

Unit 2 Introduction to Electronics

Overview

Purpose

The purpose of this unit is to provide students with an opportunity to build knowledge and skills in electronics. Students will use the theory of electronics to manipulate a variety of electronic components. They will learn how to plan design and fabricate circuits and subsequently use standard test equipment to explain the logic of the circuit and troubleshoot any problems that may exist. The skills learned in this unit will be used extensively when students move on programming and interfacing in unit 3, and building a robotic system in Unit 5. This unit is divided into seven topics:

Topic 1: Introduction to Electronics

Topic 2: AC\DC Electronics

Topic 3: Parameters of Circuits

Topic 4: Measurement and Testing

Topic 5: Power Supplies

Topic 6: Soldering

Topic 7: Circuit Board Fabrication

Profile

Students will be involved in:

- Experimenting with AC and DC electronics.

- Experimenting with electric parameters such as charge, current, and resistance.
- Defining the units of measure of electrical parameters such as charge, current, and resistance.
- Identifying the parts of a simple circuit
- Experimenting with series and parallel circuits
- Using a Multi-meter to measure voltage current and resistance in a DC circuit.
- Applying Ohm's, and Kirchoff's Laws in electronic circuits
- Using test equipment to analyze the time and voltage of a variable electric signal.
- Examining the function of discrete electronic components.
- Experimenting with integrated electronic components such as operational amplifiers, H-bridge motor controller and the passive infrared sensor.
- Interpreting and planning circuit diagrams using standard symbol sets.
- Prototyping and fabricating electronic circuits
- Experimenting with switching and non-switching power supplies.

Implementation

This unit should be completed in no more than 25 hours of class time. The electronics unit is a core unit of the course. Students will build essential skills in this unit that they will use when designing and building robots in the design activity.

Evaluation

Unit 2 is intended to introduce students to the tools and skills associated with electronics. The electronics unit should account for 20 percent of the evaluation of Robotics systems Technology 3205.

Evaluation

Outcomes and Strategies

Topic 1: Introduction to Electronics

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.1.1 define electrical parameters and their units of measurement.

Delineation:

Charge (Coulomb)

Electric Potential Difference (Volt)

Current (Ampere)

Resistance (Ohm)

Power (Watts)

Energy (Joules)

Inductance (Henry)

Capacitance (Farad)

Suggested Teaching and Learning Strategies

For the Teacher

This outcome should provide basic definitions of the eight terms. Analogies can also be presented to give alternate representations of each parameter. The basis of the units used to quantify or measure each of the parameters should be discussed.

Points to Emphasize

Basic definitions of each term:

- Charge – A property that sub-atomic particles can have. On a macroscopic level, objects have charge because of a surplus or deficiency of electrons. 1 Coulomb (C): 6.25×10^{18} of electric charges (electrons).
- Electric potential difference is based on the amount of work needed to move a charge. The unit would be based on this amount which is the Volt (V), and is defined as Joule of work per Coulomb of charge.
- Current is a flow of charge between two points in a closed circuit which has a difference in electric potential. Ampere is the unit of measure of current flow (A). 1 Coulomb of electric charge moving past a given point per second.
- Resistance is the opposition to the flow of electric charge that all substances exhibit. This is found in electric circuits, as light bulbs and heater elements. Ohm is the unit of measurement of resistance (I). The ratio of potential difference to current or V/I in a particular circuit.
- Inductance – The property of a circuit element (as example, a coil of wire) such that if a changing magnetic field is close to it, it induces an electric potential difference between the ends of the coil.

Topic 1: Introduction to Electronics

Suggested Assessment and Evaluation Strategies

Journal

- Write a paragraph on how you have heard these parameters used in everyday life.
- Examine the labels on household appliances and record how many of the parameters are listed.

Paper and Pencil

Create a grid or table of the electrical parameters and their function and the unit.

Presentation

Break class into teams and each team is assigned a parameter. Teams are to research the parameter and report their findings back to the class.

Resources

Getting Started in Electronics,
pp. 14, 33,

Specific Curriculum Outcomes*Robotic Systems Technology 3205***Students will be expected to:**

2.1.1 define electrical parameters and their units of measurement.

Delineation:

Charge (Coulomb)

Electric Potential Difference (Volt)

Current (Ampere)

Resistance (Ohm)

Power (Watts)

Energy (Joules)

Inductance (Henry)

Capacitance (Farad)

Suggested Teaching and Learning Strategies

Continued from previous page

- Henry is the unit of inductance (H) is defined as the inductance of a coil when a changing current of 1 Ampere per second induces a potential difference of 1 Volt in the coil.
- Energy is the ability to do work. Joule is the amount of work needed to move a Newton of force one meter.
 $J = IV * I * t$
- Capacitance – the ability to store a charge supplied by an external source. Farad is the unit of capacitance and a unit of measure of the ability to store charge (F). Since the capacitor is a device that stores equal but opposite charges on two metal plates, a Farad is the ratio of the charge on one plate to the potential difference between the two plates. Therefore, $1F = 1 C \text{ per } 1\text{Volt}$.

