Grade 10 Electricity/Electronics Technology (20G)

A Course for Independent Study

Manitoba

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A Course for Independent Study

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Writer	Brad Badiuk	Kelvin High School Winnipeg School Division
Development Team	Don Thiessen	Carman Collegiate Prairie Rose School Division
	Bill Sveinson	Daniel McIntyre Collegiate Winnipeg School Division
	Tony Michaluk	Maples Collegiate Seven Oaks School Division
	Raphael Masi	Murdoch MacKay Collegiate River East Transcona School Division
Revision Team Member	Gary Yakimowski	Sturgeon Heights Collegiate St. James-Assiniboia S.D.
Manitoba Education Staff	Louise Boissonneault Coordinator	Document Production Services Unit Instruction, Curriculum and Assessment Branch
	Marianne Fenn Consultant	Distance Learning Unit Instruction, Curriculum and Assessment Branch
	Lynn Harrison Desktop Publisher	Document Production Services Unit Instruction, Curriculum and Assessment Branch
	Myrna Klassen Consultant	Distance Learning Unit Instruction, Curriculum and Assessment Branch
	Gilles Landry Project Manager	Development Unit Instruction, Curriculum and Assessment Branch
	Susan Lee Coordinator	Distance Learning Unit Instruction, Curriculum and Assessment Branch
	Grant Moore Publications Editor	Document Production Services Unit Instruction, Curriculum and Assessment Branch
	Ken Nimchuk Project Leader	Learning Support and Technology Unit Instruction, Curriculum and Assessment Branch
	Cheryl Prokopanko Coordinator	Learning Support and Technology Unit Instruction, Curriculum and Assessment Branch

Grade 10 Electricity/ Electronics Technology (20G)

Introduction

Introduction to the Course

Overview

Welcome to Grade 10 Electricity/Electronics Technology!

As a student enrolled in a distance learning course, you have taken on a dual role—that of a student and a teacher. As a student, you are responsible for mastering the lessons and completing the learning activities and assignments. As a teacher, you are responsible for checking your work carefully, noting areas in which you need to improve and motivating yourself to succeed.

What Will You Learn in This Course?

In this course, you will study and learn the basics of electricity and electronics, including the following specific topics:

- How electricity plays a vital role in our lives
- The importance of electricity and electronics
- Important electronics terms
- Proper procedures for using tools and equipment
- Careers and jobs in the electronics field
- Health and safety issues when working with electronics
- How to read and interpret schematic diagrams
- How to use appropriate terminology for electricity or electronics
- How to design and/or build circuits to an acceptable standard capable of producing a desired output
- How to demonstrate the safe use and knowledge of meters and hand tools used in the electrical industry
- How to read and interpret meter readings
- How to test and evaluate the integrity of electrical and electronic components
- How to find out about post-secondary programs in the electrical and electronics fields

Electronics play a huge part in our everyday lives. You may not realize it, but just about everywhere you go and everything you do involves using electronics in some shape or form. For example, when you are travelling to and from school, the vehicle you are in is made up of various forms of electronics to make your automobile work. Listening to music on a radio, CD player, MP3 media player, or a computer involves electronics, and that music is recorded with electronic devices. While driving, you can see hydro lines carrying electricity to houses and other buildings. It's everywhere! In this day and age of technology, our lives are driven greatly by electronics.

We rarely stop to think of the role the electronic devices we use play in our lives. When we use that cordless phone or mobile phone to call up our friends, when we log onto the computer to check our email, and when we watch our favourite shows on television, we are using electronics. It is amazing when you actually consider all the electronic devices we use on a daily basis. You may be forced to notice it when the power in your area goes out and all of a sudden everything goes dark and there's not much to do! Electronics seem to make our lives a whole lot easier and much more exciting.

Electronic devices seem to be constantly evolving and improving. The record player evolved to a cassette tape player, then the CD player, and now a hard disc or solid state form of electronic equipment called an MP3 player. Video recording went from the VCR to the DVD player, and now we are able to pause and instantly replay live television using a hard disk or Personal Video Recorder (PVR) device. Sound systems for home entertainment grew from stereo systems with two speaker outputs to surround sound systems with up to six different channels of sound output.

Electronics are used everywhere—in our homes, for law enforcement and rescue units, for government business, all the way to traffic signals and emergency response systems. We have become so dependent on them, it would now be extremely difficult for us to live without them. But if you went back in time only 200 years, there would be no electronics whatsoever.

How Is This Course Organized?

The Grade 10 Electricity/Electronics Technology course consists of the following five modules:

Module 1: Introduction to Electronics

Module 2: The Basics of Electricity

Module 3: Capacitors and Semiconductors

Module 4: Ohm's Law and Circuit Fundamentals

Module 5: Magnetism and Induction

Each module in this course consists of several lessons, which are organized as follows:

- **Introduction:** Each lesson begins by outlining what you will be learning.
- **Power Words:** Throughout this course you will be introduced to words that will increase your electronics vocabulary. These words are called "power words." Each power word will be in bold and the definition for each word can be found in the glossary at the end of the booklet. You should be able to define and/or explain these words when you have completed this course.
- **Lesson:** The main body of the lesson is made up of the content that you need to learn. It contains explanations, diagrams, and fully completed examples.
- **Summary:** Each lesson ends with a brief review of what you just learned.
- **Learning Activities:** Most lessons have a learning activity. These include questions that you should complete in order to help you practise or review what you have just learned. Once you have completed a learning activity, you should check your answers with the answer key provided at the end of the module. Do not send your learning activities to the Distance Learning Unit for assessment.
- **Assignments:** Assignments are found at the end of lessons. At the end of each module, you will mail or electronically submit all your completed assignments from that module to the Distance Learning Unit for assessment.
- **Projects:** You will be completing two hand-in projects. The two projects must be **mailed** to the Distance Learning Unit for assessment.

In each lesson, you will read a few pages and then complete a learning activity and/or assignment. Some lessons may require you to do some investigative research or observation work in the community.

What Resources Will You Need for This Course?

You do not need a textbook for this course. All the content is provided directly within the course. You will, however, need access to a variety of resources.

Grade 9/10 Electronics Video

You will have the opportunity to view the Grade 9/10 Electronics video, which is available in the learning management system (LMS). If you need a copy of the video on DVD, please contact the Distance Learning Unit at 1-800-465-9915.

Grade 10 Electricity Kit

You will need the Grade 10 Electricity Kit to complete this course. If you have not ordered it, contact the Manitoaba Learning Resource Centre at www.manitobalrc.ca or telephone 1-866-771-6822. Please note that there are two options when purchasing the Grade 10 Electricity Kit. If you took the Grade 9 course, you may already have the seven items from the tool kit, or you may have access to them at home/school for another reason. If you have access to these seven items, you would order kit #13193. If you require all the supplies for this course, you would order kit #13194.

If items in the kit are not in working order, contact the Learning Resource Centre for replacement parts.

Each student needs to purchase his or her own Grade 10 Electricity Kit, as group submissions for projects and assignments will not be accepted. A list outlining all components found in the Grade 10 Electricity Kit can be found on the following two pages.

Other Supplies/Requirements

- Safe work area with 120-volt, 15-amp power supply
- Calculator
- 9-volt batteries

Variations in Components and Tools

Components and tools in the Electricity Kit might or might not be identical to those described or shown in the course and video. This is common in the electronics industry, where manufacturers often modify components and tools in order to improve them. It is also possible the kit suppliers have had to purchase the components and parts from new manufacturers, which may account for a change from time to time.

People in the electronics industry often face this challenge. It will give you the chance to practice your critical thinking skills to work around it. Troubleshooting skills are an essential part of working in the electronics industry and of life in general. If your components or tools are slightly different from the ones shown in the course or video, be assured that they work in the same way but they just look slightly different.

MTBB #13194 **Electricity Kit with Tool Kit**	MTBB #13193 **Electricity Kit without Tool Kit**
Tool Kit	
digital multimeter (DMM) wire strippers needle-nose pliers diagonal/side cutters soldering iron soldering iron stand w/cleaning sponge safety glasses solder	Students need access to the Tool Kit items but have access to these items either at home or at school. These are the same seven items that are found in the Grade 9 Electricity Kit.
Project Kit 1	Project Kit 1
electrolytic capacitor 1 green LED 1 red LED 2 – 1.0 uF electrolytic capacitors 1 – 50 k ohm trimmer resistor (a smaller version of a potentiometer) 2 – 33 k resistors (orange, orange, orange, gold) 2 – 430 ohm resistors (yellow, orange, brown, gold) 3 – 2W3906 transistors 9-volt battery clip project circuit board solder 2 touch wires	electrolytic capacitor 1 green LED 1 red LED 2 – 1.0 uF electrolytic capacitors 1 – 50 k ohm trimmer resistor (a smaller version of a potentiometer) 2 – 33 k resistors (orange, orange, orange, gold) 2 – 430 ohm resistors (yellow, orange, brown, gold) 3 – 2W3906 transistors 9-volt battery clip project circuit board solder 2 touch wires
Project Kit 2	Project Kit 2
1 – 0.047 uF capacitor 1 – 10 k ohm resistor 1 – 100 ohm resistor 1 – 555 timer chip (I.C.) 1 – 4017 chip (I.C.) 5 green LEDs 2 – IC sockets 2 braided wires 2 touch pad circuit boards 9-volt battery clip	1 – 0.047 uF capacitor 1 – 10 k ohm resistor 1 – 100 ohm resistor 1 – 555 timer chip (I.C.) 1 – 4017 chip (I.C.) 5 green LEDs 2 – IC sockets 2 braided wires 2 touch pad circuit boards 9-volt battery clip

(continued)

MTBB #13194 **Electricity Kit with Tool Kit**	**MTBB #13193** **Electricity Kit without Tool Kit**
Experiment Kit	Experiment Kit
1 solderless circuit board 2 solid hook-up wires 1 photocell 9-volt battery clip 2 LEDs (red) diode (1N4005) SPST slide switch potentiometer (10 k) 100 uF electrolytic capacitor 1000 uF electrolytic capacitor 2N3904 WPN transistor silicon controlled rectifier (SCR) 7 segment display (common anode) 1 – 100 ohm resistor 1 – 220 ohm resistor 1 – 1 k ohm resistor 1 – 330 ohm resistor 1 – 5.6 k ohm resistor 1 extra LED	1 solderless circuit board 2 solid hook-up wires 1 photocell 9-volt battery clip 2 LEDs (red) diode (1N4005) SPST slide switch potentiometer (10 k) 100 uF electrolytic capacitor 1000 uF electrolytic capacitor 2N3904 WPN transistor silicon controlled rectifier (SCR) 7 segment display (common anode) 1 – 100 ohm resistor 1 – 220 ohm resistor 1 – 1 k ohm resistor 1 – 330 ohm resistor 1 – 5.6 k ohm resistor 1 extra LED
Practice Solder Kit	Practice Solder Kit
1 spool of solder 330 ohm resistor 1 piece of printed circuit board 3 solid hook-up wires LED SPST switch 9-volt battery clip	1 spool of solder 330 ohm resistor 1 piece of printed circuit board 3 solid hook-up wires LED SPST switch 9-volt battery clip
Miscellaneous Resistor Bag	Miscellaneous Resistor Bag
100 ohms 330 ohms 1000 ohms 220 ohms 5.6 k ohms 6.8 k ohms 6.8 ohms 10 k ohms 1 M ohms 20 k ohms	100 ohms 330 ohms 1000 ohms 220 ohms 5.6 k ohms 6.8 k ohms 6.8 ohms 10 k ohms 1 M ohms 20 k ohms

It should be noted that manufacturers periodically change the design of their product and, as a result, the items in your kit may differ in some way from the illustrations in this document. This applies only to appearance and does not affect the use or strength of any of the items.

Online Resources

Visit www.careercruising.com. The user ID and password to access this website is provided in Assignment 1.4.

Optional Resources

It would be helpful if you had access to the following resources:

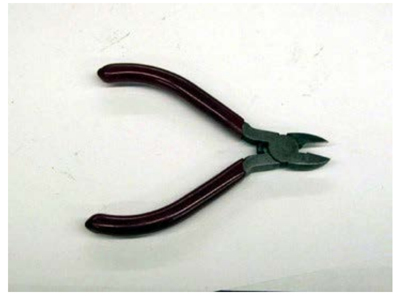
- **Photocopier/scanner:** With access to a photocopier/scanner, you could make a copy of your assignments before submitting them so that if your tutor/marker wants to discuss an assignment with you over the phone, each of you will have a copy. It would also allow you to continue studying or to complete further lessons while your original work is with the tutor/marker. Photocopying or scanning your assignments will also ensure that you keep a copy in case the originals are lost.
- **Resource people:** Access to local resource people, such as teachers, school counsellors, and librarians, would help you complete the course.
- **A computer with word processing software:** Access to word processing software (e.g., Microsoft Word) and presentation and slide software (e.g., Microsoft PowerPoint) would help you complete some assignments.
- **A computer with Internet access:** Some lessons suggest website links as sources of information or for supplementary reference and reading. If you do not have Internet access, you will still be able to complete the course, but you will need to find different ways of accessing information.

Inventory Time!

Let's go through your kit and make sure you have the following tools and equipment.

Basic Electronics Tools

Diagonal/side cutters



Needle-nose pliers

Wire strippers

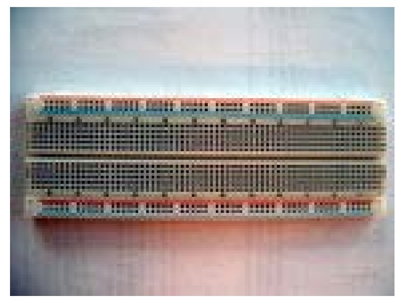
Soldering iron with
holder and cleaning sponge

Note: Parts and tools in the kit might not be identical to those described in the course or on the video.

Solder (rosin core)

Safety glasses

Solderless circuit board



Digital multimeter (DMM)

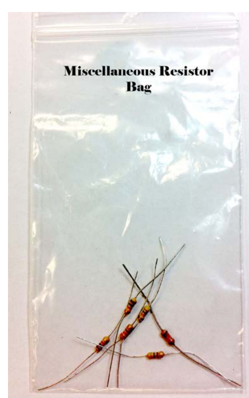
Note: Parts and tools in the kit might not be identical to those described in the course or on the video.

Experiment Kit

Project Kits 1 and 2

Practice Solder Kit

Miscellaneous Resistor Bag



Note: Parts and tools in the kit might not be identical to those described in the course or on the video.

Who Can Help You with This Course?

Taking an independent study course is different from taking a course in a classroom. Instead of relying on the teacher to tell you to complete a learning activity or an assignment, you must tell yourself to be responsible for your learning and for meeting deadlines. There are, however, people who can help you be successful in this course: your tutor/marker and your learning partner.

Your Tutor/Marker

Tutor/markers are experienced educators who tutor Independent Study Option (ISO) students and mark assignments and examinations. When you are having difficulty with something in this course, be sure to contact your tutor/marker, who is there to help you. Your tutor/marker's name and contact information were sent to you with this course. You can also obtain this information in the learning management system (LMS).

Your Learning Partner

A learning partner is someone **you choose** who will help you learn. It may be someone who knows something about electricity/electronics, but it doesn't have to be. A learning partner could be someone else who is taking this course, a teacher, a parent or guardian, a sibling, a friend, or anybody else who can help you. Most importantly, a learning partner should be someone with whom you feel comfortable, and who will support you as you work through this course.

Your learning partner can help you keep on schedule with your course work, read the course with you, check your work, look at and respond to your learning activities, or help you make sense of assignments. You may even study for your examinations with your learning partner. If you and your learning partner are taking the same course, however, your assignment work should not be identical.

How Will You Know How Well You Are Learning?

You will know how well you are learning in this course by how well you complete the learning activities, assignments, projects, and examination.

Learning Activities

The learning activities in this course will help you to review and practise what you have learned in the lessons. You will not submit the completed learning activities to the Distance Learning Unit. Instead, you will complete the learning activities and compare your responses to those provided in the Learning Activity Answer Key found at the end of each module.

Make sure you complete the learning activities. Doing so will not only help you to practise what you have learned, but will also prepare you to complete your assignments and the examination(s) successfully. Many of the questions on the examination(s) will be similar to the questions in the learning activities. Remember that you **will not submit learning activities to the Distance Learning Unit**.

Assignments

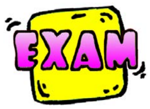
Each module in this course contains assignments, which you will complete and submit to the Distance Learning Unit for assessment. The assignments are worth a total of **55 percent** of your final course mark. There are two types of assignments in this course: the written question format, and eight hands-on experiments that involve lab reports.

The tutor/marker will mark your assignments and return them to you. Remember to keep all marked assignments until you have finished the course so that you can use them to study for your examination.

Projects

You will be completing and mailing to the Distance Learning Unit two hand-in projects, one at the end of Module 3 and one at the end of Module 5. Each student is to complete the two projects, as **group submissions will not be accepted**. Each project is worth 15 percent of the final grade for the course. Therefore, the two projects are worth **30 percent** of the total mark for the course.

Final Examination



The final examination covers the entire course and is worth **15 percent** of the final mark. The final examination must be written under the supervision of a proctor. When you start Module 5, you need to make arrangements to write the examination.

Requesting Your Examination

You are responsible for making arrangements to have the examinations sent to your proctor from the Distance Learning Unit. Please make arrangements before you finish Module 5 to write your final examination.

To write your examinations, you need to make the following arrangements:

- **If you are attending school,** your examination will be sent to your school as soon as all the applicable assignments have been submitted. You should make arrangements with your school's Independent Study Option (ISO) school facilitator to determine a date, time, and location to write the examination.
- **If you are not attending school,** check the **Examination Request Form** for options available to you. Examination Request Forms can be found on the Distance Learning Unit's website, or look for information in the learning management system (LMS). **Two weeks before** you are ready to write the examination, fill in the Examination Request Form and mail, fax, or email it to

  Distance Learning Unit
  500–555 Main Street
  P.O. Box 2020
  Winkler, MB R6W 4B8
  Fax: 204-325-1719
  Toll-Free Telephone: 1-800-465-9915
  Email: distance.learning@gov.mb.ca

How Much Time Will You Need to Complete This Course?

Learning through independent study has several advantages over learning in the classroom. You are in charge of how you learn and you can choose how quickly you will complete the course. You can read as many lessons as you wish in a single session. You do not have to wait for your teacher or classmates.

From the date of your registration, you have a maximum of **12 months** to complete this course, but the pace at which you proceed is up to you. Read the following charts for suggestions on how to pace yourself.

Chart A: Semester 1

If you want to start the course in September and complete it in January, you can follow the timeline suggested below.

Module	Completion Date
Module 1	End of September
Module 2	End of October
Module 3	End of November
Module 4	Middle of December
Module 5	Beginning of January
Final Examination	Middle of January

Chart B: Semester 2

If you want to start the course in February and compete it in May, you can follow the timeline suggested below.

Module	Completion Date
Module 1	Middle of February
Module 2	End of February
Module 3	End of March
Module 4	Middle of April
Module 5	Beginning of May
Final Examination	Middle of May

Chart C: Full School Year (Not Semestered)

If you want to start the course in September and compete it in May, you can follow the timeline suggested below.

Module	Completion Date
Module 1	End of October
Module 2	End of November
Module 3	End of January
Module 4	Middle of March
Module 5	Middle of April
Final Examination	Middle of May

Timelines

Do not wait until the last minute to complete your work, since your tutor/marker may not be available to mark it immediately. It may take a few weeks for your tutor/marker to assess your work and return it to you.

If you need this course to graduate this school year, all coursework must be received by the Distance Learning Unit on or before the first Friday in May, and all examinations must be received by the Distance Learning Unit on or before the last Friday in May. Any coursework or examinations received after these deadlines may not be processed in time for a June graduation. Assignments or examinations submitted after these recommended deadlines will be processed and marked as they are received.

When and How Will You Submit Completed Assignments?

When to Submit Assignments

While working on this course, you will submit completed assignments to the Distance Learning Unit five times. The following chart shows you exactly what assignments you will be submitting at the end of each module.

Submission of Assignments, Log Sheets, and Projects	
Submission	**Assignments You Will Submit**
1	**Module 1: Introduction to Electronics** Module 1 Cover Sheet Assignments 1.1 to 1.4
2	**Module 2: The Basics of Electricity** Module 2 Cover Sheet Assignments 2.1 to 2.8
3	**Module 3: Capacitors and Semiconductors** Module 3 Cover Sheet Assignments 3.1 to 3.5 Project 1: The Decision Maker
4	**Module 4: Ohm's Law and Circuit Fundamentals** Module 4 Cover Sheet Assignments 4.1 to 4.5
5	**Module 5: Magnetism and Induction** Module 5 Cover Sheet Assignment 5.1 Project 2: Brain Meter

How to Submit Assignments

In this course, you have the choice of submitting your assignments either by mail or electronically.

- **Mail:** Each time you **mail** something, you must include the print version of the applicable Cover Sheet (found at the end of this Introduction). Complete the information at the top of each Cover Sheet before submitting it along with your assignments.
- **Electronic submission:** You do not need to include a cover sheet when submitting assignments electronically.

Submitting Your Assignments by Mail

If you choose to mail your completed assignments, please photocopy all the materials first so that you will have a copy of your work in case your package goes missing. You will need to place the applicable module Cover Sheet and assignment(s) in an envelope, and address it to

Distance Learning Unit
500–555 Main Street
P.O. Box 2020
Winkler MB R6W 4B8

Your tutor/marker will mark your work and return it to you by mail.

Submitting Your Assignments Electronically

Assignment submission options vary by course. Sometimes assignments can be submitted electronically and sometimes they must be submitted by mail. Specific instructions on how to submit assignments were sent to you with this course. In addition, this information is available in the learning management system (LMS).

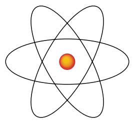
If you are submitting assignments electronically, make sure you have saved copies of them before you send them. That way, you can refer to your assignments when you discuss them with your tutor/marker. Also, if the original hand-in assignments are lost, you are able to resubmit them.

Your tutor/marker will mark your work and return it to you electronically.

The Distance Learning Unit does not provide technical support for hardware-related issues. If troubleshooting is required, consult a professional computer technician.

What Are the Guide Graphics For?

Module Focus/Specific Learning Outcomes (SLOs): Note that these SLOs are addressed within the lesson.



Power Words: This icon indicates key "power" words that you will learn in the module.

Learning Activity: Complete a learning activity. This will help you to review or practise what you have learned and to prepare you for an assignment or an examination. You will not submit learning activities to the Distance Learning Unit. Instead, you will compare your responses to those provided in the Learning Activity Answer Key found at the end of the applicable module.

Check Your Work: Check your responses against those provided in the Learning Activity Answer Key found at the end of the applicable module.

Video: View a video.

Stop/Caution: Use caution when conducting this learning activity or experiment.

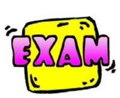
Assignment: Complete an assignment. You will submit your completed assignments to the Distance Learning Unit for assessment in accordance with the chart found in the course Introduction.

Tech Project: Complete a project that you must submit to the Distance Learning Unit.

Mail or Electronic Submission: Mail or electronically submit your completed assignments to the Distance Learning Unit for assessment at this time.

Learning Partner: Ask your learning partner to help you with this task.

Note: Take note of and remember this important information or reminder.



Examination: Write your final examination at this time.

Grade 10 Electricity/Electronics Technology (20G)

Module 1 Cover Sheet

Please complete this sheet and place it on top of your assignments to assist in proper recording of your work. Submit the package to:

Drop-off/Courier Address
Distance Learning Unit
555 Main Street
Winkler MB R6W 1C4

Mailing Address
Distance Learning Unit
500–555 Main Street
PO Box 2020
Winkler MB R6W 4B8

Contact Information

Legal Name: ____________________ Preferred Name: ____________________

Phone: ____________________ Email: ____________________

Mailing Address: ____

City/Town: ____________________ Postal Code: ____________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 1 Assignments	**Attempt 1**	**Attempt 2**
Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	____________ Date Received	____________ Date Received
❑ Assignment 1.1: Electricity: Let's Get Started	______ /17	______ /17
❑ Assignment 1.2: The Hazards of Working with Electricity	______ /9	______ /9
❑ Assignment 1.3: Practice Soldering Project*	❑ CO / ❑ INC	❑ CO / ❑ INC
❑ Assignment 1.4: Careers in Electronics**	______ /26	______ /26
	Total: ____ /52	**Total: ____ /52**
For Tutor/Marker Use		
Remarks:		

* Refer to the back of this cover sheet for the criteria to receive a "complete" on this project.

**Attach your description to the job or career advertisement to which it applies. Remember to send both advertisements and the description to the Distance Learning Unit when you have completed Module 1.

Soldering Practice Project Criteria

The purpose of the Practice Soldering Project is to demonstrate your soldering skills. In order to receive a complete on this project, your tutor/marker needs a sample of soldering that

- includes three or four components on the proper side of the PCB (use a low heat soldering iron)
- shows solder covering the copper ring that the component leg sticks through
- does not have any adjacent copper surface so that the only path for electrical flow is from one leg of the component to the other, through the component

These points cover the minimum requirements for completing the project.

Soldering that demonstrates a higher level of skill should have the following characteristics:

- nestled close to the board (but still able to get a heat sink under the component)
- contains no burn marks
- does not contain any cold soldered joints
- has the superfluous leg portions trimmed
- has been tested for continuity
- contains a solder joint that is smooth, shiny, and shaped like a Hershey's Kiss®

Grade 10 Electricity/Electronics Technology (20G)

Module 2 Cover Sheet

Please complete this sheet and place it on top of your assignments to assist in proper recording of your work. Submit the package to:

Drop-off/Courier Address
Distance Learning Unit
555 Main Street
Winkler MB R6W 1C4

Mailing Address
Distance Learning Unit
500–555 Main Street
PO Box 2020
Winkler MB R6W 4B8

Contact Information

Legal Name: ____________________ Preferred Name: ____________________

Phone: ____________________ Email: ____________________

Mailing Address: ____

City/Town: ______________________________ Postal Code: __________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 2 Assignments Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	**Attempt 1** __________ Date Received	**Attempt 2** __________ Date Received
❑ Assignment 2.1: The Atom and Electronics	_______ /24	_______ /24
❑ Assignment 2.2: Schematic Symbols	_______ /53	_______ /53
❑ Assignment 2.3: Schematic Drawings	_______ /16	_______ /16
❑ Assignment 2.4: Working with the Metric System Part 1: ____ Part 2: ____ Part 3: ____	_______ /33	_______ /33
❑ Assignment 2.5: Resistors Part 1: ____ Part 2: ____	_______ /48	_______ /48
❑ Assignment 2.6: Experiment 1, Part 2: Report 1: The Effects of Resistors on an LED	_______ /13	_______ /13

continued

Grade 10 Electricity/Electronics Technology (20G)

Module 2 Cover Sheet *(continued)*

Please complete this sheet and place it on top of your assignments to assist in proper recording of your work. Submit the package to:

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Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 2 Assignments *(continued)*	**Attempt 1**	**Attempt 2**
Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	________ Date Received	________ Date Received
❑ Assignment 2.7: Experiment 2, Part 2: Report 2: The Effects of a Photocell on an LED	_____ /11	_____ /11
❑ Assignment 2.8: Experiment 3, Part 2: Report 3: The Effects of a Potentiometer on an LED	_____ /11	_____ /11
	Total: ____ /209	**Total: ____ /209**

For Tutor/Marker Use
Remarks:

Grade 10 Electricity/Electronics Technology (20G)

Module 3 Cover Sheet

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Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 3 Assignments Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	**Attempt 1** __________ Date Received	**Attempt 2** __________ Date Received
❑ Assignment 3.1: Experiment 4, Part 2: Report 4: Capacitors	_____ /14	_____ /14
❑ Assignment 3.2: Experiment 5, Part 2: Report 5: Diodes	_____ /12	_____ /12
❑ Assignment 3.3: Experiment 6, Part 2: Report 6: Transistors	_____ /14	_____ /14
❑ Assignment 3.4: Experiment 7, Part 2: Report 7: Silicon Controlled Rectifier (SCR)	_____ /13	_____ /13
❑ Assignment 3.5: Experiment 8, Part 2: Report 8: Segment Display	_____ /11	_____ /11

continued

Grade 10 Electricity/Electronics Technology (20G)

Module 3 Cover Sheet *(continued)*

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Mailing Address: ____

City/Town: ______________________________ Postal Code: __________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 3 Assignments *(continued)*	**Attempt 1**	**Attempt 2**
Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	________ Date Received	________ Date Received
❑ Project 1: The Decision Maker	______ /100	______ /100
	Total: ____ /164	**Total: ____ /164**

For Tutor/Marker Use
Remarks:

Project 1: The Decision Maker *(100 marks)*
Marking Rubric

The assembly of parts and completion of this working brain meter are based on the following criteria:

Confirmation: *25 marks*
Construction: *25 marks*
Soldering: *25 marks*
Function: *25 marks*

This project is designed to be the work of one person and group submissions will not be accepted.

Confirmation: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**	Some of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**	Few of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**

Project 1: The Decision Maker (continued)
Marking Rubric

Construction: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**	Some of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**	Few of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**

Project 1: The Decision Maker (continued)
Marking Rubric

Soldering: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**	Some of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**	Few of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**

Project 1: The Decision Maker (continued)
Marking Rubric

Function: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**	Some of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**	Few of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**

Grade 10 Electricity/Electronics Technology (20G)

Module 4 Cover Sheet

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City/Town: ____________________ Postal Code: __________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 4 Assignments Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	**Attempt 1** __________ Date Received	**Attempt 2** __________ Date Received
❑ Assignment 4.1: Resistance Values in a Series Circuit	_____ /10	_____ /10
❑ Assignment 4.2: Series Circuits	_____ /74	_____ /74
❑ Assignment 4.3: Resistance Parallel Circuits	_____ /10	_____ /10
❑ Assignment 4.4: Parallel Circuits	_____ /72	_____ /72
❑ Assignment 4.5: Capacitors in Series	_____ /2	_____ /2
	Total: ___ **/168**	**Total:** ___ **/168**

For Tutor/Marker Use
Remarks:

Grade 10 Electricity/Electronics Technology (20G)

Module 5 Cover Sheet

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Contact Information

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Phone: ____________________ Email: ____________________

Mailing Address: ____

City/Town: ____________________ Postal Code: ____________

Attending School: ❑ No ❑ Yes

School Name: ____

Has your contact information changed since you registered for this course? ❑ No ❑ Yes

Note: Please keep a copy of your assignments so that you can refer to them when you discuss them with your tutor/marker.

For Student Use	For Office Use Only	
Module 5 Assignments Which of the following are completed and enclosed? Please check (✓) all applicable boxes below.	**Attempt 1** __________ Date Received	**Attempt 2** __________ Date Received
❑ Assignment 5.1: Magnetism	_______ /27	_______ /27
❑ Project 2: Brain Meter	_______ /100	_______ /100
	Total: ____ /127	**Total: ____ /127**

For Tutor/Marker Use
Remarks:

Project 2: Brain Meter *(100 marks)*
Marking Rubric

The assembly of parts and completion of this working brain meter are based on the following criteria:

Confirmation: *25 marks*
Construction: *25 marks*
Soldering: *25 marks*
Function: *25 marks*

This project is designed to be the work of one person and group submissions will not be accepted.

Confirmation: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**	Some of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**	Few of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**

Project 2: Brain Meter (continued)
Marking Rubric

Construction: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**	Some of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**	Few of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**

Project 2: Brain Meter (continued)
Marking Rubric

Soldering: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**	Some of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**	Few of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**

Project 2: Brain Meter (continued)
Marking Rubric

Function: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**	Some of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**	Few of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**

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Grade 10 Electricity/ Electronics Technology (20G)

Module 1
Introduction to Electronics

- Introduction
- Lesson 1: Electricity: Let’s Get Started
- Lesson 2: How Electricity Is Produced
- Lesson 3: A Brief History of Electronics
- Lesson 4: How to Solder
- Lesson 5: Practice Solder Board
- Lesson 6: Careers in Electronics
- Module 1 Summary

Module 1:
Introduction to Electronics

Module Focus

After working through this module, you should be able to

- ❑ have a basic understanding of what electricity is.
- ❑ understand the way in which it is generated and transmitted.
- ❑ learn to measure electricity with a multimeter.
- ❑ create some electricity of your own.
- ❑ understand the hazards of working with electricity.
- ❑ understand a brief history of electricity.
- ❑ learn how to solder.
- ❑ practise using a solder board.
- ❑ engage in career exploration.

Introduction

In this module, you will learn about what electricity is and how it is transmitted and generated. You will also learn how to measure with a multimeter, learn about the hazards of electricity, and learn and practise how to solder. You will also explore the various careers in electricity and electronics.

Power Words

- electrical outlet
- batteries
- static electricity
- lightning
- conductor
- turbine
- transformer
- insulator
- satellites
- electrolyte
- insulator
- potential energy
- AC
- electric shock
- volts
- electrodes
- current
- generator
- DC
- mechanical energy
- rotors
- hydroelectricity
- multimeter
- electrochemical reaction

Module 1 Assignments

When you have completed the assignments for Module 1, submit your completed assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
1	Assignment 1.1	Electricity: Let’s Get Started
2	Assignment 1.2	The Hazards of Working with Electricity
5	Assignment 1.3	Practice Soldering Project
6	Assignment 1.4	Careers in Electronics

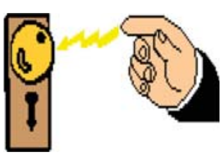
Lesson 1: Electricity: Let's Get Started

What Is It?

If you look around your house, you will see many **electrical outlets** where you can plug in all your appliances, gizmos, and gadgets. On the other hand, some of our electrical devices don't use the electricity that flows from these outlets. Instead, they use **batteries**, which can produce varying amounts of electricity, depending on how many batteries there are and the configuration that they are in.

One of the most obvious examples of electricity is during a thunderstorm. At this time, you will often see huge bolts of electricity that flash and come down from the sky. **Lightning** is one of nature's most awesome displays, and also one of the deadliest. Bolt temperatures are hotter than the surface of the Sun (27,000 degrees Celsius) and it is the shockwaves produced by the rapid heating of the air around the bolt that gives us thunder.

On a much smaller scale, you can get a shock from static electricity. Almost all of us are familiar with **static electricity** because we can see and feel it, especially in the winter. On dry winter days, static electricity can build up in our bodies and cause a spark to jump from our bodies to a piece of metal or another person's body. We can see, feel, and hear the sound of the spark when it jumps.



You walk across the rug, reach for the doorknob, and ZAP!!! You get a shock. Or, you come inside from the cold, pull off your hat, and BOING!!! All your hair stands on end. What is going on here?

The answer is **static electricity**.

It is easy to create electricity from sunlight using a **solar cell**. You've probably seen calculators that have solar cells—calculators that never need batteries and in some cases don't even have an off button. As long as you have enough light, they seem to work forever. You may have seen larger solar panels on the roofs of houses. These panels generate electricity for people to use as long as the sun is shining. Although these larger panels aren't as common as solar-powered calculators, they are not that hard to spot if you know where to look. **Satellites** also

have large arrays of solar panels, where they are used to power the electrical systems.

So what is this mysterious stuff that we call electricity? Where does it come from, and why is it able to do so many different things?

What Can Electricity Do?

The electricity that we get from power outlets and batteries can power all different kinds of devices. The fact is that electricity can be used in many different ways to do many different things.

For example:

- Electric motors can turn electricity into motion.
- Light bulbs and LEDs turn electricity into light.
- Computers use electricity to store and transmit information.
- Telephones use electricity to make communication possible.
- TVs use electricity to transmit moving pictures onto screens.
- Speakers turn electricity into sound waves and music we can hear.
- Stun guns and tasers turn electricity into weapons.
- Some furnaces and stoves turn electricity into heat.
- Radios turn electricity into waves that can travel great distances.

Be Safe!

Get this! Your whole body needs electricity in tiny amounts to make it work. And when your body encounters large amounts of electricity, it is very dangerous. The amount of electricity flowing in a lamp is enough to seriously hurt you!

It is now time for you to complete your first learning activity.

The purpose of this learning activity (along with all the other learning activities in the course) is to help you prepare to complete your assignments and write your final exam. **You will not submit any of your learning activities to the Distance Learning Unit for assessment.**

For some learning activities, there are no correct or incorrect answers. For that reason, you will not find an answer key for every learning activity.

Learning Activity 1.1

Electricity

Check your answers in the Learning Activity Answer Keys found at the end of this module.

1. List three items in your home that you need to plug in.
2. List five items in your home that use electricity, but you don't need to plug in.

How to Measure a Battery

The first thing you need to do is get out your digital multimeter (DMM) from your electronics tool kit.

In this section, you will be measuring your 9-volt battery and watching a video presentation on how to use the multimeter.

Caution: You will be working with your digital multimeter to test your battery. It is very important that you follow the instructions carefully every time you use the meter or any other equipment in this course. If you're ever not sure about something, ask your learning partner or tutor/marker.

Using Your Multimeter

One of the most commonly used tools in electronics is the **digital multimeter** or DMM. A DMM allows you to measure and compare electronic output values. Most DMMs will measure voltage, amperes, continuity, and resistance. These four measurement terms will be discussed in detail as you work through the course. Just remember that your DMM is a fairly sensitive measuring tool. You have to make sure to take good care of it and use it properly if you want it to last a long time.

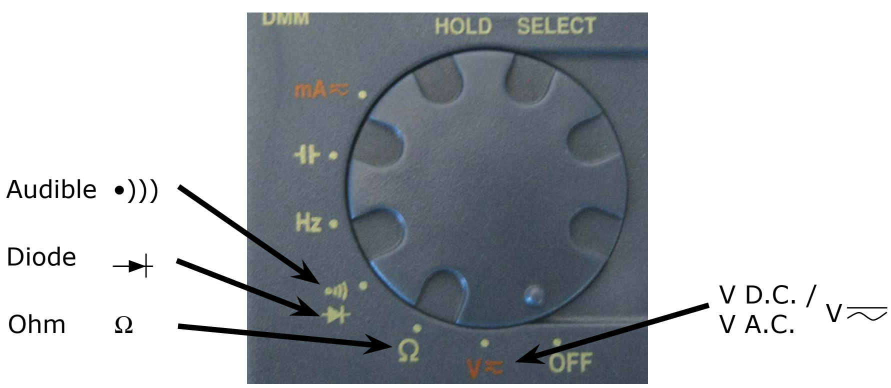
The meter in your tool kit should look similar to the one in the course pictures. From time to time, some of the settings on the meters may change position on the dial. When using your meter, always make sure you find and select the correct function symbol for the task you are performing. The symbols are the same, but their placement on the meter may vary.

Without the DMM measuring tool, it would be nearly impossible to work with electricity and electronics. It is now time to view the Grade 9/10 Electronics video found in the learning management system (LMS) or on DVD. Watch the section on the digital multimeter. After you have watched the video, come back to this page and continue on from here.

To measure battery voltage, set your DMM to the feature or function known as voltage direct current or VDC. It is important to learn about this function because your 9-volt battery needs to be tested to see if it has enough electrical energy to run your projects and experiments.

The correct setting on the multimeter dial is shown in the picture on the left. It is important to know the purpose of each setting. A white dot on a multimeter dial indicates the correct position for the selection knob. Look for the white dot on the multimeter. If you were to choose the wrong function, you could damage the DMM.

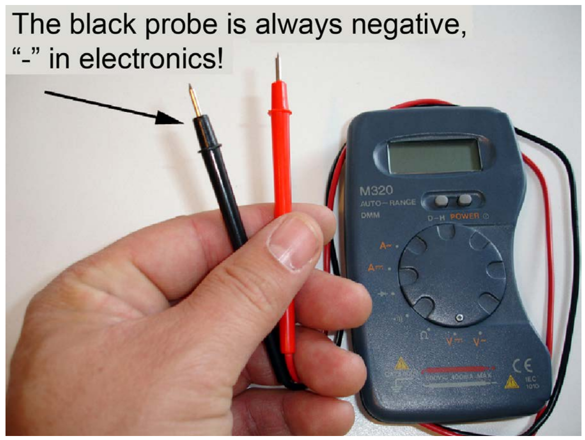
All meters are different but they have the same symbols. There are five symbols that you will be referring to and they are on all meters regardless of the make and model



Testing Your 9-Volt Battery

The negative and positive posts of the battery are clearly indicated on the battery itself. This should help you to be sure which test lead from the meter goes on which post of the battery.

It is safe to say that when using the meter the black probe is always negative and the red probe is positive. Some components, like the resistor, do not have a negative and positive side. But when measuring things that do, like your battery, you have to be sure to place the correct post on the correct pole.



Now, if you haven't already done so, turn the meter on by pressing the power button. The meter should turn on and the small screen should have a bunch of zeros on it.

Next, take the battery and find the negative and positive posts, as indicated on the side of the battery.

Place the meter selection dial to read *voltage direct current* or VDC.

Take the two test probes and place the black one on the negative post of the battery and the red one on the positive post. Watch the display screen for your reading.

Learning Activity 1.2

Reading Your Micrometer

Write down the value that the screen indicates in the space below.

1. I read the battery with my DMM and the meter indicated the battery has _______________ volts DC.

Check your answer in the Learning Activity Answer Keys found at the end of this module.

Congratulations! You have successfully measured your battery's voltage level. Now, you can turn the meter off by pressing the power button one more time.

Troubleshooting

If your DMM won't turn on, there is a possibility that the battery inside the meter is dead. Ask an adult to help you change the battery. The worst case is that you misused the meter. Once a DMM is damaged, you only have one option—purchase a new one. It is too expensive to repair a DMM.

Make sure you double- and triple-check the Function dial before you test anything.

Storing Your Meter

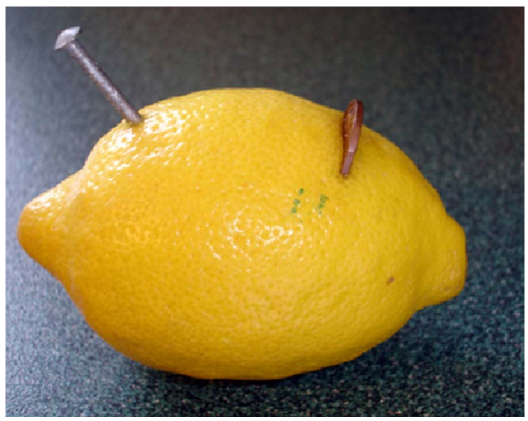
Whenever you are finished with your meter, it is a good idea to wrap the wires around the meter and snap the probes back into the side. This way your meter is safe and stored properly for the next time you need to use it.

Cool Electronics

Now that you have learned about electricity, how to measure it, and the many things that it can do, let's see if we can make some electricity on our own. Here's an experiment you can try. It may be a good idea to have your learning partner assist you in this experiment.

The Lemon Battery

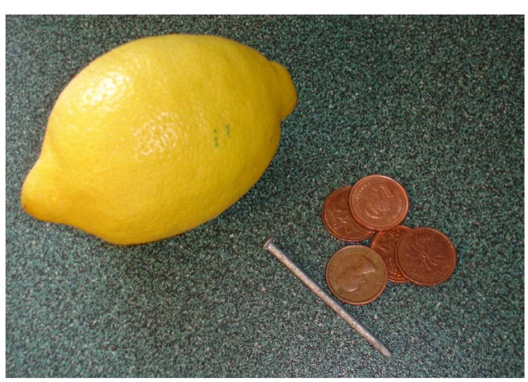
You may have already heard of this experiment, but successfully creating one of these devices is not always easy.



Batteries are made from two different metals and an acidic solution. Copper and zinc work well as the two metals, and the citric acid of a lemon will provide the acidic solution. (This lemon battery will not be able to run most light bulbs.)

Here is a list of things that you will need to do this experiment.

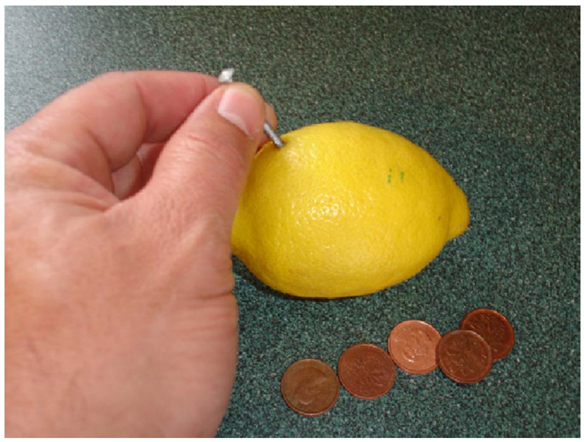
- **A lemon:** A fresh, juicy lemon works best.
- **A nail:** Galvanized nails are coated in zinc. Use a 2-inch galvanized nail (available from a hardware store).
- **A penny:** Any copper coin will work. (Canadian pennies from 1960–2001 should all work.)



Let’s create the battery:

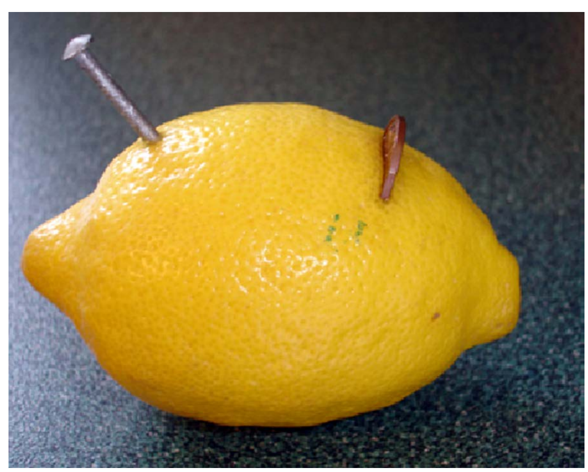
- Push a galvanized nail into one side of the lemon. (The nail and penny cannot touch.)
- Put a penny into a cut on the opposite end of the lemon.

This is a single cell of a battery. The zinc nail and the copper penny are called the **electrodes**. The lemon juice is called the **electrolyte**. All batteries have a “+” and “–” terminal. You can create a battery anytime you have two dissimilar metals and an electrolyte.



Electric current is the flow of **electrons**. **Conductors** allow electrons to flow through them. Most metals (copper, iron) are good conductors of electricity. Electrons will flow from the “–” (negative) electrode of a battery, through a conductor, towards the “+” (positive) electrode of a battery. **Volts** (voltage) is the measure of force moving the electrons or making them want to move. (High voltage is dangerous, but in this experiment the voltage is low.) We will go into exactly what electricity is and how it flows in greater detail in Module 2.

Connect the **multimeter** to our lemon battery. Put the meter selection knob to the Volts DC setting. The meter will tell us how many volts are being generated. Note the amount of voltage shown on the meter for use in Learning Activity 1.3. Unfortunately this battery will not produce enough **current** (flowing electrons) to light a bulb.

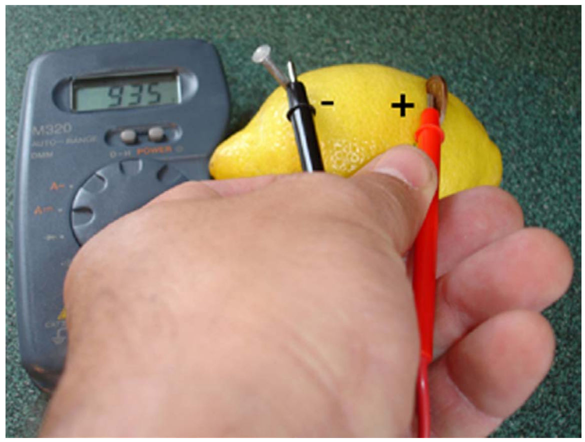


Learning Activity 1.3

Testing Volts

Record your results below.

1. The voltage that my lemon battery produced was ________ volts DC.



You might want to try using a different fruit or even a potato and see what kind of voltage you can get, if any. It goes without saying that once you put the nail and penny into the lemon, or any other fruit or vegetable, do not eat it! You will have to dispose of it.

(Optional activity)

2. I also tried using a ____________________ as a battery and the Volts DC on the meter read ____________________ .

Check your answers in the Learning Activity Answer Keys found at the end of this module.

Improving Your Battery

The quality of the copper and zinc can be a problem for a battery like this. Pennies, in particular, are rarely made of pure copper.

If you can, try substituting a piece of copper wire (common house wire) for the penny. Experiment with different lengths and configurations of electrodes. Other sources of zinc and copper may be found in the plumbing supply department of a hardware store.

It is now time for you to complete **Assignment 1.1: Electricity: Let's Get Started** on the following pages. This assignment (along with all other assignments) is worth marks and you will either mail or electronically submit it to the Distance Learning Unit when you have completed Module 1.

Assignment 1.1

Electricity: Let's Get Started *(17 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 1.

1. Give three examples of household items that you have to plug in to make work. *(1.5 marks)*

   a) ______________________________

   b) ______________________________

   c) ______________________________

2. Give three examples of household items that need batteries to make them work. *(1.5 marks)*

   a) ______________________________

   b) ______________________________

   c) ______________________________

3. What is nature's example of an awesome display of electricity? *(0.5 mark)*

   ____

4. What is another example of nature's display of electricity, but on a much smaller scale? *(0.5 mark)*

   ____

5. What do we call a device that turns sunlight into electricity? *(0.5 mark)*

   ____

(continued)

6. Provide an example for each of the nine uses of electricity given below. *(0.5 mark for each example, for a total of 4.5 marks)*

   a) electricity into motion

   Example: ______________________________

   b) electricity into light

   Example: ______________________________

   c) electricity into information

   Example: ______________________________

   d) electricity into communication

   Example: ______________________________

   e) electricity into moving pictures

   Example: ______________________________

   f) electricity into sound

   Example: ______________________________

   g) electricity into a weapon

   Example: ______________________________

   h) electricity into heat

   Example: ______________________________

   i) electricity into radio waves

   Example: ______________________________

(continued)

Assignment 1.1: Electricity: Let's Get Started (continued)

Measuring Your Battery

7. What does DMM stand for? *(0.5 mark)*

 ____

8. What are four common things that DMMs measure? *(2 marks)*

 ____

 ____

 ____

 ____

 Draw the symbol on your meter that indicates you are going to measure Voltage DC. *(0.5 mark)*

 ____

9. The two probes on your meter are red and black. What does each probe's colour tell you about that particular probe, and what does it mean? *(1 mark)*

 ____

 ____

10. What three things do you need to make up a battery? *(1.5 marks)*

 ____

 ____

 ____

(continued)

Assignment 1.1: Electricity: Let's Get Started (continued)

11. Our lemon battery had a zinc-coated nail and a penny or copper wire. These two objects were the ____________________ and the lemon juice was the ____________________ . *(1 mark)*

12. Electrons always flow from the ____________________ electrode of a battery to the ____________________ electrode. *(1 mark)*

13. Explain what is meant by "voltage." *(0.5 mark)*

    ____

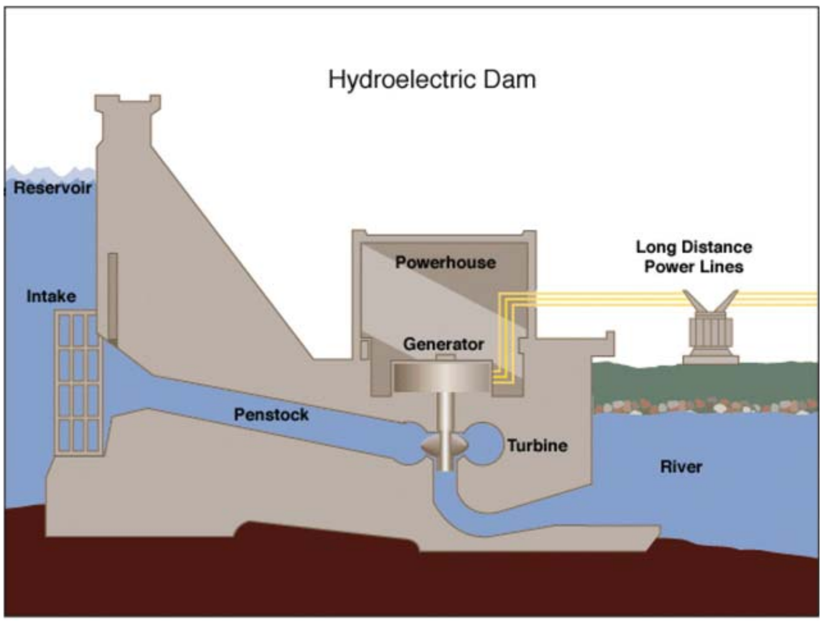
    ____

    ____

How Does Water Produce Electricity?

Hydroelectricity requires large machines, called generators, to produce electricity. These generators have a huge **electromagnet** and **coils** of electric wires inside of them. They also contain enormous **rotors that rotate with the force of water and power the generator**. These rotors can weigh as much as eight railway cars. It takes a lot of energy to rotate something that size, but our province, with its abundant supply of water, makes the solution simple.

Hydroelectricity is electricity generated using water power. A hydroelectric generating station uses the force and flow of a river as its energy source. The current that pushes a log down the river is the same flow of water that turns a generator's rotor.



The **turbine**, which is a giant propeller, is the heart of the generator. It is attached to the rotor by a huge shaft, and the turbine converts the physical energy of the water into the mechanical energy that drives the **generator**.

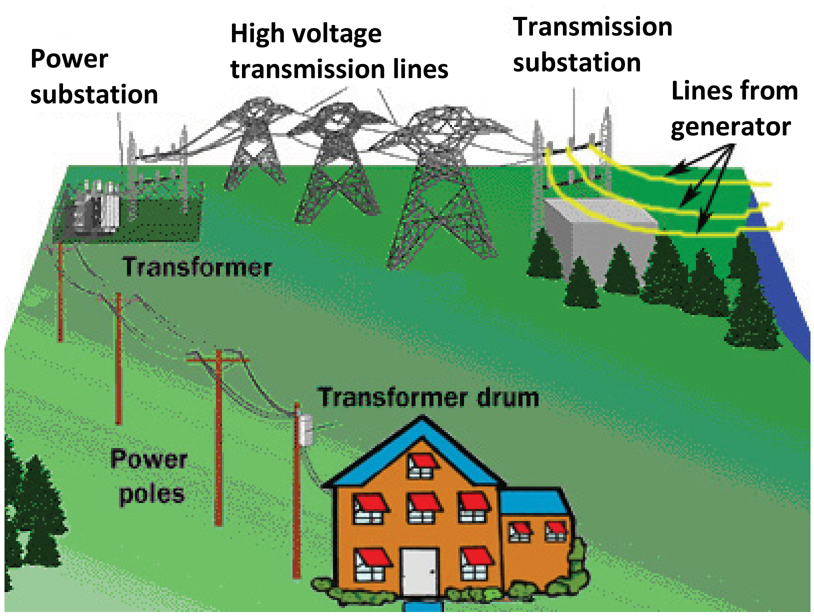
Water flows in through the intake, enters into the generator, and flows past the turbine. The spiral shape gives the incoming water a spiral movement, which pushes the blades of the turbine. As the turbine is turned, the rotor also spins, generating electricity. The **potential energy** of the flow of the water is converted into the **mechanical energy** of a generator, which produces electric energy. Just one generating station can produce 130 million watts or 133 megawatts of electricity or more! That's enough electricity to supply power to over 12,000 homes.

How Does Electricity Get To My House?

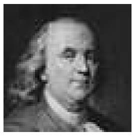
When you turn on your computer or plug your guitar amplifier into a wall socket, there is electricity waiting to flow into them. But have you ever wondered how that electricity gets from the generator in a hydroelectric station to the socket in your wall?

Hydro systems use an extensive grid of wires of varying sizes that conduct electricity throughout your area and over long distances. But that is only part of the answer.

In Manitoba, 80 percent of our electricity is produced by hydroelectric generating stations on the Nelson River in northern Manitoba. Manitoba Hydro transmits the electricity it generates to southern Manitoba (about 900 km), where most people live and work.



Manitoba uses high-voltage direct current (HVDC) technology to transmit electricity from where it is generated to where it is needed. **Direct current (DC)** is electric current that flows in *one direction only*. It is the type of power produced by batteries used in MP3 players, flashlights, and cars. The electricity in your home is **alternating current (AC)**, which is an electric current that *reverses direction* approximately 60 times a second. The advantage of DC is that there is less power loss when transmitting over great distances. In other words, DC is a cheaper way to transport electricity.



Interesting Fact

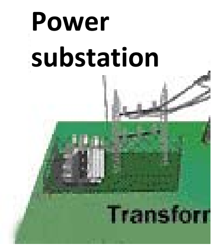
Electricity was not invented.

Electricity occurs naturally in our world and in nature. People have only invented ways to measure it and to control it for our use.

Ben Franklin started working with electricity in the 1740s. He believed that lightning was a flow of electricity taking place in nature. He performed his famous kite experiment in 1752, which proved that electricity and lightning were the same thing.

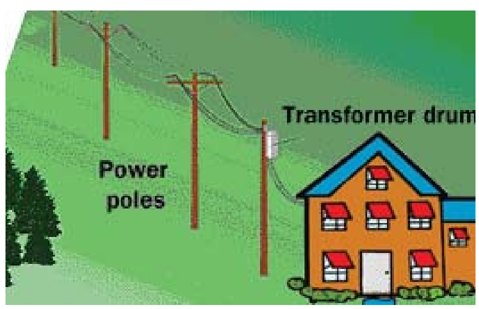
As generators spin, they produce AC electricity that has about 25 thousand volts or 25 KV of force. The electricity generated by these hydroelectric stations on the river are converted to DC, and transmitted at even higher voltages.

High-voltage lines carry the electricity to substations, which are located all over the province. These substations contain equipment that is used to transform voltages to lower levels. They can also turn the current in a line "on" or "off."



From the substations, the electricity runs through the lines, or underground cables, to transformers located near to where it will be used. Usually, these transformers are located near the tops of hydro poles or at ground level when the cable is in the ground. These transformers complete the reduction of voltage.

The electricity then travels through a wire into your home, going first to the hydro meter and then to the main switch in the electrical panel. Finally, all the wiring in your house brings it to the electrical outlets for you to use.



That is how all that electricity makes its way to our homes and businesses.

Reading Your Hydro Meter

A hydro meter is a device that records or measures how much electricity you use.

There are a few different styles of meters that measure how much electricity you use, but they all do the same thing. One of the most common looks like the meter in Figure 1.

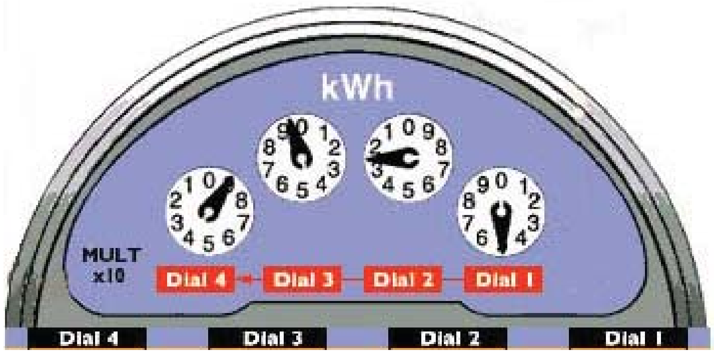
In Figure 2, you can see a digital meter that has no dials on it and provides a digital read-out instead. As you can see, the analog (non-digital) meter has a lot of dials. Unlike a clock that always has the hands going in the same direction, a hydro meter's dials go in different directions. Notice in the diagram below that the first dial (dial 4) is on the left and that its hand spins counter-clockwise. You will notice that the numbers on that dial are also going in the opposite direction than a clock's numbers (counter-clockwise).

Figure 1

Figure 2

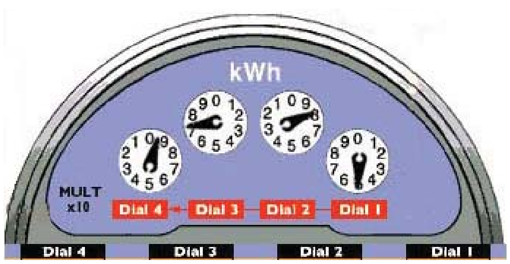
Each dial spins in a different direction, alternating direction as you go from one dial to the next. When reading the numbers, you always read the meter dial in the direction that it's going, and take the smaller number in the reading. In other words, if the meter hasn't quite reached the next number, and is between two numbers, you read the number that it just past.

Check out the example below.



Notice the direction of the numbers on the dials on this meter. The direction of the numbers indicates the direction that the hands move for each dial.
In this example, the reading would be 9925. Remember, you always have to look at the direction the needle is going, and then if the dial isn't exactly on a number, you read the number behind it.

Let's try a few more!



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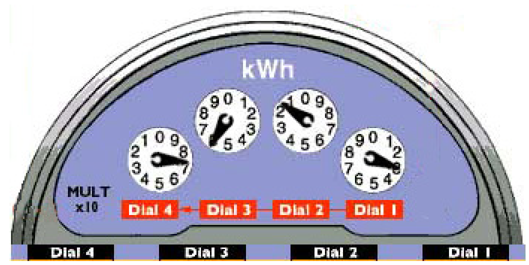

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Learning Activity 1.4

Hydro Meters

1. The machine that hydro stations use to create electricity is a ____________________ .

2. Electricity that is created using water power is called ____________________ .

3. The physical energy of the flow of water is converted to ____________________ energy that drives the generator.

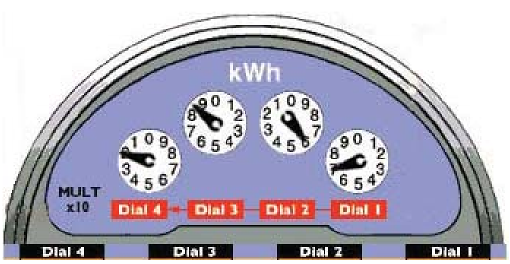
4. What percentage of Manitoba's electricity is produced by hydroelectricity?

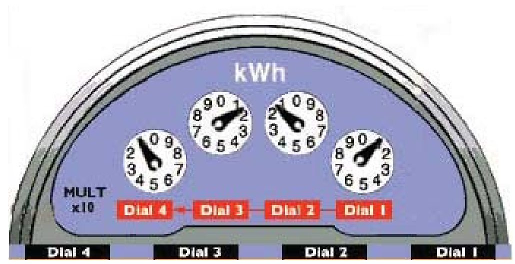
5. What is DC, or direct current? (Describe.)

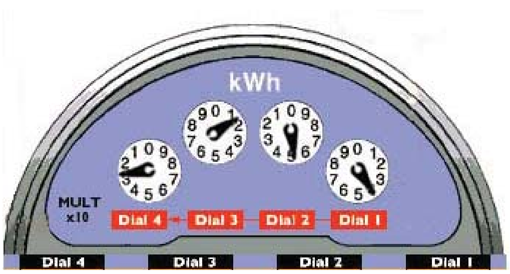
6. What is AC, or alternating current? (Describe.)

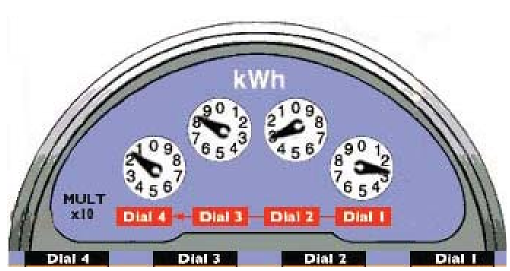
7. What does a hydro meter do?

8. Look at the meters below and write down what the reading is for each one underneath the meter.









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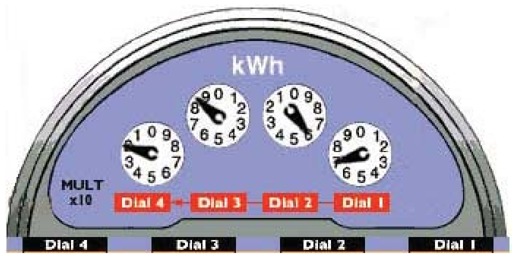
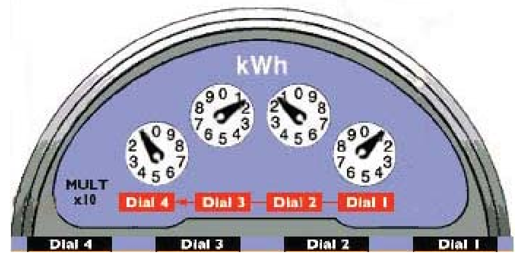
Learning Activity 1.4: Hydro Meters (continued)





Check your answers in the Learning Activity Answer Keys found at the end of this module.

The Hazards of Working with Electricity

It is not always easy to tell whether electricity is dangerous, so you must never take a chance when working with it.

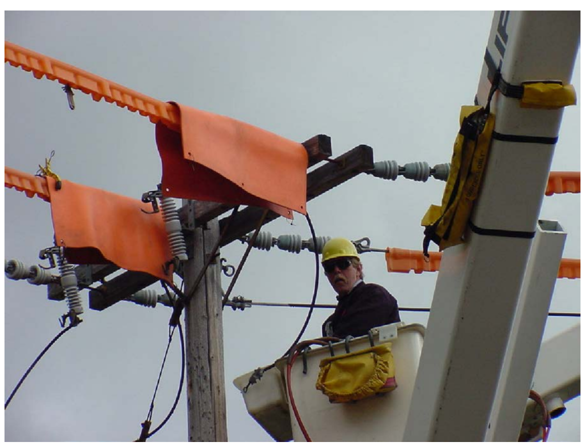
Electrical shocks can cause varying degrees of muscle spasms, weakness, shallow breathing, rapid pulse, severe burns, unconsciousness, or even death.

In a shock incident, the path that electric current takes through your body can get very hot. Burns may occur all along that path, including the places on the skin where the current enters and leaves the body.

It's not only giant power lines that can kill or injure you if you contact them. You can also be killed by a shock from an appliance or power cord in your home!

Have you seen birds sit on power lines? Have you wondered why they don't get electric shocks? Electricity is always looking for a way to get to the ground, but the birds on the power lines are not touching the ground. The pole is touching the ground, but it's a dry piece of wood so the current does not go through it.

If you touched a power line while you were in contact with the ground, electricity would travel through you to the ground. If you had a kite or balloon that got tangled in a power line and you touched the string, there's a good chance electricity would travel down the string and into your body on its way to the ground. This would mean a serious shock!



Why is it that people who work up on power lines don't get shocked? Workers are trained to work with electricity. They wear special insulated boots, hard hats, and gloves, and use insulated tools.

Home and Appliance Safety

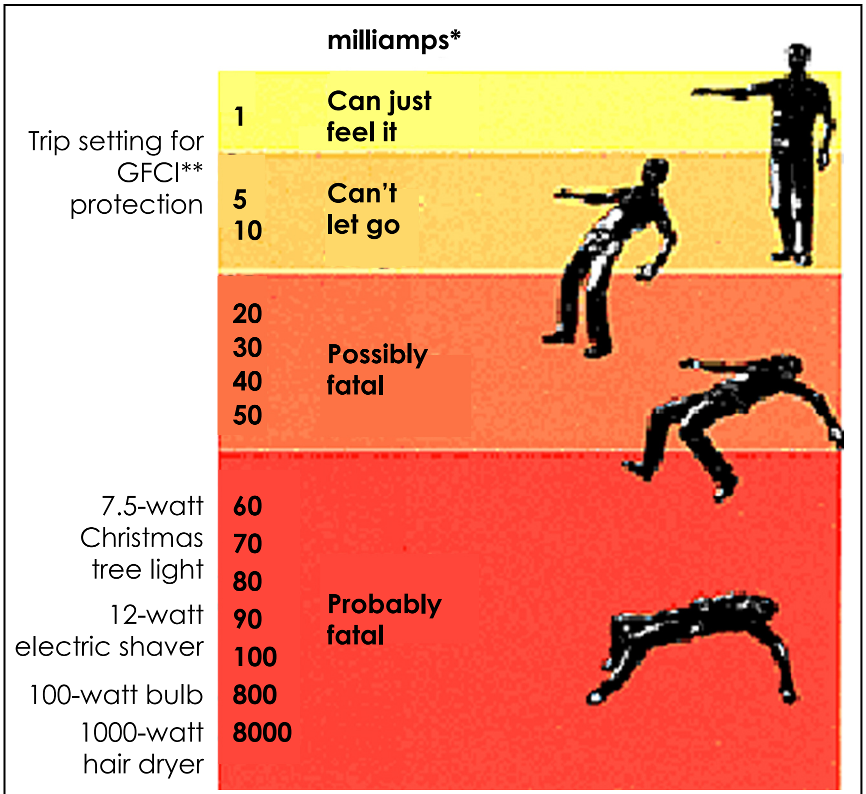
Cautions:

Remember the most important rule for appliances—electricity and water don't mix! Keep appliances, especially hair dryers, away from bathtubs, puddles, and sinks, and never use an appliance when your hands are wet.

Wet skin increases the risk of shock, so unplug appliances before cleaning. Some appliances are capable of shocking you even when they are turned off.

1. Never put metal objects in live appliances or in outlets.
2. Don't overload outlets. Doing so creates a fire hazard. Use only one plug per outlet.
3. When you use a plug with three prongs, the third prong connects inside the outlet with a "ground wire," which is connected to the breaker panel. In case of a short circuit, electricity would flow through the grounding system instead of through you. The ground wire is the path of least resistance.
4. A short or an overload will trip a circuit breaker. Before you switch the breaker back on, find out why the breaker shut off in the first place, and fix the problem.
5. Turn off lights and appliances when not in use. This is also a good energy-saving tip!
6. Practise extension cord safety. Extension cords are for temporary indoor use. Keep them away from moisture, heat, and metal pipes. Never run an extension cord under a rug.

The chart on the following page illustrates the effects that electricity can have on the body. At a certain level, the result may be fatal.



* A milliamp is 1/1000th of an ampere, a measure of electrical current.

** A GFCI is a Ground Fault Circuit Interrupter, a device which protects against serious shock.

Let's do a quick analysis of the safety around your home. Place a checkmark beside "yes" or "no" to help you perform your safety analysis.

1. Are there electrical devices located immediately beside a sink or tap?

   Yes ___ No ___ If yes, can you find a spot to relocate them so it's safe?

2. Are there any extension cords running under a carpet or over a metal pole?

   Yes ___ No ___ If yes, can you find a spot to relocate them so it's safe?

3. If you look around, are there any electrical outlets that are overloaded?

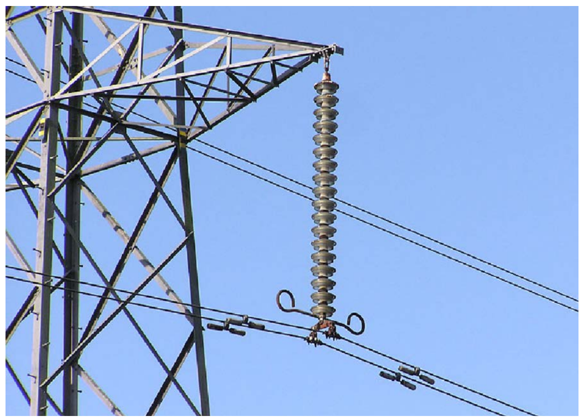
   Yes ___ No ___ If yes, can you find a way to use them so it's safe?

4. Are there any plug-in devices that have a crack, cut, or wires exposed in the cord?

   Yes ___ No ___ If yes, do not touch! But tell someone who can help make it safe.

Outdoor Safety

- Never climb power poles or transmission towers or play around them. Don't even touch them.
- Ceramic insulators keep high voltage in overhead wires away from the supporting poles and towers. Never let anyone damage or throw stones at insulators.
- Transformers in substations and on poles change high voltage to levels that can be used in homes or businesses. Keep away from transformers!



Electrical Fires

- If you smell smoke or see a flame, unplug appliances involved or turn off power at the main control panel. The smell of an electrical fire is unmistakable.
- If the fire is very small, put it out with a multipurpose fire extinguisher, class "C" electrical fire extinguisher, or baking soda. **Never use water!** (Water is a conductor.)
- If you have any doubt concerning your ability to put the fire out, leave immediately from the premises and take everyone with you.
- Call the fire department from somewhere other than the location of the fire. Be sure to give your name and the address and tell them it's an electrical fire.

If Someone Is Shocked

- Don't touch anyone in contact with a power source—you could be killed or seriously injured! First, turn off the power at the control panel, and then call for help. Tell them it's an electrical injury.
- If someone is not breathing because they were shocked, apply first aid to the best of your ability and/or your training level. Then, cover the victim with a blanket, keep his or her head low, and get medical attention. Remember to only do this after you are sure the victim is no longer in contact with any electrical current; otherwise, you will be a victim too!

It is now time for you to complete Assignment 1.2, which you will either mail or electronically submit to the Distance Learning Unit when you have completed Module 1.

Assignment 1.2

The Hazards of Working with Electricity *(9 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 1.

1. List six things that an electric shock can cause our bodies to do. *(0.5 mark each, for a total of 3 marks)*

   a) ______________________________

   b) ______________________________

   c) ______________________________

   d) ______________________________

   e) ______________________________

   f) ______________________________

2. Explain why birds sitting on power lines do not receive an electric shock. *(1 mark)*

   ____

   ____

3. What would happen to you if you touched a power line while in contact with the ground? *(1 mark)*

   ____

   ____

(continued)

Assignment 1.2: The Hazards of Working with Electricity (continued)

4. What may be the most important rule when working with home appliances? *(1 mark)*

    ____

    ____

5. If you encounter a small electrical fire, what is the one thing you should never use to try and put it out? Why? *(2 marks)*

    ____

    ____

6. If someone has been shocked or if you even suspect someone has been shocked, what should you do before you call for help? *(1 mark)*

    ____

    ____

Lesson 3: A Brief History of Electronics

Ancient History

People have always been fascinated by electricity. In ancient Greece, Thales, one of the first Greek philosophers (624–546 BCE), observed that an electric charge could be generated by rubbing amber (a type of stone) with a cloth. The Greek word for amber electron. Even though electricity is so prevalent in our modern lives, it's hard to know when people first started to tinker with electricity.

The Egyptian Lamp

In Hathor Temple in Dendera, Egypt, five stone reliefs were found in an underground cavern, two of which contained a pair of "lights." These two reliefs are decorated with human figures standing next to bulb-like objects that resemble oversized light bulbs. There appears to be a "snake" or wavy line inside the bulb, which exits from the smaller end of the bulb through what could be referred to as a "socket." This "snake" then travels to a small box with a kneeling figure on top, and this box could be interpreted as a modern-day high-voltage insulator. The entire arrangement resembles an electric lamp.

The Baghdad Battery

In the holdings of the National Museum of Iraq, there are several clay jars that have been attributed to an ancient Asian culture that ruled most of the Middle East from 247 BCE to 228 CE. The jar has been dated to approximately 200 BCE. So how is it that a 2000-year-old clay jar can be called a battery? Many scientists who have studied it are convinced that it is. It is small—only 5½ inches high by 3 inches across. The opening was sealed with a plug, which held in place a copper sheet that was rolled into a tube. A narrow metal rod was stuck through the plug and hung down into the centre of the copper tube, not touching any part of the tube. If you were to fill the jar with an acidic liquid, such as vinegar (like with our lemon battery), you would have a battery capable of generating a small current. The acidic liquid permits the flow of electrons from the copper tube to the metal rod, or an electric flow when the two metal terminals are connected.

This electrochemical reaction is no different than your lemon battery experiment. These ancient batteries would have generated between 1.5 and 2 volts. But what would batteries have been used for 2000 years ago? Well, it's possible that several batteries could have been linked together to generate a higher voltage. More experiments with several Baghdad-type batteries have shown this to be possible. The little jar in Baghdad suggests that the battery has been around for a long, long time.

Modern Electronics

Timeline:

A brief, modern-day timeline of electrical experiments and achievements is listed below.

1650 The German physicist **Otto von Guericke** experimented with generating electricity in 1650.

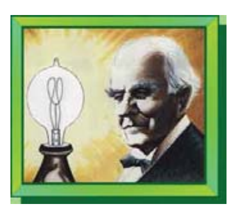
1729 The English physicist **Stephen Gray** discovered electrical conductivity in 1729.

1752 **Benjamin Franklin** came up with the idea of positive and negative charge. His famous kite experiments, identifying lightning as a form of electrical discharge, took place in 1752.

1800 **Alessandro Volta** invented an electric battery, which was the first source of DC current.

1831 **Michael Faraday** introduced magnetic induction after indirectly observing magnetic and electrical lines of force, which are now used in electric motors and transformers.

1879 **Thomas Alva Edison** invented the light bulb.



1881 **Louis Latimer** and fellow inventor **Joseph V. Nichols** patented their invention of the first incandescent light bulb with carbon filament. Prior to this breakthrough, filaments had been made from paper.

1885 In the mid-1880s, **George Westinghouse** began exploring the technology of alternating currents.

1888 **Heinrich Hertz** discovered and measured the various waves, including radio waves, which were predicted earlier by Faraday and Maxwell.

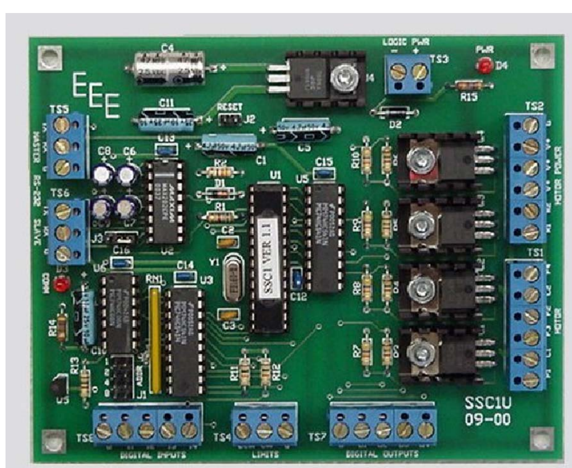
1888 **Nikola Tesla** invented the first practicable AC motor.

1902 Although the flashlight is a relatively common device today, it was not invented until the late 19th century because it first required the inventions of the electric battery and electric light bulb. **Conrad Hubert** received a US patent in 1903 for a flashlight with an on/off switch in the now familiar cylindrical casing containing a lamp and batteries.

1906 An American inventor and physicist, **Lee De Forest**, made the vacuum tube triode, or "audion" as he called it. The triode was a three-terminal device that allowed him to make an amplifier for audio signals, making AM radio possible.

1947 Three American scientists named **William Shockley**, **John Bardeen**, and **Walter Brattain** at Bell Labs announced the creation of the first transistor. The name *transistor* came from combining the words *transfer* and *resistor*—a transfer resistor—a transistor.

1958–9 **Jack Kilby** at Texas Instruments and Robert Noyce at Fairchild Camera came up with a solution to the problems involved with having large numbers of components, and the **integrated circuit** was developed. Instead of making transistors one by one, several transistors could be made at the same time on the same piece of semiconductor.



This is a fairly brief timeline of the history of electricity and some of the milestones that have taken place. Although there haven't been many revolutionary advancements in recent years, things are still changing. Most of the changes are in the form of what we already know, but involve making devices smaller and processors faster. We can't seem to get enough of those cool little gadgets that make our lives more interesting and entertain us, and also help us to communicate with one another all over the globe.

Learning Activity 1.5

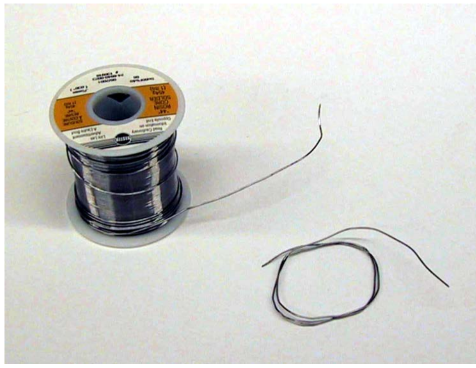
A Brief History of Electronics

1. In ancient Greece, Thales observed electric charge by doing this.
2. Approximately when do historians believe that ancient people first used a device that was similar to our lemon battery to create electricity?
3. Create a timeline of electrical experiments and achievements, including the appropriate year and the person or persons associated with that event.

Check your answers in the Learning Activity Answer Keys found at the end of this module.

Lesson 4: How to Solder

Soldering Basics



Soldering is the process whereby you connect electronic components together using a substance called solder. Before we get into just how to do this, it should be noted that soldering irons are very hot. Let's go over a few safety precautions you should observe while using the soldering iron.

Soldering Iron Safety

- **You should always wear your safety glasses while soldering.**
- **Never touch the element or tip of the soldering iron.** They are very hot and will burn you.
- **Only plug in the soldering iron when you are actually ready to use it.**
- **Always return the soldering iron to its stand when not in use.** Never lay it down on your workbench or table, not even for a second!

- **Work in a well ventilated area.** The smoke formed as you melt solder is not good for you. Like any smoke, you should avoid breathing it by keeping your head to the side of, not above, your work. Also, gently blowing while you solder will force the smoke away from you.
- **Wash your hands after using solder.** Solder contains lead, which is a poisonous metal.

To Reduce the Risk of Burns

- Always return your soldering iron to its stand immediately after use.
- Allow joints and components a minute or so to cool down before you touch them.
- Never touch the element or tip of a soldering iron unless you are certain it is cold.

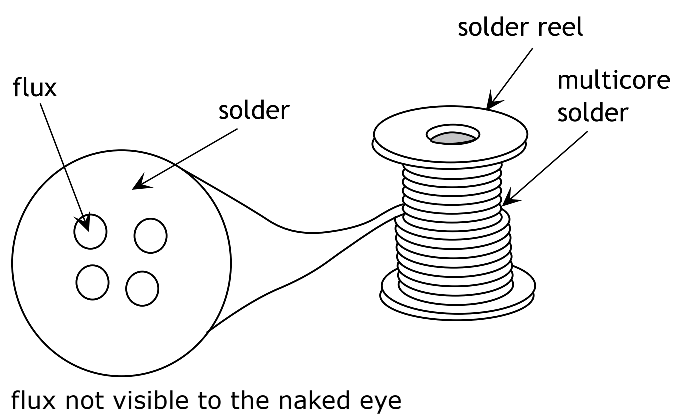
If You Do Burn Yourself

- **Immediately cool the affected area under gently running water.** Keep the burn in the cool water for at least five minutes (15 minutes recommended).
- If your burn seems bad, seek medical attention.

Soldering

Solder is an alloy (metal) that is made up of tin and lead. The solder is specifically called 60/40. The first number always represents the amount of tin in the solder. The second number is the lead quantity. The 60 represents 60 percent tin, and the 40 represents 40 percent lead.

The solder will melt around 200° C. The solder is made in a wire-style formation on a roll with a core of **flux**.

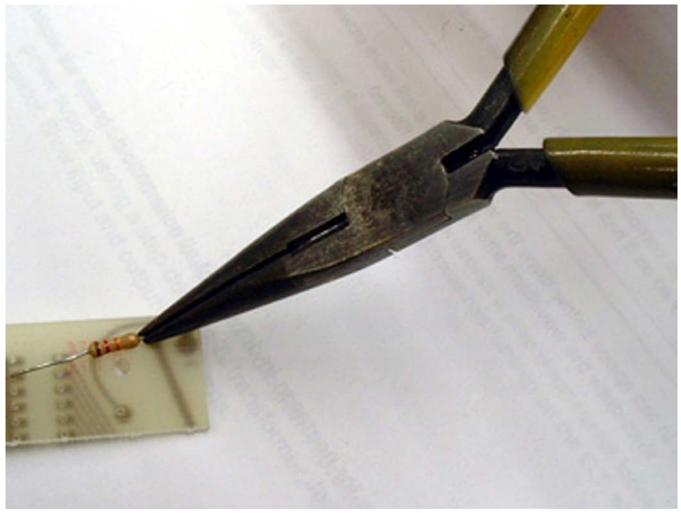


The flux is in the solder and is very important. It melts along with the solder when the solder is heated. The flux actually cleans the area where the solder is going to stick, it helps the solder flow evenly over the copper foil, and it also helps the solder stick to the copper contact area. The solder is designed to stick to copper foil and not the plastic backing of the PCB.

Using a Heat Sink

If you did not take Grade 9 Electricity/Electronics Technology, watch the video on how to use a heat sink.

Many components can be damaged by heat when soldering. If you are not an expert, it is wise to use your needle-nose pliers as a heat sink. To do this, hold the components by the lead between the joint and the component body. You can buy a special tool, but it is cheaper just to use your pliers with an elastic band around them to keep them closed.



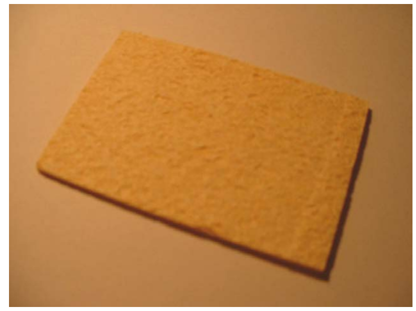
Let's Get Going!

Inventory List for Assignment 1.3

- ❒ safety glasses

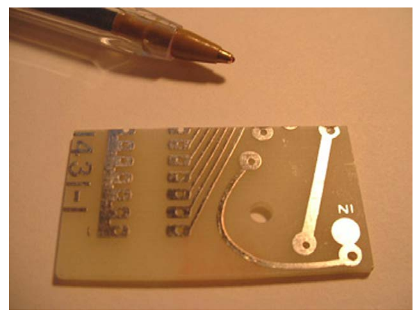
- ❒ soldering iron

❒ wet sponge
(found with soldering iron stand)



❒ solder

❒ scrap practice PC board



❒ scrap miscellaneous practice pieces

❒ soldering iron stand

❒ work table

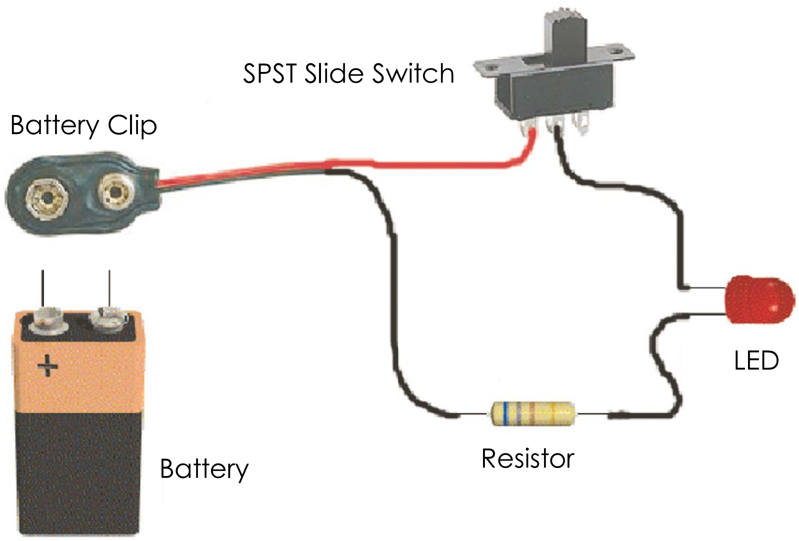
It is now time to view the Grade 9/10 Electronics video found in the learning management system (LMS) or on DVD. Watch the video on soldering techniques.

Notes

Let's Get Practical!

