CAN YOU SENSE IT? | EDUCATOR

Module 2: Sensor Technology Series

Links to Next Generations Science Standards |
MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Links to Common Core Standards |
CCSS.ELA-LITERACY.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments or performing technical tasks.

CCSS.ELA-LITERACY.RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context.

S T E M

Contributing Author | Dennis (DJ) Pevey, Science Communication Fellow
Pacing | 1-3 class periods
Background Needed | Completion of STS Module 1: Codes & Controllers
Assessment | Rubric provided
Materials/Resources |

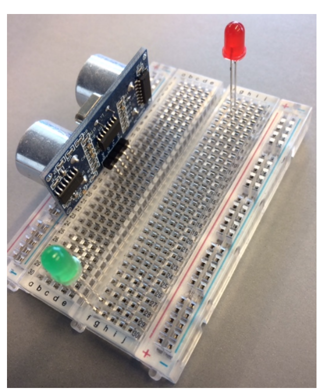
- Each group will need the following:
  - Any non-chromebook computer or laptop
  - 1 mini USB cable (http://nautl.us/2v1zbTH)
  - 1 Arduino Uno/Genuino (http://nautl.us/2uBQw4x)
  - 1 Breadboard (http://nautl.us/2u2uWml)
  - 1 HC-SR04 Ultrasonic Sensor (http://nautl.us/2f1RUZl)
  - 1 green LED (http://nautl.us/2eRHcEl)
  - 1 red LED
  - 2 (560 ohm) green, blue, brown, gold resistors (http://nautl.us/2eq82Qs)
  - 8 male-male hookup wires (http://nautl.us/2vbknSS)
  - Fritzing Diagram (http://nautl.us/2wpVguX)
  - Optional: magnifying glasses

Overview

This module will take students to the next step of incorporating a sensor with Arduino technology. Students will learn basic programming techniques for an Arduino programmed proximity sensor, design their own mini-experiment, and collect and analyze data. Students will read about how sensor technology is used on Exploration Vessel (E/V) *Nautilus*.

Objectives & Learning Outcomes

- Students will identify practical applications of sensor technology.
- Students will learn how to use a sensor and Arduino to collect data.
- Students will understand basic commands utilized to program a sensor.
- Students will demonstrate proper use of a proximity sensor and serial monitor by designing and carrying out an experiment.



Set The Stage!

Have the following questions on display when students enter the classroom to gage students' background knowledge with the topic:

- Provide some examples of how sensors are used in today's society.
- Why are sensors useful to scientists?
- How do you think a sensor works?

Extensions & Adaptations

Introductory |
Have students work in pairs to go through the code included in the student module and decipher what each line means for further understanding.

Advanced |
Have students incorporate code to see if they can make LEDs blink at different distances, for example when an object is close to the sensor the LEDs light up, and turn off the further away it is.

Activity/Tasks

Students will:

- Determine work group arrangements and group roles (suggestions: team manager, materials manager, reader, engineer, team advocate if in need of assistance, etc.).
- Read through the lesson introduction and procedure
- Gather all materials.
- Work through the all parts of the procedure and complete all associated tasks.

Educator: Lesson Procedure/Directions

✓ **LESSON SET-UP |** It is suggested that students work in small groups to complete this module.

☐ Helpful tips:

- ✓ Set up required student materials ahead of time at each student work station. It may be beneficial to establish group roles (such as materials manager, timekeeper, engineer, etc. to ensure efficiency in collaboration). Have extra materials on hand for student experiments, or have students create their own materials lists.
- ✓ Examples of experiment ideas:
  - ✓ Do hard surfaces register differently than soft surfaces?
  - ✓ How large does an object have to be to register on the sensor?
  - ✓ Do porous surfaces register differently than non-porous surfaces?
- ✓ Laminate Fritzing diagrams to have available at each student group work area.
- ✓ Arduino troubleshooting guide: https://www.arduino.cc/en/Guide/Troubleshooting
- ✓ Circuits info: http://ugweb.cs.ualberta.ca/~c274/web/ArduinoIntro/section/buildingcircuits.htm#CircuitWiring
- ✓ Remind students of the following:

** Make sure to double and triple check wiring.
** Remember to pay attention to the + end of the LEDs (the long side is positive and should be connected to the digital pins (not ground) on the Arduino board.
** Resistors are non-polar; it doesn't matter which direction they're plugged in.
** Make sure the code matches the pin numbers on the board.
** The different colored wires are all the same. Students can choose which colors and lengths of wires to use to best suit the connections needed.