For the Student

- Student should be able to identify visually the components discussed above, sources of potential differences such as cells, batteries, and have an awareness of charge as they are related to static electricity.
- Break the class into groups. Provide each group with a unit of measure. Have each group prepare a presentation on that unit for the rest of the students in the class.

Suggested Assessment and Evaluation Strategies**Journal**

- Write a paragraph on how you have heard these parameters used in everyday life.
- Examine the labels on household appliances and record how many of the parameters are listed.

Paper and Pencil

Create a grid or table of the electrical parameters and their function and the unit.

Presentation

Break class into teams and each team is assigned a parameter. Teams are to research the parameter and report their findings back to the class.

Resources**Authorized Resource:**

Getting Started in Electronics,
pp. 14, 33,

Topic 1: Introduction to Electronics

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

- 2.1.2 identify and explain the function of common discrete electronic components.

Delineation:

Transistors

Diodes

Resistors

Capacitors

Inductors

Suggested Teaching and Learning Strategies

For the Teacher

Electronic components have specific shapes and formations that often allow visual identification. Students will examine the circuit function of the various components. Data sheets can be acquired for each component that can outline the internal operating parameters of the components.

Points to Emphasize

- Transistors are usually three terminal devices. There are two major types of transistors, bipolar and field effect transistors (FET). Transistors can be used either as a solid state switch or as an amplifier.
- Diodes are solid state devices with two terminals. They allow the flow of current in one direction only and can have special functions as voltage regulators (zener) or light emitters (LED).
- Resistors' physical size depends on power dissipation. Fixed resistors are wire wound and are usually ceramic over wire or carbon composite. Variable resistors can be either rheostats, potentiometers. Resistors act to drop voltages and limit current in a circuit and convert electrical energy into heat.
- Capacitors can be either fixed or variable. A fixed capacitor can be either polarized and made from an electrolytic or non-polarized and made from tantalum, ceramic or mylar. A capacitor's function to store charge.
- Inductors are either fixed or variable and there are a range of inductors available. Inductors are used to resist changes in current in a circuit.

For the Student

Divide the class into groups. Have each group take a discrete component, examine its data sheet and present back to class providing details on things such as variations of the component and its role in an electronic circuit.

Topic 1: Introduction to Electronics

Suggested Assessment and Evaluation Strategies

Performance

Have the students role play an electronic circuit where each student builds a character based on the characteristics of electronic components

Journal

Take one component and write about how they think it is used in a common electronic device.

Paper and Pencil

Find a picture of each of the components and write a caption for the picture explaining its function.

Resources

Authorized Resource:

Getting Started in Electronics,
pp. 24-41

Topic 1: Introduction to Electronics

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

- 2.1.3 identify and explain the function of integrated electronic components.

Delineation:

Operational Amplifier

H-Bridge Motor
Controller

Hall Effect Sensor

Passive Infrared Sensor

IR Distance Sensor

555 Timer

Voltage Regulators

Voltage Trigger

Opto-Isolator

Photo-Transistor

Suggested Teaching and Learning Strategies

For the Teacher

This outcome is dedicated to investigating the function of the indicated devices in a circuit. It is not designed to examine the internal configuration or the internal workings of the device.

Points to Emphasize

Data sheets for each item would be required to show the pin configurations in a circuit (how to hook the device up)

Data sheets would provide the operating parameters for each device including: maximum operating voltage, current, and whether they require a heat sink

For the Student

Provide teams of students with specific scenarios or circuit problems that need to be solved. Students could propose a solution to the circuit problem by researching and applying the appropriate integrated electronic component.

Topic 1: Introduction to Electronics

Suggested Assessment and Evaluation Strategies

Performance

Have the students create lyrics for a song where each student based on the characteristics of electronic components

Journal

Take one component and write about how they think it is used in a common electronic device.

Paper and Pencil

Paint or sketch a picture of each of the components and write a caption for the picture explaining its function.

Resources

Authorized Resource:

Getting Started in Electronics,
pp.122 – 123, 93, 95, 126,
74 – 75,

[http://gander.cdli.ca/es3205/
unit02/section05/lesson02/3-
lesson-a.htm](http://gander.cdli.ca/es3205/unit02/section05/lesson02/3-lesson-a.htm)

[http://gander.cdli.ca/es3205/
unit02/section05/lesson03/3-
lesson-a.htm](http://gander.cdli.ca/es3205/unit02/section05/lesson03/3-lesson-a.htm)

Topic 1: Introduction to Electronics

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.1.4 recognize common symbols used in electronic circuit diagrams or schematics.

Delineation:

Transistors

Diodes

Integrated Circuits Resistors

Capacitors

Inductors

Switch

Wire

Source

Terminals

Fuses\Circuit Breaker

Suggested Teaching and Learning Strategies

For the Teacher

This outcome addresses the recognition of the standard set of symbols used in circuit diagrams. Each electronic component has a specific standard symbol.

