The Model-2
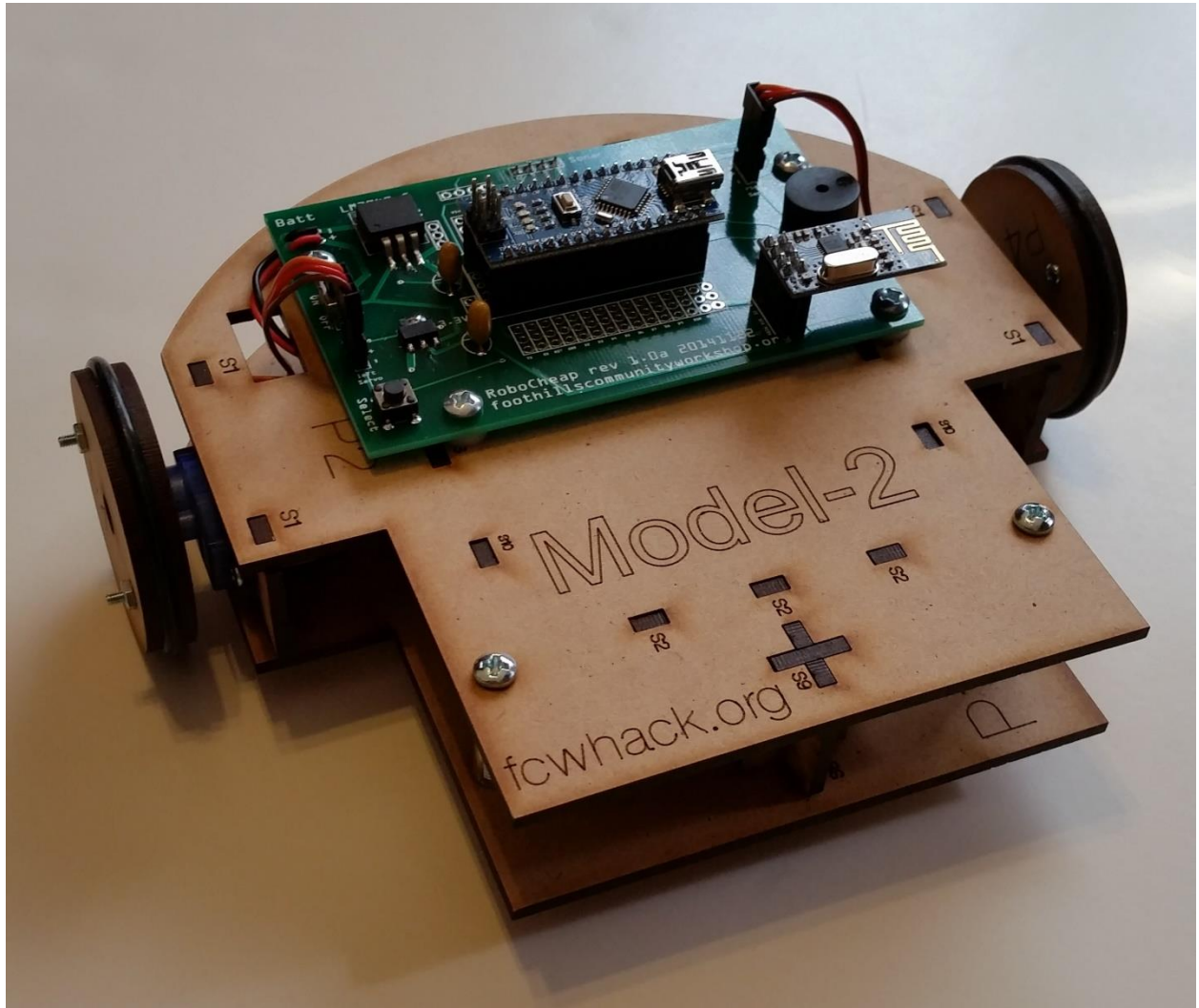
The inexpensive educational robot

User's Manual

Version 1.01 – 1/3/15

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Overview

The Model-2 educational robot kit is designed to be one of the least expensive ways to get started learning about robotics, microcontrollers and their programming. The Model-2, once assembled, will work immediately. Since it is pre-programmed it does not have to be connected to a computer. Although, when you are ready, you can connect the Model-2 to a computer and program it yourself to do whatever you want.

