PHYE- 314 – Electives 3 (B3) : Modern Trends in Spectroscopy

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

Learning Objectives:

a) Acquiring of knowledge concerning the electrical behavior of dielectric materials.
b) The students become accustomed with the nuclear magnetic resonance (NMR) methods.
c) The student will develop their abilities to investigate polyatomic molecules by NMR spectroscopy.
d) Imparting knowledge based on fundamentals of physical principles and measurement methods used for characterization.

Learning Outcomes:

a) The student will be able to analyze the molecular spectra.
b) The student will be able to analyze the FTIR spectra of thin film and molecules and determine their structure.
c) The student will be able to analyze the NMR spectra of molecules, and determine their structure

Course Contents

1. **ELECTRONS SPIN RESONANCE SPECTROSCOPY:**
Principle of ESR, ESR Spectrometer, Total Hamiltonian, Hyperfine Structure. ESR Spectrum of Hydrogen Atom, ESR Spectra of Free Radicals in Solution- Energies of Radicals with One Unpaired Electron, CH_3 Radical, Benzene Anion ($C_6H_6^-$), etc.

2. **FOURIER TRANSFORM INFRARED SPECTROSCOPY:**
Introduction, Historical Background, FT-IR Spectroscopy, Basic Integral Equation, Attenuated Total Reflectance, Experimental Setup, Advantages, Other Aspects, Applications, Surface Studies, Characterization of Optical Fibers, Vibrational Analysis of Molecules, Study of Biological Molecules, Study of Polymers.

3. **NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY**
Introduction, Magnetic Properties of Nuclei, Resonance Condition, NMR Spectrometer, Relaxation Processes and their Mechanism. Bloch Equation, Fourier Transformation, Dipolar Interaction, Chemical Shift. Indirect Spin Interaction. Spectrum of Spin $^1/_2$ AB System. Interpretation of Few NMR Spectra.

4. DIELECTRIC SPECTROSCOPY:

Classification of the experimental methods. Frequency methods: Bridges, Resonance methods, Coaxial lines, Waveguides, Transient methods, Strip lines, etc. Broad Band Dielectric Spectroscopy: A frequency response analyzer (10^4Hz 10^6 Hz), automatic radio frequency bridge (10 Hz -10^7 Hz) coaxial line reflectometer (10^6 Hz 10^9 Hz) and coaxial vector network analyzer (10^7 Hz 10^{10} Hz). Time Domain Dielectric Spectroscopy: The single reflection and transition methods. Multiple reflection, transition, lumped capacitance methods. Non-uniform sampling, Fourier transform and the time domain treatment, Applications of dielectric spectroscopy.

References :

1. Dielectric Properties and Molecular Behaviour, by Nora E. Hill, A. H. Price and Mansel Davies, ISBN 10: 0442034113 ISBN 13: 9780442034115 Published by Van Nostrand Reinhold Company (1969) London.
2. Handbook of Applied Solid State Spectroscopy, by D. R. Vij, ISBN: 978-0-387-32497-5 (Print) 978-0-387-37590-8 (Online) **DOI** 10.1007/0-387-37590-2, 2006 Springer.
3. MOLECULAR STRUCTURE AND SPECTROSCOPY, by ARULDHAS, G. , Second Edition ,2004. ISBN: 978-81-203-3215-7, PHI Learning.

PHYE-314 – Electives 3 (C3) : Reactor Physics

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

Learning Objectives:

To enable the students to study the basic and advance concepts of Reactor Physics

Learning Outcomes:

Students will be able to study the basic and advance concepts of Reactor Physics will be able have job opportunities in BARC.

Course contents:

Unit I: The Neutron

Discovery of neutron, neutron sources, basic properties of neutrons, wavelength of neutrons, high energy neutrons, measurements of energy of neutrons, time of flight method.

Unit II: Neutron Detections

Detection of neutrons, detection of slow neutrons- foil- activation method, ionization chambers and counter tubes for the detection of slow neutrons, Scintillatiors for the detection of slow neutrons, fission chambers for detection of thermal neutrons, detection of fast neutrons.

Unit III: Neutron Diffraction

Neutron diffraction from crystal, reflection for slow neutrons from mirrors, mechanical velocity selectors, measurement of neutron cross-section as a function of energy, cold neutrons and their isolations, neuton electron interaction, decay of neutrons.