CAN YOU SENSE IT? | STUDENT

Module 2: Sensor Technology Series

Learning Goals

- Learn how to use a sensor and Arduino technology to collect data.
- Understand basic commands utilized to program a sensor.
- Demonstrate proper use of a proximity sensor and serial monitor by designing and carrying out a mini-experiment.

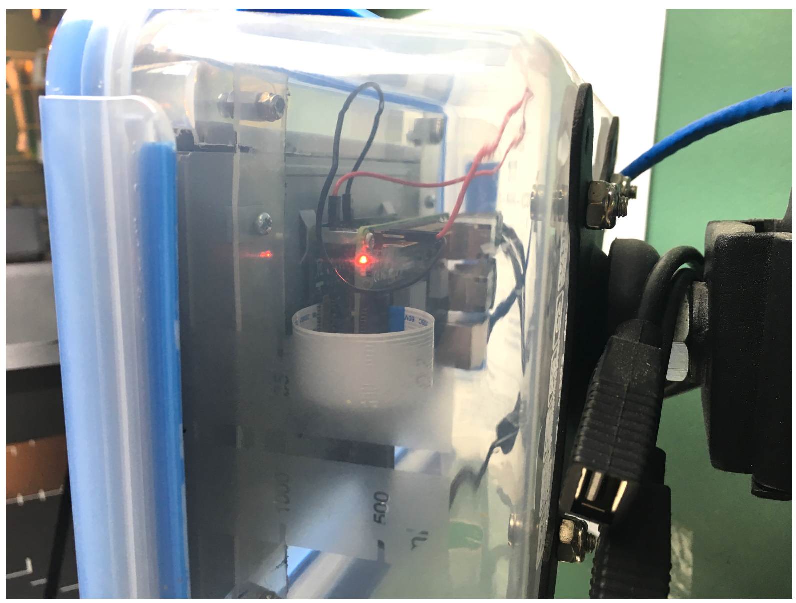
THINK About It!

Household objects, like a Roomba®, use proximity sensors to detect their surroundings.

Set a timer for 2 minutes. What other sensors can you think of? Compare your list with a friend's! Were there some different types you hadn't thought of?

Introduction | Have you ever used a digital thermometer, noticed a car's empty gas tank warning light, or used a digitized touch screen? Whether you realized or not, you were interacting with a sensor and do almost every day. Sensors detect or take measurement of physical properties like temperature, sound, and motion and report them as a signal which can be read by an observer or electronic instrument (such as a computer). There are many different types of sensors used for a wide variety of purposes such as heart rate monitors, motion sensors, darkness-sensing lights, smoke detectors, or seismic monitors which can provide an early warning system for earthquakes.

On Exploration Vessel *Nautilus*, our data engineers program sensors for important purposes like monitoring the temperature around delicate equipment in the wet lab and to track humidity in the computer server room where equipment directs the live expedition video feeds from the ship to satellites and ultimately to your screen on www.NautilusLive.org.



A side view of the temperature sensor in Nautilus' wet lab

In this module, you will learn basic programming techniques for an Arduino proximity sensor. You will also design your own mini-experiment using this new sensor tool.

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Module 2: Sensor Technology Series

Helpful Resources:

Background information on breadboard circuits:

- http://ugweb.cs.ualberta.ca/~c274/web/ArduinoIntro/section/buildingcircuits.htm#CircuitWiring

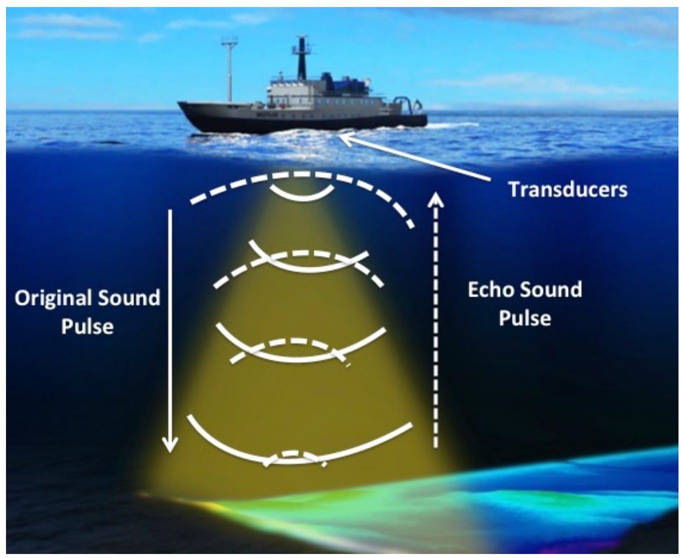
Oceanography Sensors & Samplers basic info:

