoT development, Introduction of hardware processors used for IoT (Arduino & Raspberry Pi), IoT and M2M , SDN and NFV for IoT.

Unit 3: IoT Systems – Logical Design using Python **(20 H, 20 M)**

Introduction to Python, Installing Python, Python Data Types and data structures, control flow, Functions, Modules, Packages, Object oriented programming, Classes, File handling, Date/Time operations, Python Packages of interest for IoT, GUI (Graphical User Interface) programming for IoT, Python programming for interfacing of Intel core i5 processor.

Unit 4: IoT Protocols, Security and Web of Things (16 H, 16 M)

IoT protocols, Protocol Standardization for IoT, Issues with IoT Standardization, Unified Data Standards, Protocols- IEEE 802.15.4, BACNet Protocol, Modbus

IoT Security: Vulnerabilities of IoT, Security Requirements, Challenges for Secure IoT, Threat Modelling, Key elements of IoT Security, Web of Things versus Internet of Things, Two Pillars of the Web, Architecture Standardization for WoT.

Suggested readings:

1. “Python Programming Using Problem Solving Approach” byReemaThareja, Oxford University Press
2. “Core Python Programming” by R. NageswaraRao, Dreamtech Press
3. Internet of Things – A hands-on approach By ArshdeepBahga, Vijay Madisetti, Universities Press.
4. Architecting the Internet of Things by Dieter Uckelmann, Mark Harrison, Florian Michahelles, Springer.
5. Embedded Systems: An Integrated Approach by Lyla B. Das, Pearson
6. The Internet of Things: Applications to the Smart Grid and Building Automation by Olivier Hersent, Omar Elloumi and David Boswarthick, Wiley

Course Code: PHY–515 (C)

Course Title: Computational Methods by Using 'C' Language

Course Code: PHY-515(C)	Course Category: Elective
Course Title: Computational Methods by Using 'C' language	**Type : Theory**
Total Contact Hour : 60 (4/week)	**Course Hour :04**
College Assessment (CA) Marks : 40	**University Assessment (UA) Marks :60**

Course Objectives:

- To impart knowledge of basic concepts in Computational Methods and Programming Using 'C' Language and its Applications
- The students will have knowledge of fundamental laws and principles in a variety of areas of Physics along with their applications.
- The students will develop research skills which might include advanced laboratory techniques, numerical techniques, computer algebra, computer interfacing.

Course Outcomes:

- Understand Computational Methods and Programming Using 'C' Language and Applications
- Students will gain ability to apply the techniques of Computational Methods and Programming Using 'C' Language
- Understand the Structures and Unions: Declaration and period operator, structure initialization.
- Learn the Numerical Integration: Derivation and application of Trapezoidal, Simpson 1/3 and Simpson's 3/8 th rule.

Course Content:

Unit 1: Introduction to 'C' Language (15 H, 15 M)

Review of C language for preparing and running 'C' programs.

Pointers: The concepts of pointers, the address operator, pointer arithmetic, pointers as function parameters, pointers and arrays, Dynamic storage allocation

Unit 2: The Loop Control Structure (15 H, 15 M)

The loop control structure: Loop, while and for loop, odd and do-while loop, the break and continue statement.

Structures and Unions: Declaration and period operator, structure initialization, structure and arrays, structure and functions, structure and pointers, structure within structure, Unions, Rules to use unions.

File handling: Opening and closing a data file, creating a data file, processing a data file.

Unit 3: Numerical Methods **(15 H, 15 M)**

In the following topics on numerical methods, students are expected to write programs using ‘C’ language as well as perform numerical calculations using electronic calculators and mathematical tables.

Iterative methods to obtain roots of equations: The method of successive bisection, false position method, Newton Raphson method. Derivation of formula and advantages as well as limitations of these methods, solve examples on each method.

Interpolation: Definition and difference between Interpolation and extrapolation, finite differences. Lagrange’s interpolation, curve fitting, polynomial least squares and cubic spline fitting.