Points to Emphasize

- Recognize that some components require proper orientation and it is essential that the circuit diagram reflect this orientation.
- Some circuit symbols have similar representations: recognize those similarities and differences.
- These include Transistors (Bi Polar, FET), Diodes (Power, Signal, Light Emitting), Integrated Circuits (Op Amp, 555 Timer), Resistors (Fixed , Variable (LDR, strain gage, thermister)), Capacitors (Fixed , Variable, (Polarized, Nonpolarized)), Inductors (Fixed , Variable), Switch (Toggle, Momentary, SPST, SPDT...), Wire (Connected Or Not, Loop, Dot Or No Dot), Source (DC\AC Batteries, Power Supply), Terminals, Fuses\Circuit Breaker.

For the Student

- Students could be given a number of components. They could then match the component with the correct symbol on the worksheet.
- The symbols and the component names could be written on index cards. The students could lay the cards face down and take turns turning the cards over matching the component name with its corresponding symbol.

Topic 1: Introduction to Electronics

Suggested Assessment and Evaluation Strategies

Paper and Pencil

Using a grid have students draw the set of symbols and their particular definition.

Presentation

Using a presentation tool, such as PowerPoint or Prezi, create a multimedia presentation that includes electronic symbols and their definitions

Resources

Authorized Resource:

Getting Started in Electronics,
inside cover

http://www.cdli.ca/courses/ctecx104/unit04_org01_ilo08/b_activity.html

<http://www.cdli.ca/courses/ep/predesign/t03.htm>

Topic 1: Introduction to Electronics

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

- 2.1.5 interpret a circuit diagram which includes electronic component symbols.

Suggested Teaching and Learning Strategies

For the Teacher

Students will interpret a circuit diagram by recognizing the electronic component symbols it contains. Some ability to understand the function of the circuit should also be developed.

Points to Emphasize

- The symbol set represents components of differing levels of complexity.
- While each component has its own function the collection of components, commonly called the circuit, has a specific function.

For the Student

- Students could be given a circuit diagram and asked to interpret the symbols contained in that diagram.
- Students could draw a circuit diagram with the symbol sets they have covered. It is important that students create a diagram of a realistic circuit.

Topic 1: Introduction to Electronics

Suggested Assessment and Evaluation Strategies

Performance

Draw a schematic using proper symbols.

Paper and Pencil

Given examples of circuit diagrams, explain the function of the circuit.

Presentation

Students could design their own circuit and explain it to the class.

Resources

Authorized Resource:

Getting Started in Electronics,
pp.20 – 21

http://www.cdli.ca/courses/ctecx104/unit04_org01_ilo09/b_activity.html

Topic 2: AC\DC Electricity

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.2.1 distinguish between AC and DC electricity.

Suggested Teaching and Learning Strategies

For the Teacher

Alternating current reverses direction periodically where direct current is a continuous flow in one direction. An excellent example of an AC wave form can be generated from a low voltage AC adaptor, or by attaching a stepper motor to a drill turning at a constant speed. In both cases the outputs would be attached to an oscilloscope.

Points to Emphasize

- AC and DC can be visualized on a time\voltage graph (voltage on the y-axis). In AC, the graph will extend above and below the x axis. With DC the wave will either be above or below the x-axis constantly.
- DC is usually generated by cells/batteries, solar panels
- AC is usually generated by generators called alternators. AC electricity is used in transportation of electricity because of low energy loss.
- Most electronic devices use DC electricity from the on board battery or converted from AC by the power supply.
- An example of the purest form of DC electricity is obtained from; fuel, photo-voltaic and chemical cells.

For the Student

Teachers can demonstrate the difference between AC and DC with an oscilloscope. Students can draw the graph associated with each type of current.

Topic 2: AC\DC Electricity

Suggested Assessment and Evaluation Strategies

Performance

Students could identify AC and DC current from an example provided by their teacher.

Journal

Sketch and explain the difference between AC and DC current waves

Paper and Pencil

Students could draw an example of AC and DC waves by sketching their graphical representation and explain each.

Resources

Authorized Resource:

Getting Started in Electronics,
pp. 14, 18, 36

http://www.cdli.ca/courses/ctecx104/unit04_org01_ilo02/b_activity.html

Topic 2: AC\DC Electricity

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

- 2.2.2 use an oscilloscope to examine the relationship between time and voltage of a variable electric signal.

Suggested Teaching and Learning Strategies

For the Teacher

Signals graphed on an oscilloscope are depicted as voltage versus time graphs, with voltage on the y axis and time on the x axis. Oscilloscopes can capture very fast voltage changes.

Points to Emphasize

- Oscilloscopes have controls to select the ranges for the voltage and time axis
- Oscilloscopes can measure amplitude (voltage), period (time) and frequency (cycles per second).
- Most digital oscilloscopes can save images of the wave form or the raw data used to plot the wave form.

For the Student

Students should be able to:

- use a PC based oscilloscope to display the wave forms generated by a DC source (connect the poles to the oscilloscope, view the wave form, switch the poles and view the wave form again) and from an AC source.
- adjust the controls to capture a suitable wave form image.
- save and print the wave form or the data that is generated by the wave form.