- http://www.whoi.edu/main/instruments/sensors-samplers

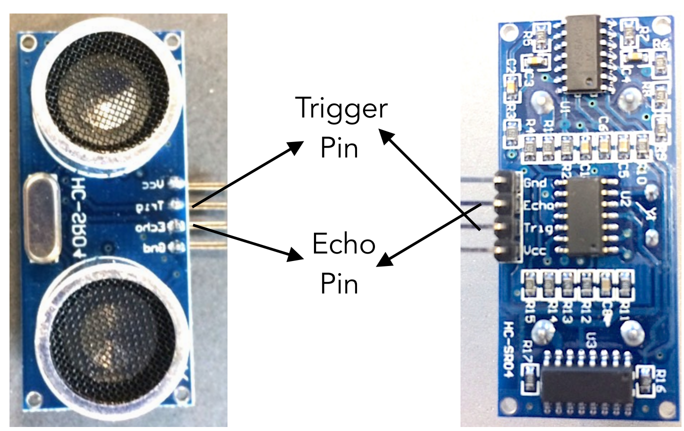
More Sensor Projects:

- http://www.instructables.com/id/Arduino-Distance-Detector-with-a-Buzzer-and-LEDs/
- http://wonderfulengineering.com/10-best-proximity-sensor-modules-for-electronics-project/

Background | A proximity sensor is a sensor detects the presence of nearby objects without any physical contact. Back-up cameras are common examples of proximity sensors. Proximity sensors also have a wide range of applications in ocean exploration. SONAR (Sound Navigation And Ranging) is a technology used by vessels such as *Nautilus* to navigate and map the seafloor. A SONAR transducer attached to the ship sends an acoustic signal pulse into the water. This signal bounces off the seafloor bouncing a return "echo" back to the transducer. The transducer can calculate a range from the seafloor to the ship using a formula that incorporates time delay from when the signal was sent to when the echo is received.



In this module, you will use a HC-SR04 Proximity Sensor which acts very similarly to a mapping transducer that generates seafloor maps on E/V *Nautilus*. The HC-SR04 contains a **trigger pin** to emit a tone and an **echo pin** to listen for an echo rebound of that sound. These tones are inaudible to the human ear.



Sensor Front Sensor Back

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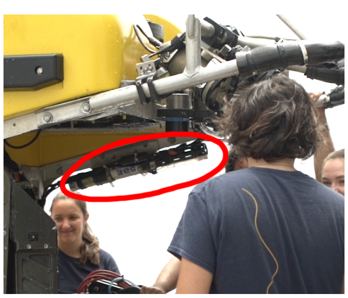
Module 2: Sensor Technology Series

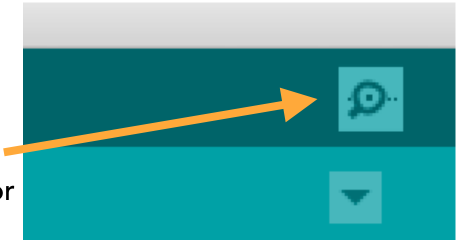
NAUTILUS NEWSFLASH

ROV (Remotely Operated Vehicle) *Hercules* is equipped with a packaged set of electronic sensors - a CTD - to measure conductivity, temperature, and depth of the water surrounding the robot. These sensors are powered by the ROV's power supply and acquire real-time data. CTD sensor data provide scientists with essential information about new marine environments as they are explored and track ocean current and climate conditions over time.



When working with sensors, it is helpful to be able to view the data on an output screen. The serial monitor in the Arduino IDE allows you to see serial data coming in from the Arduino board.