Unit IV: Physics of Nuclear Reactors

Thermalization of neutrons, dynamics of elastic scattering of neutrons, angular distribution of neutons, diffusion of thermal neutron ,Fermi age equation, condition of criticality of a reactor, critical equation of a reactor, rectangular parallelepiped reactor.
Types of Nuclear reactors : Spherical reactor, reactor in the shape of a cylinder, Physical processes in a reactor, control of reactors, nuclear fuel conversion, nuclear materials employed in reactors, moderators, some important reactors, Swimming pool (Apsara) type reactor, Zerlina type reactor.

References:

1. **Nuclear Physics,** R. C. Sharma.
2. **Nuclear Physics**, I. Kaplan, 2nd edition, Narosa, 1989.
3. **Basic Nuclear physics,** B. N. Shrivastava, Pragati prakashan, Meerut.
4. **Nuclear Physics**, D.C. Tayal, Himalaya Publishing House, Bombay.
5. **The elements of nuclear reactor theory,** Glastone and Edund.
6. **Introduction to Nuclear Engineering,** Murry.

PHYE-314 – Electives 3 (D3) : Physics of Nanomaterials

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

Learning objectives:

Students should be able to,

- describe the physical properties of nanomaterials resulting from constraints on their nanoscale organization.
- analyze structure-function relationships at the nanoscale.
- discuss how to analyze and understand nanoscale features of materials
- gain basic knowledge in the synthesis of nanomaterials, their properties and characterization.
- be able to apply basic knowledge of physics and materials science to develop proficient understanding of how nanoscale properties affect macroscale performance and enable new technologies.

Learning outcomes:

Student will,

- acquire knowledge about the techniques of how to synthesize nanomaterials and will
  understand their nanoscale properties;
- acquire insight into how macroscopic properties can be changed via molecular level engineering and nanoscale manipulation;
- acquire fundamental knowledge of nanotechnology principles and applications.

Course Contents:

Unit I: Fundamentals of nanosized particles:

Concepts of nanomaterials, Size and Dimensionality Effects, idea of quantum well structure, quantum dots, Energy levels of quantum dots. Quantum Mechanical background;(electron confinement in: square well of finite depth & infinitely deep square well, confinement in two dimensional well).

Unit II: Synthesis of nanomaterials:

Top down and Bottom up concepts, Growth techniques of nanomaterials: Plasma Arc discharge, Sputtering, Evaporation, physical vapor deposition, Chemical vapor deposition, Pulsed Laser deposition, Molecular beam epitaxy, Sol-gel process, Co-precipitation process.

Unit III: Characterization techniques:

XRD,Scanning Probe Microscopy (SPM), Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM), Electron Microscopy: Scanning Electron Microscopy (SEM & FESEM), Transmission Electron Microscopy (TEM).

Unit IV: Properties and applications of nanomaterials:

Physical Properties of nanomaterials ; i) Photocatalytic. ii) Dielectric. iii) Magnetic. iv) Optical. v) Mechanical.

Carbon clusters & Fullerenes; Carbon Nanotubes: Structures & Electronic Properties, Application of carbon Nanotubes.

References:

1. Nanotechnology: Principles and Practices, Sulbha K. kulkarni; (2009), Revised Reprint; Capital Publishing Company; ISBN:81-85589-29-1.
2. Introduction to Nanoscience, Charles P. Poole, Jr., Frank J. Owens; Reprint (2011); Wiley India Edition; ISBN: 978-81-265-1099-3.
3. The physics and Chemistry of Nanotechnology, Frank j. Owens, Charles P. Poole Jr.; John Wiley & Sons. Inc. Hoboken, New Jersey; (2008); ISBN: 978-0-470-06740-6 (cloth).
4. Nano Materials, Nanotechnologies and Design, Michael F. Ashby. Paulo J. Ferreira, Daniel L. Shodek; © 2009 First Printed in India (2011); Butterworth-Heinemann, An imprint of Elsevier; ISBN: 978-93-80931-77-7.
5. Introduction to Nanoscience, S.M.Lindsay; Indian Edition; Oxford University Press; (2010); ISBN-13: 978-0-19-959129-9
6. Nanostructures and Nanomaterials: synthesis, properties and applications, Guozhong Cao, zying Wang; 2nd Edition; World Scientific Publishing; (2011); ISBN-13:978-981-4322-50-8; ISBN-10:9814-4322-50-4; ISBN-13:978-981-4324-55-7(pbk) ; ISBN-10:981-4324-55-8(pbk)
7. Introduction to Nanoscience, Gabor L. Hornyak, Joydeep Dutta, Harry F. Tibbals, Anil Rao; CRC Press, Taylor & Francis Group; © (2008); ISBN-978-1-4200-4805-6.