The Model-2 comes with an Arduino Nano microcontroller, an ultrasonic sensor used for distance sensing, a piezo buzzer, two continuous rotation servo motors used for propulsion, a button used to communicate with the Model-2 and a 2.4GHz radio used to talk to other Model-2 robots. All of the electronics are preassembled on a printed circuit board (PCB). The servo motors and ultrasonic sensor have to be plugged into the PCB during assembly. No soldering is required.

The Model-2 is a complete kit containing all of the hardware, chassis parts, electronics and a pre-programmed microcontroller. You will, however, have to supply four AA alkaline batteries.

The chassis uses tab and slot construction which makes it very easy to assemble. All parts are marked with their part number and each slot and tab is marked so that mistakes in assembly are not easily made.

By purchasing the Model-2 Add-On Kit #1, In addition to performing as a robot, the Model-2 can also be used as a microcontroller lab. Add-On Kit #1 will give you what you need to build your own circuits using LEDs, infrared transmitters and receivers, transistors, light sensors and other parts.
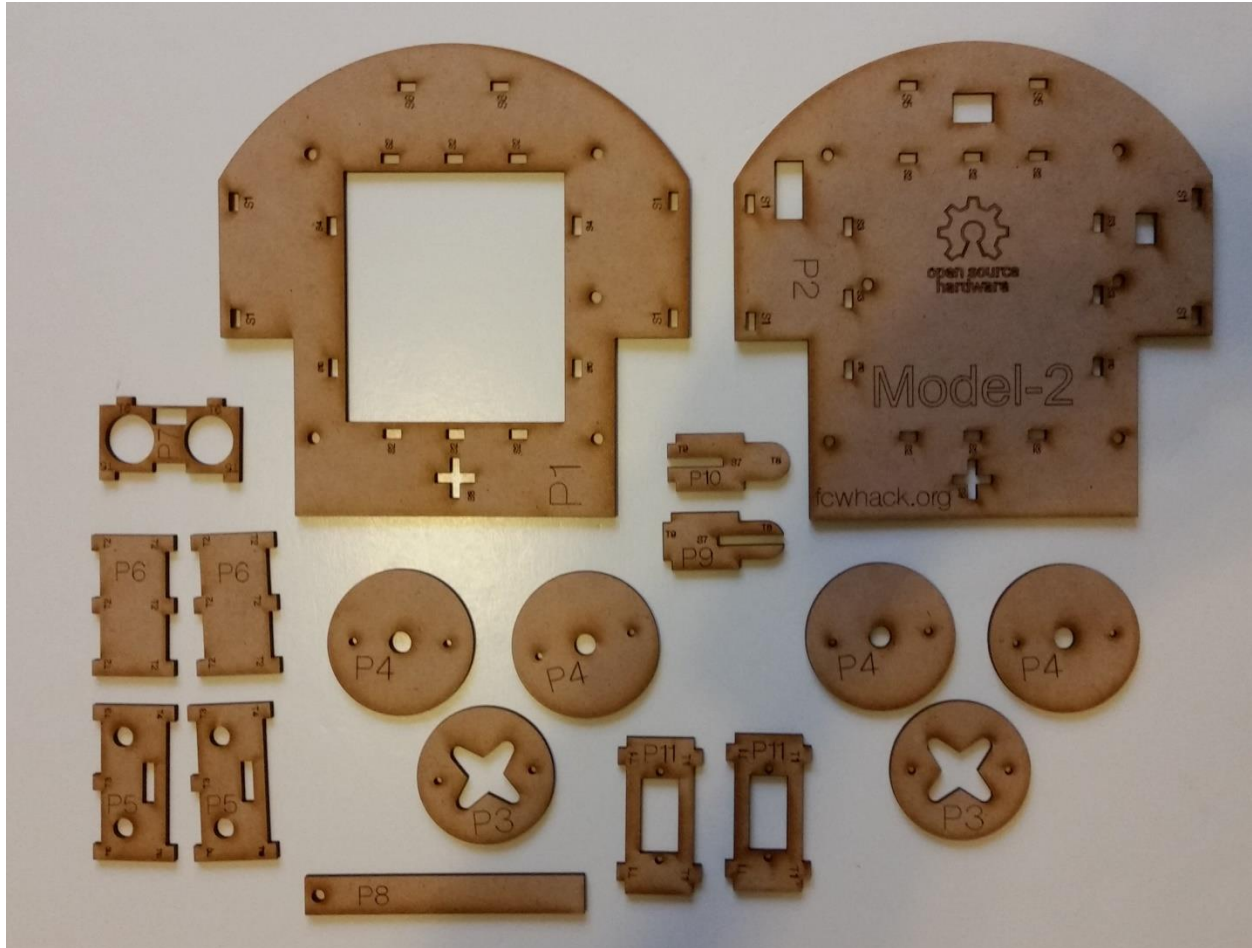
Kit Assembly