Serial Monitor



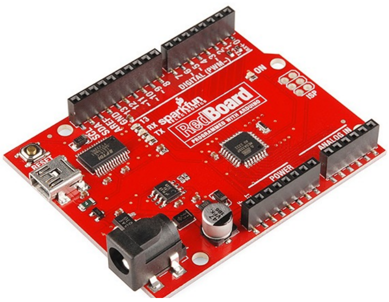
The commands "print" and "serial." in a sketch tell the serial monitor what to display. See if you can find these commands in the example sketch below:

```
/* Simple Serial ECHO script
/* Stage 2 : Delimiters */

/* Use a variable called byteRead to temporarily store
   the data coming from the computer */
byte byteRead;

void setup() {
// Turn the Serial Protocol ON
  Serial.begin(9600);
}

void loop() {
   /*  check if data has been sent from the computer: */
  if (Serial.available()) {
    /* read the most recent byte */
    byteRead = Serial.read();

    /*Listen for a comma which equals byte code # 44 */
    if(byteRead==44){
      Serial.println();
    }else{
      /*ECHO the value that was read, back to the serial port. */
      Serial.write(byteRead);
```

Materials |

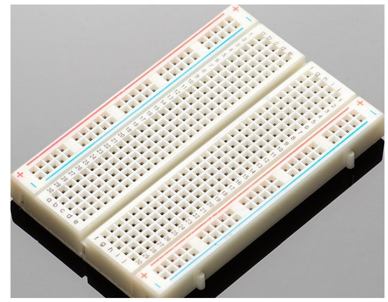
Each group will need the following:

- Any non-chromebook computer or laptop



Arduino Uno

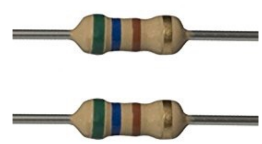
1 HC-SR04 Ultrasonic Sensor



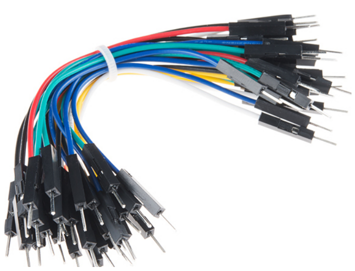
1 Breadboard

1 Green LED

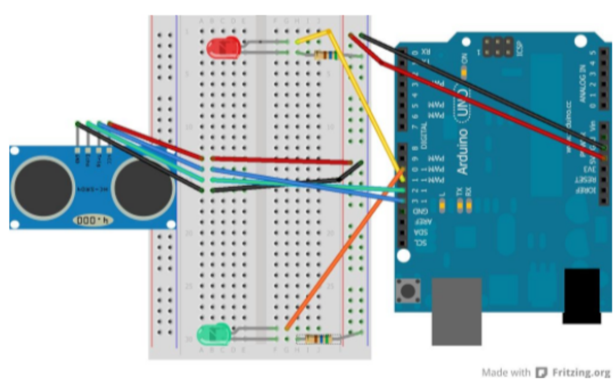
1 Red LED



2 (560 ohm) green, blue, brown, gold resistors



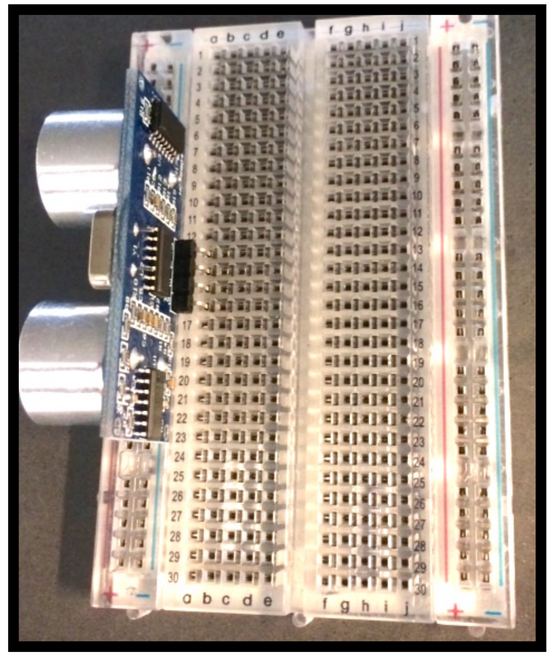
8 hookup wires

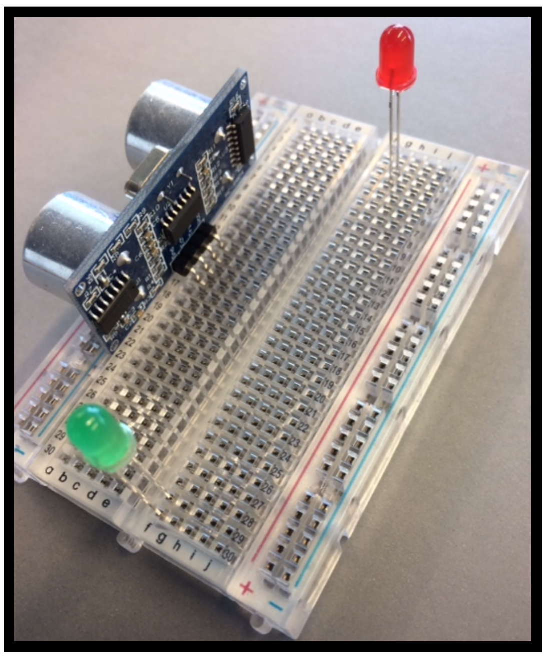


Fritzing Diagram

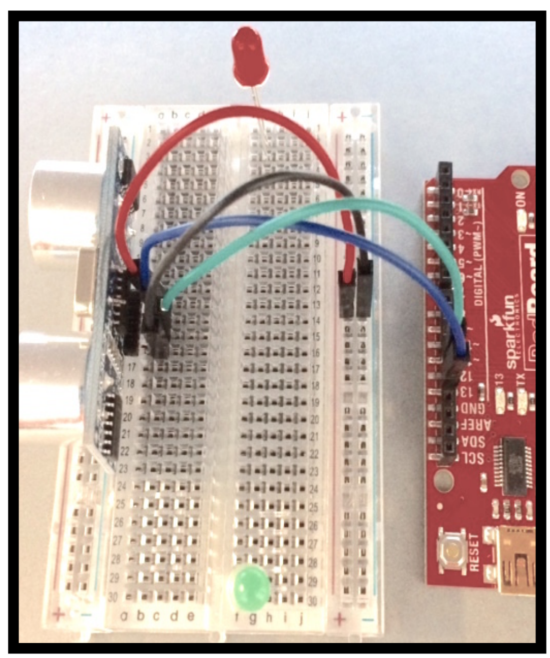
Build the Sensor Tool

1. Plug the sensor into breadboard rows A13 - A16 as shown.



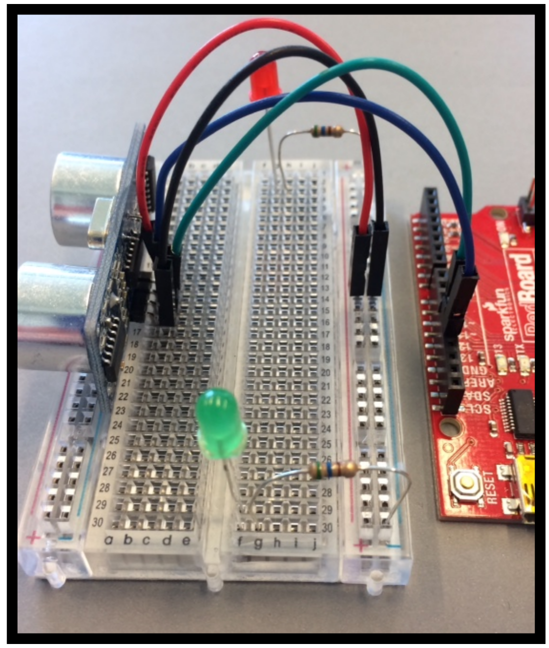


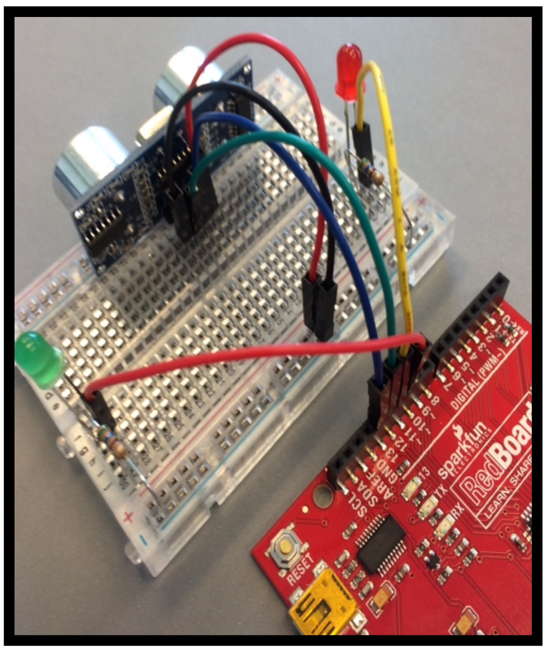
2. Plug the longer end (+) of the red LED into slot G2 and the shorter end (-) into slot G3 of the breadboard. Connect the green LED to F29 (+) and F30 (-).



