Adult Basic Education

Science

Physics 3104B

Electric and Magnetic Fields and Electricity

Study Guide

Prerequisite: Physics 3104 A

Credit Value: 1

Text: *Physics: Concepts and Connections*. Irwin.

Physics Concentration

Physics 1104
Physics 2104A
Physics 2104B
Physics 2104C
Physics 3104A
Physics 3104B
Physics 3104C

Table of Contents

To the Student

I. Introduction to Physics 3104B

In previous courses, the interaction of an object with its environment and forces such as pushes or pull involving contact with an object were studied. Gravity, a force that does not need contact was studied and will serve as the stepping off point for the studies of electric forces in this course and magnetic forces in the next course.

The concepts of fields will start the study of electric forces and information from electric fields will be used to study conductivity, resistance and voltage. The study of power associated with electric fields will then be examined.

Like your last course, understanding forces and their components will be an essential part of this course. You will need your calculator and a solid understanding of previous physics courses.

II. Use of Science Study Guides

Before beginning this course, ensure you have the text and any other resources needed *(see the information in the Introduction to this course for specifics)*.

As you work through the Study Guide, you will see that it is divided according to the Units listed in the Table of Contents. When you open a unit it will have the following components:

To the Student

Reading for this Unit:
Here you will find the chapters, sections and pages of the text you will use to cover the material for this unit. Skim the sections of the textbook, look at the titles of the sections, scan the figures and read any material in the margins. Once you have this overview of the unit, you are ready to begin. Do not be intimidated by the content. You will work through the text, section by section, gaining knowledge and understanding of the material as you go.

References and Notes	**Work to Submit**
This left hand column guides you through the material to read from the text. Read any highlighted notes that follow the reading instructions. The symbols ▶▶ direct you to the questions that you should complete when finished a reading assignment..	You come across three (3) headings in this right hand column. **Writing:** This section comprises your notes for the unit. Here you will find either written questions or references to specific questions or problems from your text. You may want to write out each question followed by the answer. This material should be checked by your instructor before moving on to the next unit. Mathematical problems should have their solutions checked as you go. **Laboratory:** This section indicates if there is a Lab that should be completed for the unit. Let the instructor know in advance that you will be ready for the lab. A lab report should be submitted for each Lab. Your instructor will provide guidelines as to how s/he wants the report written. **Assignment:** This section indicates if there is an assignment that should be completed for the Unit. The information in the "References and Notes" column will indicate how you obtain the assignment. These assignments frequently relate the science content to technology, society and the environment.

III. Recommended Evaluation

Written Notes	10%
Labs/Assignments	20%
Test(s)	20%
Final Exam *(entire course)*	50%
	100%

The overall pass mark for the course is 50%.

Unit 1 - Gravitational and Electric Fields

To fulfill the objectives of this unit, students should complete the following:

Reading for this unit: *Physics: Concepts and Connections:*
Chapter 13: Section 13.1: pages: 527
Section 13.2: pages: 527-529
Section 13.3: pages: 530-534
Lab 13.1: pages: 587-588

References and Notes	Work to Submit
	Writing:
Read page 527 of Section 13.1. ▶▶	1.1 Define electrostatic force.
Electrostatic force is the force between charges at rest.	1.2 What two other forces operate at a distance?
Read pages 527 to 529 of Section 13.2 ▶▶	1.3 What are atoms?
	1.4 Describe the three components of the atom, indicate their charge, and location in the atom.
	1.5 What is the basis of electrostatic current?
	1.6 State the three parts of the Law of Electric Charges.
See the note on Electroscopes in Appendix A at the end of your Study Guide.	1.7 Sketch and explain how an electroscope responds to the presence of a negatively charged object.
	1.8 If an object has an excess of electrons, what is its charge?

