PHYS1902 Physics 1 (Advanced) – Semester 2, 2016

MODULE 1 OUTLINE: ELECTRICITY AND MAGNETISM

Unit Description

This module is one of 3 comprising PHYS 1902 Physics 1 (Advanced). This document describes details of this module and should be read in conjunction with the more general unit of study outline for PHYS 1902 Physics 1 (Advanced).

General goals of this module

This lecture module aims to develop the ideas of electric and magnetic fields and illustrate their practical applications in engineering and physical science. It builds upon the ideas of forces on charges and currents, introducing fields as an alternative way of describing them and laying the foundations for more detailed studies of electromagnetism and electromagnetic radiation.

By the end of this module, you should be able to describe electric and magnetic fields and their effects on charges and currents, understanding each field as an alternative way of describing the corresponding force.

MODULE DEFINITION & OBJECTIVES – ELECTRICITY & MAGNETISM

(specified as references from the text: *University Physics (with Modern Physics)* by Young and Freedman, 13th edition)

LEARNING OBJECTIVES
For each topic in this Module the Specific Objectives define what we expect you to learn and understand. "Understanding" a term or concept means that you should be able to:

- *explain its meaning,*
- *interpret it correctly when you read or hear it,*
- *use it correctly in your own writing.*
- *apply it correctly to examples and problems.*

There is no easy road to learning. Your marks will depend on the work that you do. You should therefore read through and understand the sections of the textbook specified below, and work through the specified examples. You should then attempt as many as possible of the recommended questions, exercises and problems. Problem solving skills can only be acquired by practice.

This module is also supported by some web-based material accessible through the eLearning page for this unit.

Chapter 21 ELECTRIC CHARGE AND ELECTRIC FIELD
Text sections: all
Text examples: 21-1 to 14
Recommended Discussion Questions: 17

Specific objectives – after studying this chapter you should be able to:

- describe the concepts of electric charge and electric conductor
- explain why the electric field must be zero inside a conductor in a static situation
- describe Coulomb's law and use it to calculate the force between point charges
- describe the principle of superposition
- describe and explain the concept electric field and its relationship to electric forces
- use Coulomb's Law to calculate electric fields for various geometries
- describe the concept of electric field lines and their relation to the electric field
- be able to sketch electric field-line patterns for various charge distributions
- define electric dipole moment and calculate the torque on an electric dipole in an electric field

Chapter 22 **GAUSS' LAW**
Text sections: all
Text examples: 22-1 to 11
Recommended Discussion Questions: 1, 2, 6, 9, 10, 11, 12, 14, 15

Specific objectives – after studying this chapter you should be able to:

- explain the concept of electric flux and calculate it for simple geometries
- describe Gauss' law and explain how it can be used to calculate electric flux
- apply Gauss' to calculate electric fields in geometries involving lines, surfaces and volumes of charge
- use Gauss' Law to derive the charge distribution and electric field in and around conductors

Chapter 23 **ELECTRIC POTENTIAL**
Text sections: 23.1 to 23.4 (omit 23.5 Potential Gradient)
Text examples: 23-1 to 12
Recommended Discussion Questions: 9, 17

Specific objectives – after studying this chapter you should be able to:

- define and use the concepts of electric potential energy, electric potential and equipotential surface
- calculate electric potentials due to distributions of point charges
- describe, explain and sketch the electric potential in and near a conductor
- solve problems involving the relations among electric field, potential, charge distributions, work, potential energy and kinetic energy

Chapter 24 **CAPACITANCE AND DIELECTRICS**
Text sections: 24.1 to 24.3 (omit 24.4 Dielectrics to 24.6 Gauss' Law in Dielectrics)
Text examples: 24-1 to 9
Recommended Discussion Questions: 6, 8

Specific objectives – after studying this chapter you should be able to:

- define and use the concepts of capacitor, capacitance, farad and parallel-plate capacitor
- state and apply relations among capacitance, charge, potential difference, stored energy, electric field, and the dimensions of an air-filled parallel-plate capacitor
- calculate the overall capacitance of capacitors connected in series or in parallel
- describe the storage of energy in an electric field in a capacitor

Chapter 25 **CURRENT, RESISTANCE AND ELECTROMOTIVE FORCE**
Text sections: 25.1 to 25.5 (omit section in 25.2 on Resistivity and temperature, and omit 25.6 Theory of Metallic Conduction)
Text examples: 25-1 to 11
Recommended Discussion Questions: 2, 7