3. Set the Arduino beside the breadboard to connect four wires from the sensor into pins as shown. **You can use any color wires, be sure to follow the connections carefully.
   - Vcc —> (+) red power rail
   - Trig —> Arduino Pin 13
   - Echo —> Arduino Pin 12
   - Gnd —> (-) blue power rail

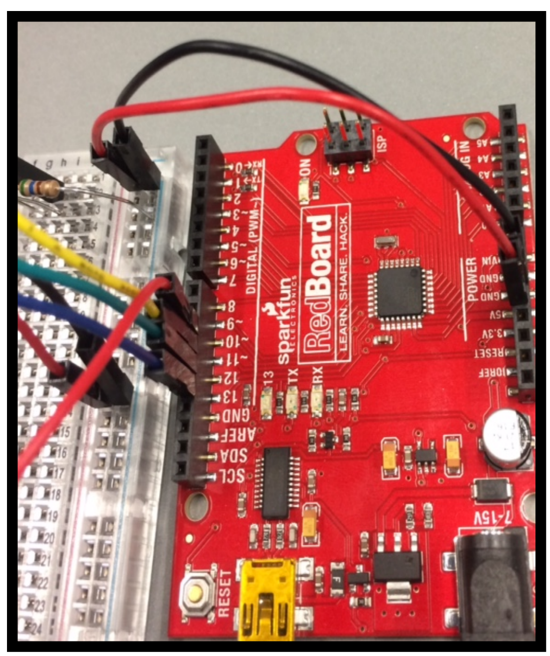
4. Add resistors. Connect one end of a resistor to the negative prong of an LED. Connect the other end to the blue, negative power rail. Repeat this on the other LED.





5. Connect a wire from the row of the positive end of the red LED to Arduino pin 11. Connect a red wire from the row of the positive end of the green LED to Arduino pin 10.

6. Connect a wire from the red power rail to the Arduino 5V pin, and a wire from the blue power rail to the Arduino GND pin.



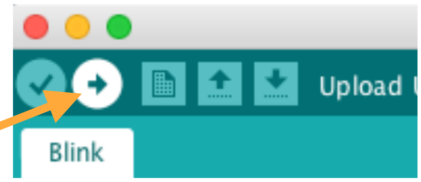
Add the Code

7. Open the Arduino IDE and copy and paste the following sketch (http://nautl.us/2wWXx1u):

```
/*
HC-SR04 Ping distance sensor]
More info at: http://goo.gl/kJ8Gl
Original code improvements to the Ping sketch sourced from Trollmaker.com
Some code and wiring inspired by http://en.wikiversity.org/wiki/User:Dstaub/robotcar
*/

#define trigPin 13
#define echoPin 12
#define led 11
#define led2 10

void setup() {
  Serial.begin (9600);
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(led, OUTPUT);
  pinMode(led2, OUTPUT);
}
void loop() {
  long duration, distance;
  digitalWrite(trigPin, LOW);  // Added this line
  delayMicroseconds(2); // Added this line
  digitalWrite(trigPin, HIGH);
//  delayMicroseconds(1000); - Removed this line
  delayMicroseconds(10); // Added this line
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance = (duration/2) / 29.1;
  if (distance < 4) {  // This is where the LED On/Off happens
   digitalWrite(led,HIGH); // When the Red condition is met, the Green LED should turn off
  digitalWrite(led2,LOW);
}
  else {
   digitalWrite(led,LOW);
   digitalWrite(led2,HIGH);
  }
  if (distance >= 200 || distance <= 0){
   Serial.println("Out of range");
  }
  else {
        Serial.print(distance);
        Serial.println(" cm");
  }
  delay(500);
}
```

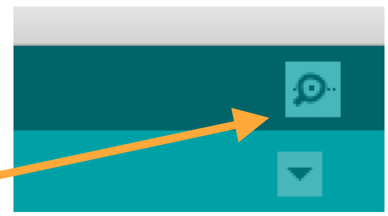
Ready to Test?

