The University of Sydney
AUSTRALIA

School of Physics

PHYS 1902 Physics 1 (Advanced) – Semester 2, 2009

Module 2 – Electricity and Magnetism

This module is one of 3 comprising PHYS 1902 Physics 1B (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 1B (Advanced).

GENERAL GOALS OF THIS MODULE

This lecture module aims to develop the ideas of electric and magnetic fields, one of the great achievements of classical physics. It builds upon the ideas of forces on charges and currents, introducing fields as an alternative way of describing them. It aims to show how Maxwell's equations describe the properties of the fields, their causes and the relationships between them. It lays the foundations for more detailed studies of electromagnetism, such as electromagnetic properties of matter, electromagnetic radiation, and the relationships between electromagnetism, special relativity and quantum mechanics.

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.
- relate each of Maxwell's equations to the properties of the fields it describes
- understand the ways that fields are created and use Maxwell's equations to calculate the fields produced
- describe the relationships between electric and magnetic fields and appreciate that light is a consequence of this relationship

TIMETABLE

All **lectures** are held in the Physics Building. There are 20 lectures in this module with three 1-hour lectures per week.

Stream	Lecture Theatre	Lecture Times	Lecturer	Room No
1	Slade	Tues, Wed and Thur – all at 2pm beginning Tue 11 Aug, ending Wed 23 Sept	Dr Boris Kuhlmey	312

You should also attend a single one-hour **workshop tutorial** per week in the Physics tutorial rooms (320-321), and one three-hour **laboratory** session per week in the Carslaw Building on Level 4 (rooms 401, 402 and 407, with room 374 on the floor below also used for some classes).

There is no lecture on Thursday 24 September. There is no lab on some weeks (consult your Lab Manual for details).

You should also plan to spend up to 6 hours per week on **independent study** to read through and understand the textbook, work through *MasteringPhysics* tutorial questions and complete assignments, and to study for lab tests and the final examination.

MASTERING PHYSICS – TUTORIAL and ASSIGNMENT QUESTIONS

Assignments are usually due at two-week intervals. Deadline dates and times are given in module outlines. They usually consist of 8 questions delivered by a web-based system called *MasteringPhysics* (www.masteringphysics.com). The course ID code and a personal access code will be required the first time you log on to *MasteringPhysics*.

The course ID code is SUPHYS1902Y2009. The access code is provided in several ways:

- Use your MasteringPhysics registration from last semester. The classes from last semester have expired and so you are able to register for a new *MasteringPhysics* class.
- Purchase a new copy of the textbook from the University Coop Bookshop (cost approximately $140) and the access code is shrink-wrapped with the book, providing access to *MasteringPhysics* and the electronic copy of the textbook

- Purchase electronic access to the textbook from the University Coop Bookshop (cost approximately $70) and the access code includes access to *MasteringPhysics*.
- Collect a *MasteringPhysics* (only) access code from the Student Support Office in the School of Physics.

All three types of new code will allow you to do assignments. However only the first two types of codes provide access to the electronic version of the textbook. This is very valuable in that it allows easy access to the textbook when doing assignments (and saves you carrying around a heavy book). If you buy the textbook in either paper or electronic form then it is better to register using the accompanying code rather than the more limited *MasteringPhysics* (only) code which we can supply.

To register for the *MasteringPhysics* class you will need your full SID. Please enter it correctly as accounts with incorrect or duplicate SIDs are checked and will be suspended. If you do enter an incorrect SID, then it is possible to correct it via *MasteringPhysics*.

Worked solutions to all assignment questions will be posted on the web, although you should have the answer and method once you complete each *MasteringPhysics* question. Note that some assignment questions use randomised values - i.e. different students see the question with different values.

Questions in *MasteringPhysics* are presented in groups (called 'assignments' by the system) with a title such as *Electricity and Magnetism - Assignment 2 and Tutorial Questions*. There are six 'assignments' for this Module. 'Introduction to *MasteringPhysics'* is an extra, short assignment illustrating the features of the system that most students will have done last semester.

Electricity and Magnetism - Assignment 2 and Tutorial Questions - (Ch. 21-23) To be completed by 7pm Friday 28 August
Electricity and Magnetism - Assignment 3 and Tutorial Questions - (Ch. 24-26) To be completed by 7pm Friday 11 September
Electricity and Magnetism - Assignment 4 and Tutorial Questions - (Ch. 27-29) To be completed by 7pm Friday 25 September

Each assignment (apart from the Introduction to *MasteringPhysics*) is divided into two components.

- **Tutorial Questions**. These all feature the full *MasteringPhysics* Socratic dialogue - when you get stuck in answering a problem it offers a simpler problem and provides feedback tailored to your answers. These have been selected by your lecturers to help your understanding and problem solving ability. There are not assessed but we strongly recommend you look at some of these questions, which will remain available after the assignment deadline until the end of the semester.
- **Assignment Questions** are compulsory questions and represent the *minimum* use you should make of the system. 8 questions are offered, each worth 5 marks even though some are a little longer than others. Each assignment is worth about 2% towards your total assessment (see the unit of study outline for full details of how marks count towards your final assessment). The questions are a mix: tutorial-style questions teaching you concepts and problem solving techniques; and end-of-chapter problems from the textbook. The tutorial-style questions have full hints and feedback, while the end-of-chapter questions do not.

  The marking scheme gives a small reward when answers are achieved without using the hints, but no penalty if you do use them. See the *MasteringPhysics* FAQ at http://www.physics.usyd.edu.au/pdfs/current/jphys/MP_faq.pdf for more details.