References and Notes	Work to Submit
Read page 530 of Section 13.3 ▶▶	1.9 What three methods can charge an object?
	1.10 Explain how objects can become charged when rubbed together.
Use Table 13.1 for question 1.11.	1.11 What are the charges on the materials when silk and gold are rubbed together?
Read "Charging by Contact" and "Charging by Induction" on pages 531-532. ▶▶	1.12 Explain how a negatively charged object charges another object by contact.
*Induction is the act of causing a change in an object **without** contact.*	1.13 Explain how a positively charged object charges another object by contact.
	1.14 What is a grounding source?
	1.15 Explain how an object can be charged by induction.
Refer to Figure 13.9 ▶▶	1.16 In terms of charge, how does charging a neutral object by contact, compare to charging an object by induction?
Read "Electrical Discharge" on pages 532-534 ▶▶	1.17 What causes static electric shock?
	1.18 How does lightning occur?
	1.19 What is the role of a lightning rod?
	1.20 Explain the difference between conductors and insulators.

Unit 1 - Gravitational and Electric Fields

References and Notes	Work to Submit
Let your instructor know that you are ready for the Core Lab #1: The Law of Electrostatic Charges on page 587 of your text. ▶▶	1.21 Complete Question 38 on page 582. **Laboratory:** 1.22 Complete and submit Core Lab #1

Unit 2 - Coulomb's Law

To fulfill the objectives of this unit, students should complete the following:

Reading for this unit: *Physics: Concepts and Connections:*
Chapter 13: Section 13.4: pages: 535-542
Section 13.5: pages: 546-551
Section 13.6: pages: 552-557

References and Notes	Work to Submit
	Writing:
Read page 535 of Section 13.4 ▶▶	2.1 What are point charges?
	2.2 What does the magnitude of the force exerted between two charges depend on?
Study Example 2 on page 536 ▶▶	2.3 Express mathematically the proportionality for the magnitude of the force (F) and the magnitude of two charges (q_1 and q_2) and the distance between them (r).
	2.4 If the value of F was 2.0 N and the size of q_1 doubled but q_2 and r remained the same, what happens to the value of F?
	2.5 If the value of F was 2.0 N and the size of q_1 doubled and the size of q_2 also doubled and r remained the same, what happens to the value of F?
	2.6 If the value of F was 2.0 N and the size of q_1 and q_2 remained the same, but the distance between the charges doubled, what happens to the value of F?

Unit 2 - Coulomb's Law

References and Notes	Work to Submit
Read the information on the bottom of page 538 ▶▶	2.7 What is a Coulomb (C)? How many electrons does it represent?
Read page 539 ▶▶	2.8 Write the mathematical relationship that is Coulomb's Law. Explain what each variable represents and include the value and units for the constant.
Read "Deja vu- Gravity" on page 540 and study Figure 13.16 ▶▶	2.9 Complete Question 7 on page 579.
Study Examples 5 and 6 on pages 540-542 ▶▶	2.10 What does (i) a positive force represent and (ii) a negative force represent?
In Example 6, the text chooses a more difficult example to use Coulomb's Law to solve for a different variable. Another example is presented in the Appendix A.	2.11 Complete Questions 1 and 2 on page 545.
Read pages 546-549 of Section 13.5 ▶▶	2.12 Explain what each of the following terms mean: (a) electric field (b) field map (c) test charge (d) equipotential lines
You are responsible for figures involving point charges, but not plates or single conductors. *Remember that field lines are used to represent field strength; they don't actually exist.* *For 2.13, the field lines should have opposite direction to those in Figure 13.25b.*	2.13 Sketch the charge distribution and associated electric field for: (a) a positive point charge (b) a negative point charge (c) two negative point charges

Unit 2 - Coulomb's Law

References and Notes	Work to Submit
Read "Deja vu - Gravity and Magnetism" on pages 550-551 ▶▶	2.14 Complete Questions 19 and 20 on page 580.
Read Section 13.6 - pages 552 to end of Example 9 on page 553 ▶▶	2.15 Define field strength and indicate the symbol used to represent it.
Note in Example 9 that the electric field strength has a direction as it is a vector.	2.16 Write the mathematical expression for field strength and explain what each variable represents.
	2.17 Complete Problems 1 (a) and (b) on page 557.
Read "Coulombs Law Revisited" on pages 554 ▶▶	2.18 What are the two equations for Electric Field strength and when are they applied (see Fig. 13.35)?
	2.19 Why does calculating the field strength for multiple charges require vector addition?
Study Example 10 on page 555 ▶▶	2.20 Complete Problems 3 (a) to (e) on page 557.
	2.21 Complete Problem 64 on page 584.
Read "Electricity, Gravity and Magnetism" on page 556 ▶▶	2.22 Why is the gravitational pull of <u>your</u> <u>chair</u> on you considered to be negligible?
Read Section 13.7 from page 557 to the end of Example 11 on page 560 ▶▶	2.23 What is electric potential energy, and what symbol is used to represent it?
	2.24 How is an electric potential energy difference created?

