_Semester - IV

Semester – IV
(Elective Courses)

PHYE-411: Generic Electives - 4 (A4/ B4/ C4/ D4): Credits 4

PHYE-411 – Generic Electives 4 (A4): Fundamentals of Sensors: Credits 4

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

Learning Objectives:

1. To facilitate the students to understand
   a) the concepts of sensor
   b) the concept of different principles of sensors
2. To provide an opportunity to the students to enter into sensor research
3. To create enthusiasm among the students to undertake research in sensors

Learning Outcome:

1. Students will be able to -
   a) learn Sensors, characteristics of sensors, optical fiber and optical sensors.
   b) develop sensor devices.
2. Students will be capable to undertake research in Sensors.

Course Contents:

Unit I : Introduction

Sensors and Sensor Science, Sensors–Eyes and Ears of Machines, The Term 'Sensor', Optical Sensors, Physical Sensors, Chemical Sensors, elements of chemical sensors, **Sensor Physics**, Solids, Energy Band Model, Lattice Defects, Ionic Conductance, Hopping, Junctions and Potential Barriers, **Primary electronics for sensors :** Amplification by Operational Amplifier, Instruments for electric measurements.

Unit II : Sensors and Sensor Characteristics

Sensors, Signals, and Systems; Ideal sensor curve, ideal sensor requisite, Sensor Classifications ; **Sensor Characteristics**: Transfer Function; Span (Full-Scale Input) ; Full-Scale Output ; Accuracy ; Calibration ; Calibration Error ; Hysteresis; Nonlinearity ; Saturation ; Repeatability ; Dead Band ; Resolution ; **Parameters of sensors** : Sensitivity, detection limit, response and recovery time, selectivity, dynamic range, linearity, stability

Unit III : Optical Sensors

Introduction of light detectors: Photodiodes, Phototransistor , Photoresistors ; photovoltaic cell, Optical waveguides and fibres, types of optical fibers : single mode, multimode and graded index optical fiber, concept of TIR and ATR, Optical fibre sensors: Introduction and classification of

sensors with optical fibres, Optical fibre sensors with amplitude modulation, Sensor with wavelength modulation; Optical chemical sensors: Introduction, Optical sensors: Methods of detection, Evanescent wave sensors.

Unit IV : Physical Sensors

Potentiometric Sensors; Gravitational Sensors; LVDT and RVDT , Eddy Current Sensors , Piezoelectric sensors, **Resistive Sensors:** Potentiometers, Strain gages; Inductive sensors, Capacitive sensors, Bridge circuits, Displacement Measurements, **Blood Pressure Measurements:** Extravascular sensors, Intravascular sensors, Disposable pressure sensors

References:

1. Chemical Sensors: An Introduction for Scientists and Engineers : Grundler, Peter; Springer Berlin Heidelberg New York **(2007),** ISBN 978-3-540-45742-8
2. Modern Sensors Handbook, Edited by Pavel Ripka and Alois Tipek; ISTE Ltd, USA **(2007),** ISBN 978-1-905209-66-8.
3. Handbook of Chemical and Biological Sensors; Edited by Richard F Taylor, Arthur D Little Inc., Jerome S Schultz, University of Pittsburgh ; Institute of Physics Publishing Bristol and Philadelphia; **(1996)** ISBN 0 7503 0323 9
4. Hand Book of Modern Sensors : Physics, Designs and Applications By Jacob Fraden Third Edition (Springer-Verlag New York, Inc.) **(2004),** ISBN 0-387-00750-4.
5. Understanding Smart Sensors By Randy Frank; Second Edition; Artech House Boston . London **(2000),** ISBN 1-58053-398-1.
6. Sensors and Transducers, Third Edition By Ian R. Sinclair; Butterworth-Heinemann publication, Woburn **(2001),** ISBN 0 7506 4932 1
7. Principles of Chemical Sensors : Janata, Jiri 2nd Edition ; Springer Dordrecht Heidelberg London, New York **(2009),** ISBN 978-0-387-69930-1 e-ISBN 978-0-387-69931-8
8. Optoelectronics Devices and System SECOND EDITION by S. C. Gupta; Prentice Hall International **(2011)** ISBN: 978-81-203-5065-6
9. Optical Fibers and fiber optic communication Systems by Subir Kumar Sarkar; S Chand & Company Ltd **(2000),** ISBN: 9788121914598
10. Lasers and Optical Fiber Communications by P Sarah; I.K. International Publishing House Pvt Ltd, New Delhi **(2008),** ISBN : 9788189866587 / 8189866583
11. Optoelectronics by R. A. Barapate (Tech-Max Publication) **(2003)**

