Adult Basic Education

Science

Science 3103

Electricity

Curriculum Guide

Prerequisite: Science 3102

Credit Value: 1

Science Courses [General College Profile]

Science 2100A
Science 2100B
Science 2100C
Science 3101
Science 3102
Science 3103
Science 3104
Science 3105
Science 3106

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To the Instructor

I. Introduction to Science 3103

Science 3103 is the second of two Science courses in the General College Profile that covers concepts in the area of Physics. **While the course is available to all students, it is specifically designed for those who plan to pursue post-secondary education in the area of industrial trades.**

Students are required to perform various calculations in this course and it would be beneficial for them to be proficient in the use of a scientific calculator. In the previous course, Science 3102, students were introduced to the mathematical skills and some other theoretical concepts that are necessary for success in this course. Therefore, **Science 3102 is a prerequisite to Science 3103**.

In this course, students are introduced to some of the basic concepts of electrical circuits. They learn about the components of circuits and how to draw simple circuit diagrams. They are introduced to electric current, potential difference, resistance, and power. They analyze series and parallel circuits using Ohm's Law and Kirchhoff's Rules and they perform an investigation to explore the properties of series and parallel circuits. Students then analyze electrical power usage in common devices. Proper safety procedures to follow when working with electric circuits are discussed and employed in this course.

There is one lab (Core Lab) and one assignment that students are required to complete for this course. Instructors may add more labs and assignments if they wish.

The textbook for the course is ***Nelson Physics 12: College Preparation;*** Hirsch, Alan J.; Nelson Thomson Canada; 2004.

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**	
Outcomes Specific curriculum outcomes for the unit.	**Notes for Teaching and Learning** Suggested activities, elaboration of outcomes, and background information.	**Suggestions for Assessment** Suggestions for assessing students' achievement of outcomes.	**Resources** Authorized and recommended resources that address outcomes.

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

Nelson Physics 12: College Preparation*; Hirsch, Alan J.; Nelson Thomson Canada; 2004. ISBN 0-17-626530-9*

Nelson Physics 12: College Preparation Solutions Manual*; Dick, Ricci, et al; Nelson Thomson Canada; 2004. ISBN 0-17-626972-X*

Nelson Physics 12: College Preparation Teacher's Resource*; Dick, Robinson, et al; Nelson Thomson Canada; 2004. ISBN 0-17-626532-5*

Recommended Resources

Nelson Physics 12: College Preparation Workbook; *Dick, Ricci, et al; Nelson Thomson Canada; 2004. ISBN 0-17-626531-7*

Nelson Physics 12: College Preparation Computerized Assessment Bank*; Brucker, McArdle, et al; ISBN 0-17-626535-X*

Other Resources

Center for Distance Learning and Innovation:

http://www.cdli.ca/

V. Recommended Evaluation

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

Electricity

Unit 1 - Introduction to Electricity

Outcomes	Notes for Teaching and Learning
1.1 Identify and describe the functions of basic electrical circuit components.	Students coming from the current Grade 9 Science course would have completed a section on electricity. Those who have completed IS2014 in the ABE program will also have some knowledge of concepts related to electricity. The concepts covered in this course will briefly review some things that students have already learned, but likely have forgotten, and will investigate these concepts further.
1.1.1 Define current electricity and electrical circuit.	
1.1.2 Describe the function of load, control, source, and conductor.	
1.1.3 Distinguish between an open and closed circuit.	
1.1.4 Describe a short circuit.	
1.2 Draw and interpret schematic diagrams of basic electric circuits.	
1.2.1 Draw circuit diagrams using the symbols for sources of electric potential, electrical loads, electric meters, wiring, and connectors.	Students will start drawing and interpreting circuit diagrams that contain only some of the components referred to in Outcome 1.2.1. They will learn how to add more components as they work through the remainder of the course.
1.2.2 Identify components in basic circuit diagrams.	
1.3 Describe current, potential difference, and resistance in electric circuits.	Students should be familiar with basic SI measurement from Level II Math and/or Science. They should also have completed Science 3102 where SI units are reviewed and some new prefixes, such as mega- (M) and micro- (μ), are introduced.
1.3.1 Define and identify SI units of measurement and symbols for: - current - potential difference - resistance.	