Unit 2 - Coulomb's Law

References and Notes	Work to Submit
	2.25 Define electric potential and write the mathematical expression. Explain what each variable represents. 2.26 Define volt. 2.27 Complete Questions 69 to 71 on page 584. 2.28 Complete Question 1 on page 561.

Unit 3 - Electric Potential

To fulfill the objectives of this unit, students should complete the following:

Reading for this unit: *Physics: Concepts and Connections:*
Chapter 14: Section 14.1: pages 590
Section 14.2: pages 591-593
Section 14.3: pages 594-598
Section 14.4: pages 598

References and Notes

Read page 590 to Example 1▶▶

Read ""Direction of Current Flow" and "Measurement of Current" on pages 591 to 592. ▶▶

You will need to recognize the symbols for elements of electrical circuits. Carefully study Figure 14.3 to see the relationship between a circuit and its schematic.

Work to Submit

Writing:

3.1 Define current and state its unit.

3.2 What colors are used to represent the positive and negative terminals of power supplies?

3.3 In what direction is current flowing when a power supply is connected?

3.4 What is the name of the device used to measure current?

3.5 What is direct current (DC)?

3.6 What is alternating current (AC)?

3.7 Complete Problems 2 and 3 on page 594.

Unit 3 - Electric Potential

References and Notes	Work to Submit
Read "Drawing Circuits" on page 593 ▶▶	3.8 What are the circuit symbols for: (a) resistor (b) cell (c) ammeter (d) voltmeter (e) lamp (f) battery
Read pages 594 to 597 of Section 14.3 ▶▶ *This starts with a continuation of the material introduced in Section 13.7.*	3.9 What is the role of the power supply in the electric circuit? 3.10 What is the name of the device for measuring potential difference? How is it connected in a circuit? Is the connection the same as an ammeter? 3.11 Complete Question 1 on page 597.
Read Section 14.4 on page 598 ▶▶	3.12 List 5 common sources of electrical energy. For each, explain how the energy is created and give one use.

Unit 4 - Ohm's Law

To fulfill the objectives of this unit, students should complete the following:

Reading for this unit: *Physics: Concepts and Connections:*
Chapter 14: Section 14.5: pages: 599-604
Section 14.6: pages: 605-609
Section 14.7: pages: 610-612
Lab 14.1: pages: 625 - 626

References and Notes	Work to Submit
	Writing:
Read pages 599 to 600 of Section 14.5 ▶▶	4.1 What two things determine the amount of current flow in a circuit?
	4.2 What is electrical resistance?
	4.3 What is the mathematical expression of Ohm's Law? Explain what each variable represents and what unit each is measured in.
Carefully Study Examples 7 to 9 on pages 601 and 602 ▶▶	4.4 Complete Problems 23 to 25 on page 621.
Read "Factors that Determine Resistance" on page 602 and Table 14.4 ▶▶	4.5 Briefly describe the four factors that determine resistance .
See the information on gauge number on page 604.	4.6 If you had a 10 gauge wire and changed the wire to 5 gauge, what happens to the resistance of the wire?
	4.7 If the temperature of the 10 gauge wire increased from 25ºC to 40ºC, what will most likely happen to the resistance?