PHYE-314 – Electives 3 (E3) : X ray Diffraction

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

Learning Objectives: With the establishment of national synchrotron source in Indore (a few hundred km from Aurangabad) this course will help a student in understanding the most powerful source of plane and circularly polarized x rays. Further such a course is not taught at present anywhere in India. Being an Elective Course this course be taught during Sem IV. This course is based on the various research activities carried out on the India's indigenously built synchrotron source INDUS 2. The students will have a prior training before they pursue their research activities on INDUS 2 or any SR in the world.

Learning Outcomes:

1. The takers can fetch a job or research fellowship at SR INDUS
2. The practice of data analyses will help a student in getting a job in pharma industries.

Course Contents:

Unit I : X ray Diffraction-1:

Limitations of x rays from tubes as regards x ray diffraction studies, synchrotron radiation as source of x rays: Production and properties of radiation from storage rings, wigglers and undulators, Insertion devices. types of polarized x rays using SR, INDUS I and INDUS II, Diffraction using SR: using plane polarized x rays and using circularly and elliptically polarized x rays (X ray Circular Magnetic Dichroism XCMD): methods of obtaining monochromatic x rays, polarized x rays; Detectors: high flux (> 10^8photons/sr/sec), very low time structure (~ 10^{-9} sec or less)

Unit II: X ray Diffraction-2:

X ray diffraction data analysis of various types of samples : cubic, tetragonal, hexagonal, etc, determination of various parameters like lattice parameters, near neighbor distances, strain, etc. Pair distribution Function (PDF) analysis

Unit III: Emission Spectroscopy:

Continuous and characteristic X-ray spectra, Energy level diagram. Dipole, forbidden and satellite lines. Regular and irregular doublets. Relative intensity of X-ray lines. Chemical effects in X-ray spectra; Experimental techniques of wavelength and energy dispersive Xray spectroscopy: Bragg and double crystal spectrometers. Focussing spectrographs: Cauchois, Johann and Johanson types. Tangential incidence grating spectrographs.

Unit IV: Absorption Spectroscopy:

Absorption of X-rays. Physical process of X ray absorption. Measurement of X-ray absorption coefficients. Units of dose and intensity, X-ray fluorescence. Auger effect. Fluorescence yield. Auger electron spectroscopy, Photoelectron spectroscopy, Chemical effects in X-ray absorption spectra. White line, Chemical shifts of absorption edges, Fine structures (XANES and EXAFS) associated with the absorption edges and their applications. Soft X-ray spectroscopy of metals and alloys, Applications to semiconductors and insulators

References:

(1) X-rays in Theory and Experiment , A.H. Compton and S.K. Allison, 1935,(New York: D. Van Nostrand Company, Inc. 1935) This is a classic book written by a Nobel Laureate.

(2) Elements of Modern X-ray Physics, Jens Als-Nielsen and Des McMorrow (ISBN 0471498580, 9780471498582, Wiley 2001)

(3) X-Ray Science and Technology, A. G. Michette and C. J. Buckley (ISBN-13: 978-0750302333 ISBN-10: 075030233X CRC Press 1993)

(4) Principles and Practice of X-ray Spectrometric Analysis, E.P. Bertin (ISBN 1461344166, 9781461344162 Springer Science & Business Media 2012)

PHYE-314 – Electives 3 (F3) : Thin film and Vacuum Technology

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

Learning Objectives: This program will help prepare students to work as technicians in industries which rely on vacuum-based processes to create and manufacture products. Individuals studying vacuum technology will learn skills in building, validating, operating, maintaining, and troubleshooting vacuum-based equipment as well as providing advice on the use of this equipment and the processes supported by this technology. Positions may include responsibilities associated with research and design, operations, quality control, technical writing, and technical sales.