Unit 1 - Introduction to Electricity

Suggestions for Assessment

Instructors should assess the student's level of understanding by reading student answers to questions from the Study Guide for this unit and providing feedback.

Students could complete *Try This Activity, Electrical Safety*, page 315. This activity might be a good starting point for the course and many students will gain confidence by their ability to recognize the equipment. Lab and Study Master (LSM) GS-1 can be used instead of the actual pieces of equipment. An answer sheet is provided on pages 164 - 165 of the *Workbook*.

Note: Lab and Study Masters (LSM's) and their answers are found in the *Teacher's Resource*.

Students could complete *Try This Activity, Analyzing Simple Electric Circuits*, page 317, for extra practice in drawing circuit diagrams. There is an answer sheet for this activity in the *Workbook*. Students could also complete 7.1 *Extension Exercise*, page 168 of the *Workbook*.

Note: Answers for all activities and questions in the student text are provided in the *Solutions Manual*.

Resources

Nelson Physics 12: College Preparation, pages 314 - 329.

Lab and Study Master (LSM) GS-1.

Nelson Physics 12: College Preparation Workbook, pages 164 - 165, 168.

Educational Software: http://www.etcai.com/

Unit 1 - Introduction to Electricity

Outcomes

1.3.2 Compare direct and alternating current in qualitative terms and describe situations where each is used.

1.3.3 Identify the ammeter as the instrument used to measure electric current and describe its connection in a circuit.

1.3.4 Identify the voltmeter as the instrument used to measure electric potential difference and describe its connection in a circuit.

1.3.5 Distinguish between electrical insulators and conductors.

Notes for Teaching and Learning

Students should understand that alternating current flows into the home and workplace because it is easier to transport over long distances. Direct current flows from battery operated devices and cannot be transported easily over long distances.

Instructors could demonstrate the proper use of ammeters and voltmeters in a circuit.

Unit 1 - Introduction to Electricity

Suggestions for Assessment

The *Extension Exercise, Direct and Alternating Current*, on page 170 of the *Workbook*, could be completed by students.

Resources

Nelson Physics 12: College Preparation Workbook, page 170.

Unit 2 - Electrical Circuits

Outcomes

2.1 Analyze electric circuits using Ohm's law and Kirchhoff's rules.

- 2.1.1 State Ohm's law in words and as an equation.
- 2.1.2 Use Ohm's law to calculate resistance, current, and potential drop.
- 2.1.3 State Kirchhoff's Current Rule (KCR) and Kirchhoff's Voltage Rule (KVR).
- 2.1.4 Use Kirchhoff's rules to calculate current and voltage.
- 2.1.5 Distinguish between series and parallel circuits.
- 2.1.6 Calculate equivalent resistance in series and parallel circuits.

2.2 Investigate the properties of resistors connected in series and in parallel.

- 2.2.1 Construct simple series and parallel circuits using common tools appropriately and safely.
- 2.2.2 Use appropriate meters to measure electrical current, potential difference, and resistance in electric circuits.
- 2.2.3 Analyze, in quantitative terms, real circuits using Ohm's law and Kirchhoff's rules.

Notes for Teaching and Learning

Students are expected to be able to complete calculations for potential difference, current and resistance in series and parallel circuits separately. They are **not** expected to analyze combination series-parallel circuits.

When completing questions that require calculations, students will be expected to use scientific notation and to express their answers using the rules for significant figures. These topics are covered in Unit 1 of Science 3102. Science 3102 is prerequisite to Science 3103.

Students may have difficulty understanding Kirchhoff's Rules and will likely require further explanation than that which is provided in the text. Instructors should make sure that students understand that Kirchhoff's Rules tell them that in a series circuit, voltage is shared and current is the same everywhere. Whereas in a parallel circuit, the opposite is true; current is shared and voltage is the same everywhere.

The Try This Activity on page 335 could be done as a lab or a demonstration to help students understand what is happening in series and parallel circuits.

