

Adult Basic Education

# Science

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## Physics 3104B

# Electric and Magnetic Fields and Electricity

## Curriculum Guide

**Prerequisite:** Physics 3104A

**Credit Value:** 1

### Physics Concentration

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



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## To the Instructor

### I. Introduction to Physics 3104B

This course further studies the concepts of fields and draws comparisons between gravitational fields which were studied in Physics 3104A and electrical and magnetic fields. Knowledge of electrical potential is developed and this leads to the study of current, voltage and resistance in circuits. Finally the concept of power studied in Physics 2104B is applied to electric circuits and household electricity.

Students taking this course need to know how to solve for unknowns and use a scientific calculator. These skills would be expected to be in place at this point if students have studied previous Physics courses.

### II. Curriculum Guides

Each new ABE Science course has a Curriculum Guide for the instructor and a Study Guide for the student. The Curriculum Guide includes the specific curriculum outcomes for the course. Suggestions for teaching, learning, and assessment are provided to support student achievement of the outcomes. Each course is divided into units. Each unit comprises a **two-page layout of four columns** as illustrated in the figure below. In some cases the four-column spread continues to the next two-page layout.

#### Curriculum Guide Organization: The Two-Page, Four-Column Spread

Unit Number - Unit Title		Unit Number - Unit Title	
<b>Outcomes</b>  Specific curriculum outcomes for the unit.	<b>Notes for Teaching and Learning</b>  Suggested activities, elaboration of outcomes, and background information.	<b>Suggestions for Assessment</b>  Suggestions for assessing students' achievement of outcomes.	<b>Resources</b>  Authorized and recommended resources that address outcomes.

## To the Instructor

### III. Study Guides

The Study Guide provides the student with the name of the text(s) required for the course and specifies the sections and pages that the student will need to refer to in order to complete the required work for the course. It guides the student through the course by assigning relevant reading and providing questions and/or assigning questions from the text or some other resource. Sometimes it also provides important points for students to note. (See the *To the Student* section of the Study Guide for a more detailed explanation of the use of the Study Guides.) The Study Guides are designed to give students some degree of independence in their work. Instructors should note, however, that there is much material in the Curriculum Guides in the *Notes for Teaching and Learning* and *Suggestions for Assessment* columns that is not included in the Study Guide and instructors will need to review this information and decide how to include it.

### IV. Resources

#### *Essential Resources*

*Physics: Concepts and Connections*

*Physics: Concepts and Connections Teacher's Resource Guide*

#### *Recommended Resources*

*Science 1206: Motion Curriculum Guide:*

<http://www.ed.gov.nl.ca/edu/sp/sh/sci/sci1206/unit4.PDF>

*Nelson Publishing Web Site:* <http://www.science.nelson.com>

*Computerized Assessment Bank for Nelson Science 10,* Nelson.

#### *Other Resources*

*Center for Distance Learning and Innovation:* <http://www.cdli.ca/>

*Physics tutorials on the web:* <http://www.physicsclassroom.com/Default2.html>

*Great physics links:*

<http://www.sciencejoywagon.com/physicszone/phylinks.htm>

*Physics Central:* <http://www.physicscentral.com/>

## To the Instructor

*Physics Note-A-Rific:*

[http://www.studyphysics.ca/index\\_files/Page618.htm](http://www.studyphysics.ca/index_files/Page618.htm)

### V. Recommended Evaluation

Written Notes	10%
Labs/Assignments	20%
Test(s)	20%
Final Exam ( <i>entire course</i> )	<u>50%</u>
	100%

**The overall pass mark for the course is 50%.**





# **Electric and Magnetic Fields and Electricity**

## Unit 1 - Gravitational and Electric Fields

### Outcomes

- 1 .1 Understand gravitational and electric fields.
  - 1 .1.1 Explain the production of static electricity and its properties.
  - 1 .1.2 Define electrostatic forces.
  - 1 .1.3 Discuss the atom as the source of electrostatics.
  - 1 .1.4 State the law of electric charges.
  - 1 .1.5 Describe the operation of an electroscope.
  - 1 .1.6 Demonstrate and explain charging by friction, contact, and induction.
  - 1 .1.7 Discuss the nature of electrical discharge.
  - 1 .1.8 Distinguish between conductors and insulators.
  - 1 .1.9 Explain the production of static electricity and its properties.