Unit 4: Numerical Integration and problems **(15 H, 15 M)**

Numerical Integration: Derivation and application of Trapezoidal Rule, Simpson 1/3rd and Simpson’s 3/8thrule.

Solution of simultaneous line equations: Gauss elimination method, Gauss Seidal method.

Solution of first order differential equation: Euler’s method, Runge-Kutta method.

References:

1. The ‘C’ Programming Language: Kernighan B.W. & Ritchie D.M. (Prentice Hall India Pvt. Ltd.).
2. Letus ‘C’: YashwantKanetkar (BPB Publications).
3. Schaum’s outline of theory and problems of programming with ‘C’: Gottfried B.S. (Tata McGraw Hill Publishing Co. Ltd.).
4. Programming in ANSIC (IIndEdition)-E. Balagurusamy (Tata McGraw Hill Publishing Co. Ltd.)
5. The C language Trainer with C graphics and C++ -J.Jayasri (New Age International Pvt. Ltd. New Delhi.)
6. The spirt of ‘C’–Mullish Cooper (Jaico Publishing Co. New Delhi)
7. Programming in ANSIC–Ramkumar (Tata McGraw Hill).
8. Introductory methods of Numerical Analysis-S.S. Sastry.
9. Numerical methods for engineers with programming and software applications-Steven C Chapra, Raymond P. Canale. (McGraw Hill)
10. Numerical Methods problems and solutions– M.K. Jain, S.R.K. Iyengar, R.K. Jain (Wiley Eastern Ltd).

11. Computer Oriented Numerical Methods – V. Rajaraman (Prentice Hall India Pvt Ltd.).

Course Code: PHY–515(D)

Course Title: SWAYAM/NPTEL Live course

See the guidelines issued by KBC NMU, Jalgaon regarding the SWAYAM/NPTEL Live course on website

Course Code: PHY: RP-516

Course Title: PROJECT

Course Code: PHY: RP-516	**Course Category: Research Project**
Course Title: Research Project-I	**Type : Project**
Total Contact Hour :60 (8/week)	**Course Hour :08**
College Assessment (CA) Marks :40	**University Assessment (UA) Marks :60**

Course Objectives:

- To give exposure to develop research culture amongst students
- To introduce students how to select a research topic, plan, perform experiments, collection and an analysis of research data.
- To boost self-confidence and self-reliance in the students as he/she learns to work and think

independently.

Course Outcomes:

- Conceive a problem based on polished research and carry comprehensive survey of literature
- Plan and carry out task in given framework of dissertation and present the work in written and viva
- Use a holistic view to critically, independently and creatively identify, formulate the problem
- Learn handling of instruments, use of chemicals and how to conduct the experiments
- Learn how to present the project in power point and answer the queries to examiners as well as enhance the skill of scientific writing.

Course Content:

Activities:

1. To display the list of 'project titles' on notice board.
2. To organize a meeting of project supervisors' and students for discussion aboutprojects.
3. To finalize the project titles so as to match student's particular interest.
4. Survey of the Literature.
5. To set the experiment/to start Preliminary Experimental work.
6. Internal examination.
7. The guide should regularly monitor the progress of the project work.

ASSESSMENT OF PROJECT TERM WORK (FIRST TERM):

Student should submit a Progress Report on the work done by him/her during the
First Phase of the project including following points;

1. Project Selection,
2. Literature Search Strategy,
3. Literature Review,
4. Project Planning.

Student will have to give a seminar on the above topics.

Internal Examination (40 marks): Components of internal assessment:

Project Selection (05 Mark.) Literature Collection and Literature Revive (10 marks), planning and design (10 marks), Submission of progress report (10 marks), regular attendance (5 marks) recorded by Research Supervisors

- **<u>External Assessment:</u> of M. Sc. Project should be on annual basis in forth semester with assessmentof PHY-RP 525.**

Suggested readings: Refer the topic in research papers, review articles published in peer reviewed and SCI indexed journals, reference books, abstracts, etc. related to topic of project Dissertation.

Semester – IV

Course Code: PHY-521
Course Title: Nuclear Physics

Course Code: PHY-521	Course Category: Core
Course Title: Nuclear Physics	Type : Theory
Total Contact Hour : 60 (4/week)	Course Hour : 04
College Assessment (CA) Marks : 40	University Assessment (UA) Marks : 60

Course Objectives:

- To provide students the basic knowledge of Nuclear Physics.
- Explore the fundamental principle of detection techniques for nuclear physics.
- To gain in-depth knowledge of radioactive decays and elementary particle Physics.

Course Outcomes:

- Describe the basic interaction mechanisms for charged particles and electromagnetic radiation.
- To study the mechanism of radiation detectors and counters
- Speculate the basic features involved in alpha and beta decays and nuclear forces

Course Content:

Unit 1: Basics of Radioactivity Phenomenon (12 H, 12 M)

Introduction, Production of various radioisotopes and its Application in various fields, Alpha particle energy and Geiger-Nuttal law, Rutherford' scattering of α particle, Rutherford's scattering formula, Neutrino hypothesis, The Fermi theory of beta-decay, selection rule for beta decay, Gamma ray spectra, Nuclear isomerism, radioactive transitions in nuclei for gamma decay, radiation hazards and safety, Problems.

Unit 2: Interaction of Nuclear Radiation with Matter (14 H, 14 M)

Introduction, Energy loss of charged particles (Bohr formula); stopping power; range and straggling of charged particles; Cerenkov radiation; gamma (γ) ray interaction through matter; law of absorption of γ – rays; linear and mass absorption coefficient; the photoelectric process; Compton effect; pair production and annihilation of electron – positron pair; Dirac's theory of pair production; problems.

Unit 3: Radiation detectors (10 H, 10 M)

Introduction, Ionization and transport phenomena in gases, Ionization chamber, Proportional counter, GM counter, Scintillation detector and photomultiplier tube (PMT), Semiconductor detector, Bubble Chamber, Cloud Chamber, spark chamber, problems.

Unit 4: Mass Spectrograph and particle accelerators (10 H, 10 M)

Introduction, Aston's mass spectrograph, Bain bridge Mass Spectrograph, The van de Graff generator, Linear accelerator, Cyclotron, Betatron, Electron synchrotron, Proton synchrotron, synchrocyclotron.

Unit 5: Elementary particles (14 H, 14 M)

Classification of Elementary Particles, Decays of Elementary Particles, Fundamental interactions in nature, Concept of force carrier, Yukawa Potential of interaction, elementary particle and their intrinsic quantum numbers (charge, Lepton number, Baryon number, iso-spin, strangeness etc.); Conservation Laws of elementary particles, Gelmann-Nishijima formula, Elementary idea about CP and CPT invariance, Electrons and Positrons, Protons and antiprotons, Neutrons and antineutrons, Neutrinos and antineutrinos; Quark: assumption and properties; Quark model; colour of a Quark and its importance.

Reference Books:

1. Introductory Nuclear Physics by K. S. Krane Wiley, India.
2. Concepts of Nuclear Physics by B. L. Cohen Tata McGraw Hill.
3. Nuclear Physics by I. Kaplan, Narosa, New Delhi.
4. Atomic and Nuclear Physics by S. N. Ghoshal, S. Chand.
5. Nuclear Physics by D. C. Tayal, Himalaya Publishing House.
6. The Atomic Nucleus by R. D. Evans Tata McGraw Hill.
7. Nuclear radiation detectors by S. S. Kapoor and V. S. Rmanurthy, Wiley Eastern Limited, New Delhi
8. Radiation Detection and Measurement by G. F. Knoll, Wiley India.
9. Fundamentals of Nuclear Physics by Jahan Singh, Pragati publication.
10. Nuclear Physics by Pandya and Yadav, KedarnathRamnath Publication.
11. Introduction to Nuclear and Particle Physics by Mittal, Varma and Gupta, PHI publication.