The Centre for Distance Learning and Innovation, CDLI, web site provides good explanations and practice for circuits in the lessons and Mutimedia Learning Objects (MLO's) for Physics 3204, Unit 2, Section 2, Electric Circuits.

Outcome 2.2 is achieved by completion of Section 7.7, *Investigation: Resistors in Series and Parallel*. While studying the properties of resistors connected in series and parallel, students will have the opportunity to practice using meters and drawing and analyzing circuit diagrams.

Suggestions for Assessment

Instructors should assess the student's level of understanding by reading student answers to questions from the Study Guide for this unit and providing feedback.

Students are required to complete **Core Lab #1**, *Resistors in Series and Parallel*. The *Answer Sheet* provided in the *Workbook* on pages 184 - 187 could be given to students to use as a lab report. Instructors should refer to the *Teacher's Resource* for information about the lab and to the *Solutions Manual* for the observations and answers to the questions.

Practice is the key to learning the concepts presented in this unit. Question #1, parts a to d, of Extension Exercise 7.6, *Resistors in Series and in Parallel - Additional Practice*, on page 181 of the *Workbook* could be used for practice. Instructors will also need to provide worksheets.

Note: Remember that students are **not** required to answer questions involving calculations for combination circuits. Therefore, any worksheets and/or tests should not include these questions.

Extension Exercise 7.7, *Series and Parallel Circuits - Additional Practice*, on pages 188 - 189 of the *Workbook* could be used for reinforcement of the concepts covered in this unit. It may be used as an assignment following completion of the Lab.

Students must complete Part I, questions 1 - 16 of Assignment 1, *Circuits & Power*. The assignment should be marked and the marks used as part of the evaluation for the course. The content covered in the assignments may also be included on any other summative evaluation.

Resources

Nelson Physics 12: College Preparation, pages 330 - 345.

Nelson Physics 12: College Preparation Workbook, pages 181, 184 - 187, 188-189.

Centre for Distance Learning and Innovation, CDLI, website: http://www.cdli.ca/

Core Lab #1, *Resistors in Series and Parallel*, pages 344 - 345.

Assignment 1, *Circuits & Power,* Part I, Appendix A.

Unit 3 - Electrical Power and Safety

Outcomes

3.1 Identify proper safety procedures to follow when working with electric circuits and potential electrical hazards.

3.1.1 Describe the importance of electrical safety.

3.1.2 Describe the use of fuses and circuit breakers.

3.2 Analyze electrical power usage in common devices.

3.2.1 State the equation used to determine power in electrical systems.

3.2.2 Calculate power, current, and potential drop using the equation for power.

Notes for Teaching and Learning

Students may think it is voltage that kills humans. However, they should realize that it is much more likely that current will kill people.

Students will likely have some familiarity with fuses and circuit breakers but may not realize how they work. The text does not go into a detailed explanation of this, but students should understand that fuses and circuit breakers protect electrical circuits by creating a break in the circuit preventing current from flowing.

Students could complete the *Try This Activity, Modelling a Circuit Breaker*, on page 348, to help them understand how a circuit breaker works. An answer sheet is provided on page 190 of the *Workbook* for this activity.

Students should have some familiarity with the concept of energy from Science 3102. This should help students in understanding that power is the rate of transforming energy.

Students should be able to use the equation for power to solve for either unknown.

Students are **not** required to complete the section on cost of electricity.

Unit 3 - Electrical Power and Safety

Suggestions for Assessment

Instructors should assess the student's level of understanding by reading student answers to questions from the Study Guide for this unit and providing feedback.

Students may need extra practice in using the power equation. Instructors should provide worksheets if needed.

Students could be assigned questions from the *Chapter 7 Self-Quiz* and/or *Review* on pages 363 - 365 in the text. They could also be assigned questions from the *Chapter 7 Self-Quiz* on pages 201 - 202 of the *Workbook*. Instructors should be careful when choosing questions to ensure that they assign only those that match the concepts covered in the outcomes.

Students must complete Part II, questions 17 - 21 of Assignment 1, *Circuits & Power*. The assignment should be marked and the marks used as part of the evaluation for the course. The content covered in the assignments may also be included on any other summative evaluation.

