THE Cautious Wall-Avoiding Robot

FINAL PROJECT
CSCI 255 – Fall 2017
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Keith Bocian
Sam Croft
Chris O'Neill

Purpose:

The purpose of this instructable is to guide someone in possession of introductory embedded systems knowledge through the process of wiring, coding, and deploying a robot car that avoids walls.

The robot senses walls by shining an IR light at the wall; an IR sensor is used to determine if this IR light is being reflected back at the robot.

A video of this robot vehicle in action can be found here:
http://www.youtube.com/watch?v=GT_mMgGX-9Q

Commented code for our project is posted here (see main.c):
https://github.com/coneill1/cautiousRobot.

Specific knowledge/capabilities required to execute this instructable include:

- An understanding of how Pulse Width Modulation (PWM) can be used, for example, to control a standard servo motor
- Setting a MSP430 or similar microcontroller's pins to input and output
- 'Active low' vs. 'active high'
- Patience

Overview: This will be presented in two parts, a materials list and a step-by-step guide to assemble the robot.

Part 1: Materials List. Pictures of Components Appear in Assembly instructions:

- 1x MSP430G2553
- 1x Development Board with the following capabilities:
  - Ground
  - Breadboard
  - Power input to drive servo motors and microcontroller
- 2x plastic wheels sized to fit servo motors
- 2x rubber bands to encircle wheels
- 2x servo motors
- 1x servo chip designed to control at least two servos, with space for power, data input to motors and ground for each servo.
- 7x Female-female wires
- 2x Male – female wires
- 1x ~340 Ohm resistor
- 1x IR sensor TSOP382 or TSOP384
- 1x IR LED
- 4xAA batteries for servo motors
- Harness for 4xAA batteries
- 1x power adapter (optional for testing)
- Electrical Tape
- Plastic or cardboard spacer (optional)
- 3D Printed Robot Vehicle Chassis (See Figure 1)

Figure 1Top down view of robot chassis

Part 2: Assembly and Wiring

This section is divided into seven steps:

1. Insert servos in robot chassis and mount wheels
2. IR LED assembly
3. IR sensor assembly:
4. Connect Servo motors:
5. Power for Development Board
6. Power for Microcontroller
7. Tape Everything together

Step 1: Insert servos in robot chassis and mount wheels

# Used in this Step	# Already Used	Item
		1x MSP430G2553
		1x Development Board with the following capabilities:
2		2x plastic wheels sized to fit servo motors
2		2x rubber bands to encircle wheels
2		2x servo motors
		1x servo chip designed to control at least two servos, with space for power, data input to motors and ground for each servo.
		7x Female-female wires
		2x Male – female wires
		1x 340 Ohm resistor
		1x IR sensor TSOP382 or TSOP 384
		1x IR LED
		4xAA batteries for servo motors
		Harness for 4xAA batteries
		1x power adapter (optional for testing)
		Electrical Tape
		Plastic or cardboard spacer (optional)
1		3D Printed Robot Vehicle Chassis (See Figure 1)

Step 1a: Insert each of the two servo motors into the robot chassis. These can be a very tight fit so considerable force is required to put them in place. Good thing our team has an Ath-Uh-Lete! Two standard servos were used to power the wheels of this 2-wheel drive robot. The left wheel's servo motor operates in an opposite direction from the right servo's motor when the robot is going forward or in reverse, because to effectively mount the servo within this robot chassis it must be flipped 180 degrees about the long edge of the vehicle (figure 2).

Figure 2 Upside-Down view of Robot Chassis; servos are flipped about the long axis of the chassis so they must be driven in 'opposite' direction to go the same way.

Step 1b: place wheels on servo motors and wrap them in rubber bands for traction.

We used PWM to control the servos. For the servos we used, 1.64 ms up-time placed the motor in neutral. Anything greater would cause the servo to spin forward; less would cause it to spin backwards. The whole period for our servos approximately 20ms. Some sensitivity among individual servo designs may cause your 'neutral' to be at a different up-time relative to the standard 20ms period.

Step 2: IR LED assembly

Materials Required:

# Used in this Step	# Already Used	Item
1		1x MSP430G2553
1		1x Development Board with the following capabilities:
	2	2x plastic wheels sized to fit servo motors
	2	2x rubber bands to encircle wheels
	2	2x servo motors
		1x servo chip designed to control at least two servos, with space for power, data input to motors and ground for each servo.
		7x Female-female wires
2		2x Male – female wires
1		1x 340 Ohm resistor
		1x IR sensor TSOP382 or TSOP 384
1		1x IR LED
		4xAA batteries for servo motors
		Harness for 4xAA batteries
		1x power adapter (optional for testing)
		Electrical Tape
		Plastic or cardboard spacer (optional)
	1	3D Printed Robot Vehicle Chassis (See Figure 1)

Our LED Light is hooked up on PIN 1.0. From 1.0 we have hooked up to the resistor, which is hooked up to the anode side of the LED which is the side of the long wire. The cathode side is hooked up to ground. "Hooked up directly" means in the same row on the dev board.