  Assignment questions must be completed by 7pm (local time) on the date noted in the table above. *MasteringPhysics* will not accept late assignments. Mark ramps down in the seven hours after the deadline. It is therefore essential that you seek permission if you need to submit the assignment late. Assignment questions remain accessible to you for review (but no more marks!) until the end of the semester.

Read and/or print each problem, then work on it *before* trying to enter your answer. We don't want you to sit down and type in the answers without working on and thinking about them first. Try the problem without a hint first, then, if you get stuck, try the hint. For assignment questions, we give you eight chances to get the correct answer (although there is a small penalty for wrong answers). The objective is to get the right answer using as much help as it takes.

Your answers need to be formatted correctly so be smart and use the help the system provides:

- Values of constants can be found using the 'constants' button near the top of the page.
- See the Help linked from "?" at the right end of relevant boxes for more help with formatting.
- Move your mouse over symbols in the question to see how to type them in correctly.

We encourage students to cooperate in understanding all the questions since the objective is to understand concepts and develop your problem solving ability. However **all Assignments Questions using *MasteringPhysics* must be completed individually**. Simply copying the work of another person without acknowledgment is plagiarism and contrary to University policies on Academic Honesty in Coursework (see http://www.usyd.edu.au/ab/policies/Academic_Honesty_Cwk.pdf).

MasteringPhysics marks the assignments automatically and you immediately know your result. Worked solutions to all Assignment Questions will be posted on the web, although you should have the answer once you complete each *MasteringPhysics* question. Note that some assignment questions use randomised values - i.e. different students see the question with different values.

Question/Problems?
Help in using *MasteringPhysics* can be obtained from:

- Extensive on-line help.
- The booklet that was provided along with the Student Access Kit, which may also be found in pdf format at http://www.physics.usyd.edu.au/pdfs/current/jphys/MP_intro.pdf
- An FAQ list at http://www.physics.usyd.edu.au/pdfs/current/jphys/MP_faq.pdf
- A discussion group on WebCT for this unit is monitored by Physics staff.

If for any reason you cannot complete the assignment on-line, you may request a paper copy of the assignment and permission to submit a paper copy of the solution. You must submit an *Application for Consideration of Special Circumstances by Physics* (see the Unit Outline or http://www.physics.usyd.edu.au/current/consideration.shtml). Paper-based assignments will not be accepted unless permission is obtained beforehand, since the objective is for you to use the tutoring ability of *MasteringPhysics* to improve your ability to solve problems and your understanding of concepts.

PRACTICE EXAM AND CIRCUITS TEST

There will be a Practice Exam designed to test your understanding of material covered in lectures, and to stimulate your mid-semester revision. It will be held during your usual laboratory session in week 5 (beginning 24th August). There will also be a Circuits Test to test your understanding of material covered in laboratory sessions. This test will be conducted from within Mastering Physics, and will be due by 7pm 18th September (end of week 8).

REMINDERS

WebCT

Unit web pages are provided under WebCT, which can be accessed from links on the Junior Physics web pages (http://www.physics.usyd.edu.au/current/jpc.shtml) or your MyUni pages (http://myuni.usyd.edu.au/). A brief introduction to help you with web access is available on the Junior Physics web page at http://www.physics.usyd.edu.au/pdfs/current/jphys/webct_handout.pdf.

Email

We expect you to periodically read your University email account or to forward mail from it to an email account you do read (eg. a hotmail account).

Help

If you need help, you can

- as a first step, always check your unit WebCT pages for information, documents and links
- ask other students using the Discussion forum provided on the unit WebCT page.
- go to the Physics Student Support Office, Room 202 in the Physics building, or phone 9351 3037
- ask your lecturer or tutor
- ask a Duty Tutor - a staff member who is available from 1 to 2 pm, Tuesday to Friday in Physics Lecture Theatre 4, with physics course material
- consult one of the many services provided by the University, such as the Maths Learning Centre. These can be found by choosing *Junior Physics Resources and Links* from the unit WebCT page or your MyUni pages (http://myuni.usyd.edu.au/).

Consideration of Factors affecting your Study

If your academic performance in a Science Faculty unit of study is adversely affected by **illness or some other serious event**, such as an accident, you should complete an *Application for Special Consideration* with accompanying documentation. If you have **another reason** for the Science Faculty to take account of your circumstances - religious commitments, legal commitments (e.g. Jury duty), elite sporting or cultural commitments (representing the University, state or country), or Australian Defence Force commitments (e.g. Army Reserve) - you should complete an *Application for Special Arrangements* with accompanying documentation.

These two forms of Consideration should cover most allowable circumstances. However, if you have **another reason** for requiring the School of Physics to take account of your circumstances, you should notify the **School of Physics Student Office** (room 202 in the Physics building) beforehand (or at the latest within 7 days afterwards), by completing an *Application for Consideration of Special Circumstances by Physics* with accompanying documentation.

You should **not** submit an application of any type if

- there is no assessment associated with a missed class (e.g. a Physics Workshop Tutorial), or
- you have a reasonable opportunity to make up any work you missed (e.g. an extra lab class in the following week).

For more information see the Unit Outline or http://www.physics.usyd.edu.au/current/consideration.shtml.

MODULE DEFINITION & OBJECTIVES – ELECTRICITY & MAGNETISM

specified as references from the text: *University Physics (with Modern Physics)* by Young and Freedman, 12^{th} 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/WebCT 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

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: 16

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, 22

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 11
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 the energy transfer between the capacitor and the 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.