Instructors should assign a mark out of 10% for the written notes generated from answering the questions in the Study Guide. Students should also be assigned a mark for lab reports and/or other assignments.

Students should be given a final exam that covers the entire course. The mark for this exam should comprise at least 50% of the final mark for the course.

Resources

Nelson Physics 12: College Preparation, pages 346 - 353.

Nelson Physics 12: College Preparation Workbook, pages 190, 201 - 202.

Assignment 1, *Circuits & Power, Part II,* Appendix A.

Appendix

Name: _____ Date: _____

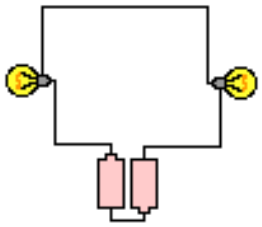
Assignment - Circuits and Power

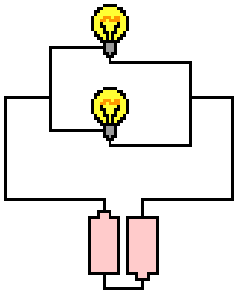
Part I

1. Draw the following electrical circuits:

   a. A single cell, light bulb and switch are placed together in a circuit such that the switch can be opened and closed to turn the light bulb on.

   b. A three-pack of cells is placed in a circuit to power a flashlight bulb.

   c. 

   d. 

2. Calculate the value of the resistance in each case:

   a. V = 12V, I = 0.25A
   b. V = 1.5 V, I = 30 mA
   c. V = 2.4 x 10^4 V, I = 6.0 x 10^{-3} A

3. Find the unknown quantities:

   a. R = 30 Ω, I = 0.45 A, V = ?
   b. R = 2.2 kΩ, I = 1.5 A, V = ?
   c. V = 6.0 V, R = 18 Ω, I = ?
   d. V = 52 mV, R = 26 Ω, I = ?

4. What current is drawn by a vacuum cleaner from a 115 V circuit having a resistance of 28 Ω?

5. Calculate the maximum rating (in volts) of a battery used to operate a toy electric motor which has a resistance of 2.4 Ω, and runs at top speed with a current of 2.5 A.

6. A walkie-talkie receiver operates on a 9.0 V battery. If the receiver draws 300 mA of current, what is its resistance?

7. An electric can opener used in a 120 V circuit has a resistance of 110 Ω. How much current does it draw?

8. An electric razor has a resistance of 20 Ω and draws a current of 250 mA. What is the potential drop across the razor?

9. Find the total resistance when three resistors, having values of 5.0 Ω, 10 Ω, and 30 Ω, are connected

   a. in series; and
   b. in parallel.

10. Find the total resistance when the following resistors are connected in series:

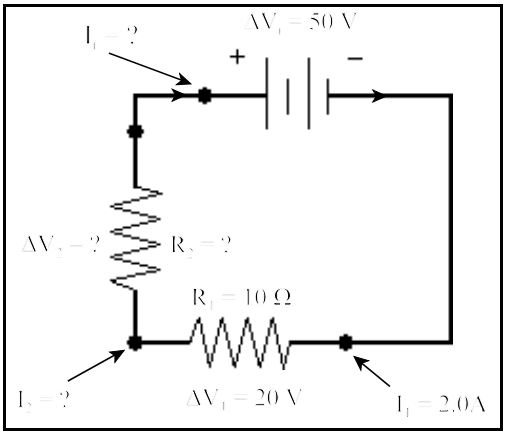
   a. 2.7 Ω, 9.8 Ω
   b. 10 Ω, 10^2 Ω, 10^3 Ω
   c. 1.0 Ω, 10^{-1} Ω, 10^{-2} Ω

11. Find the total resistance when the following resistors are connected in parallel:

   a. 4.0 Ω, 4.0 Ω
   b. 100 Ω, 100 Ω
   c. 300 Ω, 300 Ω, 300 Ω
   d. 150 Ω, 600 Ω, 600 Ω