Bill of Materials

Part #	Quantity	Description
3mm MDF Parts (brown laser-cut parts)		
P1	1	Bottom plate
P2	1	Top plate
P3	2	Center wheel disk
P4	4	Outside wheel disk
P5	2	Side supports
P6	2	Front and rear supports
P7	1	Ultrasonic sensor mount
P8	1	Battery box clamp
P9	1	Rear skid piece 1
P10	1	Rear skid piece 2
P11	2	Servo motor mount
Electronic Parts		
	2	Servo motors
	1	Ultrasonic sensor
	1	Battery box
	1	Printed circuit board (PCB)
Miscellaneous Parts		
	8	2-56 X 3/8" machine screws
	8	2-56 nuts
	2	6-32 X 1¼" machine screws
	2	6-32 X 1½" machine screws
	3	6-32 X ½" machine screws
	7	6-32 nuts
	4	Plastic printed circuit board spacers. They look like white plastic washers.
	2	O-rings
	4	Clear plastic 7/8" spacers
	1	USB programming cable
	2	Round servo horns
	3	Very small servo horn screws (they look like very small wood screws. One is extra.

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The MDF parts of the model-2

All of the 3mm MDF parts are marked with their part number (Px). They also have their slots (Sx) and their tabs (Tx) marked. The tabs go into the same numbered slot as the tab number.

Assembling the Servo Motors and Mounts
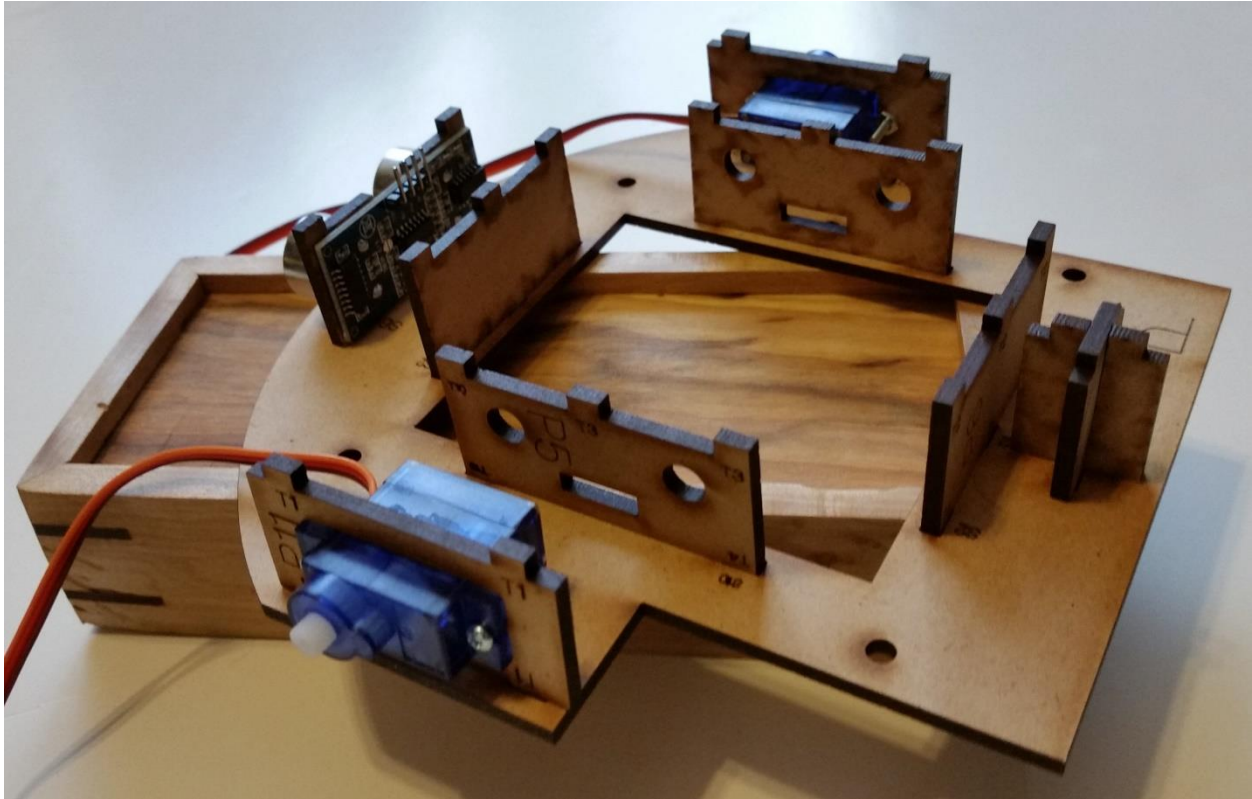The servo motors are used to turn the wheels and propel the Model-2.