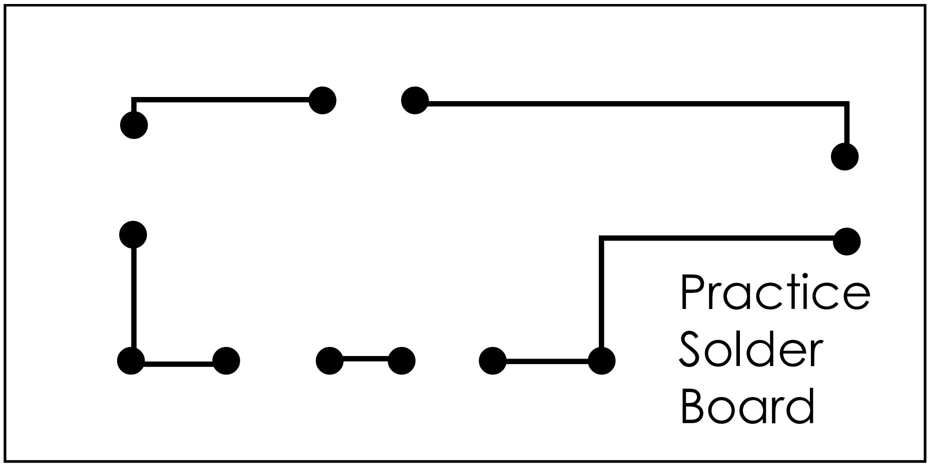
In this lesson, you are going to get out your soldering iron and some components and practise your soldering techniques so that you can build a project. It is important to master the skill of soldering before you actually build the project. The practice solder board will do just that.

Here is a diagram of the circuit that you are going to put together from the "practice circuit board" kit. It will also have some practical applications in other parts of our electronics course, so take care of it when you are done putting it together.

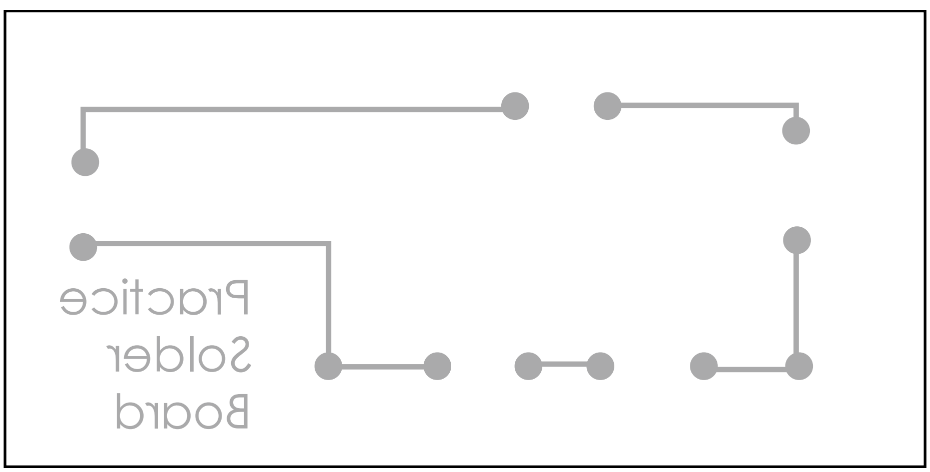


Circuit Board Diagram

Here is the printed circuit board of the Practice Soldering Kit. This diagram is of the copper side of the board. It has holes for where the components should be soldered into place.

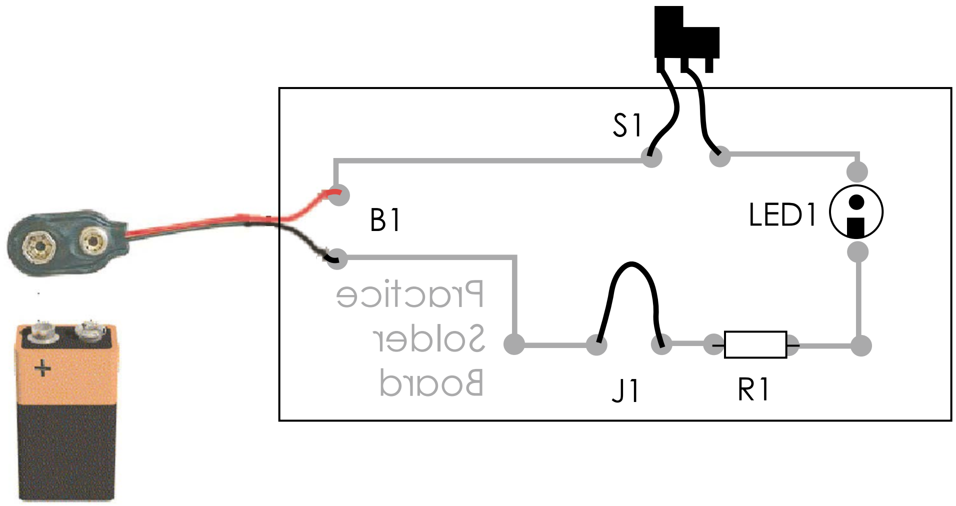


In the diagram below, notice that the writing on the circuit board is now inverted or backwards and the circuit board lines look a bit lighter. That's because we are now looking at the other side of the printed circuit board. We have flipped it over to look at the plastic side.



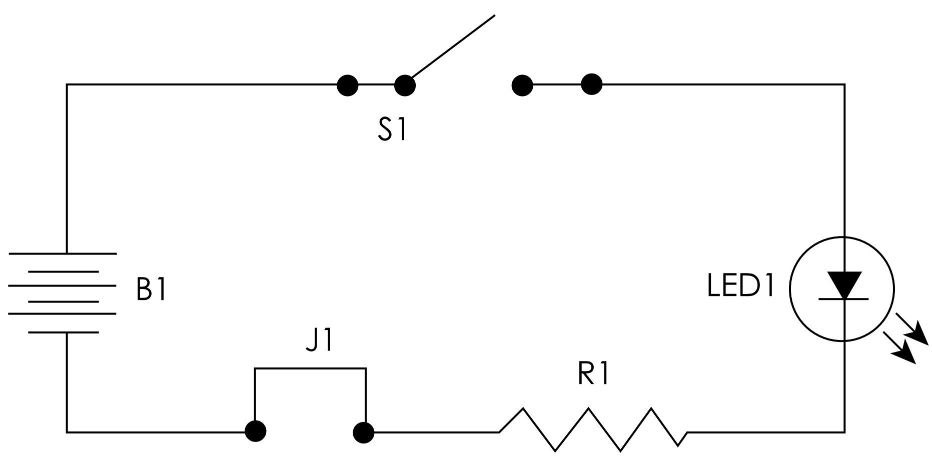
Parts Layout Diagram

This is a parts layout diagram of the practice solder circuit. Notice that in this diagram, we are no longer looking at the side of the board with the copper on it. Rather, this diagram is of the plastic side, which is the side we place the components on before we solder them. A good thing to remember when working with electronics is that solder is made from two metals: tin and lead. The leg of the component you are soldering is also made of metal, as are the copper lines on your circuit board. So when soldering, just remember that metal only sticks to metal. If you try soldering a component and it won't stick, it's probably because you are trying to solder it to the plastic side of the board.



Schematic Drawing

Finally, here is the schematic drawing of the circuit. This drawing is using the language of electronics and represents the circuit. Note again that the schematic drawing, the parts layout, and the pictorial drawing all equal the same thing.



Caution!

While working with your electronics, never connect any parts together unless instructed on how to do so in the course.

For example, connecting an LED to a battery is not only UNSAFE, but will result in your LED not working!

Never connect directly together!!

Following safe practices and procedures in this course is part of what is expected of an electronics student.

You Are Now Ready to Start Soldering

Plug in the soldering iron and let it heat up for a few minutes.

Assignment 1.3

Practice Soldering Project

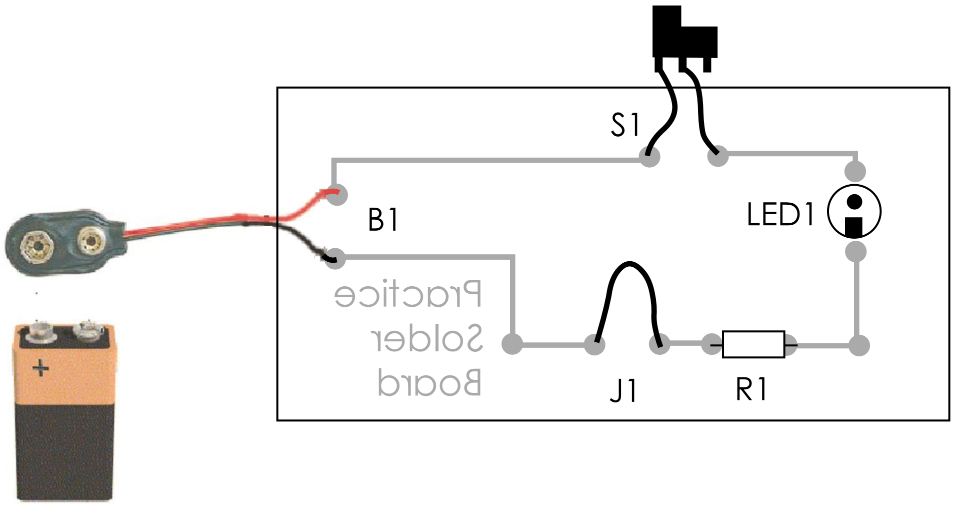
Get the components from the Tool Kit and the Practice Solder Kit and lay them out in front of you. This assignment is worth 23 marks. You will be marked on the quality of the soldering in the sample that you submit to the Distance Learning Unit. You can read about the characteristics of good soldering on page 53.

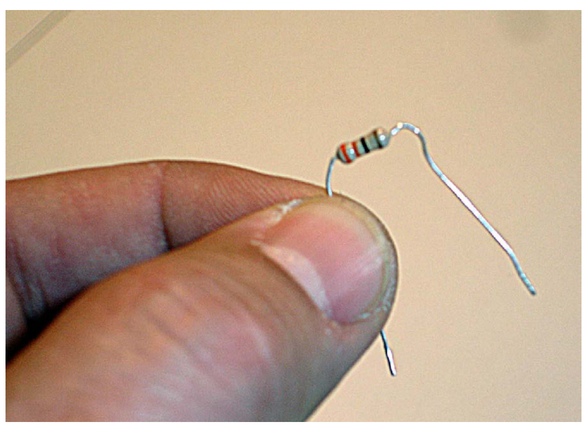
1 spool of solder
9 volt battery
330 ohm resistor
LED
SPST slide switch
Battery clip
1 printed circuit board
Soldering iron and stand
Safety glasses
Needle-nose pliers
Side cutters

(continued)

Assignment 1.3: Practice Soldering Project (continued)

Using the parts layout diagram below, find R1, which stands for *resistor 1* on the circuit board. Now find the resistor in your Practice Soldering Kit. The resistor you are looking for is a 330 ohm resistor.



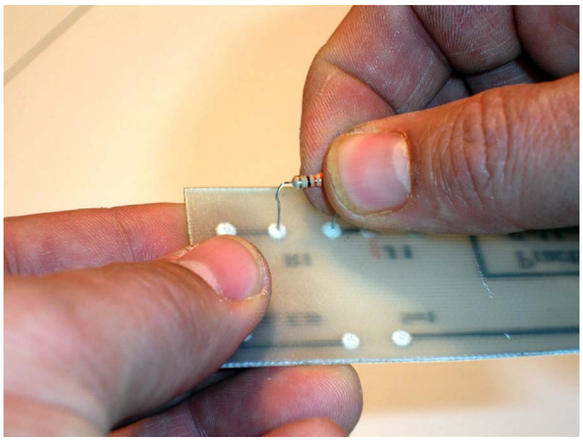


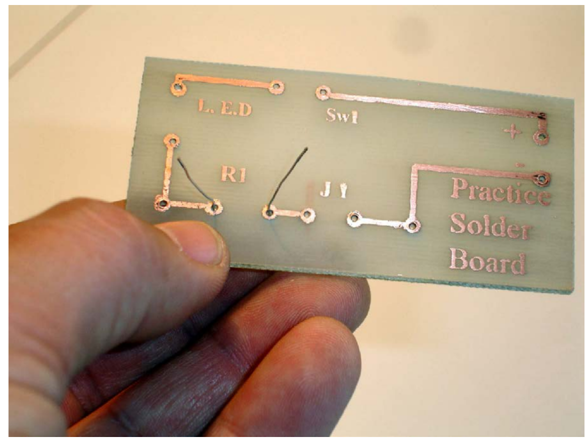
- Bend the resistor's legs on each side so that it will fit into the holes.
- Feed the resistor's legs through the pre-drilled holes on the circuit board.

(continued)

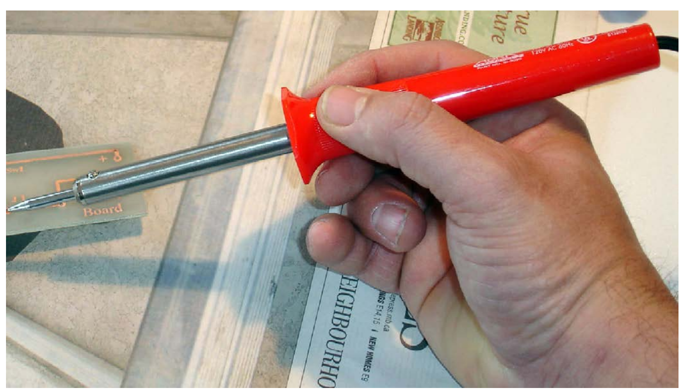
Assignment 1.3: Practice Soldering Project (continued)

Note: Make sure you feed the component legs through from the plastic side. Put a slight bend in the component legs so they do not fall out. (Remember that a resistor does not have "polarity" or a negative and positive leg, so it doesn't matter which direction you place the resistor in the holes. Just be sure it's where R1 is designated on the circuit board.)





- **Hold the soldering iron like a pen, near the base of the handle.** (Imagine you are going to write your name.)



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Assignment 1.3: Practice Soldering Project (continued)

- **Goggles on right!**

  Also, it's a good idea to rest your arm or place the side of the palm of your hand on the work surface (see picture).

  This helps steady your hand and gives you more dexterity in your arm and wrist when soldering.

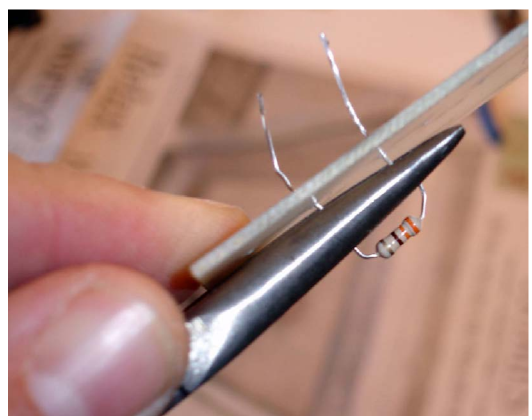
  

  Remember to never touch the hot element or tip!

- **Here's where we heat sink.**

  Hold the resistor's legs with the needle-nose pliers so the heat will not destroy it while you are soldering it. This also ensures you don't burn your fingers.

  Turn the circuit board over while holding the heat sink on the component.



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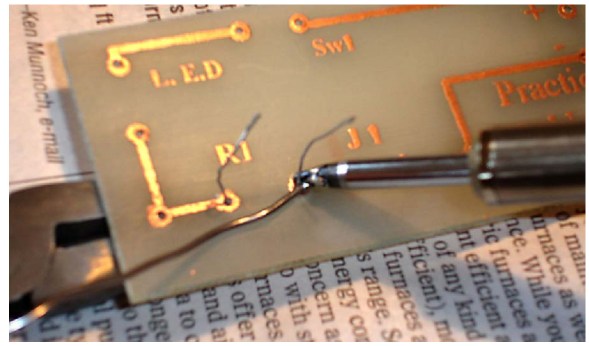
Assignment 1.3: Practice Soldering Project (continued)

- **Touch the soldering iron onto the joint to be made.**

  Make sure it touches both the component lead and the track. Hold the tip there for a few seconds to heat it up.

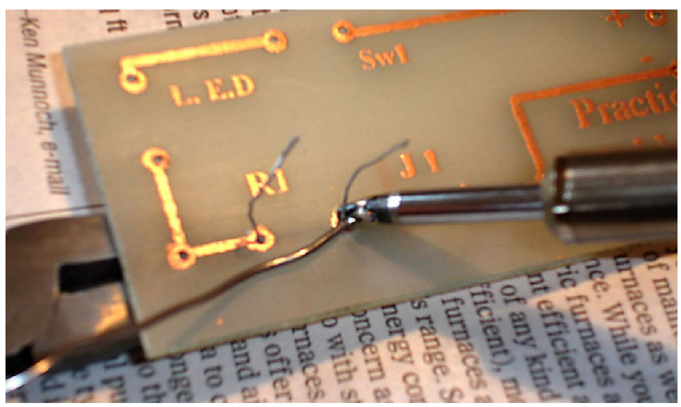


- **Feed a little solder onto the joint.**

  It should flow smoothly onto the lead and track. Apply the solder to the joint, not the iron.

- **Remove the solder, then the iron, while keeping the joint still.**

  Allow the joint a few seconds to cool before you move the circuit board.



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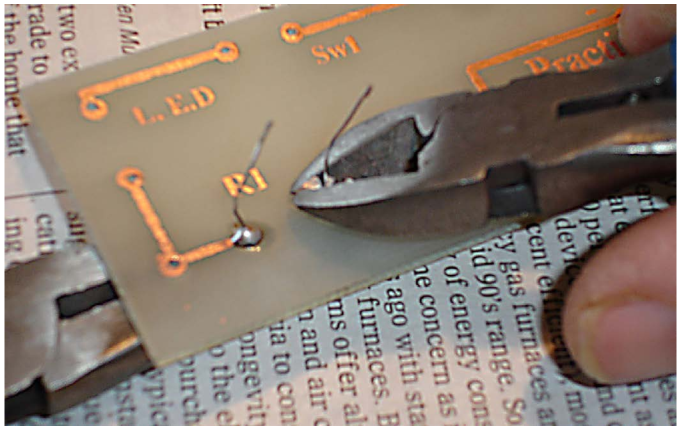
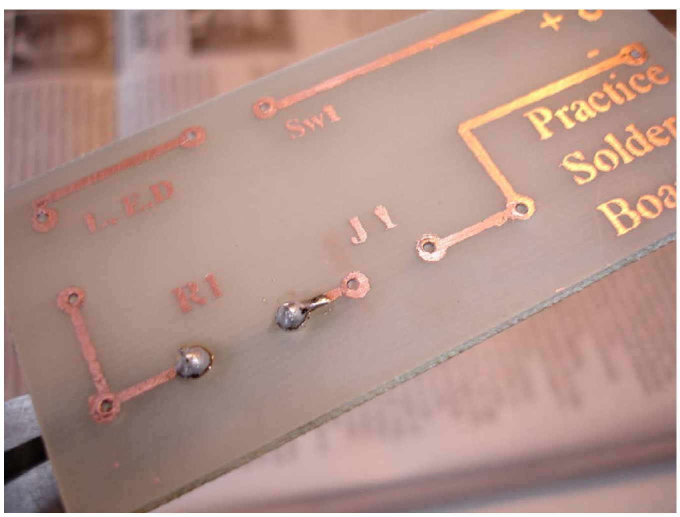
Assignment 1.3: Practice Soldering Project (continued)

- **Cut the ends of the component legs as short as possible with the side cutters**



- **Inspect the joint closely.**

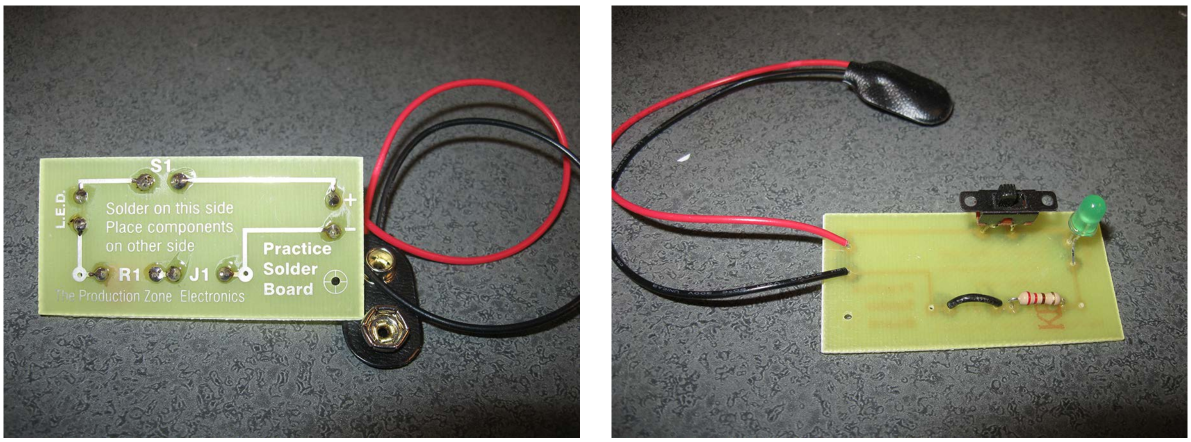
  It should look shiny and have a "volcano" shape. If not, you will need to reheat it and feed in a little more solder. This time ensure that both the lead and track are heated fully before applying solder.



When you have completed all the work in this module, submit your Practice Soldering Project to the Distance Learning Unit. Make sure you review what makes a good solder joint and compare it with your practice scrap piece. This will enable the tutor/marker to provide feedback on your soldering. Your Practice Soldering Project will be marked complete or incomplete. You will be requested to redo this activity if you receive an incomplete.

The purpose of the Practice Soldering Project is to demonstrate your soldering skills. In order to receive a complete on this project, your tutor/marker needs a sample of soldering that

- includes three or four components on the proper side of the PCB (use a low heat soldering iron)
- shows solder covering the copper ring that the component leg sticks through
- does not have any adjacent copper surface so that the only path for electrical flow is from one leg of the component to the other, through the component



Examples of a well-done soldering project that would result in a "complete" on your project.

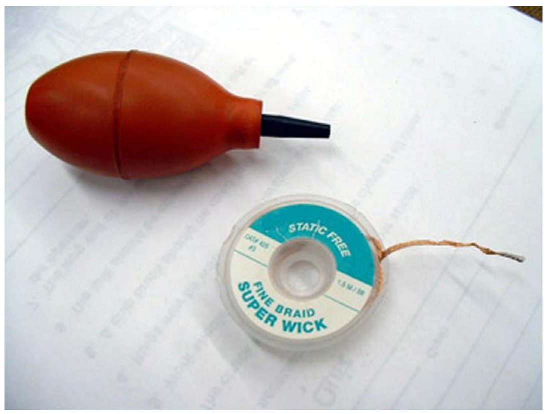
These points cover the minimum requirements for completing the project.

Soldering that demonstrates a higher level of skill should have the following characteristics:

- nestled close to the board (but still able to get a heat sink under the component)
- contains no burn marks.
- does not contain any cold soldered joints
- has the superfluous leg portions trimmed
- has been tested for continuity
- contains a solder joint that is smooth, shiny, and shaped like a Hershey's Kiss®

Repairing and Servicing Your PCB

Soldering is a permanent method of connecting components in an electrical circuit. It is a semi-permanent method of attaching components to a circuit board. But what happens if you install a component with the wrong polarity or in the wrong location? It must be removed. It is possible to remove any style of component from a PCB, but you must be very careful if you plan to reuse the same de-soldered component. The component must be treated with care. There are many ways that the component can be removed, but before you pull on the component legs from the PCB, the solder must first be removed. There are tools for removing soldering, such as small handheld solder vacuums, machine-driven solder vacuums, or solder wick. Two of these items are shown on the following page.



Desoldering

Option 1: *If you have solder wick or a de-soldering tool,* the solder can be removed. Heat the component leg and the solder together until solder is liquid. Place the wick or de-soldering vacuum into the puddle while applying heat. Wicking works automatically whereas the de-soldering vacuum needs to be activated. Then the component can be removed quickly.

Option 2: *If you do not have any type of de-soldering equipment,* when the solder melts and turns into a liquid, lift up on the one component leg you are heating with your needle-nose pliers. Go back and reheat the other component leg and carefully remove the component. Do not pull too hard because the component may crack and break. If there is any excess solder left on the board, heat up the spot where the hole is filled with solder and then quickly tap the circuit board on its side. The solder will end up as a small spatter on the tabletop. Make sure you do not damage your table. Also don't forget to use a heat sink on diodes and SCRs.

Make sure to re-inspect the component you will reuse. If it is damaged, you may have to buy more. So be very careful!

Circuit Board Repair

A magnifying glass can be used to find cracks or faults on a PCB. If you think your PCB has a crack or break in the trace, use your DMM to find the fault. A scrap piece of solid wire can very easily repair a broken copper trace on the PCB. The solid piece can be the cut-off leftovers of a previously installed component, or a piece of solid hookup wire with the insulation removed. Then lay the solid piece across the broken trace, and solder it on to act as a bridge to make the connection. Be sure to test your repair job with the DMM. Be sure you don't create a short circuit with another trace with your repair. It is very common for students to use too much solder. Take your time and do it right the first time.

Notes

Lesson 6: Careers in Electronics

Careers in the electronics industry are everywhere. Because electronics has become such a big part of our lives and there are so many kinds of electronics around us, there is definitely a career for you in the electronics industry. In order to become more aware of some of the careers available, you must look for businesses that offer some of these jobs.

In Module 1, you investigated several career possibilities that you thought you might have some interest in. In this lesson, you will investigate some of the related jobs where you live.

Careers in Electronics

Below is a list of just some of the career choices you can make in the field of electronics and related industries. Carefully read each one, taking the time to go through the entire list.

A Career in Acoustics Aircraft Instrument Mechanics and Inspectors Appliance Service Technician Appliance Tech Competencies Assemblers—Electrical and Electronic Equipment Audio and Video Equipment Technicians Audio and Video Recording Technicians Audio Visual Specialists Audiovisual Technician Audio Engineering Avionics Technician Avionics Technician—Military AV Tech Broadcast Media Careers Broadcast Technician Broadcast Technicians Cable Television Technicians Camera Repairer Engineering and Science Careers of the Future Certified Electronics Technician Equipment Repairers Career Guide—Electronics Engineering Careers of the Future	Cable Television Technicians Commercial and Industrial Electronic Equipment Repairers Communications Equipment Operator—Military Computer and Office Machine Repairers Computer Hardware Engineers Computer Science Careers Computer Service Technician Controls Engineer Electrical and Electronics Engineers—Military Electronics Assemblers Electronic Bench Tester Electronic Engineer Electro-Mechanical Technicians Electronic Equipment Repairer Electronic Home Entertainment Repairer Electronic Instrument Tradesperson Electronic Instrument Trades Electronic Sales Representative Electronic Service Technician Electronics Service Technician Electronic Service Technicians Electronics Engineers *(continued)*

Electronic and Electrical Repair—Military Electronic and Electrical Technicians Electronics Mechanic Electronics Service Person Electronics Technician Electronics Technician Electronics Technicians Engineering Careers Engineering and Technology Careers Engineering Technicians Gaffer Get Tech Careers Home Electronics Repairers Industrial Designers Lighting Technician Line Installers and Repairers Photonics Technicians Power Generation Engineer Radar and Sonar Operators—Military Radio Systems Engineer Radio Technician Recording Engineer Robot Technician	Robotics Careers Robotics Engineer Robotics Technician Security Alarm Installer Sound Effects Editor Sound Engineer Sound Engineering Technicians Sound Recording Engineer Sound Technician Space Operations Specialist—Military Technical Occupations in Electronics Technical Occupations in Electronics Engineering Telecommunication Careers Telecommunications Analyst Telecommunications Installation and Repair Telecommunications Technician Television Systems Engineer Unmanned Vehicle Operation Specialist—Military User Support Technicians Weapons Maintenance Technician—Military Hydro Linesman

It is now time for you to complete Assignment 1.4, which you will either mail or electronically submit to the Distance Learning Unit when you have completed Module 1.

Assignment 1.4

Careers in Electronics *(26 marks)*

Part 1

Find two electronics jobs or careers in the most recent copy of *Manitoba Prospects*. A copy was provided with the course or you can access it at www.gov.mb.ca/tce/lmi/prospects. Another option is to access *Career Cruising*, an online career guidance and planning system. People of all ages use career cruising to find the right career and to explore education and training options. *Career Cruising* is a web-based program and you can access the website from any computer that has access to the Internet.

In order to access *Career Cruising*, go to www.careercruising.com.

USERNAME: manitoba

PASSWORD: distancelearning

Click on "Start Career Cruising!" to begin. You can attain you own unique portfolio username and password once you have entered the *Career Cruising* website.

Part 2

Investigate and research two careers and write a brief description including some or all of the following about each choice. *(13 marks for each selection, for a total of 26 marks)*

- Describe the work duties. *(2 marks)*
- What personal qualities should individuals possess to be successful? *(2 marks)*
- Is there a process to become certified within the trade/occupation or career? *(2 marks)*
- What is the length of education and training? *(1 mark)*
- What are the school locations for training? *(1 mark)*
- What is the cost of education? *(1 mark)*
- What are the best and worst parts of the job? *(2 marks)*
- What is the beginning salary? *(1 mark)*
- Are there opportunities for advancement? *(1 mark)*

Attach your description to the job or career advertisement to which it applies. Remember to submit both advertisements and the descriptions to the Distance Learning Unit when you have completed Module 1.

Notes

MODULE 1 SUMMARY

Congratulations! You have finished the first module of this course.

In this module, you learned how electricity is generated and transmitted, how to use a multimeter to measure voltage, and about the hazards of electricity. You practised soldering parts on a printed circuit board and explored various careers in the field of electricity and electronics. In the next module, you will learn what makes up electricity, including elements such as current, voltage, resistance, and parts identification. Plus, you will be doing experiments with resistors, LEDs, and a photocell.

Submitting Your Assignments

It is now time for you to submit your assignments from Module 1 to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Remember: Assignment 1.3: Practice Soldering Project must be mailed to the Distance Learning Unit. Keep all your material together in the one mailing and do not electronically submit any material for this module.

Make sure you have completed all parts of your Module 1 assignments and organize your material in the following order:

- ❑ Module 1 Cover Sheet (found at the end of the course Introduction)
- ❑ Assignment 1.1: Electricity: Let's Get Started
- ❑ Assignment 1.2: The Hazards of Working with Electricity
- ❑ Assignment 1.3: Practice Soldering Project
- ❑ Assignment 1.4: Careers in Electronics

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Grade 10 Electricity/ Electronics Technology (20G)

Module 1
Introduction to Electronics

Learning Activity Answer Keys

Module 1: Introduction to Electronics

Learning Activity 1.1: Electricity

Record your answers to the following questions in your notebook.

1. List three items in your home that you need to plug in.

   Answer:

   Coffee maker

   Hair dryer

   Power drill

   (Any common household appliance is acceptable.)

2. List five items in your home that use electricity, but you don't need to plug in.

   Answer:

   TV remote control

   Garage door opener

   MP3 player

   (Any common household battery-operated device is acceptable.)

Learning Activity 1.2: Reading Your Micrometer

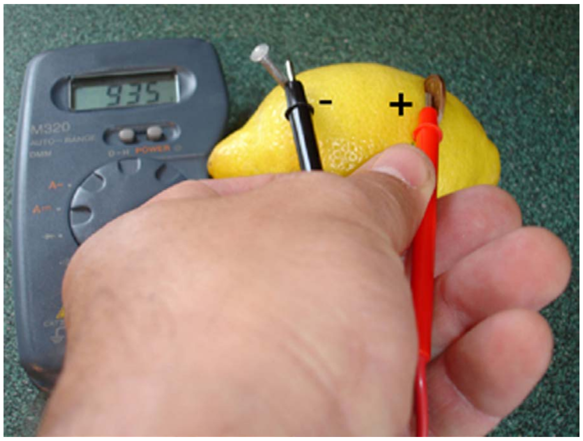
Write down the value that the screen indicates in the space below.

1. I read the battery with my DMM and the meter indicated the battery has ____________ volts DC.

   Answer: Approximately 9 volts (voltage may vary slightly).

Learning Activity 1.3: Testing Volts

1. The voltage that my lemon battery produced was ________ volts DC.



Answer: Less than 1

You might want to try using a different fruit or even a potato and see what kind of voltage you can get, if any. It goes without saying that once you put the nail and penny into the lemon, or any other fruit or vegetable, do not eat it! You will have to dispose of it.

Optional Question:

Students are not required to complete this question.

2. I also tried using a __________________ as a battery and the meter read _______________________________ ?

   Answer:

   Any fruit or vegetable. Any voltage is okay here.

Learning Activity 1.4: Hydro Meters

1. The machine that hydro stations use to create electricity is a _________________ .

   Answer: generator

2. Electricity that is created using water power is called _________________ .

   Answer: hydroelectricity

3. The physical energy of the flow of water is converted to _________________ energy that drives the generator.

   Answer: mechanical

4. What percentage of Manitoba's electricity is produced by hydroelectricity?

   Answer: approximately 80%

5. What is DC, or direct current? (Describe.)

   Answer: Electric current that flows in one direction only

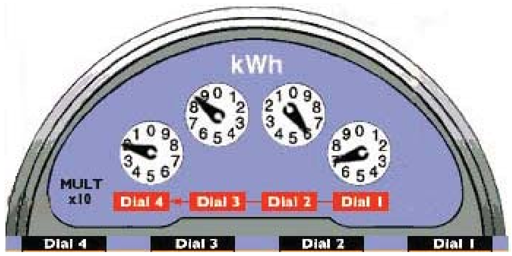
6. What is AC, or alternating current? (Describe.)

   Answer: Electric current that reverses direction approximately 60 times a second

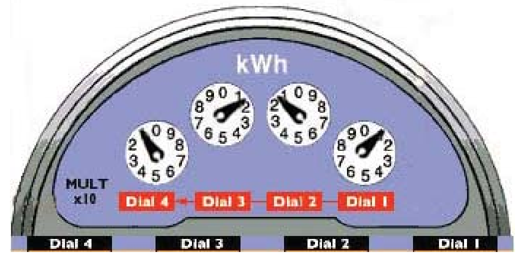
7. What does a hydro meter do?

   Answer: It is a device that records and measures how much electricity you use

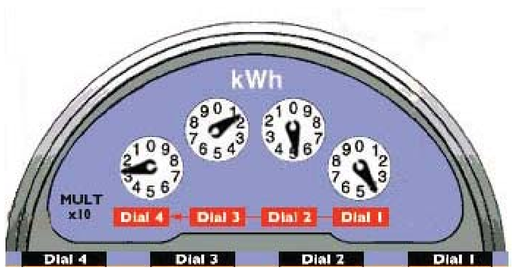
8. Look at the meters below and write down what the reading is for each one underneath the meter.



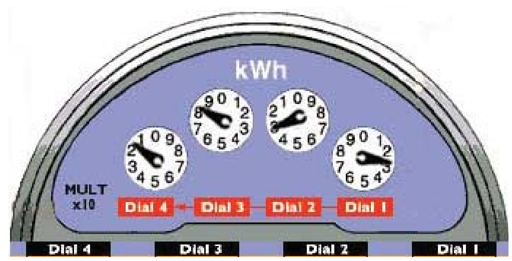
Answer: 2867



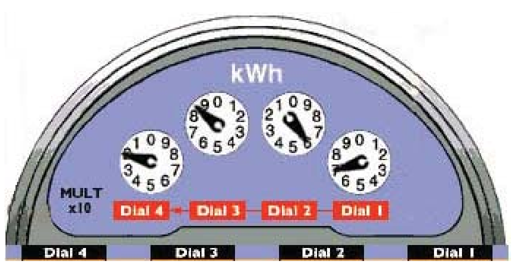
Answer: 1111



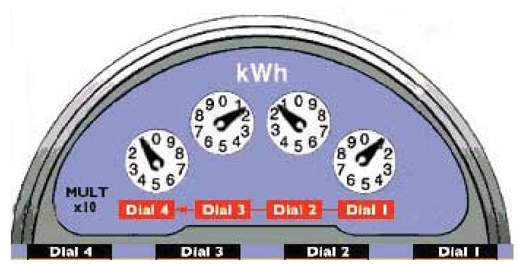
Answer: 2154



Answer: 1832



Answer: 4584



Answer: 7704

Learning Activity 1.5: A Brief History of Electronics

1. In ancient Greece, Thales observed electric charge by doing this.

   Answer:

   Rubbing a stone called amber.

2. Approximately when do historians believe that ancient people first used a device that was similar to our lemon battery to create electricity?

   Answer:

   Somewhere around 300 BCE.

3. Create a timeline of electrical experiments and achievements, including the appropriate year and the person or persons associated with that event.

   Answer:

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   1879 **Thomas Alva Edison** invented the light bulb.

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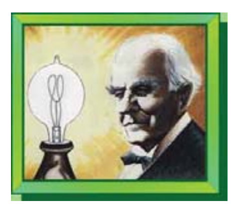

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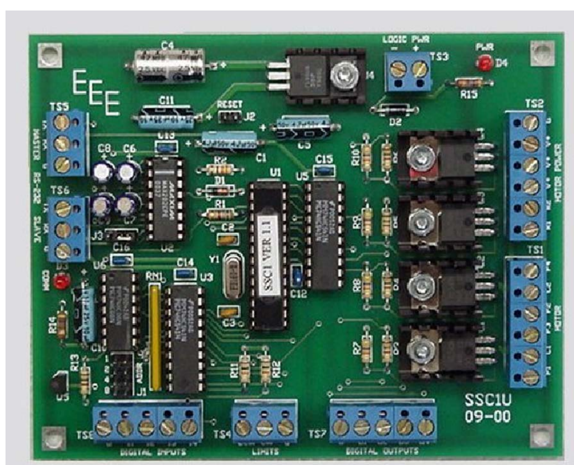


Module 1 Summary

Congratulations! You have finished the first module of this course.

In this module, you learned how electricity is generated and transmitted, how to use a multimeter to measure voltage, and about the hazards of electricity. You practised soldering parts on a printed circuit board and explored various careers in the field of electricity and electronics. In the next module, you will learn what makes up electricity, including elements such as current, voltage, resistance, and parts identification. Plus, you will be doing experiments with resistors, LEDs, and a photocell.

Submitting Your Assignments

It is now time for you to submit your assignments from Module 1 to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Remember: Assignment 1.3: Practice Soldering Project must be mailed to the Distance Learning Unit. Keep all your material together in the one mailing and do not electronically submit any material for this module.

Make sure you have completed all parts of your Module 1 assignments and organize your material in the following order:

- ❏ Module 1 Cover Sheet (found at the end of the course Introduction)
- ❏ Assignment 1.1: Electricity: Let's Get Started
- ❏ Assignment 1.2: The Hazards of Working with Electricity
- ❏ Assignment 1.3: Practice Soldering Project
- ❏ Assignment 1.4: Careers in Electronics

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Grade 10 Electricity/ Electronics Technology (20G)

Module 1
Introduction to Electronics

Learning Activity Answer Keys

Module 1: Introduction to Electronics

Learning Activity 1.1: Electricity

Record your answers to the following questions in your notebook.

1. List three items in your home that you need to plug in.

   Answer:

   Coffee maker

   Hair dryer

   Power drill

   (Any common household appliance is acceptable.)

2. List five items in your home that use electricity, but you don't need to plug in.

   Answer:

   TV remote control

   Garage door opener

   MP3 player

   (Any common household battery-operated device is acceptable.)

Learning Activity 1.2: Reading Your Micrometer

Write down the value that the screen indicates in the space below.

1. I read the battery with my DMM and the meter indicated the battery has ____________ volts DC.

   Answer: Approximately 9 volts (voltage may vary slightly).

Learning Activity 1.3: Testing Volts

1. The voltage that my lemon battery produced was ________ volts DC.

Answer: Less than 1

You might want to try using a different fruit or even a potato and see what kind of voltage you can get, if any. It goes without saying that once you put the nail and penny into the lemon, or any other fruit or vegetable, do not eat it! You will have to dispose of it.

Optional Question:

Students are not required to complete this question.

2. I also tried using a ________________ as a battery and the meter read ____________________________ ?

   Answer:

   Any fruit or vegetable. Any voltage is okay here.

Learning Activity 1.4: Hydro Meters

1. The machine that hydro stations use to create electricity is a _________________ .

   Answer: generator

2. Electricity that is created using water power is called _________________ .

   Answer: hydroelectricity

3. The physical energy of the flow of water is converted to _________________ energy that drives the generator.

   Answer: mechanical

4. What percentage of Manitoba's electricity is produced by hydroelectricity?

   Answer: approximately 80%

5. What is DC, or direct current? (Describe.)

   Answer: Electric current that flows in one direction only

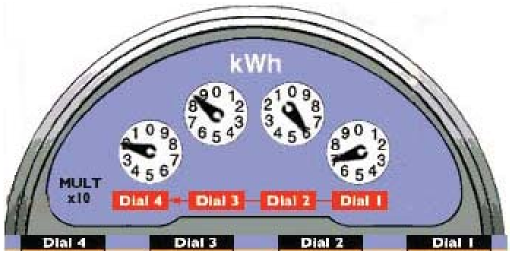
6. What is AC, or alternating current? (Describe.)

   Answer: Electric current that reverses direction approximately 60 times a second

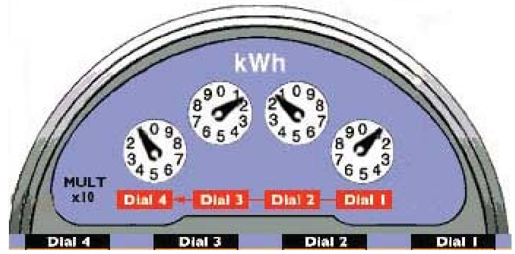
7. What does a hydro meter do?

   Answer: It is a device that records and measures how much electricity you use

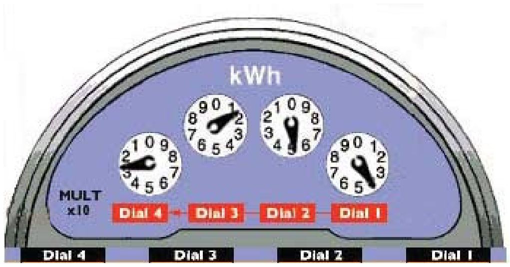
8. Look at the meters below and write down what the reading is for each one underneath the meter.



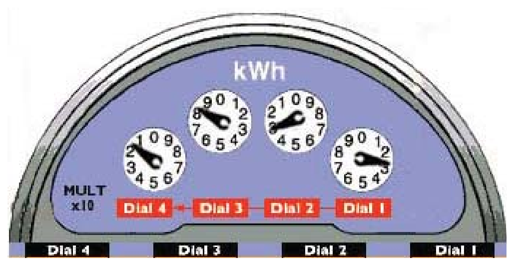
Answer: 2867



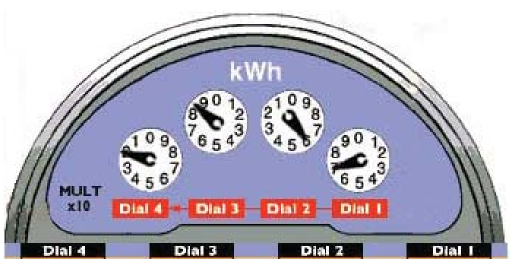
Answer: 1111



Answer: 2154



Answer: 1832



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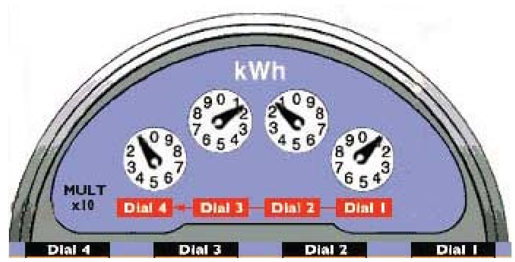

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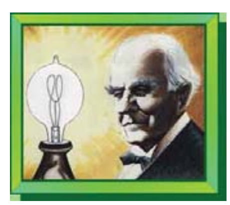

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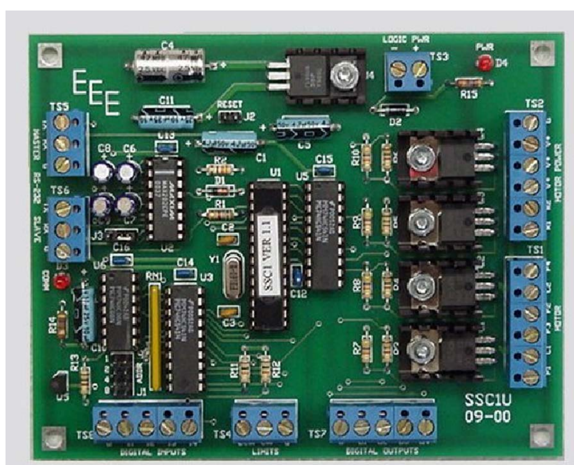


Grade 10 Electricity/ Electronics Technology (20G)

Module 2
The Basics of Electricity

- Introduction
- Lesson 1: The Atom and Electronics
- Lesson 2: How a Solderless Circuit Board Works
- Lesson 3: Identifying Electronic Component Parts
- Lesson 4: Schematic Diagrams
- Lesson 5: Metrification and Conversion of SI Units
- Lesson 6: Resistors
- Module 2 Summary

MODULE 2:
THE BASICS OF ELECTRICITY

Module Focus

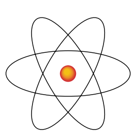
After working through this module, you should

- ❑ have an in-depth understanding of what makes up electricity.
- ❑ understand what current voltage and resistance is.
- ❑ understand how a solderless circuit board works.
- ❑ be able to identify electronic components and parts.
- ❑ understand metric units and abbreviations.
- ❑ demonstrate the effects of a resistor on an LED.
- ❑ demonstrate the effects of a photocell on an LED.
- ❑ demonstrate the effects of a potentiometer on an LED.

Introduction to Module 2

In this module, you will learn about what makes up electricity, and understand what current, voltage, and resistance are. You will learn how to use a solderless circuit board for future experiments. You will be exposed to a number of components and learn their identification, abbreviations, and metric units. There will be three experiments demonstrating the effects of resistors on LEDs.

Power Words



elektron	proton	nucleus	shells
atom	charge	siemens	potential difference
electron	matter	elements	compounds
schematic symbol	EMF		

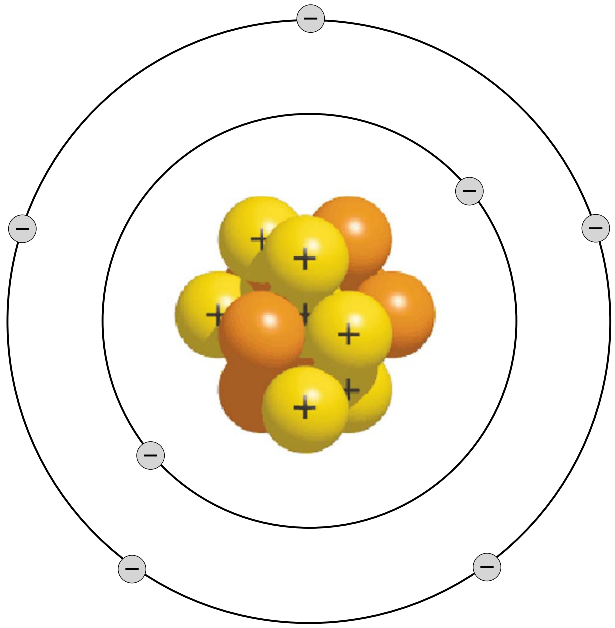
Module 2 Assignments

When you have completed the assignments for Module 2, submit your completed assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
1	Assignment 2.1	The Atom and Electronics
3	Assignment 3.2	Schematic Symbols
4	Assignment 2.3	Schematic Drawings
5	Assignment 2.4	Working with the Metric System
6	Assignment 2.5	Resistors
6	Assignment 2.6	Experiment 1, Part 2: Report 1: The Effects of Resistors on an LED
6	Assignment 2.7	Experiment 2, Part 2: Report 2 The Effects of a Photocell on an LED
6	Assignment 2.8	Experiment 3, Part 2: Report 3: The Effects of a Potentiometer on an LED

Lesson 1: The Atom and Electronics

A Brief History



Around 600 BCE, the Greeks were fascinated by the mystical properties of what they referred to as **elektron**, which meant “amber” or “pale.” This material, when rubbed or electrified with some kind of fur, moved dust specks and small objects. The Greeks thought that this phenomenon was amazing and were quite intrigued by the way that they could control this action at a distance. They thought that the object had been charged with an invisible substance they called “electricity.” This was the beginning of our introduction to static electricity. The Greeks surmised the law of electrical charges. **The law of electrical charges states that unlike charges attract, and like charges repel.** If you have ever played with two magnets, you would have found this to be true yourself. If you try to put the north ends of two magnets together, they want to push away from each other. The same thing happens when you try to put the two south poles of two magnets together. When you change the polarity of one of the magnets so that opposite poles are facing towards each other, there is an attraction.

Later, in the 17th century, Benjamin Franklin performed his famous kite experiment and proved that electricity flowed.

In 1877, J. J. Thompson discovered the electron.

In 1910, Ernest Rutherford discovered the proton.

In 1932, James Chadwick discovered the neutron.

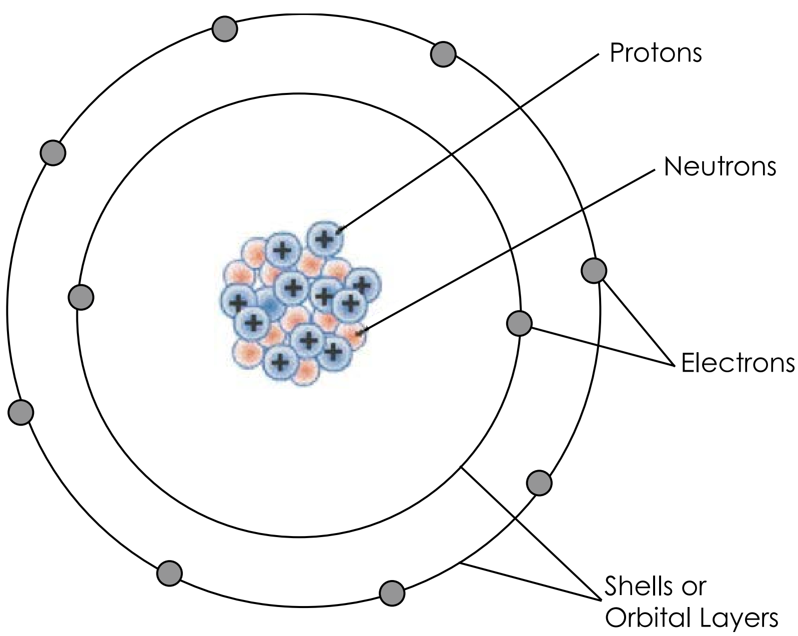
So it wasn't until fairly recently that we had enough knowledge to put our current model of the atom together to fully understand what electricity is all about.

The Atom

The atom is made up of **electrons**, which orbit around the **nucleus** or centre of the atom. The centre of the atom is made up of two particles: one called the **proton** and the other the **neutron**. Protons are positively charged particles, while neutrons are neutral or have no charge.

Did you know that protons are 1840 times heavier than electrons?

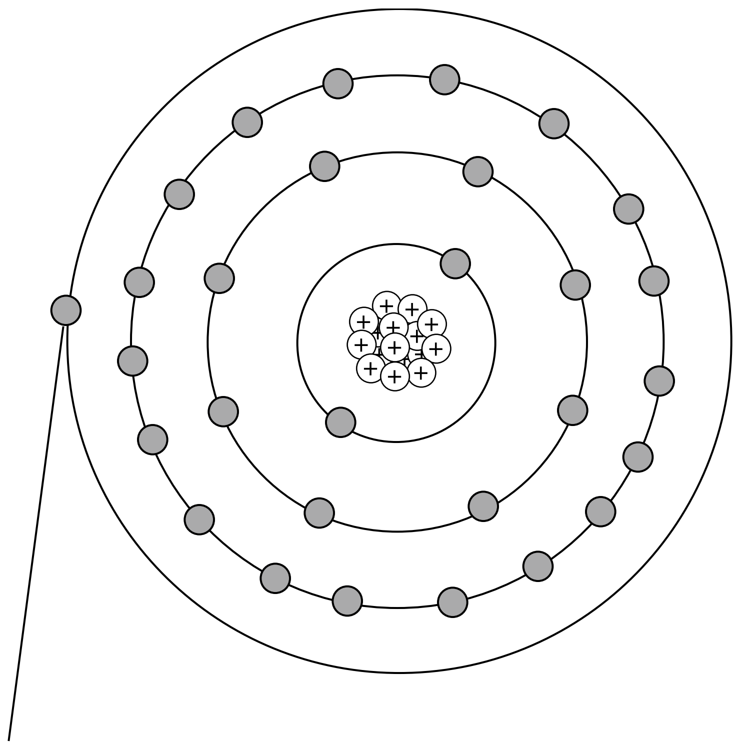
The following diagram of the two-dimensional atom helps to illustrate it.



The nucleus of the atom is made up of protons, which have a positive charge and are 1840 times heavier than the electron that orbits around them. This positive charge helps keep the electron that's zipping around the outside in its orbit. Remember the law of electrical charges—opposites attract.

Atoms have their electrons arranged in layers called **shells**.

In order to maintain electrical balance, the number of electrons is equal to the number of protons in most elements.



Notice that the copper atom has only one electron in the outer shell or valence shell.

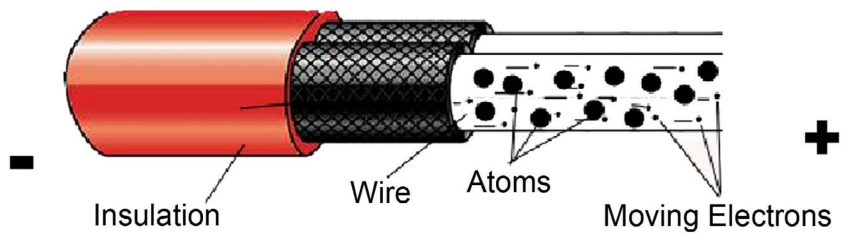
The copper atom has one electron in the fourth shell, which is far from the nucleus. This distance from the nucleus means that the positive protons have a weaker effect on keeping that negative electron in orbit. Therefore, it would be easy for the electron to dislodge and pull away from the atom. This is why copper is considered to be a good conductor.

These are often called "free" electrons because these electrons can move fairly freely from one atom to the next.

If we apply an outside force to these atoms, we can cause them to move in a copper wire. The direction that the negatively charged electrons will move is towards the positive charge of the force. Remember the law of electrical charges states *(Write the law of electrical charges in the space provided.)*

____

____



EMF (Volts)

Electromotive force, or **EMF**, is the force that makes the electrons move in a conductor. Alessandro Volta is the person credited with discovering this force and it was named in his honour. The standard metric unit on electric potential difference is the volt, abbreviated **V**. Sometimes instead of the term *volts*, the term *potential difference* may be used. EMF is the force that is created between two objects with different electrical potential.

Imagine if you were walking across the carpet, dragging your feet while wearing wool socks. What would happen if you were to touch another person or something made of metal? You would see a spark jump between you and whatever you touched. This would happen because rubbing your feet on the carpet causes you to pick up extra electrons. These are being stored on your body or clothing. You are now "**charged**." This means you have an excess amount of electrons on your body. Now, when you go to touch someone, there is a difference in the amount of electrons that you have on your body compared to the amount of electrons on the person you touch. This is called a "**potential difference**" or "**voltage**." So those extra electrons you carry want to get off of you. As soon as you provide them an opportunity, they will.

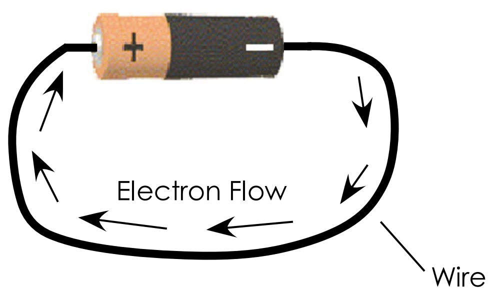
Electrical Current

Electrical current is often called the **charge in motion**. Current is the actual movement of the electrons travelling in one direction. Andre Marie Ampere studied electrodynamics and the effects of electricity in motion. The "ampere," which is the unit of measurement for electrical current flow, was named after him. The symbol for "amps" is the capital letter **I**.

Just for clarification, the force that makes the electrons want to move is EMF, which is an abbreviation for *(Write your answer in the space provided.)*

____

When the electrons actually move, we call the movement of the electrons *electrical current.* You can draw a parallel to the flow of electrons to the flow of a river. Water flows much like electrons will flow in a conductor.



Current may be electrons, protons, or ions moving in one direction. For the purpose of this course, we will study the movement of electrons in metal conductors for our understanding of electrical current flow.

Resistance

Resistance in electronics is opposition to current flow in a conductor or circuit. It is the property of a material that inhibits or makes it hard for the electrons to move through it. The **ohm**, which is the unit of measure for resistance, was named after a scientist named Georg Simon Ohm for his contributions to the field of electronics. The unit of measure for resistance is ohms, and its symbol is the Greek letter **Omega** Ω.

Resistance is just what it sounds like: it is the difficulty that electrons have to overcome in order to flow in a material. In rivers, we build dams to control the water flow. Higher resistance means more force (or voltage) is necessary for the electrons to move through that material. If the material has too great of a resistance, electrons will not be able to flow at all. These types of materials are called **insulators**.

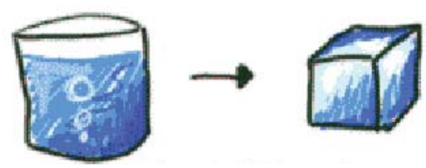
Conductance

Conductance is the ability of a material to allow current to flow through it. The unit of measure for conductance is G, and its unit of measure is **siemens**, which is represented by the letter **S**.

Conductance can be thought of as a single lane highway or road. If the current flow is represented by the traffic on the road, then all cars must travel in single file, one at a time. Even the fastest car is limited by how fast the one in front of it is going. But if we expanded the road or highway to have two or more lanes going in the same direction, then there would be more lanes and faster cars would be able to pass. There would also be more room on the road for more cars. Increased conductance in a wire means more electrons can flow in it at the same time.

What Does It Matter?

Matter is everything around us, and it exists everywhere. It is made up **atoms** and **molecules**. Matter is anything that has a mass. Even though matter can be found all over the universe, you usually find it in just a few forms. There are now considered to be five states of matter.



Physical Changes of Water and Ice

Most people have heard how matter is a solid, liquid, or a gas. But what is plasma? **Plasma** is a form of matter in which many of the electrons wander around freely among the nuclei of the atom. The plasma state is a gas that is super-heated to the point where it begins to release electrons. Plasma occurs naturally on the Sun and other stars in the universe, but it is artificially produced in fluorescent lights. Plasma displays by electrically charging a gas in order to release ultraviolet light. Applications include electric lamps, lasers, medical devices, energy converters, and flat-panel video displays or plasma TVs.

Another newly discovered state of matter is called Bose-Einstein condensates. The scientists who worked with the Bose-Einstein condensates received a Nobel Prize for their work in 1995. But what makes a state of matter? It's about the physical state of molecules and atoms. Elements and compounds can move from one physical state to another and not change.

It is now time for you to complete Assignment 2.1. This assignment (along with all other assignments) is worth marks and you will either mail or electronically submit it to the Distance Learning Unit when you have completed Module 2.

Assignment 2.1

The Atom and Electronics *(24 marks)*

Please respond to the following assignment questions in the space provided. Remember you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 2.

1. Approximately what year were the Greeks fascinated by the mystical properties of amber? *(1 mark)*

2. What is the law of electrical charges? *(1 mark)*

3. In 1877, who discovered the electron? *(1 mark)*

4. In 1910, who discovered the proton? *(1 mark)*

5. In 1932, who discovered the neutron? *(1 mark)*

6. Draw the basic atom showing electrons, protons, and neutrons. Also, label each particle with a "+" or "–" or neutral charge. *(0.5 mark for each drawing and label, for a total of 2.5 marks)*

(continued)

Assignment 2.1: The Atom and Electronics (continued)

7. What is an electron shell? *(1 mark)*

8. What is the reason that copper is considered to be a good conductor? *(1 mark)*

9. Why are some electrons called "free" electrons? *(1 mark)*

10. What do the letters EMF stand for? *(1 mark)*

11. What does it mean to be "charged?" *(1 mark)*

12. What is another name for "potential difference?" *(1 mark)*

13. Define the term *electric current*. *(1 mark)*

14. What is the unit of measure for an electrical current? *(1 mark)*

15. What is the symbol used for current? *(1 mark)*

(continued)

Assignment 2.1: The Atom and Electronics (continued)

16. Define *resistance*. *(1 mark)*

    ____

17. What is the unit of measure that we use for resistance? *(1 mark)*

    ____

18. What is the symbol for the unit of measurement used for resistance? *(1 mark)*

    ____

19. What is conductance? *(1 mark)*

    ____

20. What is the unit of measure for conductance? *(1 mark)*

    ____

21. What are the five states of matter? *(2.5 marks)*

    ____

    ____

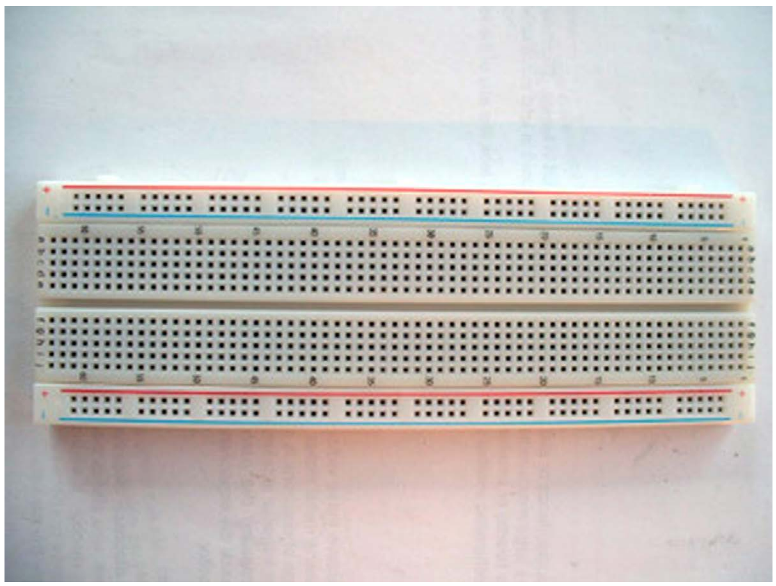
Notes

Lesson 2: How a Solderless Circuit Board Works

Introduction

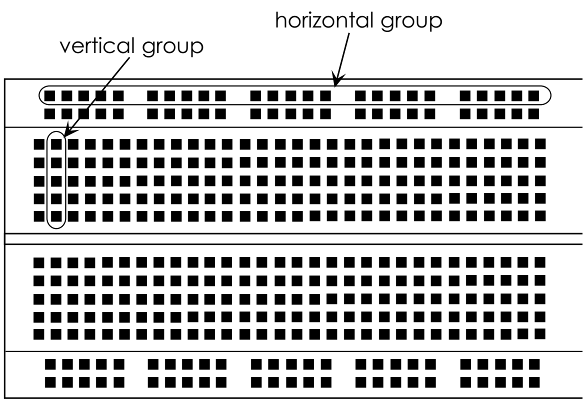
One of the things that you must do in this course is complete several experiments. In order to do this, you must learn how to use a solderless circuit board.

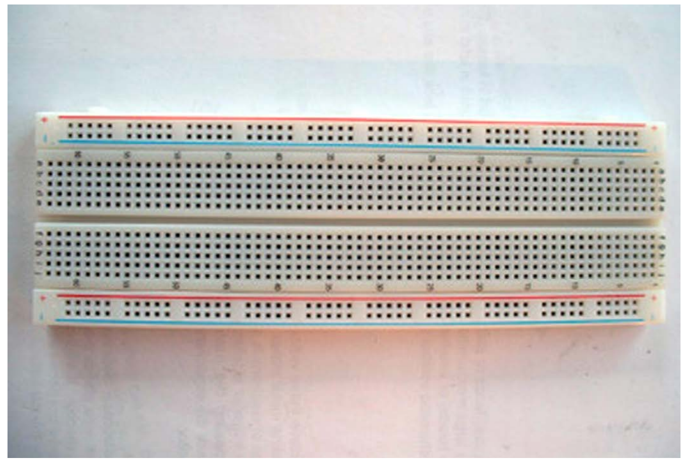
A solderless circuit board is just that—a board on which you can assemble circuits without having to make permanent connections. It is very handy for the electronic experiments that you are going to be doing.



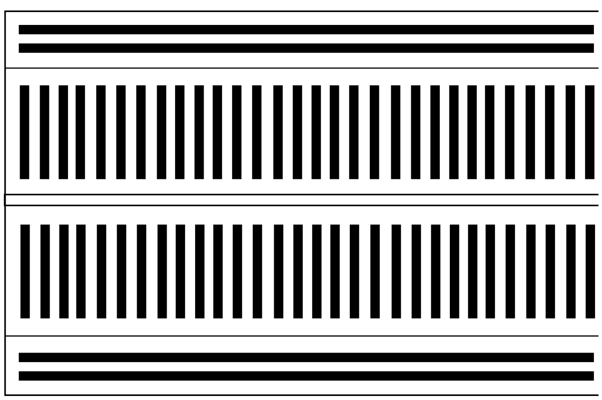
Using the Solderless Circuit Board

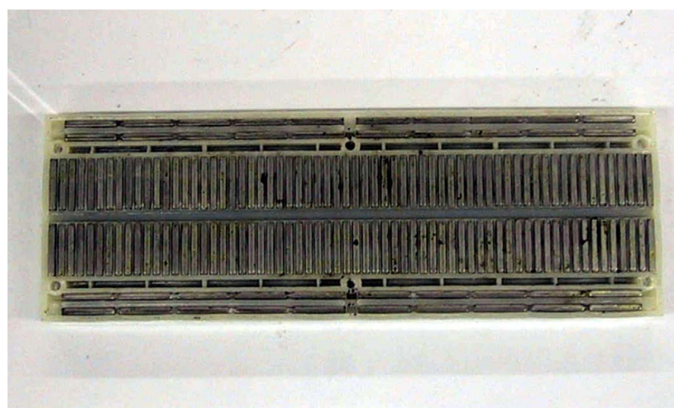
The **solderless circuit board** is a great tool for beginning electronics students. It is a safe, fast, and fun way to construct a project without creating a printed circuit board. The solderless circuit board in your project kit is arranged into vertical and horizontal groups.





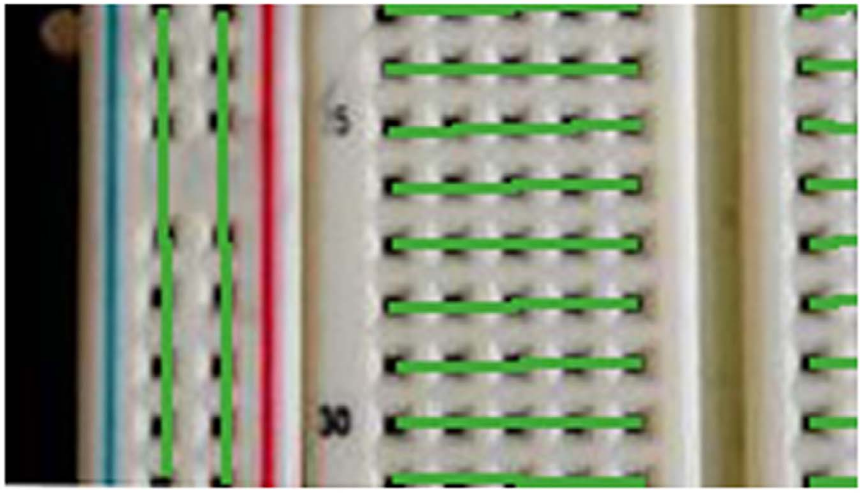
Notice how the holes are connected to each other in the bottom x-ray view.



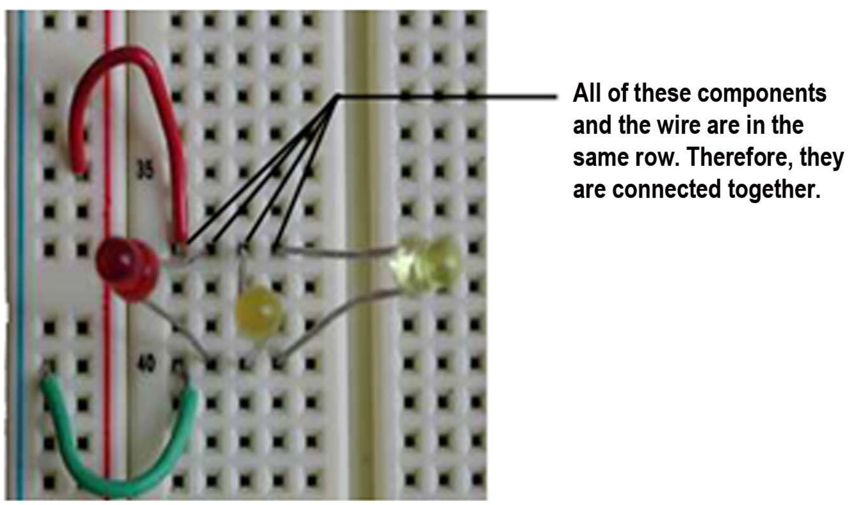


There are numerous small holes that will accept wires. Each hole is designed for only one component and/or wire.

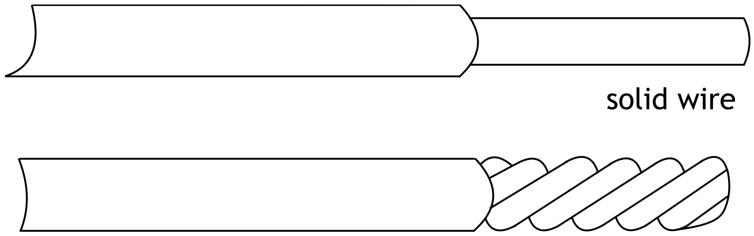
Check out how the holes are connected for the various rows on the board.

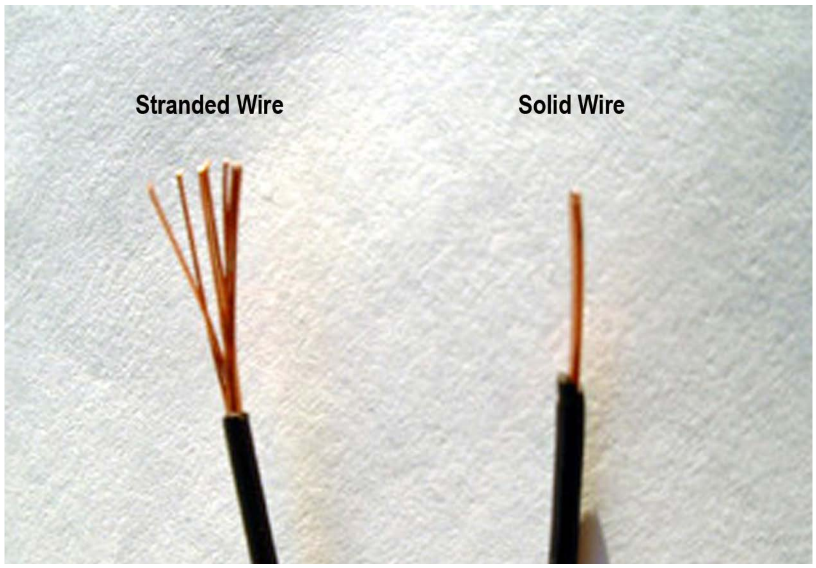


Now here's a picture of the board with a few LEDs (small lights) connected together, with the power source from the battery (not shown) from the red and green wires



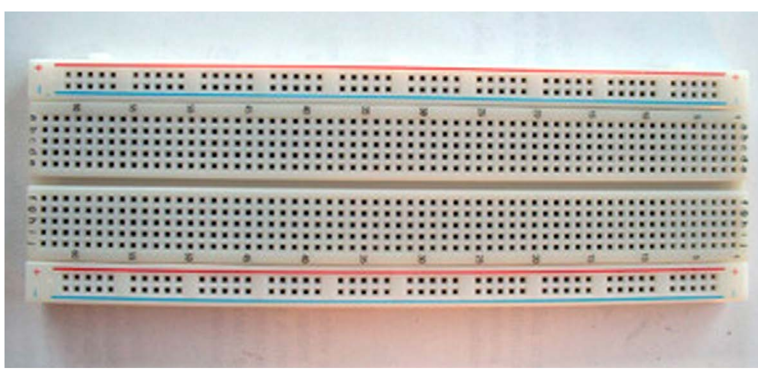
It is now time to view the Grade 9/10 Electronics video found in the learning management system (LMS) or on DVD. Watch the two sections on the video that explain how to use the wire stripper and the solderless circuit board.





Video Review

Solderless Circuit Board—The solderless circuit board allows you to assemble electronic circuits without tools or soldering. Quick and easy plug-in connections or conductors inside the plastic body are used to complete the circuits.



Before you can take the next step in building some circuits, you need to learn a secret language—schematic symbols for all the parts you are going to use.

Lesson 3: Identifying Electronic Component Parts

Introduction

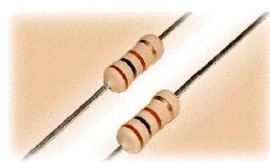
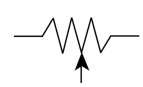
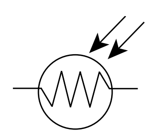
Schematic symbols are the language of electronics. These symbols are used to represent the actual electronic components. In this lesson, you will learn to recognize some of the more common symbols.

You may not yet understand the purpose of any of these parts, but you can refer back to this chapter throughout this course to review any schematic symbol.

Check your responses for Learning Activities 2.1 through 2.10 against the Learning Activity Answer Keys found at the end of this module.

Resistors

There are two basic types of resistors: carbon and potentiometer.

	Physical Appearance	**Schematic Symbol**
Carbon Resistor		
Potentiometer/ Trimmer (variable resistor)		
Photocell (also known as a light-dependent resistor or LDR)		

Function: A resistor helps control the flow of electrical current. A potentiometer is a resistor that allows you to change the resistance by turning the knob.

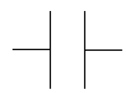
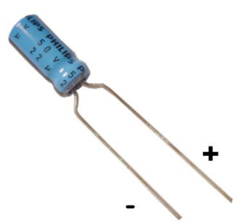
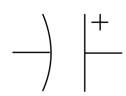
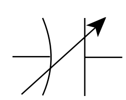
Learning Activity 2.1

Resistors

1. Draw the schematic symbol for the carbon resistor three times.
2. Draw the schematic symbol for the potentiometer resistor three times.
3. State the basic types of resistors.
4. Give the function of a resistor.

Capacitors

There are three basic types of capacitors.

	Physical Appearance	**Schematic Symbol**
Ceramic Disc Capacitor (no negative or positive leg)		
Electrolytic Capacitor (polarized)		
Variable Capacitor		

Function: A capacitor stores electrons on its plates and, therefore, holds a small electrical charge for a short period of time. Polarized capacitors have negative and positive sides.

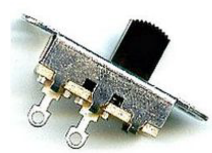
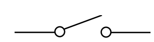
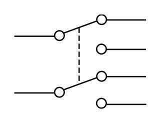
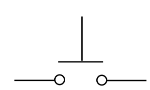
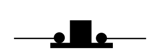
Learning Activity 2.2

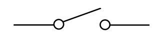
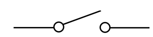
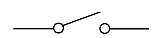
Capacitors

1. Draw the schematic symbol for the ceramic disc capacitor three times.
2. Draw the schematic symbol for the electrolytic capacitor three times.
3. Draw the schematic symbol for the variable capacitor three times.
4. State the basic types of capacitors.
5. Give the function of a capacitor.

Switches

There are many types of switches.

	Physical Appearance	Schematic Symbol
Slide Switch (SPST) (single pole single throw or referred to as an SPST)		
Slide Switch (DPDT) (double pole double throw or referred to as a dpdt)		
Pushbutton Switch (N.O.) (momentary normally open)		
Pushbutton Switch (N.C.) (momentary normally closed)		

	Physical Appearance	Schematic Symbol
Toggle Switch		
Rocker Switch		
Light Switch		

Function: The purpose of a switch is to interrupt or allow the continuation of the flow of electrical current, either momentarily or permanently.

Learning Activity 2.3

Switches

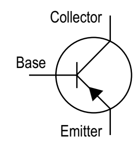
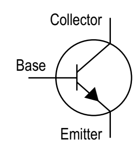
1. Draw the schematic symbol for the SPST slide switch three times.
2. Draw the schematic symbol for the DPDT slide switch three times.
3. Draw the schematic symbol for the N.O. pushbutton switch three times.
4. Draw the schematic symbol for the N.C. pushbutton switch three times.
5. Draw the schematic symbol for the toggle switch three times.

Transistors

There two major types of transistors: general purpose and power transistors.

General Purpose

These transistors can be one of two types: PNP or NPN. Both transistors have three legs on them. Each leg has a name: emitter, base, and collector.

	Physical Appearance			**Schematic Symbol**
Transistor (PNP)	 E B C	or		
Transistor (NPN)	 E B C	or		

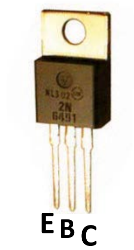
The difference between the PNP and NPN is the direction of the emitter on the schematic diagram (the little arrow on the schematic is pointing in a different direction).

Power Transistors

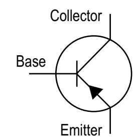
These transistors can be one of two types: PNP or NPN. Both transistors have three legs on them. Like the general transistors, each leg has a name: emitter, base, and collector.

Physical Appearance | **Schematic Symbol**

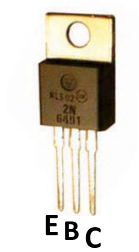
Power Transistor (PNP)



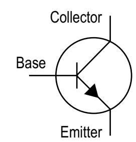
or



Power Transistor (NPN)



or



The difference between the PNP and NPN is the direction of the emitter on the schematic diagram (the little arrow on the schematic is pointing in a different direction).

Function: A transistor is an "active" component that either switches or amplifies electricity.

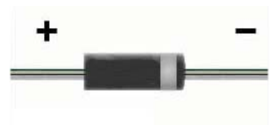
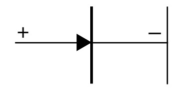
Learning Activity 2.4

Transistors

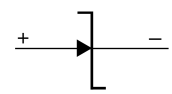
1. Draw the schematic symbol for the NPN transistor three times.
2. Draw the schematic symbol for the PNP transistor three times.

Diodes or Rectifiers

There are many types of diodes. We will cover some of the more common ones in this course.

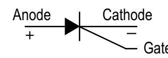
	Physical Appearance	Schematic Symbol
Power Diode		

Function: A diode is a one-way electrical gate that only allows current to pass through it from the negative side, known as the “cathode” to the positive side, known as the “anode.”

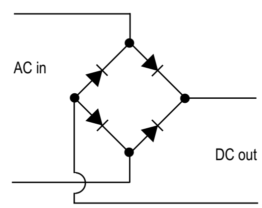
	Physical Appearance	Schematic Symbol
Zener Diode		

Function: Zener diodes are used to maintain a certain voltage. They are designed to break down in a reliable and non-destructive way so that they can be used in reverse. A regular diode only lets current flow in one direction, and so does a zener diode, but only until a certain predetermined voltage. Then it allows the current to go in the opposite direction.

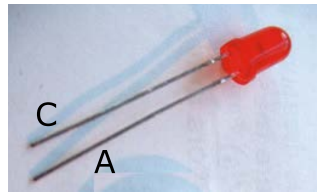
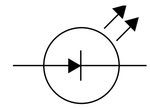
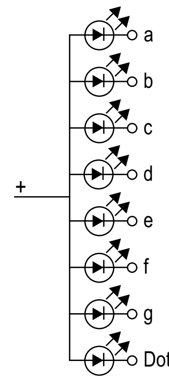
Zener diodes can be distinguished from ordinary diodes by their code and breakdown voltage, which are printed on them.

	Physical Appearance	Schematic Symbol
Silicon Controlled Rectifier (SCR)		

Function: A SCR is basically a diode with a third leg, known as the gate between the cathode and anode. SCRs prevent current flow in either direction until the gate receives a voltage signal. After receiving this trigger signal, the SCR then becomes a diode. It remains on, regardless of what happens at the gate, until the power to the SCR is turned off, at which point current ceases to flow.

	Physical Appearance	Schematic Symbol
Bridge Rectifier		

Function: Rectifiers convert alternating current (AC) into direct current (DC). There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is one of them, and it is available in special packages containing the four diodes that are required. Bridge rectifiers are rated by their maximum current and maximum reverse voltage. They have four leads or terminals. They are commonly used in power supplies.

	Physical Appearance	Schematic Symbol
Light Emitting Diode		
7 Segment Display		

Function: LEDs are diodes that emit light when an electrical current passes through them.

Learning Activity 2.5

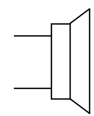
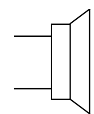
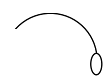
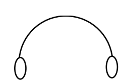
Diodes

1. Draw the schematic symbol for the power diode three times.
2. Draw the schematic symbol for the zener diode three times.
3. Draw the schematic symbol for the SCR three times.
4. Draw the schematic symbol for the bridge rectifier three times.
5. Draw the schematic symbol for the LED three times.

Note: Diodes have polarity—that is, they have a negative and a positive leg. When you are connecting any of these types of devices to a circuit, you must make sure that they are put in the right direction or they will not work.

Speakers

There are hundreds of different types of speakers. Here are a few.

	Physical Appearance	**Schematic Symbol**
Miniature Loudspeaker		
6 × 9 Speaker		
Headphone (single)		
Headphone (double)		

Function: A speaker is a transducer in that it transforms one type of energy into another. In this case, it turns electrical energy into mechanical energy that our ears interpret as sound.

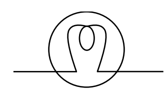
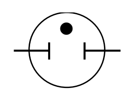
Learning Activity 2.6

Speakers

1. Draw the schematic symbol for a speaker three times.
2. Draw the schematic symbol for a single headphone three times.
3. Draw the schematic symbol for a double headphone three times.

Lamps

Lamps come in many shapes and sizes and use various voltages.

	Physical Appearance	**Schematic Symbol**
Incandescent		
Neon Bulb		

Function: The purpose of a lamp is to change electrical energy into light energy.

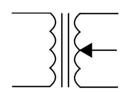
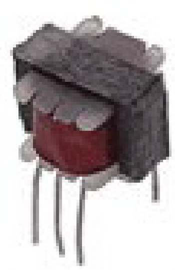
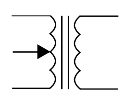
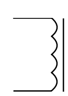
Learning Activity 2.7

Bulbs

1. Draw the schematic symbol for an incandescent bulb three times.
2. Draw the schematic symbol for a neon bulb three times.

Transformers and Chokes

A transformer is several coils of insulated wire placed in close proximity to one another. A choke is basically half of a transformer.

	Physical Appearance	Schematic Symbol
Power Transformer		
Miniature Audio Transformer		
Choke		

Function: The purpose of a transformer or choke is to increase or decrease current or voltage through the process of magnetic induction, which will be discussed later in this course.

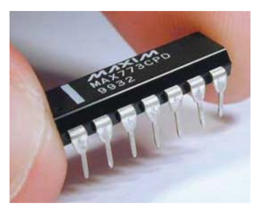
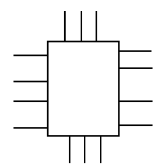
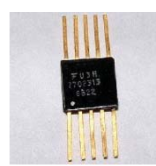
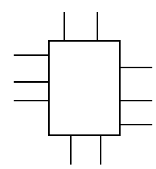
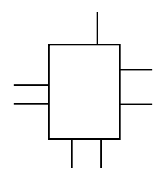
Learning Activity 2.8

Transformers and Chokes

1. Draw the schematic symbol for a power transformer three times.
2. Draw the schematic symbol for an audio transformer three times.
3. Draw the schematic symbol for a choke three times.

Integrated Circuits or ICs

There are hundreds of types of semi-conductors. We shall take a look at a few of them.

	Physical Appearance	Schematic Symbol
Dual Inline Package (DIP)		
Flat Pack		
Round		

Note: A chip schematic symbol's legs should match the number of legs actually on the chip. They don't have to be in any particular arrangement on the schematic.

Purpose: The integrated circuit's purpose is to take a very large number of circuits and electrical connections and shrink them down to a very small size.

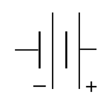
Learning Activity 2.9

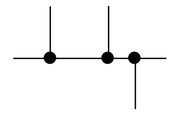
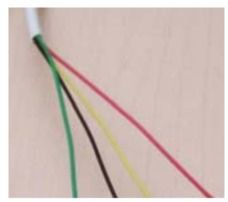
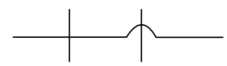
Circuits

1. Draw the schematic symbol for an integrated circuit three times.

Other Miscellaneous Components

There are hundreds if not thousands of small electrical parts or components that are used in electronics. Each one has a schematic symbol. Here are a few common components that you will come across in your electronics adventures.

	Physical Appearance	**Schematic Symbol**
Battery	 	
Battery Clips/Holder	 	

	Physical Appearance	Schematic Symbol
Wire		
Wires Hooked Together (the little circles indicate a connection and are called nodes)		
Wires Not Hooked Together		

Learning Activity 2.10

Circuits

1. Draw the schematic symbol for a battery three times.
2. Draw the schematic symbol for wires hooked together three times.
3. Draw the schematic symbol for wires not hooked together three times.

It is now time for you to complete Assignment 2.2. This assignment (along with all other assignments) is worth marks and you will either mail or electronically submit it to the Distance Learning Unit when you have completed Module 2.

Notes

Assignment 2.2

Schematic Symbols *(53 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 2.

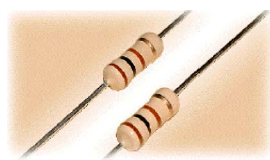
1. What do schematic symbols represent? *(1 mark)*

    ____

    ____

For the following electronic components, draw the schematic symbol and write down the component's basic function.

Resistors *(4 marks)*

	Physical Appearance	**Schematic Symbol**
Carbon Resistor		
Potentiometer/ Trimmer	 	
Photocell		

(continued)

Basic Function of Resistors

____

____

Capacitors *(4 marks)*

Indicate whether each one has a positive or negative leg.