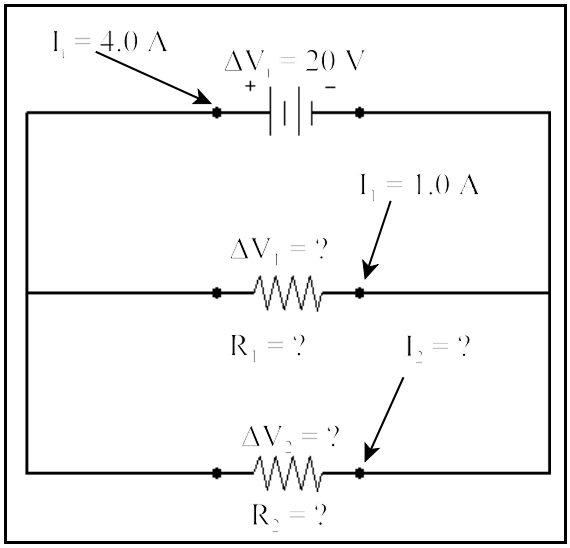
12. In the series circuit shown in the diagram, $\Delta V_1 = 20$ V, $R_1 = 10\ \Omega$, and $I_1 = 2.0$ A. Find values for the following:

a. I_2
b. ΔV_2
c. R_t
d. R_2
e. I_t



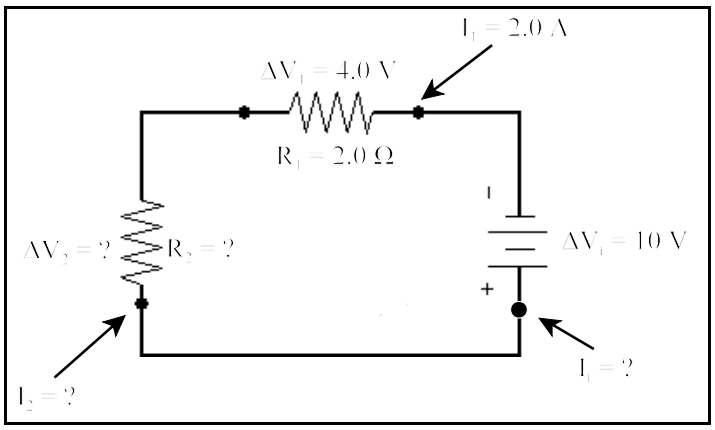
13. In the parallel circuit shown in the diagram, $\Delta V_t = 20$ V, $I_t = 4.0$ A, and $I_1 = 1.0$ A. Calculate values for the following:

a. ΔV_1
b. R_1
c. I_2
d. ΔV_2
e. R_2



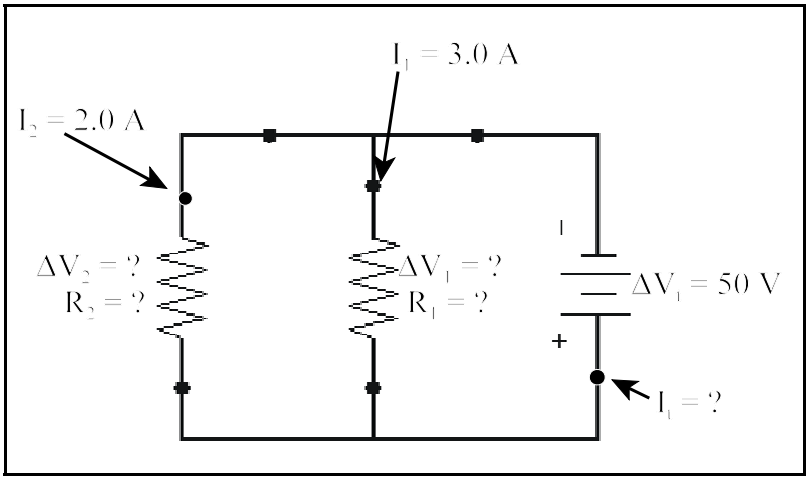
14. In the circuit shown below, find the following values:

