Faculty of Science

Bachelor of Science (B.Sc.)

SUBJECT: PHYSICS

B.Sc. III Semester

Paper-Core Course (C4)

Electromagnetic Theory

Course Outcome

CO No.	Course Outcomes	Cognitive Level*
CO -I	Learner will Explain the historical development of electromagnetic ideas and interpret ancient Indian concepts such as Rayi, Praṇa, and Vidyut in relation to modern physics.	U, R
CO -II	Learner will Apply fundamental laws of electrostatics including Coulomb's and Gauss's laws to determine electric fields and potentials in various charge configurations.	Ap, E
CO -III	Learner will Analyze magnetic fields produced by steady currents using Biot-Savart and Ampere's laws and evaluate magnetic properties of materials.	U, Ap, An, E
CO -IV	Learner will derive and interpret Maxwell's equations and use them to explain electromagnetic induction, displacement current and field conservation laws.	R, U, An, Ap
CO -V	Learner will explain and analyze the propagation, reflection, refraction and polarization of electromagnetic waves in vacuum and media.	An, Ap, E, R

Credit and Marking Scheme

	Credits	Marks		Total Marks
		Internal	External	
Theory	4	30	70	**100**
Practical	2	30	70	**100**
Total	**6**	**200**		

Assessment and Evaluation

	Marks	
	Internal-30 Marks	**External-70 Marks**
Theory	Class Test/Assignment/Presentation	1 External Exams (At the End of Semester)
Practical	Class interaction, Attendance, Assignments	1 External Exams (At the End of Semester)

Content of the Course

Theory

No. of Lectures (in hours per week): 4.5 Hrs. per week

Total No. of Lectures: 60 Hrs. **Maximum Marks:** 60

Units	Topics	No. of Lectures
I	**Historical background** 1. Ancient Indian Concepts of Charge and Field, Study of early Indian scientific thought describing fundamental interactions through the concepts of Rayi and Prana. Examination of how these ideas anticipate the modern notion of science, Concepts of Prana and Energy Fields in the Upanishads. 2. Exploration of Vaisheshika Philosophy and its theory of Padartha, particularly the concepts of Dravya, Guṇa and Karma, which form an ontological basis for describing physical phenomena, Ancient Indian interpretations of atomicity, combination and energetic interactions relevant to early electromagnetic thought, Resonance in Ancient Indian Temple Architecture. **Activities:** 1. Study and analysis of ancient Indian concepts of lightning, magnetism, and energy described in texts such as the Atharva Veda. 2. Group discussion on the scientific aspects associated with traditional descriptions of the floating Somnath Lingam. **Keywords/Tags:** Vaisheshika, Rayi and Praṇa.	8
II	**Electrostatics** 1.Coulomb's Law, Electric field, Continuous Charge Distributions, Gauss's Law and its applications Curl of Electric Field, Introduction to Potential, Poisson's and Laplace's Equations, Boundary Conditions, Work and Energy in Electrostatics, Conductors: Basic Properties, Induced Charges, Introduction of Method of Images (Plane and Sphere) 2.Electric Fields in Matter: Polarization (P), Bound Charges, Electric Displacement (D), Linear Dielectrics (Susceptibility and Permittivity), Boundary Conditions.	13

	Activities: 1. Students will demonstrate the force between two charged balloons to understand Coulomb's Law. 2. Students will draw a diagram showing alignment of dipoles in a dielectric placed in an electric field. **Keywords/Tags:** Coulomb's Law, Electric Potential, Poisson's Equation.	
III	**Magnetostatics** 1. Lorentz Force, Magnetic Fields, Forces and Currents, Biot-Savart Law: Magnetic field of a steady current, Divergence and Curl of Magnetic Field, Ampere's Law and its applications, Magnetic Vector Potential (A), Boundary conditions, Comparison of Electrostatics and Magnetostatics Magnetic Fields in Matter: Magnetization (M), Bound Currents, Derivation of Curl $M=J_b$ for a non-uniformly magnetized substance The Auxiliary Field (H), Linear and Nonlinear Media, Magnetic Susceptibility and Permeability. **Activities:** 1. Students will draw the magnetic field pattern around a straight current-carrying wire using compass needles. 2. Students will tabulate examples of materials with high and low magnetic susceptibility and discuss their uses. **Keywords/Tags:** Lorentz Force, Biot-Savart Law, Ampere's Law, Magnetization, Magnetic Permeability.	**13**
IV	**Electrodynamics and Conservation Laws** 1.Electromagnetic Induction: Faraday's Law, Integral and differential forms of Faraday's law, Induced Electric Field, Electromotive Force (EMF), Self and Mutual Inductance, Energy in Magnetic Fields, Displacement Current, Correction in Ampere's Law, Maxwell's Equations (in Vacuum and in Medium), Boundary Conditions. 2 Conservation Laws: Continuity Equation, Poynting's Theorem (Energy Conservation), Momentum in Electromagnetic Fields (Maxwell Stress Tensor qualitative). Activities: 1. Students will verify Ohm's Law by measuring voltage and current in a simple circuit.	**13**