Course Code: PHY-522

Course Title: Materials Characterization Techniques

Course Code: PHY-522	**Course Category: Core**
Course Title: Materials Characterization Techniques	**Type : Theory**
Total Contact Hour : 60 (4/week)	**Course Hour : 04**
College Assessment (CA) Marks : 40	**University Assessment (UA) Marks :60**

Course Objectives:

- To learn various materials characterization techniques.
- To facilitate students with the new insights of characterization techniques.
- To explore the fundamental principles behind various characterization techniques with their practical applications.

Course Outcomes:

- Describe the fundamental processes of advanced material characterization techniques
- Explain various applications of these techniques in pure material science
- Compare various aspect associated to characterization techniques

Course Content:

Unit 1: IR and UV- Visible spectroscopy **(16 H, 16 M)**

Range of IR absorption, requirement for IR radiation absorption, theory of IR absorption spectroscopy, linear molecules, spherical molecules, symmetric molecules, asymmetric molecules, IR spectrophotometer (single beam and double beam), Color and light absorption, concept of chromophore, theory of electronic spectroscopy-orbital's involved in electronic transitions, laws of light absorption-Beer's and Lamberts law, UV-spectrophotometer (single beam and double beam), applications of UV-Vis spectroscopy, Band gap determination (Direct, Indirect) for thin films.

Unit 2: Raman spectroscopy **(10 H, 10 M)**

Characteristic properties of Raman lines, differences between Raman spectra and infrared spectra, mechanism of Raman effect, Raman spectrometer, intensity of Raman lines, Application of Raman spectroscopy.

Unit 3: X-ray diffraction **(12 H,12 M)**

Crystalline state, X-ray diffraction methods, structure determination, particle size determination, crystallography by diffraction of radiations other than X-ray, application of X-ray diffraction measurement and analysis.

Unit 4: Electron Microscopy **(16 H, 16 M)**

Need of Electron Microscopy, Electron Specimen interaction (Emission of secondary electrons, back scattered electrons, characteristics x-rays, transmitted electrons), Specimen interaction volume, resolution, Scanning electron microscope (SEM) Schematic diagram and Short details of each component, Field Emission Gun, Field Emission Scanning electron microscope(FESEM), Principle of Image Formation, Energy Dispersive Analysis of X-rays (EDAX), Transmission electron microscope(TEM), Merits of TEM over SEM/FESEM.

Unit 5: Atomic Force Microscopy **(6 H, 6 M)**

Operating principle, Different operating modes: Contact, tapping, non-contact, forces between the tips and surfaces, limitations of AFM.

Reference Books:

1. Elements of X-ray diffraction by B.D. Cullity, Addision-Wesely Publishing Co., USA.
2. Encyclopedia of Materials Characterization, (Series) by Richard Brundle, Charles A Evans, Jr Shaun Wilson, Surface, Interfaces.
3. SEM Micro-characterization of semiconductors by B. Holt, and D.C. Joy, Academic Press, New Delhi.
4. Fundamental of molecular spectroscopy by Banwell, Tata McGraw-Hill Publ. Company Ltd New Delhi.
5. Electron Microscopes (Laboratory instruments and techniques by J. A. Swift, Kogan page, London.
6. Introduction to Diffraction in Materials Science and Engineering by Aaron D Krawitz, John Willey and Sons Inc.
7. Atomic Force Microscopy by Cheryl R Blanchard, The Chemical Education.

Course Code: PHY-523

Course Title: Special Laboratory – VI

Course Code: PHY-523	Course Category: Core
Course Title: Special Laboratory - VI	Type : Practical
Total Contact Hour : 60 (8/week)	Course Hour :08
College Assessment (CA) Marks : 40	University Assessment (UA) Marks : 60

Course Objectives:

- To learn the principles of material testing and characterization and to apply them for various scientific applications.
- To correlate knowledge of Material science and Materials Characterization Techniques practical with their theory.
- To learn basic mechanism of robotics and electric vehicles.
- To impart knowledge of basic concepts in MATLAB and its Applications

Course Outcomes:

- Prepare the specimens with the help of various synthesis techniques independently.
- Analysis of different materials based on their characterization techniques.
- Apply various test methods for characterizing physical, electrical, optical properties etc. of materials.