	Physical Appearance	**Schematic Symbol**
Ceramic Disc Capacitor (no negative or positive leg)		
Electrolytic Capacitor (polarized)		
Variable Capacitor		

Basic Function of Capacitors

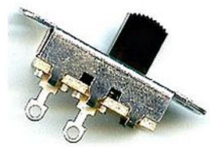
____

____

(continued)

Assignment 2.2: Schematic Symbols (continued)

Switches *(8 marks)*

	Physical Appearance	Schematic Symbol
Slide Switch (SPST) (single pole single throw or referred to as an SPST)		
Slide Switch (DPDT) (double pole double throw or referred to as a dpdt)		
Pushbutton Switch (N.O.) (momentary normally open)		
Pushbutton Switch (N.C.) (momentary normally closed)		
Toggle Switch		
Rocker Switch		
Light Switch		

(continued)

Basic Function of Switches

____

____

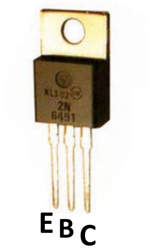
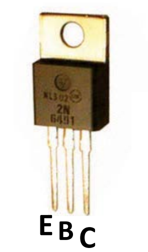
General Purpose Transistors *(2 marks)*

	Physical Appearance	Schematic Symbol
Transistor (PNP)	 E B C or 	
Transistor (NPN)	 E B C or 	

(continued)

Assignment 2.2: Schematic Symbols (continued)

Power Transistors *(3 marks)*

	Physical Appearance	**Schematic Symbol**
Power Transistor (PNP)	 or 	
Power Transistor (NPN)	 or 	

Basic Function of Transistors

____

____

(continued)

Assignment 2.2: Schematic Symbols (continued)

Diodes or Rectifiers *(11 marks)*

Label the cathode and the anode (+ and – sides) for each one.

	Physical Appearance	**Schematic Symbol**
Power Diode		

Basic Function of Power Diodes

____

____

	Physical Appearance	**Schematic Symbol**
Zener Diode		

Basic Function of Zener Diodes

____

____

(continued)

Assignment 2.2: Schematic Symbols (continued)

	Physical Appearance	Schematic Symbol
Silicon Controlled Rectifier (SCR)		

Basic Function of SCRs

____

____

	Physical Appearance	Schematic Symbol
Bridge Rectifier		

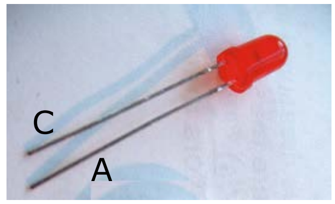
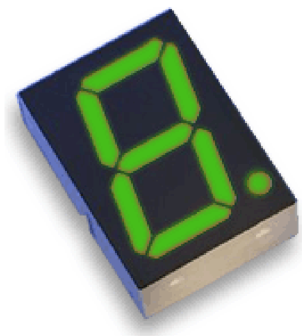
Basic Function of Bridge Rectifiers

____

____

(continued)

Assignment 2.2: Schematic Symbols (continued)

	Physical Appearance	Schematic Symbol
Light Emitting Diode		
7 Segment Display		

Basic Function of LEDs

____

____

(continued)

Assignment 2.2: Schematic Symbols (continued)

Speakers *(5 marks)*

	Physical Appearance	**Schematic Symbol**
Miniature Loudspeaker		
6 x 9 Speaker		
Headphone (single)		
Headphone (double)		

Basic Function of Speakers

____

____

(continued)

Lamps *(3 marks)*

	Physical Appearance	Schematic Symbol
Incandescent		
Neon Bulb		

Basic Function of Lamps

____

____

(continued)

Assignment 2.2: Schematic Symbols (continued)

Transformers and Chokes *(4 marks)*

	Physical Appearance	**Schematic Symbol**
Power Transformer		
Miniature Audio Transformer		
Choke		

Basic Function of Transformers or Chokes

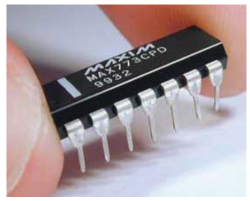
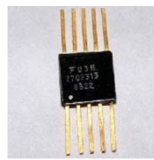
____

____

(continued)

Assignment 2.2: Schematic Symbols (continued)

Integrated Circuits or ICs *(4 marks)*

	Physical Appearance	**Schematic Symbol**
Dual Inline Package (DIP)		
Flat Pack		
Round		

Basic Function of Integrated Circuits

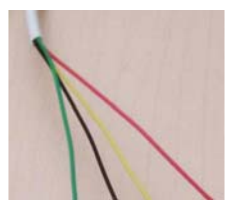
____

____

(continued)

Assignment 2.2: Schematic Symbols (continued)

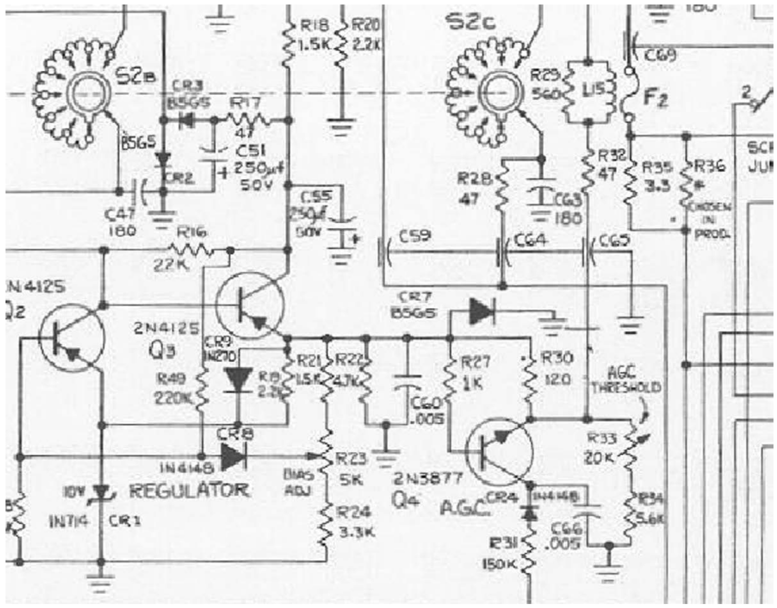
Other Components *(4 marks)*

	Physical Appearance	**Schematic Symbol**
Battery		
Wire		
Wires Hooked Together (the little circles indicate a connection and are called nodes)		
Wires Not Hooked Together		

Notes

LESSON 4: SCHEMATIC DIAGRAMS

Introduction



In the previous lesson, you were shown many electronic components and their corresponding schematic symbol. We use schematic symbols in electronics to show how electrical components are connected together. There is no magic way to become good at remembering them or drawing them. It just takes time and practice.

The best way to understand the drawings is to compare them to a picture diagram of what the actual components in the circuit look like. Picture diagrams are for people who do not understand the technical language. Schematics are for people who are working in the field of electronics in some capacity.

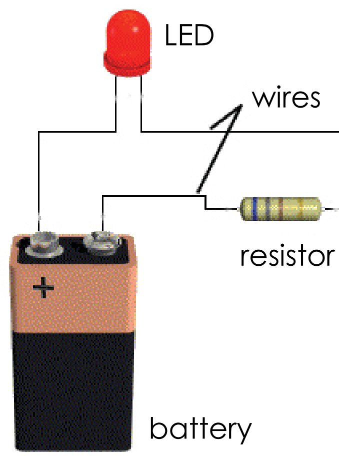
Things to remember

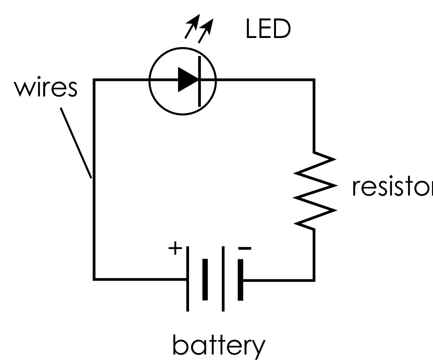
- Each schematic symbol represents one electronic component.
- The lines connecting the schematic symbols together are actually wires or copper traces on a circuit board.
- The lines in the schematic show how the components are connected together.

Check Out This Example

Here we have a drawing of a simple circuit. The circuit consists of a battery with wires connected to both poles. One is connected to the resistor, and the other is connected to the cathode of the LED and then finally back to the battery (the cathode refers to the negative leg of the LED).

On the right, we have a schematic circuit drawing of a battery that is connected to a wire. The wire is then connected to the resistor; another wire is connected to the cathode of the LED, and then finally back to the battery.



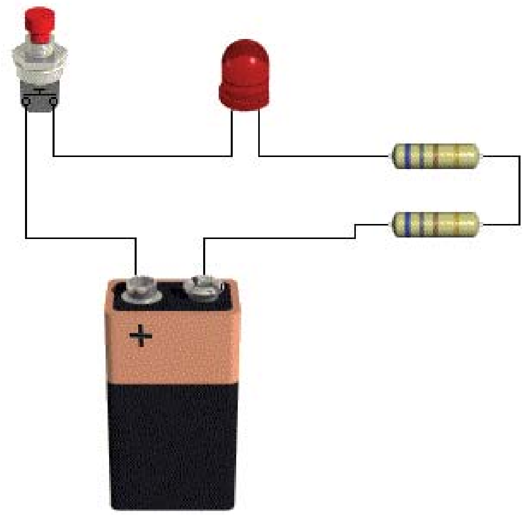


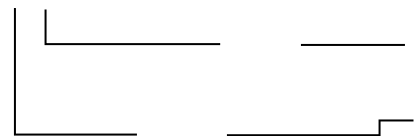
Note that these diagrams depict exactly the same thing. The diagram on the left-hand side of the page is an artistic drawing. The schematic drawing on the right is a drawing of the circuit using the language of electronics.

Let's get some practice drawing using schematic symbols. Do the next one in the space below. On the left is a circuit containing five components. On the right is the space where you are to draw in the schematic symbols to complete the circuit. Refer to the schematic diagrams in the previous lesson if you need a reminder on how to draw the schematic symbols.

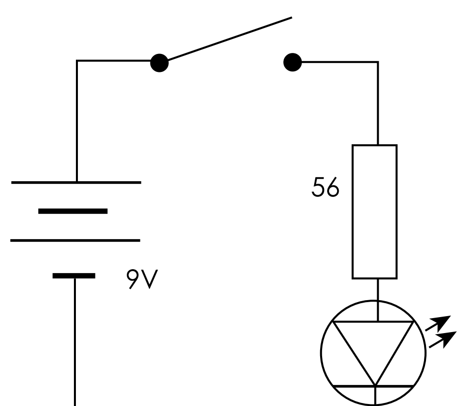
Learning Activity 2.11

Schematic Diagrams

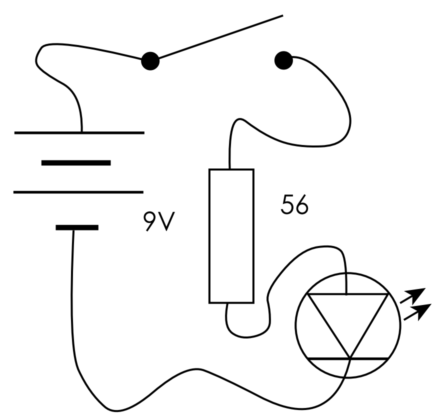




Just like everything that you do, there is a right and wrong way to do it. Look at the diagrams below. One is an example of how you should draw a circuit diagram; the other is how you should not.



Good
(clear and tidy) ✔



Bad ✗
(wires not straight and poor layout of symbols)

It is now time for you to complete Assignment 2.3. This assignment (along with all other assignments) is worth marks and you will either mail or electronically submit it to the Distance Learning Unit when you have completed Module 2.

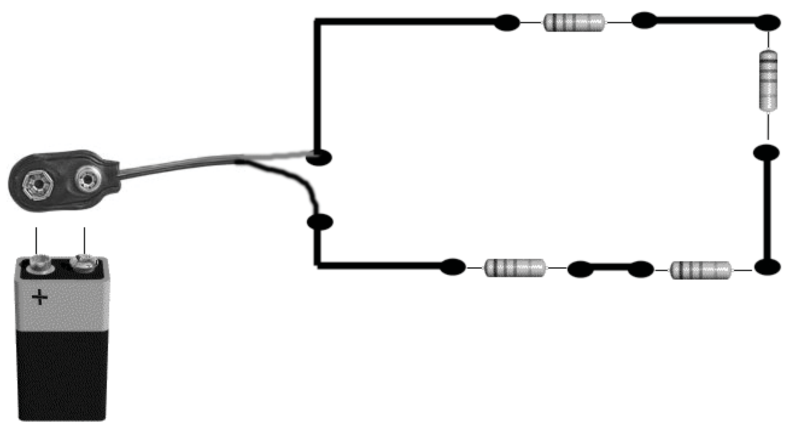
Assignment 2.3

Schematic Drawings *(16 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 2.

Draw the schematic circuit from the circuit diagrams below. You may wish to draw a practice circuit on a scrap piece of paper before you draw in your good copy that you will submit to the Distance Learning Unit. *(Each drawing is worth 2 marks for a total of 16 marks.)*

1. Circuit Diagram

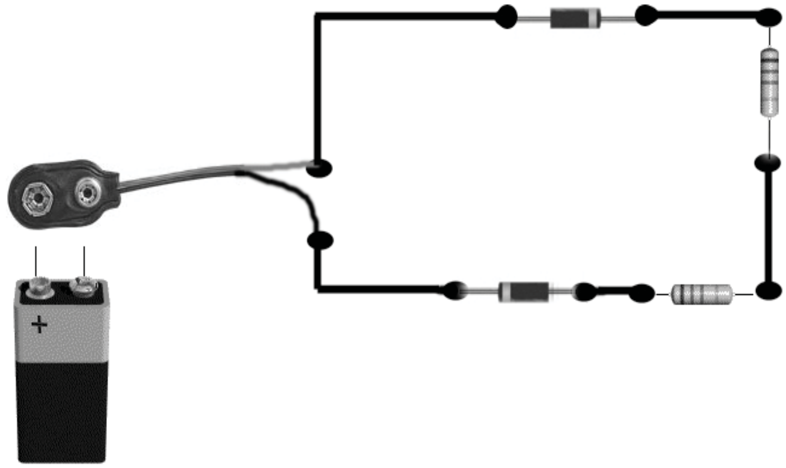


Schematic Drawing *(2 marks)*

(continued)

Assignment 2.3: Schematic Drawings (continued)

2. Circuit Diagram

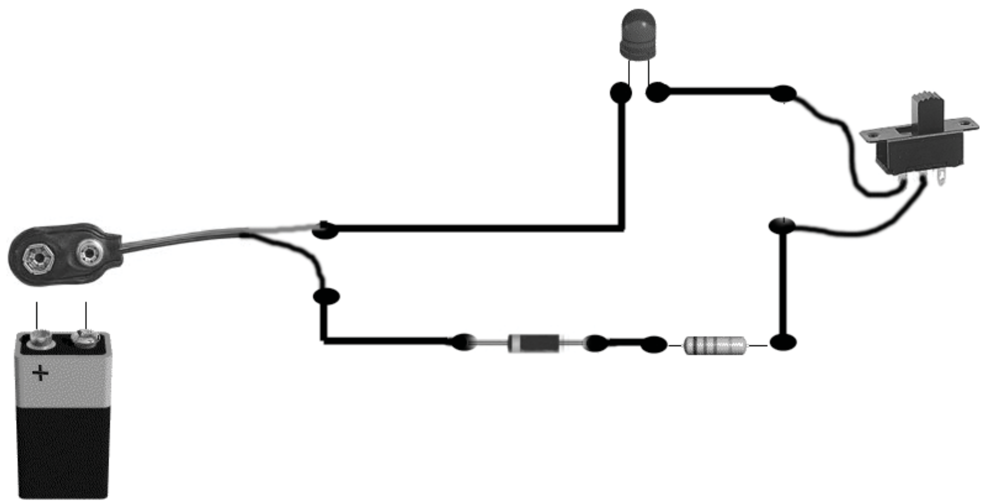


Schematic Drawing *(2 marks)*

(continued)

Assignment 2.3: Schematic Drawings (continued)

3. Circuit Diagram

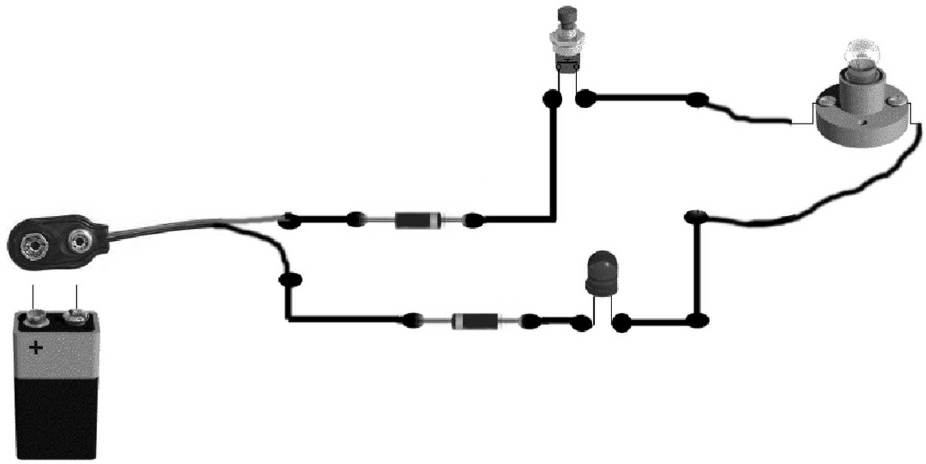


Schematic Drawing *(2 marks)*

(continued)

Assignment 2.3: Schematic Drawings (continued)

4. Circuit Diagram

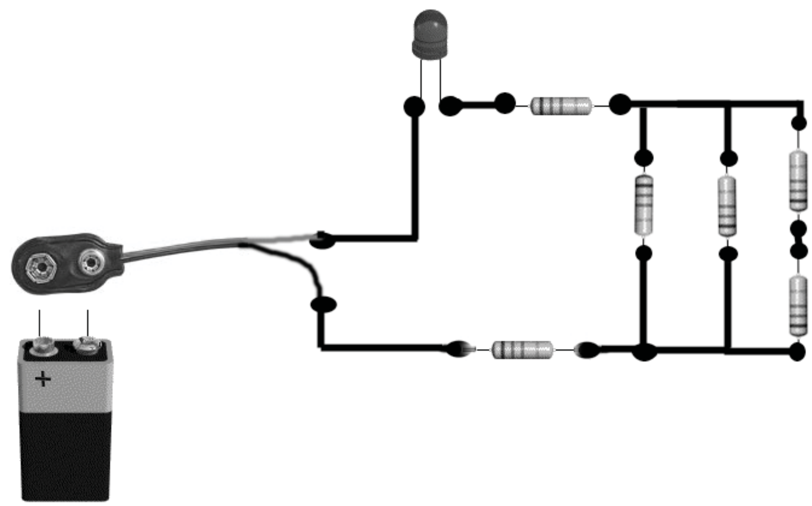


Schematic Drawing ***(2 marks)***

(continued)

Assignment 2.3: Schematic Drawings (continued)

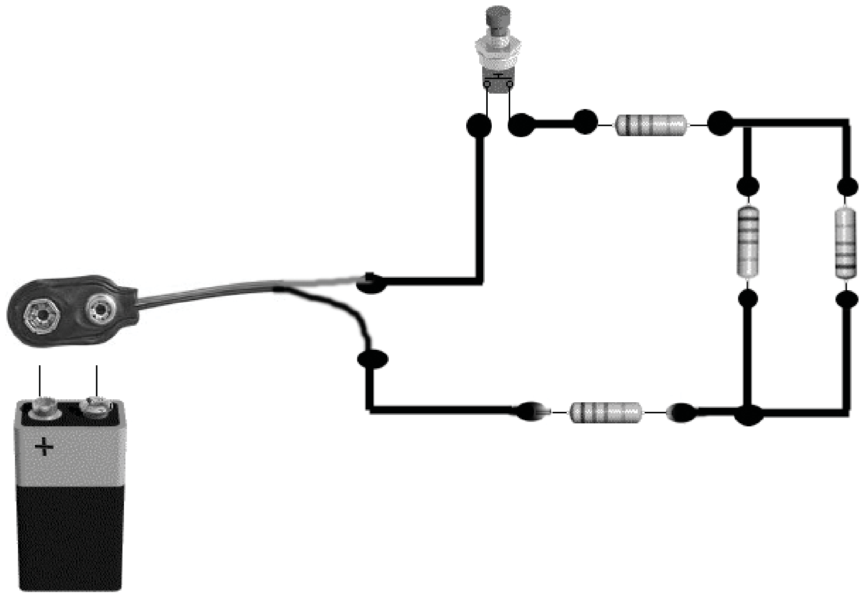
5. Circuit Diagram



Schematic Drawing ***(2 marks)***

(continued)

6. Circuit Diagram

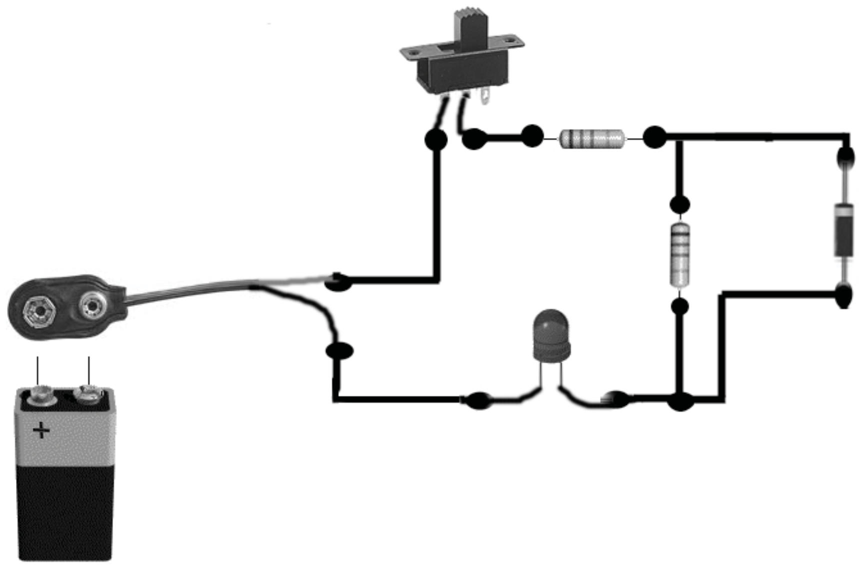


Schematic Drawing ***(2 marks)***

(continued)

Assignment 2.3: Schematic Drawings (continued)

7. Circuit Diagram

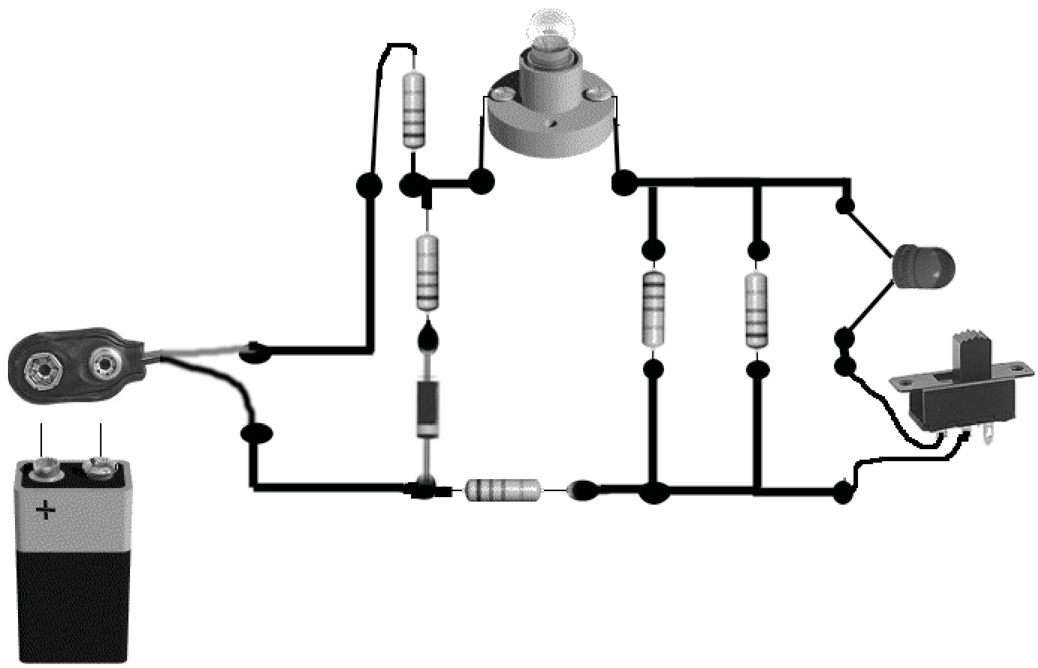


Schematic Drawing ***(2 marks)***

(continued)

Assignment 2.3: Schematic Drawings (continued)

8. Circuit Diagram



Schematic Drawing ***(2 marks)***

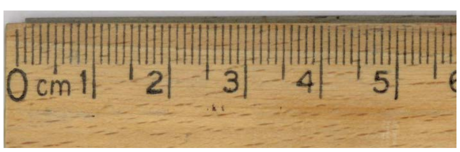
LESSON 5: METRIFICATION AND CONVERSION OF SI UNITS

Making Sense of Numbers

As you work through electronics labs, projects, and experiments, you will encounter very large or very small numbers. You will find that some of the numbers that you work with may have decimal points or many extra zeros. Those zeros and decimal points mean a world of difference. We are about to learn how to write and understand numbers without having to use too many zeros in our final answers. Adding a prefix to a number will help reduce all the zeros.

Check This Out!

A good comparison to what you will be doing is the system used to express measurement and weight. In measurement, you would always write 1000 metres as 1 kilometre or .001 grams as 1 milligram.

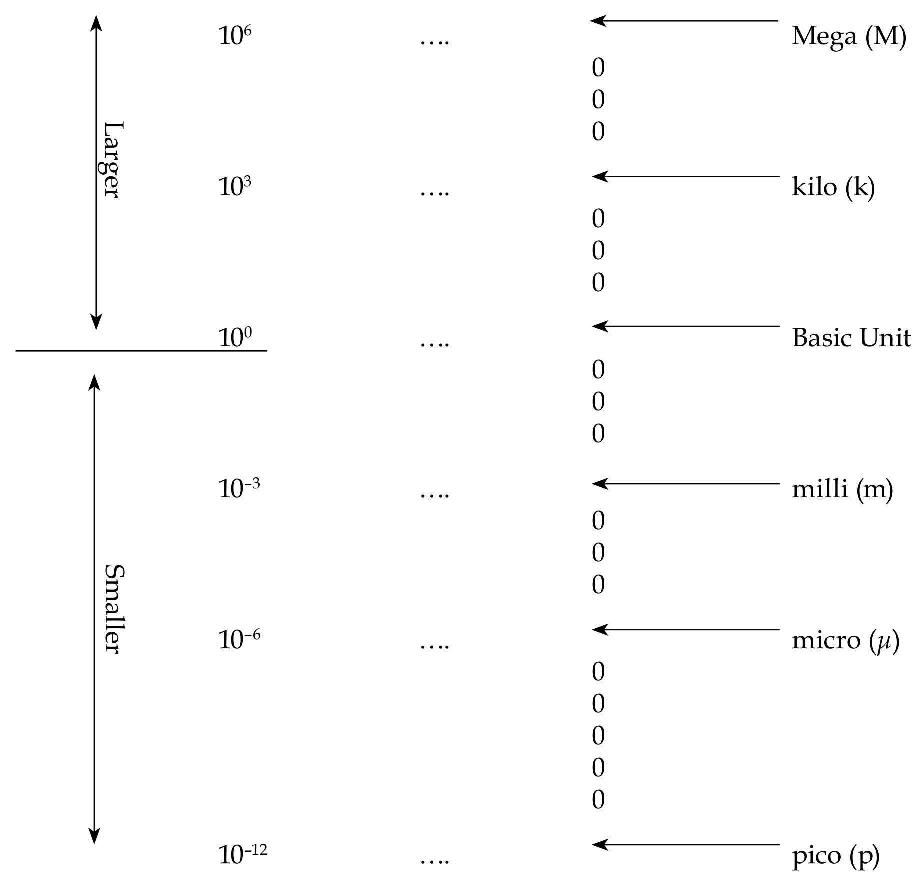


Common Electrical SI Units and Symbols			
Quantity	**Abbreviation**	**Basic SI Unit**	**SI Unit Symbol**
Electrical Potential Energy Difference	V	volt	V
Electric Current	I	ampere	A
Resistance	R	ohm	Ω
Electric Power	P	watt	W
Capacitance	C	farad	F

All you need to remember is that this system is used to physically shorten or abbreviate the number so that it will not be so long.

Common Prefixes			
tera	T	one trillion	(10^{12})
giga	G	one billion	(10^{9})
mega	M	one million	(10^{6})
kilo	k	one thousand	(10^{3})
volt, amp, ohm, watt	standard/base unit		
milli	m	one-thousandth	(10^{-3})
micro	μ	one-millionth	(10^{-6})
nano	n	one-billionth	(10^{-9})
pico	p	one-trillionth	(10^{-12})

Conversion Units



To keep things simple, remember these rules of how to use the chart. Know that all you will be doing is moving the decimal from where you see it to the left or to the right.

When you are moving up in the chart to **L**arger numbers, move the decimal to the **L**eft: **L**arger = **L**eft.

When you are moving down in the chart to smalle**R** numbers, move the decimal place to the **R**ight: **R**ight = smalle**R**.

Move the decimal place the amount of times from where it starts to where it is going.

This is how to use the chart on the previous page. Let's say you measured a resistance value that was fairly large, much like the body resistance value you will measure in the next lesson. You will get the relatively long version of the number, 1500 ohms. You could have read this value with a DMM (Digital Multimeter). There is nothing wrong with how this value is written, but it can be shortened to 1.5 kW (or 1.5 kilo ohms). Both the values are correct, but the second version did not require so many digits. By using the chart, you moved the decimal three positions to the left. If your number was .001 amps, to reduce the decimal places, go up in the chart to Larger numbers and move the decimal to the Left three places to get the number 1 milli amp. The prefix milli was added to reduce the zeros.

150,000 volts = 1.5 Megavolts: you moved up in the chart from the base standard unit to the **L**arger values of Mega, so you moved the decimal to the **L**eft six times as that is the place difference between these values.

.000000068 watts = 68 Nanowatts: you moved down in the chart from a base standard unit to the smalle**R** unit of nano, so you moved the decimal place to the **R**ight nine times.

This is how to use the chart on this page. Let's say you measured a resistance value that was fairly large. You would get the relatively long version of the number—1500 ohms. You could have read this value with a DMM (digital multimeter). There is nothing wrong with how this value is written, but it can be shortened to 1.5 kΩ (or 1.5 kilo ohms, spelt "kilohms"). Both the values are correct, but the second version did not require so many digits. By using the chart, you moved the decimal three positions to the left.

In the next example, instead of using ohms as your unit, you will use volts or voltage. Convert 15 M ohms or 15 mega ohms (spelt "megohms") to the basic unit in ohms.

Find the prefix *mega* on the chart. To convert the basic unit, you must convert or move to the right six positions or decimal places.

15 000000

By using the number 15 and doing this, the answer becomes 15,000,000 ohms. Once again, remember that 15,000,000 ohms and 15 megohms are exactly the same thing. One is just written a lot shorter.

Use the 15,000,000 ohms value for this question

.

Learning Activity 2.12

Metric

Question: What would 15,000,000 ohms look like if we converted it into kilohms? Don't forget to use the chart on the previous page.

Remember, it does not matter which unit you use in this conversion process. All you are trying to do is make the value shorter so that, if you have a very small electronics part, the value could be written right on it. Besides, who wants to waste time writing out zeros?

Check your answer in the Learning Activity Answer Keys found at the end of this module.

It is now time for you to complete Assignment 2.4. This assignment (along with all other assignments) is worth marks and you will either mail or electronically submit it to the Distance Learning Unit when you have completed Module 2.

Assignment 2.4

Working with the Metric System *(33 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 2.

Part 1: Provide the prefix and value of the following units of measurement. *(14 marks)*

In order to complete this assignment, don't forget to use the charts found in Lesson 5.

Question	Unit	Prefix	Value
1	giga	G	10^9
2	milli		
3	tera		
4	nano		
5	micro		
6	mega		
7	kilo		
8	pica		

(continued)

Assignment 2.4: Working with the Metric System (continued)

Part 2: Convert the following to the unit indicated. Refer back to the conversion chart to do this section if you need to. *(11 marks)*

Question			
1	0.02 A =		mA
2	3.42 A =		*μ*A
3	0.042 V =		mV
4	25 mA =		A
5	3.58 mHy =		*μ*Hy
6	13.5 kV =		V
7	0.00045 MΩ =		kΩ
8	165000 Ω =		MΩ
9	470 pFd =		nFd
10	12000 pFd =		*μ*Fd
11	6 pFd =		nFd

(continued)

Assignment 2.4: Working with the Metric System (continued)

Part 3: From the ***letter symbol*** of each of the common SI prefixes, write the correct full description of what each letter symbol means. An example is done for you. *(8 marks)*

Question		Answer
Example:	M	*Answer:* Mega
1	m	
2	T	
3	n	
4	μ	
5	G	
6	k	
7	p	
8	M	

Notes

Lesson 6: Resistors

Introduction

What is a resistor? A resistor is an electrical component used in an electrical circuit that resists the flow of electrical current. A resistor has two leads or ends that electrical current must pass through. A resistor is primarily used to control the flow of electrical current or electron flow.

Resistance is measured in **ohms, Ω**. A high ohm rating indicates a high resistance to current. This rating can be written in a number of different ways depending on the ohm rating. For example, 81 R represents 81 ohms, while 81 k represents 81,000 ohms (k is an abbreviation often used meaning kilo or one thousand).

The amount of resistance offered by a resistor is determined by its physical construction. A carbon composition resistor has resistive carbon packed into a ceramic cylinder, while a carbon film resistor consists of a similar ceramic. Metal film or metal oxide resistors are made much the same way but with metal instead of carbon. A wire-wound resistor, made with metal wire wrapped around clay, plastic, or fibreglass tubing, offers resistance at higher power levels. For applications that must withstand high temperatures, materials such as cermet, a ceramic-metal composite, or tantalum, a rare metal, are used to build a resistor that can endure heat.

Resistors are one of the most common electronic components and can be found in every electronic gadget made. Without them, we would be unable to control the current.

Resistors are rated in three ways:

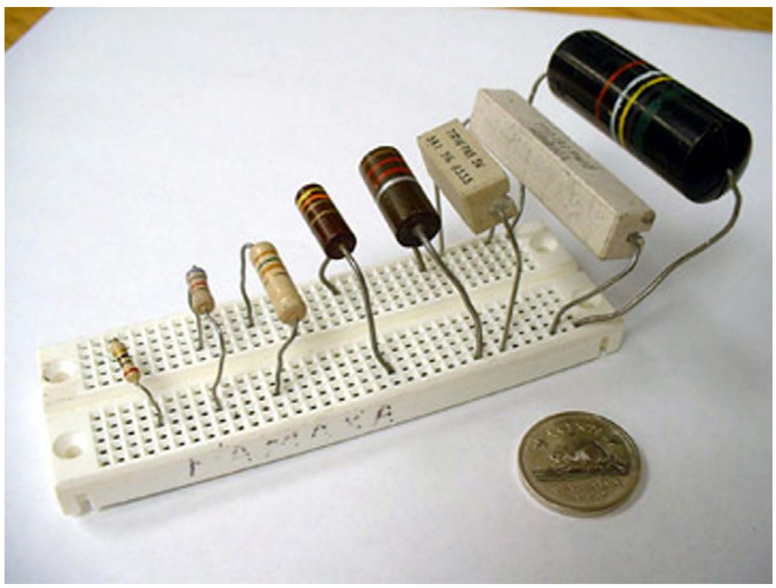
1. Measurement in **ohms**

2. **Tolerance** or accuracy rating

   In the manufacturing process of resistors, it would be virtually impossible to give every small resistor an exact ohmatic rating. That is why a tolerance system, measured by a set percentage, is used for each resistor. The goal is to find a resistor with a very small tolerance rating. We will take a closer look at resistor tolerances later in this section.

3. **Heat dissipation**

   Each resistor can oppose a certain amount of current, which produces heat. This heating of the resistor is not good, so the right size of resistor must always be used.

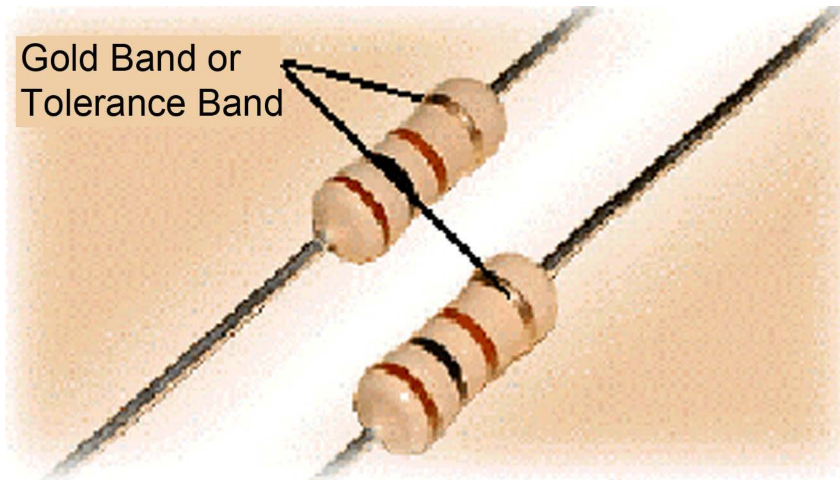


The larger the resistor, the larger the **power** rating in **watts**. Or the larger the resistor, the more heat it can **dissipate** safely without exploding.

How do we know what each resistor's value is?

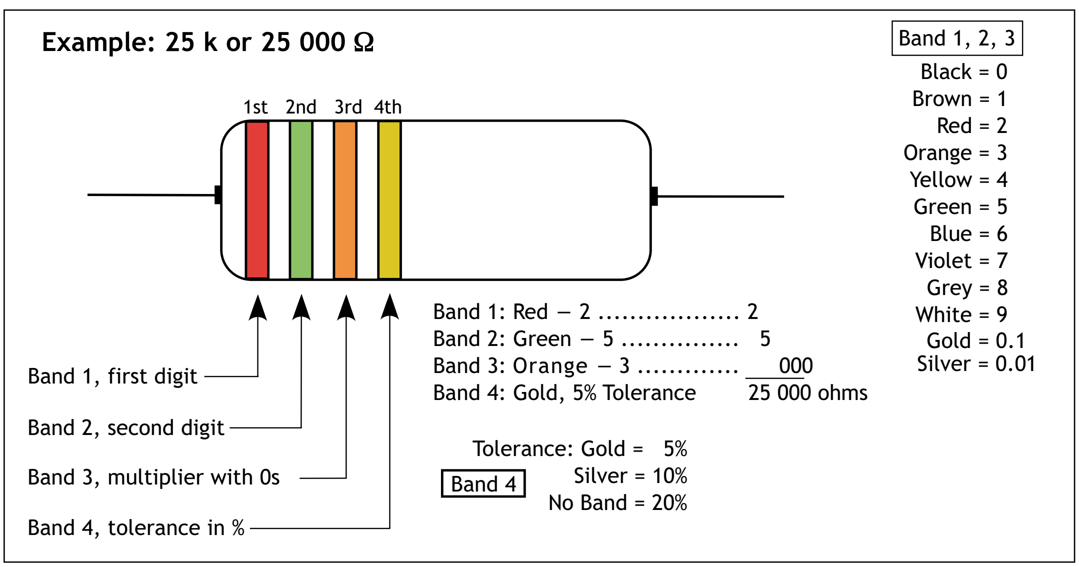
Each resistor contains a certain amount of resistance, which is measured in ohms. Some resistors are so small, however, that we cannot write down the value right on them. If we did, it would be so small that you wouldn't be able to read it. To solve this problem, the scientific community came up with a way that we can figure out the value. That system is called the **resistor colour code**.

Little coloured bands encircle the whole body of the resistor. Each band colour represents a given number or calculation technique. Observe the diagram below of a common carbon resistor and the chart that explains what each colour means.



Note: Always hold the resistor with the gold or silver band to the right when you are looking at it.

The chart below shows how a typical resistor colour code can be used.

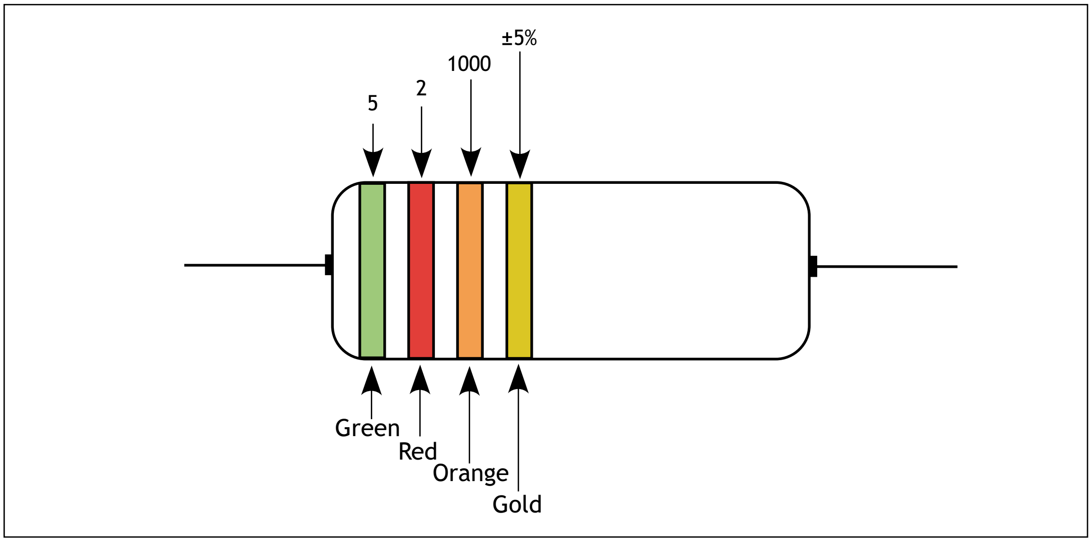


The following chart identifies the numbers and colour combinations used for electronic resistor identification.

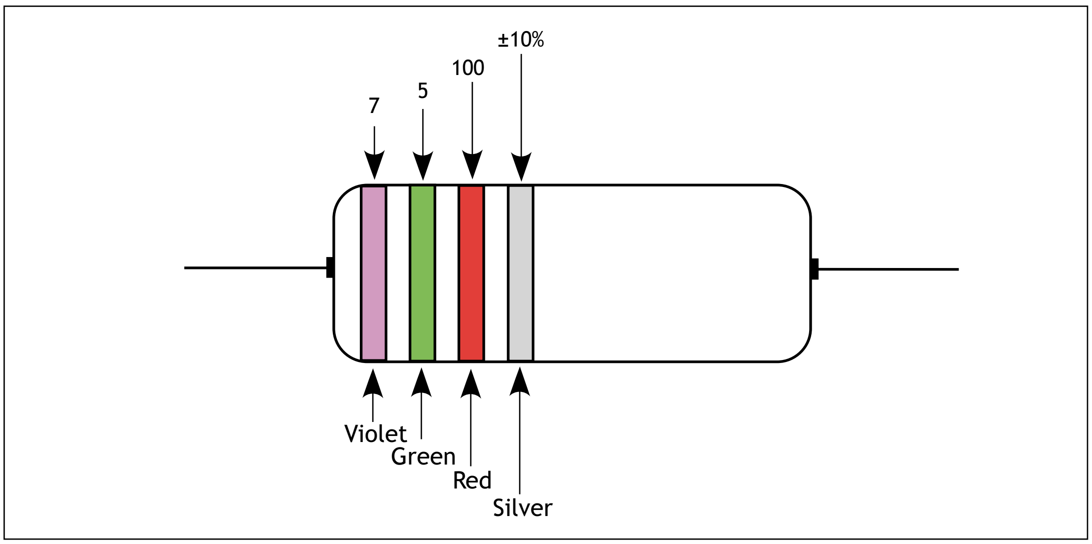
Resistor Colour Code Chart				
Colour	**1st Number**	**2nd Number**	**Multiplier**	**Tolerance (Percent)**
Black	0	0	1	
Brown	1	1	10	
Red	2	2	100	
Orange	3	3	1 000	
Yellow	4	4	10 000	
Green	5	5	100 000	
Blue	6	6	1 000 000	
Violet	7	7	10 000 000	
Grey	8	8	100 000 000	
White	9	9	1 000 000 000	
Gold			0.1	5%
Silver			0.01	10%
None				20%
	Band 1	Band 2	Band 3	Band 4

The following examples show you how to read the coloured bands on a typical carbon resistor. Remember, each colour on the resistor is referenced on the chart on the previous page.

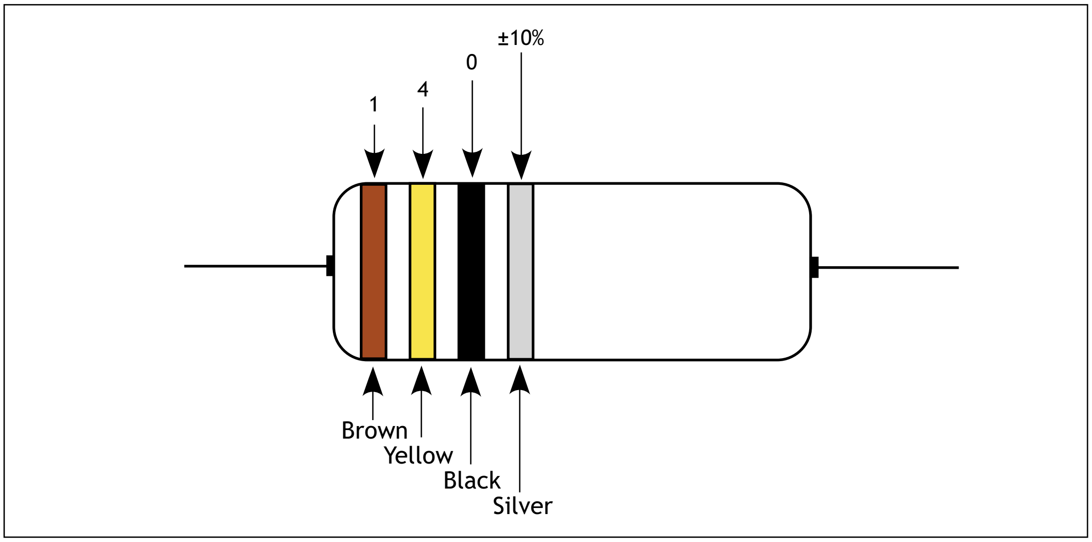
Example 1: 52000 Ω ± 5% or 52 kΩ ± 5%



Example 2: 7500 Ω ± 10% or 7.5 kΩ ± 10%



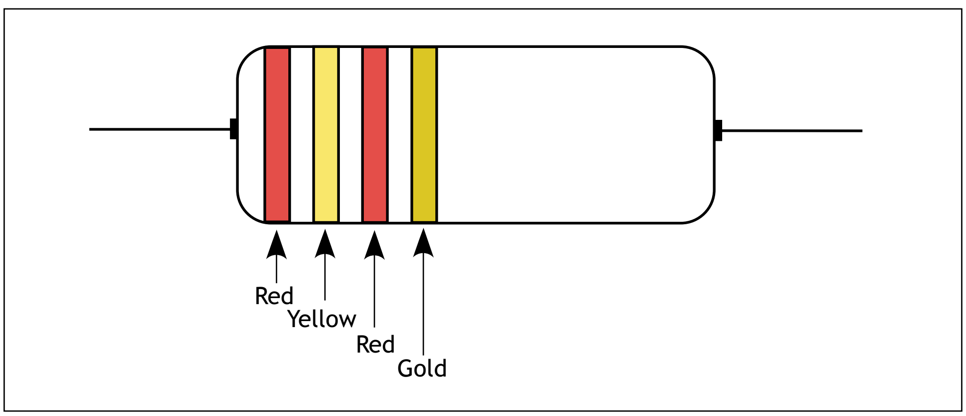
Example 3: 14 Ω ± 10%



Learning Activity 2.13

Resistors

Calculate the resistance value for the following two resistors.

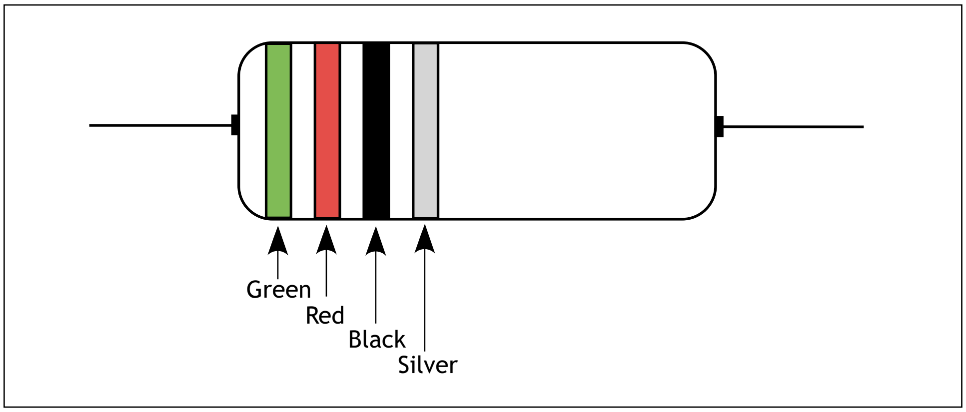


Ohm value:

Tolerance:

(continued)

Learning Activity 2.13: Resistors (continued)



Ohm value:

Tolerance:

Each answer should include the number, the unit, and the tolerance "±."

Check your answers in the Learning Activity Answer Keys found at the end of this module.

It is now time for you to complete Assignment 2.5. This assignment (along with all other assignments) is worth marks and you will either mail or electronically submit it to the Distance Learning Unit when you have finished Module 2.

Notes

Assignment 2.5

Resistors *(48 marks)*

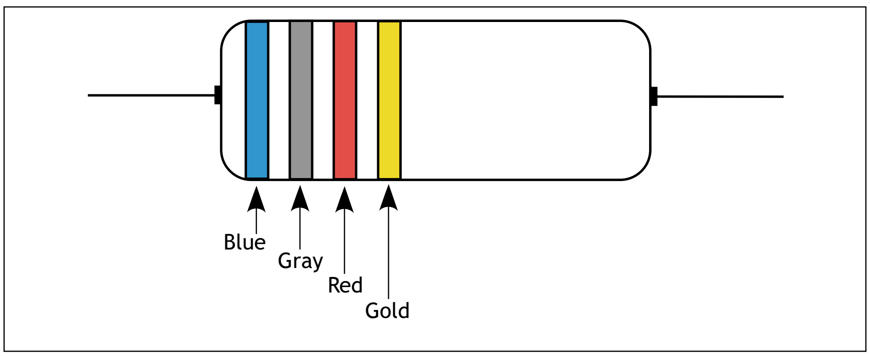
Part 1: Calculating Resistor Colour Codes ***(24 marks)***

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 2.

Calculate the values of the following resistors in the space provided. *(Each answer is worth 2 marks, for a total of 24 marks.)*

Note: All correct answers have a number value, a unit reference, and a tolerance value (+/−).

Example



1st Band	2nd Band	3rd Band	4th Band
6	8	00	5%

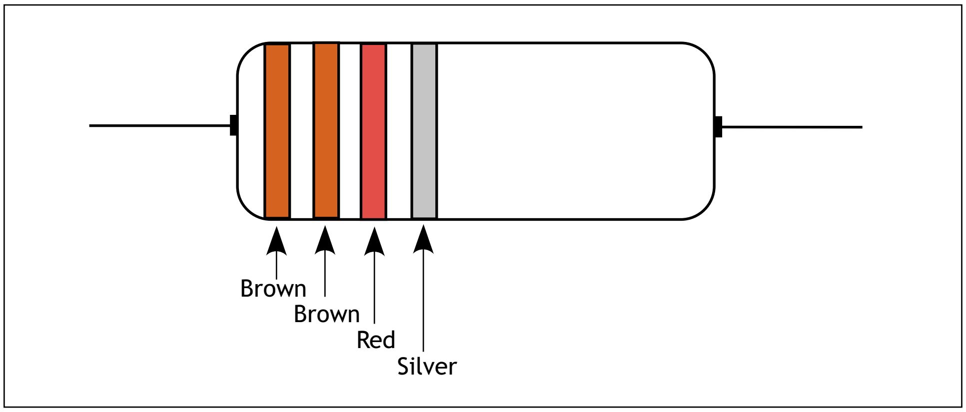
Final Answer: 6,800 Ω or 6.8 kΩ ±5%

(continued)

Assignment 2.5: Resistors (continued)

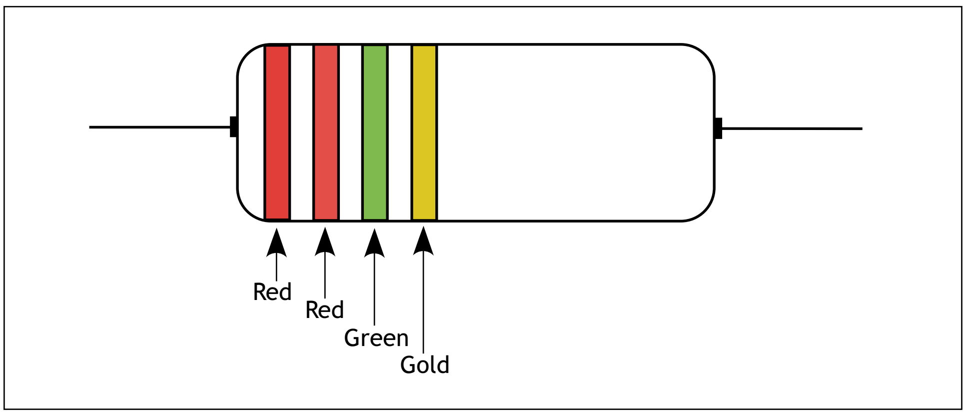
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	0
Gold	±5%
Silver	±10%
None	±20%

1.



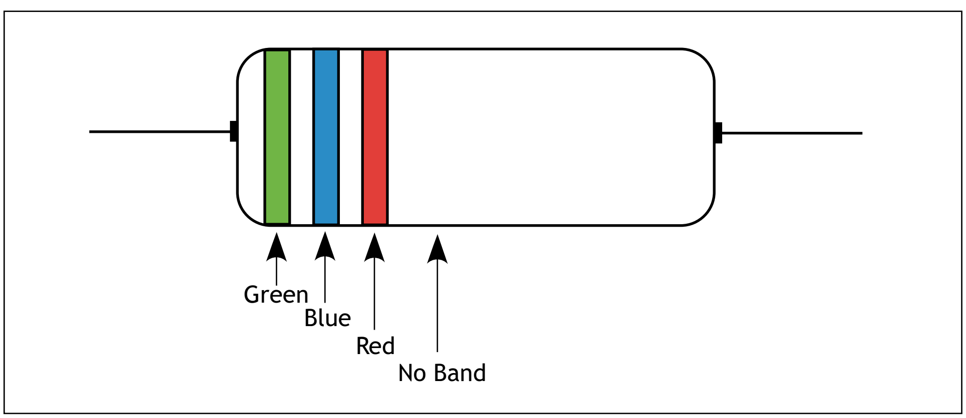
Final Answer: ____________________

2.



Final Answer: ____________________

3.



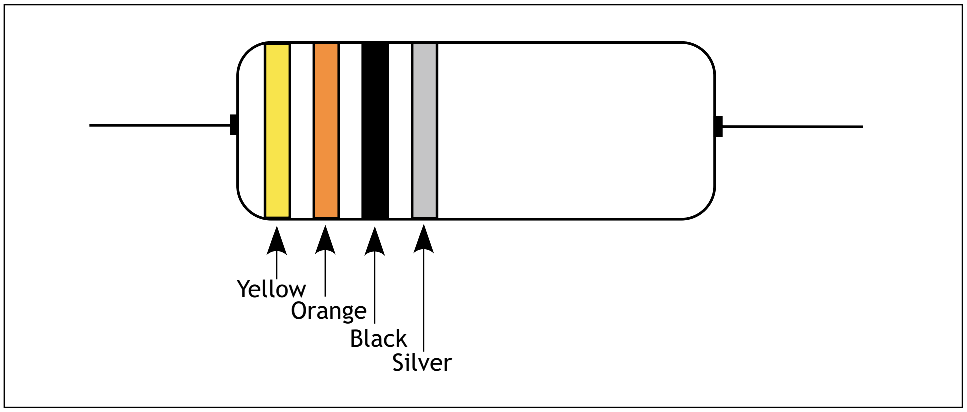
Final Answer: ____________________

(continued)

Assignment 2.5: Resistors (continued)

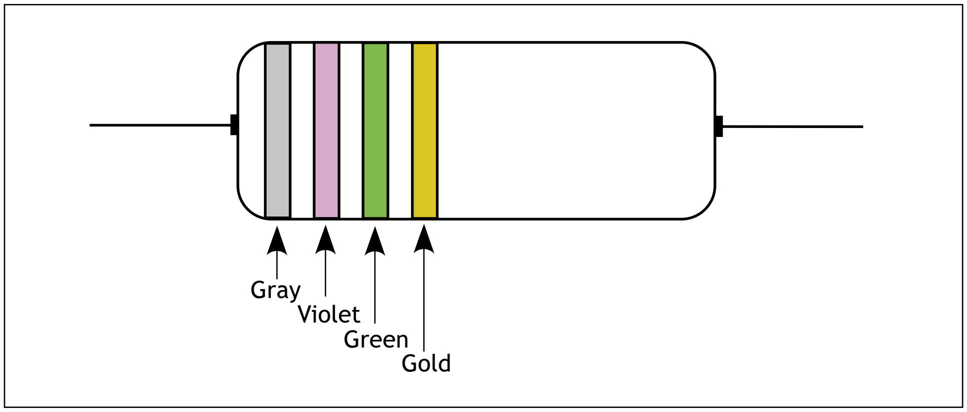
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	0
Gold	±5%
Silver	±10%
None	±20%

4.



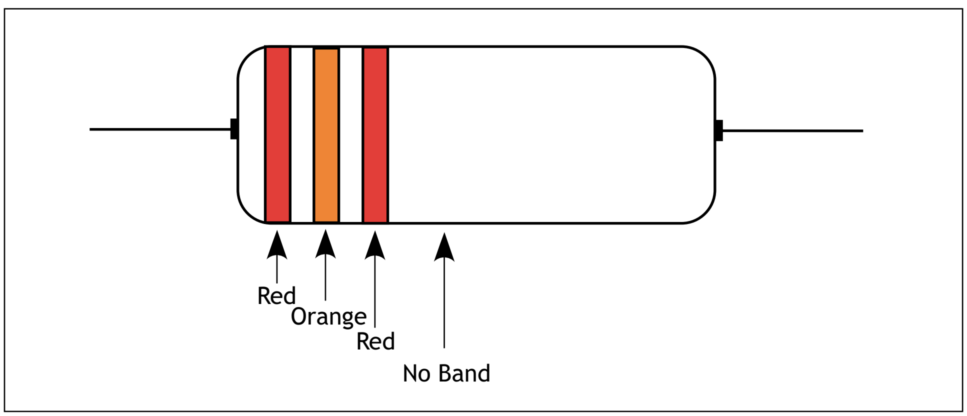
Final Answer: ______________________________

5.



Final Answer: ______________________________

6.



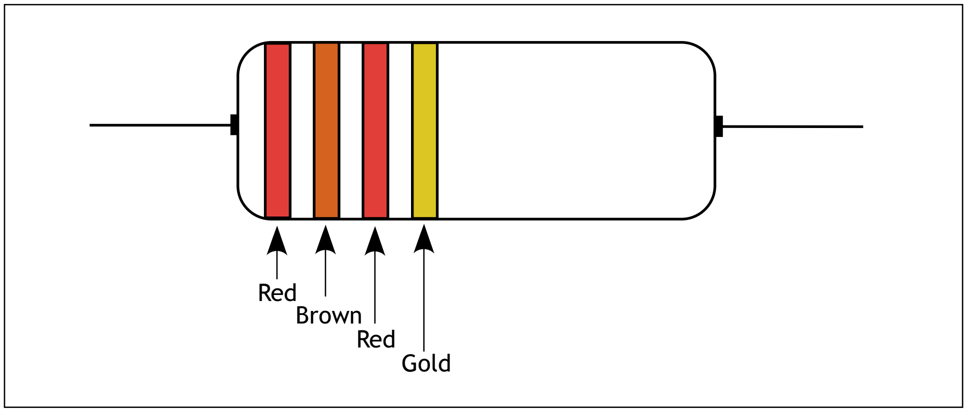
Final Answer: ______________________________

(continued)

Assignment 2.5: Resistors (continued)

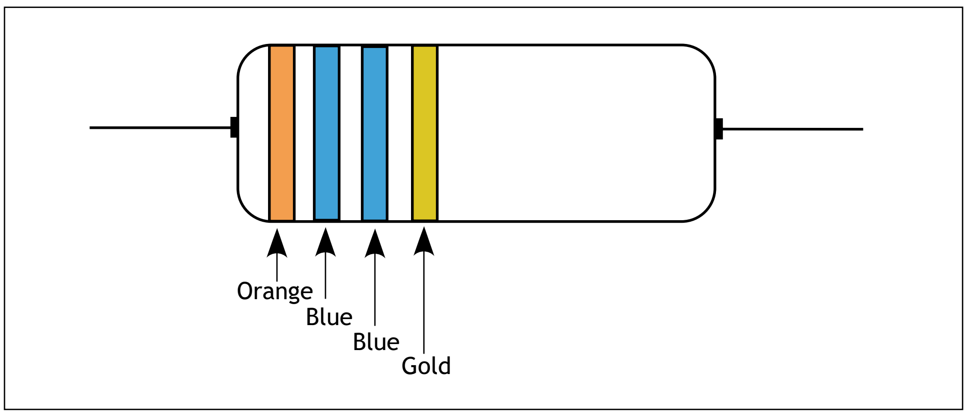
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	0
Gold	±5%
Silver	±10%
None	±20%

7.



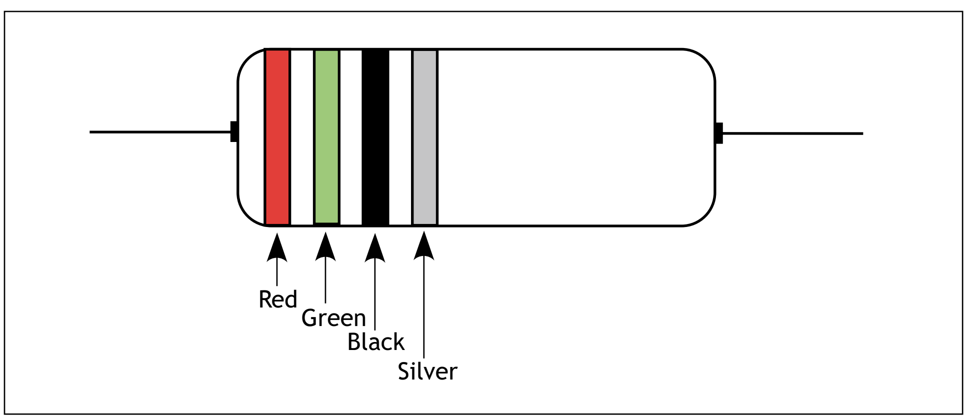
Final Answer: ______________________________

8.



Final Answer: ______________________________

9.



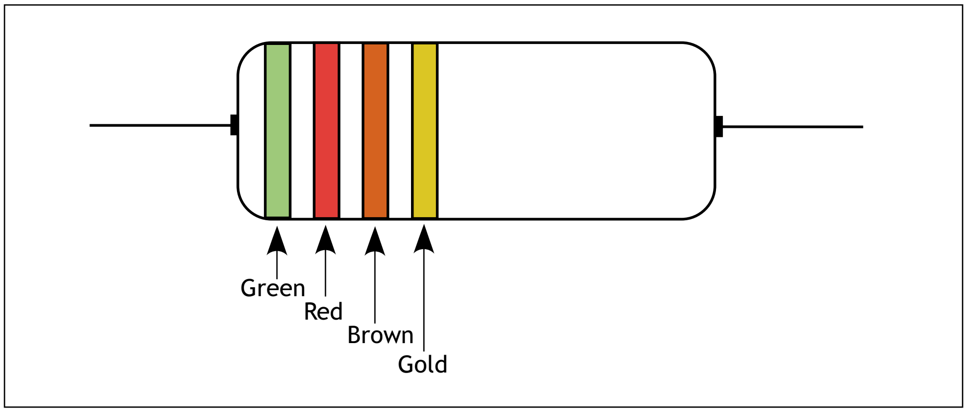
Final Answer: ______________________________

(continued)

Assignment 2.5: Resistors (continued)

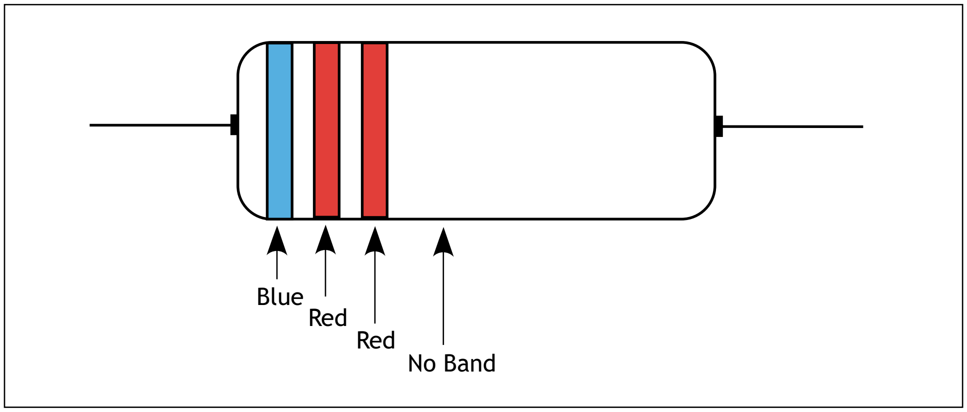
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	0
Gold	±5%
Silver	±10%
None	±20%

10.



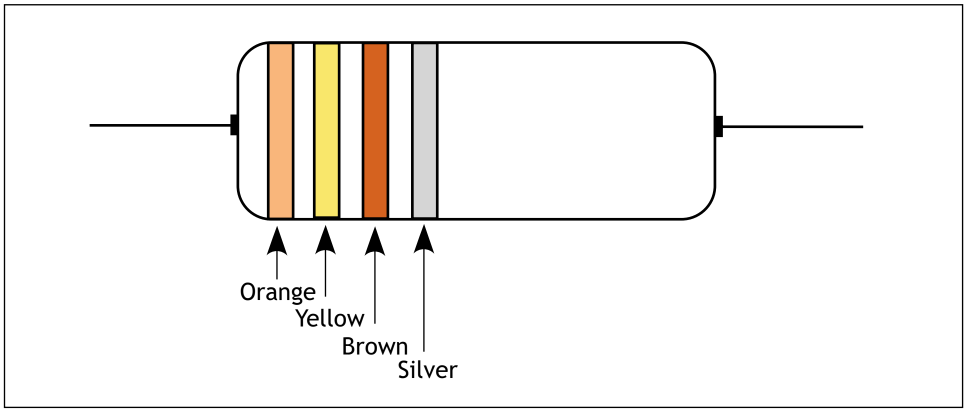
Final Answer: ______________________________

11.



Final Answer: ______________________________

12.



Final Answer: ______________________________

(continued)

Assignment 2.5: Resistors (continued)

Part 2: Calculating Resistor Numeric Values *(24 marks)*

Answer each question by writing the colour for the corresponding number values for each resistor. *(Each answer is worth 2 marks, 0.5 mark for each band, for a total of 24 marks.)*

Example

250 ohm 5% =	Red	Green	Brown	Gold
	2	5	0	5%

1. 2,500 ohms 10% =

    ____

2. 6.4 k ohms 5% =

    ____

3. 9 M ohms 5% =

    ____

4. 8,300 ohm 20% =

    ____

5. 72 k ohms 10% =

    ____

6. 670 ohms 20% =

    ____

7. 52 ohms 5% =

    ____

8. 40 M ohms 5% =

    ____

(continued)

Assignment 2.5: Resistors (continued)

9. 1,400 ohms 10% =

 ____

10. 3.8 k ohms 10% =

 ____

11. 5.2 M ohms 5% =

 ____

12. 8,000 ohms 20% =

 ____

Notes

It is now time to view the Grade 9/10 Electronics video found in the learning management system (LMS) or on DVD. Watch the section on resistance on the DMM.

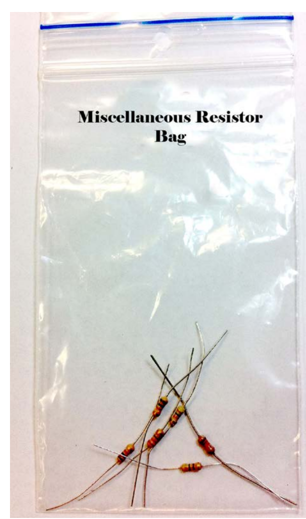
Learning Activity 2.14

Measuring Resistors with a Meter

Inventory List: Place a checkmark in each box once you have identified the item.

❑ Digital multimeter (DMM)

❑ Miscellaneous resistor bag

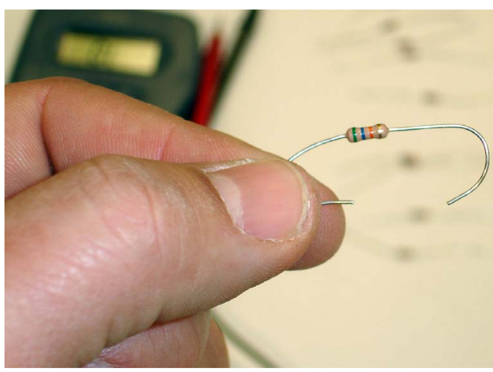


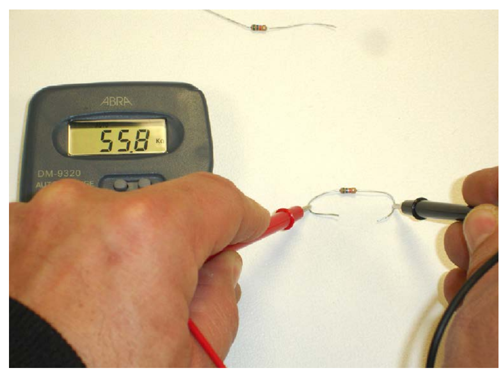
(continued)

Learning Activity 2.14: Measuring Resistors with a Meter (continued)

Procedure:

1. Turn the meter on and set the DMM to the ohm function (shown here).
2. Find the 10 carbon resistors in your miscellaneous resistor package (shown above).
3. Calculate the colour codes and record the calculated values on the resistor test sheet found at the end of the lesson.
4. Using your DMM, place a probe on one leg of the resistor and the other probe on the other leg of the resistor. Do not use your fingers to pinch the probes close to the legs. Place the resistor on a non-conducting surface. Bend the legs (as shown in the diagram) and place one of the test probes on the inside of the resistor legs, and pull them out so the resistor's legs are touching each one of the test leads.





5. Record the tested value on all 10 of the resistors on the Resistor Test Sheet on the next page.
6. Compare the **tested** and **measured** values. They should be very close, but they will likely not match perfectly because the tested value can be within 5 percent tolerance of the measured value. In other words, the **tested** value must be within 5 percent higher or 5 percent lower of the **calculated** value. If it is, we say that the resistor is "within range." If it is not, check with your tutor/marker.
7. Place all the resistors back in the bag when finished testing.

(continued)

Learning Activity 2.14: Measuring Resistors with a Meter (continued)

In the chart below, fill in the calculated and recorded values. Use all ten resistors in your miscellaneous resistor bag.

Resistor Test Sheet				
	Part Name	**Colours in Order**	**Calculated Value**	**Actual Value**
Example	Resistor	Red, Red, Brown, Gold	220 Ω + 5%	215 Ω
1	Resistor			
2	Resistor			
3	Resistor			
4	Resistor			
5	Resistor			
6	Resistor			
7	Resistor			
8	Resistor			
9	Resistor			
10	Resistor			

Answers for this learning activity will vary.

Variable Resistors

Variable resistors are resistors for which we are able to vary or change the resistance value. Many examples of these types of resistors can be found in your home or work environment. Here are a few examples.

The image on the left is a sliding dimmer switch; the one on the right is a rotary dimmer switch. Both are examples of variable resistors. Sliding or turning the switch one way increases the resistance in the circuit and causes the lights to be dimmed. Sliding or rotating the switch the other way decreases the resistance in the circuit and allows more current to flow, which in turn causes the lights to be bright.

Sliding Dimmer

Rotary Dimmer

These variable or adjustable resistors are most often referred to as potentiometers (or "pots"). These pots are used to turn volume up or down or to adjust the lighting in your home.

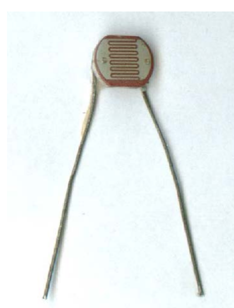
Learning Activity 2.15

Variable Resistors: Potentiometers

Take a look around the house and find five household items that would make use of a potentiometer. Record them in your notebook.

Light Dependent Resistors (LDRs)

This type of resistor, also referred to as a **photocell**, uses light to change the resistance values. Varying the amount of light that is allowed to fall on the sensitive cadmium sulphide surface brings on change in resistance. They are very suitable for detecting light conditions and are very popular for hallway or bedroom night-lights. When the room gets dark, the photocell will turn on the light. A picture of a photocell and a night-light is shown below.



Heat Sensitive Resistors

A thermistor or thermal resistor is a device whose resistance can be changed as its temperature is modified. This makes thermistors suitable for temperature-detecting circuits. A good example is a digital thermometer. A thermistor and a digital thermometer are shown below.

Learning Activity 2.16

Resistors in Review

Answer the following questions in your notebook.

1. What is a resistor?
2. What are two substances that are used to create a resistor that is able to withstand high temperature circuits?
3. What are the three ways in which resistors are rated?
4. What is another name for a variable resistor?
5. Name the resistor that varies its own resistance depending on how much light is hitting it.
6. What is a heat-sensitive resistor called?

Check your answers in the Learning Activity Answer Keys found at the end of this module.

It is now time for you to complete Assignment 2.6, Assignment 2.7, and Assignment 2.8. These assignments (along with all other assignments) are worth marks and you will either mail or electronically submit them to the Distance Learning Unit when you have finished Module 2.

Assignment 2.6, Part 1

Experiment 1, Part 1: The Effects of Resistors on an LED

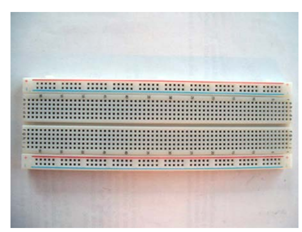
You are about to conduct the first experiment in this course. Let's do an inventory of what you need to complete this task before you proceed.

Inventory List: Place a checkmark in each box once you have identified the item.

❑ Digital multimeter (DMM)

❑ Experiment kit

❑ Solderless circuit board

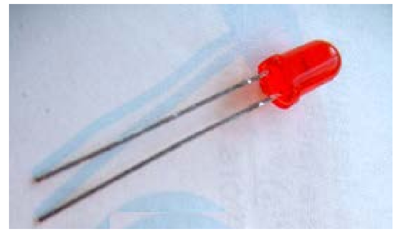


❑ 9-volt battery

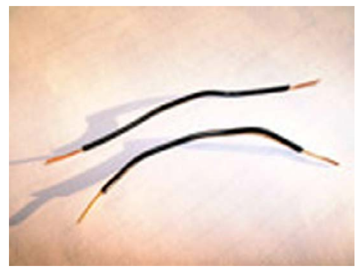
(continued)

Assignment 2.6: Experiment 1, Part 1: The Effects of Resistors on an LED (continued)

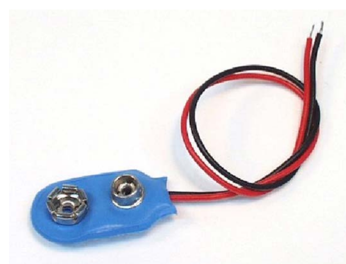
- ❑ Light emitting diode (LED)



- ❑ Solid hook-up wires



- ❑ 9-volt battery clip



- ❑ Resistors with the value of (from Miscellaneous Resistor Bag)
  - 100 ohms
  - 330 ohms
  - 1000 ohms
  - 6.8 k ohms

- ❑ Safety glasses

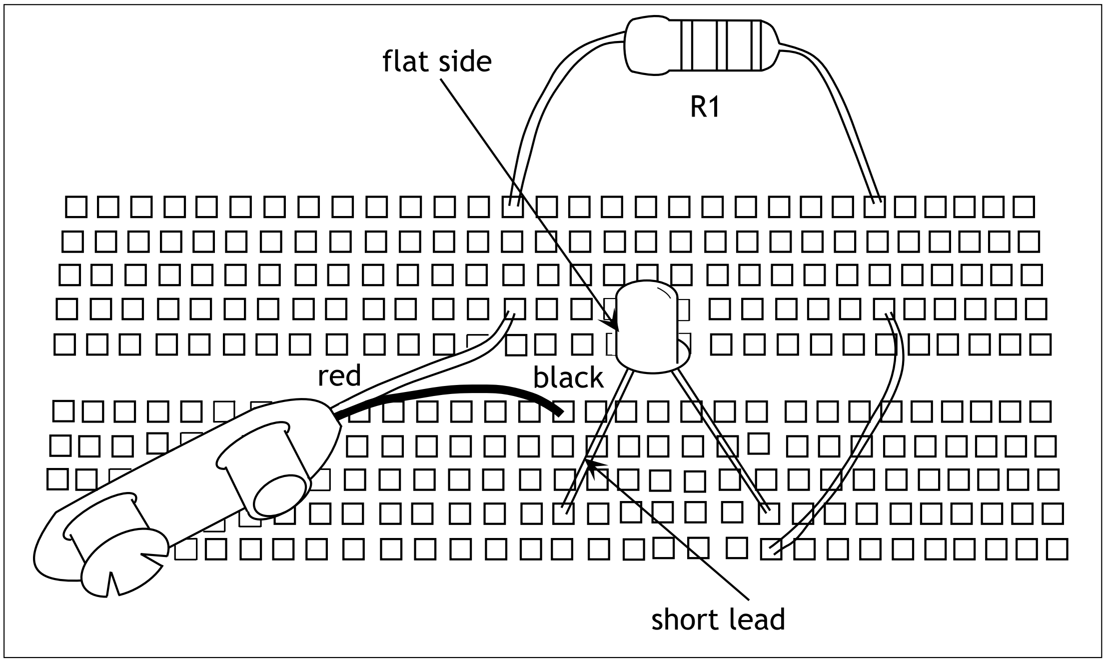
(continued)

Assignment 2.6: Experiment 1, Part 1: The Effects of Resistors on an LED (continued)

Purpose: The purpose of this experiment is to see how changing the value of the resistor affects the brightness of the LED.

Procedure: Build the circuit shown below using your Experiment Kit and solderless circuit board.

Carefully plug your components into the same vertical rows as shown below. The first resistor that you will use is the 100 ohm resistor. Find it and place it in the solderless circuit board.



SAFETY GLASSES ON!

Hook up the 9-volt battery to the battery clip. The LED should light up. If it failed to do so, check to make sure the black and red wires from the battery clip are placed the right way in the solderless breadboard. Next, make sure that the polarity of the LED is correct.

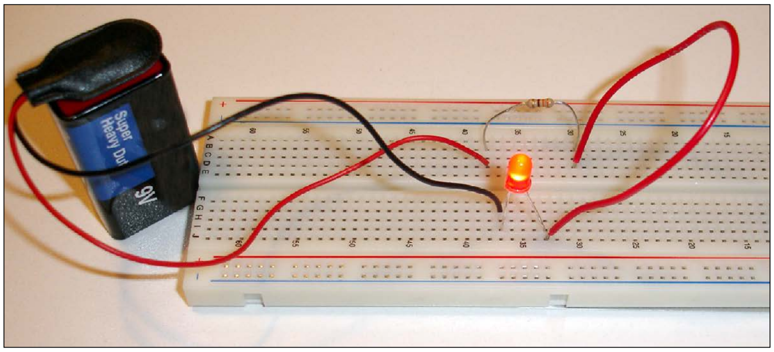
When the LED is lit, make a mental note of the brightness of the LED.

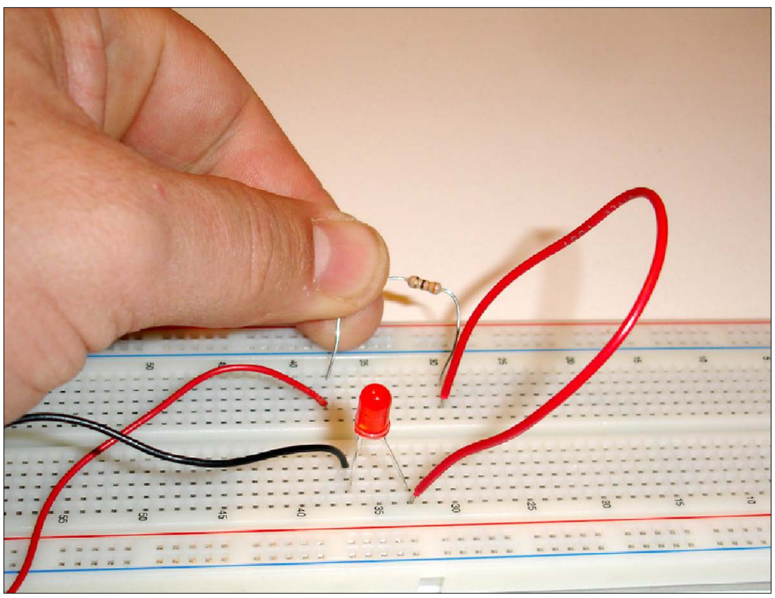
Now unhook the battery.

(continued)

Assignment 2.6: Experiment 1, Part 1: The Effects of Resistors on an LED (continued)

Next, take the 100 ohm resistor out and replace it with the 330 ohm resistor. Be sure to place the new resistor in the same holes in the solderless circuit board. Make a mental note of the brightness of the LED.





Unhook the battery once again.

At this point, you can substitute the rest of the resistors one at a time and observe what happens to the brightness of the LED as you replace the resistors.

(continued)

Assignment 2.6: Experiment 1, Part 1: The Effects of Resistors on an LED (continued)

What's Happening?

While placing the different resistors, fill out the following information.

1. When I used the 100 ohm resistor, the LED lit up. Yes or No?

   ____

2. When I used the 330 ohm resistor, was the LED brighter or dimmer than before?

   ____

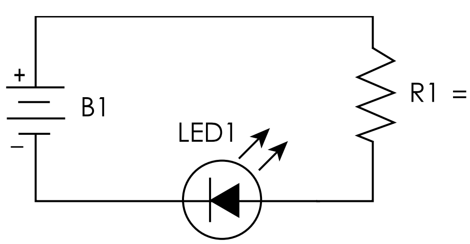
3. When I used the 1000 ohm resistor, was the LED brighter or dimmer than before?

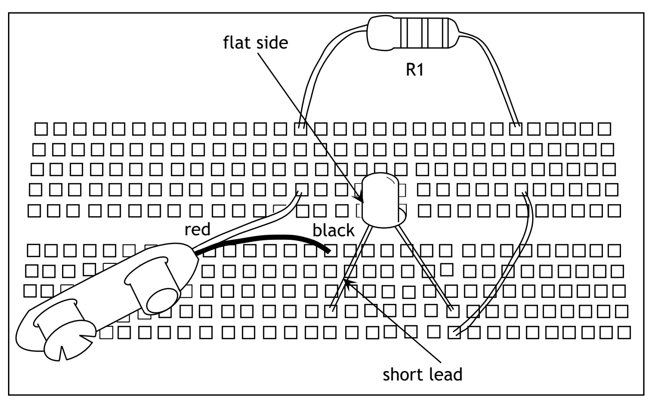
   ____

4. When I used the 6.8 K ohm resistor, was the LED brighter or dimmer than before?

   ____

Explanation: In this simple circuit, the electric current will flow from the negative terminal of the battery to the positive terminal, passing through the LED and the resistor. We will substitute the different resistors being placed in and out of the circuit to see what effect, if any, there would be on the brightness of the LED.





(continued)

Assignment 2.6: Experiment 1, Part 1: The Effects of Resistors on an LED (continued)

Reminder

Electronic components must be installed with polarity in mind. It's a good idea to look very carefully at the parts or schematics sheet that is included at the beginning of this module to determine whether a component has a positive or a negative polarity. Look for a (+) sign for the positive side and a (–) sign for the negative side. If no positive or negative symbols are visible, then polarity is not an issue. Therefore, the part can be installed in either direction in the circuit.

Note: The colour code for positive is red and the colour code for negative is black.

Now that you have successfully completed Experiment 1, place the parts back in the Experiment Kit, and then complete the experiment write-up.

Assignment 2.6, Part 2

Experiment 1, Part 2: Report 1: The Effects of Resistors on an LED *(13 marks)*

Please provide the responses to the following headings after you have completed your experiment.

Purpose of the Experiment *(2 marks)*

Explanation of the Experiment *(2 marks)*

Results of the Experiment *(2 marks)*

Schematic of the Experiment *(2 marks)*

Parts Used *(5 marks)*

Purpose of the Experiment: ***(2 marks)***

Explanation of the Experiment: Read through the experiment. Using three or four sentences, explain what happened. In your own words, show you have an understanding of what you learned and/or observed.
(2 marks)

(continued)

Assignment 2.6: Experiment 1, Part 2: Report 1: The Effects of Resistors on an LED (continued)

Results of the Experiment: This is where you write what happened during the experiment or what you observed as you followed the procedure to complete the experiment. This usually reflects the purpose and explanation of the experiment. *(2 marks)*

____

____

____

____

____

____

____

____

Schematic Diagram: Redraw the schematic representation of the circuit that you just built. The schematic diagram is provided to you in the experiment itself. *(2 marks)*

(continued)

Assignment 2.6: Experiment 1, Part 2: Report 1: The Effects of Resistors on an LED (continued)

Parts Used: Fill in the chart below, and draw the schematic symbols for the parts used in performing the experiment. Write down the value of any of the components, and make note that some components will not have a value (e.g., an LED would not have a value). *(5 marks)*

Name of Part	Value (if any)	Schematic Symbol	Picture of Part
Example: Resistor	100 ohms		
Resistor			
Resistor			
Resistor			
LED			
Battery			

Notes

Assignment 2.7, Part 1

Experiment 2, Part 1: The Effects of a Photocell on an LED

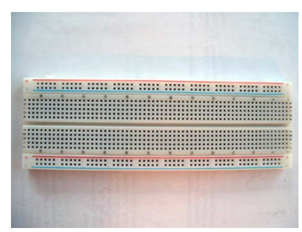
You are about to complete the second experiment in this course. Let's do an inventory of what we need to complete this task before we proceed.

Inventory List: Place a checkmark in each box once you have identified the item.