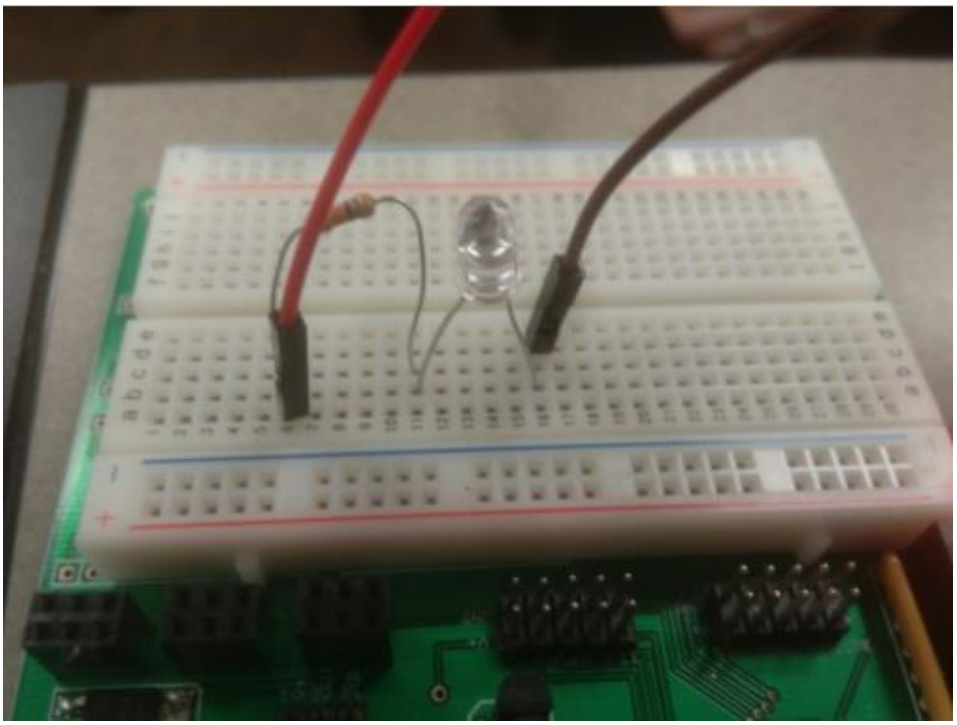


Figure 3 This diagram shows a red female to male wire running from Pin 1.6, which is set as an output on driving the LED, to a row on the development board corresponding to the resistor

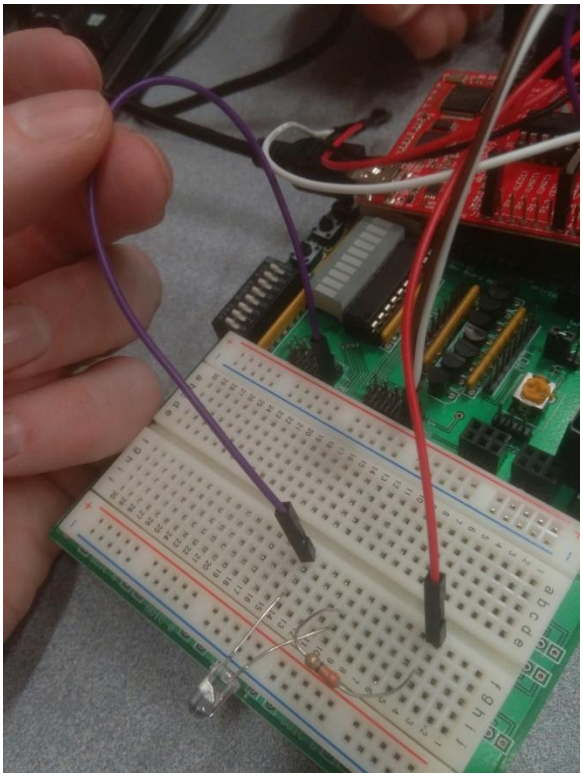


Figure 4 Above: the Cathode end of LED is hooked up to the purple ground wire.

