PHYS1003 Physics 1 (Technological) – Semester 2, 2016

MODULE 1 OUTLINE: ELECTRICITY AND MAGNETISM

Unit Description

This module is one of 3 comprising PHYS 1003 Physics 1 (Technological). This document describes details of this module and should be read in conjunction with the more general unit of study outline for PHYS 1003 Physics 1 (Technological).

General goals of this module

This lecture module aims to develop the ideas of electric and magnetic fields and illustrates 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) Note that the updated International version has removed the chapter and section numbers throughout the book.

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 included: Introduction, 21.1 Electric Charge, 21.2 Conductors, Insulators & Induced Charges, 21.3 Coulomb's Law, 21.4 Electric Field & electric Forces, 21.5 Electric Field Calculations, 21.6 Electric Field Lines
Excluded: 21.7 Electric Dipoles
Recommended Discussion Questions: 6,8,11,17,23

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

- describe the concept of electric charge
- describe the relation between charges and the structure of matter
- describe how charges move in conductors and insulators and how induced charge separation occurs
- explain Coulomb's law and use it to calculate the force between two point charges
- describe and explain the concept electric field and how it relates to electric forces
- calculate electric fields for simple geometries
- describe the concept of electric field lines and their relation to the electric field

Chapter 22 GAUSS'S LAW
Text sections included: Introduction, 22.1 Charge & Electric Flux, 22.2 Calculating Electric Flux, 22.3 Gauss's Law, 22.4 Applications of Gauss's Law, 22.5 Charges on Conductors
Recommended Discussion Questions: 11,12,13,14,15,17

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

- explain the concept of electric flux
- describe the relation between charge and electric flux
- calculate electric flux
- describe Gauss' law and understand how it can be used to calculate electric flux
- apply Gauss' to calculate electric fields in simple geometries -
- describe the motion of electric charges in conductors

Chapter 23 ELECTRIC POTENTIAL
Text sections included: Introduction, 23.1 Electric Potential Energy, 23.2 Electric Potential, 23.3 Calculating Electric Potential, 23.4 Equipotential Surfaces
Exclude: 23.5 Potential Gradient
Recommended Discussion Questions: 5,6,9,18,19

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 distribution, 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 included: Introduction, 24.1 Capacitors & Capacitance, 24.2 Capacitors in Series & Parallel, 24.3 Energy Storage in Capacitors & electric Field Energy, 24.4 Dielectrics
Exclude: 24.5 Molecular Model of Induced Charge, 24.6 Gauss's Law in Dielectrics
Recommended Discussion Questions: 3,4,6,7,8

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
- describe and calculate the effect of introducing a dielectric material into a capacitor

Chapter 25 CURRENT, RESISTANCE AND ELECTROMOTIVE FORCE
Text sections included: Introduction, 25.1 Current, 25.2 Resistivity, 25.3 Resistance, 25.4 Electromotive Force & Circuits, 25.5 Energy & Power in Electric Circuits
Exclude: 25.6 Theory of Metallic Conductors
Recommended Discussion Questions: 4,5,8,9,14,20,22

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

- define and use the term current
- 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 included: 26.1 Resistors in Series & Parallel, 26.2 Kirchhoff's Rules, 26.4 R-C Circuits, 26.5 Power Distribution Systems
Exclude: 26.3 Electrical Measuring Instruments,
Recommended Discussion Questions: 3,15,20,21,22

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 included: Introduction, 27.1 Magnetism, 27.2 Magnetic Field, 27.3 Magnetic Field Lines & Magnetic Flux, 27.4 Motion of Charged Particles in a Magnetic Field, 27.5 Applications of Motion of Charged Particles, 27.6 Magnetic Force on a Current-Carrying Conductor, 27.7 Force & torque on a Current Loop (qualitative only), 27.8 The Direct-Current Motor (qualitative only)
Exclude: 27.9 The Hall Effect
Recommended Discussion Questions: 1,5,8,14,15

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 current-carrying wire in a uniform magnetic field
- describe qualitatively the operation of motors, oscilloscopes and TV screens
- describe and calculate the force and torque on a current loop, and its use in a DC motor

Chapter 28 SOURCES OF MAGNETIC FIELD
Text sections included: Introduction, 28.4 Force Between Parallel Conductors, 28.6 Ampere's Law, 28.7 Applications of Ampere's Law
Exclude: 28.1 Magnetic Field of a Moving Charge, 28.2 Magnetic field of a Current Element, 28.3 Magnetic Field of a Straight Current-Carrying Conductor, 28.5 Magnetic Field of a Circular Current Loop, 28.8 Magnetic Materials
Recommended Discussion Questions: 3,5,9,13

Specific objectives – after studying this chapter you should be able to:
- derive and use the expression for the force between two parallel currents
- state, explain and apply Ampère's law for currents
- know and understand the magnetic field for current distributions of high symmetry (a straight current-carrying wire, a long solenoid, a pipe and a toroid)
- be able to sketch magnetic field-line patterns for such currents as well as for the Earth and for a bar magnet

Chapter 29 ELECTROMAGNETIC INDUCTION
Text sections included: Introduction, 29.1 Induction Experiments, 29.2 Faraday's Law, 29.3 Lenz's Law, 29.4 Motional Electromotive Force, 29.5 Induced Electric Fields, 29.6 Eddy Currents
Exclude: 29.7 Displacement Current & Maxwell's Equations, 29.8 Superconductivity
Recommended Discussion Questions: 1,3,4,6,7,11,13

Specific objectives – after studying this chapter you should be able to:
- describe and explain the 3 physical processes that can produce an induced electromotive force (emf): a 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

Chapter 30 INDUCTANCE
Text sections included: Introduction, 30.2 Self-Inductance & Inductors, 30.3 Magnetic Field Energy, 30.5 The L-C Circuit
Exclude: 30.1 Mutual Inductance, 30.4 The R-L Circuit, 30.6 The L-R-C Circuit
Recommended Discussion Questions: 6,7,13

Specific objectives – after studying this chapter you should be able to:
- define inductance and calculate it for a solenoid
- derive the energy stored in an inductor
- describe and explain oscillations in LC circuits, including the energy transfer between the capacitor and the inductor

