

Lesson Two: Robot Gripper Hand
Center for Sensorimotor Neural Engineering
Lesson Plan Author: Phelana Pang



LESSON OVERVIEW

Activity Time: 50+ minutes.

Lesson Plan Summary:

Students will experiment with an electromyography (EMG) controlled robot gripper hand to see that electrical signals generated by muscles can be used for electrical circuits. Students will also draw similarities between the sensory inputs and motor outputs of a nervous system with the inputs and outputs of a circuit.

STUDENT UNDERSTANDINGS

Big Idea & Enduring Understanding:

- Electrical signals produced by our neuromuscular system can be detected; these same signals can be used for electrical circuits.
- Our nervous system involves processing input from sensory neurons, causing an output through motor neurons. Circuits can also vary their output based on input.

Essential Question:

- How are the nervous system and electrical circuits similar?

Learning Objectives:

Students will know...

- Electrical signals generated by muscles in our body can be detected using electromyogram (EMG) electrodes.
- Electricity flows through a circuit.
- The same electrical signals from our muscles can be used to control a motor in a circuit.
- Nervous system pathway includes input from sensory neurons, processing by the brain, and output through motor neurons
- Robot gripper hand device takes input from muscles, electrical signals are processed by Arduino/Muscle SpikerShield, and movement results in gripper hand based on electrical signals from Arduino/Muscle SpikerShield

Students will be able to...

- Describe through words and diagrams the similarities between the nervous system and an electrical circuit.

Vocabulary:

- **Divisions of the nervous system:** central nervous system (brain and spinal cord), peripheral nervous system (sensory/afferent neurons, motor/efferent neurons)
- **Electromyogram (EMG)**

Standards Alignment: This lesson addresses the following middle school Next Generation Science Standards (NGSS).

NGSS High School Disciplinary Core Ideas

- **MS-LS1.A: Structure and Function:** Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.

NGSS Cross-Cutting Concepts

- **Systems and Systems Models**
- **Structure and Function**

NGSS Science & Engineering Practices

- **SEP:** Developing and Using Models

MATERIALS

Material	Description	Quantity
Robot Gripper Hand with Arduino and Muscle SpikerShield	\$189 from https://backyardbrains.com/products/clawBundle	1 for class
EMG electrodes	\$29 from https://backyardbrains.com/products/emglargeelectrodes	2 per student
<i>Student Handout 2.1: Robot Gripper Hand</i>	Students record questions and observations	1 copy per student

TEACHER PREPARATION

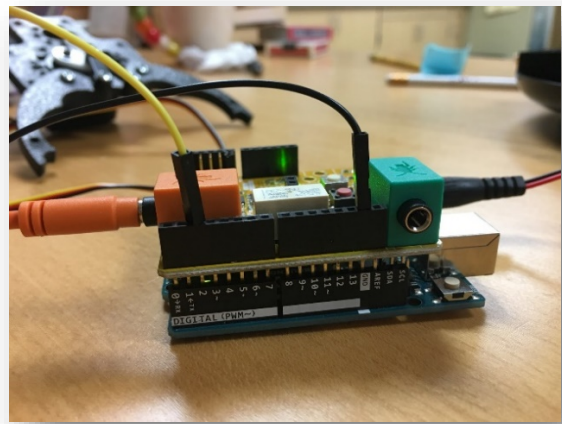
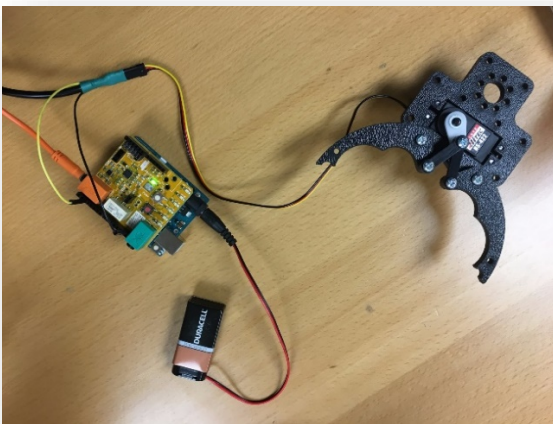
1. Set-up and test the gripper hand: Connect the gripper hand to the Arduino and Muscle SpikerShield and test its action using the EMG electrodes to make sure its works reliably. Directions come with the purchased gripper hand kit. Note: You may need to calibrate the gripper hand using the two buttons on the top of the SpikerShield to adjust the threshold and whether the claw is open or closed. The following websites may be helpful:
 - https://backyardbrains.com/experiments/musclespikershield_gripperhand
 - <https://backyardbrains.com/experiments/RobotHand>
 - <https://backyardbrains.com/products/clawbundle>
2. Copy handouts as listed in the Materials section above.

PROCEDURE

Engage: Electricity in the Nervous System (10 minutes)

1. Have students share out what they remember about the structure and function of the nervous system.
2. Pass out *Student Handout 2.1: Robot Gripper Hand* and show students the device. Ask students the question (through pair-shares or journaling): “How might something like a robotic hand that is connected to an Arduino processor be similar to our nervous system?”