### Notes for Teaching and Learning

Students will remember gravitational fields from Physics 3104A. Comparisons of electric and magnetic fields to gravitational fields should be stressed throughout this course.

The Lab 13.1 should be done as early as possible to provide a concrete introduction to electrostatics.

The operation of the electroscope is described in the Appendix of the Study Guide.

## Unit 1 - Gravitational and Electric Fields

### Suggestions for Assessment

Students can be asked to explain how electrostatic current arises in terms of atomic structure.

Students can also be asked to predict the charges on two substances that are rubbed together (given a Table like 13.1 of the text).

Problems at the end of the chapter in *Concepts and Connections* can also be used:

Questions 1-6 on page 579.

Questions 33-40 on page 582.

Students should submit Core Lab #1: The Law of Electric Charges for grading.

### Resources

*Concepts and Connections*: pages 527-534; Core Lab #1: page 587-588

*Concepts and Connections Teacher's Resource Guide*: pages 445-449

[www.cdli.ca](http://www.cdli.ca): Physics 3204: Unit 2: Section 1 Lesson 1 and Multimedia Learning Objects 01-06

*Physics 3204 Curriculum Guide*: pages 56-57

## Unit 2 - Coulomb's Law

### Outcomes

- 2.1 Understand and apply Coulomb's Law.
  - 2.1.1 Compare Newton's law of universal gravitation with Coulomb's law.
  - 2.1.2 State Coulomb's law of electric force in sentence and in formula form.
  - 2.1.3 State the SI unit of charge.
  - 2.1.4 Explain how the force between two charged particles depends on the values and types of the charges and separation.
  - 2.1.5 Calculate the fifth quantity given four of distance separating two charged particles, charge on each, force between them, and Coulomb's constant.
  - 2.1.6 Interpret patterns and trends in data, and infer or calculate the relationship among variables.

### Notes for Teaching and Learning

Students can use Table 13.2 to cover outcome 2.1.6. They will need help understanding this table. You may want to take two rows of the table at a time and say something like: in the first two rows,  $q_1$  in row 2 is doubled that in row 1, what has happened to the value of Force? Students may find it easier to understand if they compare values that are doubling, rather than halving as the text shows it.

In using Coulomb's law, encourage students to inspect the relationship to predict how the size of  $F$  varies with changes in  $q_1$  and  $q_2$  and  $r$ . This might be easier than the approach used in the text in Example 3. Take this approach with questions 2.4 - 2.6 of the Study Guide.

Example 6 in the text requires an excellent understanding of algebra. You may want to ask students to solve problems in a manner similar to that in Appendix A, where you put in all the values and then solve for the unknown.

## Unit 2 - Coulomb's Law

### Suggestions for Assessment

Problems 46, 48 and 49 (a) provide extra problems on Coulomb's Law.

Keep the problems straight forward. Ask about what happens to the size of the force when the magnitude of the charges and distance increases/decreases by some multiple of a whole number.

Use Coulomb's Law to solve for  $F$  or another variable, but always provide values for the unknowns. Do not use information like  $q_1$  is twice  $q_2$  etc.

### Resources

*Concepts and Connections*: pages 535-542

*Concepts and Connections Teacher's Resource Guide*: pages 451-460

[www.cdli.ca](http://www.cdli.ca): Physics 3204: Unit 2: Section 1 Lesson 3 and 4  
Multimedia Learning Objects Fields: 08-10

*Physics 3204 Curriculum Guide*: pages 60-61

## Unit 2 - Coulomb's Law

### Outcomes

2.2 Describe electric fields as regions of space that affect charges (like and unlike), and illustrate the source and direction of the lines of force.