❑ Digital multimeter (DMM)

❑ Experiment kit

❑ Solderless circuit board

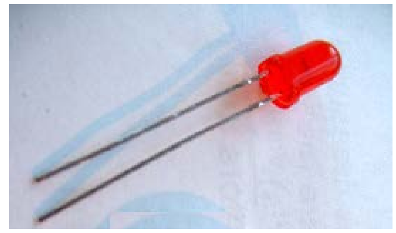


❑ 9-volt battery

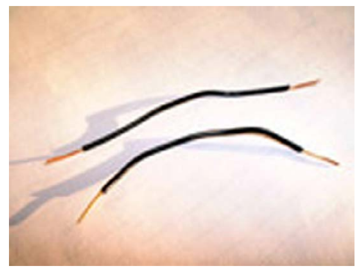
(continued)

Assignment 2.7: Experiment 2, Part 1: The Effects of a Photocell on an LED (continued)

- ❑ Light emitting diode (LED)

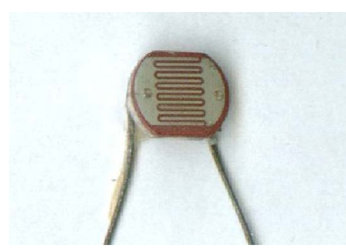


- ❑ Solid hook-up wires



- ❑ 9-volt battery clip

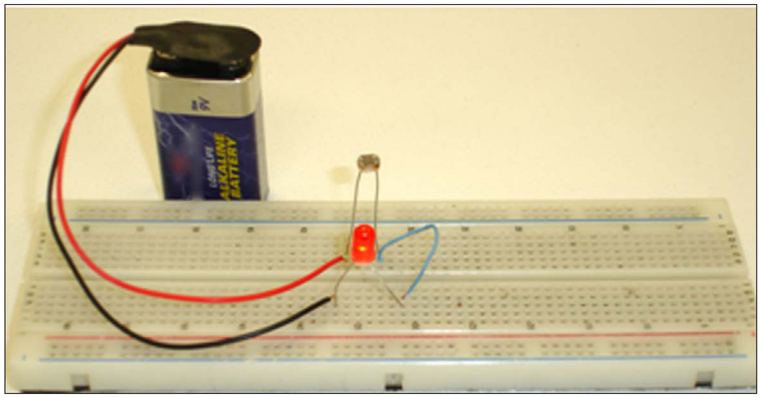
- ❑ Photocell



- ❑ Safety glasses

(continued)

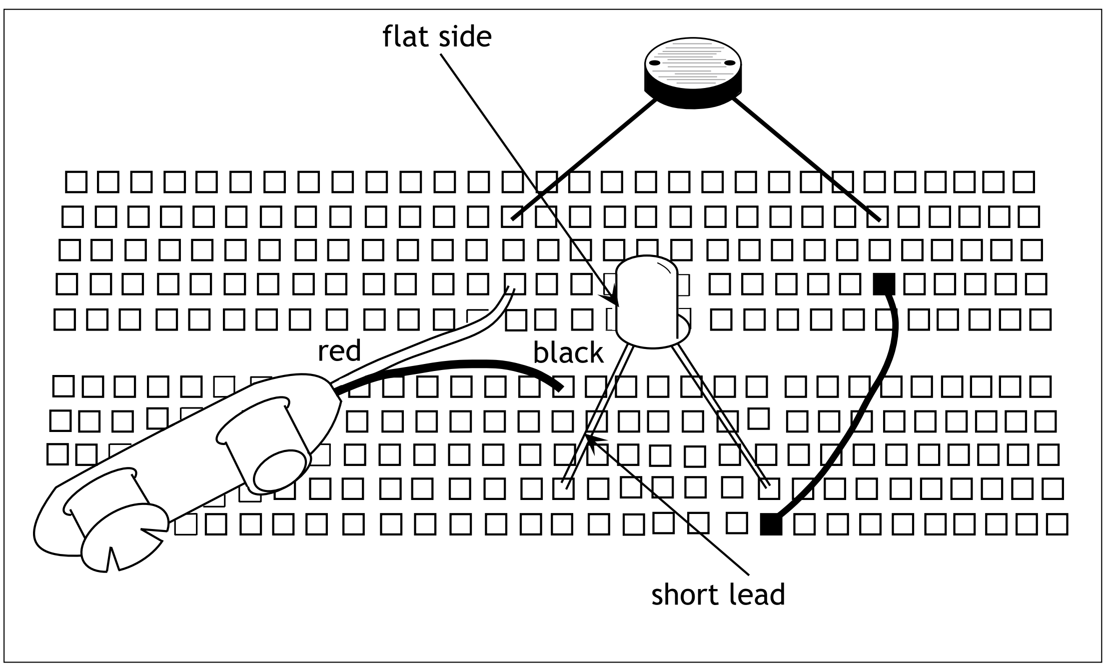
Assignment 2.7: Experiment 2, Part 1: The Effects of a Photocell on an LED (continued)



Purpose: The purpose of this experiment is to see how changing the amount of light hitting the photocell (and thus the resistance value) affects the brightness of the LED.

Procedure: Build the circuit shown below using your Experiment Kit and solderless circuit board.

Carefully plug your components into the same vertical rows as shown below. Remember, the photocell **does not** have a negative or positive side (i.e., it has no polarity). This means you can place it into the solderless circuit board in either direction.



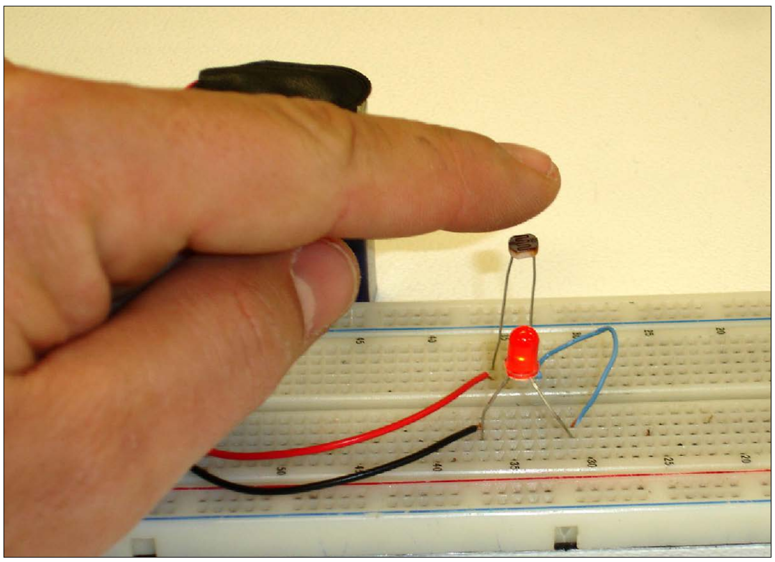
(continued)

Assignment 2.7: Experiment 2, Part 1: The Effects of a Photocell on an LED (continued)

SAFETY GLASSES ON!

Hook up the 9-volt battery to the battery clip. The LED should light up. If it failed to do so, check to make sure the black and red wires from the battery clip are placed the right way in the solderless breadboard. Next, make sure that the polarity of the LED is correct. Finally, check to make sure the wires are securely inserted into the solderless circuit board.

Place your finger on top of the photocell to see what, if any, effect it has on the LED.



Make a mental note of the results.

Now unhook the battery.

What's Happening?

After changing the resistance value of the photocell by placing your finger on top of the photocell, fill out the following information.

1. When I connected the battery to the circuit, the LED lit up. Yes or No?

    ____

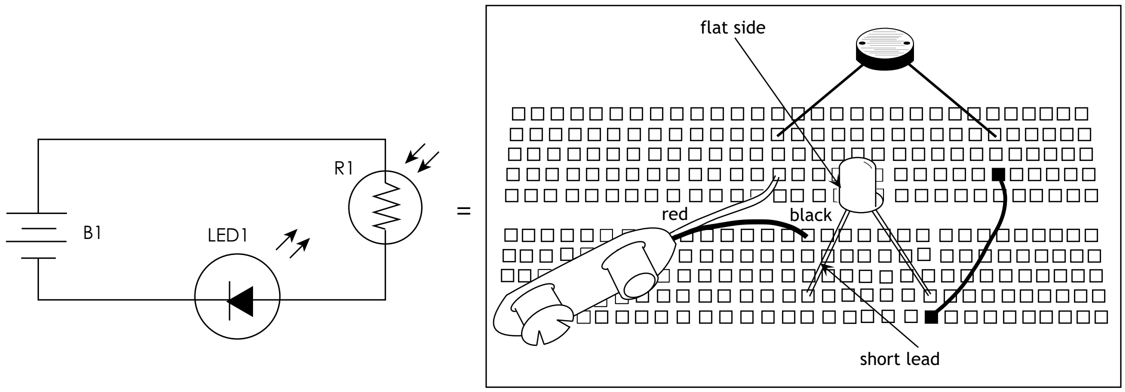
2. When I changed the resistance value by placing my finger on the photocell, was the LED brighter or dimmer than before?

    ____

(continued)

Assignment 2.7: Experiment 2, Part 1: The Effects of a Photocell on an LED (continued)

Explanation: In this simple circuit, the electric current will flow from the negative terminal of the battery to the positive terminal, passing through the LED and the photocell. Place your finger on and off the photocell to observe what effect, if any, there would be on the brightness of the LED.



Reminder

Electronic components must be installed with polarity in mind. It's a good idea to look very carefully at the parts or schematics sheet that is included at the beginning of this module to determine whether a component has a positive or a negative polarity. Look for a (+) sign for the positive side and a (–) sign for the negative side. If no positive or negative symbols are visible, then polarity is not an issue. Therefore, the part can be installed in either direction in the circuit.

Note: The colour code for positive is red and the colour code for negative is black.

Now that you have successfully completed Experiment 2, place the parts back in the Experiment Kit, and then complete the experiment write-up.

Notes

Assignment 2.7, Part 2

Experiment 2, Part 2: Report 2: The Effects of a Photocell on an LED *(11 marks)*

Please provide the responses to the following headings after you have completed your experiment.

Purpose of the Experiment *(2 marks)*

Explanation of the Experiment *(2 marks)*

Results of the Experiment *(2 marks)*

Schematic of the Experiment *(2 marks)*

Parts Used *(3 marks)*

Purpose of the Experiment: *(2 marks)*

Explanation of the Experiment: Read through the experiment. Using three or four sentences, explain what happened. In your own words, show you have an understanding of what you learned and/or observed. *(2 marks)*

(continued)

Assignment 2.7: Experiment 2, Part 2: Report 2: The Effects of a Photocell on an LED (continued)

Results of the Experiment: This is where you write what happened during the experiment or what you observed as you followed the procedure to complete the experiment. This usually reflects the purpose and explanation of the experiment. *(2 marks)*

____

____

____

____

____

____

____

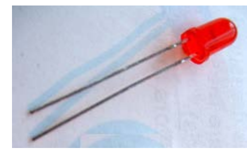
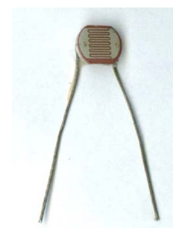
____

Schematic Diagram: Redraw the schematic representation of the circuit that you just built. The schematic diagram is provided to you in the experiment itself. *(2 marks)*

(continued)

Assignment 2.7: Experiment 2, Part 2: Report 2: The Effects of a Photocell on an LED (continued)

Parts Used: Fill in the chart below, and draw the schematic symbols for the parts used in performing the experiment. Write down the value of any of the components, and make note that some components will not have a value (e.g., an LED would not have a value). *(3 marks)*

Name of Part	Value (if any)	Schematic Symbol	Picture of Part
LED			
Photocell			
Battery			

Notes

Assignment 2.8, Part 1

Experiment 3, Part 1: The Effects of a Potentiometer on an LED

Part A: Soldering

Now that you know how to solder, let's solder some hook-up wires to the potentiometer's connectors so you can use it in the next experiment.

Inventory List: Place a checkmark in each box once you have identified the item.

❑ Two solid gauge hook-up wires with the ends stripped, exposing the wire

❑ Potentiometer

❑ Soldering Iron

❑ Soldering Iron Stand

❑ Solder

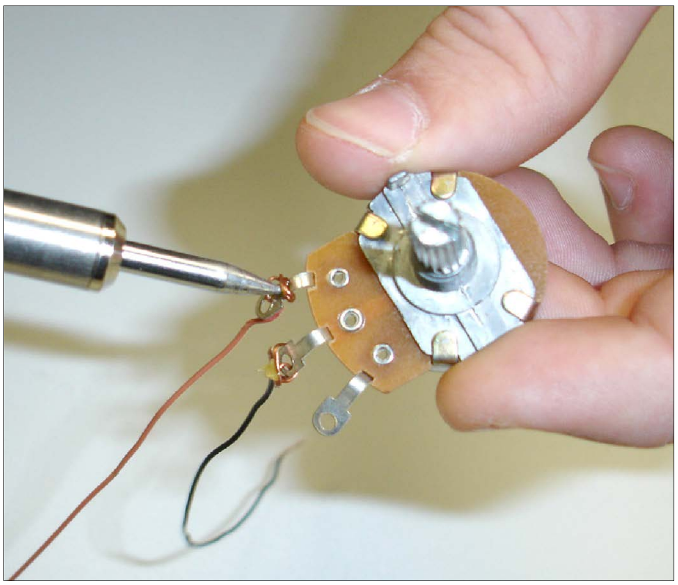
(continued)

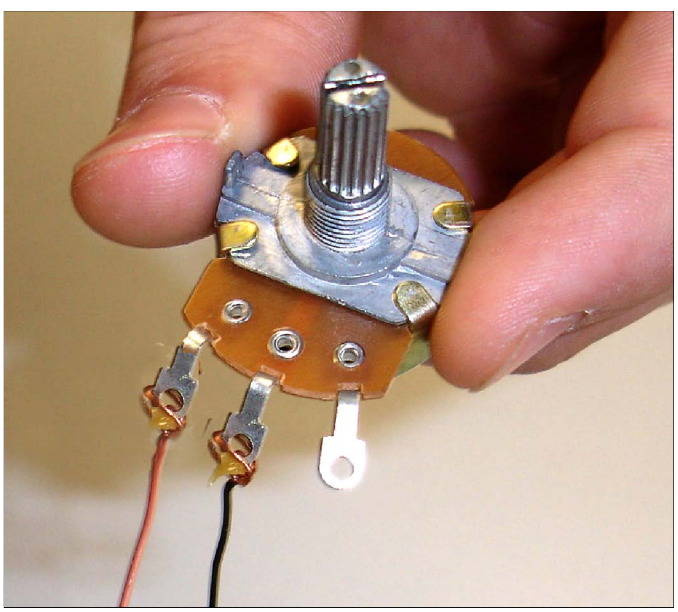
Assignment 2.8: Experiment 3, Part 1: The Effects of a Potentiometer on an LED (continued)

SAFETY GLASSES ON!

Use your wire strippers to strip the ends off of your wire.

Next, feed one of the stripped ends through the centre hole of the potentiometer's terminals, and bend it a bit so it stays in the hole. Take the other wire and connect it to either of the two remaining posts on the potentiometer.

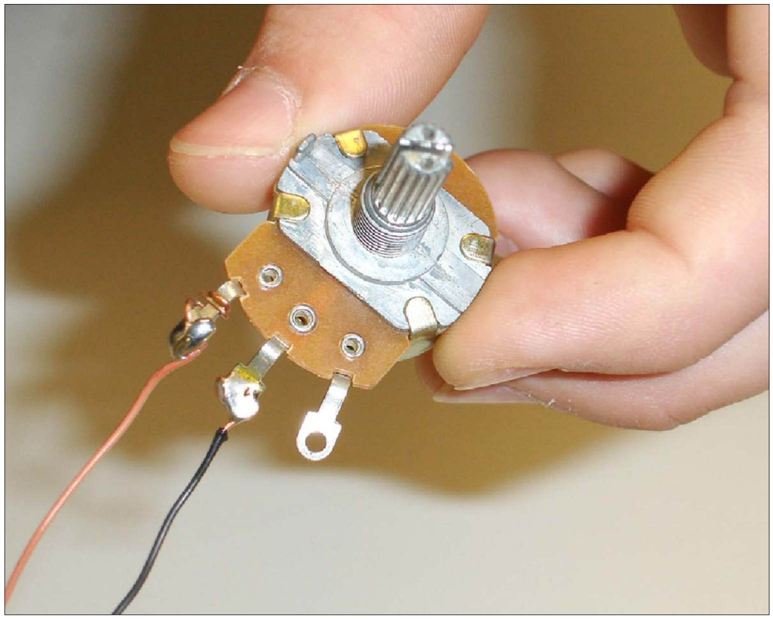




(continued)

Assignment 2.8: Experiment 3, Part 1: The Effects of a Potentiometer on an LED (continued)

Take your soldering iron and solder and make the connection. Note: You will not be able to heat sink this component, so solder as quickly as you can.



Solder it on as you did for the previous wire. Now you can use this component in the second part of this experiment.

(continued)

Assignment 2.8: Experiment 3, Part 1: The Effects of a Potentiometer on an LED (continued)

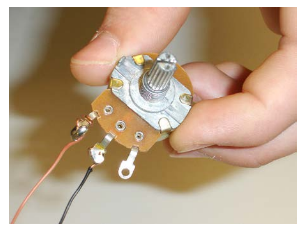
Part B: The Experiment

You will need to find the following items from your tool kit.

Inventory List: Place a checkmark in each box once you have identified the item.

- ❑ 9-volt battery

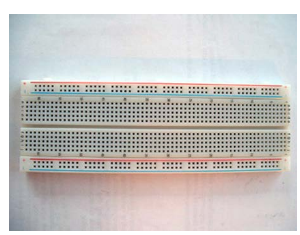
- ❑ Potentiometer with wires from the first part of this experiment



- ❑ Light emitting diode (LED)

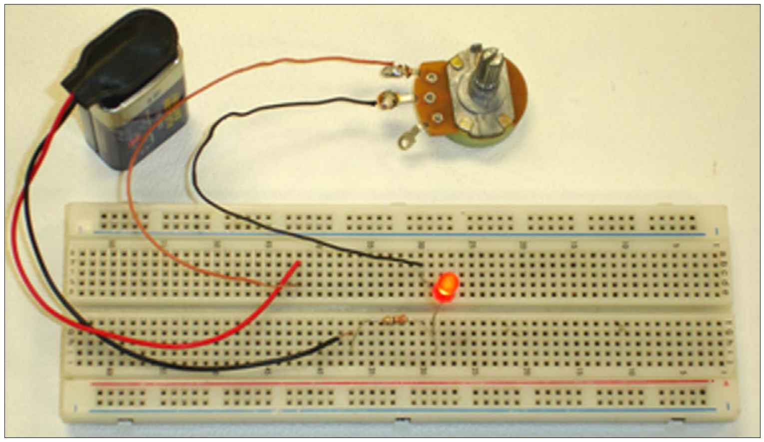
- ❑ 9-volt battery clip

- ❑ Solderless circuit board



(continued)

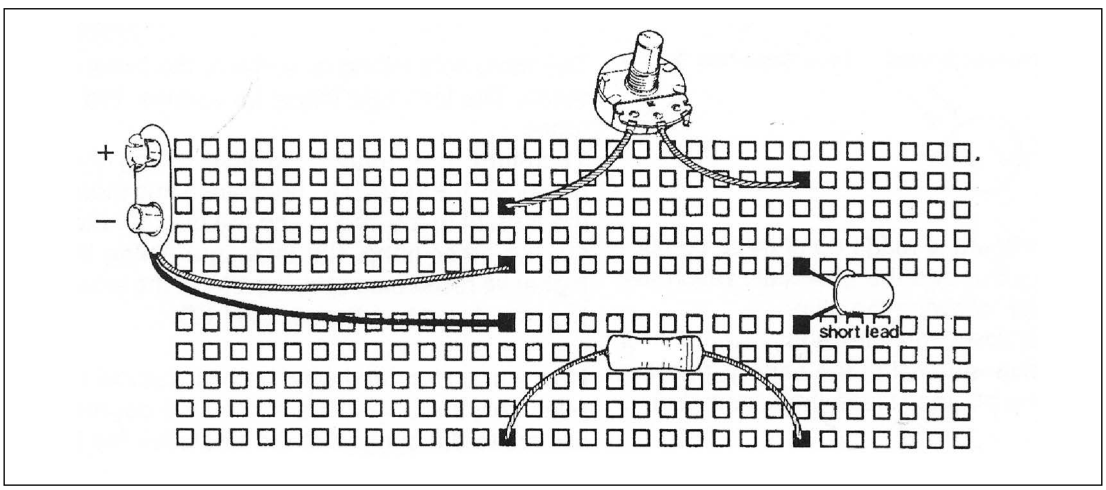
Assignment 2.8: Experiment 3, Part 1: The Effects of a Potentiometer on an LED (continued)



Purpose: The purpose of this experiment is to see the effects of changing the value of the potentiometer on the brightness of the LED.

Procedure: Build the circuit shown below using your Experiment Kit and solderless circuit board.

Carefully plug your components into the same vertical rows, as shown below. The potentiometer turning knob should be turned all the way to either the left or right so it reaches its limit stop. Find it and place it in the solderless circuit board.

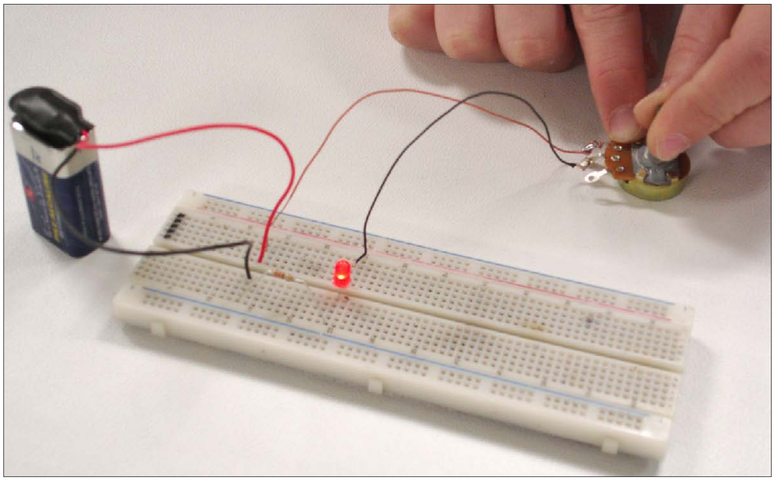


(continued)

Assignment 2.8: Experiment 3, Part 1: The Effects of a Potentiometer on an LED (continued)

SAFETY GLASSES ON!

Hook up the 9-volt battery to the battery clip.



The LED may have lit up. If it failed to do so, do the usual checks. If it did light up, continue on.

Take the potentiometer shaft and rotate it back and forth to see what, if any, effect it has on the LED.

Make a mental note of the results.

Now unhook the battery.

What's Happening?

After changing the resistance value of the potentiometer by turning the shaft back and forth, fill out the following information.

1. When I connected the battery to the circuit, the LED lit up. Yes or No? If no, try again.

   ____

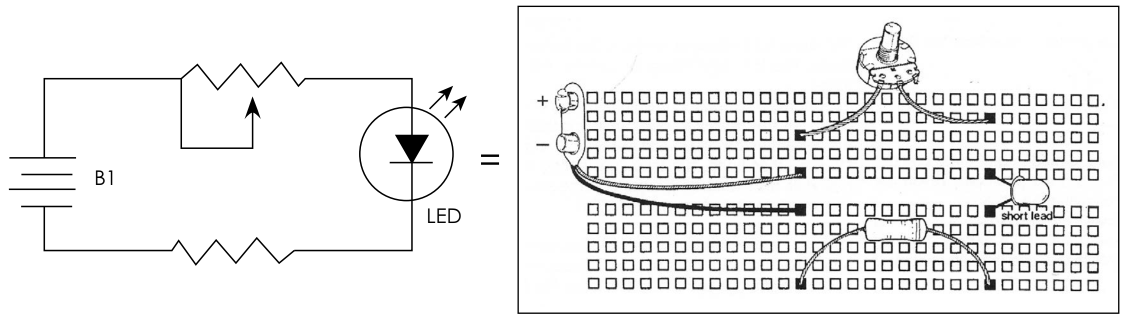
2. When I changed the resistance value by turning the potentiometer's shaft, was the LED brighter or dimmer than before?

   ____

(continued)

Assignment 2.8: Experiment 3, Part 1: The Effects of a Potentiometer on an LED (continued)

Explanation: In this simple circuit, the electric current will flow from the negative terminal of the battery to the positive terminal, passing through the resistor, LED, and the variable resistor (better known as a potentiometer). We will turn the shaft of the potentiometer back and forth to see the effect, if any, on the brightness of the LED.



Reminder

Electronic components must be installed with polarity in mind. It's a good idea to look very carefully at the parts or schematics sheet that is included at the beginning of this module to determine whether a component has a positive or a negative polarity. Look for a (+) sign for the positive side and a (–) sign for the negative side. If no positive or negative symbols are visible, then polarity is not an issue. Therefore, the part can be installed in either direction in the circuit.

Note: The colour code for positive is red and the colour code for negative is black.

Now that you have successfully completed Experiment 3, place the parts back in the Experiment Kit, and then complete the experiment write-up.

Notes

Assignment 2.8, Part 2

Experiment 3, Part 2: Report 3: The Effects of a Potentiometer on an LED *(11 marks)*

Please provide the responses to the following headings after you have completed your experiment.

Purpose of the Experiment *(2 marks)*

Explanation of the Experiment *(2 marks)*

Results of the Experiment *(2 marks)*

Schematic of the Experiment *(2 marks)*

Parts Used *(3 marks)*

Purpose of the Experiment: *(2 marks)*

Explanation of the Experiment: Read through the experiment. Using three or four sentences, explain what happened. In your own words, show you have an understanding of what you learned and/or observed. *(2 marks)*

(continued)

Assignment 2.8: Experiment 3, Part 2: Report 3: The Effects of a Potentiometer on an LED (continued)

Results of the Experiment: This is where you write what happened during the experiment or what you observed as you followed the procedure to complete the experiment. This usually reflects the purpose and explanation of the experiment. *(2 marks)*

____

____

____

____

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____

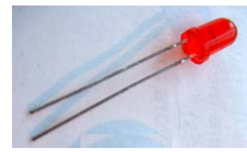
____

Schematic Diagram: Redraw the schematic representation of the circuit that you just built. The schematic diagram is provided to you in the experiment itself. *(2 marks)*

(continued)

Assignment 2.8: Experiment 3, Part 2: Report 3: The Effects of a Potentiometer on an LED (continued)

Parts Used: Fill in the chart below, and draw the schematic symbols for the parts used in performing the experiment. Write down the value of any of the components, and make note that some components will not have a value (e.g., an LED would not have a value). *(3 marks)*

Name of Part	Value (if any)	Schematic Symbol	Picture of Part
LED			
Potentiometer			
Battery			

Notes

Module 2 Summary

Congratulations! You have finished the second module of this course.

In this module, you learned about what makes up electricity and what is meant by current, voltage, and resistance. You studied electronic components and their schematic symbols, and the metric symbols associated with electronics. You found out that the resistor colour code is used to determine the values of resistors. You also learned how to use the solderless circuit board for the three experiments you performed using resistors, LEDs, and photocells.

Submitting Your Assignments

It is now time for you to submit your assignments from Module 2 to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Make sure you have completed all parts of your Module 2 assignments and organize your material in the following order:

- ❑ Module 2 Cover Sheet (found at the end of the course Introduction)
- ❑ Assignment 2.1: The Atom and Electronics
- ❑ Assignment 2.2: Schematic Symbols
- ❑ Assignment 2.3: Schematic Diagrams
- ❑ Assignment 2.4: Working with the Metric System
- ❑ Assignment 2.5: Resistors
- ❑ Assignment 2.6: Experiment 1, Part 2: Report 1: The Effects of Resistors on an LED
- ❑ Assignment 2.7: Experiment 2, Part 2: Report 2: The Effects of a Photocell on an LED
- ❑ Assignment 2.8: Experiment 3, Part 2: Report 3: The Effects of a Potentiometer on an LED

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Grade 10 Electricity/ Electronics Technology (20G)

Module 2
The Basics of Electricity

Learning Activity Answer Keys

Module 2:
The Basics of Electricity

Learning Activity 2.1: Resistors

1. Draw the schematic symbol for the carbon resistor three times.

   Answer:

2. Draw the schematic symbol for the potentiometer resistor three times.

   Answer:

3. State the basic types of resistors.

   Answer:

   There are two basic types of resistors: carbon resistor and potentiometer.

4. Give the function of a resistor.

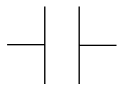
   Answer:

   A resistor helps control the flow of electrical current. A potentiometer is a resistor that allows you to change the resistance by turning the knob.

Learning Activity 2.2: Capacitors

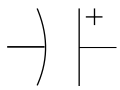
1. Draw the schematic symbol for the ceramic disc capacitor three times.

   Answer:

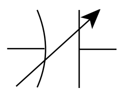
2. Draw the schematic symbol for the electrolytic capacitor three times.

   Answer:

3. Draw the schematic symbol for the variable capacitor three times.

   Answer:

4. State the basic types of capacitors.

   Answer:

   There are three basic types of capacitors: ceramic disc capacitor, electrolytic capacitor, and variable capacitor.

5. Give the function of a capacitor.

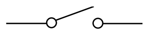
   Answer:

   A capacitor stores electrons on its plates and therefore holds a small electrical charge for a short period of time. Polarized capacitors have negative and positive sides.

Learning Activity 2.3: Switches

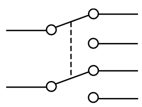
1. Draw the schematic symbol for the SPST slide switch three times.

   Answer:

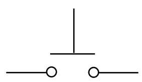
2. Draw the schematic symbol for the DPDT slide switch three times.

   Answer:

3. Draw the schematic symbol for the N.O. pushbutton switch three times.

   Answer:

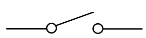
4. Draw the schematic symbol for the N.C pushbutton switch three times.

   Answer:

5. Draw the schematic symbol for the toggle switch three times.

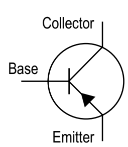
   Answer:

Learning Activity 2.4: Transistors

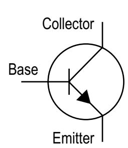
1. Draw the schematic symbol for the NPN transistor three times.

   Answer:

2. Draw the schematic symbol for the PNP transistor three times.

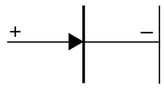
   Answer:

Learning Activity 2.5: Diodes

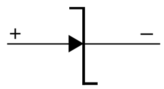
1. Draw the schematic symbol for the power diode three times.

   Answer:

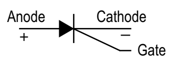
2. Draw the schematic symbol for the zener diode three times.

   Answer:

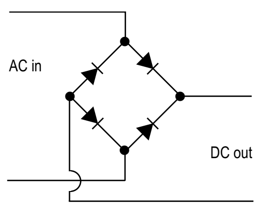
3. Draw the schematic symbol for the SCR three times.

   Answer:

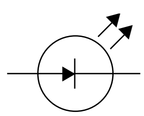
4. Draw the schematic symbol for the bridge rectifier three times.

   Answer:

5. Draw the schematic symbol for the LED three times.

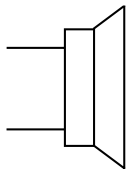
   Answer:

Learning Activity 2.6: Speakers

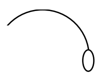
1. Draw the schematic symbol for a speaker three times.

   Answer:

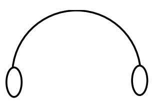
2. Draw the schematic symbol for a single headphone three times.

   Answer:

3. Draw the schematic symbol for a double headphone three times.

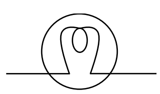
   Answer:

Learning Activity 2.7: Bulbs

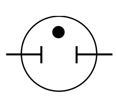
1. Draw the schematic symbol for an incandescent bulb three times.

   Answer:

2. Draw the schematic symbol for a neon bulb three times.

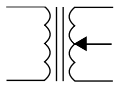
   Answer:

Learning Activity 2.8: Transformers

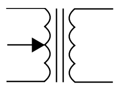
1. Draw the schematic symbol for a power transformer three times.

   Answer:

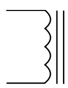
2. Draw the schematic symbol for an audio transformer three times.

   Answer:

3. Draw the schematic symbol for a choke three times.

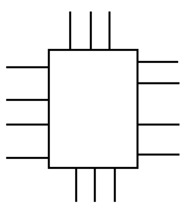
   Answer:

Learning Activity 2.9: Integrated Circuits or ICs

1. Draw the schematic symbol for an integrated circuit three times.

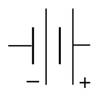
   Answer:

Learning Activity 2.10: Circuits

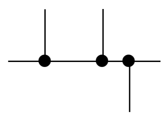
1. Draw the schematic symbol for a battery three times.

   Answer:

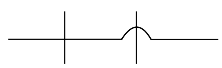
2. Draw the schematic symbol for wires hooked together three times.

   Answer:

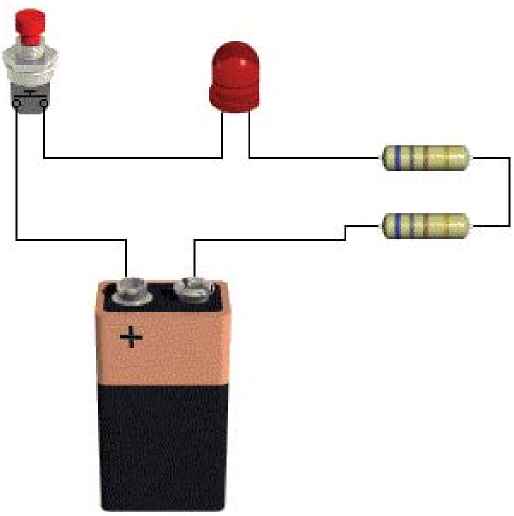
   

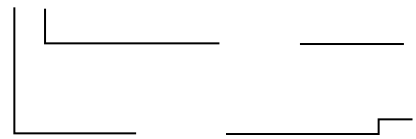
3. Draw the schematic symbol for wires not hooked together three times.

   Answer:

Learning Activity 2.11: Schematic Diagrams





Learning Activity 2.12: Metric

Question: What would 15,000,000 ohms look like if we converted it into kilo ohms? Don't forget to use the chart on the previous page.

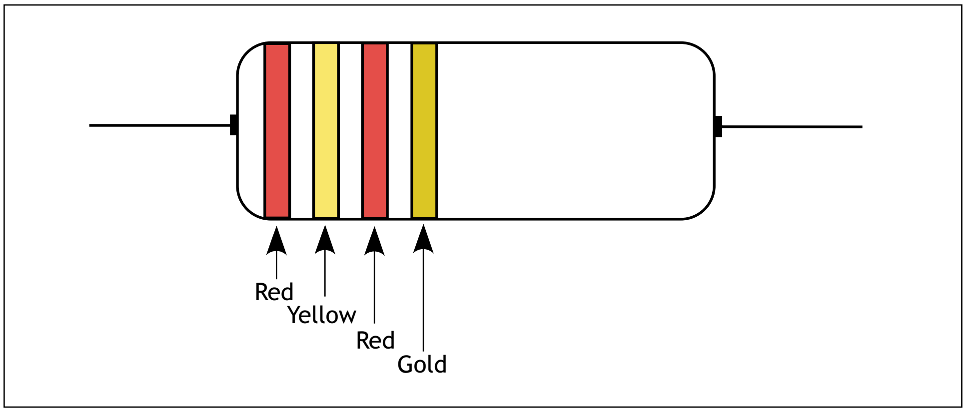
Remember, it does not matter which unit you use in this conversion process. All you are trying to do is make the value shorter so that, if you have a very small electronics part, the value could be written right on it. Besides, who wants to waste time writing out zeros?

Answer:

15^3

Learning Activity 2.13: Resistors

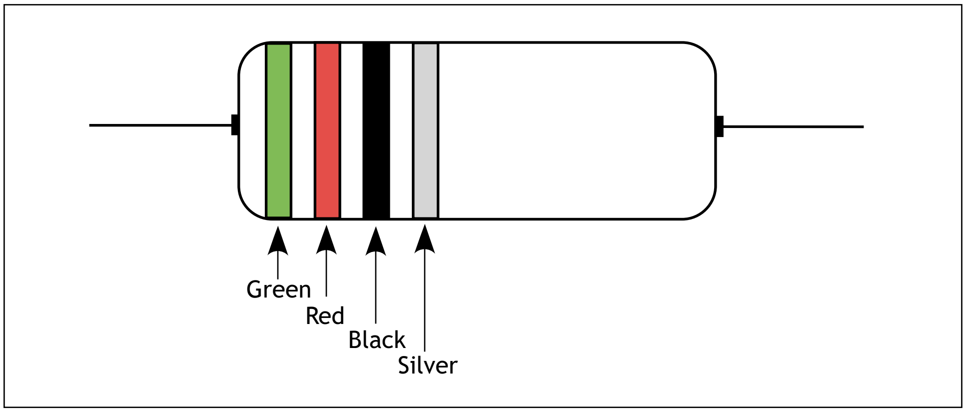
Calculate the resistance value for the following two resistors.



Answer:

Ohm value: 2400 ohms

Tolerance: 5%



Answer:

Ohm value: 52 ohms

Tolerance: 10%

Each answer should include the number, the unit, and the tolerance "±."

Learning Activity 2.14: Measuring Resistors with a Meter

Answers will vary.

Learning Activity 2.15: Variable Resistors: Potentiometers

Answers will vary.

Learning Activity 2.16: Resistors in Review

1. What is a resistor?

   Answer:

   A resistor is an electronic component that resists or controls the flow of electrical current.

2. What are two substances that are used to create a resistor that is able to withstand high temperature circuits?

   Answer:

   The two substances are cermet or tantalum.

3. What are the three ways in which resistors are rated?

   Answer:

   The three ways are ohms, tolerance, and heat dissipation.

4. What is another name for a variable resistor?

   Answer:

   Another name is potentiometer.

5. Name the resistor that varies its own resistance depending on how much light is hitting it?

   Answer:

   The resistor is called a light sensitive resistor (LDR). Photo cell is also acceptable.

6. What is a heat-sensitive resistor called?

   Answer:

   A heat sensitive resistor is called a thermistor or thermal resistor.

MODULE 2 SUMMARY

Congratulations! You have finished the second module of this course.

In this module, you learned about what makes up electricity and what is meant by current, voltage, and resistance. You studied electronic components and their schematic symbols, and the metric symbols associated with electronics. You found out that the resistor colour code is used to determine the values of resistors. You also learned how to use the solderless circuit board for the three experiments you performed using resistors, LEDs, and photocells.

Submitting Your Assignments

It is now time for you to submit your assignments from Module 2 to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Make sure you have completed all parts of your Module 2 assignments and organize your material in the following order:

- ❑ Module 2 Cover Sheet (found at the end of the course Introduction)
- ❑ Assignment 2.1: The Atom and Electronics
- ❑ Assignment 2.2: Schematic Symbols
- ❑ Assignment 2.3: Schematic Diagrams
- ❑ Assignment 2.4: Working with the Metric System
- ❑ Assignment 2.5: Resistors
- ❑ Assignment 2.6: Experiment 1, Part 2: Report 1: The Effects of Resistors on an LED
- ❑ Assignment 2.7: Experiment 2, Part 2: Report 2: The Effects of a Photocell on an LED
- ❑ Assignment 2.8: Experiment 3, Part 2: Report 3: The Effects of a Potentiometer on an LED

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Grade 10 Electricity/ Electronics Technology (20G)

Module 2
The Basics of Electricity

Learning Activity Answer Keys

MODULE 2: THE BASICS OF ELECTRICITY

Learning Activity 2.1: Resistors

1. Draw the schematic symbol for the carbon resistor three times.

   Answer:

2. Draw the schematic symbol for the potentiometer resistor three times.

   Answer:

3. State the basic types of resistors.

   Answer:

   There are two basic types of resistors: carbon resistor and potentiometer.

4. Give the function of a resistor.

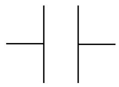
   Answer:

   A resistor helps control the flow of electrical current. A potentiometer is a resistor that allows you to change the resistance by turning the knob.

Learning Activity 2.2: Capacitors

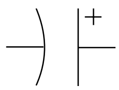
1. Draw the schematic symbol for the ceramic disc capacitor three times.

   Answer:

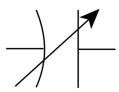
2. Draw the schematic symbol for the electrolytic capacitor three times.

   Answer:

3. Draw the schematic symbol for the variable capacitor three times.

   Answer:

4. State the basic types of capacitors.

   Answer:

   There are three basic types of capacitors: ceramic disc capacitor, electrolytic capacitor, and variable capacitor.

5. Give the function of a capacitor.

   Answer:

   A capacitor stores electrons on its plates and therefore holds a small electrical charge for a short period of time. Polarized capacitors have negative and positive sides.

Learning Activity 2.3: Switches

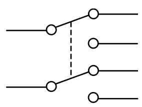
1. Draw the schematic symbol for the SPST slide switch three times.

   Answer:

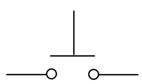
2. Draw the schematic symbol for the DPDT slide switch three times.

   Answer:

3. Draw the schematic symbol for the N.O. pushbutton switch three times.

   Answer:

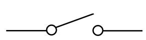
4. Draw the schematic symbol for the N.C pushbutton switch three times.

   Answer:

5. Draw the schematic symbol for the toggle switch three times.

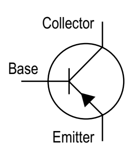
   Answer:

Learning Activity 2.4: Transistors

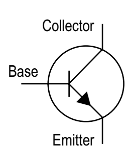
1. Draw the schematic symbol for the NPN transistor three times.

   Answer:

2. Draw the schematic symbol for the PNP transistor three times.

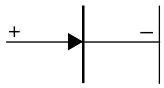
   Answer:

Learning Activity 2.5: Diodes

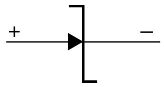
1. Draw the schematic symbol for the power diode three times.

   Answer:



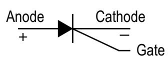
2. Draw the schematic symbol for the zener diode three times.

   Answer:



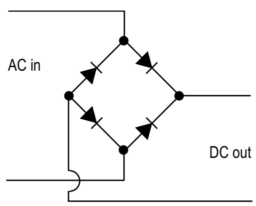
3. Draw the schematic symbol for the SCR three times.

   Answer:



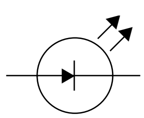
4. Draw the schematic symbol for the bridge rectifier three times.

   Answer:



5. Draw the schematic symbol for the LED three times.

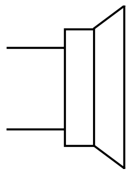
   Answer:



Learning Activity 2.6: Speakers

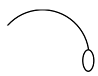
1. Draw the schematic symbol for a speaker three times.

   Answer:

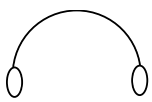
2. Draw the schematic symbol for a single headphone three times.

   Answer:

3. Draw the schematic symbol for a double headphone three times.

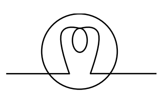
   Answer:

Learning Activity 2.7: Bulbs

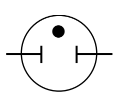
1. Draw the schematic symbol for an incandescent bulb three times.

   Answer:

2. Draw the schematic symbol for a neon bulb three times.

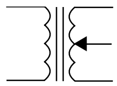
   Answer:

Learning Activity 2.8: Transformers

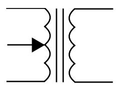
1. Draw the schematic symbol for a power transformer three times.

   Answer:

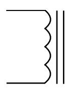
2. Draw the schematic symbol for an audio transformer three times.

   Answer:

3. Draw the schematic symbol for a choke three times.

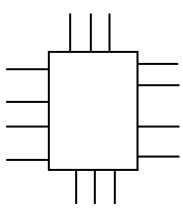
   Answer:

Learning Activity 2.9: Integrated Circuits or ICs

1. Draw the schematic symbol for an integrated circuit three times.

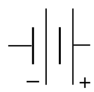
   Answer:

Learning Activity 2.10: Circuits

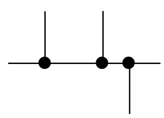
1. Draw the schematic symbol for a battery three times.

   Answer:

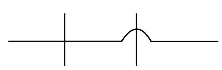
2. Draw the schematic symbol for wires hooked together three times.

   Answer:

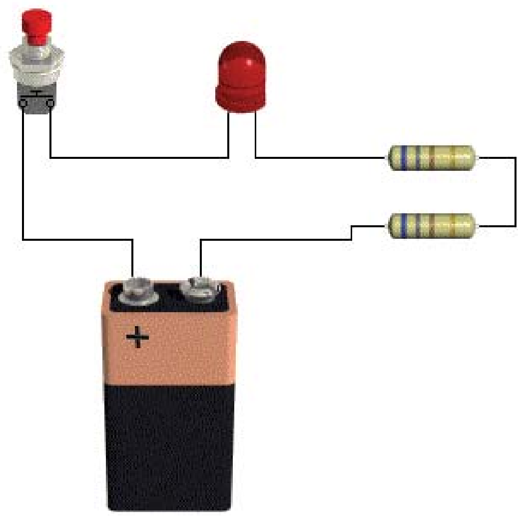
   

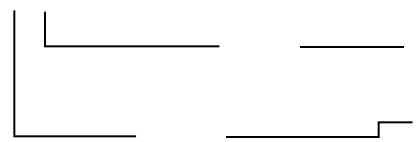
3. Draw the schematic symbol for wires not hooked together three times.

   Answer:

Learning Activity 2.11: Schematic Diagrams





Learning Activity 2.12: Metric

Question: What would 15,000,000 ohms look like if we converted it into kilo ohms? Don't forget to use the chart on the previous page.

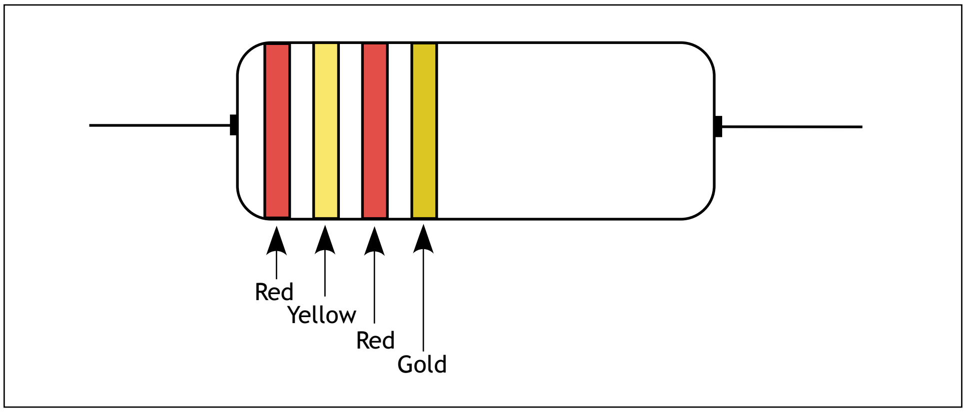
Remember, it does not matter which unit you use in this conversion process. All you are trying to do is make the value shorter so that, if you have a very small electronics part, the value could be written right on it. Besides, who wants to waste time writing out zeros?

Answer:

15^3

Learning Activity 2.13: Resistors

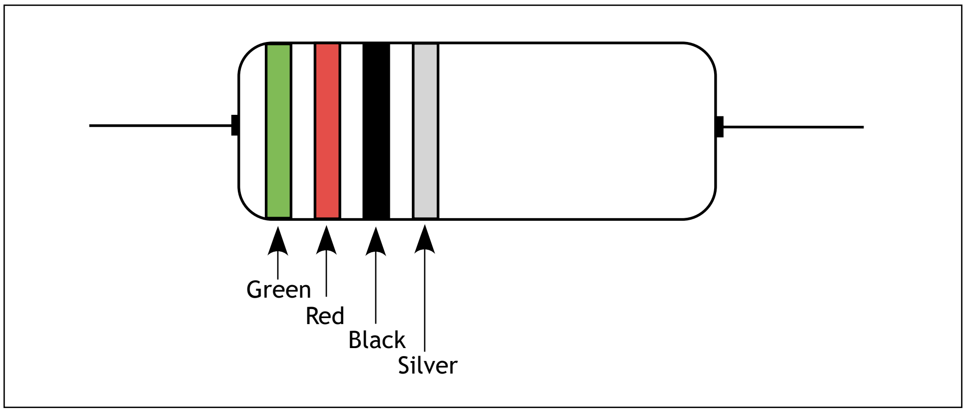
Calculate the resistance value for the following two resistors.



Answer:

Ohm value: 2400 ohms

Tolerance: 5%



Answer:

Ohm value: 52 ohms

Tolerance: 10%

Each answer should include the number, the unit, and the tolerance "±."

Learning Activity 2.14: Measuring Resistors with a Meter

Answers will vary.

Learning Activity 2.15: Variable Resistors: Potentiometers

Answers will vary.

Learning Activity 2.16: Resistors in Review

1. What is a resistor?

   Answer:

   A resistor is an electronic component that resists or controls the flow of electrical current.

2. What are two substances that are used to create a resistor that is able to withstand high temperature circuits?

   Answer:

   The two substances are cermet or tantalum.

3. What are the three ways in which resistors are rated?

   Answer:

   The three ways are ohms, tolerance, and heat dissipation.

4. What is another name for a variable resistor?

   Answer:

   Another name is potentiometer.

5. Name the resistor that varies its own resistance depending on how much light is hitting it?

   Answer:

   The resistor is called a light sensitive resistor (LDR). Photo cell is also acceptable.

6. What is a heat-sensitive resistor called?

   Answer:

   A heat sensitive resistor is called a thermistor or thermal resistor.

Grade 10 Electricity/ Electronics Technology (20G)

Module 3
Capacitors and Semiconductors

- Introduction
- Lesson 1: Capacitors
- Lesson 2: Semiconductors
- Lesson 3: The Diode
- Lesson 4: Transistors
- Lesson 5: Project 1: The Decision Maker
- Module 3 Summary

Module 3:
Capacitors and Semiconductors

Module Focus

After working through this module, you should

- ❑ have an in-depth understanding of capacitors and how they work.
- ❑ complete an experiment demonstrating a capacitor.
- ❑ understand semiconductor theory.
- ❑ understand the difference between N-type and P-type materials.
- ❑ learn about P-N Junctions.
- ❑ learn about forward and reverse bias.
- ❑ complete an experiment demonstrating a diode.
- ❑ learn about transistor construction.
- ❑ complete an experiment demonstrating a transistor.
- ❑ complete an experiment demonstrating a 7-segment display.
- ❑ complete an experiment demonstrating a SCR.
- ❑ explore potential careers in electronics.
- ❑ complete Project 1.

Introduction to Module 3

One of the basic building blocks of electronic devises is the semiconductor. Other components, such as diodes, capacitors, and transistors, are used to construct electronic devices. In this module, you will learn about these building blocks, and complete your first project.

Power Words

farads
doping
covalent bonds
P-type semiconductor
intrinsic semiconductors
forward bias
valence electrons
dielectric
semiconductors
reverse bias
N-type semiconductor
holes (virtual particles)
extrinsic semiconductors

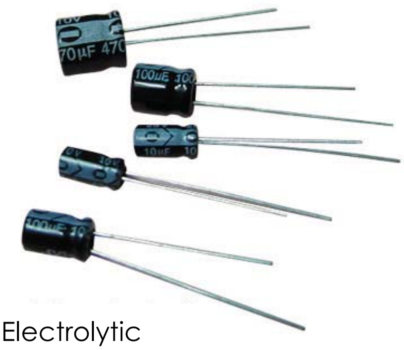
Module 3 Assignments

When you have completed the assignments for Module 3, submit your completed assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
1	Assignment 3.1	Experiment 4, Part 2: Report 4: Capacitors
3	Assignment 3.2	Experiment 5, Part 2: Report 5: Diodes
4	Assignment 3.3	Experiment 6, Part 2: Report 6: Transistors
4	Assignment 3.4	Experiment 7, Part 2: Report 7: Silicon Controlled Rectifier (SCR)
4	Assignment 3.5	Experiment 8, Part 2: Report 8: 7-Segment Display
5	Project 1	The Decision Maker

Lesson 1: Capacitors

Introduction to Capacitors

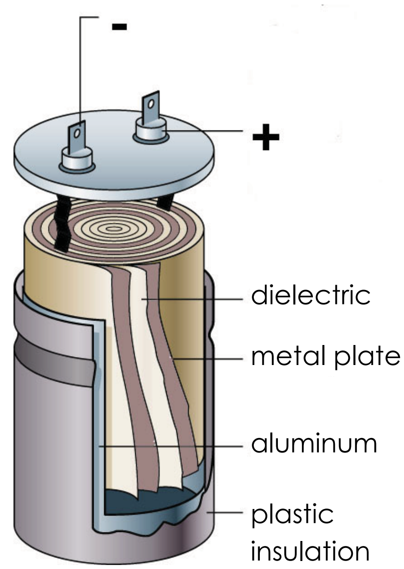


Electrolytic

Generally speaking, there are two types of capacitors: electrolytic and ceramic. A capacitor is like a battery in the sense that capacitors and batteries both store electrical energy. In a battery, a chemical reaction produces electrons on one terminal and absorbs electrons at the other terminal.

A capacitor is much simpler, and it cannot produce new electrons. It only stores them.

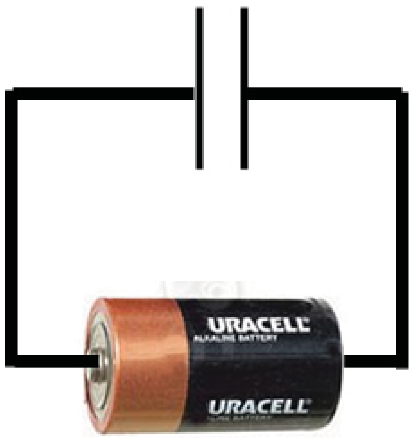
Like a battery, a capacitor has two terminals and these terminals connect to two metal plates that are separated by a **dielectric**. There are many things that can be used for the dielectric: air, paper, plastic, or anything that does not conduct electricity and keeps the two plates from touching. In the electrolytic capacitor in the picture on the right, you can see how they have rolled the two pieces of metal (plates) with the dielectric (paper) in between. This allows us to get a larger amount of capacitance out of a component in a smaller sized area.



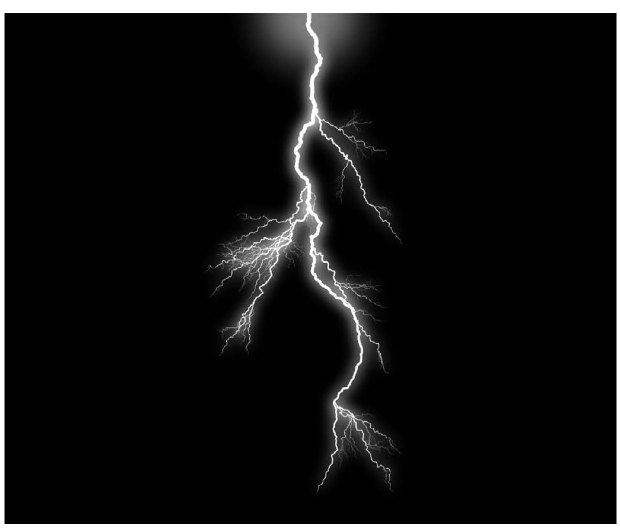
How Does It Work?

First of all, capacitors store charge—that is, physically stores electrons on one of the two plates.

1. One plate on the capacitor that attaches to the negative terminal of the battery accepts electrons that the battery is producing.
2. The other plate on the capacitor that attaches to the positive terminal of the battery loses electrons to the battery.



Once it's charged, the capacitor has the same voltage as the battery (1.5 volts on the battery means 1.5 volts on the capacitor). For a small capacitor, the capacity is small, but large capacitors can hold quite a bit of charge. An example of nature's capacitor is when you see lightning in the sky. One plate is the cloud and the other plate is the ground. The lightning is the charge released between these two plates.



Measuring Capacitance

The capacitance of a capacitor is measured in **farads**. Because these are extremely large units of measure, capacitors are usually rated in microfarads (μF). One microfarad equals one-millionth of a farad. Look at the conversion table below to see how to determine microfarads.

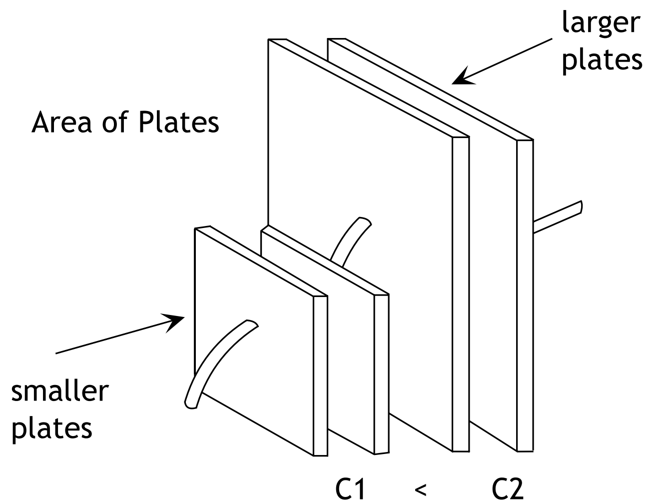
Capacitance Conversion		
Microfarads (μF)	**Nanofarads (nF)**	**Picofarads (pF)**
0.000001 μF	0.001 nF	1 pF
0.00001 μF	0.01 nF	10 pF
0.0001 μF	0.1 nF	10 pF
0.001 μF	1 nF	1000 pF
0.01 μF	10 nF	10,000 pF
0.1 μF	100 nF	100,000 pF
1 μF	1000 nF	1,000,000 pF
10 μF	10,000 nF	10,000,000 pF
100 μF	100,000 nF	100,000,000 pF

Capacitor Capacity

The following three factors determine how much a capacitor can store:

1. **Plate size**

   If the plates are what store the extra electrons, then having a bigger metal plate just means it can store more electrons because the area to store them is physically larger (just like a bigger bucket can hold more golf balls than a smaller one).



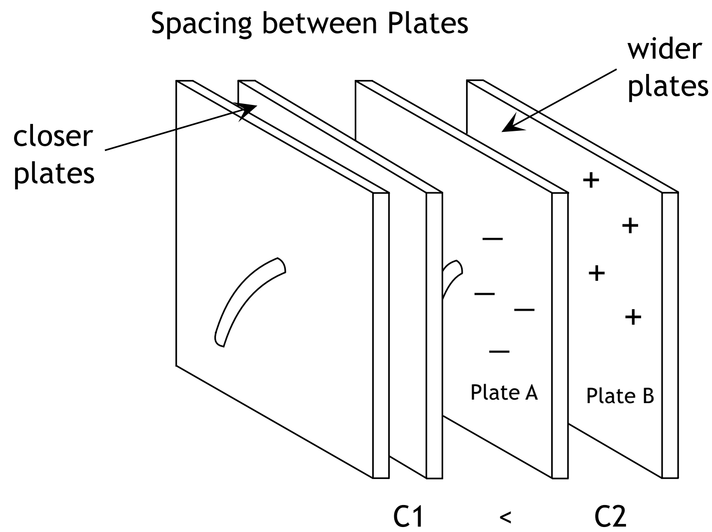
2. **Distance between the plates**

   An equal number of electrons on plate A are being held in place by an equal number of electrons being pulled off plate B. Why? Remember the law of electrical charges? It states that opposites attract and likes repel.

   Plate A is storing the extra electrons, which have a "–" charge. Plate B is actually missing those electrons. They got pulled into the battery. This makes plate A negative and plate B positive.

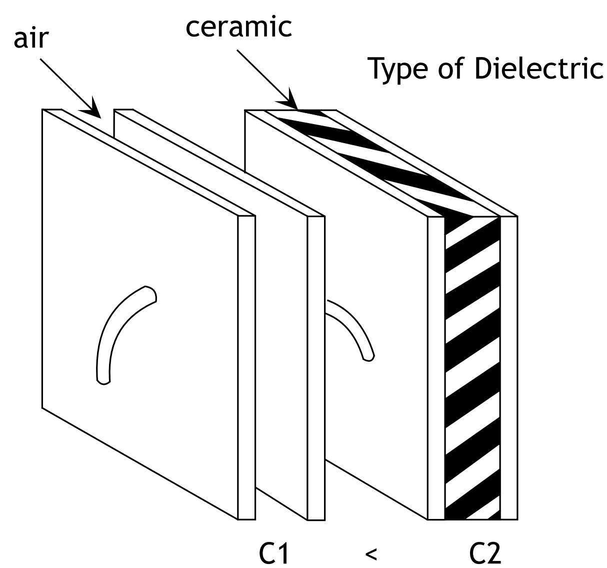
   Plate A is negative because of all the extra electrons, which have a "–" charge. Plate B's atoms are missing that electron, which means there are more protons in the nucleus than electrons in the outer shell. This makes that atom "+" charged.

   The extra electrons on plate "A" (negative) are being held on the plate by the attraction to plate "B" because opposites attract. As long as they don't touch each other, the attraction will continue.



3. **Type of dielectric**

For this factor, what we put in between the plates is important. The closer the plates are together (without touching), the greater the attraction will be between the two plates. Just like when you have two magnets and you hold them far apart, then closer and closer. The closer you get them together, the more effect they have on one another.

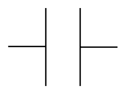


Capacitor Number Code

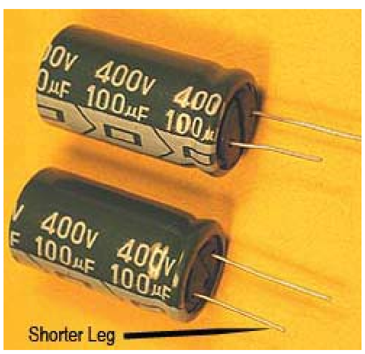
A number code is often used on small capacitors where printing is difficult:

- The first number is the first digit.
- The second number is the second digit.
- The third number is the number of zeros to give the capacitance in pF.

Ignore any letters. They just indicate tolerance and voltage rating. For example, 104 means 100,000; pF = 100 nF (not 104 pF!).

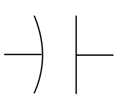


On electrolytic capacitors, the numbers and information are printed right on the side so they are easy to read.



These capacitors **will explode** if the rated working voltage or WVDC is exceeded or if the polarity is reversed, so **be careful and watch for the (–) and (+) markings**. The negative can be identified by the shorter lead on the capacitor; the positive can be identified by the longer lead.

When you use this type of capacitor in one of your projects, the rule of thumb is to choose one that is twice the supply voltage. For example, if your supply power were 12 volts, you would choose a 24-volt (25V) type. This type has improved over the years, and it will remain a very popular type unless something better comes along to replace it. Polarized electrolytic capacitors are heavily used in almost every kind of equipment and consumer electronics.

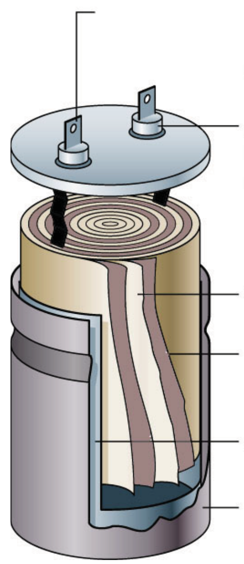


Learning Activity 3.1

Capacitors

Answer the following questions in your notebook.

1. Generally speaking, what are the two types of capacitors?
2. How are capacitors like batteries?
3. How are a capacitor and a battery different?
4. What does the "dielectric" do in an electrolytic capacitor?
5. Label the parts of the electrolytic capacitor below.



6. What is the name for the unit of measurement for capacitance?
7. List the three factors that determine capacitance and explain how each one affects the amount of capacitance.
8. When choosing an electrolytic capacitor, what is the general rule of thumb with regard to its voltage rating?

Check your answers in the Learning Activity Answer Keys found at the end of this module.

It is now time for you to complete Assignment 3.1. This assignment (along with all other assignments) is worth marks and you will submit it to the Distance Learning Unit when you have finished Module 3.

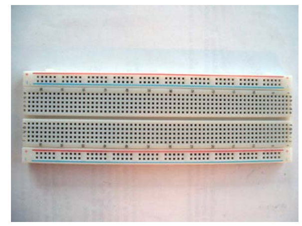
Notes

Assignment 3.1, Part 1

Experiment 4, Part 1: Capacitors

Inventory List: Place a checkmark in each box once you have identified the item.

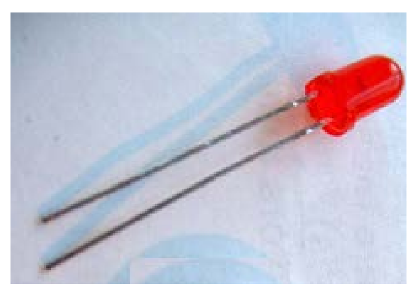
❑ Solderless circuit board



❑ 9-volt battery

❑ 9-volt battery clip

❑ Light emitting diode (LED)



(continued)

Assignment 3.1: Experiment 4, Part 1: Capacitors (continued)

- ❑ Capacitors with the value of
  100 μF
  1000 μF

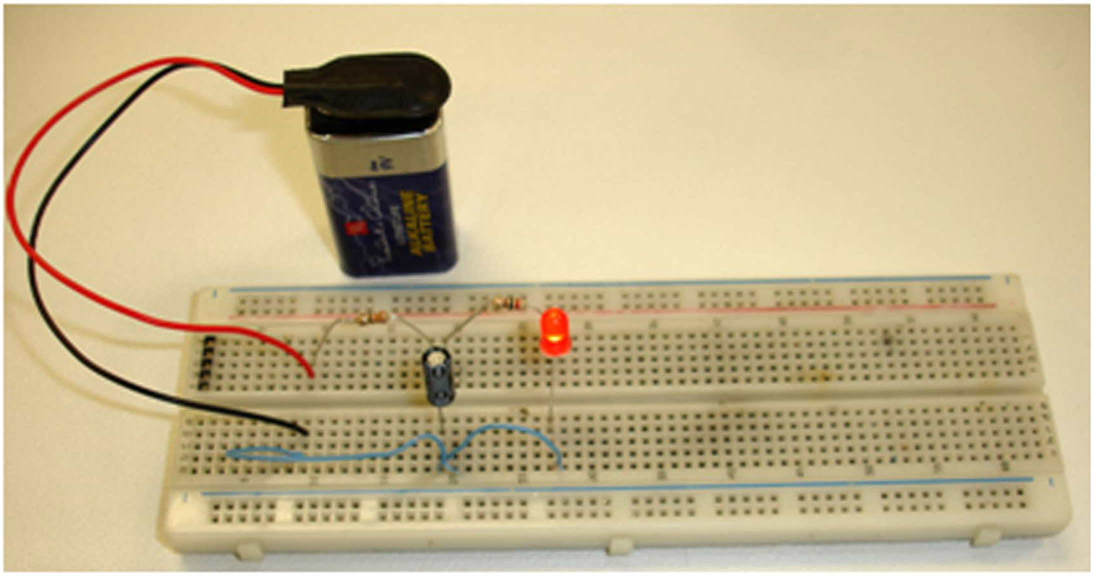
- ❑ Resistors with the value of
  220 ohms
  1 k ohms

- ❑ Potentiometer

- ❑ Safety glasses

(continued)

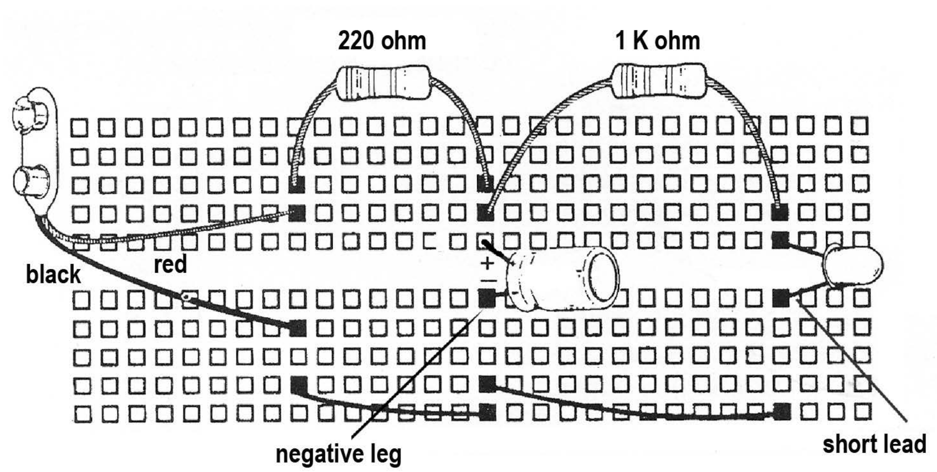
Assignment 3.1: Experiment 4, Part 1: Capacitors (continued)



Purpose: The purpose of this experiment is to see the effects of the charging and discharging of a capacitor on an LED.

Procedure: Build the circuit shown below using your Experiment Kit and Miscellaneous Resistor Bag and solderless circuit board.

Carefully plug your components into the same vertical rows as shown below. Be mindful of the direction of the electrolytic capacitor's negative and positive side.



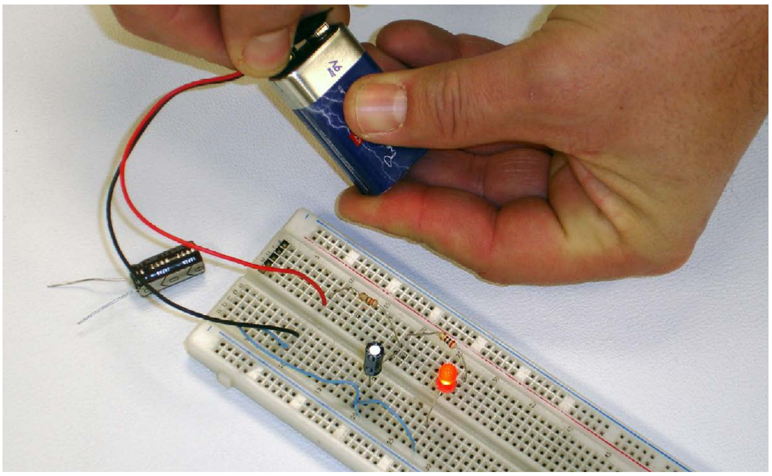
(continued)

Assignment 3.1: Experiment 4, Part 1: Capacitors (continued)

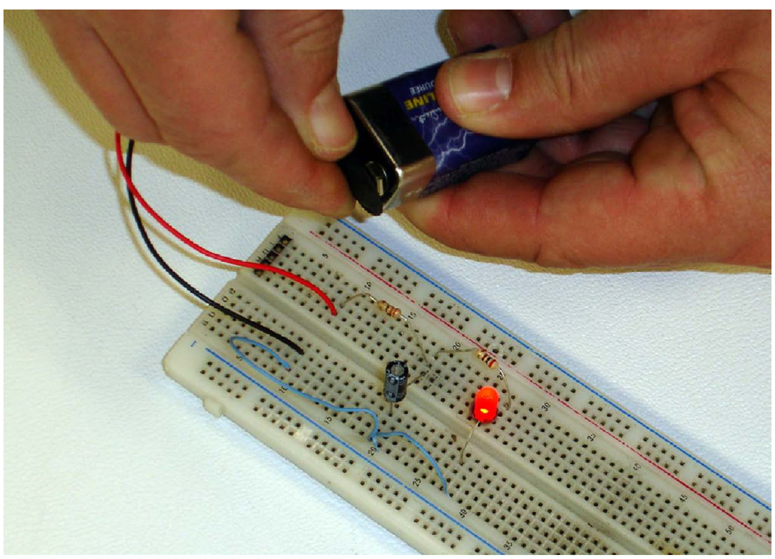
SAFETY GLASSES ON!

The first capacitor you will use is the 100 μF capacitor.

Hook up the 9-volt battery to the battery clip. The LED should light up. If it doesn't, go through the usual checks.



Now, unclip the battery and watch what happens to the LED.



(continued)

Assignment 3.1: Experiment 4, Part 1: Capacitors (continued)

What's Happening?

1. When I connected the battery to the circuit, the LED lit up.

   ❑ yes ❑ no

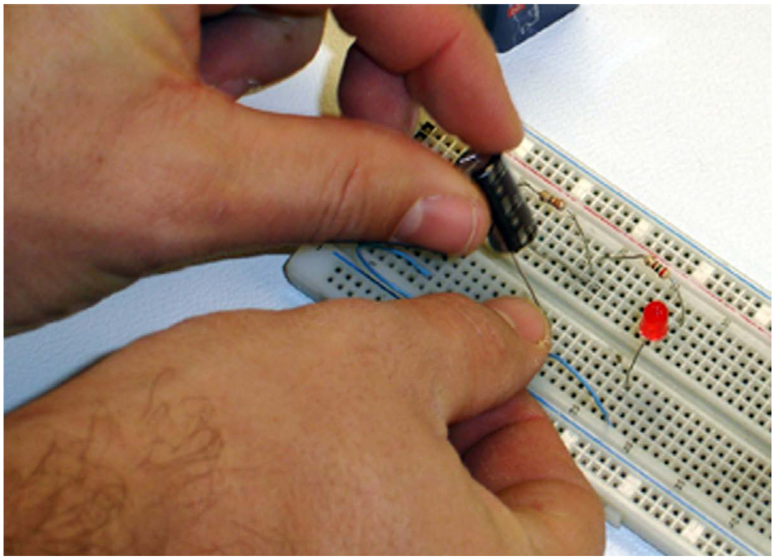
2. When I unhooked the battery, the LED faded out slowly.

   ❑ yes ❑ no

At this point, take out the 100 μF capacitor and replace it with the 1000 μF capacitor.

Hook up the 9-volt battery to the battery clip once again. The LED should light up. If it didn't, go through the usual checks.

Now, unclip the battery and watch what happens to the LED.



3. When I connected the battery to the circuit, the LED lit up.

   ❑ yes ❑ no

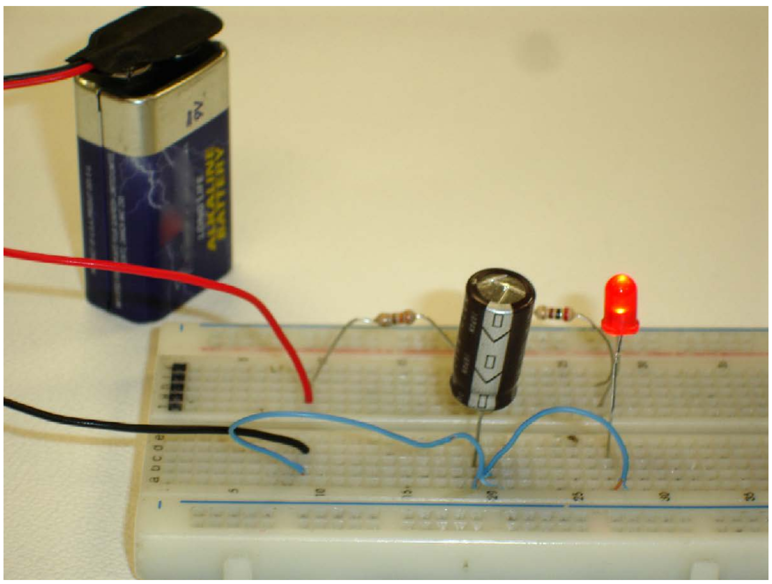
4. When I unhooked the battery, the LED faded out very slowly.

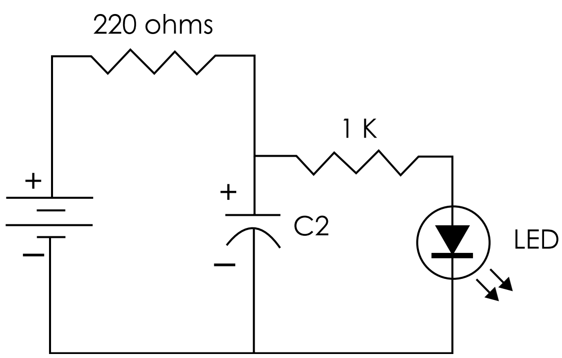
   ❑ yes ❑ no

(continued)

Assignment 3.1: Experiment 4, Part 1: Capacitors (continued)

Explanation: In this simple circuit, the electric current will flow from the negative terminal of the battery to the positive terminal, passing through the LED and charging up the capacitor. When you disconnect the battery, the source of electrons from the battery stops, but the electrons stored in one of the plates in the capacitor drains. It drains through the LED, which causes it to light but fade as the electron supply is used up. The larger the capacitor, the more electrons it can store, so the longer it takes to drain.





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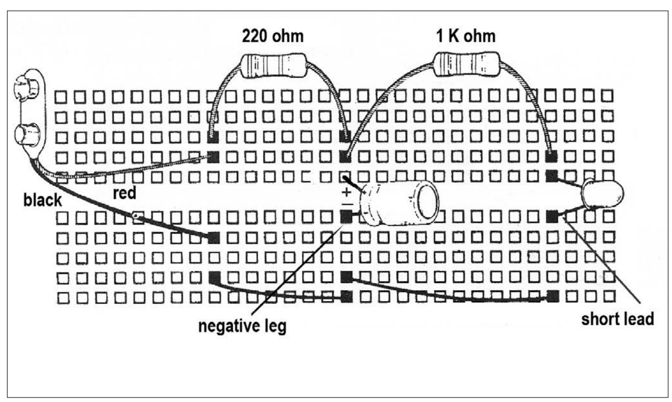


(continued)

Assignment 3.1: Experiment 4, Part 1: Capacitors (continued)

Reminder

Electronic components must be installed with polarity in mind. It’s a good idea to look very carefully at the parts or schematics sheet that is included at the beginning of this module to determine whether a component has a positive or a negative polarity. Look for a (+) sign for the positive side and a (–) sign for the negative side. If no positive or negative symbols are visible, then polarity is not an issue. Therefore, the part can be installed in either direction in the circuit.

Note: The colour code for positive is red and the colour code for negative is black.

Now that you have successfully completed Experiment 4, place the parts back in the Experiment Kit, and then complete the experiment write-up.

Notes

Assignment 3.1, Part 2

Experiment 4, Part 2: Report 4: Capacitors *(14 marks)*

Please provide the responses to the following headings after you have completed your experiment.

Purpose of the Experiment *(2 marks)*

Explanation of the Experiment *(2 marks)*

Results of the Experiment *(2 marks)*

Schematic of the Experiment *(2 marks)*

Parts Used *(6 marks)*

Purpose of the Experiment: *(2 marks)*

Explanation of the Experiment: Read through the experiment. Using three or four sentences, explain what happened. In your own words, show you have an understanding of what you learned and/or observed.
(2 marks)

(continued)

Assignment 3.1: Experiment 4, Part 2: Report 4: Capacitors (continued)

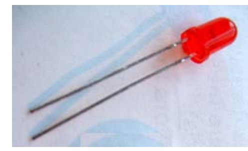
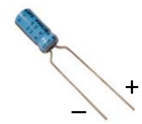
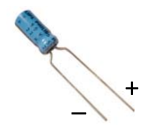
Results of the Experiment: This is where you write what happened during the experiment or what you observed as you followed the procedure to complete the experiment. This usually reflects the purpose and explanation of the experiment. *(2 marks)*

Schematic Diagram: Redraw the schematic representation of the circuit that you just built. The schematic diagram is provided to you in the experiment itself. *(2 marks)*

(continued)

Assignment 3.1: Experiment 4, Part 2: Report 4: Capacitors (continued)

Parts Used: Fill in the chart below, and draw the schematic symbols for the parts used in performing the experiment. Write down the value of any of the components, and make note that some components will not have a value (e.g., an LED would not have a value). *(6 marks)*

Name of Part	Value (if any)	Schematic Symbol	Picture of Part
LED			
Capacitor			
Capacitor			
Resistor			
Resistor			
Battery			

Notes

Lesson 2: Semiconductors

Semiconductor Theory

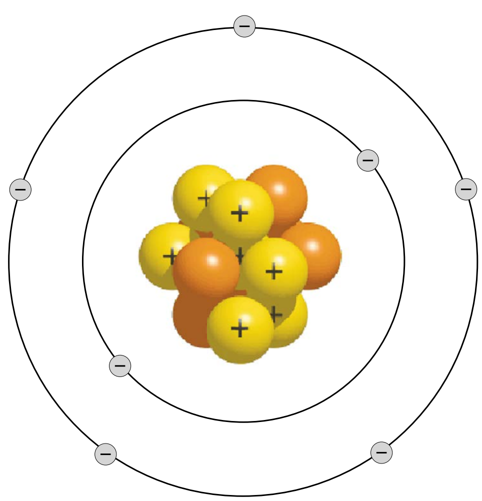
There are three basic types of materials that we work with in electronics. We have talked about two of them, conductors and insulators, but the third is neither a good conductor nor a good insulator. These are semiconductors.

Examples of Conductors	Examples of Insulators	Examples of Semiconductors
copper aluminum silver gold	rubber PVC paper	silicon germanium

First, let's take a look at the atomic structure of a semiconductor to understand its electrical properties. The concepts learned here pertain to the function of many semiconductor devices, such as transistors, diodes, and integrated circuits.

Outline of Atomic Theory

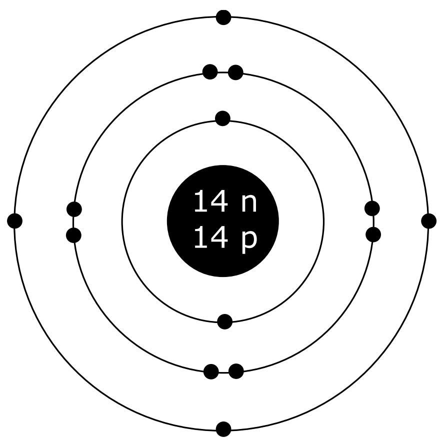
An atom can be thought of as a central positively charged nucleus orbited by negatively charged electrons. The positive charge of the nucleus is due to the positively charged protons it contains. For an atom in its natural state, the total negative charge of the electrons is equal to the positive charges of protons in the nucleus. When this happens, we say the atom is electrically neutral.



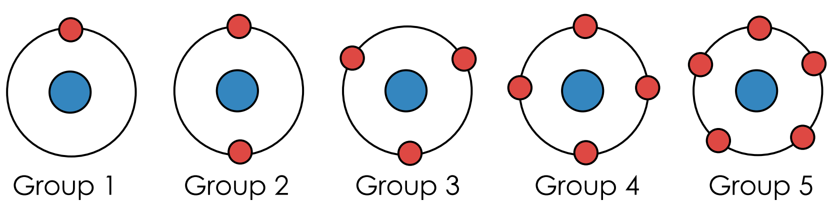
The orbits of the electrons are arranged in shells. The first shell is closest to the nucleus and contains a maximum of two electrons. The next outer shell contains a maximum of eight electrons. The next shell also contains a maximum of eight electrons.

Element Groups

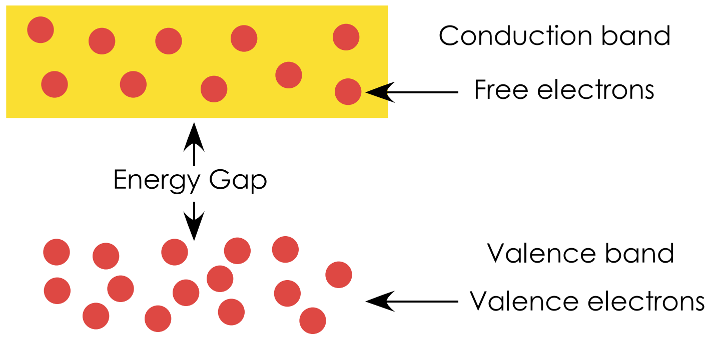
- An atom with one electron in its outer shell is called a Group 1 element.
- An atom with two electrons in its outer shell is called a Group 2 element.
- An atom with three electrons in its outer shell is called a Group 3 element.
- An atom with four electrons in its outer shell is called a Group 4 element.
- An atom with five electrons in its outer shell is called a Group 5 element (et cetera).



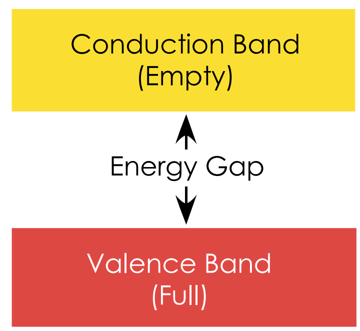
Semiconductors are Group 4 elements as they have four electrons in their outermost shell or four valence electrons.



Energy band diagrams show the energy levels of the electrons, or how far away the electrons are from the centre or nucleus. We are only interested in two of the bands: the valence band, which is the farthest from the nucleus; and the conduction band. The conduction band is where the electrons are free of their atom's nucleus and are allowed to roam around.



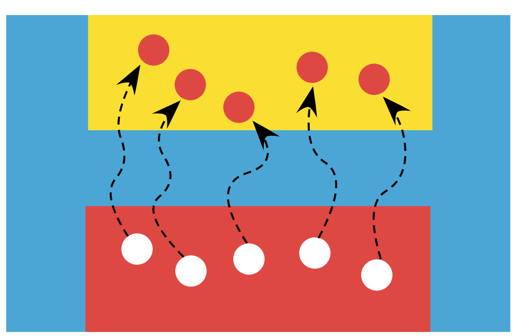
The valence shell contains electrons that are at the highest energy level but are still attracted to their atom's nucleus. The conduction band is occupied by electrons that are free from their parent atoms. These electrons have enough energy to leave their parent atoms and are free to move through the semiconductor material. When a voltage is applied to these atoms, the electrons will drift to produce an electrical current.



In semiconductors, there is a gap between the valence and conduction bands. This energy gap reflects the amount of energy that would be needed to move an electron from the valance band to the conduction band where it is free of its atom's nucleus.

If we supply an external energy source to an atom, electrons in the valance shell will transfer an electron to the conduction band. This produces a free electron in the conduction band and leaves a hole (a vacant spot where the electron was) in the valence band.

The free electrons are now available to contribute to an electrical current if a voltage is applied to the material. The holes (the vacant electron positions) in the valence band will also now allow movement of electrons in the valence band. This can also contribute to an electrical current.



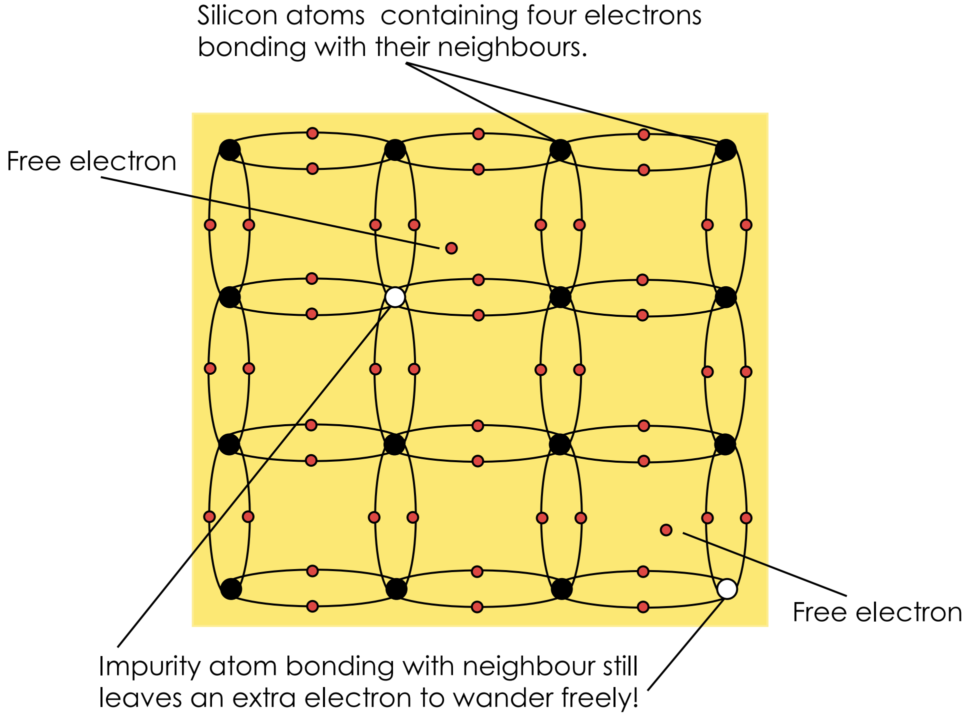
Extrinsic Semiconductors

To produce semiconductor materials, specific amounts of impurities are added to the pure silicon. This process is called **doping**, and the impurity atoms are called donor atoms.