Topic 2: AC\DC Electricity

Suggested Assessment and Evaluation Strategies

Presentation

- Debate the pros and cons of AC vs DC.
- Develop a radio commercial for either AC or DC forms of energy. Consider your audience and the sales pitch.

Performance

Set up a USB oscilloscope and use it to capture AC and DC signals

Paper and Pencil

Explain the relationship between time and voltage of a variable electrical signal.

Resources

Authorized Resource:

USB Instruments CD-ROM manual

Topic 2: AC\DC Electricity

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.2.3 describe parameters of variable electrical signals

Delineation:

Period

Frequency

Amplitude

Time

Suggested Teaching and Learning Strategies

For the Teacher

Students will gain an understanding that electrical signals can come in a variety of wave shapes and formats (square, sine, triangular, etc) This outcome is a precursor to the concept of pulse width modulation that will be covered in future material. Traditionally, signals have been depicted on voltage versus time graphs, with voltage on the y axis and time on the x axis. This outcome can be demonstrated in a whole class activity and is intended to extend the use of the oscilloscope and its ability to measure parameters of electric signals.

Points to Emphasize

- The amplitude of a wave form is representative of a level of voltage.
- AC wave forms have a peak that is on the positive and negative sides of the x axis (above and below).
- AC wave forms are either above or below the x-axis, dependent upon the polarity of the signal.
- AC wave is one repetitive cycle of a wave train measured from the same point on two consecutive waves. For example from crest to crest.
- The period is the time for one wave to occur (T).
- The frequency is the number of waves per unit time (s). The unit of frequency is the Hertz (Hz) The frequency is the inverse of the period ($f = 1/T$).

For the Student

- Sketch the wave forms for AC and DC waves indicating on your sketch the period, frequency and amplitude.
- Given a wave form, calculate the various electrical parameters (period, frequency, amplitude)
- Using an oscilloscope and the software provided perform analysis on the wave form image to determine Amplitude, period, frequency.

Topic 2: AC\DC Electricity

Suggested Assessment and Evaluation Strategies

Presentation

Capture and print out copies of the wave forms and use this to determine the amplitude, period and the frequency.

Performance

Set up a USB oscilloscope and use it to capture AC and DC signals. Analyze the frequency and amplitude.

Paper and Pencil

Explain the relationship between time and voltage of a variable electrical signal.

Resources

Authorized Resource:

USB Oscilloscope and
EasyScope II Software

Topic 3: Parameters of Circuits

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.3.1 identify the parts of a simple circuit.

Delineation:

Source

Conductors

Load

Suggested Teaching and Learning Strategies

For the Teacher

Basic design of a simple circuit includes the symbols representing basic components (source, conductors, and load) and control elements such as a simple switch.

Points to Emphasize

- Symbol set
- There is a source of potential difference and something that can use that potential difference.
- A simple circuit is an energy converter.
- Even though conductors have very low resistance, the assumption is made that in an ideal circuit, and for the purposes of calculation, the conductors have zero (0) or negligible resistance.
- The convention used to indicate current is electron flow which is negative to positive.
- In simple circuits resistance is the load.

For the Student

Examine a simple circuit and be able to:

- identify the basic structures and components in a simple schematic diagram.
- draw a simple schematic diagram using appropriate symbols.
- assemble a simple circuit from a schematic diagram using components (source, conductors, and load) and a proto-board.

Topic 3: Parameters of Circuits

Suggested Assessment and Evaluation Strategies

Performance

Students could be given a circuit where they will need to identify the source, conductor and load.

Journal

Discuss the components of a flashlight in terms of its source, conductance and load.

Paper and Pencil

In a circuit diagram, identify the source, conductor and loads.

Resources

Authorized Resource:

Getting Started in Electronics,
pp. 20

Topic 3: Parameters of Circuits

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.3.2 differentiate between a series and parallel circuit.

Suggested Teaching and Learning Strategies

For the Teacher

Through this outcome students should get a clear understanding of the difference between a series and parallel circuit.

Points to Emphasize

In a series circuit:

- Current travels along one path.
- Current is constant but voltage drops across each component in the circuit.
- Total of the voltage drops will add up to be the potential gain at the source.

In a parallel circuit:

- Current travels in multiple paths.
- Current can be different across each branch.
- The total of the currents from each branch will add up to the current drop coming from the source.
- The voltage drop across each branch is the same as the voltage coming from the source.

For the Student

Examine simple parallel and series circuits and be able to

- identify the basic structures and components in a simple schematic diagram.
- draw a simple schematic diagram using appropriate symbols.
- represent current and voltage using appropriate symbols.
- experiment with adding components in each circuit and determine the effect on voltage or current.
- assemble a simple circuit from a schematic diagram using components (source, conductors, and load) and a protoboard.

Topic 3: Parameters of Circuits

Suggested Assessment and Evaluation Strategies

Performance

Assemble a simple series and parallel circuit from a schematic diagram using components (source, conductors, and load) and a protoboard.

Paper and Pencil

- Draw a simple schematic diagram using appropriate symbols.
- Represent current and voltage using appropriate symbols.

