

B. SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC - 13: ELECTROMAGNETIC THEORY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Electromagnetic Theory DSC – 13	4	3	0	1	Class XII pass with Physics and Mathematics as main subjects	Mathematical Physics I, II; Waves and Oscillation; Electricity and Magnetism papers of this course or their equivalents

LEARNING OBJECTIVES

This core course develops further the concepts learnt in the electricity and magnetism course to understand the properties of electromagnetic waves in vacuum and different media.

LEARNING OUTCOMES

At the end of this course the student will be able to,

- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density
- Understand electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma
- Understand electromagnetic wave propagation in bounded media: reflection and transmission coefficients at plane interface in bounded media
- Understand polarization of electromagnetic waves: Linear, circular and elliptical polarization. Production as well as detection of waves in laboratory
- Learn the features of planar optical wave guide
- In the laboratory course, the students will get an opportunity to perform experiments with polarimeter, Babinet compensator, ultrasonic grating and simple dipole antenna. Also, to study phenomena of interference, refraction, diffraction and polarization

SYLLABUS OF DSC – 13

THEORY COMPONENT

Unit - I

(6 Hours)

Review of Maxwell's equations; Coulomb gauge and Lorentz gauge; Poynting's theorem and Poynting's vector; electromagnetic (em) energy density; physical concept of electromagnetic field energy density

Unit – II

(10 Hours)

EM wave propagation in unbounded media: Plane em waves through vacuum and isotropic dielectric medium: transverse nature, refractive index, dielectric constant, wave impedance. Plane em waves through conducting medium: relaxation time, skin depth, attenuation constant;

Wave propagation through dilute plasma: electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth.

Unit – III

(9 Hours)

EM waves in bounded media: Boundary conditions at a plane interface between two media; reflection and refraction of plane em waves at plane interface between two dielectric media - Laws of reflection and refraction; Fresnel's formulae for perpendicular and parallel polarization, Brewster's law; reflection and transmission coefficients; total internal reflection, evanescent waves; metallic reflection (normal incidence)

Unit – IV

(13 Hours)

Polarization of EM waves: Propagation of em waves in an anisotropic media; symmetric nature of dielectric tensor; Fresnel's formula; uniaxial and biaxial crystals; light propagation in uniaxial crystal; double refraction; polarization by double refraction; Nicol prism; ordinary and extraordinary refractive indices; production and detection of plane, circular and elliptically polarized light; phase retardation plates: quarter wave and half wave plates

Optical rotation; Biot's laws for rotatory polarization; Fresnel's theory of optical rotation; specific rotation

Unit – V

(7 Hours)

Wave guides: Planar optical wave guides; planar dielectric wave guide ($-d/2 < x < d/2$); condition of continuity at interface; phase shift on total reflection; Eigenvalue equations; phase and group velocity of guided waves; field energy and power transmission (TE mode only)

References:

Essential Readings:

- 1) Introduction to Electrodynamics, D. J. Griffiths, 3rd edition, 1998, Benjamin Cummings.
- 2) Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd edition, 2003, CBS Publisher
- 3) Classical Electrodynamics, J. D. Jackson, 3rd edition, 2010, Wiley
- 4) Principle of Optics, M. Born and E. Wolf, 6th edition, 1980, Pergamon Press
- 5) Optics, A. Ghatak, 6th edition, 2017, McGraw-Hill Education, New Delhi

Additional Readings:

- 1) Electricity, Magnetism and Electromagnetic Theory, S. Mahajan, and S. R. Choudhary, 2017, TMH
- 2) Principles of Electromagnetic Theory, C. Jain, 2017, Narosa Publishing House
- 3) Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
- 4) Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill
- 5) Problems and solution in Electromagnetics, A. Ghatak, K. Thyagarajan and Ravi Varshney, 2015
- 6) Electromagnetic field Theory, R. S. Kshetrimayun, 2012, Cengage Learning
- 7) Engineering Electromagnetic, W. H. Hayt, 8th edition, 2012, McGraw Hill.
- 8) Electromagnetics, J. A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
- 9) 2008+ Solved Problems in Electromagnetics, S. A. Nasar, 2001, SciTech

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

- Mandatory sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.
- Mandatory sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.

At least six experiments to be performed from the following list

- 1) To verify the law of Malus for plane polarized light.
- 2) To determine the specific rotation of sugar solution using polarimeter.
- 3) To analyse elliptically polarized light by using a Babinet's compensator.
- 4) To study the elliptical polarized light using Fresnel rhomb.
- 5) To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
- 6) To study the reflection and refraction of microwaves
- 7) To study polarization and double slit interference in microwaves.
- 8) To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
- 9) To determine the refractive index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
- 10) To verify the Stefan's law of radiation and to determine Stefan's constant.
- 11) To determine Boltzmann constant using V-I characteristics of PN junction diode.
- 12) To find numerical aperture of an optical fibre.
- 13) To use a prism shaped double refracting crystal to determine the refractive indices of the quartz/ calcite corresponding to ordinary and extra-ordinary rays.
- 14) To measure birefringence of Mica
- 15) To determine the dielectric constant of solids using microwaves

References for laboratory work:

- 1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
- 2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publisher
- 3) Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
- 4) Practical Physics, G. L. Squires, 4th edition, 2015, Cambridge University Press
- 5) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd