Lab 1

Get To Know Your Robot

Objectives:

- To install all of the necessary software to control the Arduino Robot

- To become familiar with the robot as well as writing Sketches in the Arduino IDE

- To get your robot moving

Deliverables:

- Lab 1 Demo on Monday, 1/13/14

- Lab 1 Code on Sunday, 1/19/14

- Lab 1 Memo on Monday, 1/19/14

Equipment: Arduino Robot Base

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Procedure:

Inventory

Your first task is to take an inventory of everything in your robot kit. You are responsible for returning the robot and all peripherals in the exact same condition that you received them in so if anything is missing, please notify your instructor immediately.

- Robot
- Robot Quick Start Guide
- Wall Adapter Power Supply
- USB Cable
- Energizer Battery Charger
- 12 AA Rechargeable Batteries
- Arduino LCD Screen with Micro-SD Reader
- Micro-SD 2GB Memory Card
- Micro-SD Adapter
- Expansion Kit
- Pocket Screwdriver

Getting Started Guide

1. Navigate to the Arduino Robot Getting Started website (http://arduino.cc/en/Guide/Robot)
2. Under *Setting up the Robot*, confirm that the LCD and Memory Card and protective cover are already installed on the robot
3. Follow the directions to connect your robot to the computer.
4. Follow the directions to Install the Driver. Please review the Troubleshooting tips on the website or on page 4 of the Robot Quick Start Guide in your kit if you run into any problems.
5. Since all of these robots have been tested, it may have a different program than *Hello User* when turned on.
6. Complete the tutorials on *Moving the Robot* and *Changing the motor speed with the potentiometer*.

YouTube Tutorials

1. Review Arduino Robot Tutorial 2 on YouTube and calibrate your robot motors.
2. We will review several of the other videos in subsequent weeks in order to complete the other lab assignments.

Resources: Arduino Language Reference: http://arduino.cc/en/Reference/HomePage

                    Arduino Robot Library: http://arduino.cc/en/Reference/RobotLibrary

                    Arduino Robot Tutorial 1:   Hello User! Introduction to Arduino
                                                       http://www.youtube.com/watch?v=vlxH0DAv5ds

                    Arduino Robot Tutorial 2:   LOGO and remote control your robot

                                                       http://www.youtube.com/watch?v=3LLLIxGvLxU

                    Arduino Robot Tutorial 3:   Avoid Obstacles

                                                       http://www.youtube.com/watch?v=p1iw-8pXwfI

                    Arduino Robot Tutorial 4:   Following lines, going to the rescue

                                                       http://www.youtube.com/watch?v=bnqDzNAU7JQ

                    Arduino Robot Tutorial 5:   Images and Sounds

                                                       http://www.youtube.com/watch?v=RuuMUHSVG5M

Demonstration

One branch of social robotics deals with designing entertainment robots such as the Sony AIBO or KeepOn. For this week's demonstration you need to choreograph a dance to music for your robot and show it to your instructor. You are not required to write your own music, you can use the default music that is stored on the SD card. You can access these 3 songs with the following code.

```
Robot.playFile("menu.sqm");  // play the music stored on the SD card
Robot.playFile("melody.sqm");  // play the music stored on the SD card
Robot.playFile("chase.sqm");  // play the music stored on the SD card
```

If you have any questions, please do not hesitate to ask your instructor.

Memo Guidelines:

Please use the following checklist to insure that your memo meets the basic guidelines.

- ✓ Format
  - o Typewritten
  - o Heading includes Date, To , From, Subject
  - o Font no larger than 12 point font
  - o Spacing no larger than double space
  - o Written as a paragraph not bulleted list
  - o No longer than three pages of text (does not include any images)
- ✓ Writing
  - o Memo is organized in a logical order
  - o Writing is direct, concise and to the point
  - o Written in first person from lab partners or individual
  - o Correct grammar, no spelling errors
- ✓ Content
  - o Starts with a statement of purpose
  - o Discusses the strategy or pseudocode for implementing the robot behavior
  - o Discusses the tests and methods performed
  - o States the results including error analysis
  - o Shows data tables with error analysis and required plots or graphs

o   Answers all questions posed in the lab procedure

o   Clear statement of conclusions

Grading Rubric:

The lab is worth a total of 30 points and is graded by the following rubric.

Points	Demonstration	Code	Memo
10	Excellent work, the robot performs exactly as required	Properly commented with a header and function comments, easy to follow with modular components	Follows all guidelines and answers all questions posed
7.5	Performs most of the functionality with minor failures	Partial comments and/or not modular with objects	Does not answer some questions and/or has spelling, grammatical, content errors
5	Performs some of the functionality but with major failures or parts missing	No comments, not modular, not easy to follow	Multiple grammatical, format, content, spelling errors, questions not answered
0	Meets none of the design specifications or not submitted	Not submitted	Not submitted

Here is an excerpt from the Splash_Screen.inf program so that you can see an example of a proper heading and properly commented code.

```
/*Splash_Screen.ino
Carlotta A. Berry
1/10/14

This program will create the Splash Screen for
the Arduino Robot.  All of the functions are from
the Arduino RobotControl library and there were none
created for this program.  The hardware used was the
LCD and speaker.
 */


#include <ArduinoRobot.h> // include the robot library

int commands[20];  //  array for storing commands

void setup() {
  Robot.begin();//initializes the robot
  Robot.beginTFT();//initialize the LCD screen
  Robot.beginSpeaker(32000);//initialize the speaker
  Robot.beginSD();//initialize the SD card
  Robot.displayLogos();// show the logos from the SD card
  Robot.playFile("chase.sqm");  // play the music stored on the SD card
  Robot.clearScreen(); // clear the screen
  Robot.text("Hello World",30,30);
  Robot.stroke(255, 255, 255); //change the pen color to white
  delay(3000); // wait for a momen
  Robot.text("Hello World",30,30);//write to erase
  delay(3000); // wait for a moment
```

Submission Requirements:

You must submit you properly commented code as a zipped folder of the Sketch code and the lab memo in a

zipped folder to **OnCourse**. Your properly commented code should be modular and organized with functions and

classes as needed in order to make it more readable.

Lab 02

Touch-free robot race

Objectives:

- To mount the sensors from the expansion kit onto your Arduino robot

- To use the sonar and infrared sensors on the robot for distance sensing

Deliverables:

- Lab 02 Demo on Monday, 02/03/14

- Lab 02 Code on Sunday, 02/03/14

- Lab 02 Memo on Monday, 02/03/14

Equipment: Arduino Robot Base

Ultrasonic sensor

Sonar sensor

****

Procedure:

Mount Hardware

1. Review Arduino Robot Tutorial 3 on YouTube.
2. Mount 4 sensors around the perimeter of your robot. You can use any combination of sonar and IR sensors.
3. Please review the following link for information on which pins to connect the sensors to.
   http://arduino.cc/en/Main/Robot
4. You can attach 4 ultrasonic sensors or 4 infrared sensors to TK0,TK2, TK4, and TK6.
5. Figure 1 shows the mount and pinout for the infrared sensors.
6. Figure 2 shows the mount and pinout for the ultrasonic sensors.

Avoid Obstacles

1. Modify the `R07_Runaway_Robot` Sketch so that your robot will work with all four of the mounted sensors. You would need to define 4 variables such as `sensorFront = TK2`, `sensorBack = TK6`, `sensorLeft = TK4`, `sensorRight = TK0` and modify the `getDistance()` function appropriately.
2. Modify the program so that the robot will turn away if any of the sensors are triggered. For example, if the back sensor is triggered the robot moves forward, if the forward sensor is triggered the robot moves back. The way this work is that anything close to the robot is pushing it away so that it avoids the obstacles.
3. The distance in inches for the ultrasound can be found by using the following code:
   `Robot.analogRead(sensorFront)/2`
4. The distance in inches for the infrared sensor can be found by using the following code:
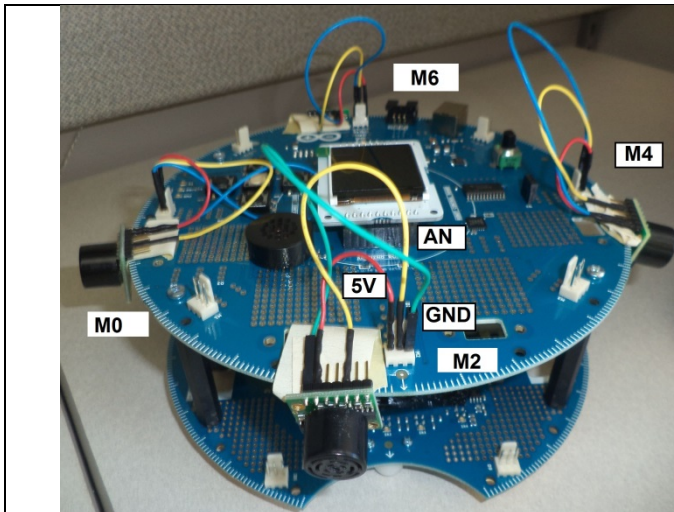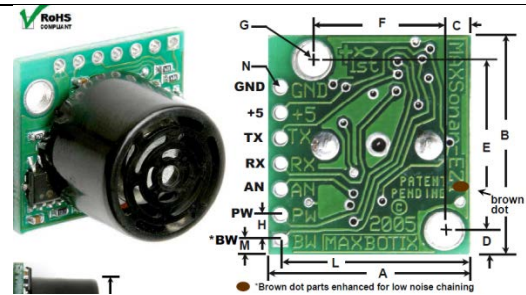   `2462.3*pow(Robot.analogRead(sensorFront),-0.984)`
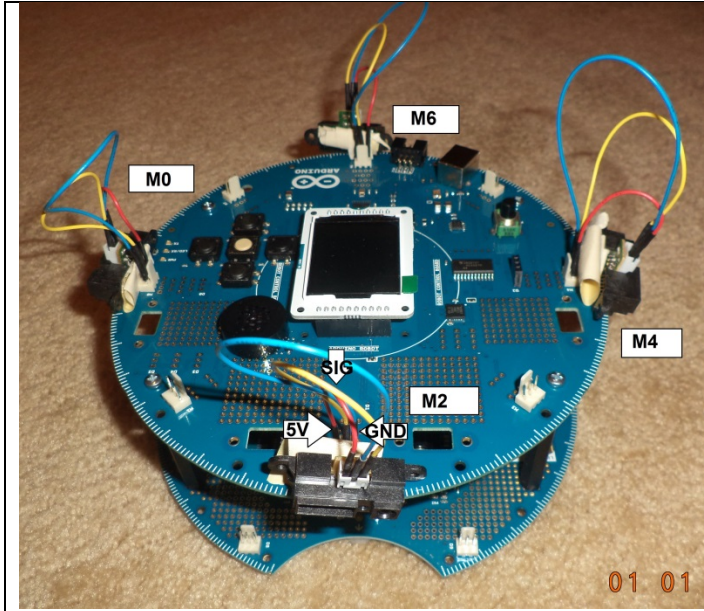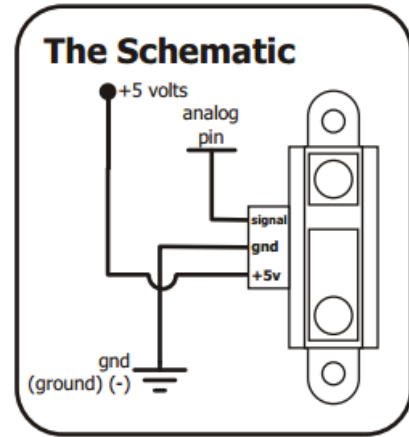
| a. Control Board Pinout | a. Sensor Pinout |

Figure 1: Infrared Sensor Mount

| a. Control Board Pinout | a. Sensor Pinout |

Figure 2: Ultrasound Sensor Mount

YouTube Tutorials

Arduino Robot Tutorial 1:	Hello User! Introduction to Arduino	
	http://www.youtube.com/watch?v=vlxH0DAv5ds	
Arduino Robot Tutorial 2:	LOGO and remote control your robot	
	http://www.youtube.com/watch?v=3LLLIxGvLxU	
Arduino Robot Tutorial 3:	Avoid Obstacles	
	http://www.youtube.com/watch?v=p1iw-8pXwfI	
Arduino Robot Tutorial 4:	Following lines, going to the rescue	
	http://www.youtube.com/watch?v=bnqDzNAU7JQ	
Arduino Robot Tutorial 5:	Images and Sounds	
	http://www.youtube.com/watch?v=RuuMUHSVG5M	

Resources:	Arduino Language Reference:	http://arduino.cc/en/Reference/HomePage
	Arduino Robot Library:	http://arduino.cc/en/Reference/RobotLibrary

Demonstration

You will use hand signals or a piece of paper or cardboard to control your robot to make a lap around the classroom.

If you have any questions, please do not hesitate to ask your instructor.

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    - o Correct grammar, no spelling errors
- ✓ Content
    - o Starts with a statement of purpose
    - o Discusses the strategy or pseudocode for implementing the robot behavior
    - o Discusses the tests and methods performed
    - o States the results including error analysis
    - o Shows data tables with error analysis and required plots or graphs
    - o Answers all questions posed in the lab procedure

o   Clear statement of conclusions

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Lab 03

Robot Conga Line

Objectives:

- To mount the light dependent resistor and bright white LED sensors from the expansion kit onto your Arduino robot

- To use the LDR, LED, sonar and/or infrared sensors on the robot for distance sensing

- To create a program to allow the robots to follow each other.

Deliverables:

- Lab 03 Demo on Monday, 02/10/14

- Lab 03 Code on Sunday, 02/10/14

- Lab 03 Memo on Monday, 02/10/14

Equipment: Arduino Robot Base

                     Infrared sensor(s)

                     Sonar sensor(s)

                     LDR Sensor

                     LED (bright white)

****

Procedure:

Mounting the LDR and LED sensors

1. Watch the last half of the Arduino Robot Video tutorial 3 to learn how to mount the LDR on the front of the robot and how to mount the bright white LED on the back of the robot.
2. You will need to mount the LDR to pin TK1 (M1) on the control board. This will be on the front of the follow robot.
3. You will need to mount the LED to pin B_Tk1 (D10) on the Robot Motor Board. This will be on the back of the lead robot.
4. You will need to also mount IR or sonar sensors to pins TK0, Tk2, TK4, and TK6 for distance sensing. These should still be mounted from Lab 02.

Creating the robot following program

1. The first step is to try to implement a program similar to the one shown on the end of Arduino Robot Video Tutorial 3.
2. Modify this program so that the robot moves forward when the bright white LED is found. You can use the LCD and beeper in order to indicate the robot is following.
3. The robot should move forward faster to close the distance if the light is further away. This can be accomplished by using an IR or sonar sensor on the front of the robot.
4. If the bright white LED is lost, the robot should move side to side to scan and search for the light. You can use the LCD and a different beeper to indicate that the light is lost.

Arduino Robot Tutorial 1:	Hello User! Introduction to Arduino
	http://www.youtube.com/watch?v=vlxH0DAv5ds
Arduino Robot Tutorial 2:	LOGO and remote control your robot
	http://www.youtube.com/watch?v=3LLLIxGvLxU
Arduino Robot Tutorial 3:	Avoid Obstacles
	http://www.youtube.com/watch?v=p1iw-8pXwfI
Arduino Robot Tutorial 4:	Following lines, going to the rescue
	http://www.youtube.com/watch?v=bnqDzNAU7JQ
Arduino Robot Tutorial 5:	Images and Sounds
	http://www.youtube.com/watch?v=RuuMUHSVG5M

| *Resources:* | Arduino Language Reference: | http://arduino.cc/en/Reference/HomePage |
| | Arduino Robot Library: | http://arduino.cc/en/Reference/RobotLibrary |

Demonstration

You will place your robot on the floor and it should use the LDR to find the bright white LED on the back of another robot or object. Then use the distance sensors to maintain a prescribed distance from the robot and follow it around the room.

If you have any questions, please do not hesitate to ask your instructor.