SECTION A:

1. To study the Thermionic emission properties of tungsten wire.
2. To study the atomic energy levels by Franck-Hertz Experiment.
3. To study the effect of temperature on various electronic properties by Hall effect set-up.
4. To determine the band gap in a semiconductor using a PN junction diode.
5. Determination of activation energy of a thermistor.
6. To determine electronic charge € and work function of the cathode material using photocell.
7. To study the characteristics of a photo-transistor and hence verify inverse square law.
8. To measure the ionic conductivity of sodium chloride (NaCl) or potassium chloride (KCl).

9. To verify Curie-Weiss Law.
10. To find water of crystallization in copper sulphate by TGA.
11. Determination calorific value of wood/ cow dung.

SECTION B:

1. Determination of optical band gap using UV Visible spectroscopy.
2. Analysis of X-ray Diffraction pattern for determination of crystal structure.
3. Synthesis of thin films by spin coating/ CBD method.
4. To study the optical properties of semiconducting film by Photoluminescence spectroscopy.
5. Analysis of IRand RamanSpectra of given sample.
6. Analysis of scanning electron microscopy (SEM) of given sample.
7. Analysis of SEM and TEM of given semiconductor sample.
8. Determination of thermoelectric power and type of sample using TEP.
9. To determine the wavelength of a LASER source using an engraved scale as a reflecting diffraction grating.
10. To determine diameter of a given wire by diffraction.
11. To verify Heisenberg uncertainty principle using He-Ne laser source.

SECTION C: List of Experiments from Elective Course - PHY -524 (A)

1. Identify the electrical circuits and test their parameters by using electrical measuring instruments, and the basic electronic circuits and analyse their circuit functioning practical
2. Battery Controller based on SoC for charging and Discharging of battery in EV using MATLAB/SIMULINK
3. State of charge (Soc) control of lithium ion battery in MATLAB/SIMULINK for EV
4. Modeling and simulation to calculate the electric vehicles speed from the motor torque
5. Design of bi directional battery circuit using Buck/ Boost converting using MATLAB/ SIMULINK

SECTION C: List of Experiments from Elective Course - PHY -524 (B)

1. Estimation of accuracy, repeatability and resolution.

2 Robot programming and simulation for peak and place.

3. Robot programming and simulation for color identification.

4. Robot programming and simulation for shape identification.

6. Robot programming and simulation for writing practice.

7. Robot programming and simulation for multiprocessor.

SECTION C: List of Experiments from Elective Course - PHY -524 (C)

1. Solve the given system of linear equations using MATLAB

2. Solve the given integrals using MATLAB

3. Solve the given linear differential equation using MATLAB and plot the results.

4. Find the Fourier coefficients and plot the given Fourier series using MATLAB

5. Write the MATLAB code for RungeKutta 2nd order.

6. Write the MATLAB code for RungeKutta4th order.

SECTION C: List of Experiments From Elective Course - PHY -524 (D)

Take list of experiments related to the SWAYAM/NPTEL Live course selected by respective college.

(**Note:-***Perform at list 10 experiments total –

- Select 5 experiments from Section: A list
- Select 3 experiments from Section: B list. And
- Select 2 Experiments from Section: C according to respective elective course from **PHY -524 (A/B/C/D)**selected by the College

More experiments can be added to this list with prior permission of Chairman BOS Physics)

Course Code: PHY-524 (A)
Course Title: Fundamentals of Electric Vehicles Science And Technology

Course Code: PHY-524(A)	Course Category: Elective
Course Title: Fundamentals of Electric Vehicles Science and Technology	Type : Theory
Total Contact Hour : 60(4/week)	Course Hour : 04
College Assessment (CA) Marks : 40	University Assessment (UA) Marks :60
Course Objectives: • The course will provide basic information about the science and technology behind EVs. • The course will discuss different components of EV with their specifications.	
Course Outcomes: • Generalize the basic issues of electrical vehicles • Analyze the electrical vehicle platforms • Evaluation and performance of driving aspects of EV's • To learn the Design of simple e-vehicle	