Unit 4 - Ohm's Law

References and Notes	Work to Submit
	4.8 If you have 25 cm of wire in your circuit and increased the length of wire to 100 cm, what happens to the resistance?
Note: the resistivity of copper is1.72 x 10^{-8} Ω·m and of gold is 2.20 x 10^{-8} Ω·m	4.9 If you changed from copper wire to gold wire, what happens to the resistance in your circuit?
Read Section 14.6 to Example 12 on page 606 ▶▶	4.10 Explain the difference between series and parallel circuits.
	4.11 State Kirchhoff's current law in words and mathematically (sketch a circuit for the mathematical expression you are applying the law to).
	4.12 State Kirchhoff's voltage law in words and mathematically (sketch a circuit for the mathematical expression you are applying the law to).
Carefully study Examples 12 and 13 on pages 606 and 607 ▶▶	4.13 Complete Problem 29 on page 622.
Read from "Resistances in Series" to the end of Section 14.6 on page 609. Carefully Study Examples 14 and 15 ▶▶	4.14 Complete Problems 1 to 4 on page 609.
You will want to sketch simple diagrams to help you with these problems.	

Unit 4 - Ohm's Law

References and Notes	Work to Submit
Read Section 14.7 ▶▶	4.15 Solve Problem 1 on page 613.
This material is very confusing in its presentation. You will probably need to sit with your instructor and work through the solution for Fig. 14.18 and through problem 1 to understand how to apply the approaches suggested in your text.	
Remember to simplify your circuits.	4.16 Complete Problems 35 (a) to (d) on page 623.
	Laboratory:
Let your instructor know you are ready to complete Core Lab #2: pages 625 to 626 ▶▶.	4.17 Complete and submit to your instructor Core Lab #2: Circuit Analysis.

Unit 5 - Power

To fulfill the objectives of this unit, students should complete the following:

Reading for this unit: *Physics: Concepts and Connections:*
Chapter 14: Section 14.8: pages 613-615
Section 14.9: pages 615-616

References and Notes	Work to Submit
Read pages 613 to 615 of Section 14.8 and study Examples 16 to 18 carefully. ▶▶	Writing: 5.1 Express the mathematical relationship for power in terms of current and voltage. 5.2 Express the mathematical relationship for power in terms of voltage and resistance. 5.3 Complete Problems 1 and 2 on page 615.
Read page 615 to 616 of Section 14.9 and study Example 19 on page 616. ▶▶	5.4 Complete Problems 1 and 2 on page 617.

Appendix A

Electroscope

(Refer to Figure 13.3 on page 529 in your text)

An electroscope is a device which is capable of detecting the presence of a charged object. It is often used in electrostatic experiments and demonstrations in order to test for charge and to deduce the type of charge present on an object.

The electroscope typically consists of a conducting knob, a conducting base and a pair of conducting leaves. Since the operating parts of an electroscope are all conducting, electrons are capable of moving from the knob on the top of the electroscope to the leaves in the bottom of the electroscope. Objects are typically touched to or held nearby the knob, thus inducing the movement of electrons into the leaves (or from the leaves to the knob). The gold leaves of the electroscope are the only mobile parts. Once an excess of electrons (or a deficiency of electrons) is present in the gold leaves, there will be a repulsive effect between like charges causing the leaves to repel each other.
(adapted from The Physics Classroom:
www.glenbrook.k12.il.us/gbssci/phys/Class/estatics/u8l2b.html)

Solving Coulomb's law for a Different Variable

Problem: A small sphere carrying a charge of -6.0 x 10^{-6} C, exerts an attractive force of 2.0 N on another sphere carrying a charge with a magnitude of 4.0 x 10^{-6} C.
(a) What is the sign of the second charge?
(b) What is the distance of separation of the centers of the spheres?

Solution:

(a) There is a force of attraction between the two spheres. As the first sphere is negative, the second must be positive. [Note the ***magnitude*** of the charge of the second sphere was given, not its charge.]

(b) You are being asked to solve for r. Attractive forces have a negative sign.

$$F = \frac{kq_1q_2}{r^2}$$

$$-2.0N = \frac{9.0x10^9\ Nm^2\ /C^2 x(-6.0x10^{-6}C)x(4.0x10^{-6}C)}{r^2}$$

$$-20N = \frac{-2.16x10^{-1}\ Nm^2}{r^2}$$

$$r^2 = \frac{-2.16x10^{-1}\ Nm^2}{-20N}$$

$$r^2 = 1.08x10^{-2}m^2$$

$$r = \sqrt{1.08x10^{-2}m^2}$$

$$r = 10m$$

Note: Answer is expressed to 2 significant figures.