Explore: EMG-Controlled Robot Gripper Hand (30 minutes)





3. Attach two electrodes per student (one on inside of upper forearm, one near inside of wrist, along the arm muscle), as pictured above. Student should hold the ground wire in other hand. Try to get robot hand to grip objects by having the student tense and relax their hand, activating the muscles in their arm.
4. Ask the following questions (think-pair-share, class discussion) and document their observations/questions on *Student Handout 2.1: Robot Gripper Hand*:
 - a. What are you observing? What questions do you have?
 - b. What is happening? Where's the input? What's the output? Is there any processing in between?
5. Have as many students try out the device as time will allow.
6. Have different variations/challenges: grip different objects (Styrofoam peanut, eraser, crumpled paper balls, etc.); use different muscles (forearm, bicep, leg, cheek); transfer objects from one bowl to another; use two people (one with the electrode patches on their body, the other holding and maneuvering the robot gripper hand). Have students record additional observations on the back of their student handout or in their lab notebook.

Explain: Wrap-up Discussion (5 minutes)

7. Class discussion: How does the robot hand and circuits connect to our nervous system? Emphasize: electricity, inputs, processing, and outputs.

Evaluate: Exit Ticket (5 minutes)

8. Exit ticket: How is the robot gripper hand connected to the nervous system? Use as many terms and connect as many ideas from our lesson today.

STUDENT ASSESSMENT

Assessment Opportunities: Student knowledge, skills, and concepts for this lesson will be assessed in a number of ways.

- Class discussions can be used to check for general understanding.
- Exit ticket can help with seeing whether students made connections between robot arm, circuits, and nervous system.

Student Metacognition:

- Provide students opportunities to come up with questions, reflect on their initial ideas about what they know and understand, and write them down in their lab notebook. They can add new/changing ideas to their lab notebook.
- Students will reflect on their learning when they complete the exit ticket.

Scoring Guide:

- *Teacher Resource 2.1* provides a scoring key for *Student Handout 2.1*.
- Look for the following in the exit ticket:
 - Electricity is used for signaling human body (muscles and nerves).
 - Electricity is used to move the gripper hand.
 - Electric signal from muscles can control gripper hand.
 - Nervous system has inputs (senses) and outputs (movements).
 - Robot hand took input (electrical signal from muscles) and output was movement.

EXTENSION ACTIVITIES

Extension Activities:

- Record and study electrical signals produced on computer, tablet, or phone by plugging the muscle shield into a computer with the Backyard Brains Spike Recorder application. Students can change variables (such as length of contraction, distance between electrodes) when exploring the robot gripper arm and observe differences in electrical signals. See <https://backyardbrains.com/experiments/muscleSpikerbox>.

- Any battery operated circuit component (motors, buzzers) can be connected to the output pin of the Arduino Muscle SpikerShield. Students can try to manipulate different outputs with their muscle activity.

TEACHER BACKGROUND & RESOURCES

Resources:

Additional experiments that can be conducted with the Muscle SpikerShield can be found at Backyard Brains (<https://backyardbrains.com/experiments/muscleSpikerShield>).

Citations:

Photographs taken by Phelana Pang.

EMG Gripper Claw from Backyard Brains.

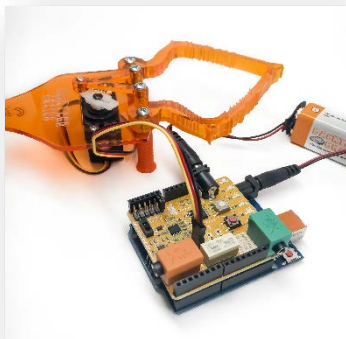


Student Handout 2.1: Robot Hand

Name: _____ Date: _____ Period: _____

Observations	Questions

The Science behind the Hand



How this connects to the Nervous System

My Ideas	Class Discussion

Photo: EMG-controlled robotic gripper hand and muscle SpikerShield from Backyard Brains.



Teacher Resource 2.1: Robot Hand Answer Key

Observations	Questions
<p>Possible answers:</p> <ul style="list-style-type: none">• When flex, gripper hand closes• When relax, gripper hand opens• Takes practice to control• When ground cable is not held by other hand, it doesn't work.• Smaller movements result in less of a grip	

The Science behind the Hand

- Electrical signal comes from the human arm and is detected by electrodes
- Wires carry the electrical signal to Arduino
- The Arduino processes the electrical signal
- Wires carry another electrical signal to the gripper hand
- Gripper hand moves as a result

How this connects to the Nervous System

My Ideas	Class Discussion
	<p>This models the nervous system. Input of electrical signal from human arm is like input into senses of nervous system. Wires from the electrodes are like sensory neurons taking the information to the brain. The brain processes the information, just like the Arduino processes the electrical signals generated by the human arm. Wires carrying the electrical signal for output are like motor neurons. Gripper hand movement is analogous to muscle movement.</p>