8. Plug the Arduino into the computer with a mini-USB. Upload your sketch.



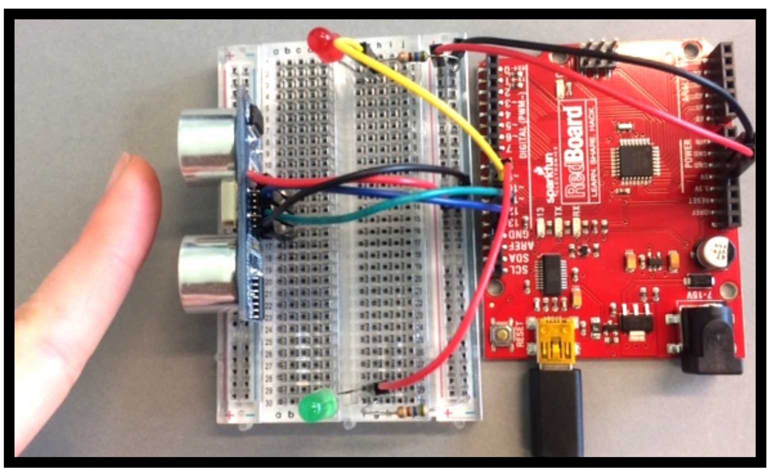
Upload Button

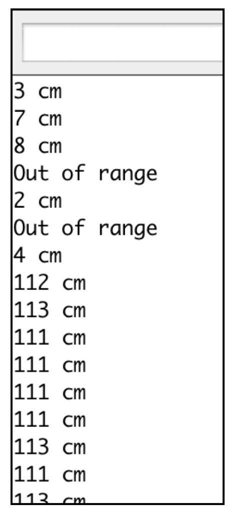
9. Switch to serial monitor view by clicking on the magnifying glass icon in the top-right corner of the IDE screen.



Serial Monitor

10. Move an object in front of the sensor and watch data display. It should look like this:





Is it working correctly? Congratulations! Move on to the experiment.

Not there yet? Keep working; you can do it! Check the reminders below.

*** Double check the wiring connections. Or triple check.*

*** Check the positive (+) end of the LEDs. The positive, long connector side should connect to the digital pins (not ground) on the Arduino board.*

*** Resistors are non-polar; it doesn't matter which direction they're plugged in.*

*** Make sure the code matches the pin numbers on the board.*

Put Your Sensor to Work. Design an Experiment | Now that you have successfully built a sensor device, uploaded code, and collected data, use supplies found around your classroom to create your own experiment. Manipulate the code as needed for your experiment. Brainstorm one variable you could test using your sensor. Use the following template to help keep track of your work:

Research Question:
Materials Needed:
Brief description of experiment:

Record trials and sample data below:

Trial # and Important Notes	Data/Findings

Conclusion Questions |

1. Describe your findings in this experiment.

2. What challenges did you experience while working through this module? How were you able to overcome them?

3. What were some of the key things you learned as a result of this lesson?

4. **Brainstorm Beyond the Classroom:** What are some questions you would like to research with your sensor outside the classroom? Think about one experiment you could perform in your school or community utilizing a sensor to collect environmental data. Ask your teacher for guidance, if needed.