Presentation

Explain the change in voltage or current as components are added to a series or parallel circuit.

Resources

Authorized Resource:

Getting Started in Electronics,
pp. 20-21

Topic 3: Parameters of Circuits

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.3.3 design a simple circuit using the electronic component symbols.

Delineation:

Source

Conductor

Load

Suggested Teaching and Learning Strategies

For the Teacher

This outcome addresses the ability of a student to utilize the knowledge gained in the preceding outcomes to design an electronic circuit.

Points to Emphasize

There are specific drawing conventions that are used in circuit diagrams that should be adhered to. For example:

- Representation for an IC
- How wires crossing over wires are represented
- How wires connected to wires are represented
- How wires connected to components are represented
- That diagrams are drawn as neat rectangular blocks

For the Student

Using software or pencil/paper students could sketch a design of a circuit using standard symbols and conventions.

Topic 3: Parameters of Circuits

Suggested Assessment and Evaluation Strategies

Performance

Create a poster demonstrating a simple circuit using electronic component symbols.

Journal

Discuss a common simple circuit you would find in your own home. Provide a sketch of that circuit

Paper and Pencil

Sketch a simple circuit and explain the components.

Resources

Authorized Resource:

Getting Started in Electronics,
pp. 20-21

Topic 4: Measurement and Testing

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

- 2.4.1 using a multi-meter, measure voltage, current, and resistance in a DC circuit.

Suggested Teaching and Learning Strategies

For the Teacher

This outcome should examine the configuration, use, and the theory of using a multi-meter to test electronic circuits.

Points to Emphasize

- A multi-meter should be configured in specific ways to gather the appropriate data (settings: selector switch and jacks)
- A multi-meter should be turned to the off position to maintain the reference source.
- Measuring current and voltage involves a different placement of the probes in a circuit. To measure current the meter has to be in series with the component. To measure voltage the meter has to be in parallel with the component.
- Resistance has to be measured across each component and there should be no current in the circuit. Measuring resistance in an active circuit can damage the multi-meter.
- When measuring resistance in parallel circuits where each leg contains a resistor, each resistor in the circuit has to be removed (at least one connection point broken) in order to obtain an accurate resistance value.
- For some general circuits wide tolerances in resistances are acceptable. For measurement circuits the tolerances need to be much smaller.

For the Student

- Obtain and measure a variety of resistances. Compare the measured values of the resistors to the theoretical values and tolerances of the resistors.
- Fabricate a simple circuit and measure voltage, current, and resistance values in the circuit using the multi-meter.
- Fabricate simple parallel and series circuits. Measure voltage, current, and resistance values in the circuits using the multi-meter.

Topic 4: Measurement and Testing

Suggested Assessment and Evaluation Strategies

Performance

Use a multi meter, to measure voltage, current and resistance in a DC circuit

Paper and Pencil

Sketch a circuit diagram demonstrating the proper placement of the probes for measurement of voltage, current and resistance.

Presentation

Create a video of proper technique for measurement of voltage, current and resistance in an electronic circuit.

Resources

Authorized Resource:

Getting Started in Electronics,
pp. 19

CDLI Intermediate Energy and Power resource:

<http://www.cdli.ca/courses/ep/predesign/t03/03optional/act-01a.htm>

Topic 4: Measurement and Testing

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

- 2.4.2 determine the relationship between voltage and current for an Ohmic conductor.

Suggested Teaching and Learning Strategies

For the Teacher

This outcome is a mathematical exploration of the relationship defined by Ohm's Law.

Points to Emphasize

- For an Ohmic conductor the ratio of voltage to current is constant and called resistance
- This can be calculated with the formula $R = V/I$

For the Student

- Using a multi-meter, obtain the voltage across and the current through a resistor configured in a DC circuit. Calculate the resistance. Confirm the predicted resistance value of the Ohmic conductor using those values. Confirm the prediction using the resistor bands, and through the direct measurement of the resistor taken out of the circuit.
- Fabricate a circuit consisting of a fixed resistor in series with a variable DC power supply. Insert a multi-meter in series with the resistor and starting with a 1 volt supply, vary the voltage in 1 volt increments to a maximum of ten volts. Measure and record the current at each interval. Graph current versus voltage with current on the x-axis and voltage on the y-axis. Find and record the slope of the line. Remove the resistor from the circuit and using the multi-meter, find the value of the resistor. Compare the calculated slope value to the measured resistance value.

Topic 4: Measurement and Testing

Suggested Assessment and Evaluation Strategies

Performance

Graph the measurements of Voltage (V) vs. Current (I) for a resistor and then calculate the slope as you vary the voltage.

Journal

Discuss various uses for resistors in common devices such as an I-pod.

Paper and Pencil

Sketch various resistors, identify their resistance by using colored bands and verifying it using a multi meter.

Resources

CDLI Intermediate Energy and Power resource:

<http://www.cdli.ca/courses/ep/predesign/t03/02knowledge-skills/act-09a.htm>

Topic 4: Measurement and Testing

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.4.3 define Ohm's Law.