2.2.1 Explain what is meant by an electric field.

2.2.2 Explain the concept of the electrical test charge.

2.2.3 Explain and be able to draw equipotential lines and electric field lines for single point charges and two point charges (opposite and alike).

2.2.4 Compare gravitational and electric fields.

### Notes for Teaching and Learning

This course will restrict its study of electric fields to no more than two point charges.

Use the analogy between gravitational fields and electric fields.

Students may not recognize that fields lines are directed from positive to negative charges. Emphasize that for a positive test charge, the electric field is in the same direction as the force acting upon it. For a negative test charge, the direction of the field is to the opposite direction of the force acting upon it.

If students are familiar with contour lines on a map to show elevation, you could use that to help them to understand field lines. Just like when contour lines are close together, the slope is steep; when electric field lines are close, the field strength is great.

## Unit 2 - Coulomb's Law

### Suggestions for Assessment

Ask students to draw field lines for positive or negative point charges. Ask them to draw field lines for pairs of like or unlike point charges.

Question 1(a) on page 551 could be given as an assignment.

### Resources

*Concepts and Connections:* pages 546-551

*Concepts and Connections Teacher's Resource Guide:*  
pages 461-462; 467-470

www.cdli.ca: Physics  
3204: Unit 2: Section 1  
Lesson 6  
Multimedia Learning  
Objects: Fields: 11

*Physics 3204 Curriculum Guide:* pages 62-63

## Unit 2 - Coulomb's Law

### Outcomes

2.3 Understand electric field strength and electric potential.

2.3.1 Write an operational definition for electric field strength, and the SI unit in which it is measured.

2.3.2 Calculate the third quantity given two of the electric field strength ( $\epsilon$ ), the size of a positive test charge ( $q$ ), and the electric force ( $F_e$ ) on it.

2.3.3 Calculate the fourth quantity given three of the charge of a particle or sphere ( $q$ ), Coulomb's constant ( $k$ ), the distance ( $r$ ) from the particle or sphere at which the field is specified, and the value of that field strength ( $\epsilon$ ).

2.3.4 Extend the work–energy theorem to develop the concept of electric potential energy ( $E_e$ ) and electric potential ( $V$ ).

### Notes for Teaching and Learning

In solving problems of the type 2.1.14 in Example 10 on page 555 of text, remind students they need to use a positive test charge, that they must square the distance and that the distance from A to  $q_1$  is the total distance.

Stress that electric potential and electrical potential energy are not the same. Electric potential is the electrical potential energy per charge.

Students may need to review the relationship between work and potential energy from Physics 2104B. Explain that the work done on an object increases its gravitational potential energy and work required to push a charged particle against the electric field of a charged object increases the particle's electrical potential energy.

The volt in electricity is analogous to the height in gravitational potential energy calculations. In the case of electricity, electrons move from a lower to a more positive voltage instead of from a low position to a higher position.

Several problems are shown in the *Physics 3204 Curriculum Guide*.



## Unit 2 - Coulomb's Law

### Suggestions for Assessment

Other questions from Section 16.6 on page 584: 59-63  
Section 16.7: 74(a)

The Center for Distance Learning and Innovation site has extra problems. The *Physics 3204 Curriculum Guide* has some extra problems.

### Resources

*Concepts and Connections*: pages 552-562

*Concepts and Connections Teacher's Resource Guide*:  
pages 463-465

[www.cdli.ca](http://www.cdli.ca): Physics  
3204: Unit 2: Section 1  
Lesson 7  
Multimedia Learning  
Objects: Fields: 11-13

*Physics 3204 Curriculum Guide*: pages 62-66

## Unit 3 - Electric Potential

### Outcomes

- 3.1 Understand and apply the concept of electrical potential.
  - 3.1.1 Use a reference point or level to define electric potential.
  - 3.1.2 Define electric potential difference and its SI unit of measurement.
  - 3.1.3 Define electric current and name its SI unit of measurement and the instrument used in such measurements.
  - 3.1.4 Define the ampere.
  - 3.1.5 Describe and compare direct current and alternating current.