This step mounts the servo motors to the servo motor mounts. You will need the two servo motors, the two servo motor mounts (P11), four 2-56 X 3/8" machine screws and four 2-56 nuts.

Do the following steps for each of the two servo motors and mount.

1. Push the servo motor cable through the rectangular hole in the servo motor mount.
2. Push the servo motor through the rectangular hole in the servo motor mount. The servo motor end with the cable has to be pushed through at an angle first. Then, push the other side of the servo motor through so that the servo motor is tight against the servo motor mount. During this step be careful not to damage the servo motor cable.

3. Put one 2-56 X ½" machine screw into each of the servo motor mounting holes. The screws go through the servo motor first and then the servo motor mount. Put a 2-56 nut on each screw and tighten them firmly.

Assembling the Model-2

Assembling the Ultrasonic Sensor Mount

The ultrasonic sensor mount holds the ultrasonic sensor and also acts as an additional front support.

1. The ultrasonic sensor mount (P7) has a small rectangular cut-out in it. The Ultrasonic sensor has a small silver box with semi-circular ends that goes into the cut-out. Place the ultrasonic sensor into the ultrasonic sensor mount by pushing the sensor through the mount. The ultrasonic sensor should be tight against the mount.
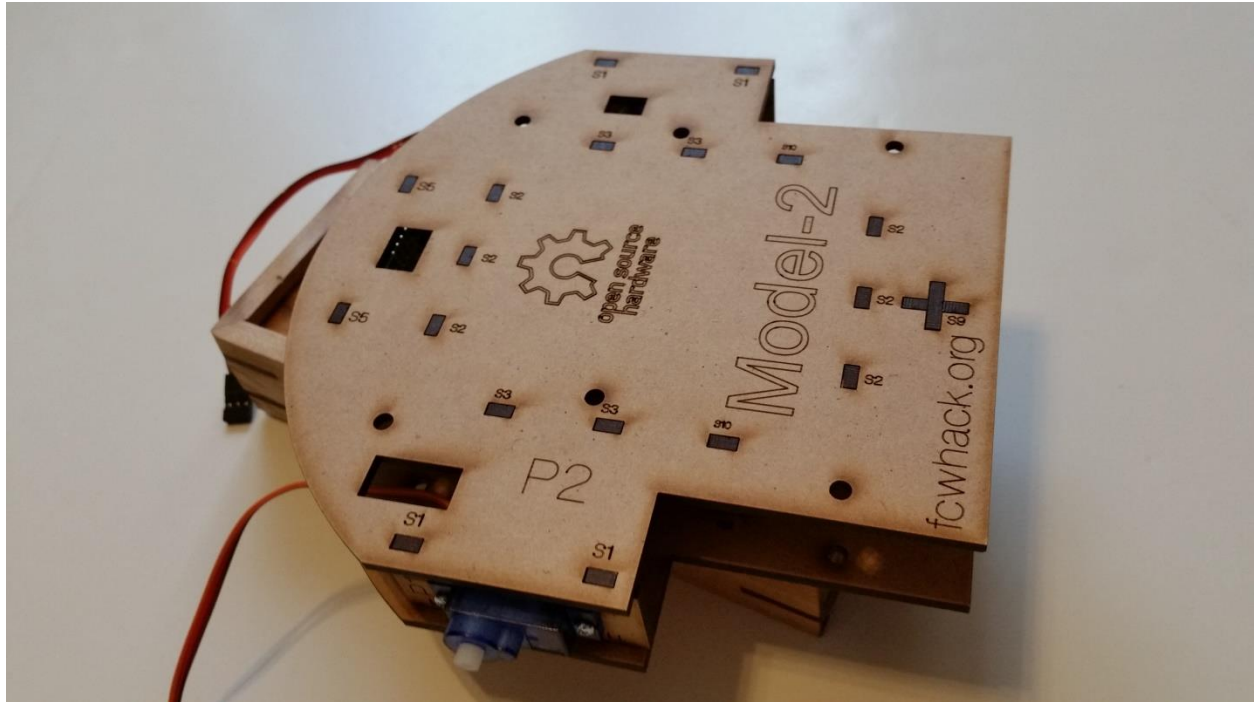
Assembling the Chassis