Suggested Teaching and Learning Strategies

For the Teacher

The theoretical definition of Ohm's Law states that the ratio of the potential difference to the current flowing through a Ohmic conductor is a constant known as the resistance of the substance. The mathematical definition of Ohm's Law is $R=V/I$

Points to Emphasize

- A linear relationship between voltage and current exists only if there is no appreciable increase in the temperature of the substance.
- An ohmic conductor is any material that follows Ohm's Law: the voltage and current are proportional in a linear sense.
- Non-ohmic conductors, as example: Tungsten filament in a light bulb does not follow Ohm's Law: temperature impacts resistance.

For the Student

- Apply the definition of Ohm's Law to word problems to calculate resistance values.
- Describe the conditions under which Ohmic conductors operate.
- Use proper units to express the relationship defined in Ohm's Law.
- In the previous outcome the relationship between voltage and current for an Ohmic conductor was explored. Examine your results and determine if this activity confirmed Ohm's Law.

Topic 4: Measurement and Testing

Suggested Assessment and Evaluation Strategies

Performance

Check the stickers on electrical appliances, and using Ohm's Law, determine V, I, and R

Paper and Pencil

Perform calculations to find the missing value in a $V=I \times R$ equation

Resources

Authorized Resource

Getting Started in Electronics,
pp. 14, 103

CDLI Intermediate Energy and Power resource:

<http://www.cdli.ca/courses/ep/predesign/t03/02knowledge-skills/act-09a.htm>

Topic 4: Measurement and Testing

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.4.4 define Joule's Law.

Suggested Teaching and Learning Strategies

For the Teacher

Joule's Law: $Q = P * t$ where Q is heat energy, P is power, and t is time. Therefore, $Q = I^2 * R * t$ and, using Ohm's Law the equation becomes $Q = V^2 / R * t$. The energy dissipated in a resistor is equal to the power through that resistor over time.

Points to Emphasize

Anything that has a current flowing through a resistor is governed by this law. Think in terms of the elements in a stove, toasters, light bulbs, transmission lines, etc.

For the Student

Discuss examples of heat energy generated in a light bulb, toaster, etc. Use mathematical variations of Joule's Law to calculate heat energy dissipated over time in a resistor.

Topic 4: Measurement and Testing

Suggested Assessment and Evaluation Strategies

Performance

Check the stickers on electrical appliances, and using Joules Law, determine power consumption.

Paper and Pencil

Perform calculations to find the missing value in a $Q=P*t$ equation.

Resources

CDLI Intermediate Energy and Power resource:

<http://www.cdli.ca/courses/ep/predesign/t03/02knowledge-skills/act-09a.htm>

Topic 4: Measurement and Testing

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.4.5 relate Kirchoff's voltage law to voltage in a series circuit.

Suggested Teaching and Learning Strategies

For the Teacher

Kirchoff's Voltage Law states that the voltage of the source should equal the sum of the voltage drops across the components in the series circuit.

Points to Emphasize

- The algebraic sum of the voltages around a closed loop will be zero.
- Mathematically stated $V_s = V_1 + V_2 + \dots V_n$ or $V_s - V_1 - V_2 - \dots - V_n = 0$

For the Student

Using a multi-meter, measure the voltages in a series circuit containing at least two resistors to confirm Kirchoff's Voltage Law.

Topic 4: Measurement and Testing

Suggested Assessment and Evaluation Strategies

Performance

Design a circuit on a protoboard and using a multi meter, measure voltage drop across multiple loads connected in series

Paper and Pencil

Given a circuit diagram that shows all but one voltage use Kirchoff's Voltage Law to calculate the missing voltage.

Resources

CDLI Senior High Physics
3204 resource:

http://www.cdli.ca/courses/phys3204/unit02_org02_ilo04/a_getready.html

Topic 4: Measurement and Testing

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.4.6 relate Kirchoff's current law to current in a parallel circuit.

Suggested Teaching and Learning Strategies

For the Teacher

Kirchoff's Current Law states that the current at the source should equal the sum of the current through the nodes in the parallel circuit.

Points to Emphasize

- The algebraic sum of the currents at a specific node will be zero.
- Mathematically stated $I_s = I_1 + I_2 + \dots I_n$ or $I_s - I_1 - I_2 - \dots - I_n = 0$

Adding devices to a circuit consumes current. Circuit designers must ensure the sum of the currents consumed by the devices used in the circuit does not exceed the current produced by the battery.

For the Student

Using a multi-meter, measure the currents in a parallel circuit containing at least two resistors to confirm Kirchoff's Voltage Law.

Topic 4: Measurement and Testing

Suggested Assessment and Evaluation Strategies

Performance

Design a circuit on a protoboard and using a multi meter, measure current drop across multiple loads connected in series.

Paper and Pencil

Given a circuit diagram that shows all but one current use Kirchoff's Voltage Law to calculate the missing current.