### Notes for Teaching and Learning

Language can cause problems. Sometimes people say “the voltage through a circuit”, and it is very important that students recognize voltage is always measured as the potential difference across two points. i.e charges move through a circuit - not voltage (or current).

Point out to students that when we say “the voltage is 6V” we mean “the electric potential difference between the two points being measured is 6V”.

Students sometimes confuse electric current with electric potential difference. An analogy with a water system may help. Relate voltage (electric potential difference) to the pressure applied by a pump. Batteries supply difference in “electrical pressure”. The current is like the water moving through the water system. Resistance is like the pipes. Wide pipes low resistance.

Remind students that household current is AC while batteries are DC.

## Unit 3 - Electric Potential

### Suggestions for Assessment

Ask students to explain electric circuits in terms of water in pipes or cars on roads.

Ask definitions of voltage, current etc.

### Resources

*Concepts and Connections*: pages 562-571

*Concepts and Connections* Teacher's Resource Guide: page 471

[www.cdli.ca](http://www.cdli.ca): Physics 3204: Unit 2: Section 2 Lesson1  
Multimedia Learning Objects: Current Electricity: 14-16

*Physics 3204 Curriculum Guide*: pages 66-67

## Unit 3 - Electric Potential

### Outcomes

3.1.6 Calculate the third quantity given two of the electric current ( $I$ ), the charge ( $q$ ) that passes through a cross-section of a conductor, and the time ( $t$ ) taken.

3.1.7 Define voltage as the energy per unit charge developed within a source, and define its SI units.

3.1.8 Identify circuit symbols and sketch simple circuits.

3.1.9 List and name the type of energy transferred from various sources of electrical energy including; voltaic cells, piezoelectricity, thermoelectricity, photoelectricity, and generator.

### Notes for Teaching and Learning

Emphasize that current involves moving charges.

## Unit 3 - Electric Potential

### Suggestions for Assessment

Examples of questions:

1. Suppose a lightning bolt carries 8.0C of charge in the  $2.0 \times 10^{-2}$  s it takes to hit the ground. What is the current carried by the lightning bolt?

Ask students to draw simple circuits showing the correct placement of ammeters or voltmeters.

**A quiz is recommended at this point before students proceed further.**

### Resources

*Concepts and Connections*: pages 590-598

*Concepts and Connections* Teacher's Resource Guide: pages 471 - 482

[www.cdli.ca](http://www.cdli.ca): Physics 3204: Unit 2: Section 2 Lesson 12

*Physics 3204 Curriculum Guide*: pages 66 - 68

## Unit 4 - Ohm's Law

### Outcomes

4.1 Understand and apply Ohm's Law to circuits.

4.1.1 Define electrical resistance and its SI unit of measurement.

4.1.2 State Ohm's law.

4.1.3 Calculate the third quantity given two of the voltage across a resistor, its resistance, and the current in it.

4.1.4 List and describe the factors that influence the resistance of a material.

4.1.5 Demonstrate series circuit properties and Ohm's law.

4.1.6 Apply Ohm's law to series, parallel, and combination circuits.

4.1.7 Draw a schematic diagram for series, parallel, and simple combination circuits.

### Notes for Teaching and Learning

Resistance can be compared to walking. Different surfaces can cause difference in the walker's experience. Walking on a sidewalk versus walking (low resistance) on a muddy field (high resistance).

Students need to manipulate Ohm's Law for all three variables.

Factors affecting resistance will be treated in a qualitative manner in this course. Students will not be responsible for problems of the type in Example 10 and 11 of the text.

Point out to students that household devices are connected in parallel because they are designed to operate off the same voltage.

## Unit 4 - Ohm's Law

### Suggestions for Assessment

Ask students to predict how a circuit's resistance and in turn current will change (voltage is constant) if the wire is thickened, shortened or if the temperature or materials are changed.