a. I_2
b. ΔV_2
c. R_t
d. R_2
e. I_t



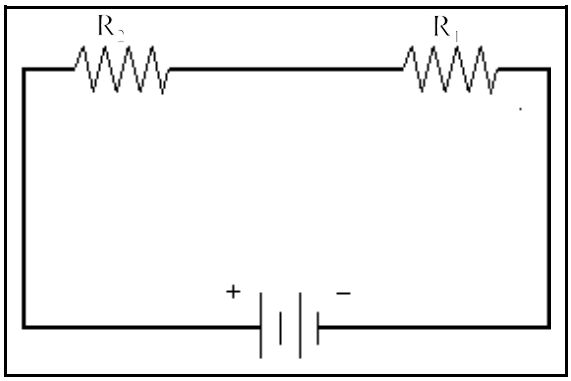
15. In the circuit shown below, calculate the following values:

a. ΔV_1
b. I_1
c. R_t
d. R_1
e. ΔV_2
f. R_2
g. I_t



16. In the circuit shown, $R_1 = 20\ \Omega$. The potential drop across R_1 is 10 V; across R_2, it is 20 V. Determine the following:

    a. The total potential rise of the source
    b. The current through R_1
    c. The current through R_2
    d. The resistance of R_2



Part II

17. Calculate the power of each appliance:

    a. A 120 V electric sander draws 2.9 A of current.
    b. An electric can opener, used in a 120 V circuit, operates at 2.2 A.
    c. A portable radio, using four 1.5 V cells in series, draws a current of 610 mA.

18. Calculate the electric potential drop across a 0.90 W calculator that draws a current of 100 mA.

19. Calculate the electric potential drop across a 34.5 kW welder that draws a current of 150 A.

20. What is the current drawn by a 1.5 kW electric kettle in a 120 V household circuit?

21. What is the current drawn by a 5.06 kW baseboard heater in a 230 V household circuit?

Answer Key

Name: _____ Date: _____

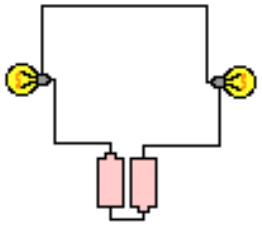
Assignment - Circuits & Power
Answer Key

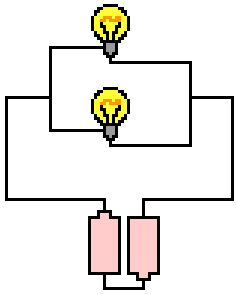
Part I

1. Draw the following electrical circuits:

   a. A single cell, light bulb and switch are placed together in a circuit such that the switch can be opened and closed to turn the light bulb on.

   b. A three-pack of cells is placed in a circuit to power a flashlight bulb.

   c. 

   d. 

2. Calculate the value of the resistance in each case:

   a. V = 12V, I = 0.25A (**48 Ω**)
   b. V = 1.5 V, I = 30 mA (**50 Ω**)
   c. V = 2.4 x 10^4 V, I = 6.0 x 10^{-3} A (**4.0 x 10^6 Ω**)

3. Find the unknown quantities:

   a. R = 30 Ω, I = 0.45 A, V = ? (**14 V**)
   b. R = 2.2 kΩ, I = 1.5 A, V = ? (**3.3 x 10^3 V**)
   c. V = 6.0 V, R = 18 Ω, I = ? (**0.33 A**)
   d. V = 52 mV, R = 26 Ω, I = ? (**2.0 mA**)

4. What current is drawn by a vacuum cleaner from a 115 V circuit having a resistance of 28 Ω? (**4.1 A**)

5. Calculate the maximum rating (in volts) of a battery used to operate a toy electric motor which has a resistance of 2.4 Ω, and runs at top speed with a current of 2.5 A. (**6.0 V**)

6. A walkie-talkie receiver operates on a 9.0 V battery. If the receiver draws 300 mA of current, what is its resistance? (**30 Ω**)

7. An electric can opener used in a 120 V circuit has a resistance of 110 Ω. How much current does it draw? (**1.1 A**)

8. An electric razor has a resistance of 20 Ω and draws a current of 250 mA. What is the potential drop across the razor? (**5.0 V**)

9. Find the total resistance when three resistors, having values of 5.0 Ω, 10 Ω, and 30 Ω, are connected

   a. in series; and (**45 Ω**)
   b. in parallel. (**3.0 Ω**)