Resources

CDLI Senior High Physics
3204 resource:

http://www.cdli.ca/courses/phys3204/unit02_org02_ilo05/a_getready.html

Topic 4: Measurement and Testing

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.4.7 calculate power and energy
in a DC circuit

Suggested Teaching and Learning Strategies

For the Teacher

- The Power equation is $P = I^2 \cdot R$.
- Know that the product of power and time is energy.
- The kiloWatt-Hr (KWh) is a unit of energy not power.

Points to Emphasize

For the power equations, there are three forms; $I^2 \cdot R$, V^2 / R , and $I \cdot V$.

For the Student

Given a DC circuit students can calculate power and energy which is:

- developed by the source.
- being consumed by each individual component.

Topic 4: Measurement and Testing

Suggested Assessment and Evaluation Strategies

Performance

Design a DC circuit and calculate the power developed by the source and consumed by each component.

Paper and Pencil

Perform calculations to find the missing value in a $P=I^2R$ equation.

Resources

CDLI Intermediate Energy and Power resource:

<http://www.cdli.ca/courses/ep/predesign/t03/02knowledge-skills/act-09a.htm>

Topic 5: Power Supplies

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.5.1 describe the operation of a non switching DC power supply.

Delineation:

Transformer

Diode (Rectifier)

Diode bridge

Filter (Capacitor)

Regulator

Suggested Teaching and Learning Strategies

For the Teacher

A non switching power supply is used to convert AC to DC for use in electronic devices.

Points to Emphasize

- A typical non switching power supply consists of a transformer, a diode bridge and filtering components (capacitors and/or inductors).
- Power supplies can be regulated and have fixed or adjustable power supplies.

For the Student

Students could use protoboards to construct a full wave power supply.

Topic 5: Power Supplies

Suggested Assessment and Evaluation Strategies

Performance

Using a diagram trace the electron flow through a diode bridge.

Paper and Pencil

Draw a schematic of a full wave power supply.

Presentation

Using a USB oscilloscope, demonstrate the effect of different size capacitors on the output waveform of a diode bridge.

Resources

Authorized Resource:

Robot Builders Bonanza, pp. 292 - 297

Authorized Resource:

Getting Started in Electronics, pp. 125

PC in Control

http://www.pc-control.co.uk/linear_psu.htm

Topic 5: Power Supplies

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.5.2 describe the operation of switching DC power supply.

Delineation:

Transformer

Diode (Rectifier)

Diode bridge

Filter (Capacitor)

Regulator

Transistor (Switch)

Suggested Teaching and Learning Strategies

For the Teacher

High speed transistors enable the conversion of AC to DC current. In any power supply, the size of the transformer and filter capacitors is inversely proportional to the frequency of the AC input.

Points to Emphasize

- In a switching power supply, the AC input is immediately changed to DC.
- The DC is then switched by a transistor at high frequency to provide the collapse and expansion of the magnetic field needed by the transformer to operate (mutual inductance).
- Because of this high frequency, the step down transformer and filter capacitors can be much smaller.

For the Student

Compare the physical dimensions and weight of a traditional and switching power supply.

Topic 5: Power Supplies

Suggested Assessment and Evaluation Strategies

Performance

Using a diagram trace the electron flow through a switching power supply.

Paper and Pencil

Draw a schematic of a switching power supply.

Presentation

Collect examples of switching and non-switching power supplies and contrast each, i.e. size, weight, current size, etc.

Resources

Authorized Resource:

Robot Builders Bonanza, pp.
292 - 297

SMPS Technology:

<http://www.smpstech.com/tutorial/t01int.htm#SMPSDEF>

Topic 6: Soldering

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.6.1 discuss wire characteristics as they apply to a variety of applications

Delineation:

Stranded versus Solid

Gauge

Type of insulation

Suggested Teaching and Learning Strategies

For the Teacher

Proper wire selection for electronics fabrication is critical to the success of robotics projects. Wire characteristics include stranded, solid, gauge of wire and type of insulation.

Points to Emphasize

- Stranded and solid wire has specific applications.
- American wire gauge (AWG) is the most common measurement for electrical wire size – the lower the wire gauge number, the larger the wire diameter and the greater the current carrying capability. For example, the wire for your oven at home requires #8 wire to carry 40 amps, while the receptacles in your home require #14 to carry 15 amps.
- Wire can be bare, have non metallic (NM) or metal coating.

For the Student

- Research the uses for stranded and solid wire.
- Determine which gauge of wire is appropriate for robotics applications.

Topic 6: Soldering

Suggested Assessment and Evaluation Strategies

Performance

Collect scraps of wire from home, around the lab, and determine the type and gauge.

Paper and Pencil

Create a table consisting of wire gauge and type and the common uses of each.

Presentation

Investigate power line types and gauge. Look up its resistance, and explain how its resistance is related to energy loss over long distance transmission.