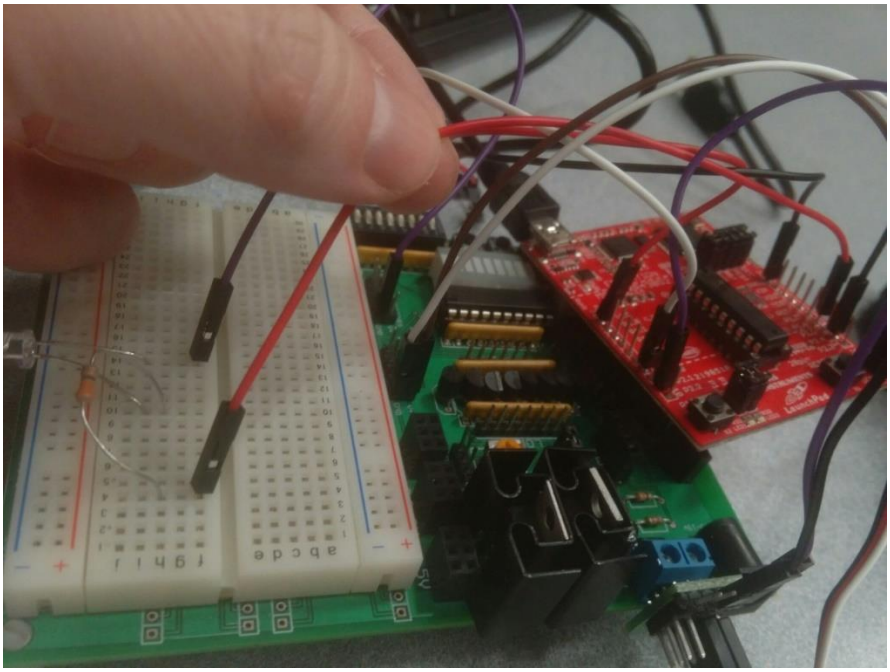


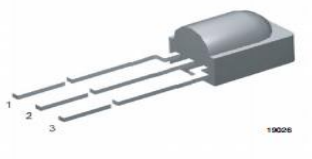
Figure 5 Shows female to male wire running from Pin 1.6 output to row on development board that is in line with resistor

Step 3: IR sensor assembly:

Components/Materials Required:

# Used in this Step	# Already Used	Item
	1	1x MSP430G2553
	1	1x Development Board with the following capabilities:
	2	2x plastic wheels sized to fit servo motors
	2	2x rubber bands to encircle wheels
	2	2x servo motors
		1x servo chip designed to control at least two servos, with space for power, data input to motors and ground for each servo.
3		7x Female-female wires
	2	2x Male – female wires
	1	1x 340 Ohm resistor
1		1x IR sensor TSOP382 or TSOP 384
	1	1x IR LED
		4xAA batteries for servo motors
		Harness for 4xAA batteries
		1x power adapter (optional for testing)
		Electrical Tape
		Plastic or cardboard spacer (optional)
	1	3D Printed Robot Vehicle Chassis (See Figure 1)

Connect 3 female to female wires to IR Sensor as shown in the diagrams below



MECHANICAL DATA

Pinning for TSOP382.., TSOP384..:

1 = OUT, 2 = GND, 3 = V_S

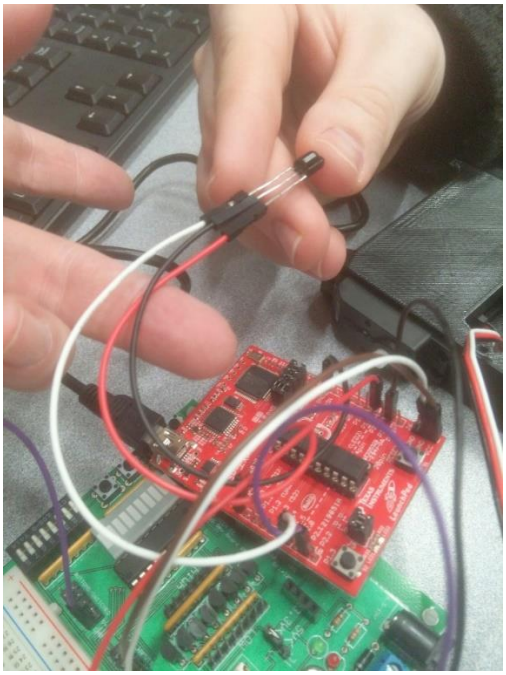


Figure 6 We have a female to female wire running from Pin 1.5 on the microcontroller to the output pin on the sensor (designated as 1 in the diagram above). The microcontroller is set to an input on pin 1.5. P1REN is also set to high for pin 1.5. The sensor kind of works like a button: whenever it receives a signal from the sensor it'll activate. The sensor is active low.

Step 4: Connect Servo motors:

Materials Required:

# Used in this Step	# Already Used	Item
	1	1x MSP430G2553
	1	1x Development Board with the following capabilities:
	2	2x plastic wheels sized to fit servo motors
	2	2x rubber bands to encircle wheels
	2	2x servo motors
1		1x servo chip designed to control at least two servos, with space for power, data input to motors and ground for each servo.
2	3	7x Female-female wires
	2	2x Male – female wires
	1	1x 340 Ohm resistor
	1	1x IR sensor TSOP382 or TSOP 384
	1	1x IR LED
		4xAA batteries for servo motors
		Harness for 4xAA batteries
		1x power adapter (optional for testing)
		Electrical Tape
		Plastic or cardboard spacer (optional)
	1	3D Printed Robot Vehicle Chassis (See Figure 1)

Hookup is illustrated below:

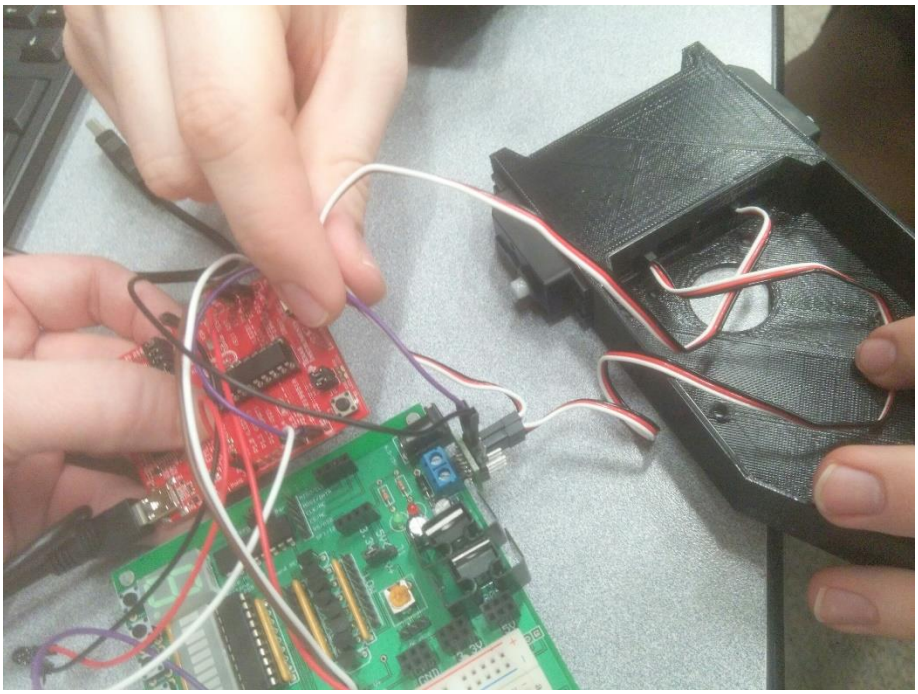


Figure 7 Right Servo Motor hooked up to Pin 2.1; Pin 2.1 is output on Microcontroller

Okay we have the right wheel hooked up to Pin 2.1...TA1CCR1 corresponds to Right Wheel. By convention, this instructable refers to the 'right wheel' as the wheel on the right hand side of the vehicle when looking down on the robot chassis and facing forward. The pin flows from the microcontroller at Pin 2.1 to the servo chip corresponding to the right wheel motor. In our case we placed this on the right hand side of the chip as observed when looking down. The vehicle chassis in the pics is upside down; the wires for each picture are identified by our fingers.

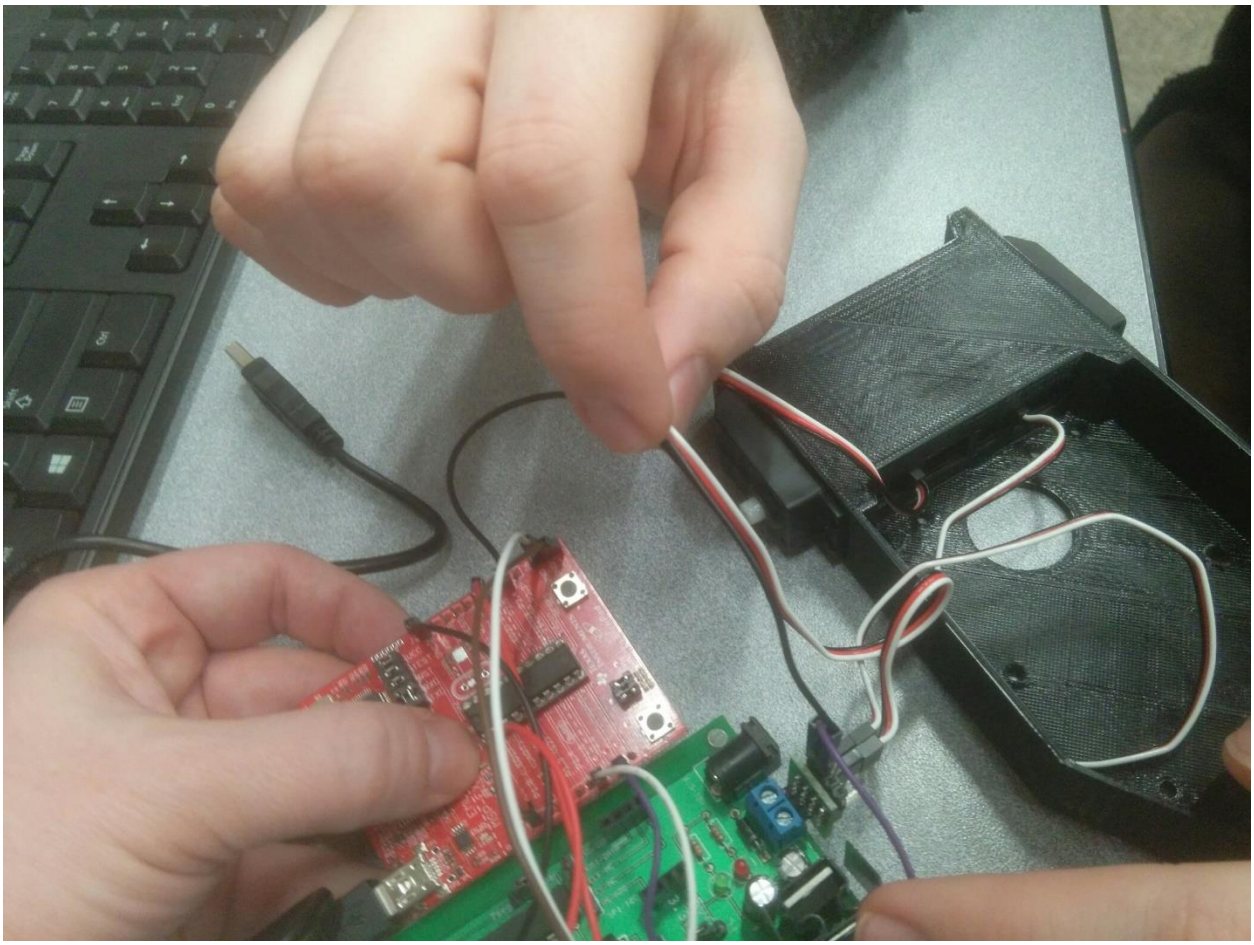


Figure 8 Left Servo Motor hooked up to Pin 2.4; Pin 2.4 is output on Microcontroller

We have the left wheel hooked up to Pin 2.4...TA1CCR2 corresponds to Left Wheel. The pin flows from the microcontroller at Pin 2.4 to the servo chip corresponding to the left wheel motor. In our case we placed this on the left hand side of the chip as observed when looking down. The vehicle chassis in the pics is upside down; the wires for each picture are identified by our fingers. It is not necessary to set P2OUT to high for pin 2.1 or pin 2.4 because the power is coming from our battery supply

Left wheel hooked up to Pin 2.4 TA1CCR2 corresponds to Left Wheel.

Step 5: Power for Development Board

Materials Required:

# Used in this Step	# Already Used	Item
	1	1x MSP430G2553
	1	1x Development Board with the following capabilities:
	2	2x plastic wheels sized to fit servo motors
	2	2x rubber bands to encircle wheels
	2	2x servo motors
	1	1x servo chip designed to control at least two servos, with space for power, data input to motors and ground for each servo.
	5	7x Female-female wires
	2	2x Male – female wires
	1	1x 340 Ohm resistor
	1	1x IR sensor TSOP382 or TSOP 384
	1	1x IR LED
1		4xAA batteries for servo motors
1		Harness for 4xAA batteries
		1x power adapter (optional for testing)
		Electrical Tape
		Plastic or cardboard spacer (optional)
	1	3D Printed Robot Vehicle Chassis (See Figure 1)

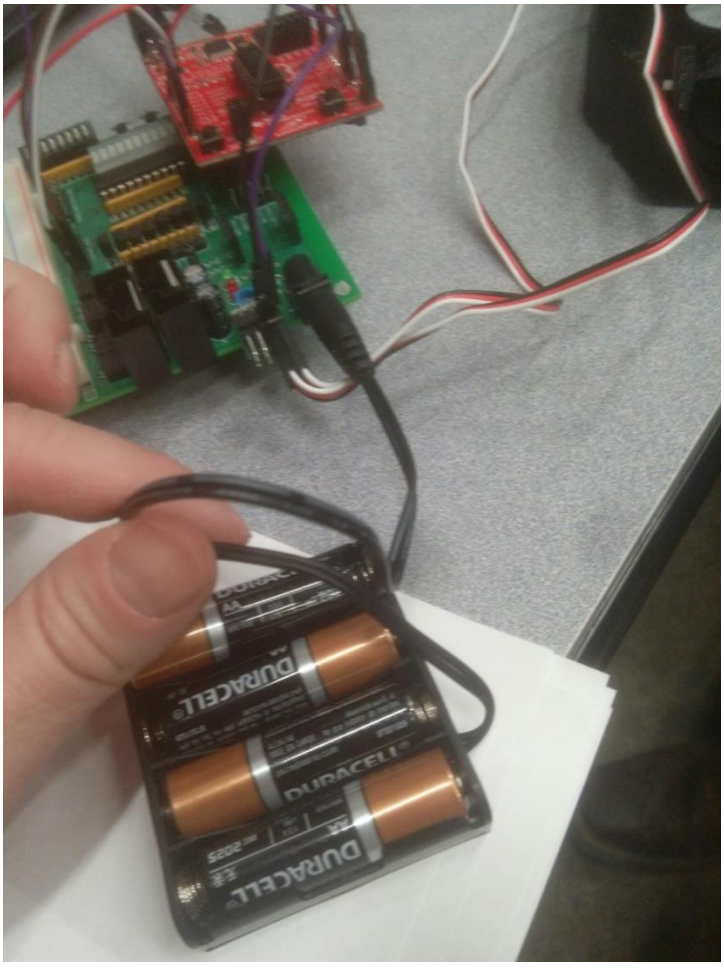


Figure 9FourxAA batteries power our development board

Step 6: Power for Microcontroller

Components Required:

# Used in this Step	# Already Used	Item
	1	1x MSP430G2553
	1	1x Development Board with the following capabilities:
	2	2x plastic wheels sized to fit servo motors
	2	2x rubber bands to encircle wheels
	2	2x servo motors
	1	1x servo chip designed to control at least two servos, with space for power, data input to motors and ground for each servo.
2	5	7x Female-female wires
	2	2x Male – female wires
	1	1x 340 Ohm resistor
	1	1x IR sensor TSOP382 or TSOP 384
	1	1x IR LED
	1	4xAA batteries for servo motors
	1	Harness for 4xAA batteries
		1x power adapter (optional for testing)
		Electrical Tape
		Plastic or cardboard spacer (optional)
	1	3D Printed Robot Vehicle Chassis (See Figure 1)

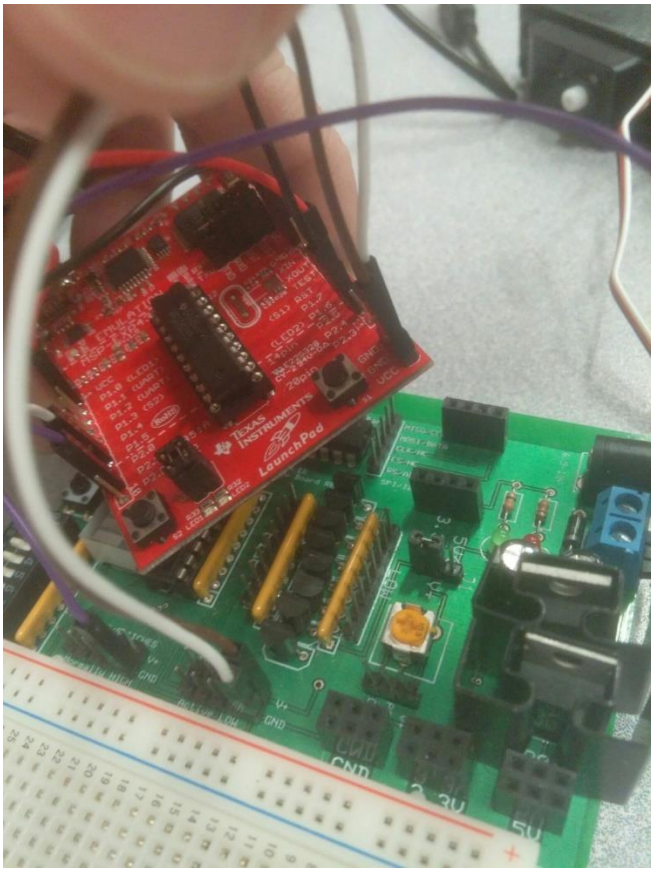


Figure 10 To power the microcontroller, we have female to female wires running from the development board to the microcontroller. White is Ground, Brown is VCC.

Step 7: Tape Everything together

Material List: Ok now we're using the electrical tape. Everything else is already in place, except the optional plastic or cardboard spacer that you can use to elevate the development board above the robot chassis as desired

# Used in this Step	# Already Used	Item
	1	1x MSP430G2553
	1	1x Development Board with the following capabilities:
	2	2x plastic wheels sized to fit servo motors
	2	2x rubber bands to encircle wheels
	2	2x servo motors
	1	1x servo chip designed to control at least two servos, with space for power, data input to motors and ground for each servo.
	7	7x Female-female wires
	2	2x Male – female wires
	1	1x 340 Ohm resistor
	1	1x IR sensor TSOP382 or TSOP 384
	1	1x IR LED
	1	4xAA batteries for servo motors
	1	Harness for 4xAA batteries
		1x power adapter (optional for testing)
1		Electrical Tape
		Plastic or cardboard spacer (optional)
	1	3D Printed Robot Vehicle Chassis (See Figure 1)

- Place sensor angling down and secure it to the front of the vehicle with electrical tape.
- Both the sensor and LED must be mounted facing the primary direction of travel of the robot vehicle. To make sure our IR sensor is facing in the correct direction; we chose to fix ours in place using tape. For the TSOP382 or TSOP 384 the rounded edge of the sensor must face the expected direction of travel.
- Angle IR LED to face forward from development board

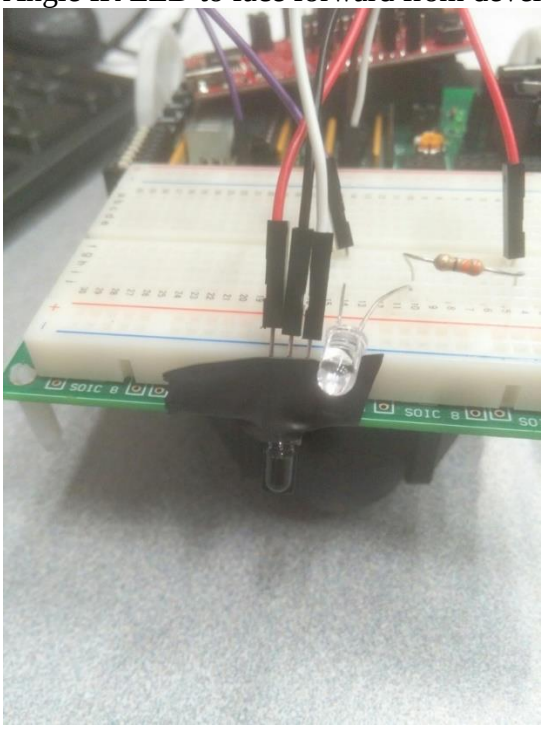


Figure 11: LED points towards front of vehicle and IR sensor is taped to face forward

- Next: tape wires leading from servo chip to each servo motor off to the side so that they do not interfere with vehicle locomotion

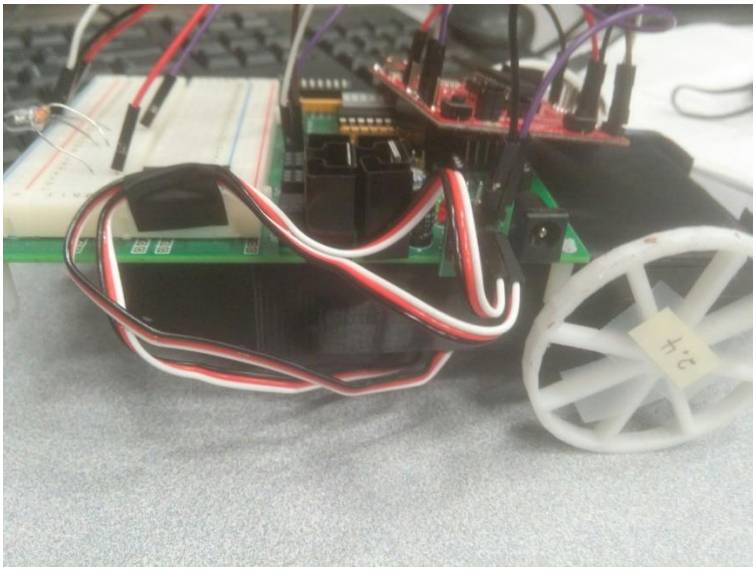


Figure 12 Servo Wires taped to side

Next: secure the devBoard and Micro controller to robot chassis with electrical tape

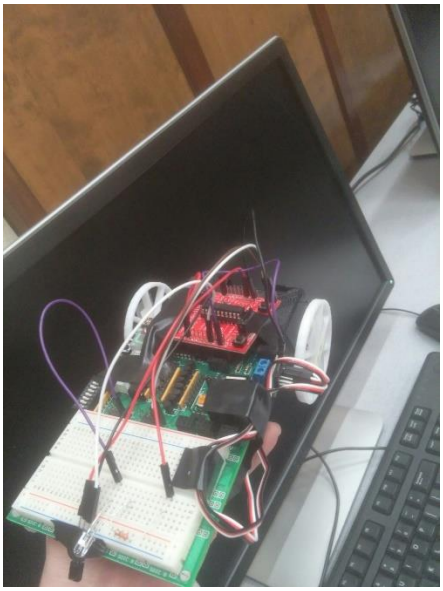


Figure 13 Taping microcontroller and devboard to the robot chassis; it's important to leave the wheels unobstructed and the microUSB microcontroller data input available for changes to code and testing.

Finally: secure the battery harness to the undercarriage of the robot chassis

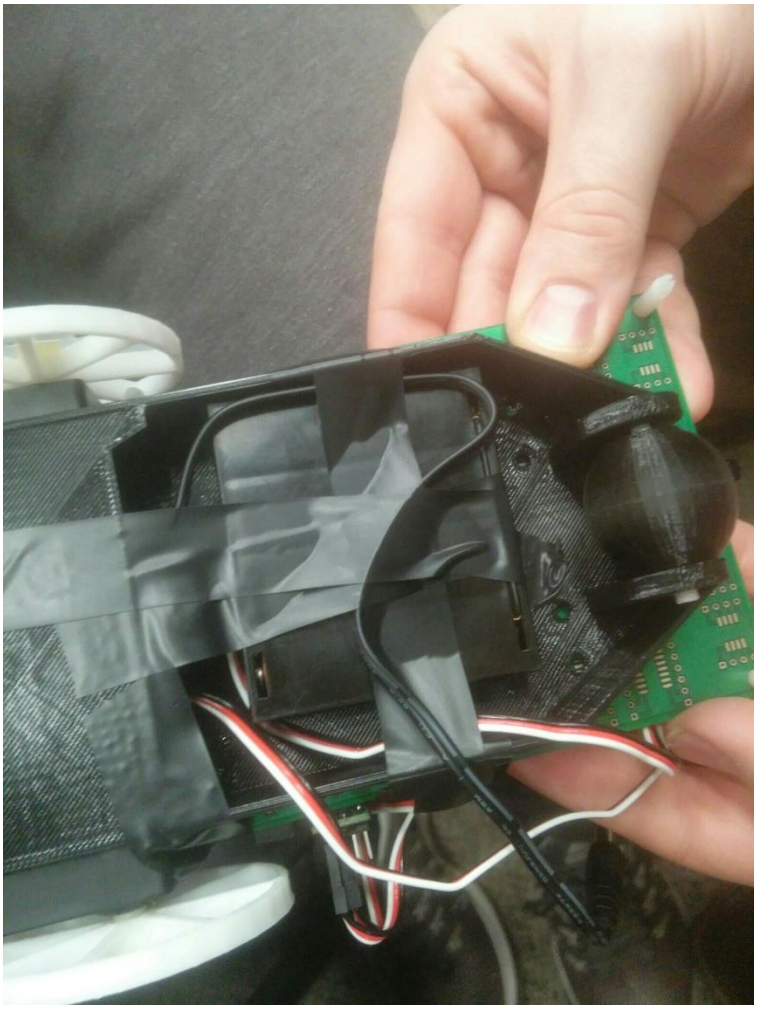


Figure 14: Finally, secure the battery harness with tape. Or, as Sam says, just wad tape in there until it sticks.