There are two types of extrinsic semiconductors: **P-type** semiconductors and **N-type** semiconductors.

The pure silicon is doped (has impurities added to it) with Group 5 elements such as phosphorus, antimony, or arsenic. These materials have atoms with five valence electrons, and silicon has only four valence electrons. Four of these electrons will form covalent bonds with neighbouring silicon atoms. Now, as there are only four bonds binding the donor atom to the neighbouring silicon atoms, the fifth electron is not part of a covalent bond and is therefore a free electron.

Every impurity atom will produce a free electron in the conduction band. These electrons will move to produce electrical current if a voltage is applied to the material.

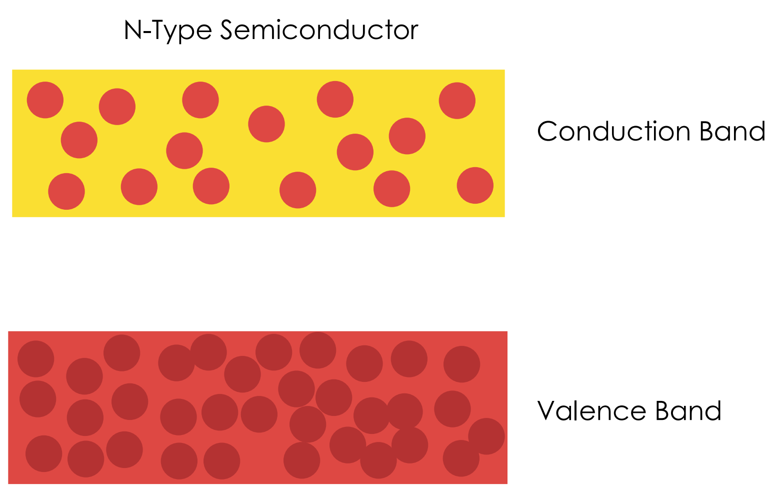


- The silicon atoms form a square lattice.
- The white atoms represent the donor atoms.
- Four of the five valence electrons form covalent bonds with neighbouring silicon atoms.
- The fifth electron has no neighbouring electron to pair with and is a free electron.
- Each donor atom produces a free electron.

Note: It is called an **N-type semiconductor** because the majority of charge carriers that will contribute to an electrical current through the material are negatively charged free electrons produced by the doping process. There will be some contribution to the current flow from positively charged holes due to electron hole generation in the silicon, but these holes are the minority charge carriers in this material.

Energy Band

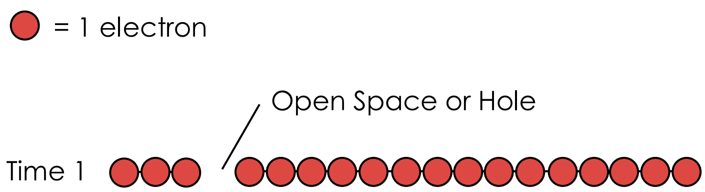
This diagram shows an energy band for an N-type semiconductor. The valence band is completely full as all of the covalent bonds are complete. The conduction band contains free electrons from the fifth valence electrons in the donor atoms.



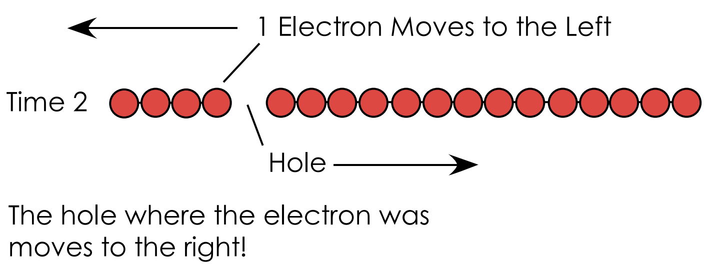
Note: This diagram does not show the electron holes that would be present. The electron holes are minority charge carriers in N-type semiconductors, the majority being the free electrons produced by the doping process.

Holes

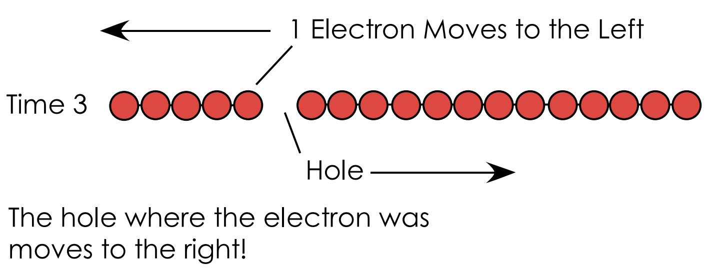
The movement of electrons in the valence band is complicated. As they move to fill the vacant electron positions, the position of the hole appears to move in the opposite direction to the electrons. In fact, it is easy to consider the movement of the hole, and we can imagine it to be a positively charged particle because of the direction of its movement (opposite to that of negatively charged electrons).



At first, this may seem to be a strange idea, but later you will see that by considering the movement of these virtual particles, it is much easier to understand how semiconductor devices work. However, it is important to remember that although we regard holes as positively charged particles, they are not real particles, and all the effects we see are actually caused by the movement of electrons in the valence band.



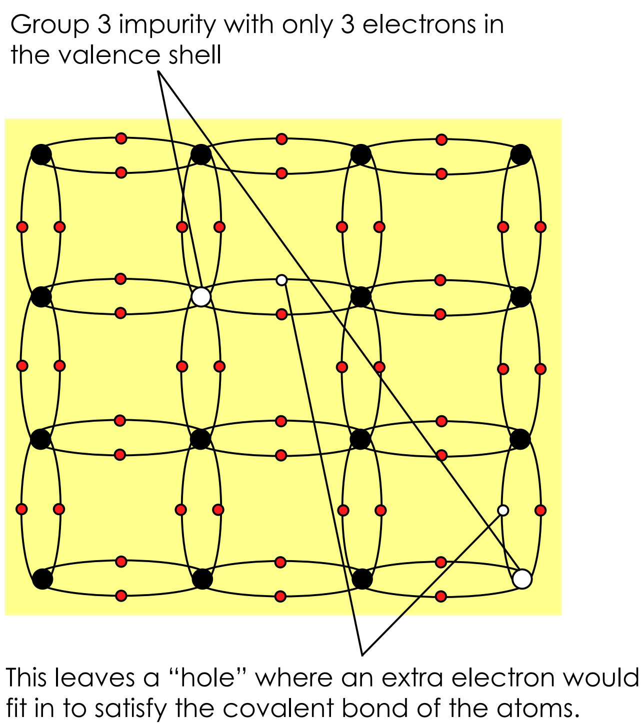
In each of the time diagrams, you can see that as one electron moves to the left, a hole is created where it came from, which in turn is filled by another electron. As this happens, the hole that the electron leaves is moving to the right. Therefore, as electrons move left, holes move right.



P-type Semiconductor

In this instance, the pure silicon is doped with a Group 3 element such as boron, aluminum, or indium. These materials have atoms with three valence electrons. The three electrons will form covalent bonds with neighbouring silicon atoms, but there are not enough electrons to form the fourth covalent bond. This leaves a hole in the covalent bond structure, and therefore a hole in the valence band of the energy level diagram.

Every impurity atom will produce a hole in the valence band. These holes will drift to produce an electrical current if a voltage is applied to the material, but the P-type semiconductor is still a much better conductor than the pure silicon material.

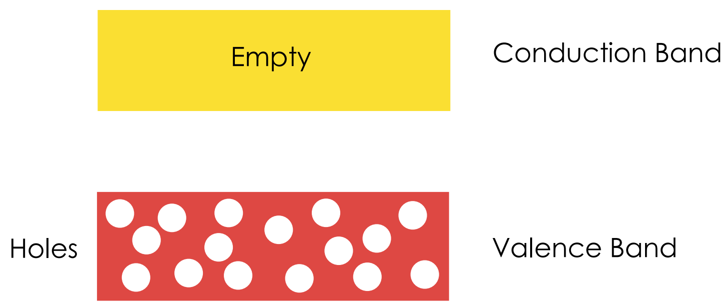


- The silicon atoms form a square lattice.
- The white atoms represent the donor atoms.
- Three of the four covalent bonds are formed with neighbouring silicon atoms.
- The fourth bond cannot be formed as there are not enough electrons. This leaves a hole in the valence band.
- Each donor atom produces a hole in the valence band.

Note: It is important to point out that the material is called P-type semiconductor because the majority of charge carriers that contribute to an electrical current are positively charged holes produced by the doping process. The majority of the current carriers here are the "holes" and not the electrons.

Energy Band Diagram

The diagram shows an energy band diagram for a P-type semiconductor. The valence band contains holes due to the incomplete covalent bond around each donor atom. The conduction band is empty, as there are no free electrons.



Learning Activity 3.2

Semiconductor Theory

Answer the following questions in your notebook.

1. List three basic types of materials that we work with in electronics.
2. Why is the nucleus of an atom positively charged?
3. When is an atom said to be electrically neutral or balanced?
4. The orbits for electrons around the nucleus of an atom are arranged in layers or sometimes referred to as ________ .
5. Atoms with one electron in the outer shell are referred to as ________ .
6. Atoms with four electrons in the outer shell are referred to as ________ .
7. What do energy band diagrams show?
8. The outermost band where electrons are farthest away but still held in orbit by the nucleus is called the ________ .
9. Electrons that have enough energy to break away from their parent atoms and are free to move around are in the ________ .
10. When an electron leaves the valence band, we say it leaves a ________ in the space it once occupied.
11. The process of adding impurities to silicon to create semiconductors is called ________ .
12. Name the two types of extrinsic semiconductor materials.
13. In N-type materials, the impurities are added from group ________ elements, so there will be a free electron available in the semiconductor material.
14. “Holes” are not really particles but spaces left by moving ________ .
15. In P-type materials, the impurities are added from group ________ elements, which leaves a hole in the covalent bond in the semiconductor material.
16. In P-type semiconductor materials, the ________ are the majority current carriers and not the electrons.

Check your answers in the Learning Activity Answer Keys found at the end of this module.

Notes

Lesson 3: The Diode

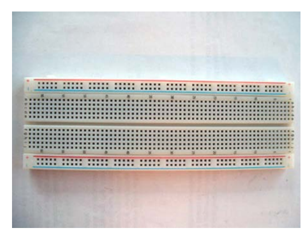
This lesson begins with Assignment 3.2. This assignment (along with all other assignments) is worth marks and you will submit it to the Distance Learning Unit when you have finished Module 3.

Assignment 3.2, Part 1

Experiment 5, Part 1: Diodes

Inventory List: Place a checkmark in each box once you have identified the item.

❑ Solderless circuit board

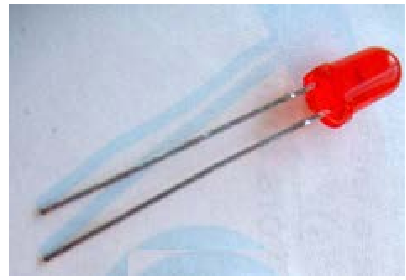


❑ 9-volt battery

❑ 9-volt battery clip

(continued)

- ❑ Light emitting diode (LED)



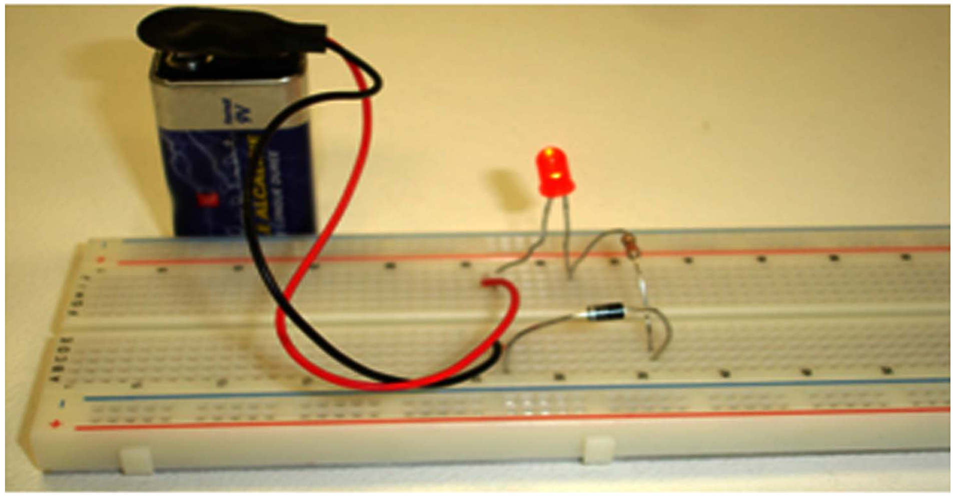
- ❑ Diode

- ❑ Resistors with the value of 220 ohms

- ❑ Safety glasses

(continued)

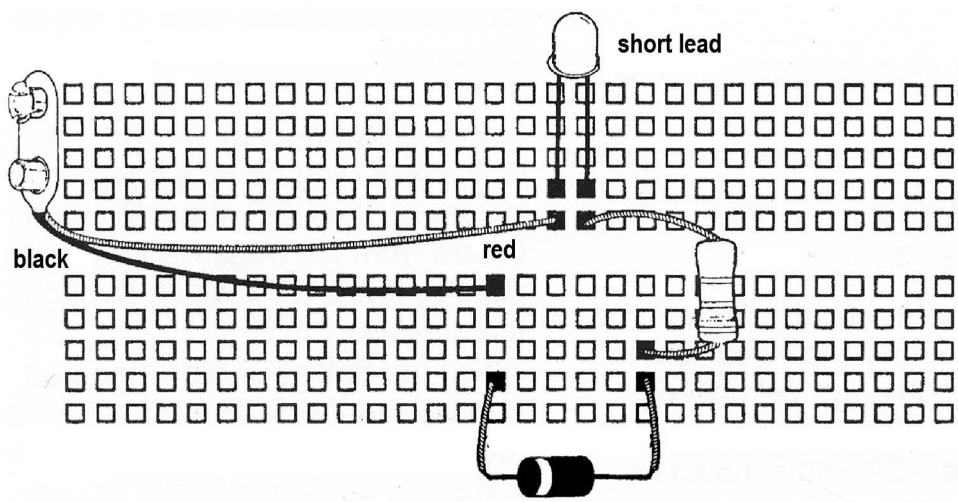
Assignment 3.2: Experiment 5, Part 1: Diodes (continued)



Purpose: The purpose of this experiment is to observe how a diode allows current to flow through it in one direction only.

Procedure: Build the circuit shown below using your Experiment Kit and solderless circuit board.

Carefully plug your components into the same vertical rows, as shown below.



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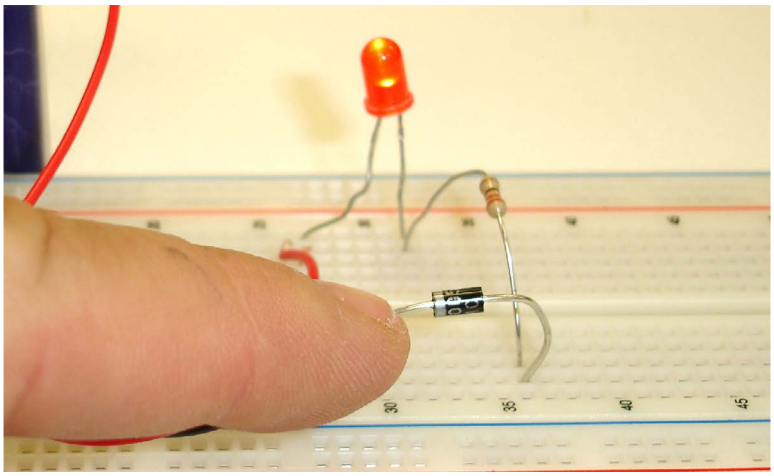
Assignment 3.2: Experiment 5, Part 1: Diodes (continued)

SAFETY GLASSES ON!

Use a 220 ohm resistor.

Be sure that the diodes, anode, and cathode are installed in the correct position.

Hook up the 9-volt battery to the battery clip. The LED should light up. If it doesn't, go through the usual checks.



(continued

Assignment 3.2: Experiment 5, Part 1: Diodes (continued)

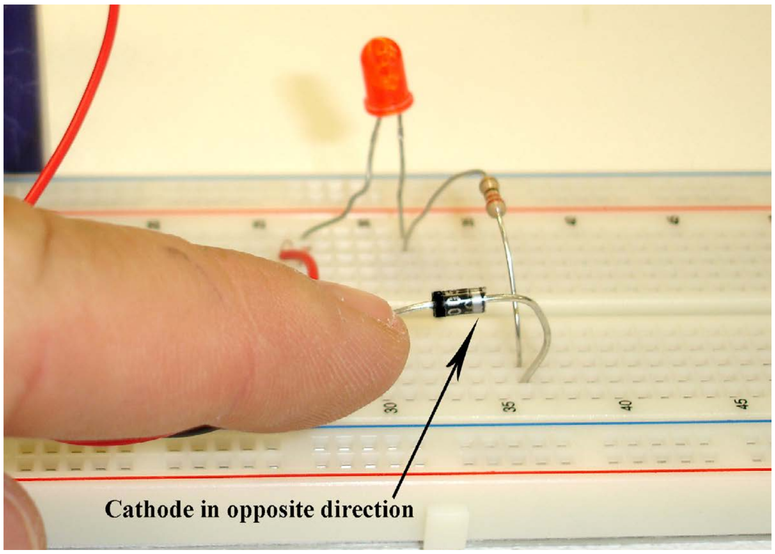
What's Happening?

1. When I connected the battery to the circuit, the LED lit up.

   ❑ yes ❑ no

Disconnect the battery from the clip.

Turn the diode around so that its cathode is opposite to the diagram.



2. When I connected the battery to the circuit, the LED lit up.

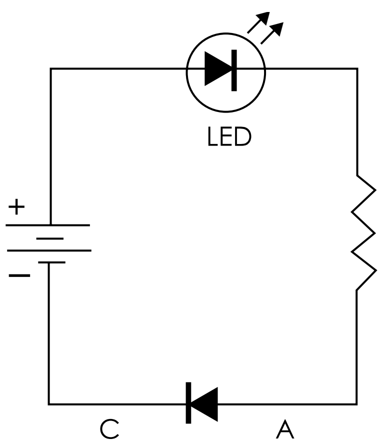
   ❑ yes ❑ no

At this point, the LED should not have lit up due to the incorrect position of the diode.

(continued

Assignment 3.2: Experiment 5, Part 1: Diodes (continued)

Explanation: In this simple circuit, the diode is an electrical one-way gate. It will only conduct when the cathode is more negative than the anode. In other words, the negative side of the battery is connected to the cathode, and the positive side of the circuit is connected to the positive side of the battery. When this occurs, we say that the diode is "forward bias." When we switched the diode around and the LED did not light up, the diode had "reverse bias."



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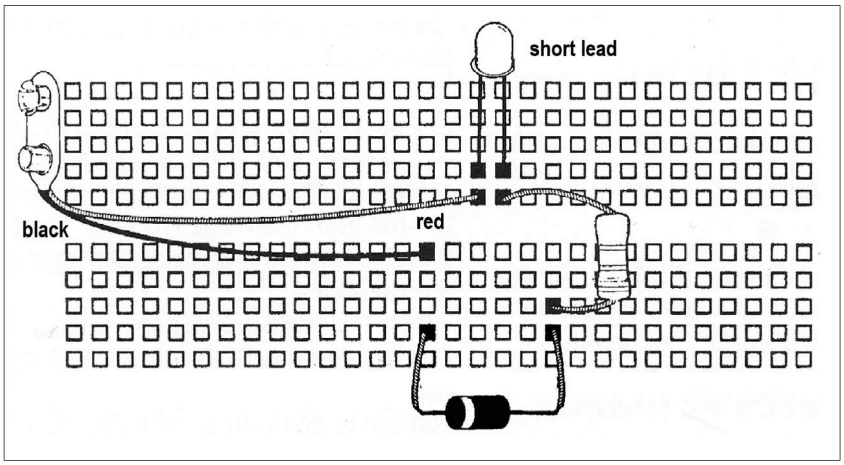

Reminder

Electronic components must be installed with polarity in mind. It's a good idea to look very carefully at the parts or schematics sheet that is included at the beginning of this module to determine whether a component has a positive or a negative polarity. Look for a (+) sign for the positive side and a (–) sign for the negative side. If no positive or negative symbols are visible, then polarity is not an issue. Therefore, the part can be installed in either direction in the circuit.

Note: The colour code for positive is red and the colour code for negative is black.

Now that you have successfully completed Experiment 5, place the parts back in the Experiment Kit, and then complete the experiment write-up.

Assignment 3.2, Part 2

Experiment 5, Part 2: Report 5: Diodes *(12 marks)*

Please provide the responses to the following headings after you have completed your experiment.

Purpose of the Experiment *(2 marks)*

Explanation of the Experiment *(2 marks)*

Results of the Experiment *(2 marks)*

Schematic of the Experiment *(2 marks)*

Parts Used *(4 marks)*

Purpose of the Experiment: *(2 marks)*

____

____

____

____

Explanation of the Experiment: Read through the experiment. Using three or four sentences, explain what happened. In your own words, show you have an understanding of what you learned and/or observed.
(2 marks)

____

____

____

____

(continued)

Assignment 3.2: Experiment 5, Part 2: Report 5: Diodes (continued)

Results of the Experiment: This is where you write what happened during the experiment or what you observed as you followed the procedure to complete it. This usually reflects the purpose and explanation of the experiment. *(2 marks)*

____

____

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Schematic Diagram: Redraw the schematic representation of the circuit that you just built. The schematic diagram is provided to you in the experiment itself. *(2 marks)*

(continued)

Assignment 3.2: Experiment 5, Part 2: Report 5: Diodes (continued)

Parts Used: Fill in the chart below, and draw the schematic symbols for the parts used in performing the experiment. Write down the value of any of the components, and make note that some components will not have a value (e.g., an LED would not have a value). *(4 marks)*

Name of Part	Value (if any)	Schematic Symbol	Picture of Part
LED			
Diode			
Resistor			
Battery			

Notes

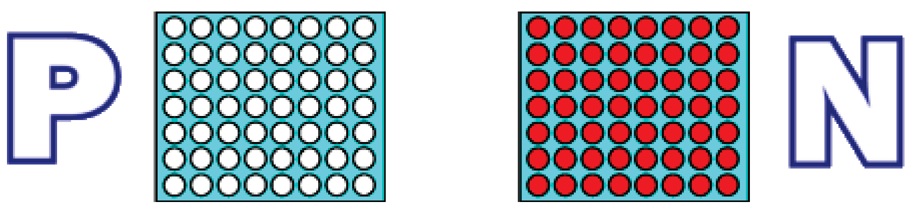
The Diode

Why and how does a diode only let electrical current flow in one direction?

Understanding the operation of the semiconductor diode is the basis for an understanding of all semiconductor devices. The diode is actually manufactured as a single piece of material, but it is much easier to explain the operation if we imagine producing two separate pieces of N-type and P-type material and then sticking them together.

Consider a piece of N-type semiconductor material. It allows charge carriers in the form of free electrons. There are free electrons as a result of the doping process and they are evenly distributed throughout the N-type material.

In the P-type material, it is the positively charged holes that are mobile and, for identical reasons to those previously described, the holes are evenly distributed throughout the P-type material.



Now consider what will happen if these two separate pieces of P- and N-type material are joined together. The random motion of the mobile electrons in the N-type material and the holes in the P-type material would cause an even distribution of electrons and holes throughout the semiconductor.

In the N-type material, the electrons start to migrate across the junction of the two materials. When they cross into the P-type material, they fill in the holes in the valence band by filling in the vacant electron positions around the donor atoms. This means that the number of holes near the junction becomes depleted, or there are fewer holes in the junction region. Also, as the electrons leave the previously neutral N-type material, a positive charge builds up at the junction. This is because the positive charge from the nucleus of atoms near the junction is now greater than the negative charge of the electrons in that region. This is due to the reduction in the number of electrons because some moved across the junction.

Similarly, as holes migrate from the P- to N-type material, they recombine with the free electron from the atoms with five electrons completing the fourth covalent bond around the atoms with only three valence electrons. This leaves a depletion of free electrons near the junction in the N-type material. Also, a negative charge builds up near the junction in the P-type material due to the loss of positively charged holes.

In plain English, when we put the two materials together, the electrons in the N-type material combine with the holes in the P-type material and form a fairly stable region called the P-N Junction.

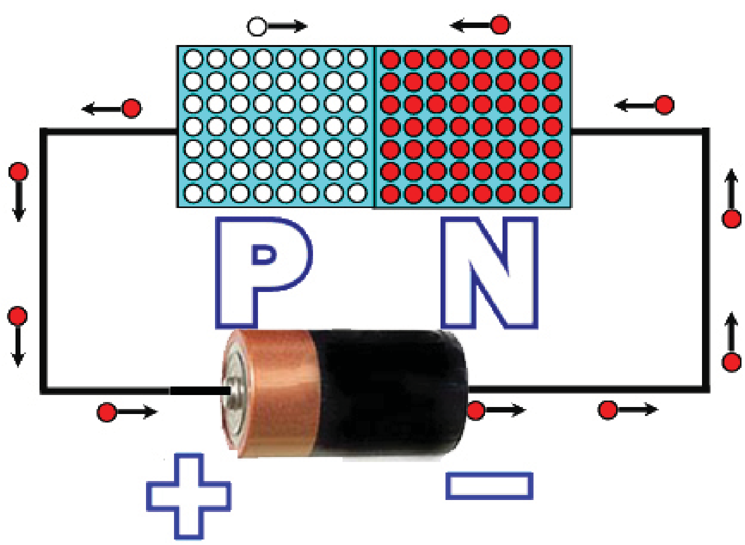
The Effect of the Barrier Voltage

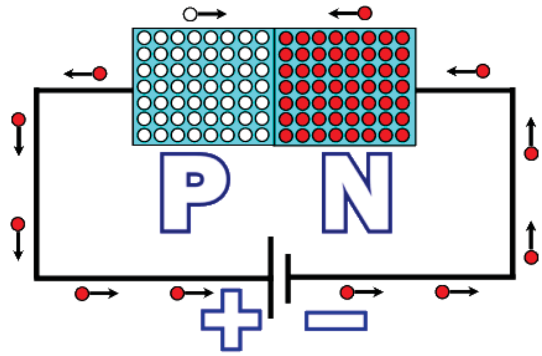
The positive charge at the N side of the junction repels any positively charged holes that would tend to migrate across the junction from the P-type material. It also attracts free electrons, and therefore prevents them from moving out of the N-type material.

Similarly, the negative charge in the P-type material close to the junction repels electrons, which would tend to migrate from the N-type material and attract the holes and prevent them from moving out of the P-type material.

When a Diode Conducts, We Say It's "Forward Bias"

Apply an external voltage to the diode with the positive terminal connected to the P-type material and the negative terminal connected to the N-type material.





The external voltage would tend to cause the movement of electrons from the negative terminal of the supply through the diode and back to the positive terminal (electron flow).

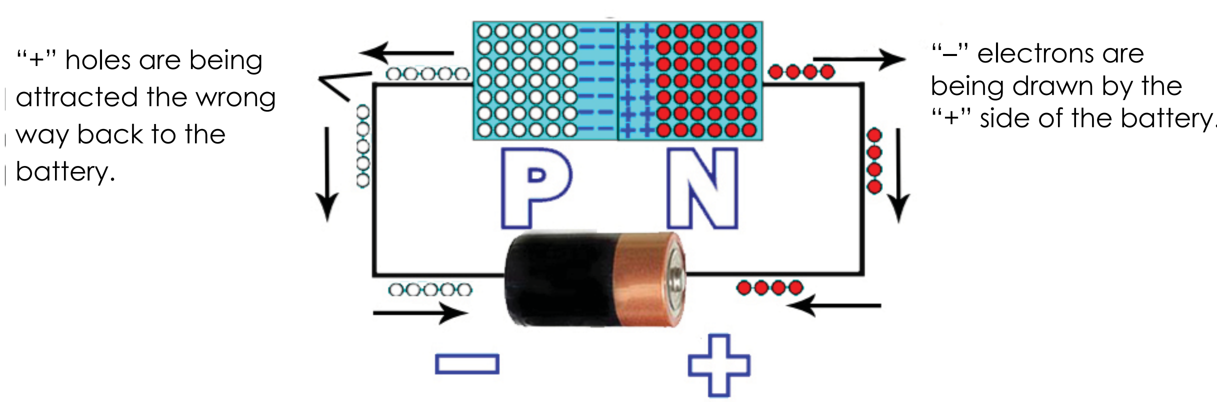
The negative terminal would tend to inject electrons into the N-type material. This would increase the number of electrons in the N-type material. Similarly, the positive terminal would tend to pull electrons from the P-type material. This would increase the number of holes. The net effect is that when the external voltage is connected, it reduces the P-N junction barrier. If the applied voltage is greater than the barrier voltage can handle, it will overcome it and produce a current flow through the diode. When an external voltage is connected to a diode with this polarity, we say that it is "forward biased." In other words, it works.

Reverse Bias

If you place a diode in a circuit the "wrong way" or what is known as "reverse bias," no current will flow through the diode.

Applying an external voltage to the diode (as shown below with the positive terminal connected to the N-type material and the negative terminal connected to the P-type material) will result in no current flow. Remember that opposites attract and likes repel. This should help you remember that when you hook up the diode with the positive side of a battery to the negative side or cathode of a diode, no current will flow. We need current to flow **through** the diode, and this is not possible in this configuration.

No electrons cross the PN junction.



No Current Flow!!

Learning Activity 3.3

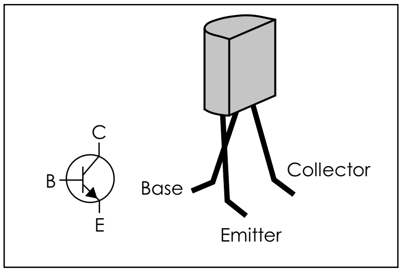
Diodes

Answer the following questions in your notebook.

1. An N-type piece of semiconductor material's charge carriers are in the form of ________ .
2. There are free electrons in N-type semiconductor material because of what process?
3. In P-type semiconductor material, the ________ are the current carriers.
4. When P- and N-type materials are joined together, some of the free electrons in the N-type material fill in some ________ in the P-type material.
5. Similarly, as holes migrate from the ________ to the ________ type material, they recombine with the free electrons from the atoms with five electrons.
6. The fairly stable region of atomic material that is formed where the N- and P-type semiconductors have joined is called ________ .
7. When a diode conducts, we say that it is ________ .
8. To connect a voltage source properly so that there is electron flow through a diode, the negative terminal of a battery must be connected to the ________ type material, and the positive terminal to the ________ type material.
9. When we connect a diode "the wrong way" and there is no current flow, we call this ________ .
10. When a diode is not able to conduct, the negative terminal of a battery would be connected to the ________ type material and the positive terminal would be connected to the ________ type material.

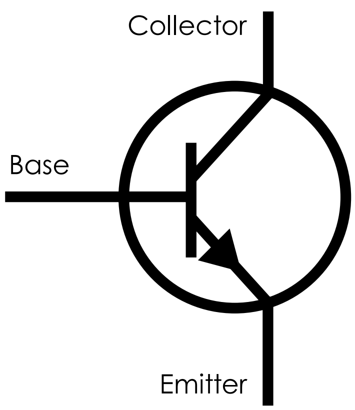
Check your answers in the Learning Activity Answer Keys found at the end of this module.

Introduction to Transistors

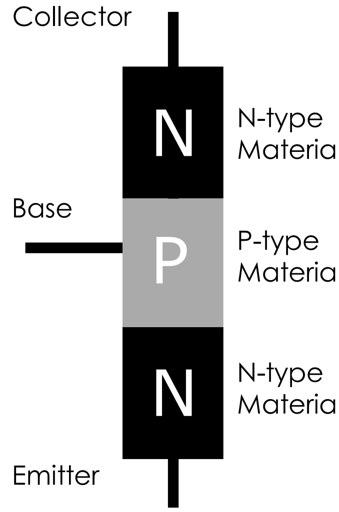


or

A transistor and a diode are alike in many ways. Both are made up of semiconductor material, but a transistor has three regions consisting of P-type and N-type materials, and a diode has only two.

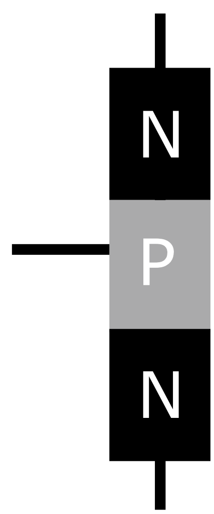


Schematic Diagram



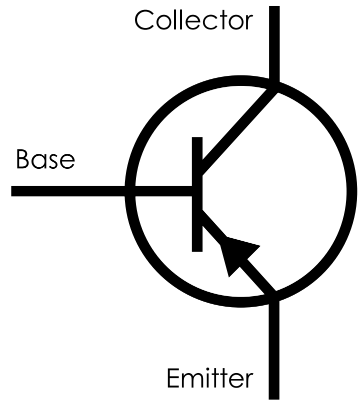
Block Diagram

Depending on the type of transistor, there may be two N-type regions with a P-type region sandwiched between them (known as an NPN transistor), or two P-type regions with an N-type region between them (PNP transistor). For this description, we will assume an NPN transistor, but the operation of a PNP transistor is basically the same if you reverse the polarity. The two N-regions are known as the collector and the emitter, and the central P-region is known as the base in a NPN transistor.



Here are three things that you should always remember about the transistor schematic symbols.

1. The arrow is always on the emitter lead of any transistor.
2. Electrons flow into the point of the emitter lead arrow.
3. The arrow on the emitter always points to the "N" type material.

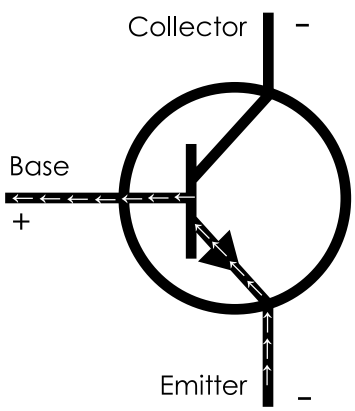


How It Works

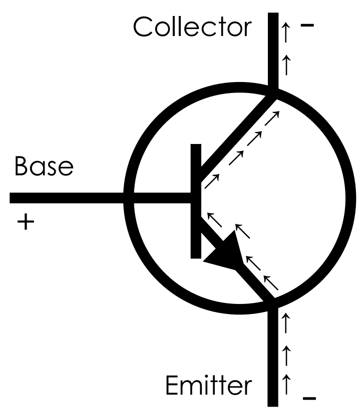
When the collector and the base are connected to a positive voltage and the emitter is connected to a negative voltage, the NPN transistor is correctly biased.

Current entering the transistor through the **emitter** lead is divided. A small portion of it is diverted back to the power source through the **base** lead, as shown by the white arrows in the diagram on the left.

The small base current controls the much larger collector current that is flowing at the same time, as shown by the black arrows in the diagram on the right.



Emitter through Base Current Diagram



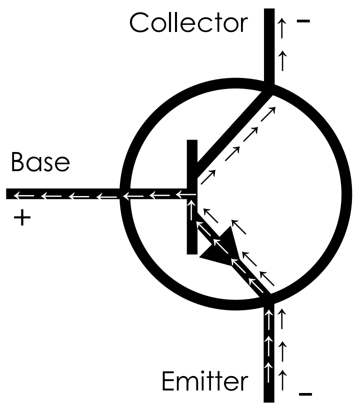
Emitter through Collector Current Diagram

This is a remarkable process of having a small current control a large current. Because of this, amplification is possible.

By varying the amount of the small base current, you can cause the larger collector current to change on a larger scale.

Things to Know

Note that the base is not always in the same pin location on the transistor. Never assume where the emitter, base, and collector are. Always make sure by checking a transistor's specifications sheet or an instruction sheet.



Emitter Base and Emitter Collector Current Flow

A transistor can also act like a switch. If you turn off the base current, there is no collector current.

The collector current is considerably larger than the base current. Depending on the type of transistor, the collector current could be anything between ten times and several hundred times the base current. By applying a small current variation to the base, we get a much larger collector current variation. The device therefore acts like an amplifier.

Learning Activity 3.4

Transistors

Answer the following questions in your notebook.

1. A transistor is like a diode in that they are both made up of ________.
2. A transistor and a diode are different in that a transistor has ________ regions of semiconductor materials and a diode has ________ .
3. Transistors are like sandwiches of different types of semiconductor materials and therefore can be two types, depending on the order of the semiconductor materials. One is a(n) ________ transistor and the other is a ________ transistor.
4. Draw and fully label a block diagram of an NPN transistor.
5. What are three things you should always remember about the transistor's schematic symbols?
6. Describe how you would hook up an NPN transistor's leads if it were correctly biased.
7. When current enters the transistor through the emitter lead, it is divided in two. A small amount goes from the emitter through the ________ , and the larger amount goes from the emitter through the ________ .
8. Draw the current flow of an NPN transistor using the schematic diagram, showing both the current flows as described in the previous question.
9. This process of a small current controlling a large current is remarkable in that it is the principle behind the process of ________ .

Check your answers in the Learning Activity Answer Keys found at the end of this module.

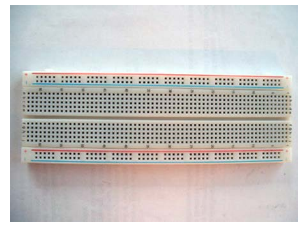
It is now time for you to complete Assignment 3.3, Assignment 3.4, and Assignment 3.5. These assignments (along with all other assignments) are worth marks and you will submit them to the Distance Learning Unit when you have finished Module 3.

Assignment 3.3, Part 1

Experiment 6, Part 1: Transistors

Inventory List: Place a checkmark in each box once you have identified the item.

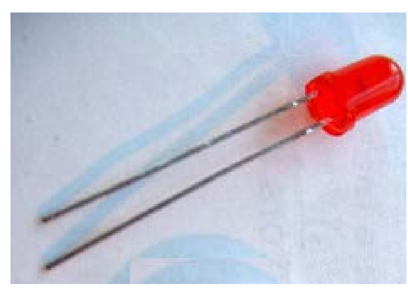
❑ Solderless circuit board



❑ 9-volt battery

❑ 9-volt battery clip

❑ 2 light emitting diodes (LED)



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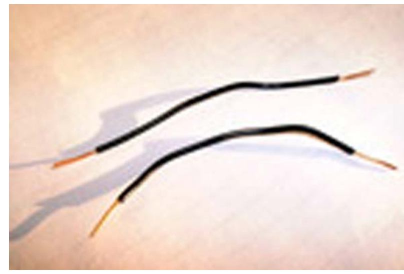
Assignment 3.3: Experiment 6, Part 1: Transistors (continued)

❑ Solid hook-up wires



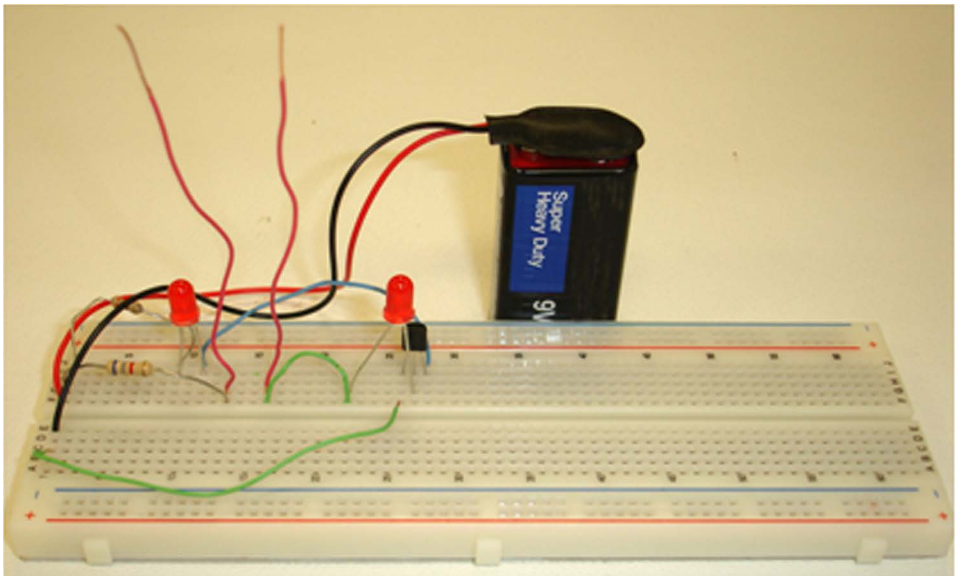
❑ Resistors with the value of
330 ohms
5.6 K ohms

❑ NPN Transistor

❑ Safety glasses

(continued)

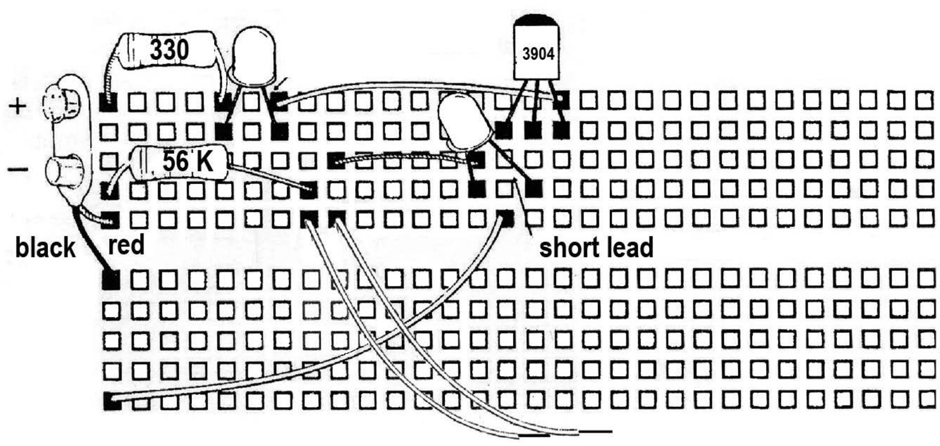
Assignment 3.3: Experiment 6, Part 1: Transistors (continued)



Purpose: The purpose of this experiment is to see how an NPN transistor works.

Procedure: Build the circuit shown below using your Experiment Kit and solderless circuit board.

Carefully plug your components into the same vertical rows as shown below. Be mindful of the direction of the transistor's flat face and the placement of the legs in the board.



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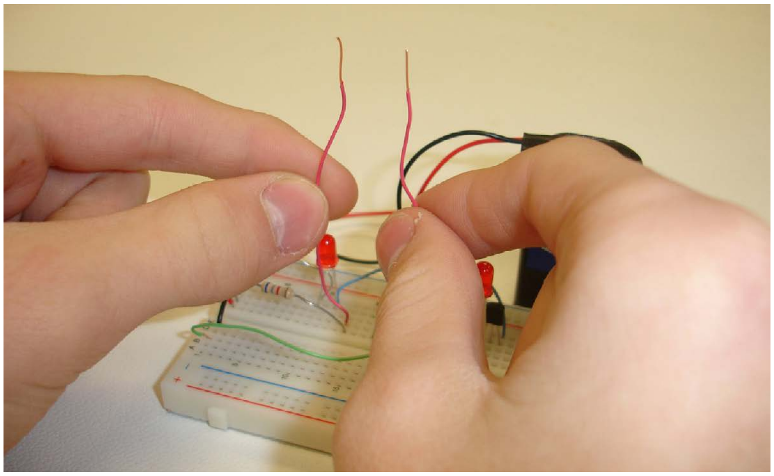
Assignment 3.3: Experiment 6, Part 1: Transistors (continued)

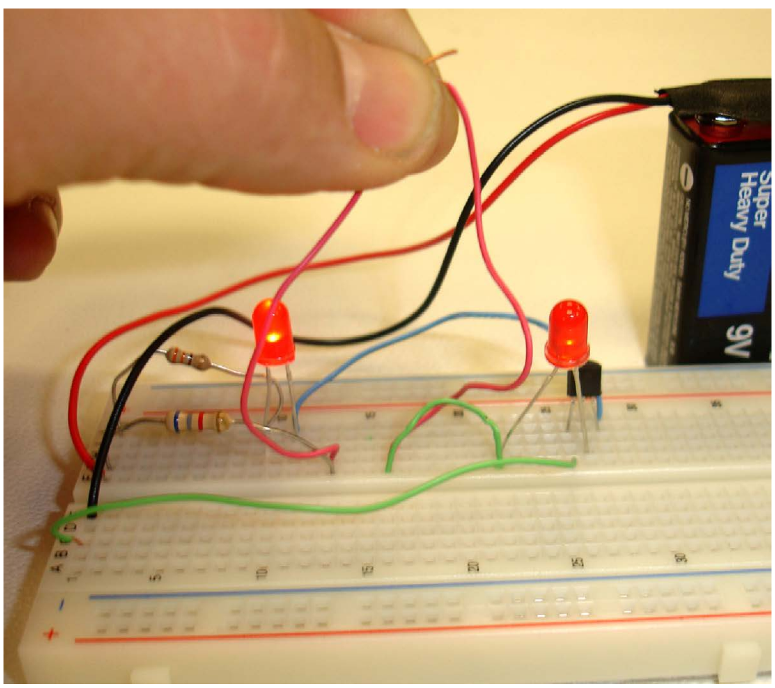
SAFETY GLASSES ON!

Hook up the 9-volt battery to the battery clip. The LED should not light up at this point.



Next, touch the two wires together that are not connected to anything. Notice that both LEDs now light up.

The two LEDs should be of different brightness. The brightness of LED 1 is proportional to the emitter-base current flow. The brightness of LED 2 is proportional to the current flow through the emitter to the collector.



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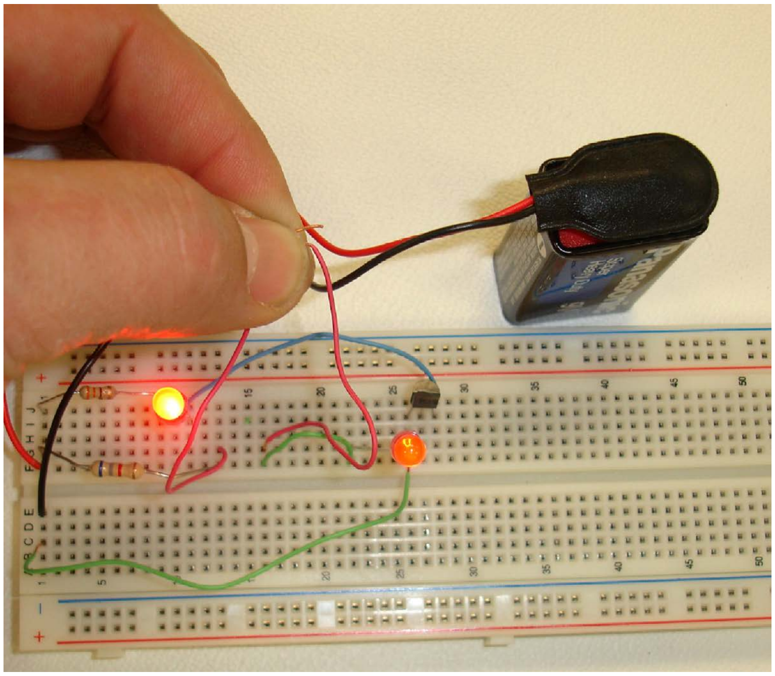
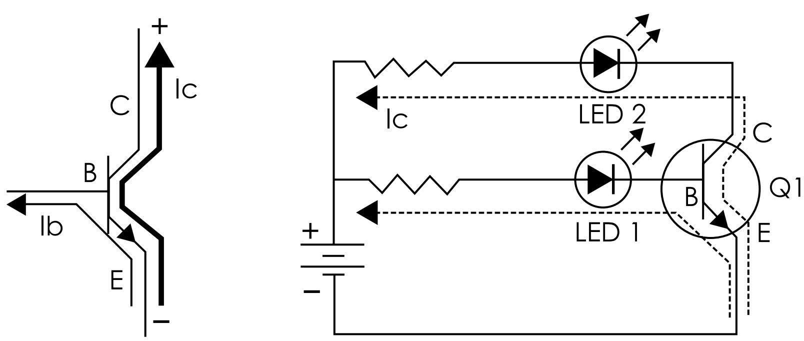
Assignment 3.3: Experiment 6, Part 1: Transistors (continued)



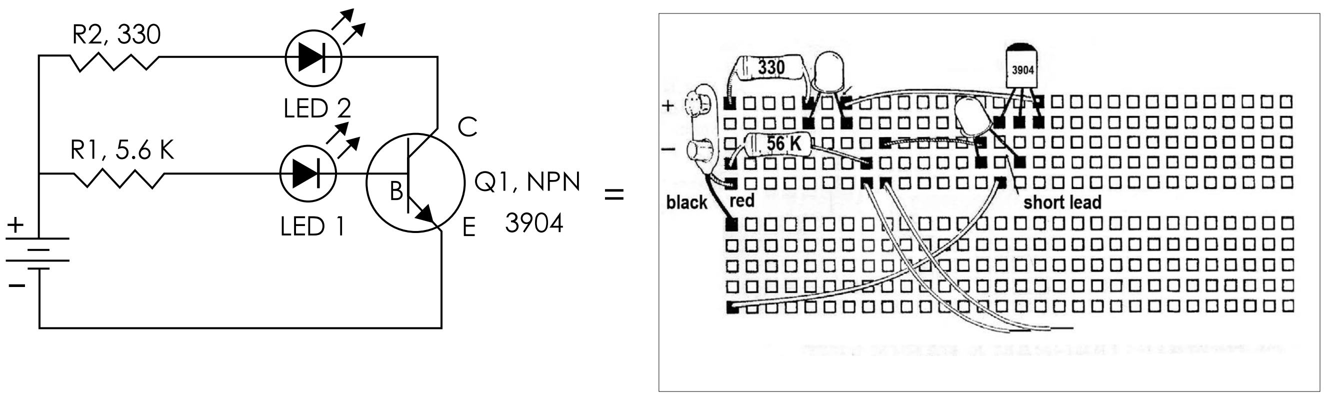
Explanation: In this simple circuit, the electric current will flow from the negative terminal of the battery to the positive terminal, passing through the LED and charging up the capacitor. When you disconnect the battery, the source of electrons from the battery stop, but the electrons stored in one of the plates in the capacitor drains. These electrons drain through the LED, which causes it to light but fade as the electron supply is used up. The larger the capacitor, the more electrons it can store, so the longer it takes to drain. There are actually two circuits here. The first is the emitter-base circuit and the second is the emitter-collector. Below is the current flow through for each.



Current Flow through Transistor

(continued)

Assignment 3.3: Experiment 6, Part 1: Transistors (continued)



Reminder

Electronic components must be installed with polarity in mind. It's a good idea to look very carefully at the parts or schematics sheet that is included at the beginning of this module to determine whether a component has a positive or a negative polarity. Look for a (+) sign for the positive side and a (–) sign for the negative side. If no positive or negative symbols are visible, then polarity is not an issue. Therefore, the part can be installed in either direction in the circuit.

Note: The colour code for positive is red and the colour code for negative is black.

Now that you have successfully completed Experiment 6, place the parts back in the Experiment Kit, and then complete the experiment write-up.

Assignment 3.3, Part 2

Experiment 6, Part 2: Report 6: Transistors *(14 marks)*

Please provide the responses to the following headings after you have completed your experiment.

Purpose of the Experiment *(2 marks)*

Explanation of the Experiment *(2 marks)*

Results of the Experiment *(2 marks)*

Schematic of the Experiment *(2 marks)*

Parts Used *(6 marks)*

Purpose of the Experiment: *(2 marks)*

Explanation of the Experiment: Read through the experiment. Using three or four sentences, explain what happened. In your own words, show you have an understanding of what you learned and/or observed. *(2 marks)*

(continued)

Assignment 3.3: Experiment 6, Part 2: Report 6: Transistors (continued)

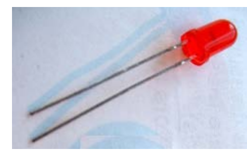
Results of the Experiment: This is where you write what did happen during the experiment or what you observed as you followed the procedure to complete the experiment. This usually reflects the purpose and explanation of the experiment. *(2 marks)*

Schematic Diagram: Redraw the schematic representation of the circuit that you just built. The schematic diagram is provided to you in the experiment itself. *(2 marks)*

(continued)

Assignment 3.3: Experiment 6, Part 2: Report 6: Transistors (continued)

Parts Used: Fill in the chart below, and draw the schematic symbols for the parts used in performing the experiment. Write down the value of any of the components, and make note that some components will not have a value (e.g., an LED would not have a value). *(6 marks)*

Name of Part	Value (if any)	Schematic Symbol	Picture of Part
LED			
LED			
NPN Transistor			
Resistor			
Resistor			
Battery			

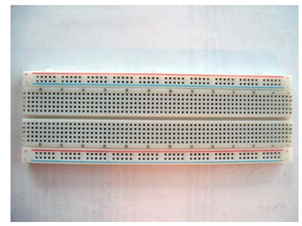
Notes

Assignment 3.4, Part 1

Experiment 7, Part 1: Silicon Controlled Rectifier (SCR)

Inventory List: Place a checkmark in each box once you have identified the item.

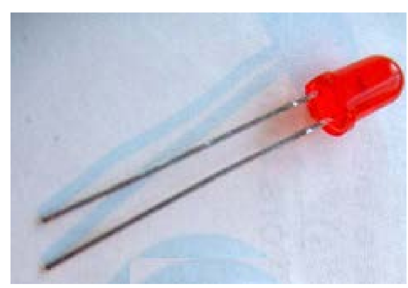
❑ Solderless circuit board



❑ 9-volt battery

❑ 9-volt battery clip

❑ 2 light emitting diodes (LED)



(continued)

Assignment 3.4: Experiment 7, Part 1: Silicon Controlled Rectifier (SCR) (continued)

- ❑ Resistors with the value of
  220 ohms
  1 K ohms

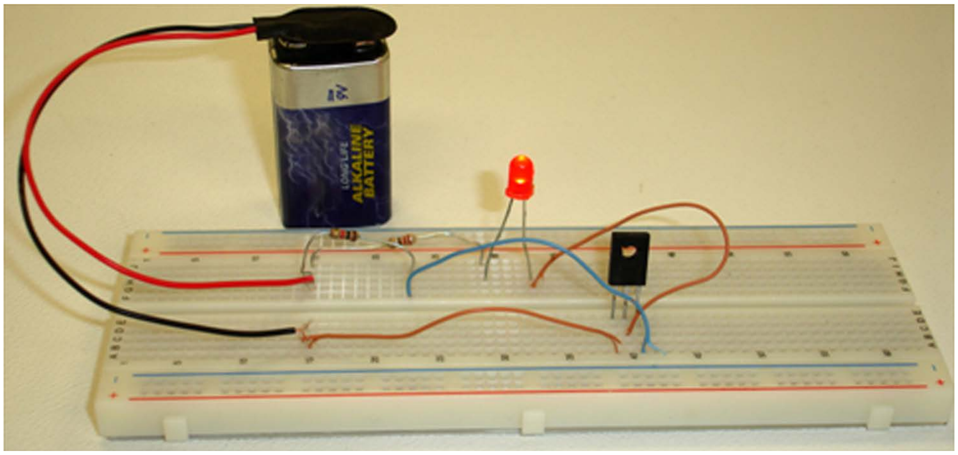
- ❑ SCR

- ❑ Safety glasses

(continued)

Assignment 3.4: Experiment 7, Part 1: Silicon Controlled Rectifier (SCR) (continued)

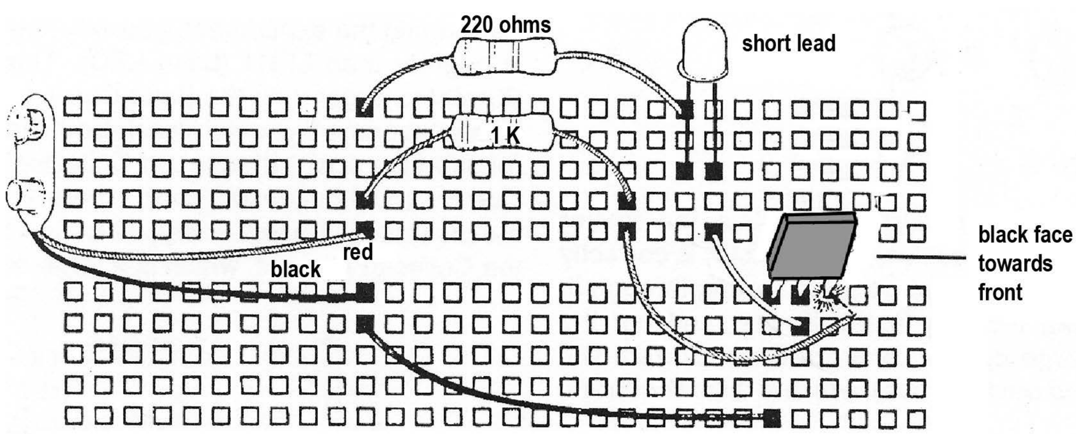
Note: The SCR is just one of many different kinds of semiconductor devices. The SCR has an anode and cathode (like a diode), but it also has a gate. The gate must receive a positive voltage in order for the SCR to conduct from the anode to the cathode.



Purpose: The purpose of this experiment is to observe how an SCR works.

Procedure: Build the circuit shown below using your Experiment Kit and solderless circuit board.

Carefully plug your components into the same vertical rows as shown below. Be mindful of the direction of the SCR, and make sure the black side is facing forwards.



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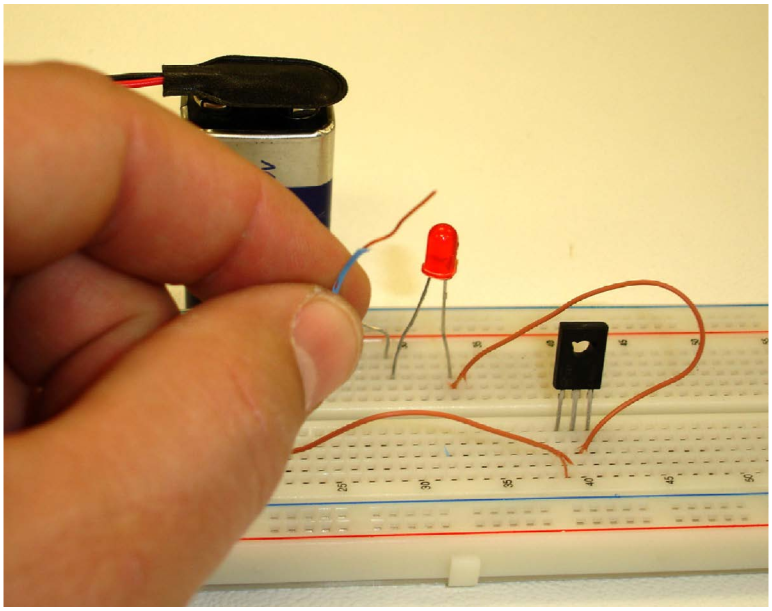
Assignment 3.4: Experiment 7, Part 1: Silicon Controlled Rectifier (SCR) (continued)

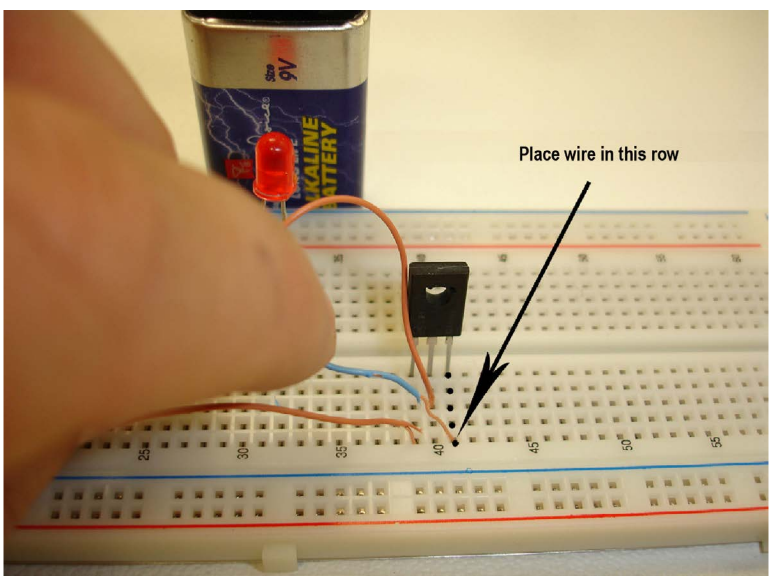
SAFETY GLASSES ON!

Once you have the circuit built, notice that there is one wire that is not connected to anything. This wire you will use to connect to the row with the SCR gate in it.



Hook up the 9-volt battery to the battery clip. The LED should not light up.

Now, take the wire that is not attached to anything and place it in the row of holes that the gate is in. At this point the SCR should light up.



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Assignment 3.4: Experiment 7, Part 1: Silicon Controlled Rectifier (SCR) (continued)

If the LED didn't light up, check your connections and try again.

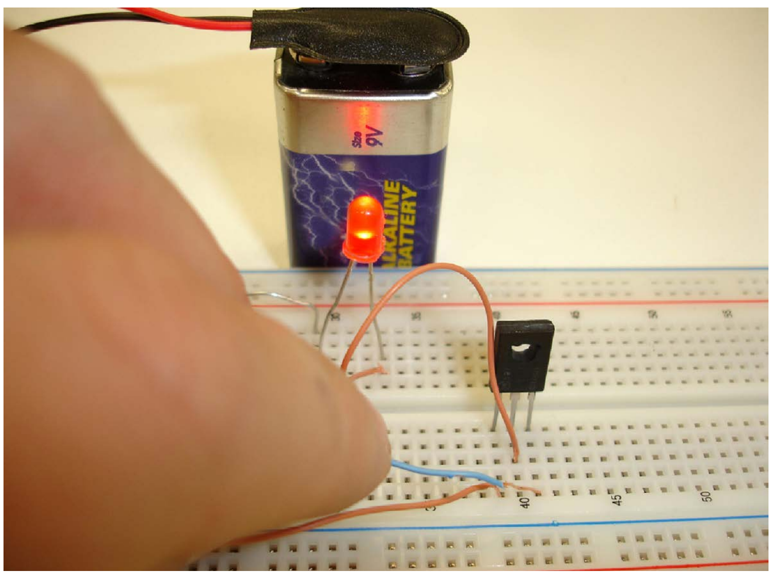
Once the SCR has been activated, remove the wire from the row of holes attached to the gate so it is no longer connected. The SCR should still be conducting and the LED should remain lit.

The SCR is like a switch that has no moving parts. Once the gate of the SCR has received a positive jolt by the loose wire you have connected, it will continue to conduct until the power source is removed.

Now, unclip the battery and watch what happens to the LED.

The LED should remain lit.

Now remove the battery from the circuit and the LED should turn off.



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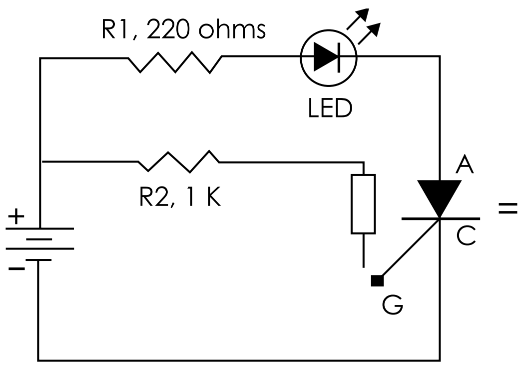
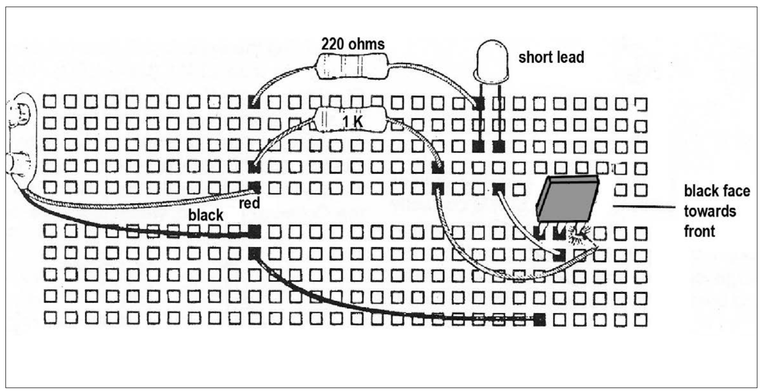
Assignment 3.4: Experiment 7, Part 1: Silicon Controlled Rectifier (SCR) (continued)

Explanation: The SCR is a semiconductor device that allows current to be conducted from the cathode to the anode providing the gate receives a positive voltage. You also learned that the only way to turn off an SCR is to remove the battery from the circuit.





Reminder

Electronic components must be installed with polarity in mind. It's a good idea to look very carefully at the parts or schematics sheet that is included at the beginning of this module to determine whether a component has a positive or a negative polarity. Look for a (+) sign for the positive side and a (–) sign for the negative side. If no positive or negative symbols are visible, then polarity is not an issue. Therefore, the part can be installed in either direction in the circuit.

Note: The colour code for positive is red and the colour code for negative is black.

Now that you have successfully completed Experiment 7, place the parts back in the Experiment Kit, and then complete the experiment write-up.

Assignment 3.4, Part 2

Experiment 7, Part 2: Report 7: Silicon Controlled Rectifier (SCR) ***(13 marks)***

Please provide the responses to the following headings after you have completed your experiment.

Purpose of the Experiment *(2 marks)*

Explanation of the Experiment *(2 marks)*

Results of the Experiment *(2 marks)*

Schematic of the Experiment *(2 marks)*

Parts Used *(5 marks)*

Purpose of the Experiment: ***(2 marks)***

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Explanation of the Experiment: Read through the experiment. Using three or four sentences, explain what happened. In your own words, show you have an understanding of what you learned and/or observed.
(2 marks)

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(continued)

Assignment 3.4: Experiment 7, Part 2: Report 7: Silicon Controlled Rectifier (SCR) (continued)

Results of the Experiment: This is where you write what did happen during the experiment or what you observed as you followed the procedure to complete the experiment. This usually reflects the purpose and explanation of the experiment. *(2 marks)*

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Schematic Diagram: Redraw the schematic representation of the circuit that you just built. The schematic diagram is provided to you in the experiment itself. *(2 marks)*

(continued)

Assignment 3.4: Experiment 7, Part 2: Report 7: Silicon Controlled Rectifier (SCR) (continued)

Parts Used: Fill in the chart below, and draw the schematic symbols for the parts used in performing the experiment. Write down the value of any of the components, and make note that some components will not have a value (e.g., an LED would not have a value). *(5 marks)*

Name of Part	Value (if any)	Schematic Symbol	Picture of Part
LED			
SCR			
Resistor			
Resistor			
Battery			

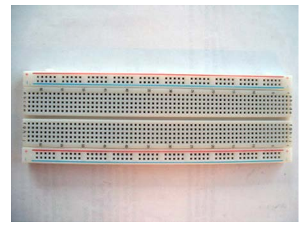
Notes

Assignment 3.5, Part 1

Experiment 8, Part 1: 7-Segment Display

Inventory List: Place a checkmark in each box once you have identified the item.

❑ Solderless circuit board



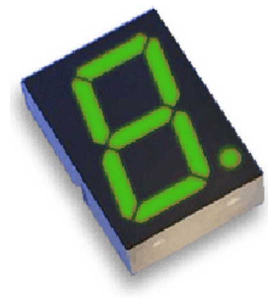
❑ 9-volt battery

❑ 9-volt battery clip

❑ Resistors with the value of 220 ohms

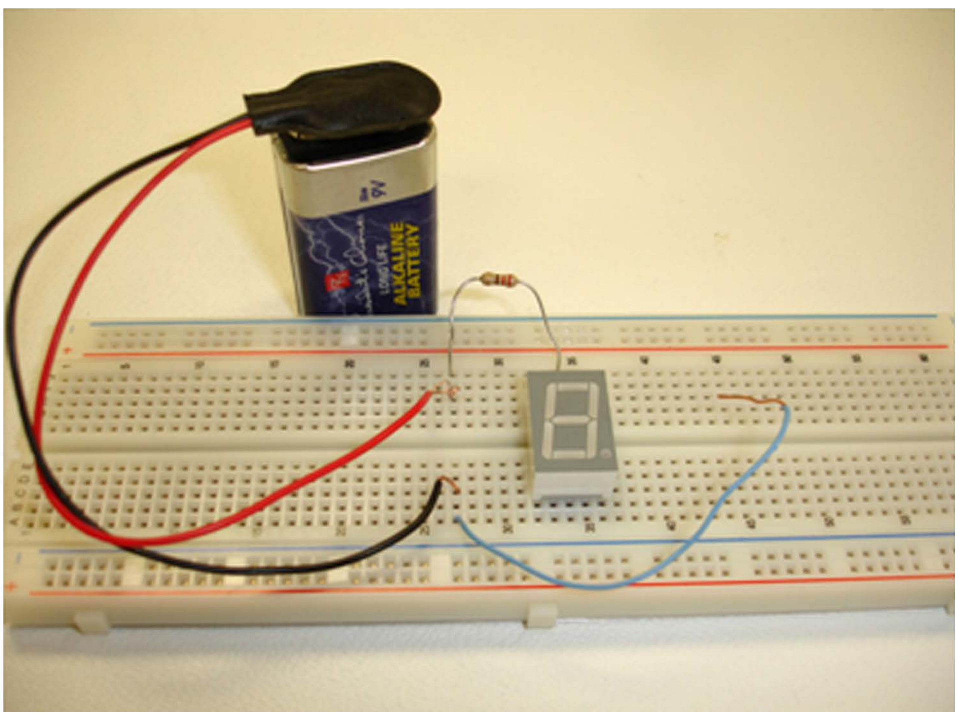
(continued)

❑ SCR



❑ Safety glasses

Note: The 7-segment display is another semiconductor device found in many consumer products. There are two types, common anode and common cathode.



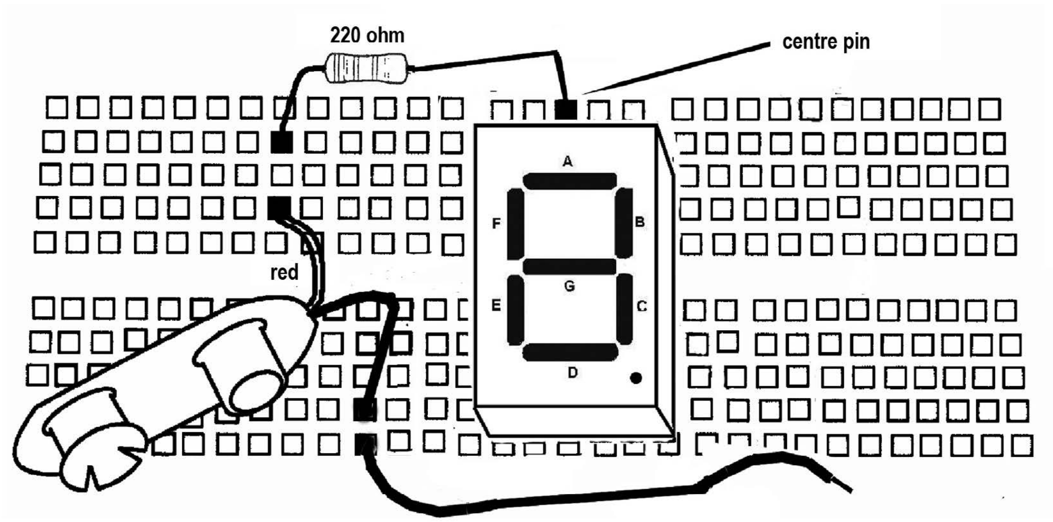
(continued)

Assignment 3.5: Experiment 8, Part 1: 7-Segment Display (continued)

Purpose: The purpose of this experiment is to learn and observe how a seven segment display works.

Procedure: Build the circuit shown below using your Experiment Kit and solderless circuit board.

Carefully plug your components into the same vertical rows as shown below.



SAFETY GLASSES ON!

Hook up the 9-volt battery to the battery clip.

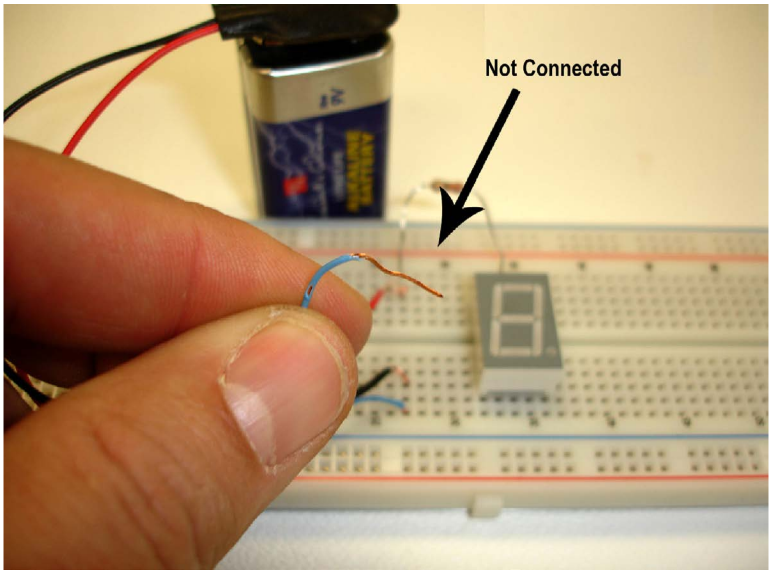
A 7-segment display has just that—seven separate little LEDs in it that, when used in conjunction with certain circuitry, illuminate and make it seem like numbers that we can read. Each one of these segments has a designated letter to it, like in the diagram.

(continued)

Assignment 3.5: Experiment 8, Part 1: 7-Segment Display (continued)

You will notice that one of the wires in the circuit board is not connected to anything. The reason for that is we are going to light up each of the segments one at a time.

Take the wire and place it in the following holes on the solderless circuit board, as in the pictures below. Watch what happens.



What's Happening

Place a checkmark beside each segment that you made light up.

a) ❑

b) ❑

c) ❑

d) ❑

e) ❑

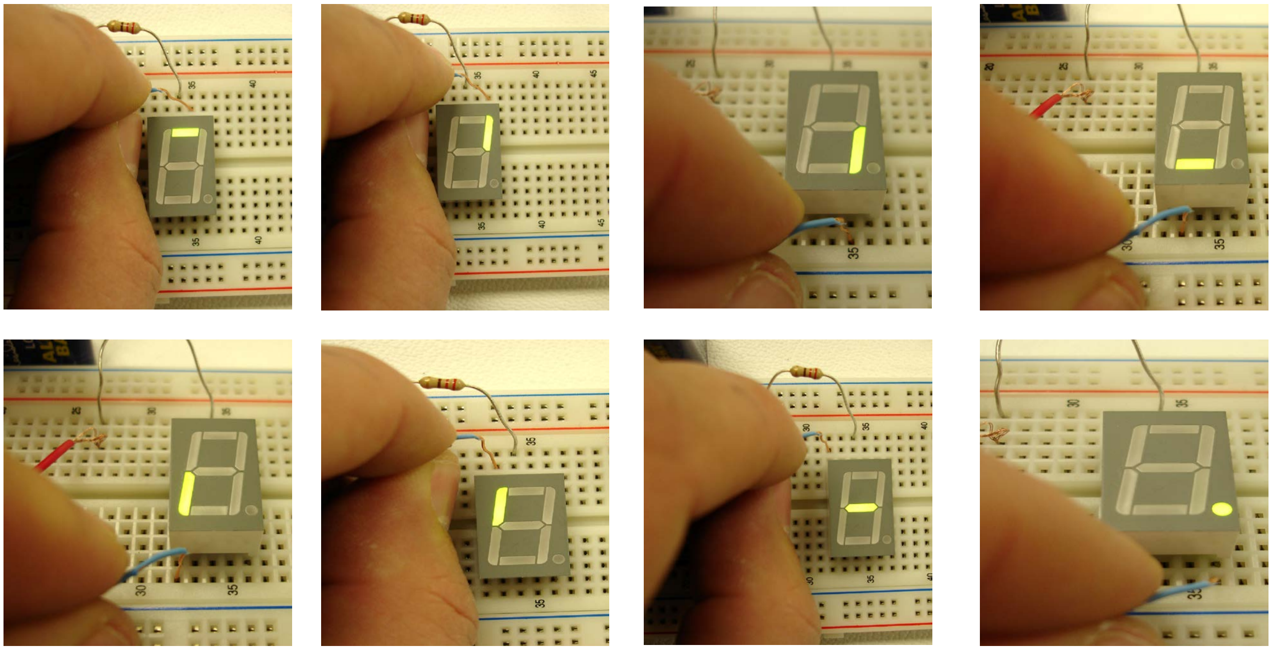
f) ❑

g) ❑

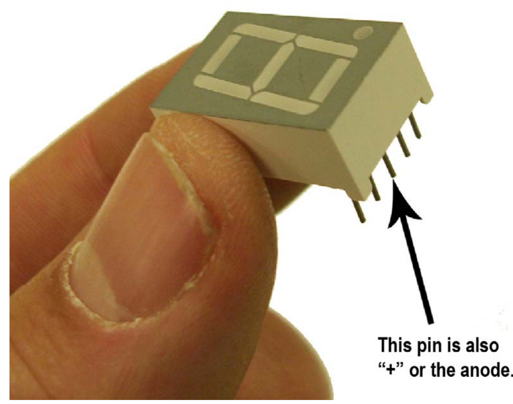
Dot ❑

(continued)

Assignment 3.5: Experiment 8, Part 1: 7-Segment Display (continued)



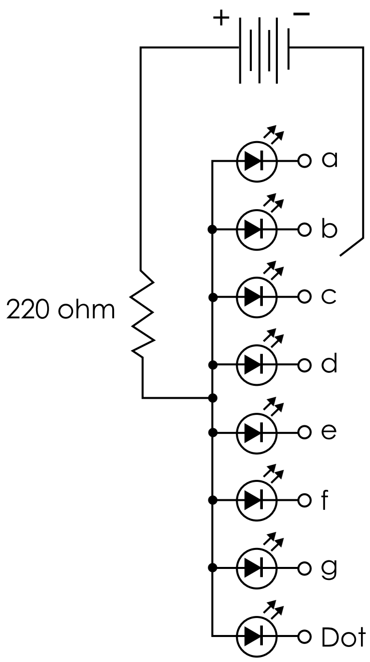
Self-challenge. Can you connect the right wires to make any number you like from 0-9? Go ahead and try!



Explanation: In this simple circuit, the electric current will flow from the negative terminal of the battery to the positive terminal, passing through each segment of the 7-segment display separately. This particular 7-segment display is called a common "anode" 7-segment display. The reason is that the negative lead from the battery lets electrons into the circuit. But all electrons drain the circuit back to the battery via a common connection or pin on the 7-segment display. You may have noticed that we did not use one pin on the display (at the bottom in the centre). That's because that pin is also a "+" connector pin for the display. There are two pins that will function as the anode in the display. As LEDs all have a cathode and an anode, all the segment anodes are connected together, as seen in the schematic diagram.

(continued)

Assignment 3.5: Experiment 8, Part 1: 7-Segment Display (continued)



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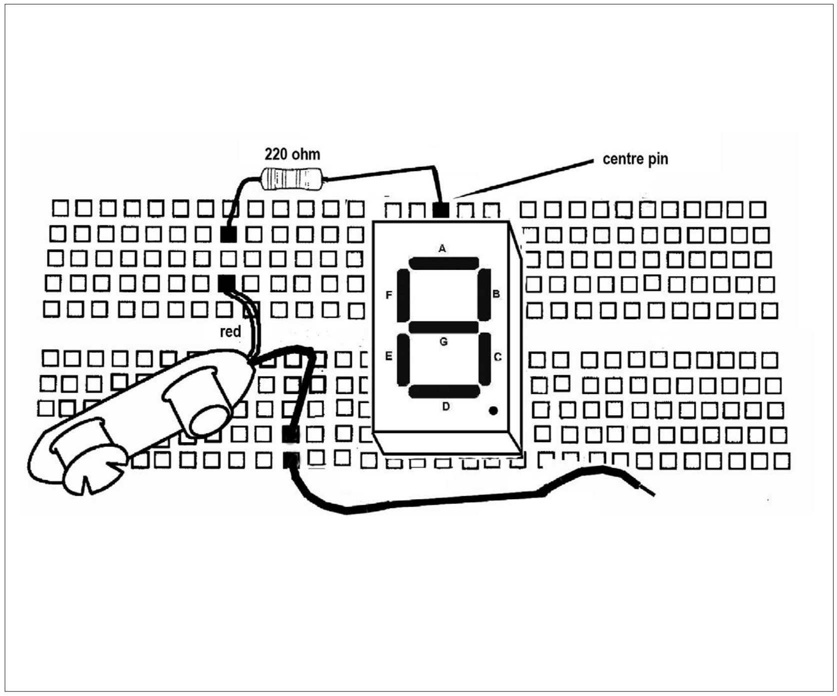

Reminder

Electronic components must be installed with polarity in mind. It's a good idea to look very carefully at the parts or schematics sheet that is included at the beginning of this module to determine whether a component has a positive or a negative polarity. Look for a (+) sign for the positive side and a (–) sign for the negative side. If no positive or negative symbols are visible, then polarity is not an issue. Therefore, the part can be installed in either direction in the circuit.

Note: The colour code for positive is red and the colour code for negative is black.

Now that you have successfully completed Experiment 8, place the parts back in the Experiment Kit, and then complete the experiment write-up.

Assignment 3.5, Part 2

Experiment 8, Part 2: Report 8: 7-Segment Display *(11 marks)*

Please provide the responses to the following headings after you have completed your experiment.

Purpose of the Experiment *(2 marks)*

Explanation of the Experiment *(2 marks)*

Results of the Experiment *(2 marks)*

Schematic of the Experiment *(2 marks)*

Parts Used *(3 marks)*

Purpose of the Experiment: *(2 marks)*

Explanation of the Experiment: Read through the experiment. Using three or four sentences, explain what happened. In your own words, show you have an understanding of what you learned and/or observed.
(2 marks)

(continued)

Assignment 3.5: Experiment 8, Part 2: Report 8: 7-Segment Display (continued)

Results of the Experiment: This is where you write what did happen during the experiment or what you observed as you followed the procedure to complete the experiment. This usually reflects the purpose and explanation of the experiment. *(2 marks)*

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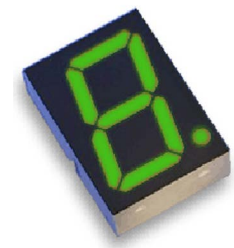
Schematic Diagram: Redraw the schematic representation of the circuit that you just built. The schematic diagram is provided to you in the experiment itself. *(2 marks)*

(continued)

Assignment 3.5: Experiment 8, Part 2: Report 8: 7-Segment Display (continued)

Parts Used: Fill in the chart below, and draw the schematic symbols for the parts used in performing the experiment. Write down the value of any of the components, and make note that some components will not have a value (e.g., an LED would not have a value). *(3 marks)*

Name of Part	Value (if any)	Schematic Symbol	Picture of Part
7 Segments			
Resistor			
Battery			

Notes

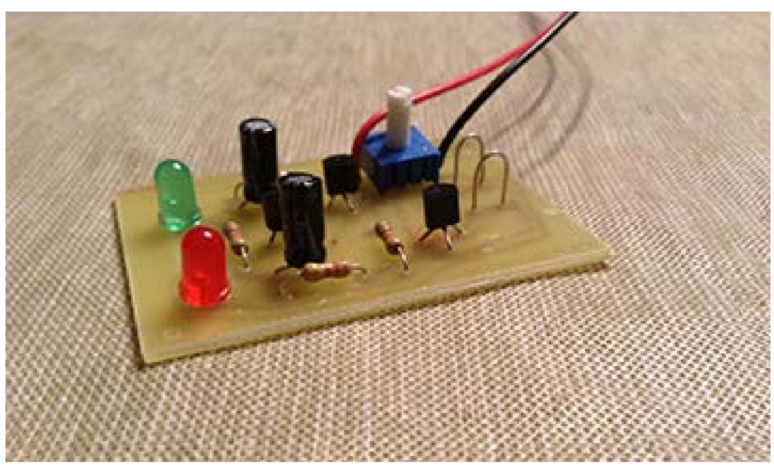
Project 1: The Decision Maker *(100 marks)*

Your Decision-Maker Project is out of 100 marks and is worth 15% of your final mark. There are four components that will be evaluated to determine your final mark on the Decision-Maker Project. A marking rubric for your major project is found at the end of the Module Summary. The four components that will be evaluated are:

- Confirmation: *25 marks*
- Construction: *25 marks*
- Soldering: *25 marks*
- Function: *25 marks*

It's time to roll up your sleeves and put together your first project. Now that you have had some solder practice and know all about schematic diagrams and various parts, it's time to put that knowledge to use.

This decision maker has two LEDs that represent a "yes" or "no" answer. When you place a finger on the contacts, both LEDs will light up. While your hand is on the contacts, ask a question and then take your hand off. Either the red or green LED will remain lit, which represents a "yes" or "no" answer.

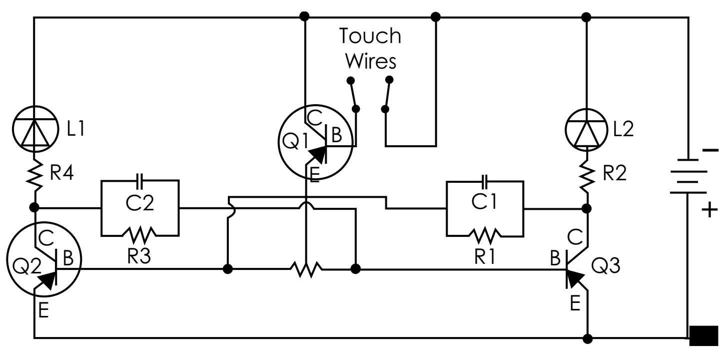


Locate your Project Kit 1 bag and set up your soldering iron and working area.

It is important that you remember to wear your safety glasses at all times when assembling your project. Remember, no one ever plans to have an accident!