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Lab 04

Braitenberg Vehicles

Objectives:

- To mount two LDR sensors to the front of the robot

- To implement the four Braitenberg vehicles by using excitatory and inhibitory connections between the motors and sensors

Deliverables:

- Lab 04 Demo on Monday, 03/03/14

- Lab 04 Code on Sunday, 03/03/14

- Lab 04 Memo on Monday, 03/03/14

Equipment: Arduino Robot Base

LDR Sensors

Keypad

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Procedure:

Mounting the Infrared Receiver

1.   User the Tinkerkit cables to mount the LDR sensors to M1 and M3 on the robot

2.   These will be analog inputs in the software that are accessed through the pin address TK1 and TK3 with the function Robot.analogRead().

3.   Finally, write a program to test the values read by the LDR sensors when reading the ambient lighting in the room and also when shining a flashlight toward the robot.

Creating the Vehicles

1. The first program you will write is a reactive controller inspired by Braitenberg's vehicle experiments. In this step, you will create a vehicle that is wired with excitatory connections where each sensor is connected to the motor on the same side. The program controls the left and right wheels based upon the light intensity seen by the left and right photoresistors (see Figure 1a).

2. How does the robot behave when (a) the light source is directly in front of the robot, (b) the light source is to one side of the robot? Is there anything about the robot's behavior that surprises you?

3. Next, repeat parts 1 and 2 except that each sensor is connected in an inhibitory manner. This means the motor slows down as it gets closer to the light (See Figure 1b).

4. Next, repeat parts 1 and 2 except cross the connections between the motors and the sensors so that the left light sensor controls the right motor's speed and vice versa in an inhibitory manner (See Figure 1c).

5. Finally, repeat parts 1 and 2 with the connections still crossed between the motors and the sensors so that the left light sensor controls the right motor's speed and vice versa in and excitatory manner (See Figure 1d).
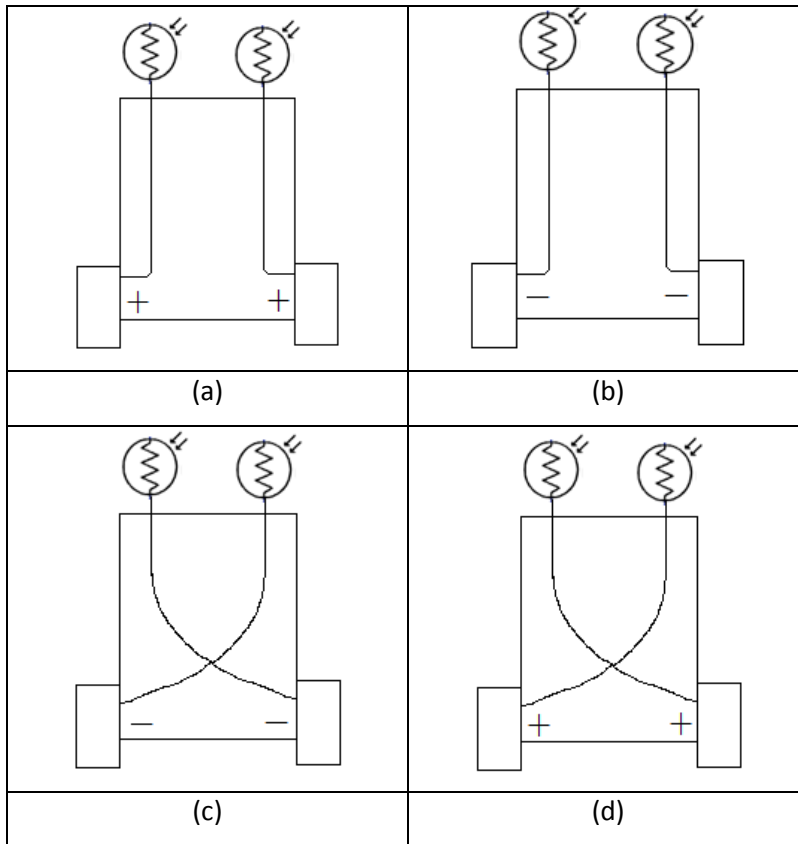

Figure 1: Valentino Braitenberg Vehicles

6. Braitenberg called these four light sensing behaviors, fear, aggression, love and explorer. These are the emergent behaviors that you did not explicitly program. Can you identify which of the four behaviors (fear, aggression, love, explorer) is exhibited for each of the prior motor/sensor connections?