Course Content:

Unit 1: Basics of EV **(12H, 12M)**

Can India Drive its EV Program Innovatively and Differently and Scale, Can India Drive its EV Program Innovatively and Differently and Scale?, Charging and Swapping Infrastructure, Where will We Get Lithium for Batteries? Forces Acting When a Vehicle Move, Power and Torque to Accelerate

Unit 2: Systems of EV **(12H, 12M)**

Concept of Drive Cycle, Drive Cycles and Energy Used per Km, EV Subsystem: Design of EV Drive Train

Unit 3: EV Batteries **(12H, 12M)**

Introduction to Battery Parameters, Why Lithium Ion Battery? Batteries in Future, Li-Ion Battery Cells, Possibilities of use of Lithium Ferro phosphate Batteries.

Unit 4: EV Parameters **(12H, 12M)**

SoH and SoC Estimation and Self Discharge, Battery Pack Development, Computation of Effective Cost of Battery, Charging Batteries, EV Motors and Controllers: Understanding Flow,

Unit 5: Power of EV's **(12H, 12M)**

Power and Efficiency, Torque Production, EV Chargers: Introduction, EV Chargers: Slow or Fast, Battery Swapping, Standardization and On Board Chargers, Brief about charge stations, Public Chargers, AC/DC chargers,

Reference Books:

1. Fundamentals of Electric Vehicle Technology: A DIY Guide for EV Beginners (DIY guru) Kindle Edition by Avinash Singh, Aayush Chimurkar, Anubhav Sen, Nikhil Raj, Ashutosh Kumar.
2. Electric Power train – Energy Systems, Power electronics and drives for Hybrid, electric and fuel cell vehicles, by John G. Hayes and A. Goodarzi, Wiley Publication.
3. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Fundamentals, Theory, and Design, by Mehrdad Ehsani, YiminGao, Sebastien E. Gay, Ali Emadi, CRC Press.

Course Code: PHY–524(B)

Course Title: Robotics and Applications

Course Code: PHY-524(B)	Course Category: Elective
Course Title: Robotics and Applications	Type : Theory
Total Contact Hour : 60(4/week)	Course Hour :04
College Assessment (CA) Marks : 40	University Assessment (UA) Marks :60

Course Objectives:

- To develop the student's knowledge in various robot structures and their workspace.
- To develop student's skills in performing spatial transformations associated with rigid body motions.
- To develop student's skills in perform kinematics analysis of robot systems.
- To provide the student with knowledge of the singularity issues associated with the operation of robotic systems.
- To provide the student with knowledge and analysis skills associated with trajectory planning.
- To provide the student with knowledge and skills associated with robot control.

Course Outcomes:

- Apply knowledge of mathematics and sciences
- Explain basic concepts, parts of robots and types of robots.
- Design automatic manufacturing cells with robotic control.
- Modify the electronic control system in manufacturing process.

Course Content:

Unit 1: End Effectors **(12H, 12M)**

Gripper force analysis and gripper design, design of multiple degrees of freedom, active and passive grippers. SELECTION OF ROBOT: Factors influencing the choice of a robot, robot performance testing, economics of robotization, Impact of robot on industry and society.

Unit 2: Sensors in Flexible Manufacturing Systems: **(10H, 10M)**

Vision sensors, image transformations, robot visual sensing tasks, detecting partially visible objects, sensors in flexible manufacturing.

Unit 3: Material Handling **(14H, 14M)**

Concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, monorails, rail guided vehicles, conveyor systems, cranes and hoists, advanced material handling systems, automated guided vehicle systems, automated storage and retrieval systems(ASRS), bar code technology, radio frequency identification technology.

Unit 4: Robot for inspection **(8H, 8M)**

Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection, software considerations.