Resources

Authorized Resource:

Getting Started in Electronics, pp. 98, 24

Authorized Resource:

Robot Builders Bonanza, pp. 49 – 52

CDLI Intermediate Energy and Power resource:

<http://www.cdli.ca/courses/ep/predesign/t03/03optional/act-08a.htm>

External Links:

<http://www.wecusurveillance.com/files/891125/uploaded/WGC.pdf>

http://www.powerstream.com/Wire_Size.htm

Topic 6: Soldering

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.6.2 demonstrate methods of splicing wire

Delineation:

Western Union splice (in-line splice)

Pigtail

Application of heat shrink tubing

2.6.3 demonstrate proper soldering techniques

Delineation:

Solder selection

Soldering iron selection

Care of soldering iron

Heat sink protection of sensitive components

Suggested Teaching and Learning Strategies

For the Teacher

Splicing and soldering wire is one of the key skills in fabrication of robotics systems. The functionality and reliability of any robotic system is dependent upon the quality of the electrical connections. Soldering irons require care and users must be use irons safely.

Points to Emphasize

- Wires are normally joined by Western Union splice or pigtail connections.
- Wire splices can be insulated using marrettes, electrical tape, heat shrink tubing or liquid electrical tape depending on the application and type of splice.
- Different types of solder have different applications. In robotics fabrication it is common to use 0.5-0.7 mm tin-lead rosin core solder.
- There are various types and qualities of soldering irons. There are several things to consider when choosing a soldering iron; wattage, adjustable or fixed temperature, portable or bench use
- Soldering iron care includes; proper tinning of the tip, keeping the tip clean, avoiding corrosive fluxes, avoiding sandpaper or abrasive material to clean your iron.
- Soldering irons get very hot and care must be taken with their use. This temperature can cause severe burns and/or melt the plastic sheathing on the soldering iron power cord causing a short.
- The heat from soldering can damage sensitive electronic components. Heat sinks absorb the heat energy and protect the component from damage.

For the Student

Make connections using stranded and solid wire using both splicing methods, solder connections as required and insulate the joins.

Topic 6: Soldering

Suggested Assessment and Evaluation Strategies

Performance

- Demonstrate wire splicing.
- Demonstrate the installation of heat shrink.
- Demonstrate proper soldering iron care.

Paper and Pencil

Research types of solder and explain their use.

Presentation

Research and determine why there is a splice named after the company Western Union.

Resources

Authorized Resource

Robot Builders Bonanza, pp. 79 – 84

CDLI Resources

http://gander.cdli.ca/es3205/videogallery/splicing_wires.wmv

External Links:

http://www.elexp.com/t_solder.htm

<http://www.mediacollege.com/misc/solder/tools.html>

<http://www.inlandcraft.com/uguides/tipcare.htm>

http://www.digikey.com/Web%20Export/Supplier%20Content/Cooper_72/PDF/Cooper_TipCareAndUse.pdf

Topic 7: Circuit Board Fabrication

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.7.1 prototype a circuit given a protoboard (breadboard).

Suggested Teaching and Learning Strategies

For the Teacher

Protoboards are solderless boards on which components can be placed for circuit design and testing. Students can transfer the circuit diagram to a prototype on the protoboard. Make the appropriate connections and test the functionality of the circuit.

Points to Emphasize

- A tutorial should be given that elaborates on how the protoboard is connected underneath and how power and ground are connected.
- Use the proper techniques when designing a circuit on a protoboard this should include: proper wire lengths that are flat and interconnected.
- Start from the central component when laying out the design
- Circuits should be neat and tidy.
- The protoboard is used to develop a temporary prototype of a circuit which is utilized to troubleshoot and perfect a working circuit.
- Sometimes a protoboard is called a breadboard in honour of the times when radios were constructed on mother's bread board!

For the Student

Using a pre-designed circuit diagram, transfer the circuit to a protoboard.

Topic 7: Circuit Board Fabrication

Suggested Assessment and Evaluation Strategies

Performance

Design, build and test a circuit on a protoboard.

Paper and Pencil

Using a grid map out a circuit and transfer this to a protoboard.

Presentation

Explain how a typical protoboard is connected internally.

Resources

Authorized Resource:

Robot Builders Bonanza, pp. 84 – 92

External Link:

<http://phet.colorado.edu/en/simulation/circuit-construction-kit-ac-virtual-lab>

Topic 7: Circuit Board Fabrication

Specific Curriculum Outcomes

Robotic Systems Technology 3205

Students will be expected to:

2.7.2 fabricate the circuit on a pre-etched board.

Suggested Teaching and Learning Strategies

For the Teacher

Care must be taken to transfer the circuit prototyped in the previous outcome to a pre-etched, permanent circuit board. The components will be soldered to the board and tested to produce a working circuit.

Points to Emphasize

- The circuit board is an approximate one-to-one representation of the protoboard.
- Proper soldering techniques and safety procedures must be followed.
- Heat sinks should be used if soldering sensitive components.

For the Student

Using a pre-etched circuit board, transfer the circuit from the protoboard to the circuit board.

Topic 7: Circuit Board Fabrication

Suggested Assessment and Evaluation Strategies

Performance

Using a pre-etched circuit board, transfer the circuit from the protoboard to the circuit board observing correct and neat placement of components, proper soldering techniques. Test the circuit.

Presentation

Demonstrate various uses for the circuit.

Resources

Authorized Resource:

Getting Started in Electronics
pp. 96-100