OBJECTIVE	CRITERIA			
	4 Exemplary	3 Commended	2 Emerging	1 Developing
Knowledge & Understanding |	Student consistently, correctly and thoroughly answers all questions. Uses an abundance of relevant vocabulary and is able to explain relationships within the content using examples. Can apply the content to other topics or real life.	Student is able to consistently answer most questions correctly. Uses an adequate amount of relevant vocabulary. Can explain relationships within the content and can apply content to other topics or real life.	Student is able to answer some questions correctly. Uses some relevant vocabulary. Student does not elaborate on relationships within the content or make connections between the content and real life.	Student is able to answer a few questions correctly. Inconsistently uses relevant vocabulary. Student does not elaborate on relationships within the content or make connections between the content and real life.
Content Organization, Methodology & Analysis |	Student effectively organizes complex ideas, concepts, and information to make important connections and distinctions. This may include detailed, labeled and thorough procedures, data tables, graphs, diagrams and/or analyses.	Student is able to organize ideas, concepts, and information to make connections and distinctions. This may include mostly detailed, labeled and thorough procedures, data tables, graphs, diagrams and/or analyses.	Student attempts to organize ideas, concepts and information to make some connections and distinctions. Student is able to provide basic procedures, data tables, graphs, diagrams and/or analyses.	Student has difficulty organizing ideas, concepts and information to make connections and distinctions. Student is unable to provide basic procedures, data tables, graphs, diagrams and/or analyses.
Self-Directed Learner |	Student is actively engaged in the learning process; consistently contributes to class discussions and asks clarifying questions. Seeks out and shares additional resources with the class or teacher. Advocates for his/her learning needs.	Student is engaged in the learning process. Often contributes to class discussions and asks clarifying questions. Advocates for his/her learning needs.	Student is inconsistently engaged in the learning process. Sometimes contributes to class discussions or asks clarifying questions. Inconsistently advocates for his/her learning needs.	Student is weakly engaged in the learning process. Rarely contributes to class discussions or asks clarifying questions. Rarely advocates for his/her learning needs.
Technological Tools |	Use of digital resources is always appropriate for the task. Willing to learn and use technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is appropriate for the task. Willing to use technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is sometimes appropriate for the task. Inconsistent use of technology for inclusion of charts, graphs, pictures, etc. to amplify the message.	Use of digital resources is rarely appropriate for the task. Inconsistent use of technology for inclusion of charts, graphs, pictures, etc. to amplify the message.
Collaboration Skills |	Consistently works effectively and respectfully with a diverse group of learners. Actively checks with others for understanding and how he or she may be of help. Student listens when others speak and incorporates or builds off of the ideas of others.	Works effectively and respectfully with a diverse group of learners. Checks with others for understanding and how he or she may be of help. Student listens when others speak.	Sometimes works effectively and respectfully with a diverse group of learners. Sometimes checks with others for understanding and how he or she may be of help. Student listens when others speak.	Has difficulty working effectively and respectfully with a diverse group of learners. Rarely checks with others for understanding and how he or she may be of help. Student may talk over other students or does not listen when others speak.
Total Score: _______________	**Comments:**			

HOW LARGE IS NAUTILUS NATION?

Tracking the reach of Ocean Exploration Trust's education programs is essential in ensuring we are funded to continue making discoveries and inspiring the next generation of explorers.

Name: **My Community (City, State):**

Email Address:

School's Name:

Instruction date: **Grade level instructed:**

Subject area:

My education space is a...

- ❏ Classroom
- ❏ After school program / Club meeting
- ❏ Fair / Festival / Event
- ❏ Museum / Science Center
- ❏ Other. Tell us more:

Who did you engage in your teaching?

Students

Community Members

Select all the OET materials you used in your instruction:

- ❏ STEM Learning Modules. Which ones? ____________________
- ❏ Digital Resource Library materials. Which ones? ____________________
- ❏ Nautilus Live website: photo albums ❏ highlight videos ❏ live stream
- ❏ Meet the Team STEM mentor profiles
- ❏ Facebook (NautilusLive) ❏ Twitter (@EVNautilus) ❏ Instagram (@nautiluslive)
- ❏ Other. Tell us more: ____________________

____

What made working with OET resources valuable to your instruction (select all that apply)?

- ❏ Hands-on activities
- ❏ Easy to use lessons
- ❏ Website resource access
- ❏ STEM career connections
- ❏ Standards-based lessons
- ❏ Real world application of curricula topics
- ❏ Excitement of cutting-edge discoveries / Unfamiliarity of deep ocean
- ❏ Another reason. Tell us more: ____________________

____

Using OET resources increased my confidence in teaching my science, technology, engineering, or math subjects.	❏ Yes	❏ No
OET provided me with helpful and relevant teaching resources.	❏ Yes	❏ No
Using OET resources increased my awareness of STEM careers.	❏ Yes	❏ No
If yes, how so? How can we improve?		

Please scan this document or snap a picture of it with your phone. Email the feedback or questions to education@oet.org. You can also submit feedback online: http://nautl.us/2cp3PNu

THANK YOU FOR ALL YOU DO!