Theory of Operation

This decision maker (Project Kit 1) consists of a circuit (commonly known as a multivibrator circuit). The circuit is made up of Q2/Q3 and a switching circuit made up from Q1. When a finger is placed on the contact wires, the skin resistance causes a forward bias to be applied to Q1, turning it on. With Q1 on, a path is created for Q2 and Q3 to be biased to the on position. The transistors alternately turn on their respective LEDs. The understanding of exactly how this circuit works is beyond the scope of this course, but these are the basics of its operation. Good luck!



Project Kit 1 Parts List

C1 & C2	1.0 uF electrolytic capacitors
L1	One green LED
L2	One red LED
P1	One 50 k ohm Trimmer resistor (a smaller version of a potentiometer)
R1, R3	Two 33 k resistors (Orange, Orange, Orange, Gold)
R2, R4	Two 430 ohm resistors (Yellow, Orange, Brown, Gold)
Q1, Q2, Q3	Three 2W3906 transistors
B1	9-volt battery clip
PCB	project circuit board

Two touch wires

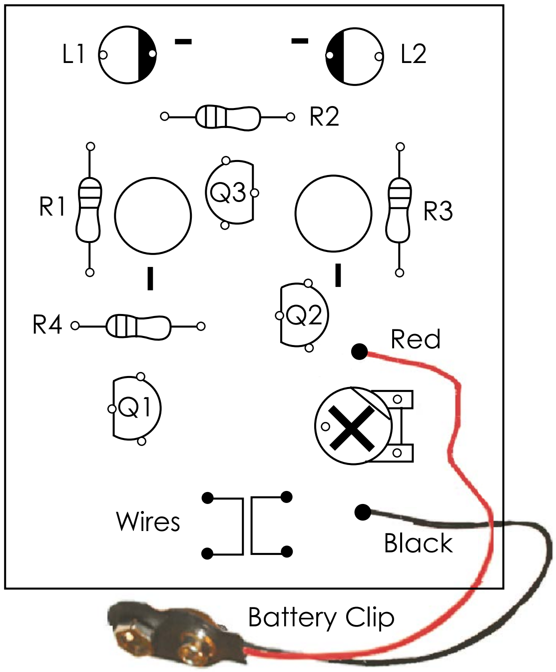
Solder

Other supplies

Soldering iron and stand

Safety glasses

Parts Layout



Assembly Instructions

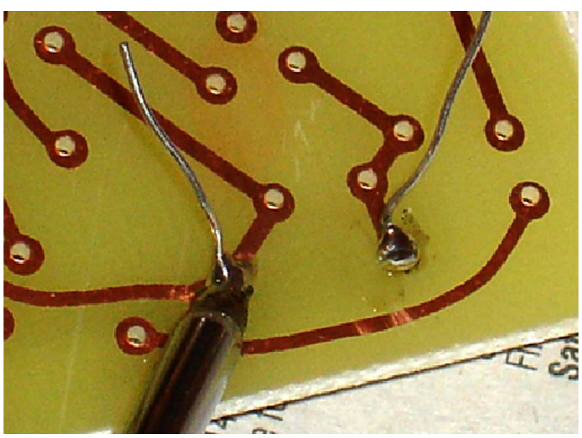
- Prepare your work area.
- Locate your circuit board and parts, and place them in front of you.
- The first thing you will do is solder in your resistors. Note that the resistors do not have a negative and positive side to them.

SAFETY GLASSES ON NOW!

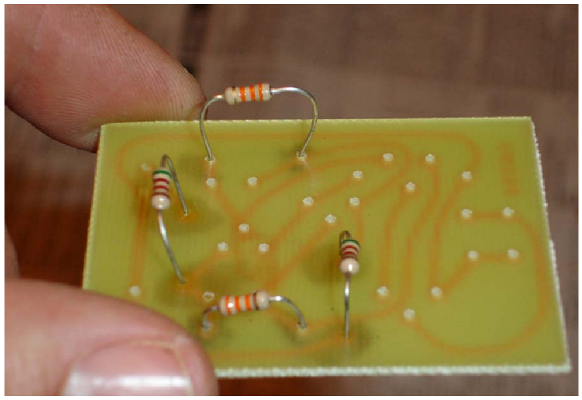
When you first start soldering in components, it may be a bit confusing as there are so many holes to put parts in. By soldering in your four resistors, you use up eight holes. Once these four components are in, the placement of the other components may become clearer.

Find R1, the 33 k ohm resistor. Bend the legs of the resistor and place it through the circuit board so the resistor is on the plastic side and the legs of the resistor go through to the metal side of the circuit board.

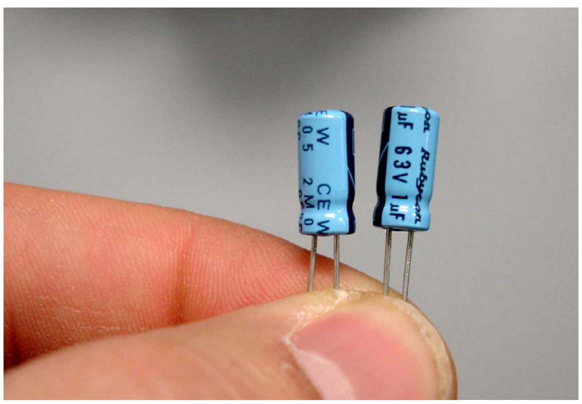
Use the needle-nose pliers to heat-sink the legs of the resistor as you solder them in, so as not to burn out the resistor itself. It is helpful to put an elastic band around the pliers' handles to keep them closed so you don't have to hold them.

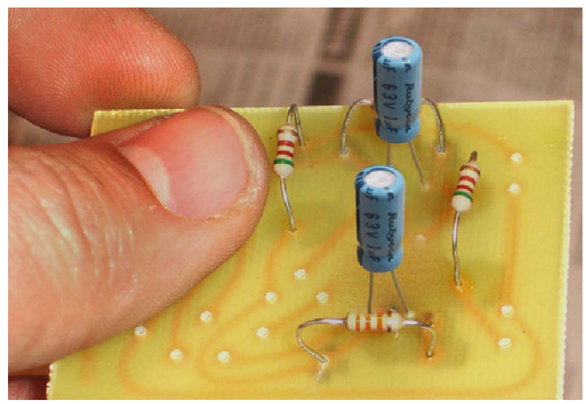


Solder R1 in and snip the legs off using your side cutters after it has been soldered in. Solder in R2, R3, and R4, making sure that you place the correct value resistor in the correct place according to the parts layout diagram.

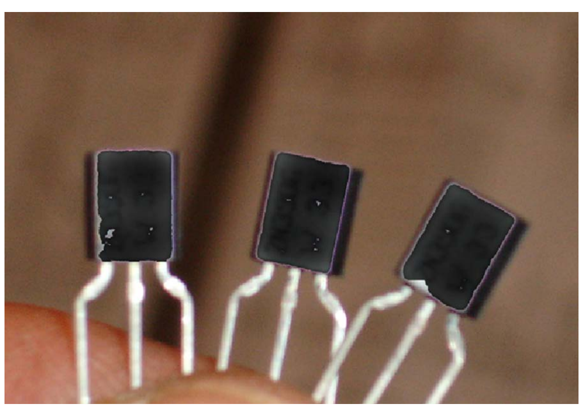


Next, install capacitors C1 and C2. Note that the capacitors do have a negative and positive side on them so they cannot be put in with the legs in any direction.



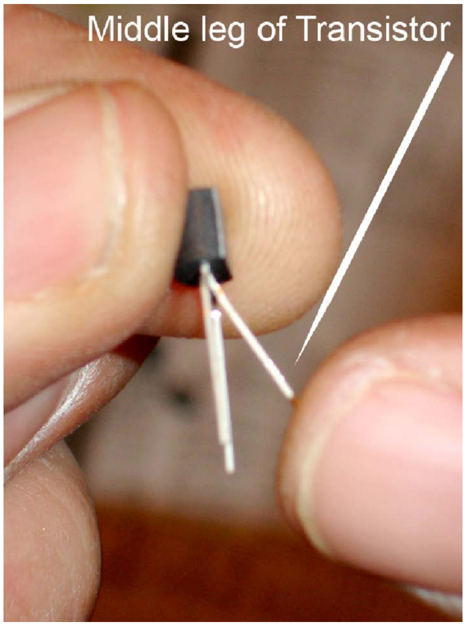


Next, solder in the transistors. There are a few things to note when soldering in the transistors, so read all the instructions here first.

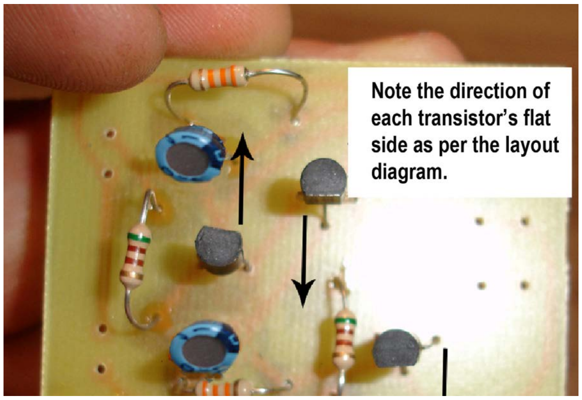


1. Use a heat-sink for each leg of the transistor and solder in one leg at a time. Hold each leg of the transistor while you solder it in. Do not attempt to heat-sink all three at one time as they will break.

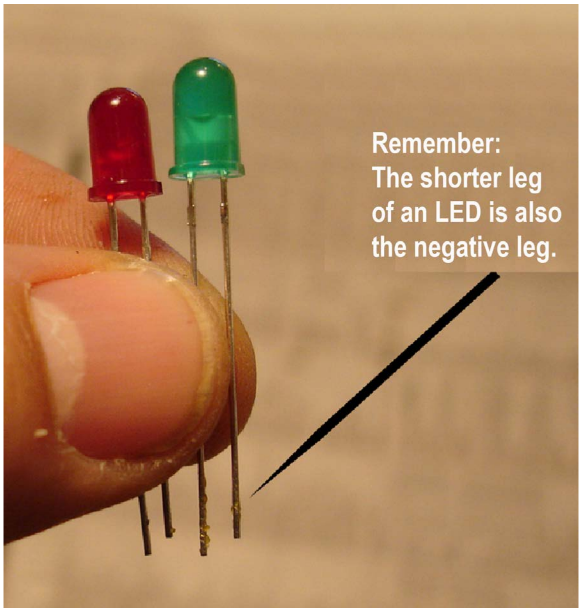
2. Note also the direction of the flat face of the transistor in the parts layout diagram. With the direction in mind, you will have to bend the centre leg of each transistor forwards or towards the flat face to be able to fit it into the proper holes in the circuit board.



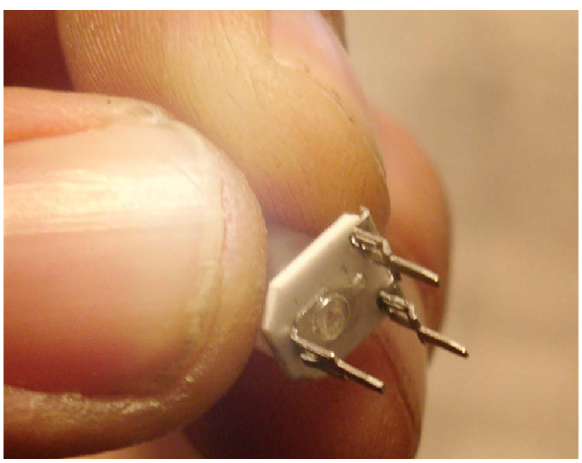
Go ahead and solder Q1, Q2, and Q3, making sure you heat-sink each leg individually. Even though you are using a heat-sink, solder the component in as quickly as possible.



Locate and solder in the two LEDs, noting that each has a positive and negative leg and must be placed correctly in the circuit board in order to work properly. Don't forget to heat-sink the legs of the LEDs.

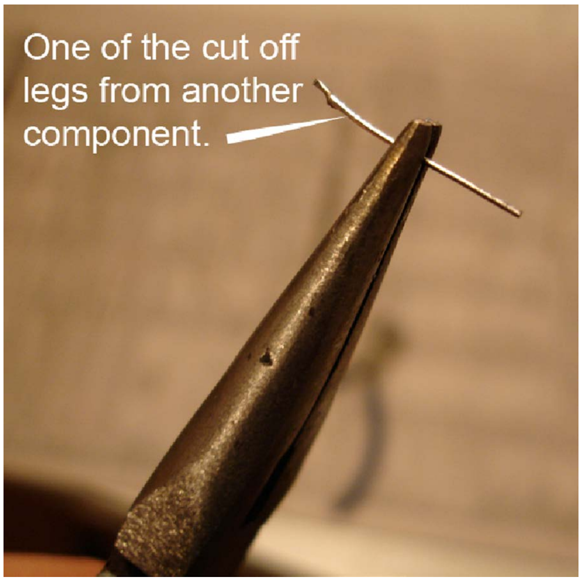


Find the small potentiometer (trimmer) and solder it in. Note that because the legs on this component are so short, you are not able to heat-sink it. Just solder it in as quickly as you can without keeping the soldering iron on it for too long.

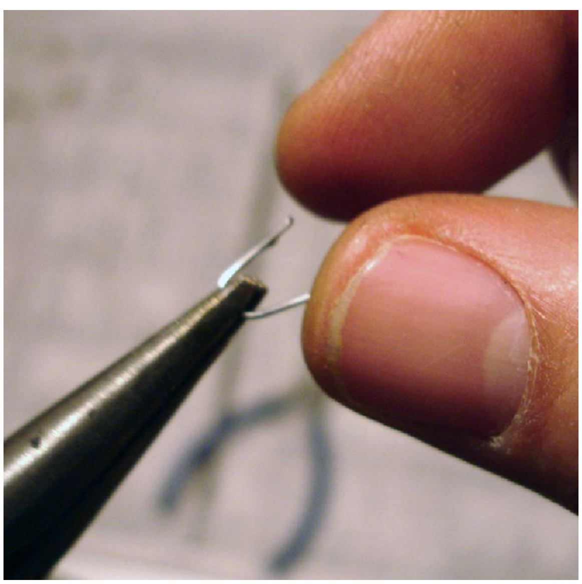


Next, find the 9-volt battery clip and install the black (negative) and red (positive) wires into the circuit board according to the parts layout diagram.

The two touch wires we will use are simply two pieces of solid gauge wire that have all their insulation removed so the bare wire is exposed in order for your finger to make contact with it. You can also use the cut-off ends of some of your other components.

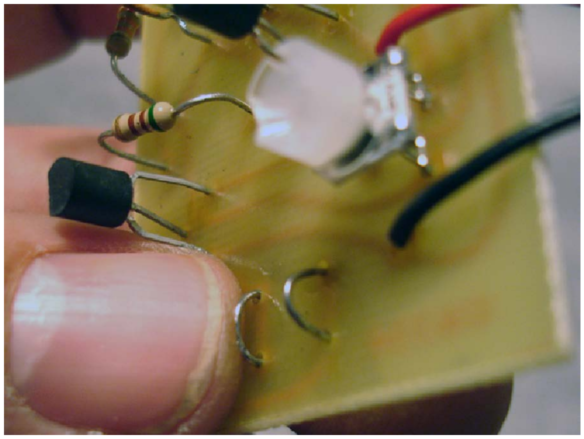


You can use needle-nose pliers to hold the small wire while you bend it.



Place the two touch wires into the circuit board and solder them in.

Once they are in, bend them over towards each other, but make sure they do not make contact with each other.



You're done!

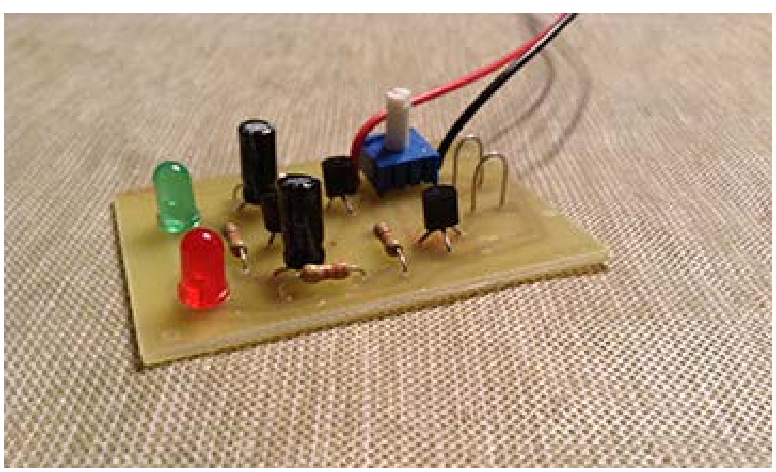
Note: Make sure that before you try connecting the battery you inspect the back of the circuit board to ensure that you have not accidentally connected any two separate trace lines together on the circuit board.

Now, unplug your soldering iron and make sure it's in the holder.

Connect a battery to the project. Notice that one LED lights up! Simply place your finger on the touch wires and both LEDs light up. When you remove your finger, your decision is shown by the LED that remains on. Red means no and green means yes.

You will have to adjust the P1 for 50/50 odds by turning the top of it with a screwdriver or with your finger.

Your project is now ready to be marked by your tutor/marker.



Troubleshooting

What If My Project Isn't Working?

1. First of all, it's fairly common to have a few problems when building electronic projects. Go through the following checklist and see if you can find the problem.
2. Check for good soldering joints, making sure that all components are soldered in and not loose.
3. Make sure solder is not connecting two separate lines on the circuit board that are not supposed to be connected.
4. Check your project against the parts layout to make sure all components are in the correct place.
5. Check your capacitors and be sure the polarity is correct.
6. Check the colour code of each resistor to make sure they are in the correct places.
7. Check the flat sides of the transistors to make sure they are facing the right directions and the emitter, base, and collectors are in their respective places.
8. Check the LEDs to make sure the flat side is facing the right direction.
9. Check to make sure that your battery clip was put in correctly, and that the battery is good.
10. If your kit still does not work, contact your tutor/marker.

How Will Your Project Be Marked?

Your tutor/marker will use the following rubric to mark Project 1: The Decision Maker.

Module 3 Summary

Congratulations! You have finished the third module in the course.

Submitting Your Assignments

It is now time for you to submit your assignments from Module 3 to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Remember: Project 1: The Decision Maker must be mailed to the Distance Learning Unit. Keep all your material together in the one mailing and do not electronically submit any material for this module.

Make sure you have completed all parts of your Module 3 assignments and organize your material in the following order:

- ❑ Module 3 Cover Sheet (found at the end of the course Introduction)
- ❑ Assignment 3.1: Experiment 4, Part 2: Report 4: Capacitors
- ❑ Assignment 3.2: Experiment 5, Part 2: Report 5: Diodes
- ❑ Assignment 3.3: Experiment 6, Part 2: Report 6: Transistors
- ❑ Assignment 3.4: Experiment 7, Part 2: Report 7: Silicon Controlled Rectifier
- ❑ Assignment 3.5: Experiment 8, Part 2, Report 8: 7-Segment Display
- ❑ Project 1: The Decision Maker

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Project 1: The Decision Maker *(100 marks)*
Marking Rubric

The assembly of parts and completion of this working brain meter are based on the following criteria:

Confirmation: *25 marks*
Construction: *25 marks*
Soldering: *25 marks*
Function: *25 marks*

This project is designed to be the work of one person and group submissions will not be accepted.

Confirmation: ___________ / 25 marks

(20–25 marks)	**(11–19 marks)**	**(less than 10 marks)**
All or most of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**	Some of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**	Few of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**

Project 1: The Decision Maker (continued)
Marking Rubric

Construction: ___________ / 25 marks

(20–25 marks)	**(11–19 marks)**	**(less than 10 marks)**
All or most of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**	Some of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**	Few of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**

Project 1: The Decision Maker (continued)
Marking Rubric

Soldering: __________ / 25 marks		
(20–25 marks)	**(11–19 marks)**	**(less than 10 marks)**
All or most of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**	Some of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**	Few of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**

Project 1: The Decision Maker (continued) Marking Rubric

Function: ___________ / 25 marks		
(20–25 marks)	**(11–19 marks)**	**(less than 10 marks)**
All or most of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**	Some of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**	Few of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**

Grade 10 Electricity/ Electronics Technology (20G)

Module 3
Capacitors and Semiconductors

Learning Activity Answer Keys

Module 3: Capacitors and Semiconductors

Learning Activity 3.1: Capacitors

1. Generally speaking, what are the two types of capacitors?

   Answer:

   Electrolytic and ceramic

2. How are capacitors like batteries?

   Answer:

   They are the same in the sense that capacitors and batteries both store electrical energy.

3. How are a capacitor and a battery different?

   Answer:

   A capacitor cannot produce new electrons, it only stores them.

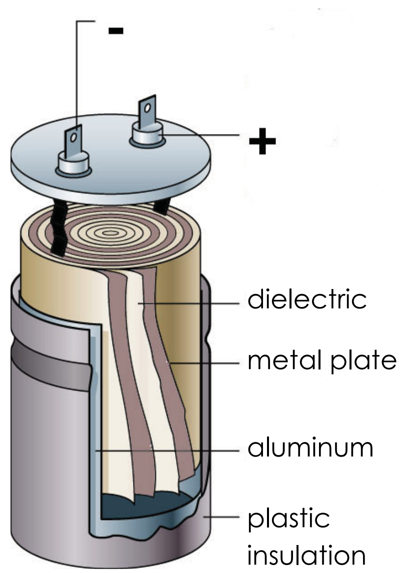
4. What does the “dielectric” do in an electrolytic capacitor?

   Answer:

   The dielectric separates the two plates in a capacitor and prevents them from touching.

5. Label the parts of the electrolytic capacitor below.

   Answer:



6. What is the name for the unit of measurement for capacitance?

   Answer:

   Farads

7. List the three factors that determine capacitance and explain how each one affects the amount of capacitance.

   Answer:

   a) Plate size

      Explanation: The greater the physical size of the plates, the more electrons can be stored on them.

   b) Distance between plates

      Explanation: The farther apart the plates are, the less effect each will have on the other. The law of electrical charges states that unlike charges attract, and that attraction is what is holding the excess electrons on one of the plates.

   c) Type of dielectric

      Explanation: The closer you can get the plates without touching, the greater the capacitance. So what we put between them (dielectric) will determine how close we can get them without having them short out across the plates.

8. When choosing an electrolytic capacitor, what is the general rule of thumb with regard to its voltage rating?

   Answer:

   The rule of thumb is to choose one that is about double the required amount of voltage needed.

Learning Activity 3.2: Semiconductor Theory

1. List three basic types of materials that we work with in electronics.

   Answer: conductors, insulators, and semiconductors

2. Why is the nucleus of an atom positively charged?

   Answer:

   This is due to the fact that it is comprised of positively charged protons.

3. When is an atom said to be electrically neutral or balanced?

   Answer:

   This occurs when there are an equal number of electrons as there are number of protons in the nucleus.

4. The orbits for electrons around the nucleus of an atom are arranged in layers or sometimes referred to as ***shells***.

5. Atoms with one electron in the outer shell are referred to as ***group 1 elements***.

6. Atoms with four electrons in the outer shell are referred to as ***group 4 elements.***

7. What do energy band diagrams show?

   Answer:

   They show the energy levels of the electrons or how far away the electrons are from the centre or nucleus.

8. The outermost band where electrons are farthest away but still held in orbit by the nucleus is called the ***valence band.***

9. Electrons that have enough energy to break away from their parent atoms and are free to move around are in the ***conduction band***.

10. When an electron leaves the valence band, we say it leaves a ***hole*** in the space it once occupied.

11. The process of adding impurities to silicon to create semiconductors is called ***doping***.

12. Name the two types of extrinsic semiconductor materials.

13. In N-type materials, the impurities are added from group ***5*** elements, so there will be a free electron available in the semiconductor material.

14. "Holes" are not really particles but spaces left by moving ***electrons***.

15. In P-type materials, the impurities are added from group ***3*** elements, which leaves a hole in the covalent bond in the semiconductor material.

16. In P-type semiconductor materials, the ***holes*** are the majority current carriers and not the electrons.

Learning Activity 3.3: Diodes

1. An N-type piece of semiconductor material's charge carriers are in the form of ***electrons***.
2. There are free electrons in N-type semiconductor material because of what process?

   Answer: The doping process.
3. In P-type semiconductor material, the ***holes*** are the current carriers.
4. When P- and N-type materials are joined together, some of the free electrons in the N-type material fill in some ***holes*** in the P-type material.
5. Similarly, as holes migrate from the ***P-*** to the ***N-***type material, they recombine with the free electrons from the atoms with five electrons.
6. The fairly stable region of atomic material that is formed where the N- and P-type semiconductors have joined is called the ***P-N junction***.
7. When a diode conducts, we say that it is ***forward biased***.
8. To connect a voltage source properly so that there is electron flow through a diode, the negative terminal of a battery must be connected to the ***N-***type material, and the positive terminal to the ***P-***type material.
9. When we connect a diode "the wrong way" and there is no current flow, we call this ***reverse bias***.
10. When a diode is not able to conduct, the negative terminal of a battery would be connected to the ***N-***type material and the positive terminal would be connected to the ***P-***type material.

Learning Activity 3.4: Transistors

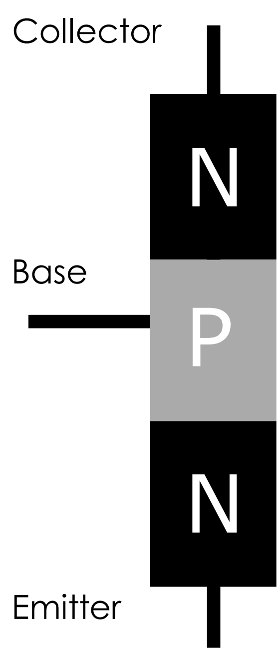
1. A transistor is like a diode in that they are both made up of ***semiconductor materials.***

2. A transistor and a diode are different in that a transistor has **3** regions of semiconductor materials and a diode has **2**.

3. Transistors are like sandwiches of different types of semiconductor materials and therefore can be two types, depending on the order of the semiconductor materials. One is a(n) ***NPN*** transistor and the other is a ***PNP*** transistor.

4. Draw and fully label a block diagram of an NPN transistor.

   Answer:



5. What are three things you should always remember about the transistor's schematic symbols?

   Answer:

   a) The arrow is always on the emitter lead of any transistor.
   b) Electrons flow into the point of the emitter lead arrow.
   c) The arrow on the emitter always points to the N-type material.

6. Describe how you would hook up an NPN transistor's leads if it were correctly biased.

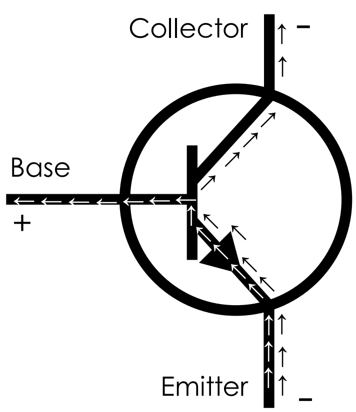
   Answer:

   The collector and the base are connected to a positive voltage, and the emitter is connected to a negative voltage.

7. When current enters the transistor through the emitter lead, it is divided in two. A small amount goes from the emitter through the ***base***, and the larger amount goes from the emitter through the ***collector***.

8. Draw the current flow of an NPN transistor using the schematic diagram, showing both the current flows as described in the previous question.

   Answer:



9. This process of a small current controlling a large current is remarkable in that it is the principle behind the process of ***amplification***.

Module 3 Summary

Congratulations! You have finished the third module in the course.

Submitting Your Assignments

It is now time for you to submit your assignments from Module 3 to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Remember: Project 1: The Decision Maker must be mailed to the Distance Learning Unit. Keep all your material together in the one mailing and do not electronically submit any material for this module.

Make sure you have completed all parts of your Module 3 assignments and organize your material in the following order:

- ❑ Module 3 Cover Sheet (found at the end of the course Introduction)
- ❑ Assignment 3.1: Experiment 4, Part 2: Report 4: Capacitors
- ❑ Assignment 3.2: Experiment 5, Part 2: Report 5: Diodes
- ❑ Assignment 3.3: Experiment 6, Part 2: Report 6: Transistors
- ❑ Assignment 3.4: Experiment 7, Part 2: Report 7: Silicon Controlled Rectifier
- ❑ Assignment 3.5: Experiment 8, Part 2, Report 8: 7-Segment Display
- ❑ Project 1: The Decision Maker

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Project 1: The Decision Maker *(100 marks)*
Marking Rubric

The assembly of parts and completion of this working brain meter are based on the following criteria:

Confirmation: *25 marks*
Construction: *25 marks*
Soldering: *25 marks*
Function: *25 marks*

This project is designed to be the work of one person and group submissions will not be accepted.

Confirmation: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**	Some of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**	Few of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**

Project 1: The Decision Maker (continued) Marking Rubric

Construction: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**	Some of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**	Few of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**

Project 1: The Decision Maker (continued)
Marking Rubric

Soldering: __________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**	Some of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**	Few of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**

Project 1: The Decision Maker (continued)
Marking Rubric

Function: ___________ / 25 marks

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Grade 10 Electricity/ Electronics Technology (20G)

Module 3
Capacitors and Semiconductors

Learning Activity Answer Keys

MODULE 3: CAPACITORS AND SEMICONDUCTORS

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   Answer:

   Electrolytic and ceramic

2. How are capacitors like batteries?

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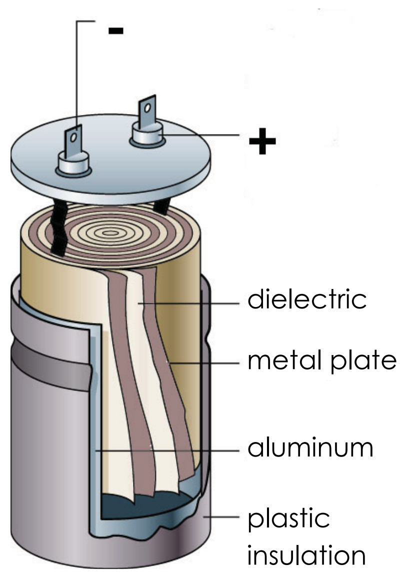

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7. List the three factors that determine capacitance and explain how each one affects the amount of capacitance.

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      Explanation: The greater the physical size of the plates, the more electrons can be stored on them.

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Learning Activity 3.4: Transistors

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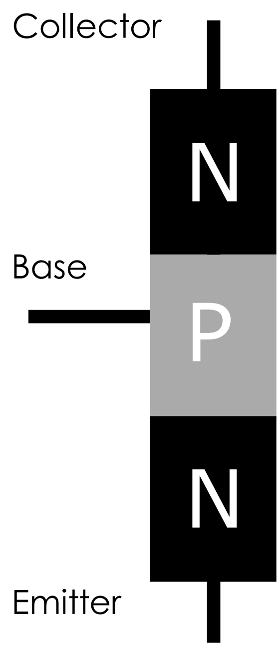
3. Transistors are like sandwiches of different types of semiconductor materials and therefore can be two types, depending on the order of the semiconductor materials. One is a(n) ***NPN*** transistor and the other is a ***PNP*** transistor.
4. Draw and fully label a block diagram of an NPN transistor.

   Answer:



5. What are three things you should always remember about the transistor's schematic symbols?

   Answer:

   a) The arrow is always on the emitter lead of any transistor.
   b) Electrons flow into the point of the emitter lead arrow.
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6. Describe how you would hook up an NPN transistor's leads if it were correctly biased.

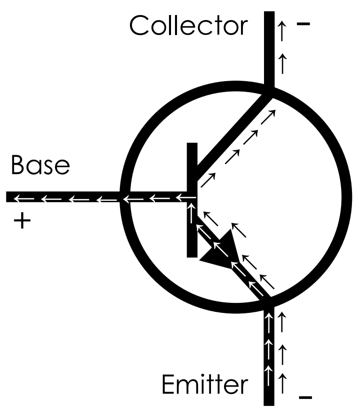
   Answer:

   The collector and the base are connected to a positive voltage, and the emitter is connected to a negative voltage.

7. When current enters the transistor through the emitter lead, it is divided in two. A small amount goes from the emitter through the ***base***, and the larger amount goes from the emitter through the ***collector***.

8. Draw the current flow of an NPN transistor using the schematic diagram, showing both the current flows as described in the previous question.

   Answer:



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Grade 10 Electricity/ Electronics Technology (20G)

Module 4
Ohm’s Law and Circuit Fundamentals

- Introduction
- Lesson 1: Ohm’s Law
- Lesson 2: Watt’s Law
- Lesson 3: Series Circuits
- Lesson 4: Parallel Circuits
- Lesson 5: Capacitors in Series
- Module 4 Summary

Module 4:
Ohm's Law and Circuit Fundamentals

Module Focus

After working through this module, you should

- ❑ have an in-depth understanding of Ohm's Law.
- ❑ have an in-depth understanding of Watt's Law.
- ❑ understand examples of series circuits.
- ❑ understand examples of parallel circuits.
- ❑ solve problems using Ohm's Law.
- ❑ solve problems using Watt's Law.
- ❑ solve series circuit problems for resistance.
- ❑ solve parallel circuit problems for resistance.
- ❑ solve series circuit problems for capacitance.
- ❑ solve parallel circuit problems for capacitance.

Introduction to Module 4

The most fundamental equation in electrical circuits is called Ohm's Law. Watt's Law describes a relationship among voltage, current, and power in an electric circuit. Understanding Ohm's Law and Watt's Law is useful for calculating circuit characteristics. Components of an electrical circuit can be connected in many different ways. The two simplest ways are called series and parallel, and they occur very frequently. A circuit composed solely of components connected in series is known as a series circuit; likewise, one connected completely in parallel is known as a parallel circuit. Resistors and capacitors are connected in series and in parallel. Capacitors can also be interconnected with resistors. The end of this module will concentrate on capacitors in series.

One of the most important laws in electronics is Ohm's Law. In this module, you will learn Ohm's Law and how to use it.

Power Words

Ohm's Law
power
watts
Watt's Law
series circuit
parallel circuit
voltage
short circuit

Module 4 Assignments

When you have completed the assignments for Module 4, submit your completed assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
3	Assignment 4.1	Resistance Values in a Series Circuit
3	Assignment 4.2	Series Circuits
4	Assignment 4.3	Resistance Parallel Circuits
4	Assignment 4.4	Parallel Circuits
5	Assignment 4.5	Capacitors in Series

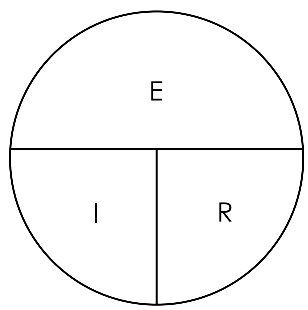
Lesson 1: Ohm's Law

Introduction to Ohm's Law

Ohm's Law is the scientific and mathematical reason that circuits do the things they do. In order to understand how to design circuits and what components to use, you must have a good understanding of Ohm's Law. You will use three formulas in this lesson. The symbols and the lines that separate them show the relationship they have with one another (see the circle below). Let's take a look at how to use it.

This is generally known as Ohm's magic circle. Although there isn't anything magical about the circle, it is useful in explaining how to use Ohm's Law.

The "magic circle"



Ohm's Law: E = I/R where
E = volts, I = amps, and R = ohms

The symbols represent the different electrical quantities used for Ohm's Law. The "E" represents EMF (electromotive force, also known as voltage), the "I" represents current, and the "R" represents resistance. We will use standard abbreviations and not the SI units in this course.

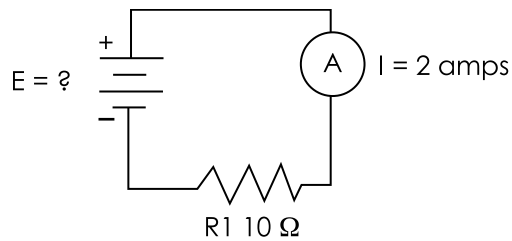
Ohm's Law is $E = I \times R$.

The formula states that volts (E) are equal to current (I) multiplied by resistance (R).

1. **Calculating Voltage (E)**

   Example 1

   In the schematic below, we have a resistance value of 10 ohms and a current value of 2 amps. How many volts were used?



   When solving for E, then we can use the base formula E = I × R.

   When you plug in the values, you get the following:

   E = 2 × 10

   E = 20 volts

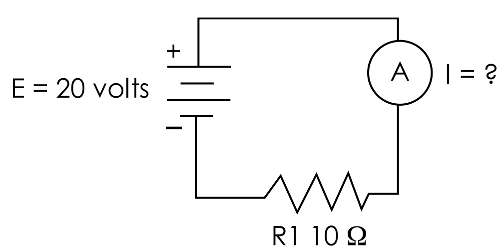
   Therefore, E is equal to 20 volts.

2. **Calculating Current (I)**

   Example 2

Common SI Units and Symbols			
Potential Difference	V	volt	V
Electric Current	I	ampere	A
Resistance	R	ohm	Ω
Electric Power	P	watt	W

   In the same schematic below, we have a resistance value of 10 ohms and a voltage of 20 volts. How many amps were used?



   If solving for I, we have to manipulate the formula to solve for the unknown value. In order to do this, we need to get "I" by itself on one side of the equal sign.

The equation you use is now $I = \frac{E}{R}$.

When you plug in the values, you get the following:

$$I = \frac{20}{10}$$

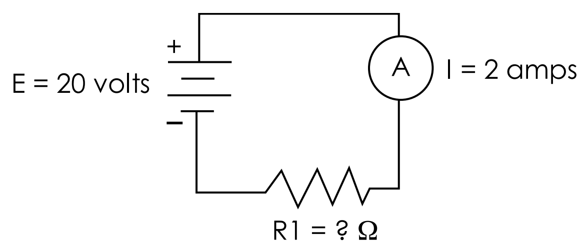
$$I = 2 \text{ amps}$$

3. **Calculating Resistance (R)**

   Example 3

   In the same schematic below, we have 20 volts, a current value of 2 amps. How much resistance is there?

   If solving for R, you have to manipulate the formula to solve for the unknown value. In order to do this, you need to get "R" by itself on one side of the equal sign.



   The equation you use is now $R = \frac{E}{I}$.

   When you plug in the values, you get the following:

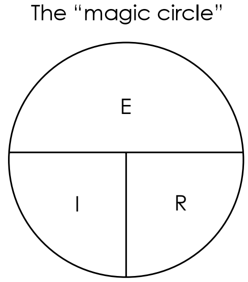
$$R = \frac{20}{2}$$

$$R = 10 \text{ ohms}$$

But how will you remember which formula to use where? This is where the magic circle can help.

Always draw out the circle first.

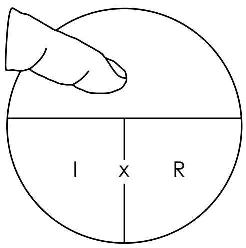
The "magic circle"



Cover up whichever value you want to solve. For example, if you want to solve for E, put your finger on it and the two other values are left, as seen below. In Example 1, I and R are the only two variables left showing, and that line in between them means to multiply.

Example 1

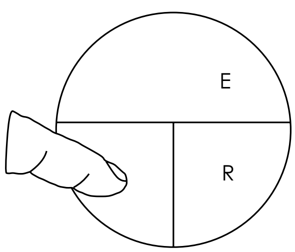
The "magic circle"



Now let's say you want to solve for I. The first thing you should do is cover it up and then see what's left showing. Check out Example 2. When you cover up the I, only the E is left on top of the R. The line between them means to divide.

Example 2

The "magic circle"

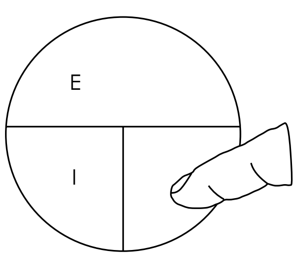


The last thing to solve for would be R. Cover it up and you can see that E is left, over I.

You can use this circle anytime you need to determine the equation to solve for an unknown value.

Example 3

The "magic circle"



Summary

Ohm's Law is one of the most important laws in electronics.

The three forms of the equation are as follows:

Solving for E	$E = I \times R$
Solving for I	$I = \frac{E}{R}$
Solving for R	$R = \frac{E}{I}$

An Analogy for Ohm's Law

Ohm's Law also makes intuitive sense if you apply if to the water-and-pipe analogy. If you have a water pump that exerts pressure (voltage) to push water around a circuit (current) through a restriction (resistance), you can model how the three variables interrelate. If the resistance to water flow stays the same and the pump pressure increases, the flow rate must also increase.

Pressure = increase	Voltage = increase
Flow rate = increase	Current = increase
Resistance = same	Resistance = same

↑ ↑

E = I R

If the pressure stays the same and the resistance increases (making it more difficult for the water to flow), then the flow rate must decrease.

Pressure = increase	Voltage = increase
Flow rate = increase	Current = increase
Resistance = same	Resistance = same

↑

E = I R

↓

If the flow rate were to stay the same while the resistance to flow decreased, the required pressure from the pump would necessarily decrease.

Pressure = increase	Voltage = increase
Flow rate = increase	Current = increase
Resistance = same	Resistance = same

$$E = I\,R$$

As odd as it may seem, the actual mathematical relationship among pressure, flow, and resistance is actually more complex for fluids like water than it is for electrons. If you pursue further studies in physics, you will discover this for yourself. Thankfully for the electronics student, the mathematics of Ohm's Law is very straightforward.

Learning Activity 4.1

Ohm's Law

Fill in the missing values in the table below.

E (volts)	I (amps)	R (ohms)
	7 A	10 Ω
200 V		50 Ω
1000 V	20 A	
	40 A	10,000 Ω
10,000 V	1 A	
900 V		200 Ω
	22 A	330 Ω
600 V	3 A	
290 V		80 Ω

Check your answers in the Learning Activity Answer Keys found at the end of this module.

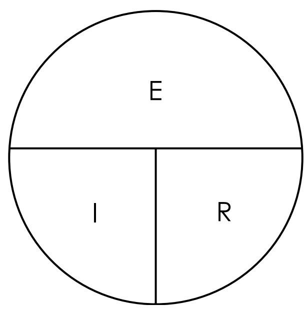
Lesson 2: Watt's Law

Introduction to Watt's Law

Power is a measure of how much work can be performed in a given amount of time, or the rate at which energy is consumed.

Watt's Law is used to calculate the power that is dissipated by a resistor or several resistors. The unit of measure is called **watts**. It works somewhat like Ohm's Law in that there is a "magic circle" for it as well. It is similar also in that it has a base formula and two variations of it to work with.

The "magic circle"

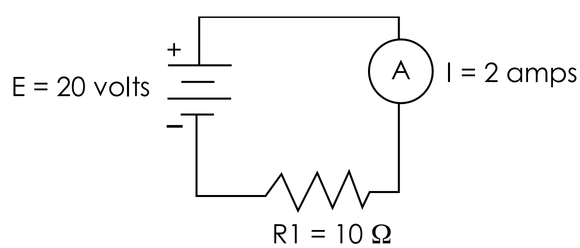


If you have a 40 watt light bulb and a 60 watt light bulb, the 60 watt will be brighter as it consumes more power. Similarly, a 1000 watt hair dryer is not as hot as a 1200 watt hair dryer.

In order to find power, you have to multiply current by voltage or $P = I \times E$.

Calculating Power

The diagram below depicts the total power used.



Remember the formula $P = I \times E$.

Now plug in the values.

$P = 2 \times 20$

$P = 40$ watts

Just like with Ohm's Law, there are two other formulas besides the base formula that you can use with Watt's Law.

Power Equations

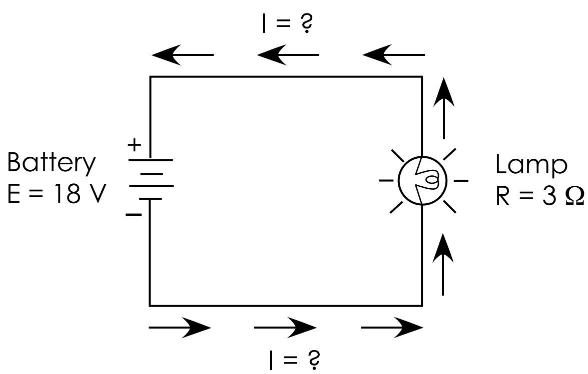
$$P = IE$$

$$P = \frac{E^2}{R}$$

$$P = I^2R$$

You've seen the formula for determining the power in an electric circuit: by multiplying the voltage by the current, you arrive at an answer in "watts."

Now apply this to a circuit example where you don't know one of the variables. In this case, it will be current. First, you must calculate the current value using Ohm's Law.



In the above circuit, you know you have a battery voltage of 18 volts and a lamp resistance of 3 Ω. Using Ohm's Law to determine current, you get:

$$I = \frac{E}{R}$$

$$I = \frac{18\ V}{3\ \Omega}$$

$$I = 6\ A$$

Now that you know the current, you can take that value and multiply it by the voltage to determine power:

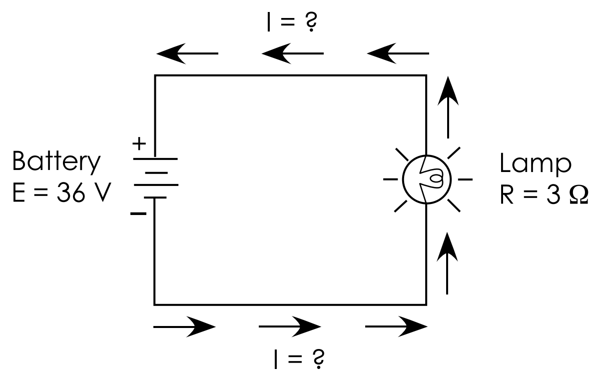
$$P = IE$$

$$P = (6\ A)(18\ V)$$

$$P = 108\ W$$

Answer: The lamp is dissipating (releasing) 108 watts of power, most likely in the form of both light and heat.

Let's try taking that same circuit and increasing the battery voltage to see what happens. Intuition should tell you that the circuit current will increase as the voltage increases and the lamp resistance stays the same. Likewise, the power will increase as well.



Now, the battery voltage is 36 volts instead of 18 volts. The lamp is still providing 3 Ω of electrical resistance to the flow of electrons. The current is now:

$$I = \frac{E}{R}$$

$$I = \frac{36\ V}{3\ \Omega}$$

$$I = 12\ A$$

It stands to reason that if $I = \frac{E}{R}$ and you double E (36 volts) while R stays the same, the current should double. Indeed, it has. You now have 12 amps of current instead of 6. Now, what about power?

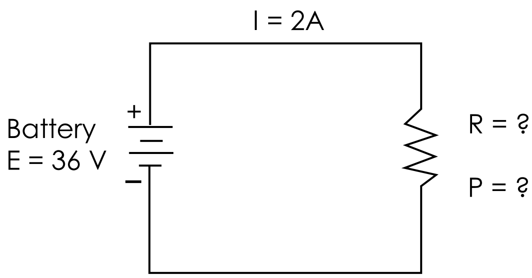
$$P = IE = (12\ A)(36\ V) = 432\ W$$

Notice that the power has increased quite a bit more than the current. Why is this? Because power is a function of voltage multiplied by current, and *both* voltage and current doubled from their previous values, the power will increase by a factor of 2 × 2, or 4.

Learning Activity 4.2

Watt's Law

To summarize what you've learned in this lesson, analyze the following circuit and determine all that you can from the information given.



You are given the battery voltage (10 volts) and the circuit current (2 amps). You don't know the resistor's resistance in ohms or the power dissipated by it in watts.

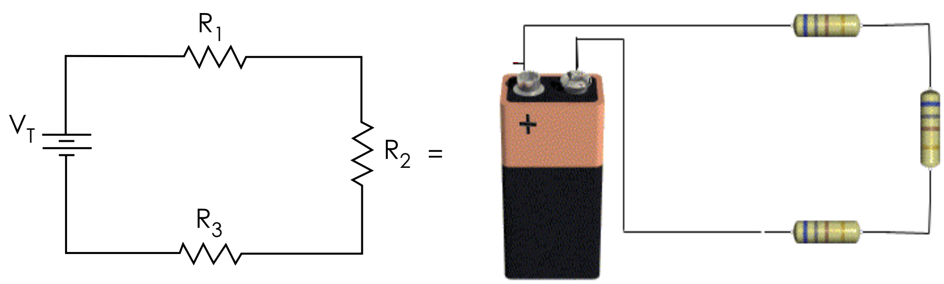
Write out the two formulas used and solve for resistance and power.

Check your answers in the Learning Activity Answer Keys found at the end of this module.

Lesson 3: Series Circuits

Introduction to Series Circuits

A series circuit is a circuit that has only one path for electrons to flow through.



The following three formulas are used to explain the laws of series circuits:

1. $E_T = E_1 + E_2 + E_3 \ldots + E_N$
2. $I_T = I_1 = I_2 = I_3$ (current does not change in series)
3. $R_T = R_1 + R_2 + R_3 \ldots + R_N$

where E_T means voltage total, E_1 means voltage at resistor 1, etc.

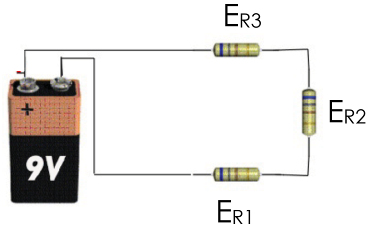
Voltage in a Series Circuit

Gustav Kirchhoff was a 19th-century scientist who discovered that the sum of voltage drops in a closed loop is equal to the applied voltage. This is Kirchhoff's law.

In other words, the total voltage is equal to all of the individual voltage drops added together.

Expressed mathematically, it looks like this:

$$E_T = E_1 + E_2 + E_3 \ldots + E_N$$

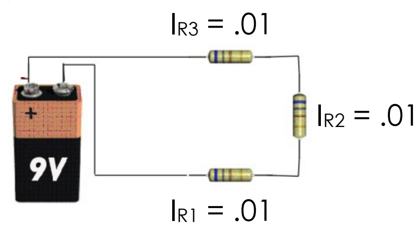


Voltage total here would equal 9 volts.

Current in a series circuit (where I_T means current total, I_1 = current at resistor 1, etc.).

Since there is only one path for the electrons to flow, current must be the same everywhere.

$$I_T = I_1 = I_2 = I_3 \ldots$$



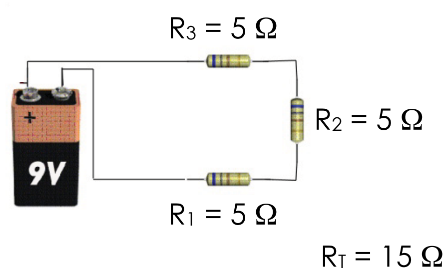
The values for current in this example are fictional.

Current total would equal 0.01 amps.

Resistance in a Series Circuit

The total resistance in a series circuit is equal to the total circuit resistances combined. Put another way, by adding the value of the individual resistors together, you can find the total resistance of the circuit.

$$R_T = R_1 + R_2 + R_3 \ldots + R_N$$

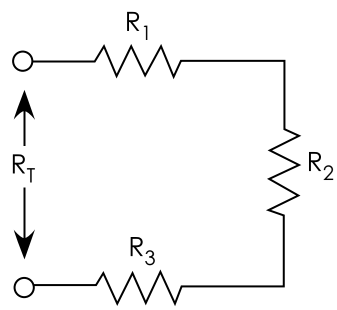


Learning Activity 4.3

Resistance Values in Series Circuits

Calculate the unknown resistance total in the series circuits below.

Circuit 1



Given:

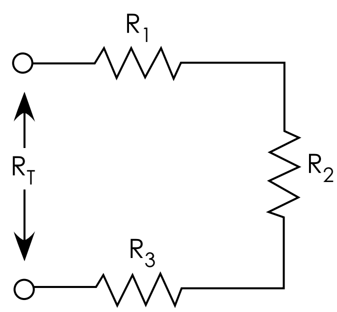
$R_1 = 30\ \Omega$

$R_2 = 30\ \Omega$

$R_3 = 40\ \Omega$

Solve:

Circuit 2



Given:

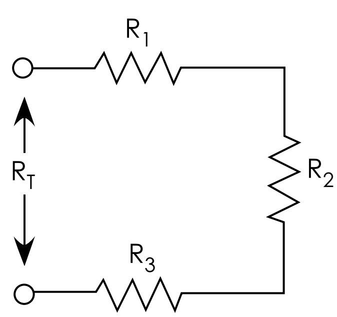
$R_1 = 100\ \Omega$

$R_2 = 5000\ \Omega$ or $5\ k\Omega$

$R_3 = 1{,}000{,}000\ \Omega$ or $1\ M\Omega$

Solve:

Circuit 3



Given:

$R_1 = 1\ M\Omega$ or $1{,}000{,}000\ \Omega$

$R_2 = 5\ M\Omega$ or $5{,}000{,}000\ \Omega$

$R_3 = 100\ M\Omega$ or $100{,}000{,}000\ \Omega$

Solve:

Check your answers in the Learning Activity Answer Keys found at the end of this module.

It is now time for you to complete Assignment 4.1. This assignment (along with all other assignments) is worth marks and you will submit it to the Distance Learning Unit when you have finished Module 4.

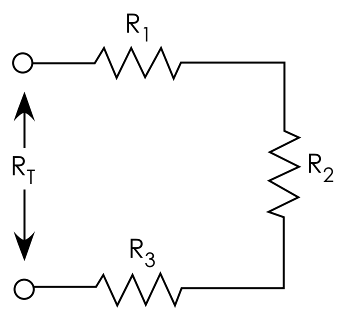
Assignment 4.1

Resistance Values in a Series Circuit *(10 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 4.

Solve the unknown resistance value in the following circuits. Make sure you pay close attention to the values as to whether they are in megohms, kilohms, etc. *(1 mark each, for a total of 10 marks)*

Circuit 1



Given:

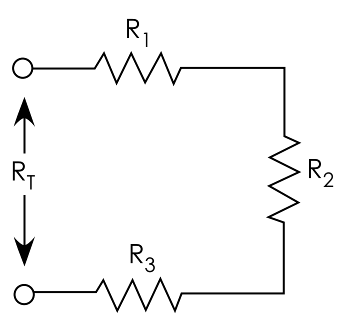
R_1 = 3 MΩ

R_2 = 880 kΩ

R_3 = 810 kΩ

Solve:

Circuit 2



Given:

R_1 = 640 kΩ

R_2 = 800 kΩ

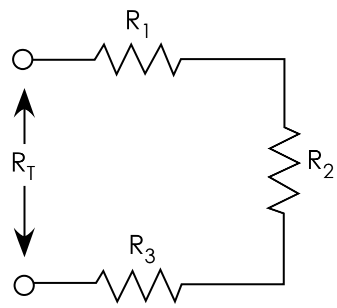
R_3 = 700 kΩ

Solve:

(continued)

Assignment 4.1: Resistance Values in a Series Circuit (continued)

Circuit 3



Given:

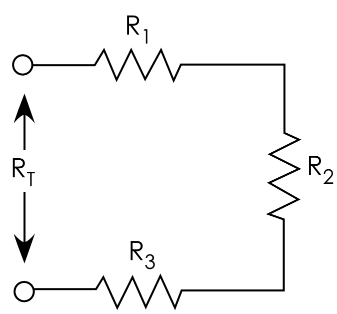
$R_1 = 640\ \Omega$

$R_2 = 530\ \Omega$

$R_3 = 440\ \Omega$

Solve:

Circuit 4



Given:

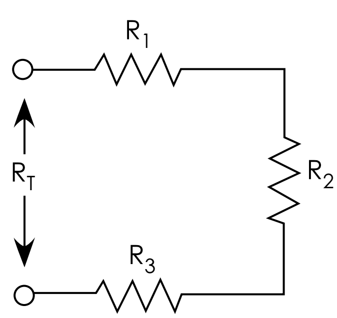
$R_1 = 170\ k\Omega$

$R_2 = 830\ k\Omega$

$R_3 = 560\ k\Omega$

Solve:

Circuit 5



Given:

$R_1 = 940\ k\Omega$

$R_2 = 140\ k\Omega$

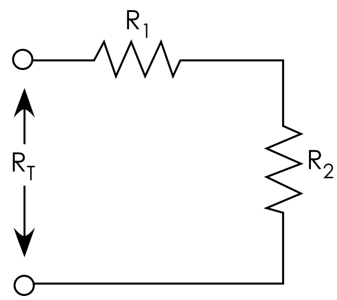
$R_3 = 3\ M\Omega$

Solve:

(continued)

Assignment 4.1: Resistance Values in a Series Circuit (continued)

Circuit 6



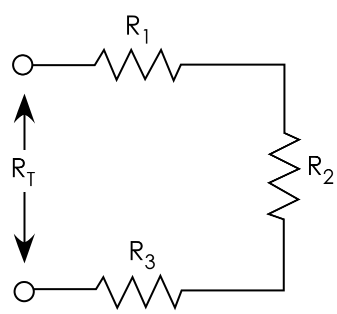
Given:

R_1 = 680 kΩ

R_2 = 720 kΩ

Solve:

Circuit 7



Given:

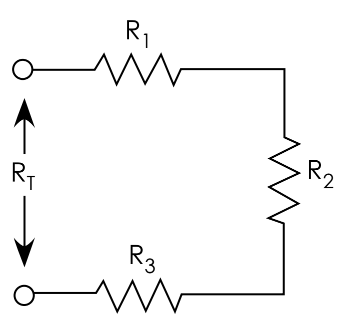
R_1 = 1 MΩ

R_2 = 3 MΩ

R_3 = 530 kΩ

Solve:

Circuit 8



Given:

R_1 = 160 kΩ

R_2 = 920 kΩ

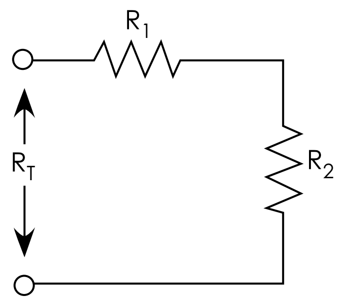
R_3 = 840 kΩ

Solve:

(continued)

Assignment 4.1: Resistance Values in a Series Circuit (continued)

Circuit 9



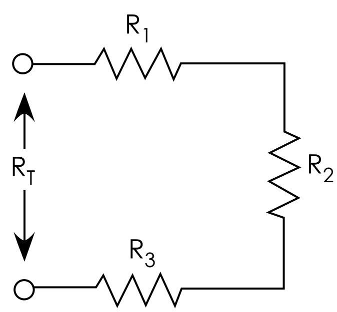
Given:

$R_1 = 550\ \Omega$

$R_2 = 620\ \Omega$

Solve:

Circuit 10



Given:

$R_1 = 480\ k\Omega$

$R_2 = 4\ M\Omega$

$R_3 = 3\ M\Omega$

Solve:

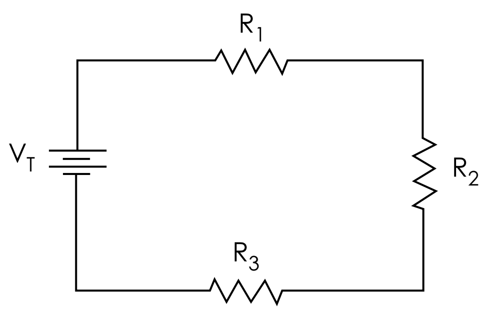
Learning Activity 4.4

Series Circuits

Solve for all unknowns in the series circuits below. Show all your work.

Check your answers in the Learning Activity Answer Keys found at the end of this module.

Circuit 1



Given:

E_T = 10 V

R_1 = 2 Ω

R_2 = 2 Ω

R_3 = 8 Ω

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

I_{R3} =

E_{R1} =

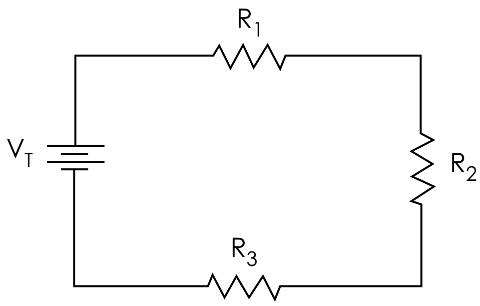
E_{R2} =

E_{R3} =

(continued)

Learning Activity 4.4: Series Circuits (continued)

Circuit 2



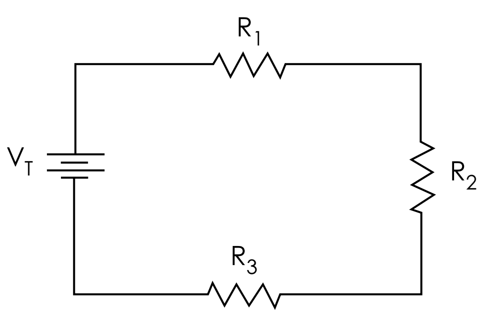
Given:

E_T = 20 MV
R_1 = 40 kΩ
R_2 = 30 kΩ
R_3 = 2 MΩ

Solve:

R_T =
I_T =
I_{R1} =
I_{R2} =
I_{R3} =
E_{R1} =
E_{R2} =
E_{R3} =

Circuit 3



Given:

E_T = 2 V
R_1 = 10 kΩ
R_2 = 550 Ω
R_3 = 100 Ω

Solve:

R_T =
I_T =
I_{R1} =
I_{R2} =
I_{R3} =
E_{R1} =
E_{R2} =
E_{R3} =

It is now time for you to complete Assignment 4.2. This assignment (along with all other assignments) is worth marks and you will submit it to the Distance Learning Unit when you have finished Module 4.

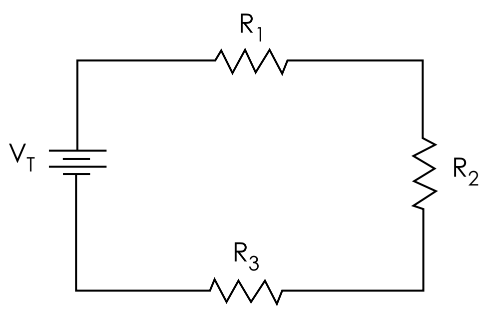
Assignment 4.2

Series Circuits *(74 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 4.

Solve for the unknown values in each question using Ohm's Law and the rules for series circuits. Answers may vary slightly due to the number of significant figures. Remember to show your work.

1. Circuit 1 *(8 marks)*



Given:

E_T = 9.8 V

R_1 = 2.3 MΩ

R_2 = 800 kΩ

R_3 = 3.2 MΩ

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

I_{R3} =

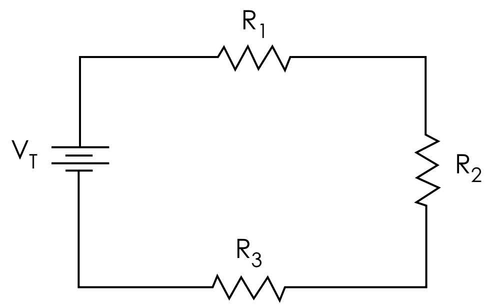
E_{R1} =

E_{R2} =

E_{R3} =

(continued)

2. Circuit 2 *(8 marks)*



Given:

E_T = 17.1 V

R_1 = 50 kΩ

R_2 = 22 kΩ

R_3 = 180 kΩ

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

I_{R3} =

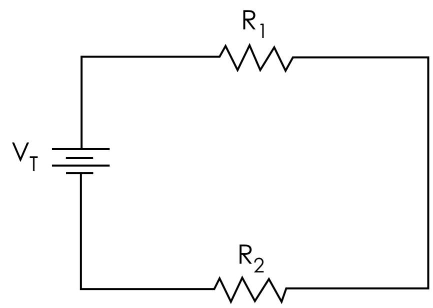
E_{R1} =

E_{R2} =

E_{R3} =

(continued)

3. Circuit 3 *(6 marks)*



Given:

E_T = 21.6 V

R_1 = 10 MΩ

R_2 = 6.7 MΩ

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

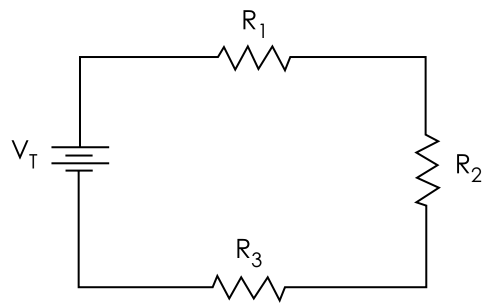
E_{R1} =

E_{R2} =

(continued)

Assignment 4.2: Resistance Values in a Series Circuit (continued)

4. Circuit 4 *(8 marks)*



Given:

E_T = 9.7 V

R_1 = 530 kΩ

R_2 = 390 kΩ

R_3 = 710 kΩ

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

I_{R3} =

E_{R1} =

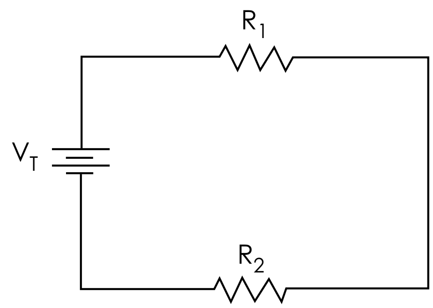
E_{R2} =

E_{R3} =

(continued)

Assignment 4.2: Resistance Values in a Series Circuit (continued)

5. Circuit 5 *(6 marks)*



Given:

E_T = 18.2 V

R_1 = 8.4 kΩ

R_2 = 10 kΩ

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

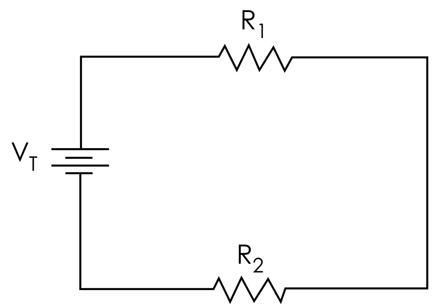
E_{R1} =

E_{R2} =

(continued)

Assignment 4.2: Resistance Values in a Series Circuit (continued)

6. Circuit 6 *(6 marks)*



Given:

E_T = 18.4 V

R_1 = 970 Ω

R_2 = 2.6 kΩ

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

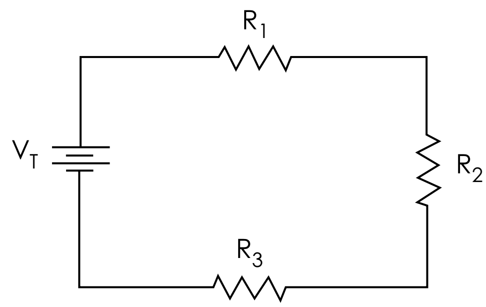
E_{R1} =

E_{R2} =

(continued)

Assignment 4.2: Resistance Values in a Series Circuit (continued)

7. Circuit 7 *(8 marks)*



Given:

E_T = 1.2 V

R_1 = 8.9 MΩ

R_2 = 7.9 MΩ

R_3 = 6.4 MΩ

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

I_{R3} =

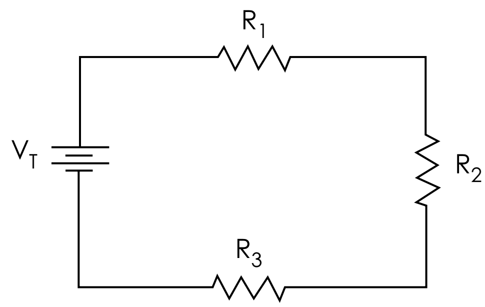
E_{R1} =

E_{R2} =

E_{R3} =

(continued)

8. Circuit 8 *(8 marks)*



Given:

E_T = 8.2 V

R_1 = 250 kΩ

R_2 = 76 kΩ

R_3 = 88 kΩ

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

I_{R3} =

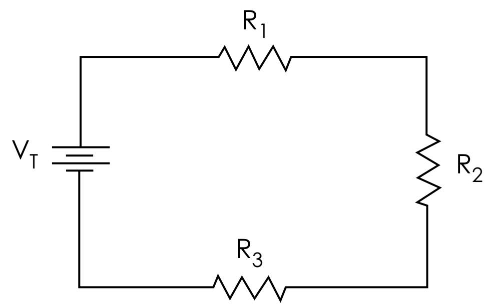
E_{R1} =

E_{R2} =

E_{R3} =

(continued)

9. Circuit 9 *(8 marks)*



Given:

E_T = 10.1 V

R_1 = 5.1 MΩ

R_2 = 8.3 MΩ

R_3 = 3.6 MΩ

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

I_{R3} =

E_{R1} =

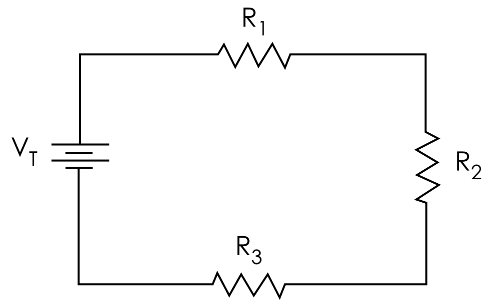
E_{R2} =

E_{R3} =

(continued)

Assignment 4.2: Resistance Values in a Series Circuit (continued)

10. Circuit 10 *(8 marks)*



Given:

E_T = 16 V

R_1 = 820 kΩ

R_2 = 400 kΩ

R_3 = 920 kΩ

Solve:

R_T =

I_T =

I_{R1} =

I_{R2} =

I_{R3} =

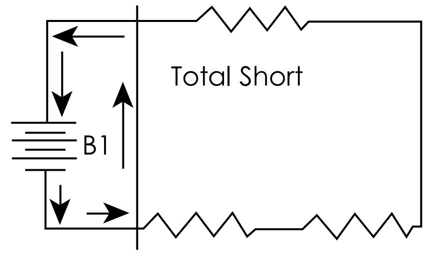
E_{R1} =

E_{R2} =

E_{R3} =

Short Circuits

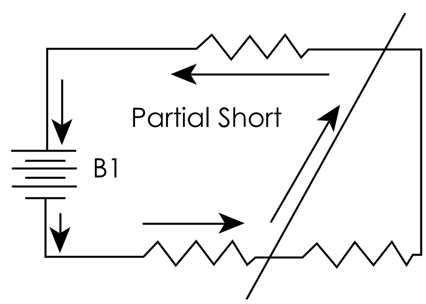
A **short circuit** is a circuit that offers very little resistance to current flow, and can cause dangerously high current flow through a circuit. These short circuits are usually caused by an inadvertent connection between two points in a circuit that offers little or no resistance in the circuit.



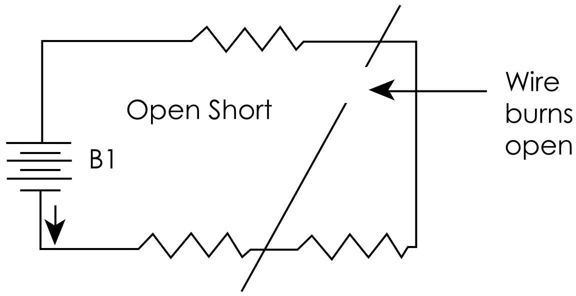
Basically, electricity is much like the flow of water in that it will take the path of least resistance. If electrical current has a choice either to go through a resistor or to go through the shortage connection shown here, it will go through the short. A resistor offers resistance to the current flow and the wire does not.

This example is called a total short. The reason is that the current flows through the battery and doesn't have a chance to get to the rest of the circuit.

Partial shorts are short circuits that occur within the circuit but current still goes through some of the components, but not all. In this example, you can see that the current still flows through two of the resistors but not all of them.



Because of the extra load having to be absorbed by the two remaining resistors in this circuit, there is a danger of the circuit burning open. This is called an open short. In an open short, there is no current flow at all because the circuit fails to provide a complete path for the electrons to flow.



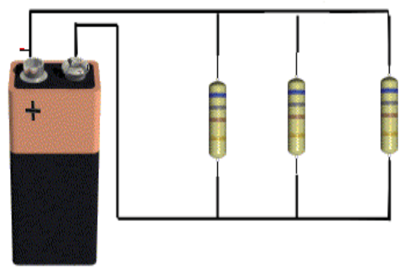
When this happens, a wire can actually catch fire. This fire could then spread to the whole house. In order to protect ourselves, we use fuses or circuit breakers in circuits to prevent this from happening. Fuses and circuit breakers "open" the circuit when there is an excess current that the wire was not designed to handle.

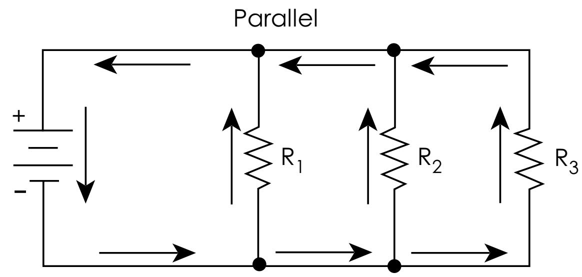
Breaker Panel

Lesson 4: Parallel Circuits

Introduction to Parallel Circuits

A **parallel circuit** is a circuit that has two or more paths for electrons to flow.

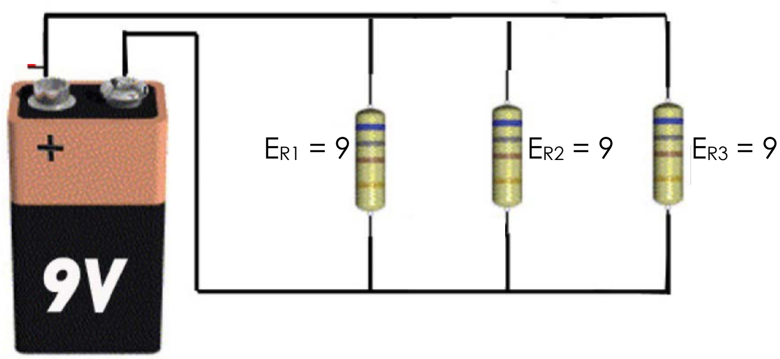




Voltage in Parallel

Voltage in a parallel circuit is equal to the source voltage. Put another way, voltage in parallel is the same everywhere in the circuit.

$$E_T = E_1 = E_2 = E_3 \ldots = E_N$$

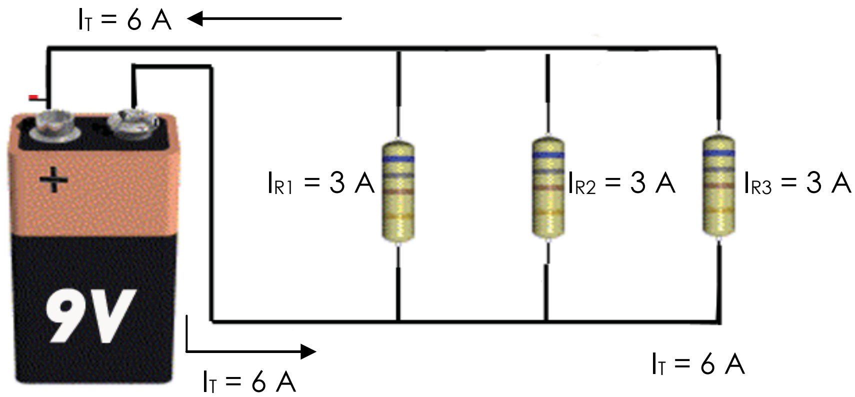


Current in a Parallel Circuit

Kirchhoff's current law states that *the algebraic sum of all the currents entering any point will equal the sum of all currents leaving that point.*

Put another way, the total circuit amperes of a parallel circuit is equal to the sum of the individual branch currents.

$$I_T = I_1 + I_2 + I_3 \ldots + I_N$$



As you can see, six amps of current come from the battery. It divides according to the amount of resistance in each of the parallel branches. The total amperage going back to the battery is the same as the total amperage that left the battery. In other words, total current can be found by adding the branch currents together.

Parallel Circuit

Resistance in a Parallel Circuit

Resistance in parallel is quite different than resistance in series. In series, you can just add up all the resistances to find the total resistance. In parallel, you have to use three different formulas to calculate resistance. Knowing when to use which formula is part of the challenge.

When working with resistance in parallel, your final answer for the resistance total will always be less than the smallest resistor found in the circuit. So after you have completed your calculations, take a look at your answer and compare it to the smallest resistor value in the question. Your answer should be less than that value.

Method 1: The Equal Resistance Method

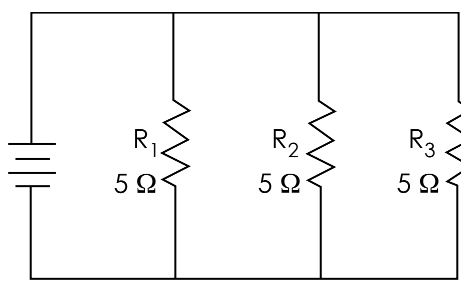
(Sometimes called the *equal* branch method.)

When a parallel circuit consists of two or more resistors of equal values, the total resistance is equal to the value of the resistor divided by the number of the equal-valued resistors.

$$R_T = \frac{R}{N}$$

where "N" is the value of the number of equal-valued resistors in the circuit.

Example:



$$R_T = \frac{5}{3}$$

$$R_T = 1.667\ \Omega$$

Method 2: The Product over the Sum Method

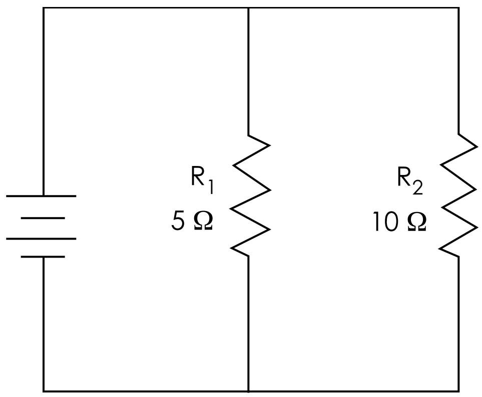
(Sometimes called the *unequal* branch method)

This method is used *only* when there are *two* resistances of unequal value connected in parallel.

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

Example:

(Follow steps (a), (b), (c), and (d).)



a) $R_T = \dfrac{R_1 \times R_2}{R_1 + R_2}$

b) $R_T = \dfrac{5 \times 10}{5 + 10}$

c) $R_T = \dfrac{50}{15}$

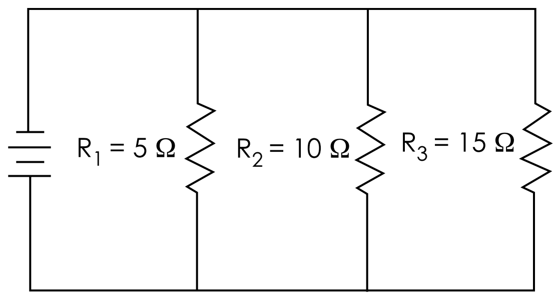
d) $R_T = 3.33\ \Omega$

Method 3: The Reciprocal Method

This method is used to find the total resistance when there are three or more resistances in parallel.

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Example:



Plug in the values from the example above, and go through steps (a), (b), (c), and (d) to see how to solve the problem.

a) $R_T = \frac{1}{\frac{1}{5\ \Omega} + \frac{1}{10\ \Omega} + \frac{1}{15\ \Omega}}$

b) $R_T = \frac{1}{0.2 + 0.1 + 0.067}$

c) $R_T = \frac{1}{0.367}$

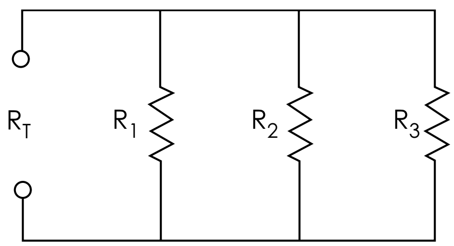
d) $R_T = 2.72$

Learning Activity 4.5

Resistance Parallel Circuits

Solve for resistance in the parallel circuits below. Show all your work.

Circuit 1



Given:

R_1 = 2.7 kΩ

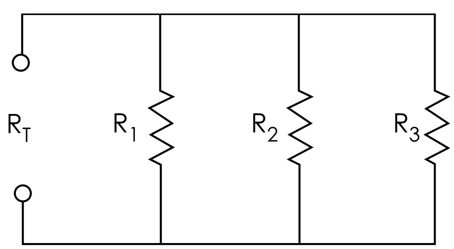
R_2 = 910 Ω

R_3 = 600 kΩ

Solve:

R_T =

Circuit 2



Given:

R_1 = 3 MΩ

R_2 = 3 MΩ

R_3 = 3 MΩ

Solve:

R_T =

Check your answers in the Learning Activity Answer Keys found at the end of this module.

It is now time for you to complete Assignment 4.3. This assignment (along with all other assignments) is worth marks and you will submit it to the Distance Learning Unit when you have finished Module 4.

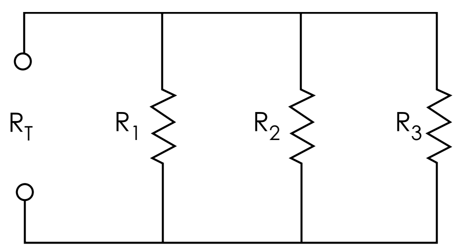
Assignment 4.3

Resistance Parallel Circuits *(10 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 4.

Solve for the resistances in each of the questions. Be sure to make note that the resistances may be in kilo or mega ohms. You will choose which of the three formulas to use based on the configuration of the circuit for each question. *(1 mark each, for a total of 10 marks)*

1. Circuit 1



Given:

R_1 = 800 Ω

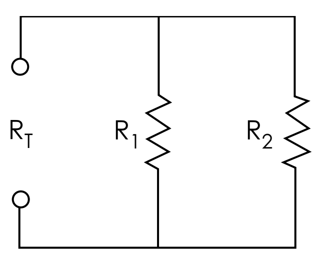
R_2 = 3.2 kΩ

R_3 = 400 Ω

Solve:

R_T =

2. Circuit 2



Given:

R_1 = 1 MΩ

R_2 = 590 kΩ

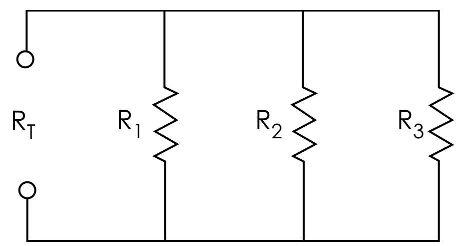
Solve:

R_T =

(continued)

Assignment 4.3: Resistance Parallel Circuits (continued)

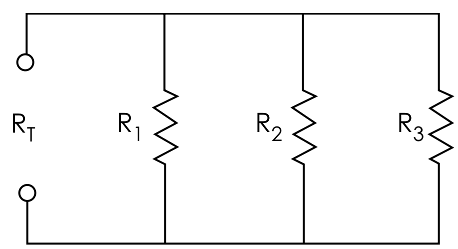
3. Circuit 3



Given:
R_1 = 1.7 MΩ
R_2 = 810 kΩ
R_3 = 870 kΩ

Solve:
R_T =

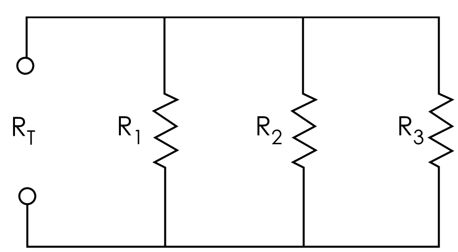
4. Circuit 4



Given:
R_1 = 10 kΩ
R_2 = 16 kΩ
R_3 = 9.7 kΩ

Solve:
R_T =

5. Circuit 5



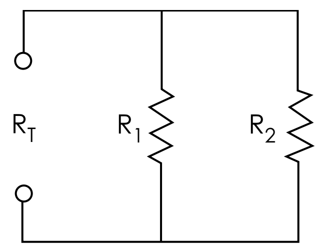
Given:
R_1 = 1.1 MΩ
R_2 = 2.6 MΩ
R_3 = 320 kΩ

Solve:
R_T =

(continued)

Assignment 4.3: Resistance Parallel Circuits (continued)

6. Circuit 6



Given:

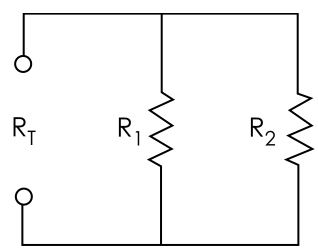
R_1 = 480 kΩ

R_2 = 870 kΩ

Solve:

R_T =

7. Circuit 7



Given:

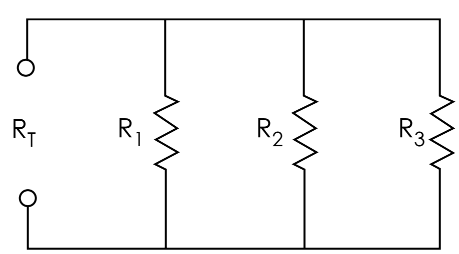
R_1 = 340 Ω

R_2 = 320 Ω

Solve:

R_T =

8. Circuit 8



Given:

R_1 = 9.2 MΩ

R_2 = 6.6 MΩ

R_3 = 9 MΩ

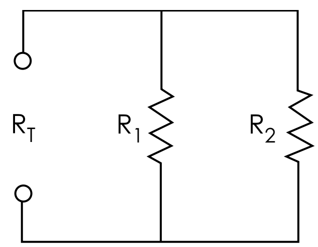
Solve:

R_T =

(continued)

Assignment 4.3: Resistance Parallel Circuits (continued)

9. Circuit 9



Given:

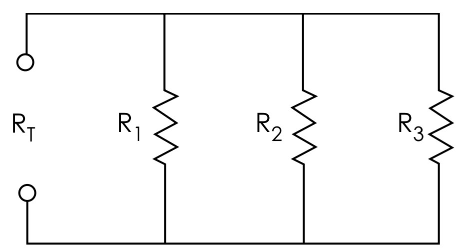
R_1 = 760 kΩ

R_2 = 770 kΩ

Solve:

R_T =

10. Circuit 10



Given:

R_1 = 36 kΩ

R_2 = 53 kΩ

R_3 = 54 kΩ

Solve:

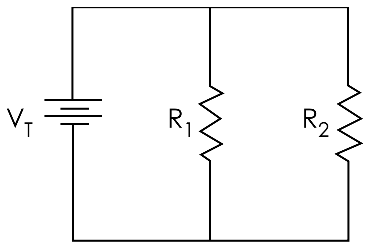
R_T =

Learning Activity 4.6

Parallel Circuits

Solve for all unknowns in the parallel circuit below. Show all your work.

Circuit 1



Given:

E_T = 100 V

R_1 = 50 Ω

R_2 = 200 Ω

Solve:

R_T =

I_T =

E_{R1} =

E_{R2} =

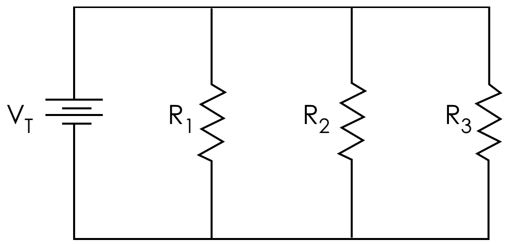
I_{R1} =

I_{R2} =

(continued)

Learning Activity 4.6: Parallel Circuits (continued)

Circuit 2



Given:

E_T = 210 V

R_1 = 420 kΩ

R_2 = 60 Ω

R_3 = 25 kΩ

Solve:

R_T =

I_T =

E_{R1} =

E_{R2} =

E_{R3} =

I_{R1} =

I_{R2} =

I_{R3} =

Check your answers in the Learning Activity Answer Keys found at the end of this module.