The chassis is the main part of the Model-2. It supports the electronics, servo motors, ultrasonic sensor and batteries. The curved edge of the bottom (P1) and top (P2) plates are the front of the Model-2. The straight edge opposite of the front edge is the rear of the Model-2. Looking at the top and bottom plates as if they are a car, the driver's side is the left side of the Model-2 and the passenger side is the right side of the Model-2. The following are the steps to assemble the chassis.

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1. Position the bottom plate (P1) so that the text is visible and the cross slot (S8) that holds the rear skid is off the edge of your work surface.
2. Assemble the rear skid (P9 and P10) and place it in the cross slot (S8). Since the rear skid extends below the bottom plate (P1) the bottom plate has to hang off of your work surface or be supported on a small block or box.
3. Place the front and rear supports (P6) into the bottom plate.
4. Place the side supports (P5) into the bottom plate.
5. Place the ultrasonic sensor mount (P7) into the bottom plate being careful to position it so that the sensor is pointing to the outside of the Model-2.
6. Place the servo motor mounts (P11) into the bottom plate. The servo mounts must be installed with the servo motor shafts toward the front and the screw heads on the outside of the servo motor mount.
7. Carefully fit the top plate (P2) onto the various supports and mounts. Start by getting the rear skid to fit into the top cross slot (S9). Next, do the rear support. Then progress to one of the servo motor mounts and the side support on the same side. Repeat on the other side with the side support and the servo motor mount. Finally, do the front support and the ultrasonic sensor mount. The top plate should fit without having to force any of the tabs into the slots. Just be careful to get the tabs lined up with the slots.
8. While holding the top and bottom plates together slide one of the clear plastic spacers between the plates so that it lines up with one of the two holes at the rear of the top and bottom plates. Then, place a 6-32 X 1¼" machine screw into the hole in the top plate, through the clear plastic spacer and into the hole in the bottom plate. Place a 6-32 nut on the screw and tighten lightly. Now, do the same with another spacer, screw and nut in the other hole on the rear of the top and bottom plates. Temporarily do the same with a 6-32 X 1½" machine screw in one of the holes near the front of the top and bottom plates and tighten lightly. Now, firmly tighten the two screws at the rear of the top and bottom plates. Do not put the remaining screw in yet.