Learning Outcome : Employment opportunities span a variety of industries such as semiconductor, microelectromechanical systems (MEMS), glass, optics, light-emitting diodes (LEDS), solar cells, vacuum-based equipment and other industries which used thin film coating processes. The duties of a technician include building, validating, operating, maintaining, and troubleshooting vacuum-based equipment as well as providing advice on the use of this equipment and processes supported by this technology. The Vacuum and Thin Film Technology program prepares a student to work as a technician in industries which rely on vacuum-based processes to create and manufacture products. Employment opportunities span a variety of industries such as:Semiconductor, Microelectromechanical systems (MEMS), Glass, Optics, Light-emitting diodes (LEDS), Solar cells, Vacuum-based equipment, Other industries which use thin film coating processes

Course contents:

Unit I: .

Thermodynamics and Thin Film growth, Vacuum Technology: Gas Laws, Kinetic Theory of Gases, Conductance and Throughput, Gas Sources in a Vacuum Chamber, Vacuum Pumps.

Unit II: .

Physical Vapor Deposition: Sputtering (Plasma Physics (DC Diode), rf Plasmas, Magnetic Fields in Plasmas, Sputtering Mechanisms) and Evaporation.

Unit III: .

Chemical Vapor Deposition: Mechanisms, Materials, Chemistries, Systems. Module-V Etching: Wet Chemical Etching (Mechanisms, Materials and Chemistries), Dry Plasma Etching/Reactive Ion Etching (Mechanisms, Materials and Chemistries).

Unit IV: .

FILM Formation and Structure: Capillarity Theory, Atomistic Nucleation processes, Cluster Coalescence, Grain Structure of Films. Thin Film Characterization: Structural, optical, electrical and magnetic

References

1. R. K. Waits, Thin Film Deposition and Patterning, American Vacuum Society, 1998. M. Ohring, ISBN 10: 156396872X ISBN 13: 9781563968723
2. The Materials Science of Thin Films, Academic Press, Boston, 1991. Ludmila Eckertova, Physics of Thin Films, 2nd Plenum Press New York, 1986 (QC 176.83.E2613 1986) ISBN 10: 0123418240 ISBN 13: 9780123418241
3. Kasturi L. Chopra, Thin Film Phenomena (McGraw-Hill, 1969). ISBN 10: 0070107998 ISBN 13: 9780070107991
4. Handbook of Thin Film : Maissel and Glang (1970). ISBN 10: 0070397422 ISBN 13: 9780070397422

PHYE-314 – Electives 3 (G3) : Nuclear Spectroscopy

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

PHYE-314 – Electives 3 (H3) : Micro Electro Mechanical System

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

PHYL-321 : Lab course 5 (Based on Electives A1/ B1/ C1/ D1)

PHYL-321 – Lab course 5 (A1) : 8086 Microprocessor and interfacing : Credits 3

Learning Objectives:

1. To facilitate the students to understand
   a) the concepts of microprocessor and assembly language programming.
   b) the concept of interfacing devices at laboratory as well industrial level

2. To provide an opportunity to the students to enter into entrepreneurship.

Learning Outcome:

1. Students will be able to learn

   a) Microprocessor architecture, physical configuration of memory, logical configuration of memory, microprocessor programming and interfacing.

2. Students will be capable to perform following job

   a) Industrial automation using 8086 interfacing and programming.
   b) Start his / her own small scale industry for manufacturing microprocessor based automated devices.

3. Students will have option to start his / her teaching career either in science or engineering colleges / institutes as this course is included in science as well engineering discipline.

Experiments using 8086 Kit

1. Data transfer, addition, subtraction, multiplication, division and sum of series
2. Factorial and square of the number
3. Sorting of data (ascending / descending), square root of a number
4. Arithmetic mean of N- numbers and sum of square of Numbers
5. Interfacing of SPDT switches and 7 segment display as a position encoder / decoder
6. Interfacing of stepper motor
7. Interfacing of DC motor
8. Interfacing of DAC to generate ramp wave, triangular wave and square wave.
9. Interfacing of 8-bit ADC
10. Interfacing of LCD display

Experiments Using 8086 Assembler

11. Data transfer, addition, subtraction, multiplication, division and sum of series
12. Factorial and square of the number
13. Sorting of data (ascending / descending), square root of a Number
14. Arithmetic mean of N- numbers and sum of square of Numbers

Note: Students should perform any eight experiments.

PHYL-321 – Lab course 5 (B1) : Atomic Spectroscopy : Credits 3

Learning Objectives:

a) Recording the atomic spectra using latest computer interfaced instruments
b) Analysis of recorded atomic spectra
c) Study of various types of excitation mechanisms and excitation sources
d) Study the effect of external electromagnetic fields on the atomic spectra
e) Analysis of the recorded atomic spectra

Learning Outcomes:

a) The student will get a training for using state of the art data acquisition system in spectroscopy laboratory
b) The student will get a training for analysis of recorded atomic spectra
c) The student will be able to design various kinds of spectroscopic emission sources and their power supplies
d) The student will be able to design the electromagnets and their power supplies
e) Hence the Entrepreneurship.

Course Contents:

1. Record the spectrum of Hydrogen using HR 4000 spectrometer and determine Rydberg constant
2. Record the spectra of (arc sources) copper, iron, zinc and brass using HR 4000 spectrometer
3. Record the spectra of (gas discharge sources) Hg, Cd using HR 4000 spectrometer
4. Record the spectra of (inert gases) Ne, He using HR 4000 spectrometer
5. Study of NMR spectra of various samples using NMR spectrometer
6. To verify the line spectra of calcium and to verify the Lande interval rule
7. To verify the Lande interval rule for the sharp series lines of Zinc
8. Record the absorption spectrum of the Sun using HR 4000 spectrometer and identify the elements in the spectrum
9. Study of hyperfine structure using Zeeman effect
10. Study of normal Zeeman effect and calculation of *e/m*
11. Determining earth's magnetic field with ESR

References:

1. ATOM, LASER AND SPECTROSCOPY by THAKUR, S. N. , RAI, D. K. , SECOND EDITION , 2010 ; ISBN: 978-81-203-4832-5

Note: Students should perform any eight experiments.

PHYL-321 – Lab course 5 (C1) Nuclear Physics Credits 3

1. To study characteristics of Geiger-Muller (G-M) counter.
2. Determination of dead time of Geiger-Muller G-M) counter (Two source method).
3. Determination of dead time of Geiger-Muller (G-M) counter (Absorber method).
4. To study absorption of beta particles in matter.
5. Verification of the Inverse Square Law.
6. Window thickness of a Geiger-Muller (G-M) counter.
7. Window thickness of a Geiger-Muller (G-M) counter (Inverse Square Law).
8. Shelf ratios of a sample holder.
9. Determination of Efficiency of a Geiger-Muller (G-M) counter.
10. Energy dependence of Geiger-Muller (G-M) counter efficiency.
11. Determination of beta decay energy.
12. Relationship between thickness of absorber and backscattering
13. Shielding effect of radiation penetrability
14. Strength of a beta-source
15. Determination of Half-Life of unknown sample
16. Half-life of ^{40}K.
17. Statistics of radioactive measurements.
18. Poisson distribution of radioactive measurements.
19. Gaussian distribution of radioactive measurements.
20. Chi-Square test of Geiger-Muller (G-M) counter.
21. Study of Mossbauer spectra of magnetic materials.
22. Statistical aspects of radioactivity measurements.
23. Beta backscattering as a function of atomic number.
24. Determination of the air borne activity.
25. Secular equilibrium.
26. Transient equilibrium.

Note: Students should perform any eight experiments.

PHYL-321 – Lab course 5 (D1) : CRYSTALLOGRAPHY : Credits 3

Experiments on Crystallography:

1. Determination of energy band gap of semiconducting material (Thermister) by Bridge method.
2. Measurement of Hall coefficient of a given sample..
3. Energy band gap of a P-N junction
4. To measure the ionic conductivity of ionic solids and to determine activation energy
5. Variation of specific heat of solid with temperature
6. To determine the coefficient of thermal conductivity
7. Determination of velocity and wavelength of ultrasonic waves.
8. Study of crystal structure by Powder method front reflection, back reflection (measurement of lattice parameter and indexing of powder photograph / X ray powder diffractometer data cubic, tetragonal, orthorhombic)
9. Interpretation of transmission Buare photograph
10. Determination of orientation of crystal by back reflection Laue method
11. Rotation / Oscillation photograph and their interpretation
12. Determination of particle size using X-ray powder method
13. Porosity determination of semiconducting material.
14. Structural analysis of thin film by XRD

Note: 1) Other experiments may be added as per the availability of instruments. 2) Students should perform any eight experiments.

PHYL-322 : Lab course 6 (Based on Electives A2/ B2/ C2/ D2)

PHYL-322 – Lab course 6 (A2) : Microwave and communication Electronics: Credits 3

Experiments based on Microwave and communication Electronics:

1. Demonstrate the relationship between frequency (f), wavelength (λ_0) in free space and wavelength in waveguide (λ_g)
2. Reflex Klystron Characteristics – Mode diagrams, ETR and ETS
3. Gunn Diode Characteristics; I-V Characteristics, Power versus bias characteristics and Power-frequency characteristics
4. Microwave Horn Antenna E-H Plane pattern and Beam width
5. Study of square law behavior of microwave crystal detector and hence to determine Operating range and detection frequency
6. Study of high and low VSWR and impedance measurements using Smith chart.
7. Measurement of S- parameters of a) E-Tee b) Magic Tee c) Directional coupler.
8. Determination of dielectric constant of solids – Two point method
9. Determination of dielectric constant of liquids – Robert-Von Hipple method
10. Study of Faraday's rotational principle
10. Study of PAM and its detection
11. Study of Balance modulator using IC 1596
12. Study of FSK modulation and detection
13. Study of PPM and detection
14. Study of PLL
15. Study of PWM and detection

Note: Students must perform at least <u>**eight**</u> experiments from above list.

PHYL-322 – Lab course 6 (B2) : Molecular Spectroscopy: Credits 3

Learning Objectives:

a) Recording the molecular spectra using latest computer interfaced instruments
b) Vibrational and rotational analysis of the recorded molecular spectra and estimation of molecular parameters
c) Study of various types of excitation mechanisms and excitation sources
d) Theoretical knowledge of potential energy curves, wavefunctions, molecular orbitals, basis sets, functions

Learning Outcomes:

a) The student will get a training for using state of the art data acquisition system in spectroscopy laboratory
b) The student will get a training for analysis of recorded molecular spectra
c) The student will be able to design various kinds of spectroscopic emission sources and their power supplies
d) The student will be able to design the electromagnets and their power supplies
e) Hence the Entrepreneurship.

Experiments based on Molecular Spectroscopy

1. Vibrational analysis AlO : Record the spectrum of Al arc in air using HR4000 spectrometer. Construct the Deslandre's table by using known wavelengths and calculate the vibrational constants of upper and lower electronic states
2. Vibrational analysis C_2 Swan system: Record the spectrum of gas flame (C_2 Swan system) in air using high resolution monochromator. Construct the Deslandre's table by using known wavelengths and calculate vibrational constants of upper and lower electronic states
3. Recording the high resolution spectra of BeO using high resolution spectrometer with CCD camera and calculate vibrational constants of upper and lower electronic states
4. Rotational analysis of spectra of diatomic molecules (High resolution spectroscopy)
5. Studies of IR spectra of organic molecules containing various functional groups using IR/FTIR spectrometers.
6. Spectroscopic investigations of molecules using Raman Spectrometer.
7. Record the spectrum of Iodine and determine dissociation energy of I_2 molecule by Brige-Spooner method
8. Calculation of Morse potential energy curves for molecular X and B states of AlO, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states

9. Calculation of Morse potential energy curves for molecular states of Swan system of C_2, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states.
10. Calculation of Morse potential energy curves for molecular states of visible system of BeO, and to plot wavefunctions and probability amplitudes for first three vibrational levels of the two states
11. "Comparing STO's and GTO's " Lab procedure
12. Basis sets, Functions , and CPU time Lab Procedure
13. Study of ESR spectra of various samples using ESR spectrometer

Note: Students should perform any eight experiments.

PHYL-322 – Lab course 6 (C2) : Nuclear Physics: Credits 3

Experiments based on Nuclear Physics

1. Study of gamma ray spectrum using scintillation counter using single channel analyzer.
2. Absorption of gamma rays in lead.
3. Absorption of gamma rays in aluminium.
4. Alpha spectroscopy with surface barrier detector- energy analysis of an unknown gamma source.
5. Determination of range of beta particles in aluminium.
6. X-ray fluorescence with proportional counter.
7. Determination of range of beta particles from unknown source by feather analysis.
8. Design, fabrication and study of Linear pulse amplifier.
9. Excitation of K-X-rays in different material by beta radiation (verification of Mosley's law).
10. Kinematics of Compton scattering. Compton scattering process.

Note: Students should perform any eight experiments.