It is now time for you to complete Assignment 4.4. This assignment (along with all other assignments) is worth marks and you will submit it to the Distance Learning Unit when you have finished Module 4.

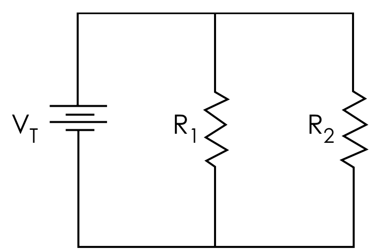
Assignment 4.4

Parallel Circuits *(72 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 4.

In this assignment, you will solve for the unknown values in each question using Ohm's Law and the rules for parallel circuits. Answers may vary slightly due to the number of significant figures.

1. Circuit 1 *(6 marks)*



Given:

E_T = 15.9 V

R_1 = 50 Ω

R_2 = 200 Ω

Solve:

R_T =

I_T =

E_{R1} =

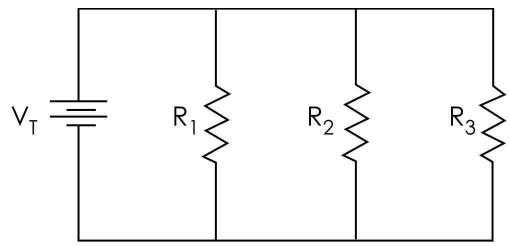
E_{R2} =

I_{R1} =

I_{R2} =

(continued)

2. Circuit 2 *(8 marks)*



Given:

E_T = 10 V

R_1 = 420 Ω

R_2 = 960 Ω

R_3 = 880 kΩ

Solve:

R_T =

I_T =

E_{R1} =

E_{R2} =

E_{R3} =

I_{R1} =

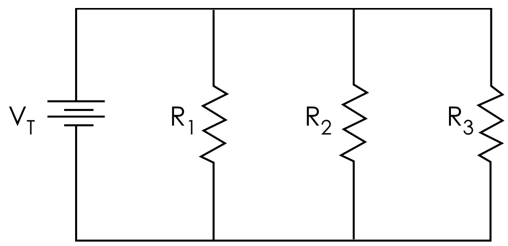
I_{R2} =

I_{R3} =

(continued)

Assignment 4.4: Parallel Circuits (continued)

3. Circuit 3 *(8 marks)*



Given:

E_T = 9.8 V

R_1 = 3.2 kΩ

R_2 = 1.7 kΩ

R_3 = 2.4 kΩ

Solve:

R_T =

I_T =

E_{R1} =

E_{R2} =

E_{R3} =

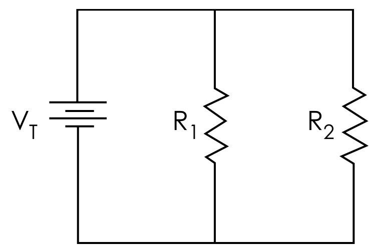
I_{R1} =

I_{R2} =

I_{R3} =

(continued)

4. Circuit 4 *(6 marks)*



Given:

E_T = 7.4 V

R_1 = 300 Ω

R_2 = 920 Ω

Solve:

R_T =

I_T =

E_{R1} =

E_{R2} =

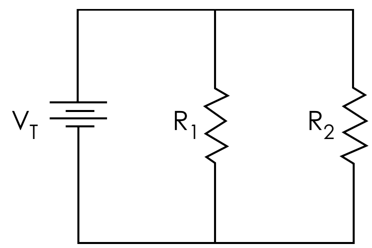
I_{R1} =

I_{R2} =

(continued)

Assignment 4.4: Parallel Circuits (continued)

5. Circuit 5 *(6 marks)*



Given:

$E_T = 9.8$ V

$R_1 = 39\ \Omega$

$R_2 = 33\ \Omega$

Solve:

$R_T =$

$I_T =$

$E_{R1} =$

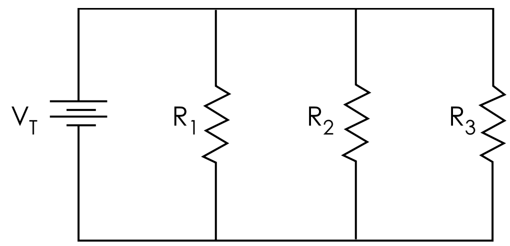
$E_{R2} =$

$I_{R1} =$

$I_{R2} =$

(continued)

6. Circuit 6 *(8 marks)*



Given:

E_T = 1.1 V

R_1 = 54 Ω

R_2 = 99 Ω

R_3 = 73 Ω

Solve:

R_T =

I_T =

E_{R1} =

E_{R2} =

E_{R3} =

I_{R1} =

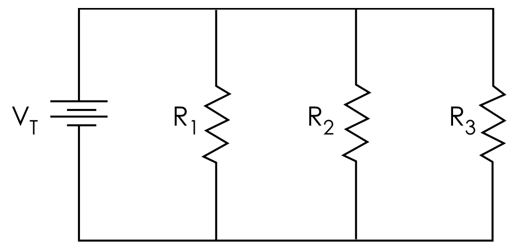
I_{R2} =

I_{R3} =

(continued)

Assignment 4.4: Parallel Circuits (continued)

7. Circuit 7 *(8 marks)*



Given:

$E_T = 16.8$ V

$R_1 = 810\ \Omega$

$R_2 = 480\ \Omega$

$R_3 = 720\ \Omega$

Solve:

$R_T =$

$I_T =$

$E_{R1} =$

$E_{R2} =$

$E_{R3} =$

$I_{R1} =$

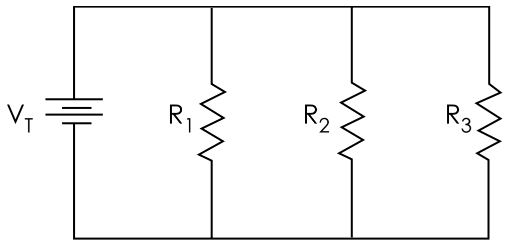
$I_{R2} =$

$I_{R3} =$

(continued)

Assignment 4.4: Parallel Circuits (continued)

8. Circuit 8 *(8 marks)*



Given:

E_T = 7.9 V

R_1 = 6.8 kΩ

R_2 = 7.6 kΩ

R_3 = 2.6 kΩ

Solve:

R_T =

I_T =

E_{R1} =

E_{R2} =

E_{R3} =

I_{R1} =

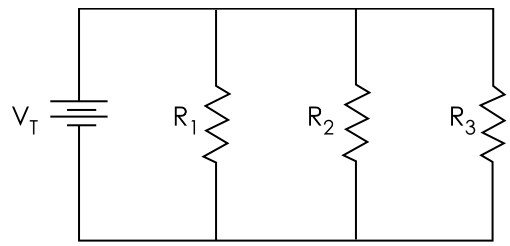
I_{R2} =

I_{R3} =

(continued)

Assignment 4.4: Parallel Circuits (continued)

9. Circuit 9 *(8 marks)*



Given:

E_T = 19.6 V

R_1 = 7.1 MΩ

R_2 = 5 MΩ

R_3 = 3.6 MΩ

Solve:

R_T =

I_T =

E_{R1} =

E_{R2} =

E_{R3} =

I_{R1} =

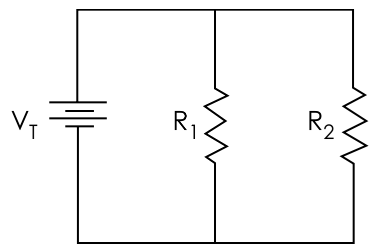
I_{R2} =

I_{R3} =

(continued)

Assignment 4.4: Parallel Circuits (continued)

10. Circuit 10 *(6 marks)*



Given:

E_T = 20.1 V

R_1 = 50 kΩ

R_2 = 11 kΩ

Solve:

R_T =

I_T =

E_{R1} =

E_{R2} =

I_{R1} =

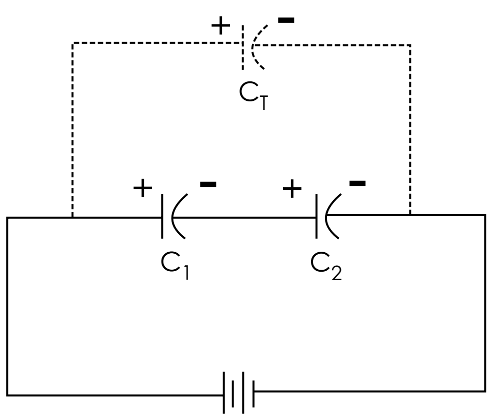
I_{R2} =

Lesson 5: Capacitors in Series

Introduction to Capacitors in Series

You have looked at volts, amps, and resistance in series. Now let's explore capacitance in series. The formulas for capacitance in series are remarkably similar to those for resistance in parallel.

When connecting capacitors in series, they act as if the plates of the capacitors are further apart.



Notice that the junction between C_1 and C_2 has both a negative and a positive charge. This causes the junction to be essentially neutral. The total capacitance of the circuit is developed between the left plate of C_1 and the right plate of C_2. Because these plates are farther apart, the total value of the capacitance in the circuit is decreased.

Solving for the total capacitance (C_T) of capacitors connected in series is similar to solving for the total resistance (R_T) of resistors connected in parallel.

Note the similarity between the formulas for R_T and C_T.

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots \frac{1}{R_N}}$$

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots \frac{1}{C_N}}$$

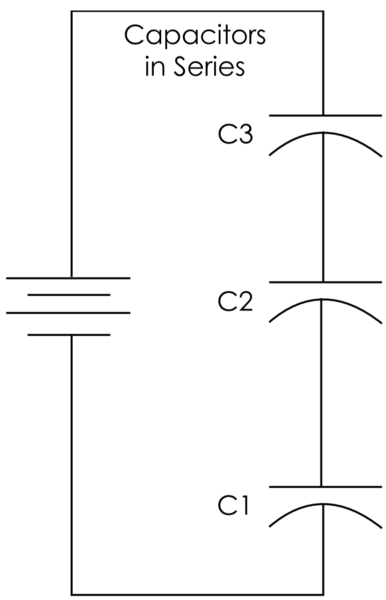
If the circuit contains more than two capacitors, use the above formula. If the circuit contains only two capacitors, use the formula below—the product over the sum method.

$$C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$

It should be evident from the above formulas that the total capacitance of capacitors in series is less than the capacitance of any of the individual capacitors. In other words, the total capacitance of a series circuit is less than the smallest capacitor in the circuit.

Example 1

Let's calculate the total capacitance of a series circuit containing three capacitors whose values are 0.01 μF, 0.25 μF, and .5 μF, respectively.



Given:

$C_1 = 0.01\ \mu F$

$C_2 = 0.025\ \mu F$

$C_3 = 0.5\ \mu F$

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots \frac{1}{C_N}}$$

a) $C_T = \dfrac{1}{\dfrac{1}{0.01\ \mu F} + \dfrac{1}{0.025\ \mu F} + \ldots \dfrac{1}{0.5\ \mu F}}$

b) $C_T = \dfrac{1}{100\ \mu F + 40\ \mu F + 2\ \mu F}$

c) $C_T = \dfrac{1}{142\ \mu F}$

d) $C_T = 0.007\ \mu F$

The total capacitance of 0.007 μF is slightly smaller than the smallest capacitor (0.01 μF).

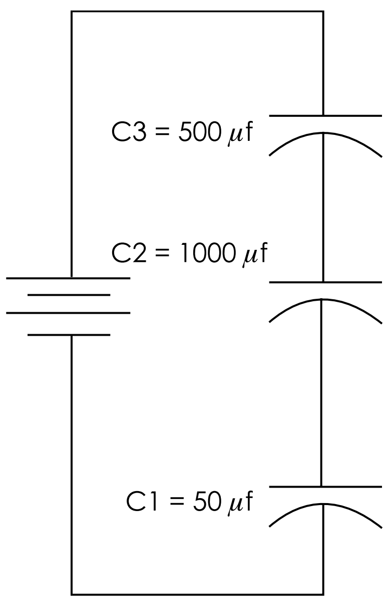
Note: Like in any series circuit, the voltages add up to the battery voltage.

Learning Activity 4.7

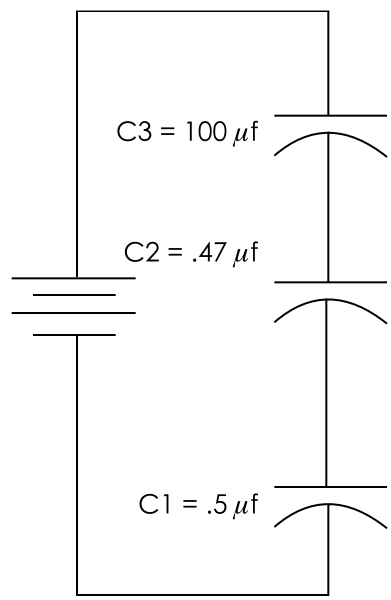
Capacitors in Series

Solve for the unknown capacitance total value. Show your work below each question.

Capacitor 1



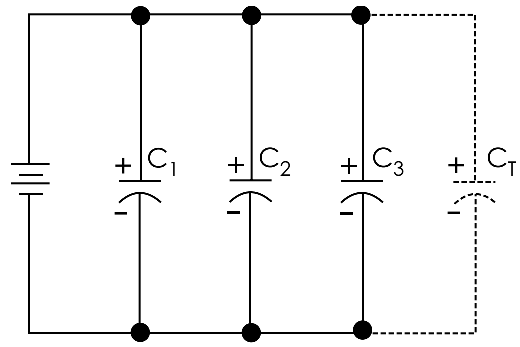
Capacitor 2



Check your answers in the Learning Activity Answer Keys found at the end of this module.

Capacitors in Parallel

When capacitors are connected in parallel, one plate of each capacitor is connected directly to one terminal of the source, while the other plate of each capacitor is connected to the other terminal of the source. The diagram shows all the negative plates of the capacitors connected together and all the positive plates connected together. C_T, therefore, appears as a capacitor with a plate area equal to the sum of all the individual plate areas.



As you learned in Module 3, one of the factors that determines capacitance is plate area. Connecting capacitors in parallel effectively increases plate area and thereby increases total capacitance.

For capacitors connected in parallel, the total capacitance is the sum of all the individual capacitances. The total capacitance of the circuit may by calculated using the formula:

$$C_T = C_1 + C_2 + C_3 + \ldots C_N$$

Example:

Determine the total capacitance in a parallel capacitive circuit containing three capacitors whose values are 0.03 μF, 2.0 μF, and 0.25 μF, respectively.

Given:
$C_1 = 0.03\ \mu F$
$C_2 = 2\ \mu F$
$C_3 = 0.25\ \mu F$

Solution:
$C_T = C_1 + C_2 + C_3$
$C_T = 0.03\ \mu F + 20\ \mu F + 0.25\ \mu F$
$C_T = 2.28\ \mu F$

In other words, in a parallel circuit, you simply add the capacitances to find the total capacitance.

Why Would You Want to Join Capacitors?

There are several reasons to join capacitors together. The first might be that large capacitors are very expensive and smaller ones are not quite as expensive. You can connect smaller capacitors together to create larger capacitors in order to save money.

Another reason is that you may not have the capacitor that a particular device calls for, so you may need to connect the capacitors together to create the capacitor you need.

It is now time for you to complete Assignment 4.5. This assignment (along with all other assignments) is worth marks and you will submit it to the Distance Learning Unit when you have finished Module 4.

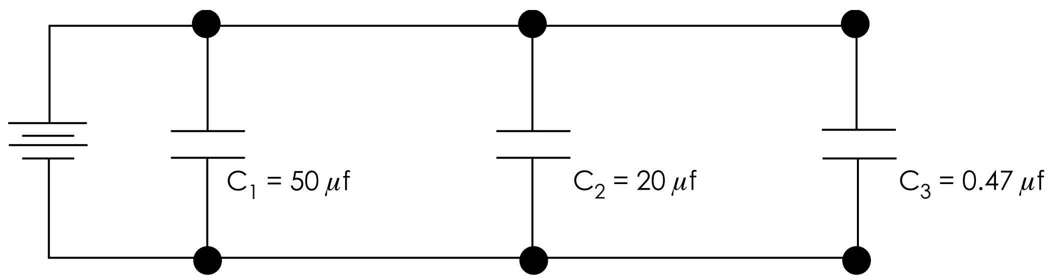
Assignment 4.5

Capacitors in Series *(2 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 4.

In this assignment, you will solve for the unknown capacitance total value. Show your work below each question. *(1 mark each, for a total of 2 marks)*

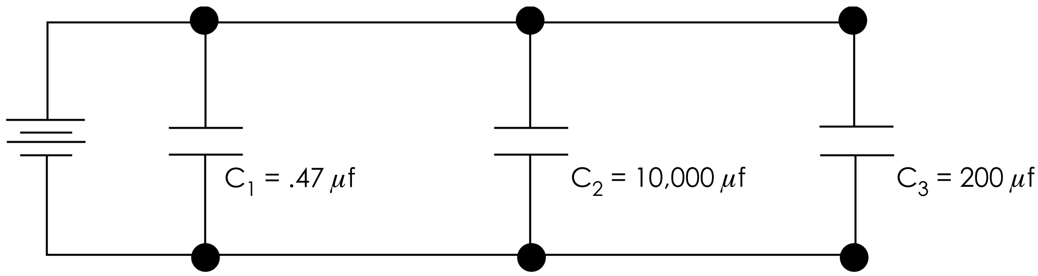
Question 1



(continued)

Assignment 4.5: Capacitors in Series (continued)

Question 2



Summary Sheet

Ohm's Law, Series and Parallel Circuit Laws

The three forms of the Ohm's Law equation are as follows:

Solving for E $E = I \times R$

Solving for I $I = \frac{E}{R}$

Solving for R $R = \frac{E}{I}$

Power Equations

$$P = IE$$

$$P = \frac{E^2}{R}$$

$$P = I^2R$$

Series Circuit Rules

Kirchhoff's voltage law states: The sum of voltage drops in a closed loop is equal to the applied voltage.

Voltage is additive. $E_T = E_1 + E_2 + E_3 \ldots + E_N$

Current is the same everywhere in the circuit. $I_T = I_1 = I_2 = I_3 \ldots + I_N$

Resistance in series is additive. $R_T = R_1 + R_2 + R_3 \ldots + R_N$

Parallel Circuit Rules

Voltage in parallel is the same everywhere in the circuit. $E_T = E_1 = E_2 = E_3 \ldots = E_2$

Current is equal to the sum of the branch currents. $I_T = I_1 + I_2 + I_2 \ldots + I_N$

Resistance needs to use one of three different formulas.

1. The Product over Sum Method (unequal branch method)

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

2. The Equal Resistance Method (equal branch method)

$$R_T = \frac{R}{N}$$

3. The Reciprocal Method

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Capacitors

The laws for capacitors and resistors are similar in many ways but differ in a few as well.

Capacitors in Series

You must use one of two methods for solving for total capacitance, depending on circuit construction

1. Reciprocal Method

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$

2. Product over Sum Method

$$C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$

Capacitors in Parallel

Capacitors in parallel are additive. You simply add the individual capacitors' values to come up with the capacitance total.

$$C_T = C_1 + C_2 + C_3 + \ldots C_N$$

Module 4 Summary

Congratulations! You have finished the fourth module in the course..

Submitting Your Assignments

It is now time for you to submit your assignments from Module 4 to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Make sure you have completed all parts of your Module 4 assignments and organize your material in the following order:

- ❑ Module 4 Cover Sheet (found at the end of the course Introduction)
- ❑ Assignment 4.1: Resistance Values in Series Circuits
- ❑ Assignment 4.2: Series Circuits
- ❑ Assignment 4.3: Resistance in Parallel Circuits
- ❑ Assignment 4.4: Parallel Circuits
- ❑ Assignment 4.5: Capacitors in Series

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Grade 10 Electricity/ Electronics Technology (20G)

Module 4
Ohm's Law and Circuit Fundamentals

Learning Activity Answer Keys

Module 4: Ohm's Law and Circuit Fundamentals

Learning Activity 4.1: Ohm's Law

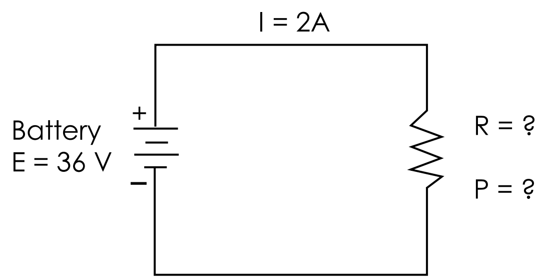
Fill in the missing values in the table below.

Answers:

E (volts)	**I (amps)**	**R (ohms)**
70 V	7 A	10 Ω
200 V	4 A	50 Ω
1000 V	20 A	50 Ω
400,000 V	40 A	10,000 Ω
10,000 V	1 A	10,000 Ω
900 V	4.5 A	200 Ω
7,260 V	22 A	330 Ω
600 V	3 A	200 Ω
290 V	3.625 A	80 Ω

Learning Activity 4.2: Watt's Law

To summarize what you've learned in this lesson, analyze the following circuit and determine all that you can from the information given.



You are given the battery voltage (10 volts) and the circuit current (2 amps). You don't know the resistor's resistance in ohms or the power dissipated by it in watts.

Write out the two formulas used and solve for resistance and power.

Answer:

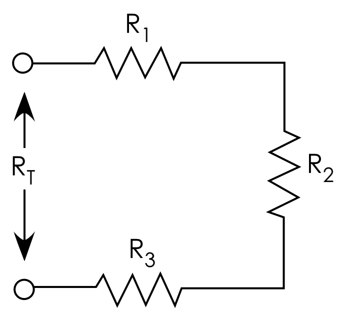
$$R = \frac{E}{I}$$

$$P = IE$$

Learning Activity 4.3: Resistance Values in Series Circuits

Calculate the unknown resistance total in the series circuits below.

Circuit 1



Given:

$R_1 = 30\ \Omega$

$R_2 = 30\ \Omega$

$R_3 = 40\ \Omega$

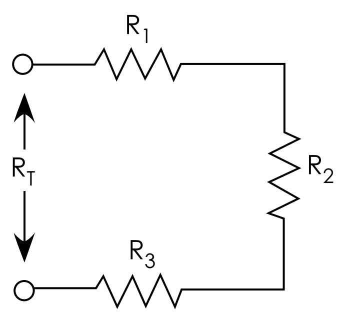
Answer:

$R_T = R1 + R_2 + R_3 + \ldots + R_N$

$R_T = 30 + 30 + 40$

$R_T = 100\ \Omega$

Circuit 2



Given:

$R_1 = 100\ \Omega$

$R_2 = 5000\ \Omega$ or $5\ K\ \Omega$

$R_3 = 1{,}000{,}000\ \Omega$ or $1\ M\ \Omega$

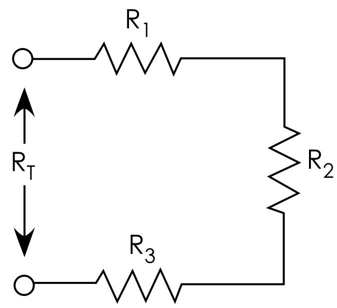
Answer:

$R_T = R1 + R_2 + R_3 + \ldots + R_N$

$R_T = 100 + 5{,}000 + 1{,}000{,}000$

$R_T = 1{,}005{,}100\ \Omega$

Circuit 3



Given:

R_1 = 1 MΩ or 1,000,000 Ω

R_2 = 5 MΩ or 5,000,000 Ω

R_3 = 100 MΩ or 100,000,000 Ω

Answer:

$R_T = R1 + R_2 + R_3 + \ldots + R_N$

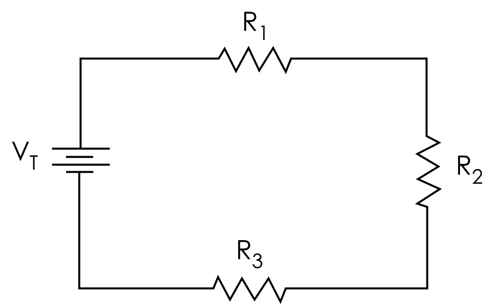
$R_T = 1{,}000{,}000 + 5{,}000{,}000 + 100{,}000{,}000$

$R_T = 106{,}000{,}000\ \Omega$

Learning Activity 4.4: Series Circuits

Solve for all unknowns in the series circuits below. Show all your work.

Circuit 1



Given:

$E_T = 10$ V

$R_1 = 2\ \Omega$

$R_2 = 2\ \Omega$

$R_3 = 8\ \Omega$

Answer:

Formula:

$R_T = R_1 + R_2 + R_3 \ldots + R_N$

$R_T = 2 + 2 + 8 = 12$

Formula:

$$I = \frac{E_T}{R_T}$$

$$I = \frac{10}{12}$$

$I_T = 0.833$

Formula:

$E = I \times R$

$E_{RI} = 0.833 \times 2$ $E_{R1} = 1.66$

$E_{R2} = 0.833 \times 2$ $E_{R2} = 1.66$

$E_{R3} = 0.833 \times 8$ $E_{R3} = 6.66$

$R_T = 12\ \Omega$

$I_T = 0.833$ A

$I_{R1} = 0.833$ A

$I_{R2} = 0.833$ A

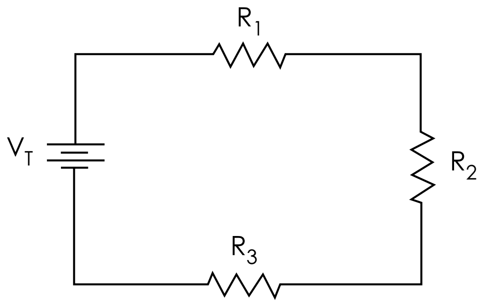
$I_{R3} = 0.833$ A

$E_{R1} = 1.66$ V

$E_{R2} = 1.66$ V

$E_{R3} = 6.66$ V

Circuit 2



Given:
E_T = 20 MV
R_1 = 40 kΩ
R_2 = 30 kΩ
R_3 = 2 MΩ

Answer:

Formula:

$R_T = R_1 + R_2 + R_3 \ldots + R_N$

$R_T = 40{,}000 + 30{,}000 + 2{,}000{,}000 = 2{,}070{,}000$

Formula:

$$I = \frac{E_T}{R_T}$$

$$I = \frac{20{,}000{,}00}{2{,}070{,}000}$$

$I_T = 9.66$

Formula:

$E = I \times R$

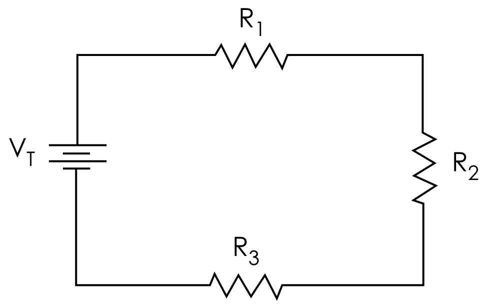
$E_{RI} = 9.66 \times 40{,}000$ $E_{R1} = 386{,}400$

$E_{R2} = 9.66 \times 30{,}000$ $E_{R2} = 289{,}800$

$E_{R3} = 9.66 \times 2{,}000{,}000$ $E_{R3} = 19{,}320{,}000$

R_T = 2,070,000 Ω
I_T = 9.66 A
I_{R1} = 9.66 A
I_{R2} = 9.66 A
I_{R3} = 9.66 A
E_{R1} = 386.4 kV
E_{R2} = 289.7 kV
E_{R3} = 19.320 MV

Circuit 3



Given:
$E_T = 2$ V
$R_1 = 10$ kΩ
$R_2 = 550$ Ω
$R_3 = 100$ Ω

Answer:

Formula:
$R_T = R_1 + R_2 + R_3 \ldots + R_N$
$R_T = 10{,}000 + 550 + 100 = 10{,}650$

Formula:

$$I = \frac{E_T}{R_T}$$

$$I = \frac{2}{10{,}650}$$

$$I_T = 0.000{,}188$$

Formula:
$E = I \times R$

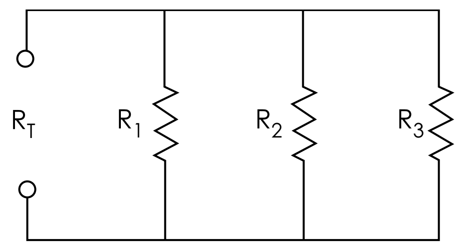
$E_{RI} = 0.000188 \times 10{,}000$ $E_{R1} = 1.88$
$E_{R2} = 0.000188 \times 550$ $E_{R2} = 0.1034$
$E_{R3} = 0.000188 \times 100$ $E_{R3} = 0.0188$

$R_T = 10{,}650$ Ω
$I_T = 0.188$ mA
$I_{R1} = 0.188$ mA
$I_{R2} = 0.188$ mA
$I_{R3} = 0.188$ mA
$E_{R1} = 1.88$ V
$E_{R2} = 10.3$ mV
$E_{R3} = 18.8$ mV

Learning Activity 4.5: Resistance Parallel Circuits

Solve for resistance in the parallel circuits below. Show all your work.

Circuit 1



Given:
R_1 = 2.7 kΩ
R_2 = 910 Ω
R_3 = 600 kΩ

Answer:

R_T = 684.93 Ω

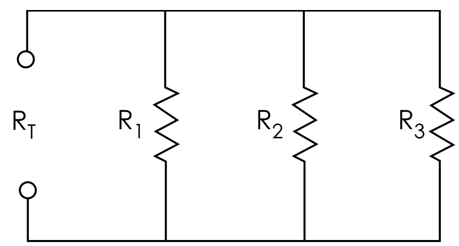
$$R_T = \frac{1}{\frac{1}{2{,}700\ \Omega} + \frac{1}{910\ \Omega} + \frac{1}{600{,}000\ \Omega}}$$

$$R_T = \frac{1}{0.000370 + 0.00109 + 0.00000166}$$

$$R_T = \frac{1}{0.00146}$$

$$R_T = 684.93 \text{ ohms}$$

Circuit 2



Given:

R_1 = 3 MΩ

R_2 = 3 MΩ

R_3 = 3 MΩ

Answer:

$R_T = 1\ M\Omega$

$$R_T = \frac{R}{N}$$

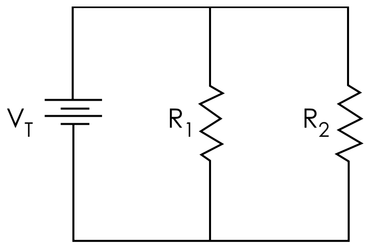
$$R_T = \frac{0.003}{3}$$

$$R_T = 0.001\ \Omega \text{ or } 1\ M\Omega$$

Learning Activity 4.6: Parallel Circuits

Solve for all unknowns in the parallel circuit below. Show all your work.

Circuit 1



Given:
E_T = 100 V
R_1 = 50 Ω
R_2 = 200 Ω

Answer:

Formula: To find R_T

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$R_T = \frac{50 \times 200}{50 + 200}$$

$$R_T = \frac{10,000}{250}$$

$$R_T = 40\ \Omega$$

R_T = 40 W
I_T = 2.5 A
E_{R1} = 100 V
E_{R2} = 100 V
I_{R1} = 2 A
I_{R2} = 5 A

Formula: To find I_T

$$I_T = \frac{E_T}{R_T}$$

$$I_T = \frac{100}{40}$$

$$I_T = 2.5\ \text{A}$$

Formula: To find I_{R1}

$$I_{R1} = \frac{E_{R1}}{R_1}$$

$$I_{R1} = \frac{100}{50}$$

$$I_{R1} = 2\ \text{A}$$

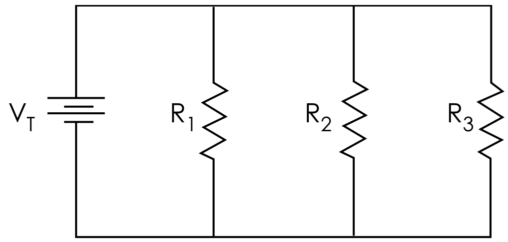
Formula: To find I_{R2}

$$I_{R2} = \frac{E_{R2}}{R_2}$$

$$I_{R2} = \frac{100}{200}$$

$$I_{R2} = 0.6\ \text{A}$$

Circuit 2



Given:
E_T = 210 V
R_1 = 420 kΩ
R_2 = 60 Ω
R_3 = 25 kΩ

Answer:

R_T = 59.85 W
I_T = 3.51 A
E_{R1} = 210 V
E_{R2} = 210 V
E_{R3} = 210 V
I_{R1} = 0.5 mA
I_{R2} = 3.5 A
I_{R3} = 8.4 mA

Formula: To find R_T

$$R_T = \frac{1}{\frac{1}{420,000\ \Omega} + \frac{1}{60\ \Omega} + \frac{1}{250\ \Omega}}$$

$$R_T = \frac{1}{0.00000238 + 0.0167 + 0.00004}$$

$$R_T = \frac{1}{0.0167423}$$

$$R_T = 59.72$$

Formula: To find I_T

$$I_T = \frac{E_T}{R_T}$$

$$I_T = \frac{210}{59.72}$$

$$I_T = 3.51\text{ A}$$

Formula: To find I_{R1}

$$I_{R1} = \frac{E_{R1}}{R_1}$$

$$I_{R1} = \frac{210}{420,000}$$

$$I_{R1} = 0.0005\text{ A or }0.5\text{ mA}$$

Formula: To find I_{R2}

$$I_{R2} = \frac{E_{R2}}{R_2}$$

$$I_{R2} = \frac{210}{60}$$

$$I_{R2} = 3.5\text{ A}$$

Formula: To find I_{R3}

$$I_{R3} = \frac{E_{R3}}{R_3}$$

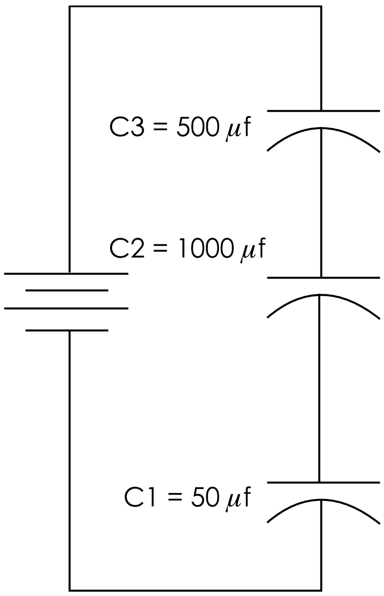
$$I_{R3} = \frac{210}{25,000}$$

$$I_{R3} = 0.0084\text{ A or }8.4\text{ mA}$$

Learning Activity 4.7: Parallel Circuits

Solve for the unknown capacitance total value. Show your work below each question.

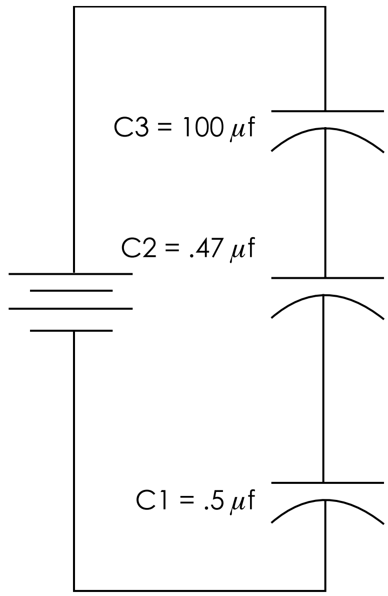
Capacitor 1



Answer:

43.48 μF

Capacitor 2



Answer:

24 μF

Module 4 Summary

Congratulations! You have finished the fourth module in the course..

Submitting Your Assignments

It is now time for you to submit your assignments from Module 4 to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Make sure you have completed all parts of your Module 4 assignments and organize your material in the following order:

- ❑ Module 4 Cover Sheet (found at the end of the course Introduction)
- ❑ Assignment 4.1: Resistance Values in Series Circuits
- ❑ Assignment 4.2: Series Circuits
- ❑ Assignment 4.3: Resistance in Parallel Circuits
- ❑ Assignment 4.4: Parallel Circuits
- ❑ Assignment 4.5: Capacitors in Series

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Grade 10 Electricity/ Electronics Technology (20G)

Module 4
Ohm's Law and Circuit Fundamentals

Learning Activity Answer Keys

MODULE 4:
OHM'S LAW AND CIRCUIT FUNDAMENTALS

Learning Activity 4.1: Ohm's Law

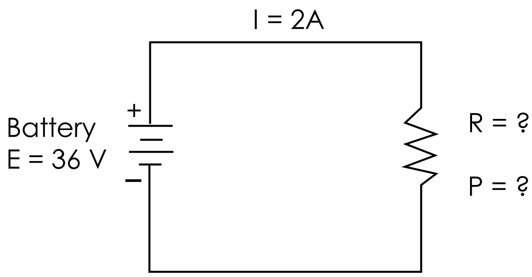
Fill in the missing values in the table below.

Answers:

E (volts)	I (amps)	R (ohms)
70 V	7 A	10 Ω
200 V	4 A	50 Ω
1000 V	20 A	50 Ω
400,000 V	40 A	10,000 Ω
10,000 V	1 A	10,000 Ω
900 V	4.5 A	200 Ω
7,260 V	22 A	330 Ω
600 V	3 A	200 Ω
290 V	3.625 A	80 Ω

Learning Activity 4.2: Watt's Law

To summarize what you've learned in this lesson, analyze the following circuit and determine all that you can from the information given.



You are given the battery voltage (10 volts) and the circuit current (2 amps). You don't know the resistor's resistance in ohms or the power dissipated by it in watts.

Write out the two formulas used and solve for resistance and power.

Answer:

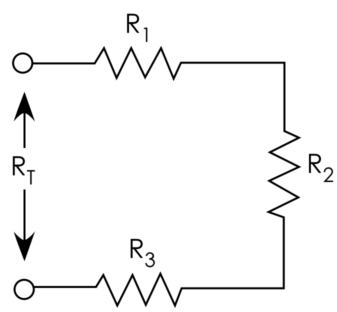
$$R = \frac{E}{I}$$

$$P = IE$$

Learning Activity 4.3: Resistance Values in Series Circuits

Calculate the unknown resistance total in the series circuits below.

Circuit 1



Given:

$R_1 = 30\ \Omega$

$R_2 = 30\ \Omega$

$R_3 = 40\ \Omega$

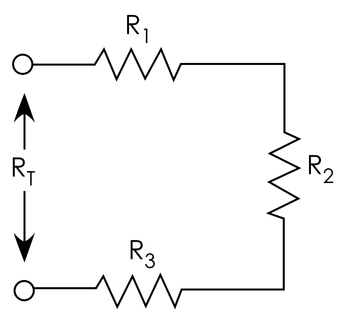
Answer:

$R_T = R1 + R_2 + R_3 + \ldots + R_N$

$R_T = 30 + 30 + 40$

$R_T = 100\ \Omega$

Circuit 2



Given:

$R_1 = 100\ \Omega$

$R_2 = 5000\ \Omega$ or $5\ K\ \Omega$

$R_3 = 1{,}000{,}000\ \Omega$ or $1\ M\ \Omega$

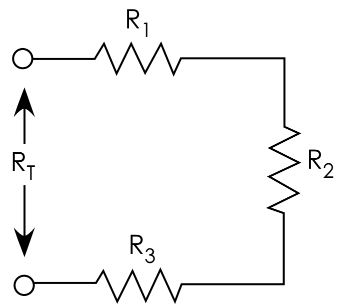
Answer:

$R_T = R1 + R_2 + R_3 + \ldots + R_N$

$R_T = 100 + 5{,}000 + 1{,}000{,}000$

$R_T = 1{,}005{,}100\ \Omega$

Circuit 3



Given:

R_1 = 1 MΩ or 1,000,000 Ω

R_2 = 5 MΩ or 5,000,000 Ω

R_3 = 100 MΩ or 100,000,000 Ω

Answer:

$R_T = R1 + R_2 + R_3 + \ldots + R_N$

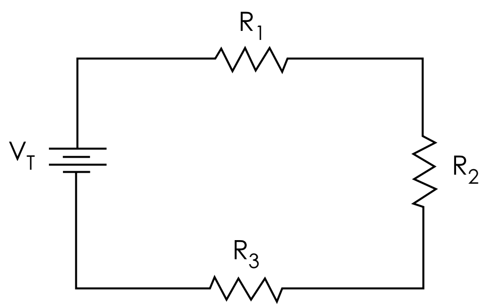
$R_T = 1{,}000{,}000 + 5{,}000{,}000 + 100{,}000{,}000$

$R_T = 106{,}000{,}000\ \Omega$

Learning Activity 4.4: Series Circuits

Solve for all unknowns in the series circuits below. Show all your work.

Circuit 1



Given:

$E_T = 10$ V

$R_1 = 2\ \Omega$

$R_2 = 2\ \Omega$

$R_3 = 8\ \Omega$

Answer:

Formula:

$R_T = R_1 + R_2 + R_3 \ldots + R_N$

$R_T = 2 + 2 + 8 = 12$

Formula:

$$I = \frac{E_T}{R_T}$$

$$I = \frac{10}{12}$$

$I_T = 0.833$

Formula:

$E = I \times R$

$E_{RI} = 0.833 \times 2$	$E_{R1} = 1.66$
$E_{R2} = 0.833 \times 2$	$E_{R2} = 1.66$
$E_{R3} = 0.833 \times 8$	$E_{R3} = 6.66$

$R_T = 12\ \Omega$

$I_T = 0.833$ A

$I_{R1} = 0.833$ A

$I_{R2} = 0.833$ A

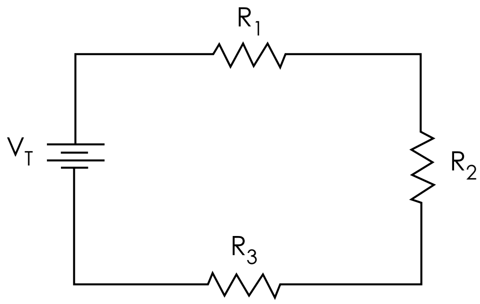
$I_{R3} = 0.833$ A

$E_{R1} = 1.66$ V

$E_{R2} = 1.66$ V

$E_{R3} = 6.66$ V

Circuit 2



Given:

E_T = 20 MV

R_1 = 40 kΩ

R_2 = 30 kΩ

R_3 = 2 MΩ

Answer:

Formula:

$R_T = R_1 + R_2 + R_3 \ldots + R_N$

$R_T = 40{,}000 + 30{,}000 + 2{,}000{,}000 = 2{,}070{,}000$

Formula:

$$I = \frac{E_T}{R_T}$$

$$I = \frac{20{,}000{,}00}{2{,}070{,}000}$$

$$I_T = 9.66$$

Formula:

$E = I \times R$

$E_{RI} = 9.66 \times 40{,}000$	$E_{R1} = 386{,}400$
$E_{R2} = 9.66 \times 30{,}000$	$E_{R2} = 289{,}800$
$E_{R3} = 9.66 \times 2{,}000{,}000$	$E_{R3} = 19{,}320{,}000$

R_T = 2,070,000 Ω

I_T = 9.66 A

I_{R1} = 9.66 A

I_{R2} = 9.66 A

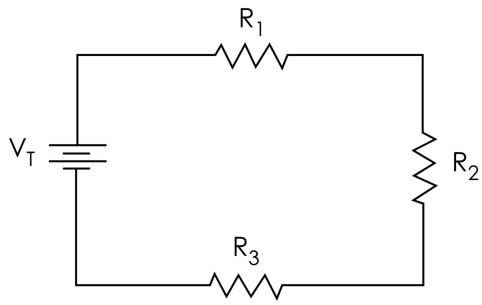
I_{R3} = 9.66 A

E_{R1} = 386.4 kV

E_{R2} = 289.7 kV

E_{R3} = 19.320 MV

Circuit 3



Given:

$E_T = 2$ V

$R_1 = 10$ kΩ

$R_2 = 550$ Ω

$R_3 = 100$ Ω

Answer:

Formula:

$R_T = R_1 + R_2 + R_3 \ldots + R_N$

$R_T = 10{,}000 + 550 + 100 = 10{,}650$

Formula:

$$I = \frac{E_T}{R_T}$$

$$I = \frac{2}{10{,}650}$$

$$I_T = 0.000{,}188$$

Formula:

$E = I \times R$

$E_{RI} = 0.000188 \times 10{,}000$	$E_{R1} = 1.88$
$E_{R2} = 0.000188 \times 550$	$E_{R2} = 0.1034$
$E_{R3} = 0.000188 \times 100$	$E_{R3} = 0.0188$

$R_T = 10{,}650$ Ω

$I_T = 0.188$ mA

$I_{R1} = 0.188$ mA

$I_{R2} = 0.188$ mA

$I_{R3} = 0.188$ mA

$E_{R1} = 1.88$ V

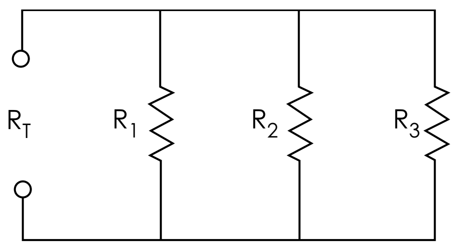
$E_{R2} = 10.3$ mV

$E_{R3} = 18.8$ mV

Learning Activity 4.5: Resistance Parallel Circuits

Solve for resistance in the parallel circuits below. Show all your work.

Circuit 1



Given:

R_1 = 2.7 kΩ

R_2 = 910 Ω

R_3 = 600 kΩ

Answer:

R_T = 684.93 Ω

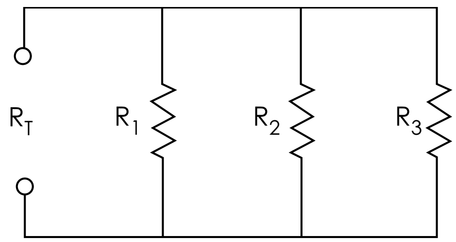
$$R_T = \frac{1}{\frac{1}{2{,}700\ \Omega} + \frac{1}{910\ \Omega} + \frac{1}{600{,}000\ \Omega}}$$

$$R_T = \frac{1}{0.000370 + 0.00109 + 0.00000166}$$

$$R_T = \frac{1}{0.00146}$$

$$R_T = 684.93 \text{ ohms}$$

Circuit 2



Given:
R_1 = 3 MΩ
R_2 = 3 MΩ
R_3 = 3 MΩ

Answer:

$R_T = 1\ \text{M}\Omega$

$$R_T = \frac{R}{N}$$

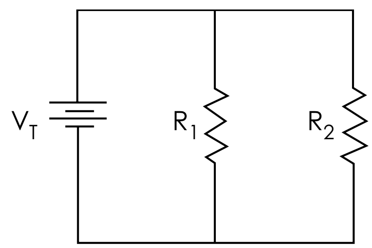
$$R_T = \frac{0.003}{3}$$

$$R_T = 0.001\ \Omega \text{ or } 1\ \text{M}\Omega$$

Learning Activity 4.6: Parallel Circuits

Solve for all unknowns in the parallel circuit below. Show all your work.

Circuit 1



Given:
E_T = 100 V
R_1 = 50 Ω
R_2 = 200 Ω

Answer:

R_T = 40 W
I_T = 2.5 A
E_{R1} = 100 V
E_{R2} = 100 V
I_{R1} = 2 A
I_{R2} = 5 A

Formula: To find R_T

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$R_T = \frac{50 \times 200}{50 + 200}$$

$$R_T = \frac{10,000}{250}$$

$$R_T = 40\ \Omega$$

Formula: To find I_T

$$I_T = \frac{E_T}{R_T}$$

$$I_T = \frac{100}{40}$$

$$I_T = 2.5\ \text{A}$$

Formula: To find I_{R1}

$$I_{R1} = \frac{E_{R1}}{R_1}$$

$$I_{R1} = \frac{100}{50}$$

$$I_{R1} = 2\ \text{A}$$

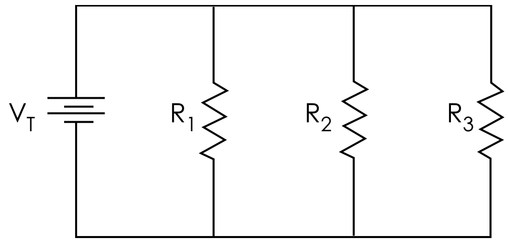
Formula: To find I_{R2}

$$I_{R2} = \frac{E_{R2}}{R_2}$$

$$I_{R2} = \frac{100}{200}$$

$$I_{R2} = 0.6\ \text{A}$$

Circuit 2



Given:
E_T = 210 V
R_1 = 420 kΩ
R_2 = 60 Ω
R_3 = 25 kΩ

Answer:

Formula: To find R_T

$$R_T = \frac{1}{\frac{1}{420,000\ \Omega} + \frac{1}{60\ \Omega} + \frac{1}{250\ \Omega}}$$

$$R_T = \frac{1}{0.00000238 + 0.0167 + 0.00004}$$

$$R_T = \frac{1}{0.0167423}$$

$$R_T = 59.72$$

R_T = 59.85 W
I_T = 3.51 A
E_{R1} = 210 V
E_{R2} = 210 V
E_{R3} = 210 V
I_{R1} = 0.5 mA
I_{R2} = 3.5 A
I_{R3} = 8.4 mA

Formula: To find I_T

$$I_T = \frac{E_T}{R_T}$$

$$I_T = \frac{210}{59.72}$$

$$I_T = 3.51\ \text{A}$$

Formula: To find I_{R1}

$$I_{R1} = \frac{E_{R1}}{R_1}$$

$$I_{R1} = \frac{210}{420,000}$$

$$I_{R1} = 0.0005\ \text{A or } 0.5\ \text{mA}$$

Formula: To find I_{R2}

$$I_{R2} = \frac{E_{R2}}{R_2}$$

$$I_{R2} = \frac{210}{60}$$

$$I_{R2} = 3.5\ \text{A}$$

Formula: To find I_{R3}

$$I_{R3} = \frac{E_{R3}}{R_3}$$

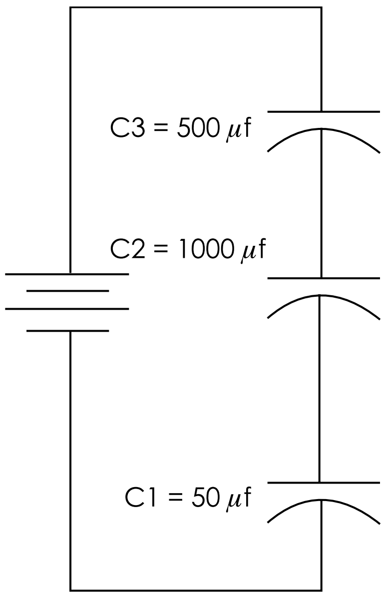
$$I_{R3} = \frac{210}{25,000}$$

$$I_{R3} = 0.0084\ \text{A or } 8.4\ \text{mA}$$

Learning Activity 4.7: Parallel Circuits

Solve for the unknown capacitance total value. Show your work below each question.

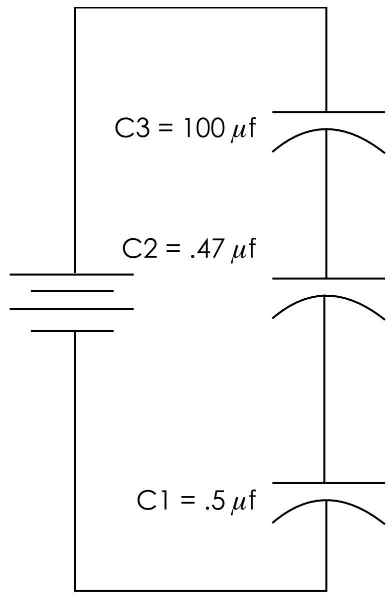
Capacitor 1



Answer:

43.48 μF

Capacitor 2



Answer:

24 μF

Grade 10 Electricity/ Electronics Technology (20G)

Module 5
Magnetism and Induction

- Introduction
- Lesson 1: Magnetism
- Lesson 2: Electromagnetic Induction
- Lesson 3: Transformers
- Lesson 4: Project 2: Brain Meter
- Lesson 5: Final Examination Review
- Module 5 Summary

Module 5:
Magnetism and Induction

Module Focus

After working through this module, you should

❑ have an in-depth understanding of magnetism.

❑ understand the law of magnetic attraction and repulsion.

❑ understand the difference between permanent and electromagnets.

❑ understand magnetic induction.

❑ understand electromagnetic induction.

❑ understand counter-EMF.

❑ learn transformer construction.

❑ understand how induction works in a transformer.

❑ understand how a step-up and step-down transformer works.

❑ understand turn ratios in a transformer.

❑ complete an experiment demonstrating induction.

❑ understand how short circuits occur.

❑ complete Project 2.

Introduction to Module 5

Magnetism is an interesting aspect of electricity that describes the forces of an electric field. In this module, you will also learn about the phenomenon of electromagnetic induction that has a great many important applications related to the operating principles of transformers, inductors, and many types of electrical motors and generators. This is your last module in this course. At the end of this module, you will complete your second project.

Power Words

ferromagnetism
solenoid
transformer
magnetosphere

reluctance
primary
hysteresis
permeability

magnetic induction
secondary
soft iron

Module 5 Assignments

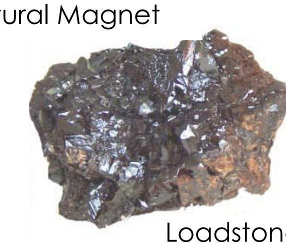
When you have completed the assignments for Module 5, submit your completed assignments to the Distance Learning Unit either by mail or electronically through the learning management system (LMS). The staff will forward your work to your tutor/marker.

Lesson	Assignment Number	Assignment Title
1	Assignment 5.1	Magnetism
4	Project 2	Brain Meter

Lesson 1: Magnetism

Introduction

Natural Magnet



Loadstone

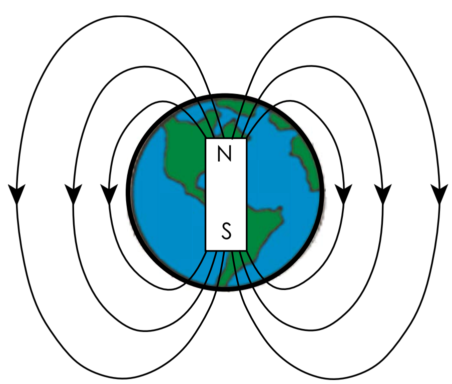
The ancient Greeks near the city of Magnesia knew about magnetism. Also, around the year 1000 C.E., the Chinese found that a steel needle stroked with a "lodestone" became "magnetic," and such a needle, when freely suspended, pointed north-south.

The magnetic compass soon spread to Europe. Columbus used it when he crossed the Atlantic Ocean, noting not only that the needle varied slightly from exact geographical north (as indicated by the stars) but also that it changed somewhat during the voyage. Around 1600 C.E., William Gilbert, physician to Queen Elizabeth I of England, proposed an explanation—Earth itself was a giant magnet, with its magnetic poles some distance away from its geographic ones (i.e., near the points defining the axis around which Earth turns).

The Magnetosphere

On Earth, one needs a sensitive needle to detect magnetic forces. A region exists around Earth known as the **magnetosphere**. This region surrounds Earth and contains a mix of electrically charged particles and electric and magnetic phenomena. We call it Earth's **magnetosphere**.

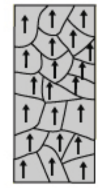
Only a few of the phenomena observed on the ground come from the magnetosphere: fluctuations of the magnetic field known as magnetic storms, and the polar northern lights. This phenomenon appears as colourful lights in the night skies in Canada.



What Is Magnetism?

Iron, nickel, and cobalt exhibit a unique magnetic behaviour that is called **ferromagnetism**. Magnetism is produced as a result of electrons spinning on their own axes while rotating around the nuclei of atoms.

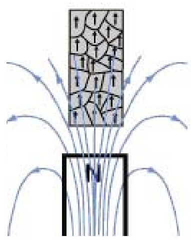
No magnetic material where domains are not aligned.



Magnetic material where domains are aligned.

There are certain areas called domains. This is when atoms align. When this happens, most of the electrons spin in the same direction. Magnetic poles are formed at the ends of the magnet. The lines of magnetic field from a bar magnet form a closed loop. The magnetic field direction is outward from the north pole and in towards the south pole of the magnet. Permanent magnets can be made from ferromagnetic materials.

Aligned domains result in magnetism.



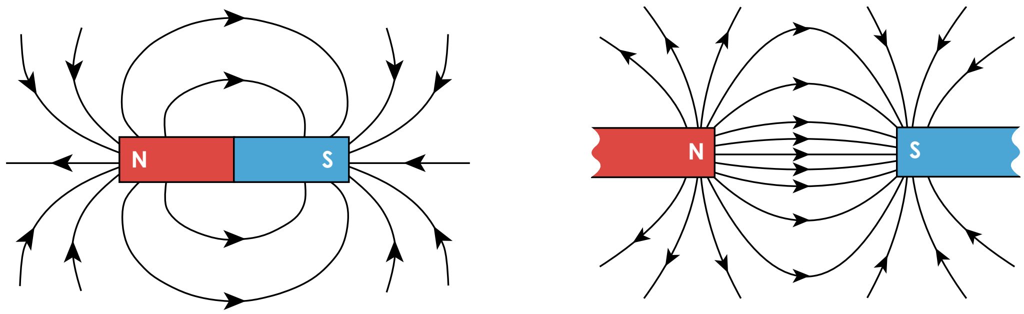
Ferromagnets tend to stay magnetized to some extent after being subjected to an external magnetic field. This tendency to remember their magnetic history is called hysteresis.

The law of magnetic attraction and repulsion states that unlike magnetic poles attract each other and like magnetic poles repel each other. The energy of a magnet is in the form of a magnetic field. This field surrounds the magnet. The magnetic field is made of invisible lines of force or flux. The lines of flux run from the north pole to the south and form a loop, and the lines never cross each other.

Notice how the magnetic field lines come out of N and go into S, and the field lines are more concentrated at the poles. The magnetic field is strongest at the poles, where the field lines are most concentrated.

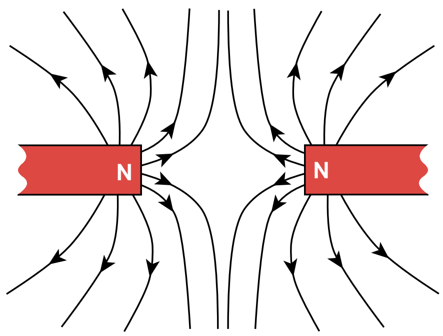
Attraction and Magnetic Fields

Looking at the field lines, you will notice that they go from the north pole of one magnet to the south pole of the other magnet.



Repulsion and Magnetic Fields

Looking at the field lines, you will notice that they do not go from one magnet to the other, and they do not cross.



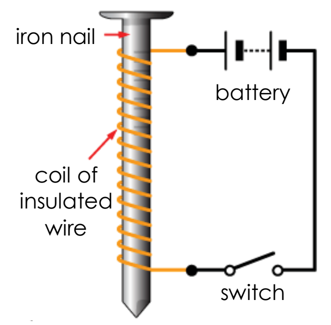
There are two sources of magnetism: permanent magnets and electromagnets.

Permanent Magnets

In order to make a magnet, an object must be brought into the magnetic field of a magnet. This process is called **magnetic induction**. If you take a nail and place it parallel to and near a magnet, the lines of force from the permanent magnet pass through the nail. This causes some of the domains in the steel of the nail to align. This magnetic induction process produces magnetic poles at the ends of the nail. The nail then becomes a magnet, and is able to attract objects made of magnetic materials.

Electromagnets

A magnetic field is produced when an electric current flows through a wire. This is the basis of the electromagnet. When current is put through the conductor that is wrapped around the nail, the nail itself becomes a fairly strong magnet.



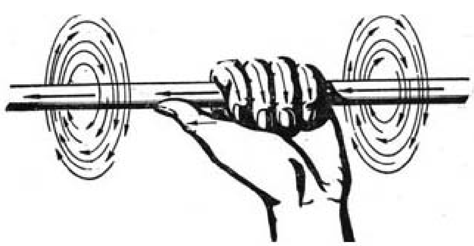
You can make an electromagnet stronger by doing the following things:

- wrapping the coil around an iron core
- adding more turns to the coil
- Increasing the current flowing through the coil

Electromagnetic Fields

Magnetic Fields Around Conductors

When a current flows through a conductor, a magnetic field surrounds the conductor. As current flow increases, so does the number of lines of force in the magnetic field.



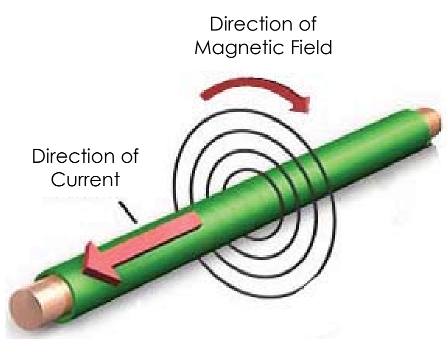
Left-Hand Rule for Conductors

1. Thumb points in direction of current flow.
2. Finger direction shows direction of magnetic field.

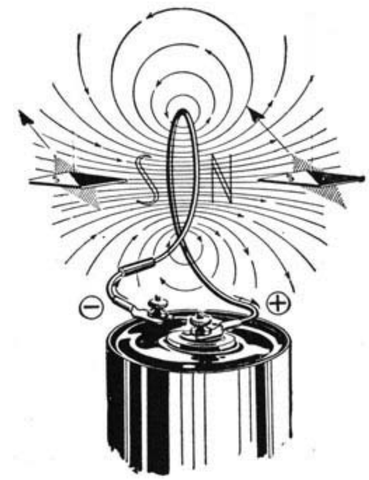
The left-hand rule helps demonstrate the relationship between conductor current and the direction of magnetic field. Grasp a wire conductor in your right hand, put your thumb on the wire with it pointing in the direction of the current flow, and wrap your four fingers around the wire. The fingers curl around the wire in the direction of the magnetic field.

Coils

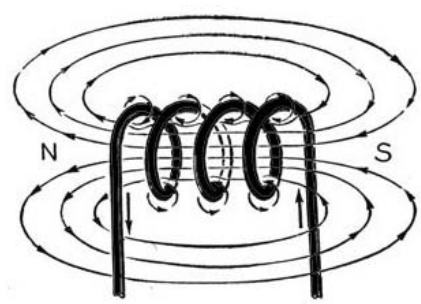
To concentrate the magnetic field produced by current flowing in a wire, the wire is wound into a coil. When you do this, the magnetic field around the wire becomes concentrated and increases the overall magnetic strength of a coil. A coil wound in this manner is referred to as a *solenoid*.



A solenoid has magnetic poles and a magnetic field with the same properties as those of a permanent magnet. If a solenoid is connected to an AC source, the magnetic field changes direction or polarity with each reversal of the direction of current, as you will see later on.



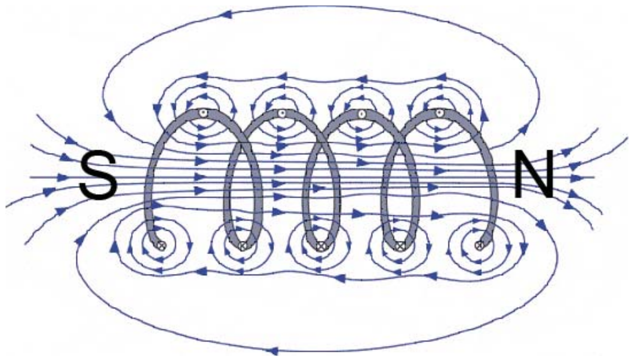
Magnetic Field Produced by a Coil



Solenoid

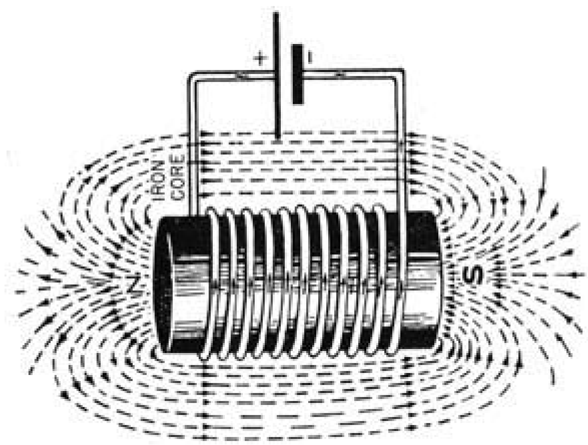
When a current-carrying conductor is formed into a loop, or several loops to form a coil, a magnetic field develops that flows through the centre of the loop. The magnetic field circling each loop of wire combines with the fields from the other loops to produce a concentrated field down the centre of the coil. A loosely wound coil is illustrated below to show the interaction of the magnetic field. The magnetic field is essentially uniform down the length of the coil when it is wound tighter.

The strength of a coil's magnetic field increases not only with increasing current but also with each loop that is added to the coil. A long, straight coil of wire is called a solenoid and can be used to generate a nearly uniform magnetic field similar to that of a bar magnet. The concentrated magnetic field inside a coil is very useful in magnetizing ferromagnetic materials.



Please be aware that the field outside the coil is weak and is not suitable for magnetizing ferromagnetic materials.

Iron Core Electromagnets



Although magnetic lines of force pass through all substances under normal conditions, some materials do not allow them to pass through as easily as others. This opposition is known as its **reluctance**.

Reluctance is a property of all material. Just as there is no perfect electric conductor, under normal conditions, there is no perfect magnetic conductor.

However, **soft iron** has a very low reluctance and is a good conductor of magnetic lines in comparison with most other materials. **Permeability** describes the ease of passage of magnetic lines of force. So a material with a high permeability has a low reluctance, and vice versa. Reluctance of soft iron is low compared to that of air. Soft iron also has a low **residual magnetism**. Magnetism remaining in the core of an electromagnet after the coil current is removed is referred to as residual magnetism. Put those two properties of soft iron together, and you have the reason for using soft iron cores in electromagnets.

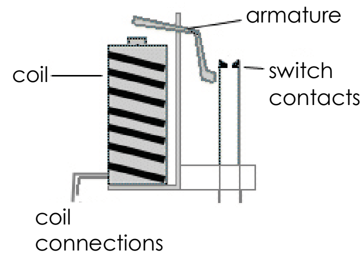
The iron core concentrates the magnetic flux into a small area inside the coil, increasing the overall magnetism. Electromagnets have an almost endless list of applications in electric motors, generators, relays, and in thousands of other electrical devices.

Relays

A relay is a magnetically operated switch that opens or closes one or more of the contacts between its terminals. The relay is a mechanical switch that is controlled by electromagnetism. When a current flows through the coil, the resulting magnetic field attracts an armature that is mechanically linked to a moving contact.

Time 1

No current in the coil; therefore, no magnetic field being generated.

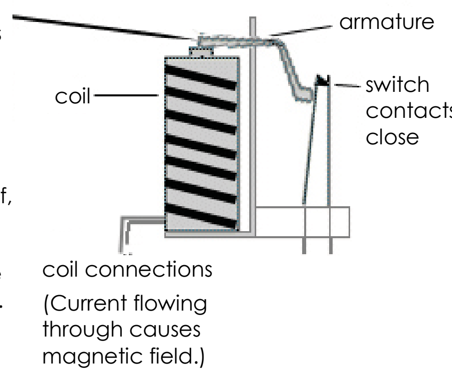


The movement either makes or breaks a connection with a fixed contact. When the current to the coil is switched off, the armature is returned to its relaxed position. Usually this is a spring, but gravity is also commonly used in industrial motor starters. Most relays are manufactured to operate quickly and act like a switch.

Time 2

a) Magnetic field in coil causes armature contact to be attracted to coil. This causes the armature to push the switch contacts together allowing current to flow through switch.

b) When current to coil shuts off, there is no more magnetic field which in turn releases the armature and opens the switch contacts once again.



It is now time for you to complete Assignment 5.1. This assignment (along with all other assignments) is worth marks and you will submit it to the Distance Learning Unit when you have completed Module 5.

Notes

Assignment 5.1

Magnetism *(27 marks)*

Please respond to the following assignment questions in the space provided. Remember that you must submit this assignment to the Distance Learning Unit for assessment at the end of this module, along with the other assignments from Module 5.

1. What is the magnetosphere? *(1 mark)*

2. What is magnetism? *(1 mark)*

3. In which direction do magnetic lines from a bar magnet travel? *(1 mark)*

4. What is hysteresis? *(1 mark)*

5. What is the law of magnetic repulsion and attraction? *(1 mark)*

(continued)

Assignment 5.1: Magnetism (continued)

6. Draw a bar magnet labelling the north and south poles. Draw the magnetic field that would surround this magnet, and indicate the direction of the magnetic flux lines. *(3 marks)*

7. Draw and label two bar magnets with their magnetic fields interacting. In this drawing, have the opposite poles face each other. *(3 marks)*

8. Draw and label two bar magnets with their magnetic fields interacting. In this drawing, have the same poles face each other. *(3 marks)*

9. What are two sources of magnetism? *(1 mark)*

____

____

(continued)

Assignment 5.1: Magnetism (continued)

10. What is magnetic induction? *(1 mark)*

    ____

    ____

11. When electric current flows through a wire, what happens around the wire? *(1 mark)*

    ____

    ____

12. How do you make an electromagnet with a nail, a wire, and a battery? *(1 mark)*

    ____

    ____

13. What are two ways to make the electromagnetic field stronger? *(1 mark)*

    ____

14. Explain the left-hand rule for conductors. *(1 mark)*

    ____

    ____

15. What is the result when a current-carrying wire is wrapped into a coil? *(1 mark)*

    ____

    ____

(continued)

Assignment 5.1: Magnetism (continued)

16. What is another name that is sometimes given to a coil of wire? *(1 mark)*

____

____

17. What is reluctance? *(1 mark)*

____

____

18. What is meant by permeability? *(1 mark)*

____

____

19. What does the iron core do in an electromagnet? *(1 mark)*

____

____

20. What is a relay? *(1 mark)*

____

____

21. Explain how a relay works. *(1 mark)*

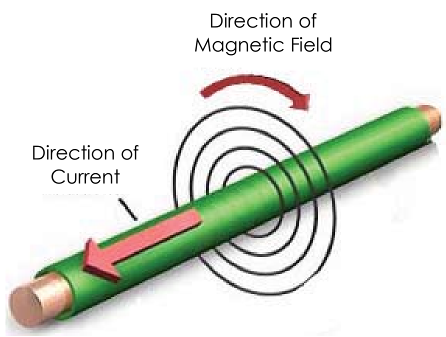
____

____

Lesson 2: Electromagnetic Induction

Introduction

Now that you know a bit more about magnetism and magnetic lines, let's take a deeper look into some of the intricacies of electromagnetism and induction.

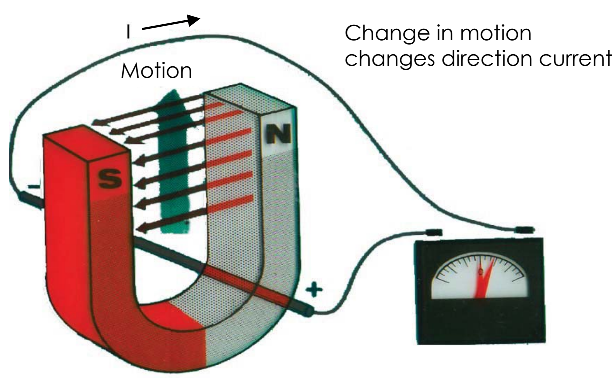


In the previous lesson, you learned that if you pass a current through a wire, you will produce a magnetic field. This involves a very important relationship that we have not discussed until now.

Electromagnetic induction is not a complicated concept. Michael Faraday, one of the principal early scientists of electricity, discovered that *if he moved a wire through a magnetic field, it produced a current in the wire*. This is electromagnetic induction. The current direction can be found using the left-hand rule, which you already know.

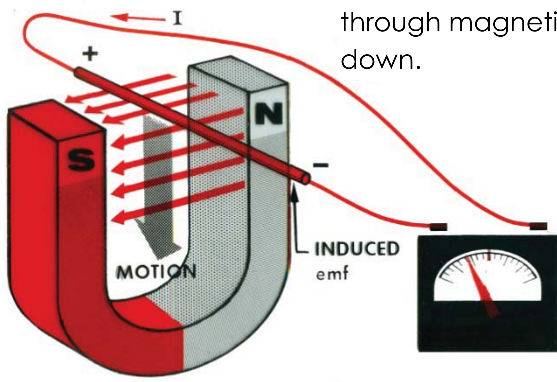
When a wire moves in a magnetic field, a force acts on the atoms in the wire. Just like a magnet affects certain metals, the same effect happens when you move a wire through a magnetic field.

The magnetic field actually has an effect on the electrons in the wire. This is called inducing an EMF. EMF stands for electromotive force, but EMF isn't really force at all. EMF is measured in volts, just like potential difference.



Note that as the wire is moved up through the magnetic field, the meter pointer deflects in one direction. As it is moved down through the magnetic field, it moves in the other direction. This illustration demonstrates how the current moves in different directions, depending on which direction the wire cuts through the magnetic field.

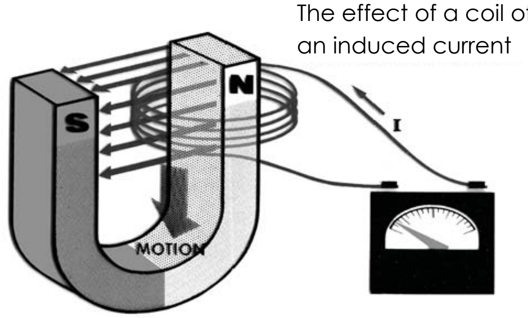
Direction of wire moving through magnetic field is down.



As wire moves through the magnetic field, electrons in the wire are forced to move causing an induced current.

If you can take and pass more of the conductor through the magnetic field, you will have a greater effect on the amount of induced EMF. A coil of wire increases the amount of EMF in the conductor.

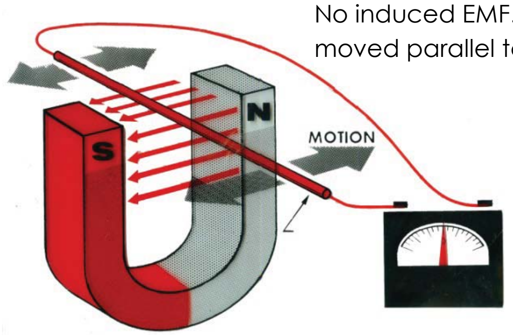
The effect of a coil of wire on an induced current



You can increase the amount of EMF induced by passing more of the conductor through the magnetic field. A coil of wire has this effect.

The magnetic field has the greatest effect on the atoms in a conductor when the wire is moved perpendicular or 90 degrees to the magnetic field.

The wire has to move through the magnetic field to have an effect. If the wire is moved in a direction that coincides with the field and does not actually pass through or cut through some of the lines, current will not be induced in the wire.



No induced EMF. Wire being moved parallel to flux lines!

Note that the direction of the movement of the conductor is relative to induced EMF. If no magnetic flux lines are being crossed, there is no induced current in the wire.

Counter-EMF

Therefore, the two basic principles of induction are the following:

1. When you have a current going through a wire, you get a magnetic field around that wire.
2. When you take a wire and pass it through a magnetic field, you induce current in the wire.

You may have noticed a paradox in what you have learned. Current induces a magnetic field. A conductor moving in a magnetic field induces current. So as a wire moves through a field, it will have induced current. This induced current that is created in the wire will actually create a magnetic field of its own. The direction of the magnetic field that is created by the induced current is opposite to the original magnetic field that created the induced current. Hence the name counter-EMF, because the induced current created a magnetic field that actually opposes or counteracts the very current that created it in the first place.

Lenz's Law

Lenz said that whenever there is an induced electromotive force (EMF) in a conductor, it is always in such a direction that the current it would produce would oppose the change that causes the induced EMF. This is Lenz's Law. This will create a current that opposes the current in the wire, creating a current conflict. Fortunately the opposing current is never strong enough to counteract the original current. The occurrence of a counter-current is called a counter-EMF.

Learning Activity 5.1

Electromagnetic Induction

Answer the following questions in your notebook.

1. Explain what Michael Faraday discovered.
2. What is the effect of the direction that you move a wire through a magnetic field?
3. Explain the effect of placing a coil of wire through a magnetic field.
4. What happens when you move a wire in the direction that coincides with the magnetic field?
5. Explain what is meant by counter-EMF.

Check your answers in the Learning Activity Answer Keys found at the end of this module.

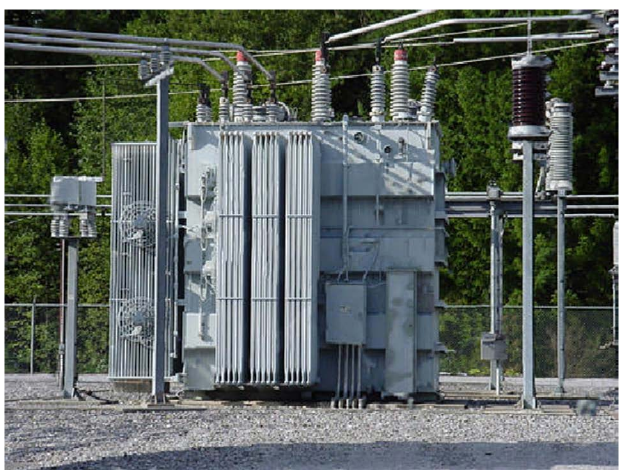
Lesson 3: Transformers

Introduction

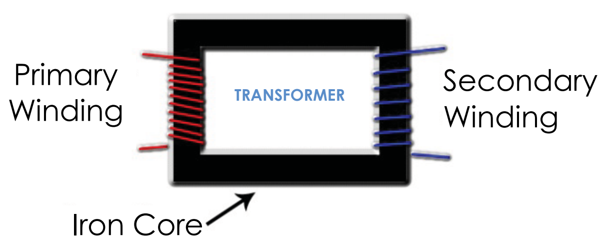
A transformer transforms electricity, increasing voltage and decreasing current. If you have ever noticed a large electrical box on a boulevard or street corner, there is probably a transformer inside.

A transformer is a device used to transfer energy from one circuit to another using electromagnetic induction.

It basically consists of two or more coils of wire wound around a piece of iron. Transformers do not have any moving parts and require very little care. They are fairly rugged devices and are designed to use various amounts of electrical current.

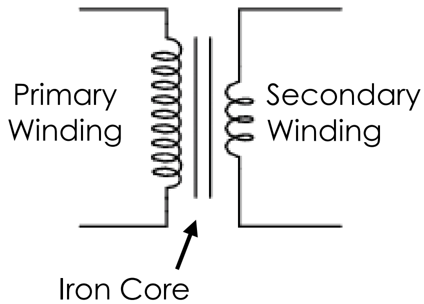


Construction of a transformer consists of the primary coil and the secondary coil. The primary coil is the input coil, which receives the energy from the source. The second winding, or secondary winding, is the output winding or coil of wire. The output load is attached to the secondary.



How It Works

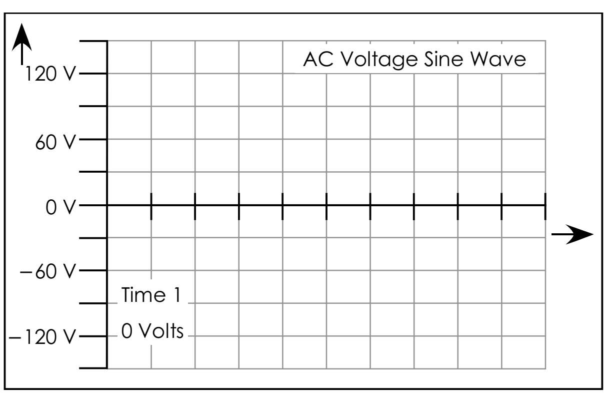
The energy in the secondary winding is caused by the changing magnetic field generated by the primary or input windings.

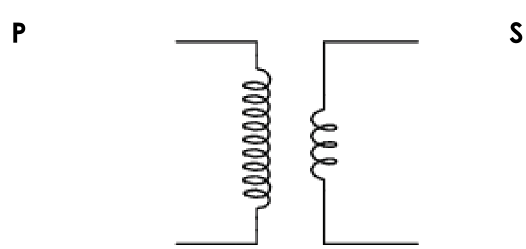


A current is put through the primary windings in the transformer. We all know that when we put current through a wire, we get a magnetic field around the wire. Also, remember that not only are we forcing current through a wire, we are forcing it through a coil of wire with a piece of iron in the middle. By wrapping the wire around a piece of iron, the magnetic field is increased many times. The iron core and wire-wrapping is an electromagnet. This will increase the amount of magnetic lines of flux generated by the primary coil.

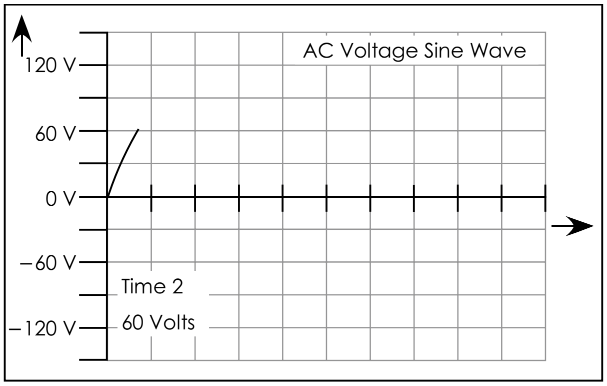
Relation to Voltage

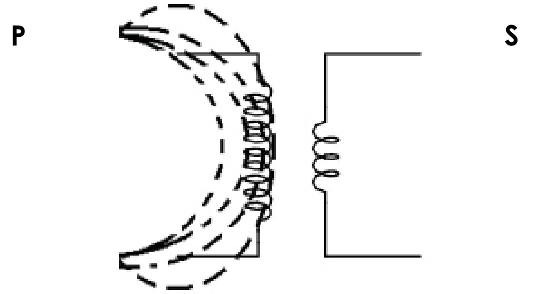
The greater the current through the wire (or the higher the voltage), the greater the strength of the electromagnet. So for alternating current that changes direction, there is a buildup as current goes from zero to the maximum of 120 V, then back down to zero. The following diagrams illustrate how the magnetic lines increase and decrease with the change in current and direction.



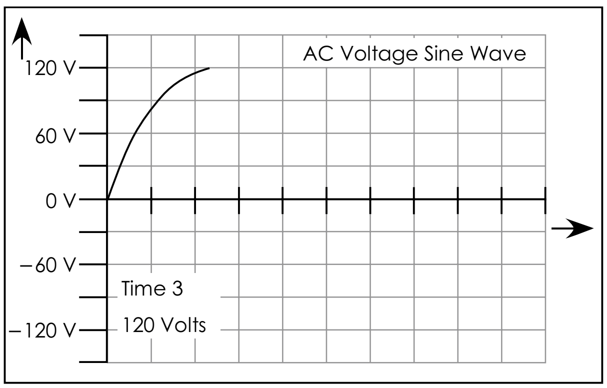


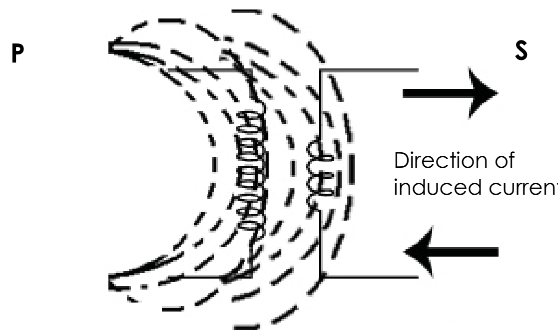
Time 1
No magnetic field as there is no current going into the primary coil.



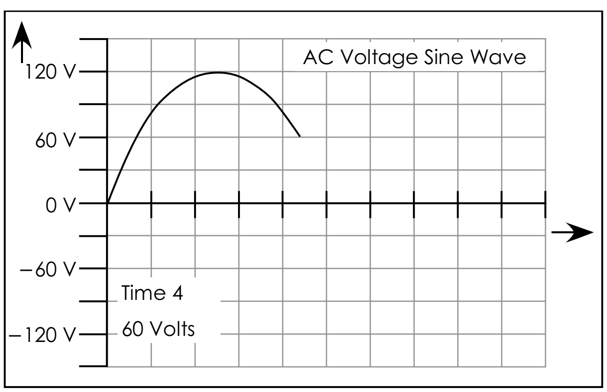


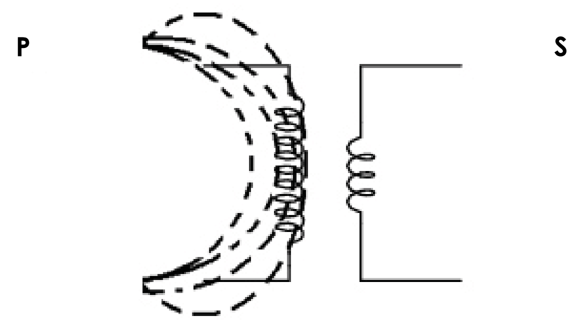
Time 2
Small magnetic field grows as current starts to flow through the primary coil.



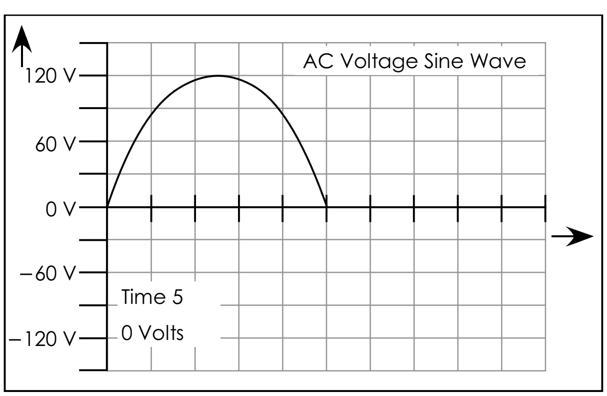


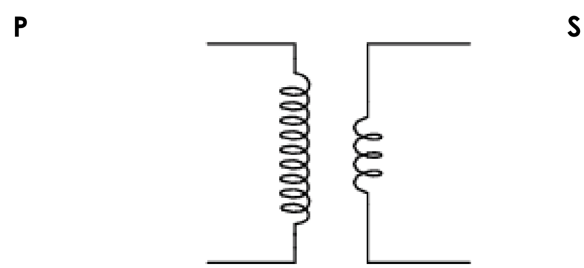
Time 3
Large magnetic field grows and cuts through the secondary coil, inducing current in the secondary.



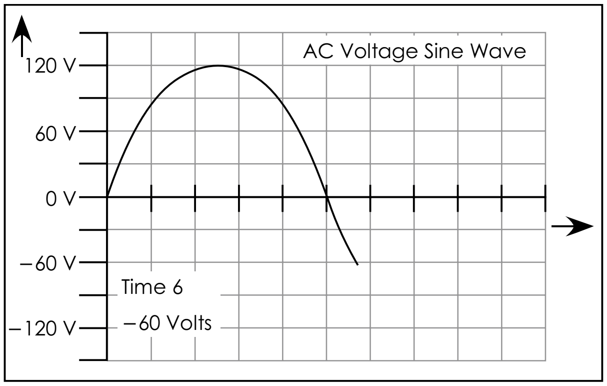


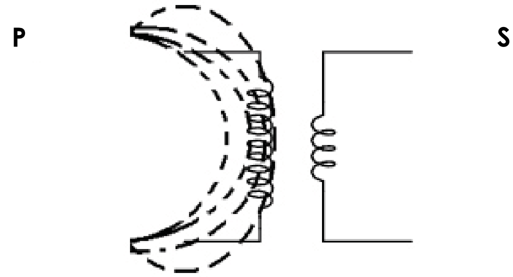
Time 4
Magnetic field starts to collapse as current is reduced.



