Miami Dade College

Course Description

PHY4320 | Intermediate Electromagnetism | 3.00 Credits

This course will provide students with a deep understanding of electricity and magnetism at an intermediate level. It will reinforce the concepts learned in PHY2049, providing a better understanding of the fundamental electromagnetic phenomena. Content includes vector calculus, electrostatics, dielectrics, electric currents, magnetostatics, electromagnetic induction, Maxwell's equations, wave optics, and electromagnetic radiation. The course will emphasize classical models and problem-solving techniques. Prerequisites: PHY2049, MAP2302, PHZ3113.

Course Competencies:

Competency 1: The student will demonstrate knowledge, analysis, and application of vector calculus by:

1. Defining vector algebra operations and deriving and applying their properties.
2. Defining and applying vector differential operators in different coordinate systems.
3. Stating and applying the fundamental vector calculus theorems such as Stokes theorem, the divergence theorem, and Helmholtz's theorem.

Learning Outcomes:

1. Computer / Technology Usage
2. Critical thinking
3. Information Literacy

Competency 2: The student will demonstrate knowledge, comprehension, analysis, and application of the electrostatics of charges and conductors by:

1. Stating Coulomb's law and applying it to discrete and continuous charge distributions.
2. Defining the electric field and calculating its magnitude and direction for discrete and continuous charge distribution by the principle of superposition.
3. Defining electric potential and calculating its value for discrete and continuous charge distributions.
4. Relating the electric field to the electric potential. Stating Gauss' law and using it to calculate electric fields, fluxes, and enclosed charges.
5. Solving electrostatic problems in different coordinate systems using techniques involving Green's functions, delta functions, Laplace's equation, Poisson's equation, the method of images, and conformal mapping.
6. Deriving and applying expressions for the energy stored in an electric field.
7. Performing multipole expansions.
8. Deriving and applying expressions for the torque and energy of dipoles in electric fields.
9. Deducing the electrostatic properties of conductors.

Learning Outcomes:

1. Computer / Technology Usage
2. Critical thinking
3. Information Literacy

Competency 3: The student will demonstrate knowledge, comprehension, and analysis of the electrostatics of dielectrics

1. Using a microscopic model to explain the effects of dielectrics.
2. Using the macroscopic quantities of electric displacement and polarization to explain the effects of dielectrics.
3. Describing capacitors and deriving expressions quantifying their ability to store charge and energy.
4. Deriving and applying expressions quantifying the effect of capacitors when connected in DC and AC circuits.
5. Deducing the boundary conditions for the electric and the displacement fields in the presence of dielectrics.

Learning Outcomes:

1. Computer / Technology Usage
2. Critical thinking
3. Information Literacy

Competency 4: The student will demonstrate knowledge, comprehension, analysis, and application of electric currents by:
1. Defining current, current density, and electrical resistance.
2. Defining resistivity and conductivity and relating them to electrical resistance.
3. Using a classical microscopic model to explain the characteristics of electrical conduction in metals.
4. Stating and applying the continuity equation and Ohm's law.
5. Applying work-energy methods to situations involving the flow of charge through conductors.
6. Stating and applying the temperature dependence of conductivity.

Learning Outcomes:
1. Computer / Technology Usage
2. Critical thinking
3. Information Literacy

Competency 5: The student will demonstrate knowledge, comprehension, analysis, and application of magnetostatics by:
1. Defining the magnetic field vector.
2. Describing common magnetic fields such as that of the earth, bar magnets, compass needles, etc.
3. Stating and applying the expression quantifying the effects of magnetic fields on moving charges, currents, and current loops.
4. Deriving expressions for the storage of energy in magnetic fields.
5. Stating Biot-Savart's and Ampère's laws and using them to perform calculations involving currents and magnetic fields.
6. Defining the vector potential and using it to calculate magnetic fields.
7. Defining the concept of dipole moment and applying it to calculate torques and energy of magnetic dipoles in magnetic fields.
8. Describing the design of electric motors and using magnetic forces and torques to explain their functioning.

Learning Outcomes:
1. Computer / Technology Usage
2. Critical thinking
3. Information Literacy

Competency 6: The student will demonstrate knowledge, comprehension, analysis, and application of the magnetic properties of matter by:
1. Describing the different magnetic properties of matter.
2. Explaining magnetic properties of matter in terms of electron orbital and spin characteristics.
3. Explaining the magnetic properties of matter using the concepts of magnetization, susceptibility, permeability, bound currents, and the magnetic intensity H.
4. Deriving the boundary conditions for magnetic fields.
5. Describing and explaining ferromagnetism, permanent magnetization, and magnetization curves.

Learning Outcomes:
1. Computer / Technology Usage
2. Critical thinking
3. Information Literacy

Competency 7: The student will demonstrate knowledge, comprehension, analysis, and application of electromagnetic induction by:
1. Defining electromotive force and motional emf.

2. Using magnetic flux and Faraday's law to calculate the magnitude of electromagnetic induction.
3. Using Lenz's law to calculate the direction of the induced emf.
4. Using magnetic fields and electromagnetic induction to explain the formation of eddy currents as well as their interaction with magnetic fields.
5. Describing the design of electric generators and induction motors and using electromagnetic induction to explain their functioning.
6. Explaining the functioning of transformers.
7. Explaining the functioning of particle accelerators whose functioning is based on electromagnetic induction.
8. Defining self-inductance and mutual inductance.
9. Describing inductors deriving expressions quantifying their ability to affect current changes and to store energy.
10. Deriving and applying expressions quantifying the effect of inductors when connected in DC and AC circuits.

Learning Outcomes:

1. Computer / Technology Usage
2. Critical thinking
3. Information Literacy

Competency 8: The student will demonstrate knowledge, comprehension, analysis, and application of Maxwell equations by:

1. Defining and motivating the introduction of the concept of displacement current.
2. Stating the Maxwell equations in vacuum in integral and differential form.
3. Defining the scalar and vector potentials and relating them to gauge transformations and invariance.
4. Stating the Maxwell equations in matter, including boundary conditions of fields.
5. Stating and deriving Poynting's theorem.
6. Using the Maxwell equations to derive the equation for electromagnetic waves in a vacuum.
7. Finding plane wave solutions of the wave equation and deducing their properties

Learning Outcomes:

1. Computer / Technology Usage
2. Critical thinking
3. Information Literacy

Competency 9: The student will demonstrate knowledge, comprehension, analysis, and application of the electromagnetic theory of light by:

1. Relating electromagnetic waves to light.
2. Deriving the properties of reflection and refraction of light at different interfaces.
3. Deriving the properties of skin depth and reflectivity for electromagnetic waves incident on a metallic conductor.
4. Electromagnetic waves in a conductor.
5. Describing and deriving the radiation of electromagnetic waves by a dipole antenna and accelerating charges.
6. Using the classical model of dispersion to explain its frequency dependence.
7. Deriving the frequency dependence of Rayleigh scattering.

Learning Outcomes:

1. Computer / Technology Usage
2. Critical thinking
3. Information Literacy