PHYE-411 – Generic Electives 4 (B4) : Applied Spectroscopy

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

Learning Objectives:

a) Describe the basic principles of physics as related to the field of photonics.
b) Integrate the concepts of light, geometric and wave optics and their practical applications in photonics.
c) Theory and practice of instrumental methods for the separation, identification and quantitative analysis of chemical substances.
d) To understand how structure and bonding influence the physical properties and reactivity of molecules.
e) To be able to use crystal field theory to understand the electronic and magnetic properties of transition metal complexes.
f) To be able to use symmetry to predict molecular orbital diagrams and explain electronic spectra

Learning Outcomes:

a) After completing this course the student will be able to use spectroscopic methods for qualitative and quantitative analysis.

Course Contents

1. **SPECTROSCOPIC INSTRUMENTATION:** Spectrographs and Monochromators, Speed of Spectrometer, Spectral Transmission Range, Spectral Resolving Power, Free Spectral Range, Prism Spectrometer, Basic Considerations and Spectral Resolving Power of Grating Spectrometers, Multiple Beam Interferometry: Basic Concepts, Comparison between Spectrometer and Interferometer: Spectral Resolving Power, Light Gathering Power, Accurate Wavelength Measurement.

2. **DETECTION OF LIGHT**: Thermal Detectors, Photodiodes, Photoconductive Diodes, Photovoltaic Detectors, Fast Photodiodes, Photodiode Arrays, Photoemissive Detectors, Photocathodes, Photomultipliers, Detection Techniques and Electronic Equipment, photon counting, Charge Couple Devices.

3. **FLUORESCENCE & PHOSPHORESCENCE SPECTROSCOPY**: Fluorescence. Joblanski Diagram, Resonance Fluorescence and Normal Fluorescence. Intensity of Transitions. Non Radiative Decay of Fluorescent Molecules, Effects of Medium on Fluorescence Spectra. Population of Triplet States, Phosphorescence Intensity, Solvent

Effect, Delayed Fluorescence. Excitation Spectra. Experimental Methods, Emission Life Time Measurement. Application of Fluorescence and Phosphorescence.

4. **MOLECULAR SYMMETRY AND GROUP THEORY:** The Defining Properties of a Group, Some Examples of Groups, Subgroups, Classes, Symmetry Operations, Symmetry Elements, Algebra of Symmetry Operations, Multiplication Table. Molecular Point Groups, Matrix Representation of Symmetry Operations, Reducible and Irreducible Representations, Character Table for C_{2v} and C_{3v} Point Groups, Symmetry Species of Point Groups, Complete Character Table for Point Group, Distribution of Fundamentals among the Symmetry Species, Infrared Activity, Raman Activity.

References :

1. Laser Spectroscopy, Volume 1: Basic Principles, Fourth Edition by Wolfgang Demtroder, Springer,
   ISBN: 978-3-540-73415-4 e-ISBN 978-3-540-73418-5, DOI 10.1007/978-3-540-73418-5 Library of Congress Control Number: 2007939486, © 2008, 2003, 1996, 1981 Springer-Verlag Berlin Heidelberg.
2. Modern Spectroscopy by J. M. Hollas, ISBN: 9780470844167, Published by John Wiley & Sons Ltd. (2004) Fourth Edition.
3. Spectroscopy by B. P. Straughan & S. Walker, ISBN: 0470150319 (v.1, Halsted Press), ISBN: 0470150327 (v.2), ISBN: 0412133806 (v.3, Cased Ed.) London: Chapman & Hall, New York, Vol. 1,2 & 3 (1976)
4. MOLECULAR STRUCTURE AND SPECTROSCOPY, by ARULDHAS, G. , Second Edition ,2004. ISBN: 978-81-203-3215-7, PHI Learning
5. Chemical Applications of Group Theory by F. Albert Cotton, ISBN: 9780471510949, John wiley & Sons (Wiley - Interscience) (1990) Third Edition.
6. Elements of Group Theory for Physicists by A. W. Joshi, ISBN: 812240975X, New Age International Private Limited publishers, New Delhi, (1997) Revised Fourth Edition.
7. Group Theory and Quantum Mechanics by M. Tinkham, ISBN: 9780486432472, Mc-Graw Hill Book Company, New Delhi (1964).