Specific objectives – after studying this chapter you should be able to:

- define and use the terms current and current density
- state and apply Ohm's law, and define resistance, resistivity, and electrical power
- define and use the concept of electromotive force
- describe and calculate energy and power in circuits

Chapter 26 **DIRECT-CURRENT CIRCUITS**
Text sections: 26-4 (RC circuits)
Text examples: 26-12 and 13
Recommended Discussion Questions: 20

Specific objectives – after studying this chapter you should be able to:

- Calculate and describe voltage, current and time constant in an RC circuit

Chapter 27 **MAGNETIC FIELD AND MAGNETIC FORCES**
Text sections: 27.1 to 27.7 (omit 27.8 and 27.9)
Text examples: 27-1 to 8
Recommended Discussion Questions: 2, 16

Specific objectives – after studying this chapter you should be able to:

- understand the concepts of magnetic fields and field lines
- state and apply expressions for the magnetic force on a moving point charge
- describe and explain the motion of a charged particle under the influence of a magnetic field alone
- describe and use the concept of magnetic flux and Gauss' law for magnetic flux
- state and apply expressions for the magnetic force on a straight curent-carrying wire in a uniform magnetic field

- describe and calculate the force and torque on a current loop
- define magnetic dipole moment and calculate the torque on a magnetic dipole in a magnetic field

Chapter 28 SOURCES OF MAGNETIC FIELD
Text sections: all except 28.8
Text examples: 28-1 to 10
Recommended Discussion Questions: 6, 11

Specific objectives – after studying this chapter you should be able to:
- describe the magnetic field of a moving charge
- define current element and describe its magnetic field (law of Biot and Savart)
- use the law of Biot and Savart to calculate magnetic fields for various geometries
- derive and use the expression for the force between two parallel currents
- describe Ampere's law and understand how it can be used to calculate magnetic fields
- apply Ampere's law to calculate magnetic fields in geometries involving a high degree of symmetry
- be able to sketch magnetic field-line patterns for various current distributions

Chapter 29 ELECTROMAGNETIC INDUCTION
Text sections: all except 29.8
Text examples: 29-1 to 12
Recommended Discussion Questions: 7, 11, 12

Specific objectives – after studying this chapter you should be able to:
- describe and explain the 3 physical processes that can produce induced emf: magnet moving relative to wire loop; a wire loop carrying current moving relative to another wire loop, and 2 fixed loops with current varying in one loop
- state and apply Faraday's law of induction
- state and explain the general rule for finding emf in a conductor moving through a region of magnetic field and apply it to simple cases
- appreciate that the induced electric field is not electrostatic, since it is caused by changing magnetic flux, rather than by charge separation; state Faraday's law in terms of this field and apply this statement
- apply Faraday's law to cases in which the conductor moves through the electric field
- state Lenz's law and apply it to determine the direction of an induced current or emf or the direction of the associated electric field
- describe and explain eddy currents
- understand Maxwell's generalisation of Ampere's Law and the concept of displacement current
- appreciate that the Maxwell-Ampere law describes how magnetic fields are produced by changing electric fields
- relate each of Maxwell's equations to the properties of the fields it describes
- describe the ways that electric and magnetic fields are created and the relationships between them, as embodied in Maxwell's equations

Chapter 30 INDUCTANCE
Text sections: all except 30.6
Text examples: 30-1 to 10
Recommended Discussion Questions: 1, 11

Specific objectives – after studying this chapter you should be able to:
- describe the concept of mutual inductance and calculate it for simple geometries
- describe the concept of self-inductance and calculate it for simple geometries
- calculate and describe the storage of energy in a magnetic field in an inductor
- calculate and describe voltage, current and time constant in an RL circuit
- describe and explain oscillations in LC circuits including energy transfer between capacitor and inductor

Chapter 32 ELECTROMAGNETIC WAVES
Text sections: 32.1 and 32.2 (omit section in 32.2 on Derivation of the wave equation)
Recommended Discussion Questions: 1

Specific objectives – after studying this chapter you should be able to:
- appreciate that the relationship between electric and magnetic fields, as embodied in Maxwell's equations, implies the existence of self-sustaining electromagnetic fields
- derive the speed of a simple electromagnetic plane wave in terms of the constants ε_o and μ_0.