Unit 5: Industrial Robotics **(8H, 8M)**

Robot Anatomy and Related Attributes – Classification of Robots- Robot Control systems – End Effectors – Sensors in Robotics – Robot Accuracy and Repeatability - Industrial Robot Applications – Robot Part Programming – Robot Accuracy and Repeatability.

Unit 6: Industrial Application of Robot **(8H, 8M)**

Application of Robots in continuous arc welding, Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications.

REFERENCES:

1. "Introduction to Robotics in CIM Systems"By James A Rehg, Prentice Hall of India.
2. "Robotics Technology and Flexible Automation"by Deb S R, Tata McGraw Hill, New Delhi, 1994
3. "Robotics and Control"by Nagrath and Mittal,, Tata McGraw-Hill
4. "Robot Dynamics and Control"by Spong and Vidhyasagar,, John Wiley and sons
5. Robotics, control, sensing, Vision and Intelligence
   by Fu. K.S, Gonzalez, R.C., Lee, C.S.G, McGraw Hill International

Course Code: PHY-524 (C)

Course Title: MAT-LAB

Course Code: PHY-524(C)	Course Category: Elective
Course Title: MAT-LAB	Type : Theory
Total Contact Hour : 60(4/week)	Course Hour :04
College Assessment (CA) Marks : 40	University Assessment (UA) Marks :60

Course Objectives:

- To provide a foundational understanding of MATLAB programming concepts.
- Students will acquire knowledge of fundamental laws and principles in various areas of Physics, along with the ability to apply them using MATLAB programming.
- Students will cultivate research skills encompassing advanced laboratory techniques, numerical methods, graphical methods, and advance calculus, all applied through MATLAB programming.

Course Outcomes:

- Upon completion of the course, students are expected to have acquired proficiency in MATLAB programming.
- Students will develop the ability to apply MATLAB techniques into physical systems effectively.
- Upon completion of the course, students will be equipped to solve complex physical systems characterized by nonlinear differential equations and random walk processes.

Course Content:

UNIT 1: Introduction to MATLAB (10 H, 10M)

MATLAB environment; working with data sets; data input and output; logical variables and operators; array; X-Y Plotting and simple graphics.

UNIT 2: Data types and File Operations (15 H, 15M)

Data types: matrix, string, cell, and structure; file input and output; File functions; MATLAB files; Matrices and array operations, elemental matrix functions; simple programs; Conditional Statements and loops.

UNIT 3: Applications of MATLAB (15 H, 15M)

Solving linear algebraic equations; Curve fitting; Interpolation and Extrapolation; Numerical and symbolic Integration/differentiation; Fourier transformation; Basic and Specialized 2D plots; Overlay plots; 3D plots and view.

UNIT 4: Advance MATLAB Techniques and Problems (20 H, 20M)
Diffusion Limited Aggregation – fractals; Lagrangian of a compound system; Non-linear Differential equation; Finite Difference method; Optimization Problem; Interactive basic animation.

References :

1. MATLAB Programming Fundamentals – 1984-2021 by the Math Works.Inc.
2. R. Pratap, Getting started with MAT-LAB: A quick Introduction for scientist and engineers, oxford university press (201

Course Code: PHY-524 (D)

Course Title: SWAYAM/NPTEL Live Course

See the guidelines about Swayam /NPTEL live course issued by KBC NMU Jalgaonon website

Course Code: PHY-RP -525
Course Title: PROJECT

Course Code: PHY-RP-525	**Course Category: Research Project**
Course Title: Project	**Type : Project**
Total Contact Hour : 60 (12/week)	**Course Hour : 12**
College Assessment (CA) Marks : 40	**University Assessment (UA) Marks :60**

Course Objectives:

- To give exposure to develop research culture amongst students
- To introduce students how to select a research topic, plan, perform experiments, collection and an analysis of research data.
- To boost self-confidence and self-reliance in the students as he/she learns to work and think independently.