Top plate on partially assembled Model-2

Assembling the Electronics

1. Locate the PCB. You will notice that there are a few parts on the top of the board, but only a four pin female header on the back of the board.
2. The correct orientation of the PCB is with its female header lined up with the ultrasonic sensor pins that stick up through the top plate of the Model-2 and the four mounting holes of the PCB lined up with the corresponding holes in the top plate.
3. Orient the PCB so that you can read the text printed on the board. The radio is the small PCB in the lower right hand corner of the main PCB. It may or may not be mounted on your board. If it is mounted it will be in a header above a mounting hole. If it is mounted remove the radio from the PCB by gently pulling the radio up until the radio's pins have completely released from the header.
4. Remove the 6-32 X 1½" machine screw, nut and clear plastic spacer that was temporarily placed in one of the holes in the top and bottom plates.
5. Carefully push the PCB's female header onto the ultrasonic sensor pins. Put one white plastic spacer under the PCB mounting hole from which you just removed the 6-32 X 1½" machine screw and replace the 6-32 X 1½" machine screw, clear plastic spacer and nut. Do the same with the other 6-32 X 1½" screw, white plastic spacer, clear plastic spacer and 6-32 nut in the PCB mounting hole that lines up vertically with the first one. Now, put one white plastic spacer under the two remaining PCB mounting holes and add the 6-32 X ½" machine screws and nuts. Firmly tighten all four of the screws, but be very careful not to tighten them so much that the PCB cracks.

6. Plug the radio back into the main PCB. Make sure you put it in the header so that the radio extends to the right over the mounting hole.
7. Thread the battery clip from the PCB through the rectangular hole next to the left top mounting screw and into the battery compartment below the top plate.
8. Plug the left and right servo motor cables into the marked three pin male headers on the PCB. Be very careful to get the brown wire in the cable onto the minus (-) pin on the header.

Assembling the Wheels

The Model-2's wheels are a sandwich of three parts, an outside wheel disk (P4), a center wheel disk (P3) and another outside wheel disk (P4). The center wheel disk has a slightly smaller diameter than the outside wheel disks. This creates a slot to hold an O-ring that acts like a tire.

Do the following steps for each of the two wheels.

1. Locate a servo horn (white plastic cross with a lot of small holes in it).
2. Put a 2-56 X3/8" machine screw through one of the outer holes in an outside wheel disk (P4). Then, add a center wheel disk (P3). Put the servo horn in to the cross shaped cutout in the center wheel disk. The servo horn has a hub on each side of it. One of the hubs is deeper that the other. Make sure the deep servo horn hub is not in the large hole in the outside wheel.
3. Put a second outside wheel on the stack of outside wheel and center wheel.
4. Now, put a 2-56 nut on the screw and tighten very lightly. Line up the other hole in the wheel sandwich and put another 2-56 X 3/8" screw into it. Lastly, firmly tighten the screws.
5. Stretch an O-ring over the slot in the wheel. It will take some effort, but the O-ring will stretch to fit.

Mounting the Wheels

The wheels are mounted on to the spline (looks like a very small white gear) of the servo motors. The servo motor horn has a similar spline inside its hub.

1. Place a wheel onto a servo motor by lining up the spline on the servo motor with the spline in the servo horn hub. Do this by placing the wheel onto the servo motor and turning very gently until you feel the two splines mesh. Then, press the wheel onto the servo motor with a small amount of force.
2. Put one of the very small servo horn screws into the hole in the wheel, oriented so that the point of the screw will go through the hub of the servo horn. Firmly, but not using too much force, tighten the screw securely onto the servo motor.
3. Do the same for the other wheel.

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Installing the Battery Box

1. Put four alkaline batteries into the battery box. Be careful to get the batteries in correctly. The negative sides of the batteries go to the springs. Orient the Model-2 so that you are looking into the battery box compartment with the rear skid at the bottom. Place the battery box into the battery box compartment on the bottom of the Model-2 so that the battery connection clip is at the top right with the batteries showing and the battery box touching the rear support and centered horizontally.
2. Attach the battery clip to the battery box.
3. Clamp the battery box into the battery box compartment using the battery box clamp (P8). The battery box clamp has a hole in one side. There is also an empty hole to the left of the battery box compartment. Put the end of the battery box clamp with the hole into the slot in the side support near the hole. Push the battery box clamp all the way to the left and then down into the battery box compartment. Push the battery box clamp to the right until the screw hole in the battery box clamp and the bottom plate line up.
4. Put a 6-32 X ½" machine screw through the bottom plate hole into the hole in the battery box clamp. Fasten it with a 6-32 nut. Do not tighten enough to deform the end of the battery box clamp.

Your Model-2 is now ready to run.

Using the Model-2

Mode Button
There is a small momentary contact push button on the PCB. This is the mode button. Multiple pushes of the mode button specify which mode the Model-2 should enter. After pushing the button the required number of times for the mode you wish to select, you will hear the Model-2 beep that same number of times. If you hear more or less beeps than button pushes, try again.