YouTube Tutorials

Arduino Robot Tutorial 1:	Hello User! Introduction to Arduino	
	http://www.youtube.com/watch?v=vlxH0DAv5ds	
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	http://www.youtube.com/watch?v=bnqDzNAU7JQ	
Arduino Robot Tutorial 5:	Images and Sounds	
	http://www.youtube.com/watch?v=RuuMUHSVG5M	

Resources:	Arduino Robot:	http://arduino.cc/en/main/robot
	Arduino Language Reference:	http://arduino.cc/en/Reference/HomePage
	Arduino Robot Library:	http://arduino.cc/en/Reference/RobotLibrary

Demonstration

You will place your robot on the floor and use the keypad to demonstrate the four different vehicles when the light is shown toward the robot.

If you have any questions, please do not hesitate to ask your instructor.

****

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  - o Shows data tables with error analysis and required plots or graphs

o   Answers all questions posed in the lab procedure

o   Clear statement of conclusions

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Lab 05

Robot Music Machine

Objectives:

- To create a music machine with the robot. Create a song for the robot to play and use the buttons, LEDS, infrared and sonar sensors to make unique behaviors with the robot.

Deliverables:

- Lab 05 Demo on Monday, 03/10/14

- Lab 05 Code on Sunday, 03/10/14

- Lab 05 Memo on Monday, 03/10/14

Equipment: Arduino Robot Base

Various Sensors

****

Procedure:

Select the Song

1. Your first step is to review the example program at the following link: Examples\Robot_Control\learn\melody
2. You will modify this code to create your Music Machine so save it under a unique name in your course folder
3. Search the internet for the song you would like to play and find the notes and length for each note
4. Modify your code to play your preferred song

Create the Machine

1. Once you have the robot playing the song correctly, create the machine
2. Determine how you will use the keypad, sonar and infrared sensors to play the song
3. Determine how the LEDs will work while the song is playing
4. Program the robot to exhibit the behavior that you designed

YouTube Tutorials

Arduino Robot Tutorial 1:	Hello User! Introduction to Arduino	
	http://www.youtube.com/watch?v=vlxH0DAv5ds	
Arduino Robot Tutorial 2:	LOGO and remote control your robot	
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	http://www.youtube.com/watch?v=bnqDzNAU7JQ	
Arduino Robot Tutorial 5:	Images and Sounds	
	http://www.youtube.com/watch?v=RuuMUHSVG5M	

Resources: Arduino Language Reference: http://arduino.cc/en/Reference/HomePage

Arduino Robot Library: http://arduino.cc/en/Reference/RobotLibrary

Demonstration

You will place your robot on the floor and use the pushbuttons to start the song and demonstrate how your music machine works.

If you have any questions, please do not hesitate to ask your instructor.

****

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Lab 06

Robot Remote Control

Objectives:

- To mount the infrared receiver onto the robot.

- To use the infrared receiver with a universal remote with an infrared transmitter to design a movement routine for the robot.

Deliverables:

- Lab 64 Demo on Monday, 03/31/14

- Lab 06 Code on Sunday, 03/31/14

- Lab 06 Memo on Monday, 03/31/14

Equipment: Arduino Robot Base

                                Infrared Receiver

                                Remote Control

****

Procedure:

Mounting the Infrared Receiver

1. Watch the Arduino Robot Video Tutorial 2 on LOGO and the remote control.
2. We will use a soldering iron to mount a header pin to TKD1 (D1) on the robot.
3. Mount the infrared receiver to TKD1. The pin out for the infrared receiver is shown in the following figure. Recall that the pins are not in the same order as they are on the Arduino robot. On the robot the order is +5V, Signal (OUT), GND.