Course Outcomes:

- Conceive a problem based on published research and carry comprehensive survey of literature
- Plan and carry out task in given framework of dissertation and present the work in written and viva
- Use a holistic view to critically, independently and creatively indentify, formulate the problem.
- Learn handling of instruments, use of chemicals and how to conduct the experiments
- Learn how to present the project in power point and answer the queries to examiners as well as skill of writing of research project.

Course Content:

Activities:

1. To complete the experimental work.
2. To carry out the measurements.
3. To characterize the samples.
4. To obtain the results.
5. To draw the conclusions.
6. To write the project report.
7. To appear for Internal examination
8. To appear for External examination

Project Report:

1. Students have to write a ‘project report’.

2. A report should be a concise account of project work containing full descriptions of the aims, method and outcomes.
3. Length of report should not normally exceed 40 pages. Assessment Criteria of the project: The following criteria are to be used in assessing the project work:

(i)The conduct of project work:
The following questions are considered in assessing how well students have carried out the project work:
1. How difficult was the project?
2. How well did the student understand the scientific principles behind the project?
3. How well did the student plan the project work?
4. How much effort was put into the project?
5. Was an interim report presented on time?
6. Is the student's project logbooks adequate?
7. How much initiative and/or originality did the student contribute to the project?
8. How well did the student cope with problems that arose during the course of project?
9. Did a project reach a stage of completion where meaningful results were obtained and definite conclusions could be drawn?

(ii) The Project Report:
1. How well did the report set out the background?
2. How well did the report describe the underlying them?
3. Was the report a reasonable length?
4. How well was the report structured?
5. How understandable was the written content?
6. How well did the report describe the execution of the project?
7. Did the report have an adequate summary or conclusions?

(iii) Oral Examination:
1. Did the student adequately describe what he/she had done in their project?
2. Did the student have a clear interpretation of his/her results?
3. What was the clarity and overall standard of the presentation?
4. How well was the talk/presentation structured?
5. Did the student cover all the relevant material in a reasonable time?
The project is allotted during the third semester. The students will get an opportunity to become a part of ongoing research activities in the respective supervisor's laboratory. The students will acquire skill to write, compile and analyze data if any, and present the detailed technical/scientific report. At the end of successful project semester training, potentially the students become employable in the industries/organizations.
It is expected that the students will design experiments and collect experimental data. At the end, they will submit a detailed thesis for evaluation. The students should be introduced to research methodology in the beginning through few lectures.
The systematic approach towards the execution of project should be as follows:

1.Selection of topic relevant to priority areas of Physics.

2.Collection of literature on the topic of research from libraries, internet, online journals, Planning of research experiments.

3.Performing the experiments with scientific and statistical acceptability.

4.Presentation of observations and results.

5.Interpretation of results and drawing important conclusions.

6.Discussion of obtained results with respect to literature reports.

7.Writing monthly progress report

8.Preparation of report (Dissertation) containing introduction, materials and methods, results and discussion, conclusions, bibliography and submission of at least 3 copies (1 copy retained in the department and after examination submitted to Library, 1 copy submitted to the guide and 1 copy kept with the candidate).

9.Presentation of research data during university examination and submission of project dissertation in abound form.

1. **Internal examination (40 marks):** Components of continuous internal assessment: Submission of progress report (8 marks), Literature collected, experiment planning and design (10 marks),

Experiments conducted (10 marks), outcome of the experiments and viva (8 marks) and regular attendance (4 marks) recorded: Research Supervisors

2. **External examination, [PHY-RP516 (60 Marks) + PHY-RP-525 (60 marks)]** and Components of external assessment: Subject matter (5+5 marks), Review of literature (10+10 marks), Writing of dissertation submitted in bound form at the time of examination (Title page, Certificate, Main content: Abstract, Introduction, Literature, Materials and methods, results and discussion and conclusion with relevant references) (15+15 marks), Presentation structure (PPT format) (10+10 marks), Overall presentation reflecting contribution of work (5+5 marks), Response to questions (15+15 marks).

Suggested readings: Refer the topic in research papers, review articles published in peer reviewed and SCI indexed journals, reference books, abstracts, etc. related to topic of project dissertation