Questions 29-32 on page 622 are problems of the type students are responsible for in this unit.

### Resources

*Concepts and Connections*: pages 599-605

*Concepts and Connections* Teacher's Resource Guide: pages 483 - 492

[www.cdli.ca](http://www.cdli.ca): Physics 3204: Unit 2: Section 2 Lesson 3  
Multimedia Learning Objects: Current Electricity: 16 - 19

*Physics 3204 Curriculum Guide*: pages 66 - 67; 70-73

## Unit 4 - Ohm's Law

### Outcomes

- 4.1.8 State and apply Kirchhoff's current law.
- 4.1.9 Use the equation for the effective value of resistance in series and parallel circuits.
- 4.1.10 Solve problems involving circuits with both series and parallel combinations of resistors.
- 4.1.11 Investigate the relationship between voltage rises and voltage drops across linear resistors and sources.
- 4.1.12 Apply Kirchhoff's voltage and current laws.

### Notes for Teaching and Learning

Students may have trouble with using the formula for total resistance in a parallel circuit. They may need convincing that the equivalent resistance is less when resistors are connected in parallel.

Tell students to check that the total resistance they calculate for a parallel system is less than the resistance of their smallest resistor.

There are many versions of "Rules and Strategies" of the "Circuit Analysis Game" used in the text. The problem and explanation in the text is not easy to follow. You may want to show students another way. If you have access to a computer the Center for Distance Learning and Innovation site lesson "Analyzing Circuits" covers this material well.



## Unit 4 - Ohm's Law

### Suggestions for Assessment

Students are to complete and submit for grading the Core Lab #2: "Circuit Analysis."

Supply students with circuits like those in the text, changing voltages and resistances.

### Resources

*Concepts and Connections*: pages 605-612; Core Lab #2: pages 625-626

*Concepts and Connections Teacher's Resource Guide*: pages 483-492

[www.cdli.ca](http://www.cdli.ca): Physics 3204: Unit 2: Section 2 Lesson 4-8  
Multimedia Learning Objects: Current Electricity # 20-25

*Physics 3204 Curriculum Guide*: pages 74-77

## Unit 5 - Power

### Outcomes

#### 5.1 Understand Power.

5.1.1 Define power for electrical circuits using  $P= IV$ ,  $P= I^2 R$ , and  $P= V^2 /R$ .

5.1.2 Calculate the other quantities given two of power, resistance, current, and potential difference.

5.1.3 Calculate the cost of operating electrical equipment given the power rating or means of determining the power rating, the amount of time, and the cost per kilowatt-hour of electrical energy.

### Notes for Teaching and Learning

To help students understand energy consumption and cost, ask them to compare the cost of operating various household appliances by explaining the relationships among power, current drawn and the cost of operating 1000W, 250 W and 50 W appliances at household voltages.

One analogy that might be used is to compare an electric circuit (with a 6V battery and  $4\Omega$  resistor) to a conveyor belt. Imagine a circuit made up of consecutive segments of charge  $q = 1.0$  C, each carrying  $qV = 6$ J of energy supplied by the battery. The current  $I = V/R = 1.5$ A or  $1.5$  C/s. The power (or energy delivery rate) to the resistor is  $(1.5\text{C/s})(6\text{J/C}) = 9\text{J/s}$  or  $9\text{W}$ .

Because people pay their “power bill” students may not understand the need to calculate the kilowatt-**hours** for calculating energy cost. This may need to be explained.

## Unit 5 - Power

### Suggestions for Assessment

Problems 36-40 on page 624 provide extra problems.

### Resources

*Concepts and Connections:* pages 613-616

*Concepts and Connections Teacher's Resource Guide:* pages 493-494

[www.cdli.ca](http://www.cdli.ca): Physics 3204: Unit 2: Section 2 Lesson 9  
Multimedia Learning Objects: Current Electricity # 26-27

*Physics 3204 Curriculum Guide:* pages 80-81