10. Find the total resistance when the following resistors are connected in series:

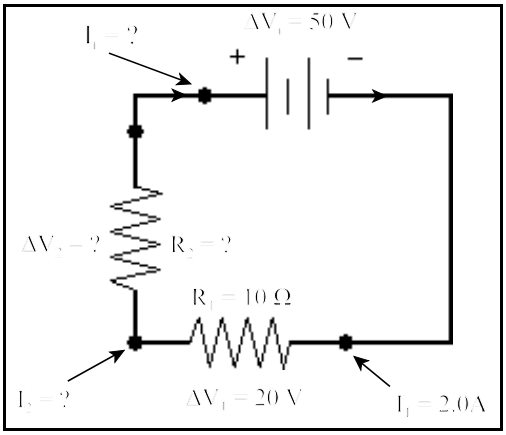
   a. 2.7 Ω, 9.8 Ω (**2.0 Ω**)
   b. 10 Ω, 10^2 Ω, 10^3 Ω (**1.1×10^3 Ω**)
   c. 1.0 Ω, 10^{-1} Ω, 10^{-2} Ω (**1.1 Ω**)

11. Find the total resistance when the following resistors are connected in parallel:

   a. 4.0 Ω, 4.0 Ω (**2.0 Ω**)
   b. 100 Ω, 100 Ω (**50 Ω**)
   c. 300 Ω, 300 Ω, 300 Ω (**100 Ω**)
   d. 150 Ω, 600 Ω, 600 Ω (**100 Ω**)

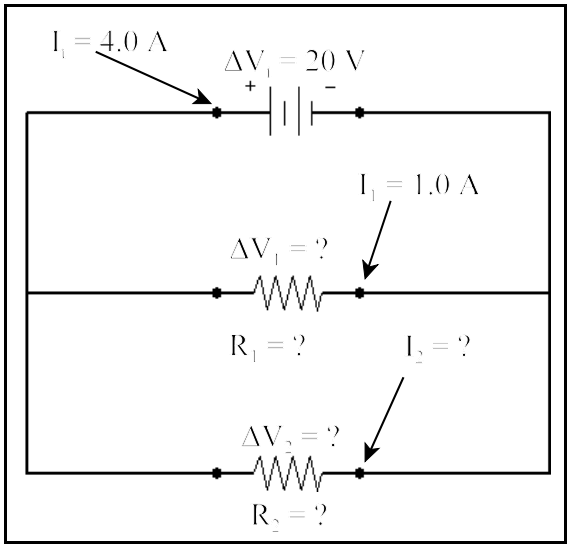
12. In the series circuit shown in the diagram, $\Delta V_1 = 20$ V, $R_1 = 10\ \Omega$, and $I_1 = 2.0$ A. Find values for the following:

a. I_2 (**2.0 A**)
b. ΔV_2 (**30 V**)
c. R_t (**25 Ω**)
d. R_2 (**15 Ω**)
e. I_t (**2.0 A**)



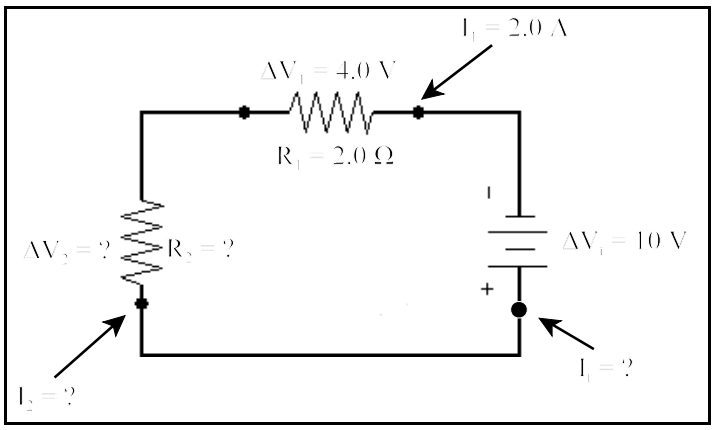
13. In the parallel circuit shown in the diagram, $\Delta V_t = 20$ V, $I_t = 4.0$ A, and $I_1 = 1.0$ A. Calculate values for the following:

a. ΔV_1 (**20 V**)
b. R_1 (**20 Ω**)
c. I_2 (**3.0 A**)
d. ΔV_2 (**20 V**)
e. R_2 (**6.7 Ω**)