1 = OUT, 2 = V$_S$, 3 = GND
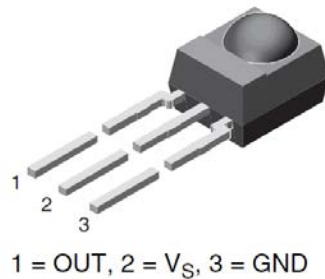
Creating the program

1. The first step is to start with the Arduino robot example program at *Examples\Robot_Control\explore\R08_Remote_Control*
2. Download the Arduino-IRremote library from the following link: https://github.com/shirriff/Arduino-IRremote. Click on the "Downloads" link in the upper right, click "Download as zip", and get a zip file. Unzip it and rename the directory, *shirriff-Arduino-IRremote-nnn* to *IRremote*.
3. To install, move the downloaded *IRremote* directory to *arduino-1.x/libraries/IRremote* where arduino-1.x is your Arduino installation directory.   After installation you should have files such as: *arduino-1.x/libraries/IRremote/IRremote.cpp*

4. Run the program and press various keys on the remote control. The code received by the infrared receiver should be shown under Remote Control Code. If the value displayed is not negative and does not change after several presses then record the key for that key. You need to be able to program at least 6 keys for the robot motion and other behaviors such as dancing, playing music, obstacle avoidance or anything else you would like to do.

5. You should then modify the code to work with your keys and test it on the robot. At minimum, you must have a move forward, back, left and right behavior.

YouTube Tutorials

Arduino Robot Tutorial 1:	Hello User! Introduction to Arduino	
	http://www.youtube.com/watch?v=vlxH0DAv5ds	
Arduino Robot Tutorial 2:	LOGO and remote control your robot	
	http://www.youtube.com/watch?v=3LLIxGvLxU	
Arduino Robot Tutorial 3:	Avoid Obstacles	
	http://www.youtube.com/watch?v=p1iw-8pXwfI	
Arduino Robot Tutorial 4:	Following lines, going to the rescue	
	http://www.youtube.com/watch?v=bnqDzNAU7JQ	
Arduino Robot Tutorial 5:	Images and Sounds	
	http://www.youtube.com/watch?v=RuuMUHSVG5M	

Resources:	Arduino Language Reference:	http://arduino.cc/en/Reference/HomePage
	Arduino Robot Library:	http://arduino.cc/en/Reference/RobotLibrary
	Infrared Remote Library:	http://www.righto.com/2009/08/multi-protocol-infrared-remote-library.html

Demonstration

You will use the remote control to demonstrate the different robot behaviors you have programmed to the respective keys. Then, you will place your robot on the floor and use the remote control to drive it through an obstacle course.

If you have any questions, please do not hesitate to ask your instructor.

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Memo Guidelines:

Please use the following checklist to insure that your memo meets the basic guidelines.

✓ Format
- o Typewritten
- o Heading includes Date, To , From, Subject
- o Font no larger than 12 point font
- o Spacing no larger than double space
- o Written as a paragraph not bulleted list
- o No longer than three pages of text (does not include any images)

✓ Writing
- o Memo is organized in a logical order
- o Writing is direct, concise and to the point
- o Written in first person from lab partners or individual
- o Correct grammar, no spelling errors

✓ Content
- o Starts with a statement of purpose
- o Discusses the strategy or pseudocode for implementing the robot behavior
- o Discusses the tests and methods performed
- o States the results including error analysis
- o Shows data tables with error analysis and required plots or graphs
- o Answers all questions posed in the lab procedure
- o Clear statement of conclusions

Grading Rubric:

The lab is worth a total of 30 points and is graded by the following rubric.

Points	Demonstration	Code	Memo
10	Excellent work, the robot performs exactly as required	Properly commented with a header and function comments, easy to follow with modular components	Follows all guidelines and answers all questions posed
7.5	Performs most of the functionality with minor failures	Partial comments and/or not modular with objects	Does not answer some questions and/or has spelling, grammatical, content errors
5	Performs some of the functionality but with major failures or parts missing	No comments, not modular, not easy to follow	Multiple grammatical, format, content, spelling errors, questions not answered
0	Meets none of the design specifications or not submitted	Not submitted	Not submitted

Submission Requirements:

You must submit you properly commented code as a zipped folder of the Sketch code and the lab memo in a zipped folder to **OnCourse**. Your properly commented code should be modular and organized with functions and classes as needed in order to make it more readable.