Autonomous Mode (default) – One Mode Button Push
The autonomous mode is the default mode of the Model-2. When in autonomous mode the Model-2 will roam autonomously while not hitting any obstacles. As soon as you turn on the power switch, the Model-2 will enter autonomous mode and will start moving forward. While it is moving it is continually emitting short bursts of high frequency sound from the transmitter of the ultrasound sensor. These are called pings. A human can't hear the pings.

When there is an object within about twelve feet of the ultrasound sensor and directly in front of it the ping will reflect off of the object and be received by the receiver of the ultrasound sensor. The computer calculates the distance to the object by measuring the time between the transmitted ping and the received ping and calculating the distance based on the speed of

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sound in air. When an object is about one foot away the Model-2 will randomly turn right or left looking for a place where there is no object within one foot. It will then start moving forward again.

Swarm Behavior Mode – Two Mode Button Pushes

Swarm mode can be used when there are multiple Model-2s running in an area. By entering swarm mode one Model-2 becomes the leader. The leader sends radio signals to all of the other Model-2s and all of the Model-2s (including the leader) will start dancing the same dance at the same time. When the dance is over, all of the Model-2s will enter autonomous mode. Do not make more than one Model-2 the leader. If you do, the radio signals will get mixed together and the results are unpredictable.

While in swarm mode the Model-2 will ignore the ultrasound sensor and may hit an obstacle.

If there is only one Model-2 running it will perform the dance by itself.

Servo Calibration Mode – Three Mode Button Pushes

The continuous rotation servo motors can be tuned so that they react to commands more similarly. This can help if, as an example, one wheel is moving faster than the other and causing the Model-2 to move in a circle. When the Model-2 enters servo calibration mode the servo motors stop, although one or both of the servo motors may be rotating very, very slowly. The servo motors contain a potentiometer (like a volume control) on their back side. There is an adjustment slot in the potentiometer that is accessed through a hole in the back of the servo motor.

This adjustment is accessible with a small straight screwdriver through the hole in part P5 by removing the battery box. The battery box must be removed, but left attached to the PCB. Adjust the servo motor until it completely stops and is no longer making noise. It may not be possible to get the servo motor completely stopped. Just do the best that you can. Also, note that this adjustment will drift with time and battery power level and may have to be repeated from time to time. However, this not a critical adjustment and only has to be done if you are having severe problems with the servo motors running at different speeds.

Test Mode

The Model-2 can be completely tested by going into test mode. Test mode is entered by pressing and holding the mode button while turning on the Model-2. When test mode is entered the buzzer will beep twice.

Next, the Model-2 will enter a mode where the ultrasound sensor is activated. If you put your hand within six inches of the ultrasound sensor, the Model-2 will beep and continue beeping until you remove your hand.

Now, press the mode button and you will enter the radio test. When you press the mode button the radio will send a signal out. If there is another Model-2 within range it will beep. This

tests the radio's transmitter. To test the receiver, put another Model-2 in test mode and enter its radio test mode. Press the mode button on the second Model-2 and you will hear the first Model-2 beep.

To exit test mode, turn the Model-2 off and then on again.

Hardware

Maintenance
There is very little that has to be done to maintain the Model-2. The batteries will have to be changed when the Model-2 stops working or is not responding to swarm mode. Always use a fresh set of four alkaline AA batteries. When you change batteries you must change all of them.

Depending on your environment, you may have to clean the servo motors once in a while. You may find that hair, dust balls or other matter accumulates between the servo motors and wheels. You should remove this matter periodically. If it is not easy to remove, then remove the wheels from the servo motors by using a small Phillips screwdriver to remove the hub screw from the center of the wheel. Then, gently pull the wheel off of the servo spline. Remove the hair or dust and reinstall the wheels by following the "Mounting the Wheels" topic in the "Kit Assembly" portion of this manual.

The Microcontroller
The microcontroller on the Model-2 is an Arduino Nano 3.0 clone. The Arduino is a group of microcontrollers designed for educational purposes. The best place to start learning about the Arduino that the Model-2 uses is here:

http://www.arduino.cc/