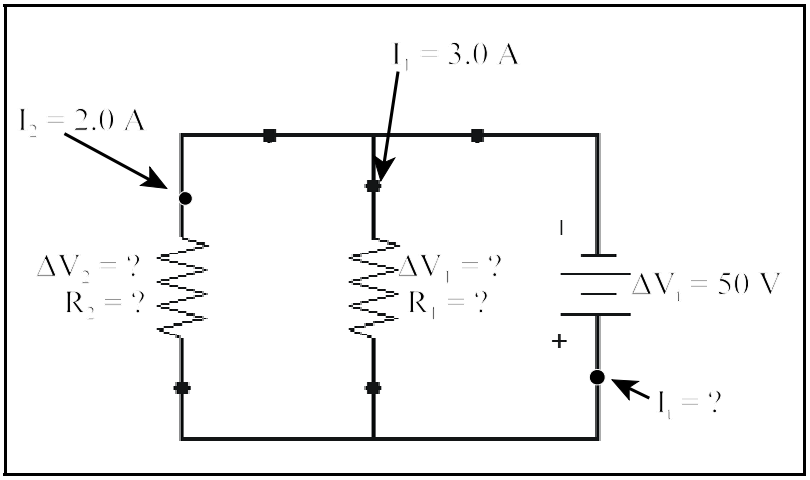
14. In the circuit shown below, find the following values:

a. I_2 (**2.0 A**)
b. ΔV_2 (**30 V**)
c. R_t (**25 Ω**)
d. R_2 (**15 Ω**)
e. I_t (**2.0 A**)



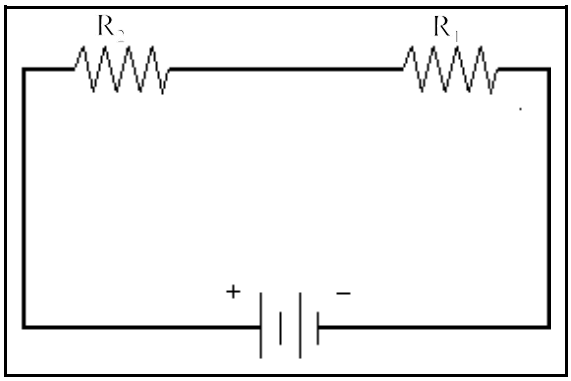
15. In the circuit shown below, calculate the following values:

a. ΔV_1 (**50 V**)
b. I_1 (**5.0 A**)
c. R_t (**10 Ω**)
d. R_1 (**16.7 Ω**)
e. ΔV_2 (**50 V**)
f. R_2 (**25 Ω**)
g. I_t (**5.0 A**)



16. In the circuit shown, $R_1 = 20\ \Omega$. The potential drop across R_1 is 10 V; across R_2, it is 20 V. Determine the following:

a. The total potential rise of the source (**30 V**)
b. The current through R_1 (**0.50 A**)
c. The current through R_2 (**0.50 A**)
d. The resistance of R_2 (**40 Ω**)



Part II

17. Calculate the power of each appliance:

a. A 120 V electric sander draws 2.9 A of current. (**3.5×10^2 W**)
b. An electric can opener, used in a 120 V circuit, operates at 2.2 A. (**2.6×10^2 W**)
c. A portable radio, using four 1.5 V cells in series, draws a current of 610 mA. (**3.7 W**)

18. Calculate the electric potential drop across a 0.90 W calculator that draws a current of 100 mA. (**9.0 V**)

19. Calculate the electric potential drop across a 34.5 kW welder that draws a current of 150 A. (**230 V**)

20. What is the current drawn by a 1.5 kW electric kettle in a 120 V household circuit? (**13 A**)

21. What is the current drawn by a 5.06 kW baseboard heater in a 230 V household circuit? (**22 A**)