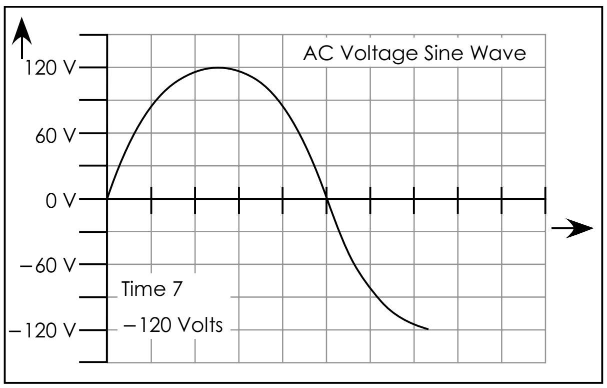


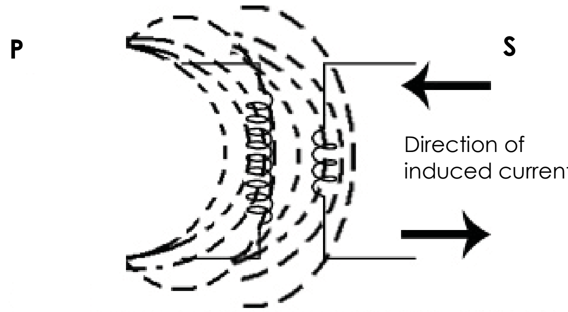
Time 5
Magnetic field is gone when current is at zero.



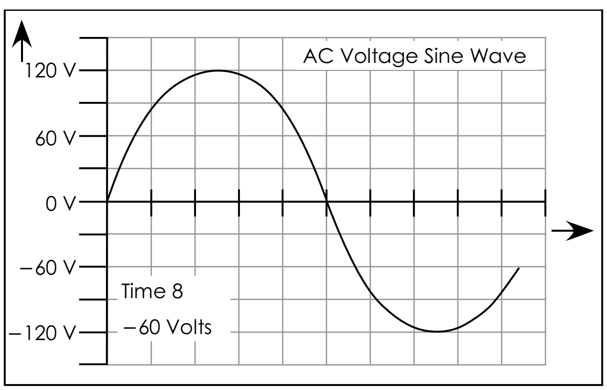


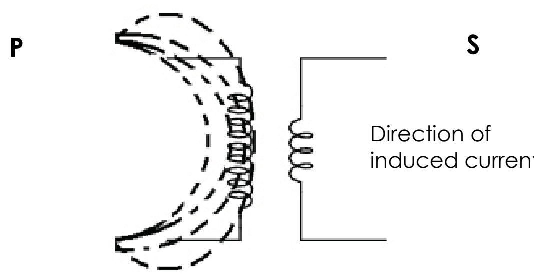
Time 6
Magnetic field grows once again, but now it is in the opposite direction, as the current into the primary has changed direction.



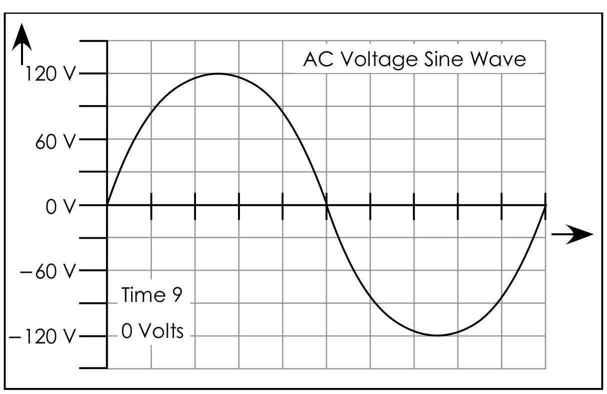


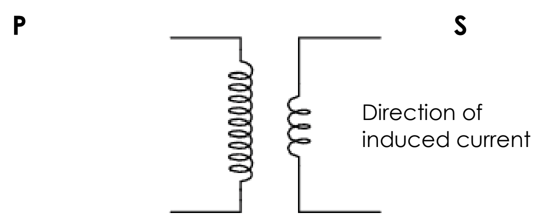
Time 7
Magnetic field at its maximum, as input current is also at its maximum. Note the direction of the magnetic field is in opposite direction to the first output.





Time 8
Magnetic field is decreasing as input current also decreases.





Time 9
Magnetic field is gone as there is no current flow in the primary.

Note: There is only a magnetic field when there is an increase or decrease in the current flow. This is an important principle to remember. In DC voltage, there is only a brief magnetic field when the current goes from zero to whatever the DC maximum value is. Let's say you are using a 9-volt source. There is a brief magnetic field around a conductor while the voltage goes from 0 to 9 volts. When there is no change in current, there is no magnetic field.

Direction of Magnetism

The direction of the magnetic field is determined by the direction of the current and the direction of the turns around the iron core. If you change the direction of the current, the north and south poles of the electromagnet will switch.

Relation to Turns of Wire

The greater the number of turns around the iron core, the greater the strength of the electromagnet, as explained earlier. The strength is approximately proportional to the number of turns. Triple the number of turns and you triple the strength of the electromagnet.

The strength of the magnetic field is proportionate to the input voltage and the number of turns of wire in the primary coil. This looks and sounds fairly complicated, but it's not.

As a step-down transformer converts high-voltage, low-current power into low-voltage, high-current power, the larger-gauge wire used in the secondary winding is necessary due to the increase in current. The primary winding, which doesn't have to conduct as much current, may be made of smaller-gauge wire.

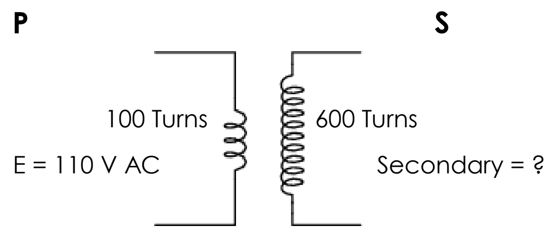
Transformer Turn Ratios

Let's start out by defining a bunch of abbreviations that are used.

- E_P = primary voltage (voltage in the primary of a transformer)
- E_S = secondary voltage (voltage in the secondary of a transformer)
- N_P = number of turns in the primary winding
- N_S = number of turns in the secondary winding

Step-Up Transformer.

For example, if the transformer's primary winding has 100 turns and 600 turns in the secondary winding, and you connect 110 volts AC to the primary, you will get 660 V AC in the secondary. This is an example of a step-up transformer.



The relationship is written as follows:

$$\frac{N_P}{N_S} = \frac{E_P}{E_S}$$

Now let's plug in the values:

$$\frac{100}{600} = \frac{110\ \text{V}}{E_S}$$

$$100E_S = 66{,}000\ \text{V}$$

$$E_S = 600\ \text{V}$$

Step-Down Transformers

Next, let's look at a step-down transformer. If you apply 1000 volts to a primary winding of 50 turns and the secondary winding has 10 turns, what do you suppose you will get? Same formula:

$$\frac{N_P}{N_S} = \frac{E_P}{E_S}$$

Plug in the values

$$\frac{50}{10} = \frac{1000\ \text{V}}{E_S}$$

$$50E_S = 10{,}000\ \text{V}$$

$$E_S = 200\ \text{V}$$

Adapters

Most people use adapters when they power devices that also use batteries. An adapter is a transformer that changes the 110 V AC house current to 12 V DC or 9 V DC or whatever other current the device is designed to use. Your MP3 player, your rechargeable batteries, and many other devices use transformers to step current and voltage up or down to deliver the required amount for use.

Conclusion

Using the principles of AC and electromagnets, you can use magnetic fields to induce current in a coil and increase or decrease the voltage output. The output voltage of a transformer is proportional to the ratio of the number of turns of the coils. Transformer applications are found everywhere in our everyday lives and are used to reduce the high voltage to a safer home voltage level.

You have almost completed the entire course. If you have made it this far, you should go back and read it all again. Then you'll be a REAL expert.

Learning Activity 5.2

Transformers

Answer the following questions in your notebook.

1. What is a transformer device, and what does it do?
2. What does a transformer's construction consist of?
3. The input on a transformer is known as the ____________ and the output is called the ____________ coil.
4. Explain how a transformer's primary coil induces current in the secondary coil.
5. What happens to the current in the secondary coil as the alternating current source switches from one direction to another?
6. What do the following abbreviations mean?

   E_P ______________________________

   E_S ______________________________

   N_P ______________________________

   N_S ______________________________
7. What does a step-up transformer do, and how does it achieve this?
8. What does a step-down transformer do, and how does it achieve this?

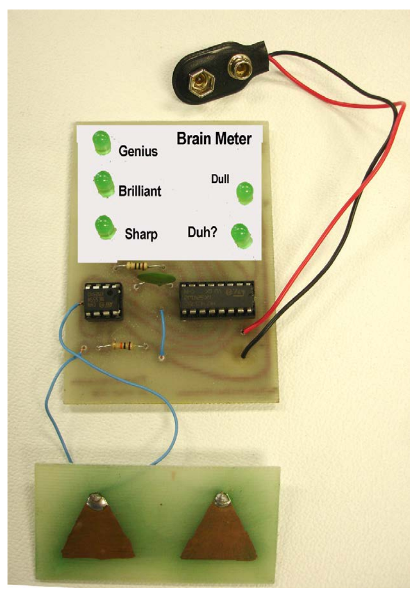
Check your answers in the Learning Activity Answer Keys found at the end of this module.

Project 2: Brain Meter *(100 marks)*

Your Brain Meter Project is out of 100 marks and is worth 15% of your final mark. This project must be mailed to the Distance Learning Unit along with Assignment 5.1 (see course Introduction for instructions). There are four components that will be evaluated to determine your final mark on the Brain Meter Project. A marking rubric for your major project is found at the end of the Module Summary. The four components that will be evaluated are:

- Confirmation: *25 marks*
- Construction: *25 marks*
- Soldering: *25 marks*
- Function: *25 marks*

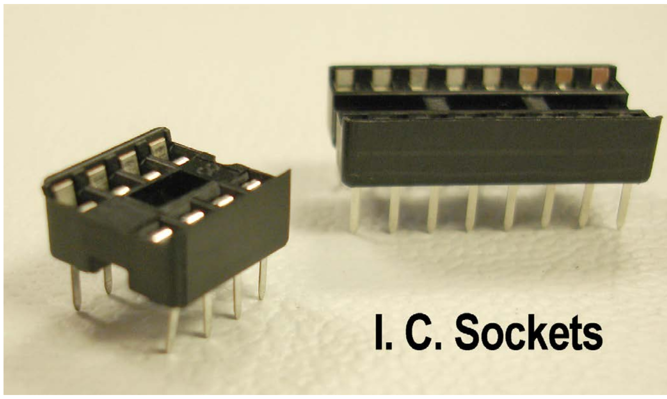
This project is a fun electronics kit that utilizes two integrated circuit chips. When the set-up is completed, a person places two fingers on the touch pads of the meter. When the person is touching the pads, the five LEDs flash randomly. When the person lets go, one of the LEDs remains lit beside a comment that describes the efficiency of his or her brain.



Use your Project 2 Kit for this project. Step-by-step instructions are not necessary, as you have already successfully completed your first kit. The procedure of soldering is the same for this kit as it was for the first. The only difference is that this project uses two IC chips. The soldering procedure for both of them will be illustrated.

A Word about ICs

Integrated circuit chips are very sensitive to heat. In order to utilize the two chips for this project, we are going to have to solder in two IC holders. These holders are great because they are not susceptible to heat when soldering. By putting in the two chip holders, we do not run the risk of burning out the chips.



There are two different types of IC location marks. One is a dot in the lower left-hand corner of the IC. The other is a small notch in the centre of the IC. Either mark is correct, and some even use both. If an IC has a dot and a notch, the notch always takes precedence.

Parts Found in Project Kit 2

C_1 0.047 μF capacitor

R_1 10 k ohm resistor

R_2 100 ohm resistor

I_{C1} 555 timer chip

I_{C2} 4017 chip (IC)

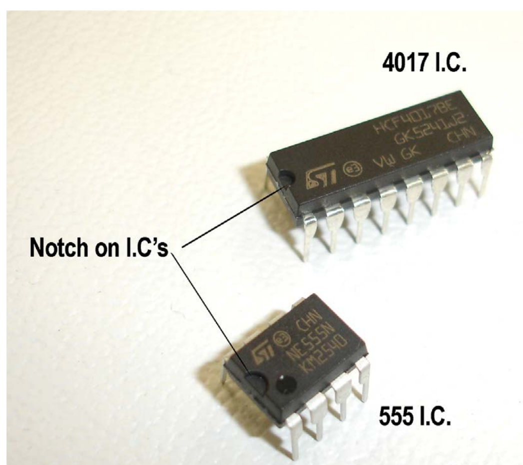
L_1–L_5 green LEDs

2 IC sockets

2 braided wires

2 touchpad circuit boards

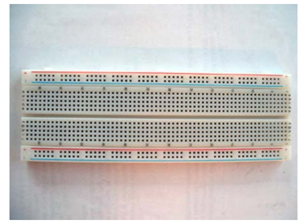
9-volt battery clip



Other Supplies Required

Place a checkmark in each box once you have identified the item.

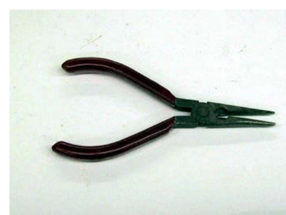
❑ Solderless circuit board



❑ 9-volt battery

❑ 9-volt battery clip

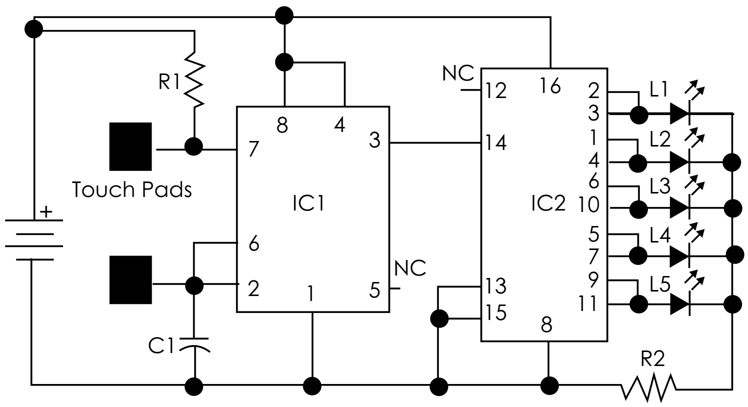
❑ Needle-nose pliers



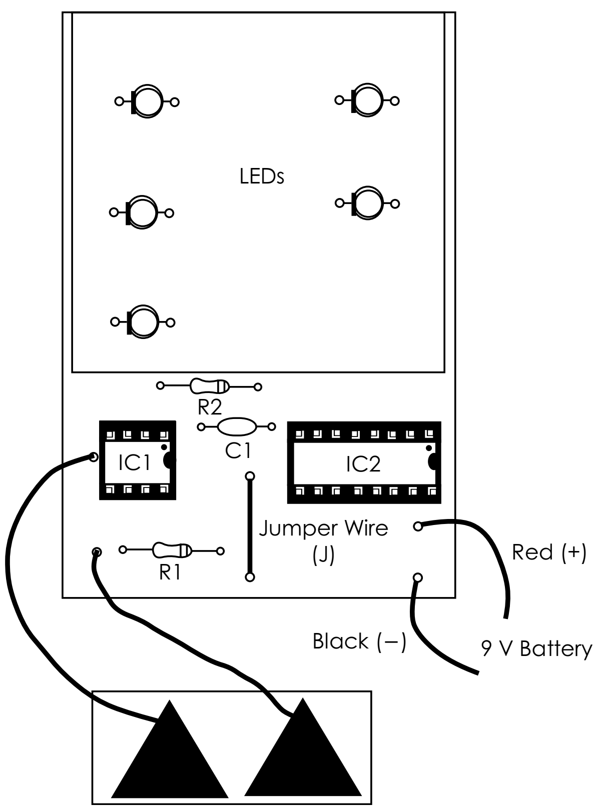
❑ Soldering iron and stand

- ❑ Safety glasses

Schematic Diagram

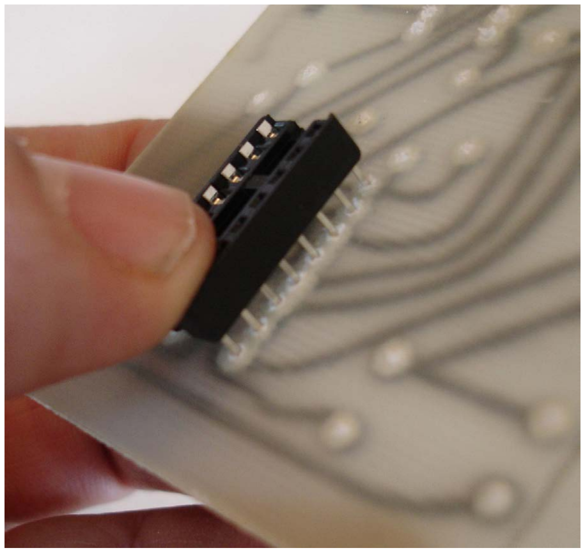


Parts Layout



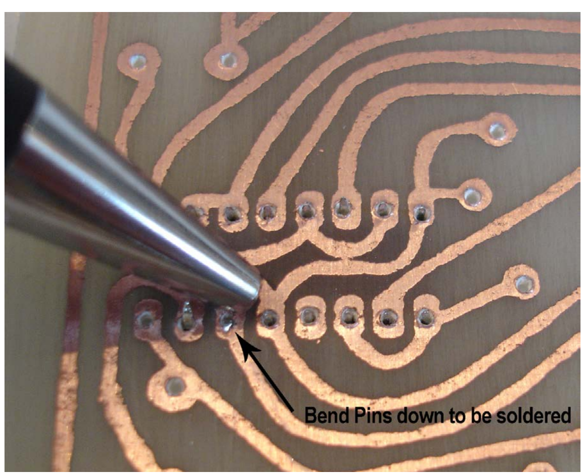
SAFETY GLASSES ON NOW!

1. You can start your project by soldering the two IC sockets into your circuit board. Because the sockets are made of plastic and metal, you do not need to heat-sink them. The procedure for soldering them is slightly different than for a regular component.

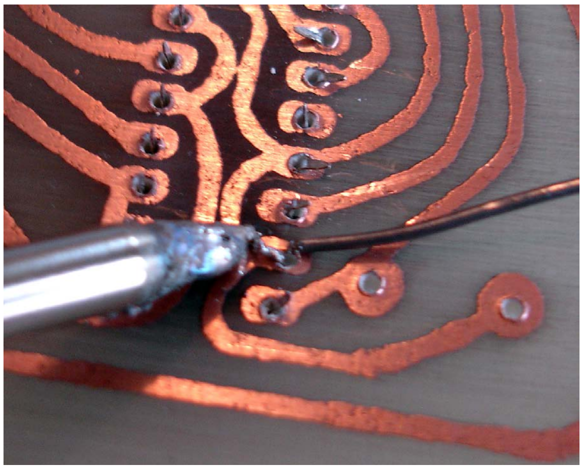
   The first thing you will have to do is to get them into where they need to be soldered. You can use a small knife tip or screwdriver to persuade the little legs on the IC holder into their holes. Once you have them lined up, put a bit of pressure with your finger on it to make sure it's tight against the plastic side of your circuit board.

2. Next, bend the small pins down onto the line that they are going to be soldered onto.

3. Place the soldering iron tip onto the pin that you want to solder, and heat the IC pin for 10 or 15 seconds.

   Remember that you don't have to heat-sink the IC socket, but you cannot apply endless heat to anything when soldering because you always run the risk of destroying the part.

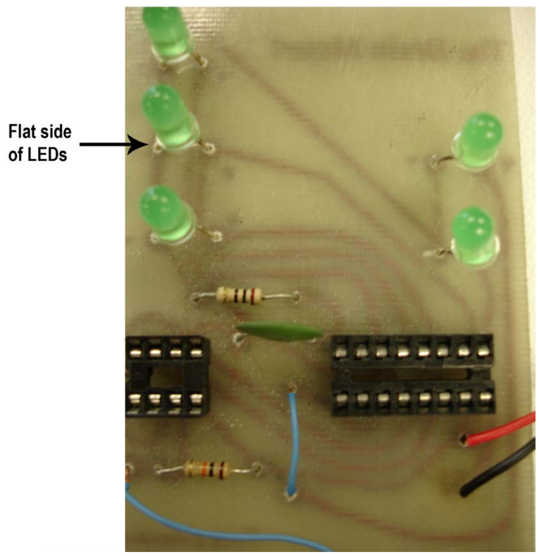
   

4. With your other hand, take your solder and touch the pin that you have been heating. While keeping the soldering iron on the pin, feed a small amount of solder until the pin is covered.

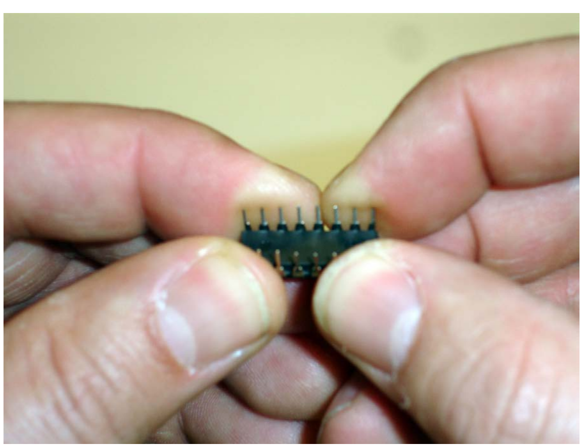
   

   Notice in the example that one whole side of the pins are soldered and the solder is not connecting between any of the pins. In order for your project to work, you must make sure that each pin's connection is separate and not connected to its neighbour. If you use too much solder and touch the next pin, run your soldering iron in between the pins and the solder should separate.

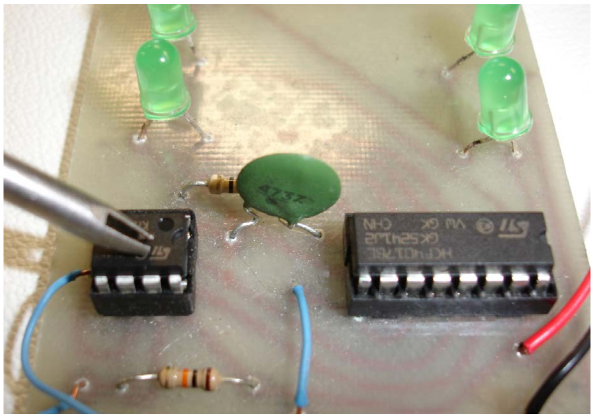
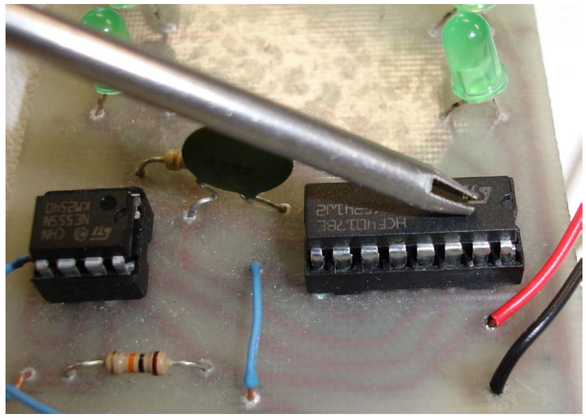
You can solder in the remaining parts, making sure to observe the polarity of the LED's battery clip. Don't forget to use your needle-nose pliers to heat-sink the components.



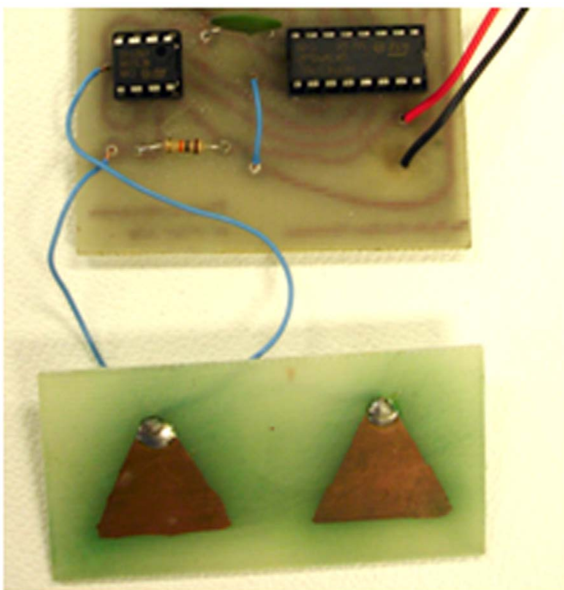
Once you have your components soldered in, it's time to put in your ICs. Because your ICs are new, you will have to bend the legs of the IC a bit so they are pointing straight down. Be careful not to poke your finger. Apply light pressure evenly to bend the legs ever so slightly.



Notice the direction of the "notches" on both of the chips in the pictures below. If you put the chips in the wrong way and connect the battery, there is a good chance that the chips will not work.

Next, solder on the two touchpads on the second circuit board with the small pieces of braided wire. It doesn't matter which wire goes to which touch pad.



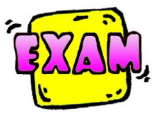
Before you connect the battery, check all your components and all your soldering work to make sure you don't have a bad solder connection, especially on your ICs.

Connect the battery and place your fingers on the pads. The LEDs should flash randomly. When you take your fingers off, it will stop and just one LED will remain lit.

Cut out the paper cover and place it on the circuit board to complete your Brain Meter. You can create your own if you would like to personalize what it says.

Lesson 5: Final Examination Review

Introduction



This lesson explains how to order your final examination, and provides you with information on the format of the exam you will be writing. Remember, your mark on the final examination determines 15 percent of your final mark in this course.

You are responsible for making arrangements to have the examinations sent to your proctor from the Distance Learning Unit. Please make arrangements before you finish Module 5 to write the final examination.

To write your examination, you need to make the following arrangements:

- **If you are attending school,** your examination will be sent to your school as soon as all the applicable assignments have been submitted. You should make arrangements with your school's Independent Study Option (ISO) school facilitator to determine a date, time, and location to write the examination.

- **If you are not attending school,** check the **Examination Request Form** for options available to you. Examination Request Forms can be found on the Distance Learning Unit's website, or look for information in the learning management system (LMS). **Two weeks before** you are ready to write the examination, fill in the Examination Request Form and mail, fax, or email it to

  Distance Learning Unit
  500–555 Main Street
  P.O. Box 2020
  Winkler, MB R6W 4B8
  Fax: 204-325-1719
  Toll-Free Telephone: 1-800-465-9915
  Email: distance.learning@gov.mb.ca

Examination Format

The final examination consists of five types of questions, the values of which combine to a total of 100 marks:

True or False (10 marks)

In this section of the examination, you will decide whether each statement is true or false, and you will indicate your choice by printing either "T" or "F" in the space provided for each statement.

Multiple Choice (35 marks)

In the multiple choice section of the examination, you will choose the single best answer to each of the questions given.

Short Answer (55 marks)

You will be asked to answer each question clearly and thoroughly in the space provided. Remember to include your calculations.

Study Strategies

In preparing for this examination, review all learning activities and assignments that you completed in the course.

Reviewing the power words is also an excellent way to review concepts. You could practise defining those terms, perhaps by using index cards—using one side for each term and the other side for its definition.

Summary

Good luck as you prepare for the final examination. If you have completed all of the learning activities and assignments and have studied using the suggestions above, you have prepared yourself well. The examination will be an opportunity for you to show what you know.

Module 5 Summary

Congratulations! You have finished the Grade 10 Electricity/Electronics Technology course.

Submitting Your Assignments

It is now time for you to submit your assignments from Module 5 to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

Remember: Project 2: Brain Meter must be mailed to the Distance Learning Unit. Keep all your material together in the one mailing and do not electronically submit any material for this module.

Make sure you have completed all parts of your Module 5 assignments and organize your material in the following order:

- ❑ Module 5 Cover Sheet (found at the end of the course Introduction)
- ❑ Assignment 5.1: Magnetism
- ❑ Project 2: Brain Meter

For instructions on submitting your assignments, refer to How to Submit Assignments in the course Introduction.

Notes

Project 2: Brain Meter *(100 marks)*
Marking Rubric

The assembly of parts and completion of this working brain meter are based on the following criteria:

Confirmation: *25 marks*
Construction: *25 marks*
Soldering: *25 marks*
Function: *25 marks*

This project is designed to be the work of one person and group submissions will not be accepted.

Confirmation: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**	Some of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**	Few of the components have the following characteristics: ❑ They are property placed. ❑ They are nestled close to the board within 1 mm. ❑ The legs are spread out. ❑ The legs are trimmed after soldering. **Tutor/marker comments:**

Project 2: Brain Meter (continued)
Marking Rubric

Construction: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**	Some of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**	Few of the following have the identified characteristics: ❑ The length of wire is correct. ❑ The amount of insulation stripped off the wires is correct. ❑ There are no avoidable projections. ❑ The parts are aligned. ❑ The project is smooth. ❑ The wires and traces are not broken. **Tutor/marker comments:**

Project 2: Brain Meter (continued)
Marking Rubric

Soldering: __________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**	Some of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**	Few of the joins have the following characteristics: ❑ They are large enough to cover the foil pad. ❑ They are small and stay clear of pathways. ❑ They are smooth and shiny. ❑ They are in full contact between the solder and leg of each component on all sides of the leg. ❑ They are not burnt or have no spatter marks on the project. **Tutor/marker comments:**

Project 2: Brain Meter (continued)
Marking Rubric

Function: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
All or most of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**	Some of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**	Few of the following project functions have the following characteristics: ❑ It does not function before the project is armed. ❑ It does not function after arming and before input. ❑ It has immediate and continuous output after arming and input. ❑ The output does not stop by manipulation of the input button. ❑ The output can only be stopped by switching off the arming slide switch. **Tutor/marker comments:**

Grade 10 Electricity/ Electronics Technology (20G)

Module 5
Magnetism and Induction

Learning Activity Answer Keys

Module 5: Magnetism and Induction

Learning Activity 5.1: Electromagnetic Induction

1. Explain what Michael Faraday discovered.

   Answer:

   He discovered that if you move a wire through a magnetic field, you produce current in the wire.

2. What is the effect of the direction that you move a wire through a magnetic field?

   Answer:

   The direction of the current depends on the direction that the wire cuts through the magnetic field.

3. Explain the effect of placing a coil of wire through a magnetic field.

   Answer:

   If you make the conductor into a coil of wire, the number of turns increases the effect that the magnetic field has on the wire, and would increase the amount of induced current.

4. What happens when you move a wire in the direction that coincides with the magnetic field?

   Answer:

   You do not have any induced current because the lines are going through the conductor.

5. Explain what is meant by counter-EMF.

   Answer:

   Whenever there is an induced current in a wire, the induced current creates a magnetic field in the opposite direction to the magnetic field that created the induced current.

Learning Activity 5.2: Electromagnetic Induction

1. What is a transformer device, and what does it do?

   Answer:

   A transformer is a device that transfers energy from one circuit to another using electromagnetic induction.

2. What does a transformer's construction consist of?

   Answer:

   A transformer consists of two or more coils of wire wound around a piece of iron.

3. The input on a transformer is known as the ***primary*** and the output is called the ***secondary*** coil.

4. Explain how a transformer's primary coil induces current in the secondary coil.

   Answer:

   A current is put through the primary windings. As the current increases, a magnetic field builds until it get so big its lines cut through the secondary coil, which in turn induces current.

5. What happens to the current in the secondary coil as the alternating current source switches from one direction to another?

   Answer:

   The current in the secondary also changes direction due to the change in direction of the magnetic field produced in the primary.

6. What do the following abbreviations mean?

   E_P *Answer:* Voltage primary

   E_S *Answer:* Voltage secondary

   N_P *Answer:* Number of turns in the primary

   N_S *Answer:* Number of turns in the secondary

7. What does a step-up transformer do, and how does it achieve this?

   Answer:

   A step-up transformer increases the amount of voltage by having more turns of wire in the secondary winding than in the primary winding.

8. What does a step-down transformer do, and how does it achieve this?

   Answer:

   A step-down transformer decreases the amount of voltage by having fewer turns of wire in the secondary winding than in the primary winding.

Module 5 Summary

Congratulations! You have finished the Grade 10 Electricity/Electronics Technology course.

Submitting Your Assignments

It is now time for you to submit your assignments from Module 5 to the Distance Learning Unit so that you can receive some feedback on how you are doing in this course. Remember that you must submit all the assignments in this course before you can receive your credit.

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Make sure you have completed all parts of your Module 5 assignments and organize your material in the following order:

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Notes

Project 2: Brain Meter *(100 marks)*
Marking Rubric

The assembly of parts and completion of this working brain meter are based on the following criteria:

Confirmation: *25 marks*
Construction: *25 marks*
Soldering: *25 marks*
Function: *25 marks*

This project is designed to be the work of one person and group submissions will not be accepted.

Confirmation: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
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Project 2: Brain Meter (continued)
Marking Rubric

Construction: ___________ / 25 marks

(20–25 marks)	(11–19 marks)	(less than 10 marks)
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Project 2: Brain Meter (continued)
Marking Rubric

Soldering: ___________ / 25 marks

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Project 2: Brain Meter (continued)
Marking Rubric

Function: _________ / 25 marks		
(20–25 marks)	**(11–19 marks)**	**(less than 10 marks)**
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Grade 10 Electricity/ Electronics Technology (20G)

Module 5
Magnetism and Induction

Learning Activity Answer Keys

Module 5: Magnetism and Induction

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1. What is a transformer device, and what does it do?

   Answer:

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2. What does a transformer's construction consist of?

   Answer:

   A transformer consists of two or more coils of wire wound around a piece of iron.

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4. Explain how a transformer's primary coil induces current in the secondary coil.

   Answer:

   A current is put through the primary windings. As the current increases, a magnetic field builds until it get so big its lines cut through the secondary coil, which in turn induces current.

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   Answer:

   A step-up transformer increases the amount of voltage by having more turns of wire in the secondary winding than in the primary winding.

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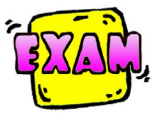
   Answer:

   A step-down transformer decreases the amount of voltage by having fewer turns of wire in the secondary winding than in the primary winding.

Lesson 5: Final Examination Review

Introduction



This lesson explains how to order your final examination, and provides you with information on the format of the exam you will be writing. Remember, your mark on the final examination determines 15 percent of your final mark in this course.

You are responsible for making arrangements to have the examinations sent to your proctor from the Distance Learning Unit. Please make arrangements before you finish Module 5 to write the final examination.

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  Distance Learning Unit
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  P.O. Box 2020
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  Toll-Free Telephone: 1-800-465-9915
  Email: distance.learning@gov.mb.ca

Examination Format

The final examination consists of five types of questions, the values of which combine to a total of 100 marks:

True or False (10 marks)

In this section of the examination, you will decide whether each statement is true or false, and you will indicate your choice by printing either "T" or "F" in the space provided for each statement.

Multiple Choice (35 marks)

In the multiple choice section of the examination, you will choose the single best answer to each of the questions given.

Short Answer (55 marks)

You will be asked to answer each question clearly and thoroughly in the space provided. Remember to include your calculations.

Study Strategies

In preparing for this examination, review all learning activities and assignments that you completed in the course.

Reviewing the power words is also an excellent way to review concepts. You could practise defining those terms, perhaps by using index cards—using one side for each term and the other side for its definition.

Summary

Good luck as you prepare for the final examination. If you have completed all of the learning activities and assignments and have studied using the suggestions above, you have prepared yourself well. The examination will be an opportunity for you to show what you know.

Grade 10 Electricity/ Electronics Technology (20G)

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Grade 10 Electricity/ Electronics Technology (20G)

Glossary

Glossary

alternating current (AC)
A current of electrons that moves first in one direction and then in another.

ampere:
The number of electrons that pass a given point in a given amount of time (the rate of flow). The measurement is referred to as amps and was named after Andre Marie Ampere.

amplifier
An electrical device that is used to increase the volume of sound.

amplify
To boost or increase the current or voltage level in a circuit.

anode
A positive electrode or lead.

armature
The rotating coils of a conductor in an alternator. Electrical current is induced as the armature passes through a magnetic field.

artificial resuscitation
The act of helping another person to breathe and to keep his or her blood circulating while he or she is unconscious.

assembly technician
An individual who would physically build or assemble electronic items.

atom
The smallest particle of an element that can exist either alone or in combination.

automatic pilot
A device used to maintain consistent flight control without the use of a pilot.

battery
Several voltaic cells connected in series or in parallel and usually contained in one case.

cascade
A waterfall or something that acts like a waterfall. Outputs that become inputs are said to "cascade" or rush through a series of operations.

cathode
A negative electrode or lead.

CD player
An electrical device that uses a laser beam to scan digitally encoded audio, video, or text material from a disk and transmit the material to a playback system.

charge
An accumulation of impelling force; an excess or lack of electrons in a place.

circuit
A path that a source of electrical energy travels.

cladding
Material made of copper and bonded to fibreglass material that is used to make printed copper traces.

cold solder joint
A connection that is poorly made during the soldering process and that will cause electrical devices to fail.

combination circuit
A circuit that includes parts or components that are connected in both a series and a parallel configuration.

communicate
To move information from one place or person to another.

compound
A molecule made of more than one type of atom.

conductor
A material or element that allows electrons to flow through it easily from one point to another.

contacts
The location where the physical connection occurs inside a switch.

control
To direct or to have influence over.

covalent bonds
Atoms joined together, sharing each other's electrons to form a stable molecule.

current
Transfer of electrical energy in a conductor by means of electrons moving constantly and changing positions in a vibrating manner.

design technician
An individual who designs or creates electronic and electrical devices or circuits.

dielectric
The insulating material inside a capacitor that separates the two metal plates.

diode
An electronic component that allows current to flow in just one direction.

direct current (DC)
Flow of electrons in one direction.

dissipate
The removal of an electric charge from a battery, capacitor, or any other electronic storage device.

doped
The process of adding arsenic or gallium to a semi-conductive material such as silicon or germanium to make it more of a conductor or insulator.

draftsperson
An individual who draws up the technical drawings used in the construction of a project.

electrical charge
The property of basic particles that causes them to execute a force upon one another. It can be negative like an electron or positive like a proton and, subsequently, they either repel or attract each other.

electricity
The flow of free electrons through a conductor.

electrolyte
An acid solution in a cell.

electromotive force (EMF)
Force that causes free electrons to move in a conductor. Unit of measure is the volt.

electron
A tiny negatively charged particle that vibrates or orbits quickly around the nucleus of an atom.

electronic components
Parts and pieces used in the construction of electronic projects and circuits.

electronic
Having to do with electricity—in a small quantity, for special purposes, or in semiconductors.

electronics engineer
An individual who aids in the design, approval, and construction of electronic projects and ideas.

electrostatic force field
The area of attraction or repulsion that surrounds electrons and protons.

element
One of over 100 types of matter that has its own unique physical, electrical, and chemical properties.

energy
The ability to act or to cause activity.

epoxy
A two-part material that is mixed to form a solid bonding agent.

etchant
The liquid material used to remove unwanted copper–ferric chloride and ammonium persulfate are two common chemicals used in this process.

etching
The process of removing unwanted copper with a chemical reaction.

farad
Unit of measurement of capacitance. A capacitance of one farad is a capacitor that carries a charge of one coulomb when a potential difference of one volt is applied across it.

ferrous metals
Any metal that contains irons or is derived from iron.

fibreglass
A trade name used to describe material made of glass fibres and resins.

filament
A metallic wire or ribbon used to produce heat by means of an electron flow—found inside light bulbs.

foil pattern
The pattern of copper conductors on a printed circuit board.

forward bias
Connection of potential current across the PN junction.

fossil fuels
A fuel formed in the earth from plant and animal remains.

free electrons
Electrons that have been forced out of their orbits and are therefore readily affected by electric or magnetic fields.

gate
An electronic switch that prevents or allows the flow of current in a circuit.

generate
To produce electricity.

generator
A rotating electric machine that provides a source of electrical energy. A generator converts mechanical energy to electrical energy.

grounding
The process of intentionally attaching part of a circuit to a grounding plate or rod—protects the circuit or individual from an electrical shock.

heat sink
Any metal clamp or device attached to a component that protects the component from excessive heat—also used while soldering to absorb part of the heat from the soldering iron when melting the solder.

holes
Positive charge. A space left by a removed electron.

humidity
Refers to a moderate degree of wetness or dampness in the atmosphere.

hydroelectricity
Electricity generated from water power, such as through a hydroelectric dam.

infrared emitting diode
An electronic component used to transmit or receive an electrical signal.

inputs
Information fed into a data processor.

insulator
A material or element that does not allow electrons (or very few) to flow through it easily from one point to another.

intrinsic semiconductor
A semiconductor with no impurities added that has the same number of electrons and hole densities when at thermal equilibrium.

laminate
The process of layering two materials together.

leads
Wires connected to the two metal plates inside a capacitor.

liquid crystal display (LCD)
A display that uses liquid crystals such as a seven segment numerical display in digital watches or calculators.

load
An electronic or electrical device or component that makes use of part of the energy of electrons that are forced through it.

machinist
An individual who uses specialty tools and/or equipment to form material into specific shapes and sizes.

matter
That which all physical things are composed of. It occupies space and has mass.

molecule
Smallest unit of matter that can exist by itself and retain all its chemical properties (a group of atoms held together by chemical forces).

multimeter
Combination volt, ampere, and ohm meter.

neon bulb
An electronic component that uses low pressure and electricity to light the gas in a tube.

neutral charge
Having no positive or negative charge.

neutron
A particle found in the nucleus of an atom that has about the same mass as a proton but lacks an electric charge.

nichrome wire
Wire made from nickel and chromium. When electricity passes through the wire, it quickly gets hot and turns a red or orange colour (e.g., nichrome wire is found in toasters).

nuclear power
Energy from nuclear fission or fusion.

nucleus
The centre of an atom.

ohms
The measurement of the electrical resistance to the flow of electrons, named after George Simon Ohm.

output
Information produced by data processing.

overload
A load on a circuit that exceeds the amount for which the circuit was designed (i.e., too much power). It may cause electric shock or fire.

parallel circuit
A circuit with more than one path for current to flow.

piezoelectricity
Electricity created by pressure applied to a crystal.

plates
The two metal pieces inside a capacitor that store the electrical energy.

polarized
The term used to indicate when an electronic device has positive and negative poles.

potential difference
The amount of energy per unit charge needed to move a charged particle from one point to another designated point in a static electric field.

potential energy
Electrical pressure or voltage.

power
The rate at which work is done.

printed circuit board
An insulating board with a fibreglass backing that has conductive printed copper traces of copper lines and copper lands on which small components are later mounted.

proton
A positively charged particle found in the nucleus of an atom.

pushbutton switch
An electronic component that connects a circuit when a button is pushed.

radar
A device that uses high frequency microwaves to determine the speed and/or location of an object.

relay
An electromechanically driven device used to control current flow in a separate circuit.

repair technician
An individual who services or repairs electronic/electrical devices.

resistance
Opposition to the flow of electrons within a given circuit.

reverse bias
A connection of potential so small that no current will flow across the PN junction.

rotors
The rotating part of a generator.

satellites
An object that is placed in orbit around Earth in order to collect information or for communication (television signals are sent by means of satellites).

schematic diagram
A drawing of a circuit that shows connected components using international standardized symbols.

schematic symbol
A circuit diagram with symbols that represent actual electronic components.

semiconductor N-type
Uses electrons as the majority carrier.

semiconductor P-type
Uses holes as the majority carrier.

semiconductor
An element that can act as a conductor or an insulator (silicon and germanium are two excellent examples of semi-conductive material).

series circuit
A circuit in which the components or contact symbols are connected end to end; the circuit must be closed to allow the current to flow.

short circuit
An undesirable path of very low resistance in a circuit connecting two points.

siemens
Unit of measurement for conductance.

silicon controlled rectifier (SCR)
A semiconductor device used to turn circuits on and off; in some situations, SCRs have replaced mechanical relays.

simple machine
The simplest parts of a complex machine (e.g., lever, wedges, and wheel and axle).

sine wave
A periodic oscillation that goes from positive high to negative high and back again (alternating current).

slide switch
An electronic component that connects a circuit when a small sliding lever is moved.

soldering gun
A high temperature soldering device used to melt solder to join larger connections.

sonar
A device that uses high frequency sound waves to locate items. A sound wave bounces back from the object and the device registers the vibrations reflected from the object.

static electricity
An electrical charge that is usually caused by friction. The charge builds up on the surface of an object.

switch
An electronic component that connects a circuit when either a small lever is moved or a button is pushed.

technical designer
An individual who designs circuits and electrical plans for a project.

thermocouple
The junction of two dissimilar metals. Electromotive force is generated if the two ends of the thermocouple are at two different temperatures.

tolerance
The limiting values within which a device such as a resistor is expected to function.

torque
The act of twisting or turning.

transform
To change. In electricity, to use a transformer to change the voltage.

transmit
To send out a signal, current, or wave.

transport
To move from one place to another.

troubleshoot
The process of inspection to find the problem with a faulty electronic item.

valance electrons
These make up the outermost ring of electrons surrounding the atom.

VCR (video cassette recorder)
An electrical device used to record a program that can then be played back at a later time on a television.

voltage
The amount of pressure applied to a given circuit (usually referred to as "volts").

water power
Using the force of moving water to do work.

watt
The SI unit of power equal to 1 joule per second (letter symbol “W”).

wind power
Using the force of the moving air to do work.

work
Transference of energy. In electricity, the energy necessary to free an electron from a metal atom.

working voltage direct current (WVDC)
The voltage at which an electrical or electronic device would normally operate.

Notes


2013
MANITOBA
PROSPECTS
BUILD IT AND THEY WILL COME
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Manitoba
Manitoba School Counsellors' Association

BUILD IT AND THEY WILL COME

Manitoba's gathering places boost economy, job prospects

The new Investors Group Field is more than a field of dreams. It becomes a reality when it opens its doors this year. Home to the Winnipeg Blue Bombers, Manitoba Bisons (football and soccer), Winnipeg Rifles, and a variety of amateur sports and events, it will also be a host venue when the FIFA Women's World Cup Soccer Championship comes to Winnipeg in 2015.

With major concerts and other international events ready to transform the stadium into a concert bowl, this multi-purpose, state-of-the-art facility will be filled with cheering fans for years to come.

In this issue of Manitoba Prospects, we will meet some athletes who are excited to take to the field and play in front of enthusiastic home crowds. We will also take a look at how other sports, arts and entertainment facilities are popping up throughout Manitoba. These gathering places are creating a variety of employment opportunities, strengthening our economy and giving us lots to cheer about! ■

MANITOBA PROSPECTS is provided free of charge and is distributed throughout the province. Editing and coordinating functions were performed with the assistance of an editorial committee with representatives from the Manitoba School Counsellors' Association; Manitoba Education; and Manitoba Entrepreneurship, Training and Trade.

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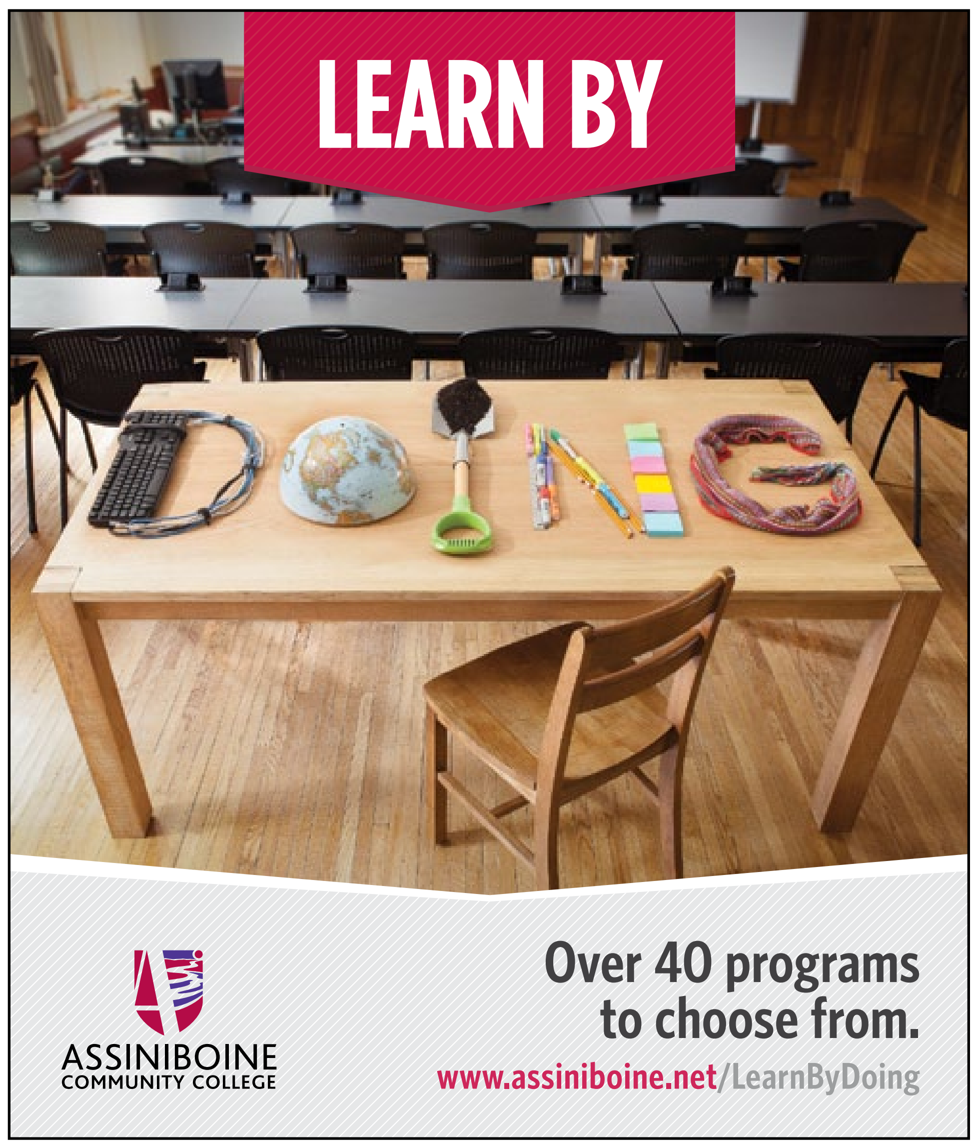
Additional copies may be obtained by contacting your school counsellor or nearest employment centre. You may also phone **(204) 945-1037** or email: **ana.escobar@gov.mb.ca**



When Investors Group Field opens its gate this year, Manitobans will be treated to a new state-of-the-art facility that will be home to professional and amateur sports, concerts and other international events. The building of this $190 million stadium is just one of the mega construction projects in our province that has been generating employment opportunities and having a positive impact on the community and our economy.

Currently in Winnipeg, Assiniboine Park and Zoo is in the middle of a major redevelopment; the Canadian Museum for Human Rights will soon open and attract visitors from around the world; a Sports, Hospitality & Entertainment District (SHED) is working to revitalize downtown; the Winnipeg Convention Centre is about to undergo a major expansion that will see it double in size; multiple hotels are being built and major retailers are staking claim in the market place.

In rural Manitoba, recreation complexes, arenas, curling rinks and pools are being built in towns and cities of all sizes. From Rivers, Russell, Swan River, Asessippi, Virden, Portage la Prairie, Steinbach and Dauphin, new community centres are being built and creating gathering places for local events and activities.

Together, these and a number of other exciting construction projects are changing the face of the province. So what does this mean for you? There is a continuing need for tradespeople and other skilled workers to build these projects and a variety of jobs are being created for the long term. These new facilities are diversifying the economy and creating new market opportunities. It's a win-win situation for everyone. ■

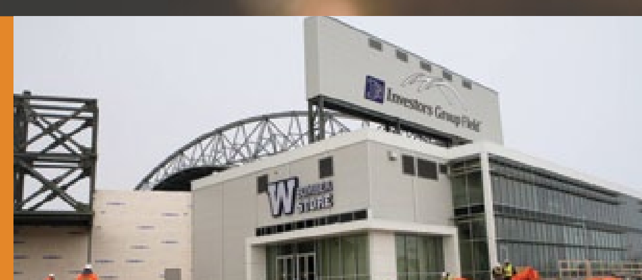
WHERE PEOPLE GO TO PLAY AND WORK

MANITOBA'S GATHERING PLACES

FUN FACTS

New state-of-the-art stadium means great fan experience

- 33,500 seats expandable to 40,000 for Grey Cup game
- Significantly larger seats, with on average 50% more leg room than the old Winnipeg Stadium and a cup holder for every seat.
- Two massive video HD Boards (110' wide x 30' high) which are comparable to many NFL stadiums and the Jumbotron at Rogers Centre in Toronto
- The canopy provides rain protection for 80% of fans and is the largest canopied structure in Canada
- The canopy and stadium configuration will deflect '13th player' noise back to the field.
- 50% more washrooms with separate entrances and exits to improve wait times



- 50% more concessions with a wide variety of food choices
- Over 240 TV monitors throughout the stadium concourse
- Enhanced game day experience with entertainment inside and outside
- 4,000 sq. ft. retail store that will be open year-round

MANITOBA'S OLYMPIC HERO

Desiree Scott, Canadian Olympic Women's Soccer Team

Standing on the newly laid turf at Investors Group Field, Desiree Scott looks in awe of the new facility that will be home to the University of Manitoba Bisons Women's Soccer program and will host the 2015 FIFA Women's World Cup Soccer Championship.

Scott, a former Bison soccer player herself, is now a Bison coach and continues to train and play with Canada's national women's soccer team. While working towards completing her arts degree with a major in psychology at the University of Manitoba, this hard working 25-year-old is as motivated as ever.

Coming off the high of Team Canada's much celebrated 1-0 win over France earning the bronze medal at the 2012 Olympics in London, Scott and her team-mates have set their sights on the 2015 FIFA World Cup and then the 2016 Olympic games. The win in London boosted the interest in women's soccer and has made Scott a local celebrity.

"Playing in the Olympics has been a highlight of my career. I am so proud of Team Canada and am especially proud to wear that bronze medal around my neck," said Scott. The fan support in this province has been tremendous. It's such an honour to be a role model," Scott adds. "When we bring the biggest women's sporting event in the world to Winnipeg in 2015, I hope the momentum and support of the game grows."

Scott hopes her experience and success at the Olympics can inspire young women to play the game, study hard in school and strive to be the best in everything they do.

"Soccer and school have always been an important part of my life. My family has always supported me and have been my biggest fans. My brother was such a great player and I wanted to play like him. I tried other sports while growing up but I always came back to soccer," she said. "Being one of the shorter players, I had to prove that I belonged. It became a huge motivator for me and pushed me to work and train even harder."

This feisty midfielder's natural talent shines when she's on the field. Scott is working hard to win the coveted FIFA World Cup with the hopes of adding a little gold to her medal collection. ■

HENOC MUAMBA

Middle Linebacker, Winnipeg Blue Bombers

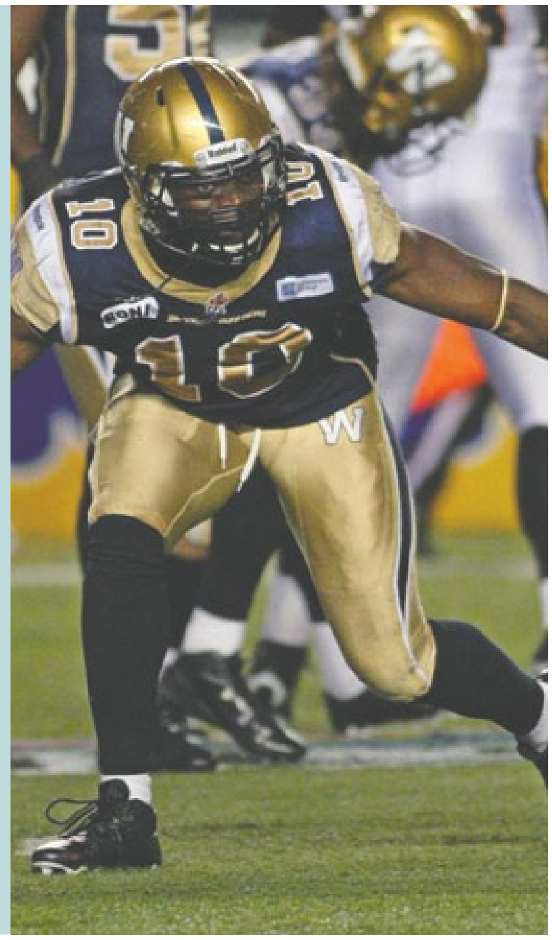
As the first overall pick in the 2011 CFL Draft, Henoc Muamba knew he would need to work hard to prove to his coaches and his Winnipeg Blue Bomber team-mates that he was 'the real deal'. Now, after a solid 2011 rookie season and outstanding play in 2012, Muamba has quickly made a name for himself in the Canadian Football League.

"As a Canadian linebacker, it's hard to break into the league," said Muamba. "There are so many obstacles to overcome. I'm glad things are working in my favour but there's no time to take anything for granted. I need to keep hungry and consistent."

Muamba credits this positive attitude and strong work ethic to his parents. Growing up in Mississauga, Ontario, it was his parents that kept him on track. "My parents have always been a positive influence and my biggest supporters," he said. "If I would slack off in my studies, they would be first in line to take me off the basketball court or football field. Education always came first. No questions asked."

"I studied information systems at University. I've always enjoyed computers and business and with changing technology, there will always be a good future and job prospects in this field. I know that professional sports will not be there forever and it's important to have a backup plan."

Receiving the CFL's Canadian Player of the Week honour twice during the 2012 season, this middle linebacker has established himself as someone the team can count on for years to come. With a long and prosperous football career ahead of him, Muamba's backup plan and dream job of working as a computer programmer may have to be put on hold for now. ■



DAVE DARICHUK

HOME SWEET HOME

Brett MacFarlane, Manitoba Bisons
Adam Folz, Winnipeg Rifles

Investors Group Field is also home for the University of Manitoba Bisons and Winnipeg Rifles football teams.

Bison defensive back Brett MacFarlane and Rifles defensive end Adam Foltz (pictured on the cover & above) are both looking forward to playing in the best stadium in Canada. "Playing in the new Investors Group Field in front of a big home-town crowd will be incredible and we can't wait to lace up the pads," said Foltz. ■

JOEY ELLIOTT

Quarterback, Winnipeg Blue Bombers

When quarterback Joey Elliott graduated from Purdue University in Indiana and joined the Winnipeg Blue Bombers in 2010, he knew that earning a spot was all part of the waiting game. Keeping focused, dedicated and ready to play worked in Elliott's favour. In 2012, he played the most games in his career and was named the CFL's Offensive Player of the Week twice.

No stranger to the obstacles of football, Elliott was a back-up quarterback at Purdue for four years and never saw the field. "It was a long wait," said Elliott. "I trained hard and stayed true to my roots. I have a strong work ethic and just waited for my opportunity. Patience and passion always wins out in the end."

Elliott worked hard in school and obtained his business degree with a minor in communications. "It's important to get an education while you're following your dreams," he said. "My degree in communications has been helpful as football is such a unique sport. There are 12 players in a huddle and, as quarterback, I only have 20 seconds to pass on as much information as possible."

DAVE DARICHUK

Communicating, connecting and volunteering are so important for staying in touch with the community and Elliott believes that volunteering is essential. "It's vital that we give back to our community. I've been so fortunate to be in this position and realize that it means so much to fans of all ages."

Whether it's reading to a group of students, running a football camp or visiting a YMCA, Elliott demonstrates his leadership on and off the field. ■

LANDING A GREAT CAREER

As a flight service specialist with NAV CANADA, Keri Neima plays a key role in ensuring pilots land and take off safely at the Churchill, Manitoba airport.

"My job is ensuring safe movement of aircraft and vehicles at the airport," said Neima. "From the flight service station, I provide pilots with information on weather, runway conditions and air traffic so that they can make a safe decision on how to land and take off."

A passion for aviation that runs in the family – and the weather-related nature of the job – are what pushed her to pursue a career in air traffic services. "I was in air cadets and my father and sister both had their pilot's license," said Neima.

She earned her own pilot's licence when she was 16, but knew she didn't want to be a pilot as a career. "I felt that it would take the fun out of flying," she said. "I decided I wanted to pursue a career in air traffic services when I did my first flight into Winnipeg International. I enjoyed talking over the radio as much as flying the plane and so I took an Air Traffic Control course with the air cadets in 2004."

Those interested in becoming a flight service specialist or air traffic controller require only a high school diploma to apply, as NAV CANADA provides all the necessary training.

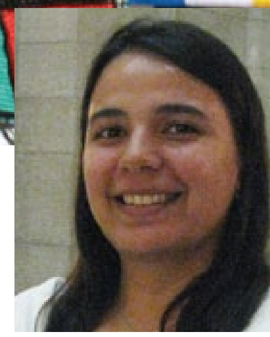
"The selection process is long and training is very challenging," added Neima. "You have to stay focused, relaxed and patient and remind yourself that it's all worth the effort."

When asked what she likes best about her job, Keri says that the work environment is second to none. "My desk is in a tower with a 360 degree panoramic view of the tundra," she marvels. "You can see the best northern lights from my position. Everyday is rewarding – you never have the same situation so you're constantly learning and I love that." ■

Visit: www.navcanada.ca

PROSPECTS / FOR ABORIGINAL YOUTH

ANGIE HUTCHINSON – FINDING A DREAM JOB



'What career should I select?' 'What is the best job for me?' Angie Hutchinson faced these challenging questions. Although Angie did not know what her dream job was, she knew she had a passion to influence change and have a positive effect in the Aboriginal community.

After graduating from Mennonite Collegiate Institute in the small town of Gretna, Manitoba, Angie took a two-year course in massage therapy. After earning a diploma, she worked successfully in the field for six years. "I enjoyed this career, but over time realized I needed a change. I wanted to return to my passion," said Hutchinson.

At first, Angie wasn't sure how to achieve her dream. She discovered that the Manitoba government, with over 700 occupations to choose from, could provide her an avenue to pursue her employment goals.

"I took the initiative and applied for a position with Manitoba Health," she said. "The medical terminology knowledge I gained as a massage therapist and the transferable skills and experiences I could draw from allowed me to be successful in getting the job."

After six months of employment, Angie applied to the Aboriginal Public Administration program with the Manitoba government. In this two-year internship, individuals complete four placements designed to provide broad public administration experience and training and assist in furthering career goals.

"As a young First Nation woman from Misipawistik Cree Nation, I thought this would be perfect," said Hutchinson. "I applied to the program and was successful and have since worked for a number of areas including the First Nations, Métis and Inuit Health Branch, the crime prevention unit and the deputy minister's office with Manitoba Children and Youth Opportunities."

Asked what lessons she has learned, Angie said, "I try to stay informed through research, volunteer as much as possible and am proactive in building strong networks."

Find out more about job opportunities and internship programs within the Manitoba government at: **www.gov.mb.ca/govjobs** ■

Aboriginal Youth Liaison Officers

ASSINIBOINE COMMUNITY COLLEGE
Chris Tataryn
Student Recruitment Officer
(204) 725-8700 ext. 6613
Toll free: 1-800-862-6307 ext. 6613
E: recruit@assiniboine.net
www.assiniboine.net

BRANDON UNIVERSITY
Doug Pople
Career Planning Officer
(204) 727-9651
E: pople@brandonu.ca
www.brandonu.ca

RED RIVER COLLEGE
Jamie Richard
Aboriginal Liaison/Advisor
(204) 632-2483
E: jrichard@rrc.ca
www.rrc.ca

UNIVERSITY COLLEGE OF THE NORTH
Louise Dewar
Student Recruitment Officer
(204) 627-8637
E: ldewar@ucn.ca
Toll-free: 1-866-627-8500
www.ucn.ca

UNIVERSITY OF MANITOBA
Jen Storm
Aboriginal Student Recruitment Officer
(204) 474-7144
E: jen_storm@umanitoba.ca
www.umanitoba.ca

UNIVERSITY OF WINNIPEG
Tanis Kolisnyk
Aboriginal Liaison Officer
(204) 786-9922
E: t.kolisnyk@uwinnipeg.ca
www.uwinnipeg.ca

WINNIPEG TECHNICAL COLLEGE
Rae-Lynn Rempel
Manager, Marketing & Communications
(204) 989-6511
E: raerem@wtc.mb.ca
www.wtc.mb.ca

YELLOWQUILL COLLEGE
Bernice Rundel-Hotomani
MI2 Coordinator
(204)953-2804
E: bernice@yellowquill.org
www.yellowquill.org

IT PAYS TO BE AN APPRENTICE

The High School Apprenticeship Program (HSAP)

What are you waiting for? Start your apprenticeship training while you are still in high school. It's your opportunity to combine regular high school instruction with paid, part-time on-the-job apprenticeship training. Here are a few things to think about:

Research Your Trade of Interest: There are more than 50 trades in Manitoba. Go online and find a trade that is right for you.

Know Your Requirements: To be eligible for HSAP, you must be at least 16 years of age, completed Grade 9 and enrolled in a Manitoba School in grade 10, 11 or 12.

Find an Employer: Your employer must be a certified Journeyperson or a Designated Trainer. Start your job search by talking to your HSAP contact.

Register as a High School Apprentice and Submit your Application Fee: Once you have an employer willing to hire you, visit **www.manitoba.ca/tradecareers** to apply.

Get Paid and Start Your Career: Once your application is accepted you will receive a letter of acceptance. Work with your employer to set up a work schedule. Attend your high school classes. Graduate and transfer to the full-time apprenticeship program. It's that easy!

For more information on the High School Apprenticeship Program visit Apprenticeship Manitoba at **www.manitoba.ca/tradecareers** ■

PROSPECTS / IN MANAGEMENT

HEALTH CARE MANAGERS (NOC 0311)

Health care managers are responsible for planning, organizing, evaluating and maintaining the delivery of health care services in hospitals, medical clinics, nursing homes and other health care organizations. They specialize in specific health care services such as dietetics, clinical medicine, laboratory medicine, nursing, physiotherapy or surgery.

DUTIES:

- develop evaluation systems to monitor the quality of health care for patients
- monitor the use of diagnostic services, in-patient beds and facilities
- develop and implement plans for new programs, special projects, equipment and future staffing requirements
- plan and control budgets
- supervise health care professionals
- recruit health care staff

SKILLS:

- effective verbal and written communication skills
- strong leadership skills
- strong interpersonal skills
- good analytical skills
- the ability to develop and implement policies and procedures
- several years of experience in health care
- certification

CAREER OPPORTUNITIES IN MANITOBA

- Accommodation Service Manager
- Advertising, Sales and Marketing Manager
- Banking, Credit and Investment Manager
- Commissioned Officer, Armed Forces
- Construction Manager
- Health Care Manager
- Information Systems Manager
- Restaurant and Food Service Manager
- Retail Sales Manager
- Transportation Manager

OPEN FOR BUSINESS

Manitoba's front door is open wide and large big box stores and other businesses are stepping right in. The result – more jobs for Manitobans!

With a solid economy and a strong US dollar, new retail stores and restaurants are popping up everywhere. From Famous Dave's BBQ, IKEA, Target, Five Guys Burger & Fries, Victoria's Secret, Marshalls, Banana Republic, Forever 21 and Lowe's, stores that once enticed us across the border are now in our own backyard.

"The retail community in both Winnipeg and Manitoba has changed dramatically over the past decade," says Winnipeg Chamber of Commerce President and CEO Dave Angus. "When you look at statistics that show retail sales in Manitoba, they are consistently above the Canadian average. Add in the population growth that is occurring and you can understand why retail stores and restaurants that didn't have a Winnipeg location are setting up shop here."

With growth in business comes employment opportunities and the demand for efficient and competent retail managers. The doors may be opening but superior service and experienced staff are essential in keeping customers coming back. Our province has a reputation to uphold. We're called Friendly Manitoba for a reason! ■

RESTAURANT AND FOOD SERVICES MANAGER (NOC 0631)

MARC PRIESTLEY & KYLE MATHESON, OWNERS, UNBURGER

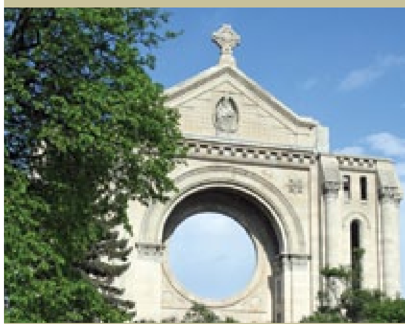
Even during their high school days, these two friends from Glenlawn Collegiate knew that one day they would start their own business. It was their love of burgers that became their inspiration.

At the age of 23, Marc Priestley and Kyle Matheson packed up their newly written business plan and visited every bank in Winnipeg asking for a loan to start their own business. Without financial partners and previous ownership experience, the young entrepreneurs felt the sting of rejection over and over again. After a year of banging on doors, the Business Development Bank of Canada took a risk and UnBurger became a reality.

"We always loved burgers. Knowing that they could be bad for you, we wanted to find a way to make a burger healthier but still taste wonderful," said Priestley. "We enlisted the expertise of a local chef and began our research. We must have visited over 100 different restaurants and tasted every burger in the city. In the end, it became quite clear that there was potential to create a healthy gourmet burger restaurant in Winnipeg."

As University of Manitoba graduates with Honours degrees in Business (Matheson) and Psychology (Priestley), the friends sacrificed three years to make their dream a reality.

Today, they manage the successful UnBurger restaurant in Osborne Village that couples a trendy environment with fresh, homemade veggie, beef and chicken burgers. ■



FRENCH
AN OPPORTUNITY OF A LIFETIME

In today's economy, the ability to communicate effectively in both English and French is an advantage for young people seeking the right career. A variety of occupations in Canada and internationally are wide open to those with bilingual skills. Industries where bilingualism is considered to be a clear advantage include: communications, law, tourism, health care, dentistry, politics, the arts, public service, education and business.

French: An Opportunity of a Lifetime is a program that responds to the increasing number of students who question why they should continue their studies in French, and provides information pertaining to French in relation to post-secondary options, life-enrichment opportunities and careers.

French: An Opportunity of a Lifetime has three main components; a magazine, a documentary DVD and in-class presentations on the process of life and career planning. Focusing on French language opportunities in Manitoba, Canada and internationally, the information provided relates to work experiences, cultural exchanges and bilingual post-secondary education options.

The DVD is suitable for students in Grades 7 and beyond, parent groups, educators, school trustees and other French-second-language stakeholders. It includes testimonials from individuals who have benefited from their ability to speak both English and French, including Manitoba Premier Greg Selinger and local radio host Ace Burpee.

French: An Opportunity of a Lifetime was created by Canadian Parents for French-Manitoba, in partnership with l'Association manitobaine des directrices et directeurs des écoles d'immersion française and Université de Saint Boniface. ■

Find helpful and interactive French-second-language resources at: **www.frenchforlife.ca**

PROSPECTS / IN BUSINESS, FINANCE AND ADMINISTRATION

CONFERENCE AND EVENT PLANNER
(NOC 1226)

Employed by tourism associations, convention centres, event-planning companies and professional associations, event planners are responsible for planning, organizing and coordinating conferences meetings, seminars, exhibitions, festivals and other events.

DUTIES:

- meet with trade and professional associations to promote and deliver conference, convention and trade show services
- monitor budgets and review progress of events
- co-ordinate services for events, such as accommodation and transportation for participants, facilities, catering, signage, displays, translation, special needs requirements, audio-visual equipment, marketing and security
- organize registration of participants, prepare programs and promotional material, and publicize events
- plan entertainment and social gatherings for participants
- hire, train and supervise support staff

SKILLS:

- ability to work under pressure in order to meet deadlines
- strong decision-making and problem-solving skills
- ability to work well with people
- strong interpersonal skills
- excellent verbal and written communication skills
- strong leadership and delegating skills
- strong public relations abilities
- creative skills

BE A TEAM PLAYER

When our Winnipeg Blue Bombers, Goldeyes or Jets take to the field or step onto the ice, there's another team that has worked really hard to make that moment possible.

They may not lace up skates or snap on a helmet, but they do wear many hats and are the backbone to any thriving sports and entertainment organization.

From finance, corporate communications, information technology, marketing, retail operations, ticket administration, audiovisual services, corporate partnership, brand management, client services, payroll, accounting, event coordinators and security, these teams of professionals have important roles to play.

"The success of any organization, including True North Sports & Entertainment Limited, is based upon the ability to get everyone to perform at their maximum potential regardless of industry," said Robert Thorsten, Vice-President, People & Patron Services at True North. "There is so much that goes on behind the scenes to deliver an entertaining, successful event at MTS Centre. We strive to create a great team environment in our workplace – one where everyone realizes the value of their role and works to be successful as a team."

It's all business on and off the ice or field. Being part of that team can bring huge rewards and maybe even a championship one day! ■

PURCHASING AGENT (NOC 1225)

RODERICK CRUZ, NORTH WEST COMPANY

You can thank Roderick Cruz for lining the shelves of Giant Tiger with your favourite products. As a purchasing agent for the North West Company, it's Cruz who decides what new products are worth featuring in their stores and flyers.

"I meet with vendors and sales reps from different companies and they try to sell me on why we should carry their product," said Cruz. "My job is to negotiate the best deal for our company. I base purchasing decisions on research, market analysis and my own instincts. It is so exciting to have the power to make some pretty major decisions."

Employed with the North West Company for five years, Cruz is responsible for purchasing grocery and non-food products for all Giant Tiger stores in Western Canada as well as the Northern Stores from the Yukon to the west and Goose Bay to the east.

Cruz is a graduate of the University of Manitoba's Asper School of Business with a Bachelor of Commerce Degree (Honours) and a double major in marketing and human resource management. In his second year at Asper, Cruz was accepted in their Co-operative Education Program where students are placed in three work placements over three years. It was Cruz's work placement experience at the North West Company that landed him a job after graduation.

"The co-op program is a great way to get your foot in the door and find out what area of the industry you might want to explore," Cruz adds. "I always imagined I would be working more on the finance side but am so happy that I changed my focus."

Analyzing, strategizing, negotiating, travelling and having the opportunity to try products before they come to market is a perfect fit for Cruz. ■

CAREER OPPORTUNITIES

IN MANITOBA

- Accountant
- Conference and Event Planner
- Customer Service/ Information Clerk
- Customer Services Representative Financial Services
- Financial Planner/ Investment Counsellor
- Human Resources Specialist
- Insurance Claims Adjuster/ Investigator
- Loan Officer
- Purchasing Agent
- Recruitment Officer

PROSPECTS / IN NATURAL AND APPLIED SCIENCES

FEELING A LITTLE GREEN?

If you're feeling a little green, you're not alone. Manitoba is a hub for sustainable development and green innovation. With education and career opportunities on the rise, our growing environmental sector can use your help.

Environmental Careers Organization (ECO) Canada lists top growth prospects for careers in the green economy and they include such areas as renewable energy, wind power, solar industries, bio-energy, hydrogen fuel cell, battery technologies, electric vehicles, urban and transportation planning, environmental protection and environmental sustainability.

Recently, an innovative new sustainable energy program was introduced at W.C. Miller Collegiate in Altona. The program offers courses on sustainable/green energy with the focus on four main technology areas – biomass, wind, geothermal and solar. Using the most common types of renewable energies in southern Manitoba, students are introduced to the core skills needed to work in these industries and trades.

The future is ours and we all should be putting our green to good use. Regardless of what career path we choose, there is always an opportunity to be environmental leaders. ■

LAND SURVEYOR (NOC 2154)

TRICIA CHRISTIE, BARNES & DUNCAN

Who knew that in the year 2012, Tricia Christie would go down in history as being named Manitoba's first female land surveyor. In the 131-year history of the Association of Manitoba Land Surveyors, there had never been a female land surveyor in this province until Christie came onto the scene.

Employed with Barnes & Duncan, Land Surveying and Engineering, the oldest land surveying company in Western Canada, Christie never thought her years of hard work and dedication to a profession she loved would receive such fanfare.

"It takes years to become a commissioned land surveyor and I was just plugging along and working towards completing all the requirements. The fact that I was the first female to achieve this status was secondary," said Christie. "I'm proud of this honour. I know of other women currently articling for their commission so expect I won't be alone for much longer."

There was a time when land surveying was considered a man's job due to the physical demands and often long periods away from home. With today's advances in technology such as cell phones, GPS, computers and satellite phones, collecting and analyzing surveying data has become much easier.

Coupled with a construction boom in our province, commissioned land surveyors like Christie have tons of work ahead of them. ■

CIVIL ENGINEERS (NOC 2131)

Civil engineers play a major role in planning, designing, developing and managing projects for the construction of structures such as bridges, dams, highways, railways and sewers. They often are employed by government, engineering consulting companies, construction firms or other industries.

DUTIES:

- plan and design major projects such as buildings, roads, bridges, dams, water and waste management systems and structural steel fabrications
- conduct research to determine project requirements
- evaluate and recommend appropriate building and construction materials
- monitor air, water and soil quality and develop procedures to clean up contaminated sites
- interpret, review and approve survey and civil design work
- act as project supervisor for land survey or construction work

SKILLS:

- ability to work as a team
- strong communication skills
- problem-solving skills
- an interest in construction and building
- strong math and computer skills
- ability to plan, organize and supervise projects
- management skills and abilities
- commitment to constantly upgrading knowledge of new technologies, materials and work methods

CAREER OPPORTUNITIES

IN MANITOBA

- Agricultural and Fish Products Inspector
- Aircraft Pilot
- Architect
- Biologist and Related Scientists
- Chemist
- Civil Engineer
- Computer Programmer
- Electrical and Electronic Engineer
- Mechanical Engineer
- Web Design/Internet Developer

VETERINARIAN
(NOC 3114)

Veterinarians prevent, diagnose and treat diseases and disorders in animals and advise clients on the feeding, hygiene, housing and general care of animals. Veterinarians may work in private practice or may be employed by animal clinics, farms, laboratories, government or industry.

DUTIES:

- Treat sick or injured animals by prescribing medication, setting bones, dressing wounds or performing surgery
- Vaccinate animals to prevent and treat diseases
- Perform routine, emergency and post-mortem examinations
- Advise on feeding, housing, behaviour, breeding, hygiene and general care of animals
- Diagnose diseases or abnormal conditions in individual animals, herds and flocks
- Provide a range of veterinary services including obstetrics, dentistry and euthanasia
- May conduct veterinary research related to areas such as animal nutrition, health care products development and disease prevention and control

SKILLS:

- comfortable around animals
- ability to communicate openly with clients
- strong analytical and problem solving skills
- observant in order to make quick decisions
- confident in emergency situations
- hard-working with a strong dedication to animals

CAREER OPPORTUNITIES

IN MANITOBA

- Doctor
- Health Care Aide
- Medical Sonographer
- Nuclear Medicine Technologist
- Occupational Therapist
- Optometrist
- Paramedic
- Physiotherapist
- Registered Nurse
- Speech Language Pathologist

A HEALTHY FUTURE

If you like helping people and have a desire to work in a challenging and changing environment, a career in the health care industry could be in your future.

With an aging population, there is a need for more health care services – and with advances in technology, a need for skilled technicians. The health care industry is also dealing with an aging workforce and there is a need to fill vacancies today and in the foreseeable future. From registered nurses, psychologists, therapists, counsellors, audiologists, physicians, pharmacists, radiologists, medical sonographers, and health care aides, the career opportunities are endless.

Health care in Manitoba is constantly evolving and adapting to meet the needs of our communities. There is a commitment to improving health care and promoting healthy living from remote northern towns to urban settings.

In The Pas, Amy Mink works as a Registered Nurse at the Primary Health Care Centre, where she facilitates the Positive Parenting Program. "We work to promote healthy child development by helping parents to connect with their child with positive attention and good nutrition," said Mink. "Our sessions are full and we're definitely meeting a need in the community."

This type of programming is just one example of the opportunities available for skilled health care providers who are ready to meet the challenge and ensure that the best care is being offered to all Manitobans. ■

MASSAGE THERAPY (NOC 3236)

NICOLE KLASSEN, NEW LEAF MASSAGE & SPORTS REHABILITATION

Volunteering and hard work has paid off for 25-year-old Nicole Klassen. A graduate of the Wellington College of Remedial Massage Therapy, Klassen is a certified sports massage therapist and registered massage therapist with her own business and a desire to keep volunteering and making a difference in the community.

"Volunteering is so important. I accumulated over 300 volunteer hours while I was in school. That was nine times more than anyone else!" said Klassen. "I still volunteer today by attending sporting events and working with the Canada Games Women's Softball Team as well as Badminton Manitoba. This summer alone we were at 15 charity golf tournaments. Being involved with teams and organizations is a great way to make contacts while I apply my training and sports knowledge."

As an athlete, Klassen is well aware of the aches and pains that can be felt by her clients. "Sports massage is so important to prevent injury and speed up healing. It's important to restore balance."

With relaxation and remedial massage her goal is to improve the quality of life of each client so they leave feeling better, moving better and are able to sleep a little better every night. ■

POLAR BEARS IN OUR OWN BACKYARD

Journey to Churchill Exhibit at Assiniboine Park Zoo

Did you know that Churchill is called the 'Polar Bear Capital of the World'? Polar bears sometimes roam the town and cause quite a stir among locals and the thousands of tourists that flock to catch a glimpse of these magnificent creatures.

The Assiniboine Park Zoo is bringing polar bears to the big city as they build a new polar bear exhibit called Journey to Churchill. This interactive display will highlight issues related to climate change, conservation, polar bears and other northern species. Visitors will experience a variety of landscapes and animal viewing areas as well as other educational and interactive displays.

Scheduled to open in 2014, Journey to Churchill will be the highlight of the redeveloped Assiniboine Park Zoo, setting a new international standard for polar bear exhibits world-wide. ■

PROSPECTS / IN ARTS, CULTURE, RECREATION AND SPORT

TRANSLATORS AND INTERPRETERS
(NOC 5125)

Translators translate written material from one language to another. Interpreters translate oral communication from one language to another. Both professions could be employed by government, private translation and interpretation agencies, private corporations, international organizations and the media.

DUTIES:

- translate a variety of written material such as correspondence, reports, legal documents, technical specifications and textbooks
- localize software and its technical documents to adapt them to another language
- revise and correct translated material
- interpret and translate oral communications
- provide interpretation services in a court of law
- interpret language for individuals and small groups travelling in Canada and abroad

SKILLS:

- love of languages is essential
- well organized
- strong attention to detail
- ability to handle stress and perform under pressure
- good listening and observational skills
- good verbal and written communication skills

CAREER OPPORTUNITIES

IN MANITOBA

- Announcer/Broadcaster
- Audio/Video Recording Technician
- Art Curator
- Fashion Designer/Theatrical Designer
- Film Producer/Director/Editor
- Interior Designer
- Journalist
- Librarian
- Public Relations Officer
- Recreation and Sport Program Leader

FEELING THE BOOM

Statistics Canada predicts that there will be more seniors than children in Canada by 2017. This will be quite the milestone in our country's history and a development that is being felt around the world.

With new medications and technology, people are living longer. Add this to the aging baby boomers and seniors make up the fastest growing age group.

Since this trend is expected to continue for the next several decades, we must start looking for opportunities to tap into this market and find ways to offer services to this dynamic group of individuals. Offering leisure and recreation programming is just one way to make a difference and it has a huge impact on community development and healthy living.

"There are so many opportunities to work with seniors. Whether it's working with independent seniors who choose to remain at home or in assisted living facilities where the programming comes to them. Either way, the opportunities are there," said Roxanne Greaves-Tackie, Executive Director, St. James Assiniboia 55+ Centre.

Promoting healthy lifestyles, wellness, and arts and cultural activities is essential for quality of life to any age group. We all want to grow to be productive members of society and staying active and healthy along the way is important. ■

FILM PRODUCER/DIRECTOR/EDITOR (NOC 5131)

LISANNE PAJOT, FILM DIRECTOR AND PRODUCER

After graduating with a degree from the University of Winnipeg and a diploma at Red River College in Creative Communications, Lisanne Pajot began her career at CBC working as video librarian. She moved from the library into researching, then into producing documentaries and lifestyle television.

Eventually, Pajot left CBC to join James Swirsky at BlinkWorks Media, a commercial production company. Together, they produced videos for some of Canada's biggest brands, and ventured out to produce their first feature film, *Indie Game: The Movie*.

This documentary film about making video games has been receiving awards and accolades since it premiered at the Sundance Film Festival in 2012. Winning Best Editing Award in World Documentary Cinema at Sundance, HBO acquired the rights for a fictional TV series based on the film.

Indie Game: The Movie has screened in theaters all over the world, online (iTunes, Netflix and their own website, and is available in 20 languages. Not bad for two first-time filmmakers from Manitoba.

"We dedicated three years of our lives to making and promoting this film. It's been exciting to create something that connects a lot of people" said Pajot. "It's been an interesting process and we've learned so much. You soon realize that you have to be more than a filmmaker. You have to be an entrepreneur and know how to run a business."

Pajot's advice to budding filmmakers is to make your own opportunities. "Don't wait for someone to give you permission to make something. With all the accessible technology out there, you can start creating films and videos now. The more you produce, the better you get at your craft and the more you learn." ■

WIN AN iPOD SHUFFLE!

If you take a few minutes to fill out this questionnaire, you could win an iPod Shuffle!
Last year's winner was Aminata Condeh of Winnipeg, Manitoba.

1 I am a
- ☐ high school student
- ☐ college student
- ☐ university student
- ☐ employed youth
- ☐ employed adult
- ☐ unemployed youth
- ☐ school counsellor
- ☐ parent
- ☐ unemployed adult
- ☐ newcomer/immigrant

2 Where did you obtain your copy of Prospects?
- ☐ high school
- ☐ college
- ☐ friend
- ☐ private post-secondary
- ☐ university
- ☐ parent
- ☐ employment centre
- ☐ friendship centre
- ☐ career symposium or job fair
- ☐ training/vocational institution
- ☐ post-secondary institution
- ☐ immigration and settlement agency
- ☐ N/A
- ☐ other: ______________________

3 Was Manitoba Prospects used in the classroom?
- ☐ Yes
- ☐ No

4 Did you attend a career symposium this year?

☐ Yes ☐ No ☐ N/A

If so, which one did you attend?

____

5 Have you shown Manitoba Prospects to:
Your parent or guardian?
- ☐ Yes
- ☐ No

Family and friends?
- ☐ Yes
- ☐ No

6 Which article did you find most interesting?

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Do you have any suggestions for the next issue of Prospects?

____

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7 What occupation would you like to see profiled in Prospects?

____

____

Name: ________________________________

Address: ________________________________

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Phone Number: ________________________________

PLEASE MAIL TO: Manitoba Prospects Survey
Manitoba Labour Market Information Unit • 910–259 Portage Ave, Winnipeg, MB R3B 3P4
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