	2. Students will draw Maxwell's equations and identify the role of displacement current in completing Ampere's Law. **Keywords/Tags:** Inductance, Displacement Current, Maxwell's Equations, Poynting's Theorem.	
V	**Electromagnetic Waves** 1. Wave Equation, Electromagnetic (EM) Waves in Vacuum (monochromatic plane waves), Energy and Momentum in EM Waves. 2. Propagation in Linear Media, Reflection and Refraction (Normal Incidence, Snell's Law, Fresnel Equations qualitative for parallel/perpendicular polarization), Brewster's Angle, Total Internal Reflection. 3. Wave Guides: Introduction and TE Wave in Rectangular waveguides. **Activities:** 1. Students will draw a diagram showing electric and magnetic field components of a plane electromagnetic wave. 2. Students will verify Snell's Law using a glass slab and a laser light. **Keywords/Tags:** Wave Equation, Electromagnetic Waves.	**13**

References

Test/Reference Books:

Suggested Readings

1.Swami Paramananda, The Upanishads (Vol. I), Third Edition, The Vedanta Centre, Boston, Massachusetts, U.S.A.

2. Ganga Sahay Sharma, Atharva Veda, Sanskrit Sahitya Prakashan, New Delhi.

3. Raja Bhojadeva, Samarangana Sutradhara (Hindi Commentary by Sudhakar Malaviya), 1981, Chaukhamba Publications, Varanasi.

4. Mahajan S. and Choudhury, "Electricity, Magnetism & Electromagnetic Theory",2012, Tata McGraw.

5. Griffiths D.J., "Electricity and Magnetism", 3rd Edn., 1998, Benjamin Cummings.

6. A Concise History of Science in India, D. M. Bose, S. N. Sen, and B. V. Subbarayappa, Indian National Science Academy (INSA), New Delhi.

7. Vaiśeşika Philosophy of Nature, Debabrata Sinha, Bharatiya Vidya Prakashan.

8. Tayal D. C., "Electricity and magnetism", Himalaya Publishing Co.

9. Murugesan, "Electricity and magnetism", S. Chand & Co.

10. Feynman R. P., Leighton R.B., Sands M., "Feynman Lectures Vol.2", 2008, Pearson Education

11. Kshetrimayun R. S., "Electromagnetic field theory", 2012, Cengage Learning.

12. मध्य प्रदेश हिंदी ग्रंथ अकादमी, भोपाल द्वारा प्रकाशित पुस्तकें।

Web Links:

1. https://youtu.be/NED2C18u9Q0 Electromagnetic Theory by Prof. D.K. Ghosh, Department of Physics, IIT Bombay.
2. https://www.eshiksha.mp.gov.in/mpdhe/ Learning Management System, Department of higher education, Government of Madhya Pradesh (M.P.).
3. https://onlinecourses.nptel.ac.in/e-learning/preview/noc23_ph44 , Introduction To Electromagnetic Theory, NPTEL

List of Experiments

1. To draw the B-H curve and determination of Hysteresis loss.
2. Determination of voltage, frequency and phase difference using CRO.
3. To study of the charging and discharging of a condenser through a resistor.
4. Determination of impedance and power factor using LCR circuit.
5. Study of frequency response curve of a series LCR circuit and determination of resonant frequency, Quality factor and Band width.
6. To study of frequency response curve of a parallel L.CR circuit and determination of anti-resonant frequency and Quality factor.
7. Determination of Dielectric constant of Kerosene by resonance method.
8. To study the magnetic field along the axis of a circular coil.
9. Determination of M and H using vibrational magnetometer and deflection magnetometer.
10. Comparison of capacity of two capacitors using Ballistic Galvanometer
11. To plot the IV curve of several circuit elements (Through expEyes)
12. To plot two signals in the XY mode and find out their phase difference. The phase difference be generated by CR circuit. (Through expEyes)
13. To Study the transient response of RC circuit. (Through expEyes)
14. To Study the transient response of RL circuit. (Through expEyes)
15. To Study the transient response of LCR circuit. (Through expEyes)
16. **To determine the value of e/m of an electron by Thomson's method**
17. To determine the frequency of A.C. supply with the help of a wire vibrating under Lorentz force.

REFERENCES

1. Prakash I. & Ramakrishna, "A Text Book of Practical Physies", Kitab Mahal, 2011JLe
2. Squires G. L., "Practical Physics", Cambridge University Press, 2015, 4/c.
3. Flint B. L. and Worsnop H. T., "Advanced Practical Physics for students". Asia Publishing House, 197.
4. Chattopadhyay D. & Rakshit P. C., "An Advanced Course in Practical Physies", New Central Book Agency.
5. Singh S.P., "Advanced Practical Physics", Pragati Prakashan.
6. Tayal D. C., "University Practical Physics", Himalaya Publishing House
7. Kumar P. R. Sasi, "Practical Physics", PHI Publication
8. Srivastava Anchal, Shukla R. K., "Practical Physics", New Age International Publishers.
9. Agarwal D. C., "Experimental electronics", Technical Publishing House.
10. Srivastava J. P., "Elements of Solid-state Physics", PHI Publication.
11. Ghosh & Majumdar , Practical Physics, Modern Book Agency
12. मध्य प्रदेश हिंदी ग्रंथ अकादमी, भोपाल द्वारा प्रकाशित पुस्तके