PHYE-411 – Generic Electives 4 (C4) : Particle Physics, Nuclear forces and Cosmic rays:

(Credits: 04; Contact Hours: 60)

Lectures: 48

Tutorials: 12

Learning Objectives:

This course is necessary for the students to make aware to various elementary particles apart from proton, neutron and electron. The knowledge of elementary particles is helpful in understanding the nuclear structure, their interactions, the course should be taught as an elective and it should be taught at Semester-IV as it requires understanding of interactions of those particles with other particles (elementary particles) which is a very involved topic and requires knowledge of other aspects of nuclear physics covered in IIIrd semester. The course will help the student for preparation of NET/SET and other competitive examinations.

Learning Outcomes:

The course is useful to students as it provides knowledge of various elementary particles, their properties etc and the nature of strongest force i.e. Nuclear force. The students can get job and opportunity of research in nuclear energy sector and accelerator center. The course is extremely important for carrying out theoretical research leading to more and more elementary particles and ultimately vision of universe. The origin of universe is a hot topic these days, for which studies in cosmic rays in also necessary in short, the course for the basis for front-line research in physics in present times.

Course Contents:

Unit I: Elementary Particles physics-I

Concept of elementary particle, Fundamental properties of elementary particles, Classification of elementary particles, Particle Interactions, Coupling constant, Quantum numbers of elementary particles, Conservation laws of elementary particles, Relationship between particle and antiparticle.

Unit II: Elementary Particle Physics-II

Properties of massless and Lepton Particles, Properties of mesons (Pions, Neutral π-meson, K-mesons, η-meson), Properties of Baryons (Nucleons, Hyperons, resonant particle), Description of strange particles (K-mesons and Hyperons, Violation of parity, Strangeness and hypercharge, Properties of strange particles), Quarks and Gluons, Inversions in elementary particles (Time-reversal, Parity, Charge conjugation), Elementary particle symmetries (SU (3)-symmetry, Gell-Mann-Okubo mass formula).

Unit III: Nuclear Forces

Introduction, Characteristics of nuclear forces, The deuteron, The ground state of deuteron, Radius of deuteron, n-n and n-p scattering, p-p scattering below 10MeV, Distinction between p-p and n-p scattering, Similarity between n-n and p-p forces, Meson theory of nuclear forces.

Unit IV: Cosmic rays

Introduction, Types of cosmic rays, Properties of primary cosmic rays, Geomagnetic effect, Interpretation of geomagnetic effect, Properties of secondary cosmic rays, Absorption of cosmic rays, cosmic ray showers, Extensive air showers, origin of cosmic rays.

References:

1. **Fundamentals of Nuclear Physics,** Jahan Singh, 1st edition, Pragati Prakashan, Meerut- (2012) (ISBN-978-93-5006-593-8)
2. **Nuclear Physics,** D. C. Tayal, 10th edition, Himalaya Publishing House, Mumbai- (2005) (ISBN-81-8318-281-x).
3. **Nuclear Physics,** Satya Prakash, 2nd edition, Pragati Prakashan, Meerut (2011) (ISBN-81-7556-915-8).
4. **Nuclear Physics,** S. B. Patil, 1st edition, New Age International Publishers, New Delhi-(1991) (ISBN-978-81-224-0125-7).
5. **Nuclear Measurement Techniques,** K. Sri Ram, 1st edition, Affiliated East-West Press, Madras(1986) (ISBN-81-85095-56-6).
6. **Basic Nuclear Physics,** B. N. Srivastava, 14th edition, Pragati Prakashan, Meerut (2008) (ISBN-978-81-8398-474-4).
7. **Nuclear Physics,** R. C. Sharma, 1st edition, K. Nath & Co. Meerut- (2007) (ISBN-EBK0036746).
8. **Nuclear Physics,** K. P. Das, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-517-3).
9. **Radioactive Materials,** Dr. B. M. Rao, 1st edition, Himalaya Publishing House, Mumbai-(2002).
10. **Nuclear Energy,** R. K. Taneja, 1st edition, Cyber Tech Publications, New Delhi- (2009) (ISBN-978-81-7884-516-6).