

Activity 4 - Analog v.s. Digital

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Learning Outcomes

Students will,

1. build an analog motor control circuit
2. use a multimeter to observe a changing analog voltage

This activity should take **~1 hour** to complete:

- 10m review of previous concepts
- 10m introduction to new concepts
- 30m hands-on activity

It assumes free access to a black-and-white printer and a classroom with a whiteboard, blackboard, or chart-paper. This activity does not require regular access to electricity.

Materials and Costs per Student

Item	Qty.	Cost per Student ¹	Expendable ²	Supplier
Push Button	1	0.02	y	Aliexpress
Potentiometer 10k*	1	0.38	y	Aliexpress
LED Assorted 3mm 5mm	1	0.02	y	Aliexpress
Resistor 220 ohm 1/4W	1	0.01	y	Aliexpress
9V Battery Snap	1	0.16		Aliexpress
Jumper cables MM 10cm	4	0.08	y	Aliexpress
Breadboard 400 point	1	1.49		Aliexpress
Vibrator Coin 3V	1	0.61		Aliexpress
Breadboard Power Supply	1	0.75		Aliexpress
9V Ni-Mh 450mAh	1	5.17		Aliexpress
Total Cost per Student		\$8.69 CAD		

*The potentiometers are likely to be broken during the activity due to short-circuits. It is helpful to have extras on-hand.

Lesson

Before class: connect each of the power supplies to a breadboard; snap the battery snaps onto the 9V batteries; print student handouts.

Outline:

1. Review
 1. Show the completed motor control circuit and explain the objective of the activity
 2. Review the rockslide analogy of electricity
 3. Review turning the LED circuit ON/OFF using a switch or providing providing 5V or 0V digital output from Arduino
2. Analog Values
 1. Introduce the concept of analog electronic values
 2. Give examples of analog applications
 3. Introduce potentiometer (pot): gives an range of output voltages depending on position (pinout, circuit diagram)
 4. Explain potentiometer function using the rock-slide analogy (multiple trees to divide voltage)
3. Motor Circuit Diagram
 1. Draw motor vibration circuit diagram.
 2. Give the students the handouts and materials and have them try building the circuit

1. Review

- Explain that the objective of the activity is to build a circuit to control the speed of a motor
- Show a working example of the motor control circuit
- Draw the rockslide analogy of electricity
- Recall the use of a digital value from the Arduino to control the LED: ON (5V), OFF (0V)
- What if we want to turn the LED on at 1/2 brightness? Or make it strobe smoothly on and off?

2. Analog Values

- Analog divides a voltage into a continuous range, with an infinite number of values
- ask students to classify some examples
 - controlling the brightness of a light (analog)
 - A switch (digital) (use class light as example)
 - playing music on a speaker (analog)

- controlling the speed of a fan (analog) (use class fan if available)
- Rockslide analogy: energy (voltage) is lost as the rocks (current) pass through the trees. If we have 5 trees (resistors), on a 5V “hill,” and the trees are all the same size, we will lose 1V as the rock passes each tree. This can be extended to 10 trees, or 100 trees, or 1000 trees, until we have an infinite number of voltage points along the “hill.”

3. Potentiometer

- A potentiometer is a variable resistor that gives us access to one of these points on the hill
- Show a visual drawing of a pot, its circuit-diagram representation, and its pinout (see the images on the student handout)
- If we attach pin 1 to 5V, and pin 3 to GND, pin 2 will give us an analog voltage between 5V and 0V as we turn the knob
- Draw circuit examples of the potentiometer turned to different sides (different resistances), to show how pin 2 becomes connected with 5V on one side and 0V on the other, depending on how the knob is turned
- Short-circuit warning: pin 2 should never be attached directly to 0V or 5V

4. Motor Circuit Diagram

- Explain that the objective is to build a circuit to control the speed of a vibrating motor
- Draw circuit diagram from Student Handout, and explain the flow of current, and how the voltage applied to the motor changes using the pot
- Give the students the handouts and all of the parts needed to build the circuit and have them begin to try it out

Challenge and Explore

Evaluate the students’ understanding of the learning objectives by asking them to try the following:

- Can you add a switch to make the motor start and stop, like a digital value?
 - Skill: Building breadboard circuits
 - Skill: Understanding electricity (rock-slide analogy)
- Can you change the circuit so that it controls the brightness of the LED? (must combine with 220 ohm resistor to prevent burnout)
 - Skill: Using analog values to control a circuit
 - Skill: Building breadboard circuits
 - Skill: Understanding electricity (rock-slide analogy)
- Can you control both the LED brightness and the motor together?
 - Skill: Using analog values to control a circuit

- Skill: Building breadboard circuits
 - Skill: Understanding electricity (rock-slide analogy)
 - Can you change the circuit so that when the LED becomes brighter the motor slows down and visa versa?
 - Skill: Using analog values to control a circuit
 - Skill: Building breadboard circuits
 - Skill: Understanding electricity (rock-slide analogy)
 - Can you explain why the current goes through the motor, and not through the pot?
 - Skill: Understanding electricity (rock-slide analogy)
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1. Currency is CAD, 2017-06-10. Assuming one set of parts per student. [↵](#)
2. Likely to be broken or lost during the activity. [↵](#)