Robotics Badges: ***Programming Robots 1***

Motorized Robot Building Instructions

THINGS TO KNOW:

About robot prototyping:

- **Robot prototypes or test models are often made using recycled, repurposed, or spare parts.** Learning to take devices apart to reuse the components is a handy skill!
- **You can use the motor from a fan or other device to power a robot.** You may need to modify the motor so it makes the robot move around. To make it roll, you can attach wheels made from recycled materials. To make a robot that moves by vibration, attach an off-center weight to the spinning shaft. Or adjust the motor so the shaft spins against the tabletop or floor, like a top.

About circuits:

- **Electricity is the flow of electrons from one atom to another.** When the energy from a chemical reaction or other source knocks an electron off an atom, electrical current begins to flow.
- **A circuit is a path for electricity to flow.** It is made of conductive material such as metal which carries electricity easily. It is surrounded by insulating material such as paper or plastic that doesn't carry electricity.
- **A closed circuit is a continuous path that allows electricity to flow.** That's because electricity always needs to be a place to go. Usually a circuit is designed in a loop, so that the electrical energy flows around and around.
- **An open circuit occurs when there is a gap anywhere in the circuit.** This interrupts the flow of electricity.
- **A battery (or other power source) has a positive (+) end where the electricity comes out and a negative (-) end where it goes back in.** For electricity to flow, the circuit must be connected to both ends of the battery.
- **A switch controls the flow of electricity by opening and closing the circuit.** It's like a drawbridge over the gap in the circuit.
- **A sensor works like an on-off switch.** When a sensor is activated, it closes the circuit and allows electricity to flow. This sends a signal to a computer or other kind of electronic controller.
- **A sensor can also act like a dimmer switch that lets varying amounts of electricity through.** A robot's computer brain can be programmed to do different things depending on the sensor reading.

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Materials:

Figure 1—Example Mini Fan that could be used

- 1.5 volt DC motor (sometimes called "toy" or "hobby" motor), at least one per robot, available from sellers of student science equipment or electronics components; can substitute recycled or dollar store motorized devices such as hand-held mini fans or electric toothbrushes
- AA or AAA batteries (1 or 2 per motor, depending on type)
- **Optional:** 3 volt vibrating motor and 3 volt coin battery (will work with very light-weight robots)
- **Tools**, including: Small Phillips head and flat screwdrivers, scissors, wire strippers/wire cutters, hot glue gun
- **Assorted types of connectors**, such as: electrical tape, foam mounting tape roll or squares, glue dots, zip ties, twist ties, rubber bands, paper clips (various sizes)
- **Conductive materials** for making circuits, such as: aluminum foil, insulated wire, metal paper clips
- **Assorted crafts materials and recycled items**, such as: recycled cardboard, plastic, or foam cups and containers; bottle caps and lids; cardboard tubes; pool noodles; small corks or foam balls; CDs or DVDs; craft sticks and other wood shapes, including bamboo BBQ skewers and dowels; pencils with unused erasers; thin washable markers; googly eyes, beads, and other small lightweight decorations, pipe cleaners, drinking straws
- **Optional:** Additional cheap or recycled electronics to take apart and reuse, including: solar garden lights or solar moving decorations, LED keychains and keychain "alarms", motorized cars and other toys
- Plastic ziptop bags or other containers for taking robots and any loose pieces home

Steps:

First, expose the parts of the motor you want to use:

- Test your motor by turning it on and off. How does the on/off switch work? Does the motor turn smoothly or does it vibrate?
- On a mini fan, you can pull off the fan blades to expose the shaft. Some cheap electric toothbrushes already have vibrating motors built in. You may be able to use these devices as is, by attaching them securely to the robot's body.
- If you open up a device to remove the motor, try to keep the motor connected to the battery case.

Safety Notes:

- The battery used in this project is too small to give you a shock. However, if the positive and negative sides are connected accidentally, the battery may get hot or cause a fire. This is called a short circuit. Don't connect the positive and negative sides of the battery to each other unless there is a load in the circuit.
- If you are cracking open the outside casing of a device, wear safety goggles to keep broken bits from flying into your eyes.

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- If you need to reconnect the motor and the batteries, you can use anything conductive, including electrical wires, aluminum foil, paperclips, or twist ties (with the paper peeled off the ends to expose the metal wire inside).
- To use insulated wire, you need to strip about 1/4 inch of the insulation off the ends to reveal the metal inside. Use a wire stripper by clamping it onto the insulation where you want to cut it, then sliding it towards the end, pulling the insulation with it.
- To connect wires, twist the ends of each wire together—making sure that the conductive metal parts of each wire are touching. To ensure a good electrical connection, wrap it with a postage-stamp-sized piece of aluminum foil. Cover the exposed wires or connections with insulating electrical or other tape.
- Make a new on-off switch by leaving one wire loose enough to remove from the battery terminal.
- For very light-weight robots, you can use a vibrating motor (which come as discs or cylinders and can be salvaged from some electric toothbrushes or old pagers/phones) and a 3 volt coin battery. See the photos for how to connect the motor to a coin battery with foam tape.

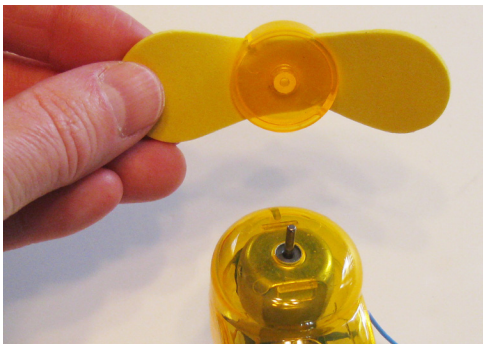

Figure 2—Removing the fan blades to get to the vibrating motor.

Figure 3—Finished "FanBot"

Next, figure out how you want to use the spinning motor to make the robot move.

- If you want to make a motor vibrate, add an off-center weigh. You can form a lopsided lump of clay over the shaft, push the end of the shaft into cork or another soft material like packing foam, or attach a weight to (such as beads) using hot glue. (Avoid getting glue inside the motor where it could gum up the works.)
- You can also use the tip of the spinning motor shaft to move the robot around the way a top wobbles around. Position the motor so the shaft is resting on the table or floor.
- Or use the motor to turn a wheel. Wrap a rubber band around the outside of the wheel and connect it to the shaft of the motor, like a drive belt. (See suggestions below for making wheels.)

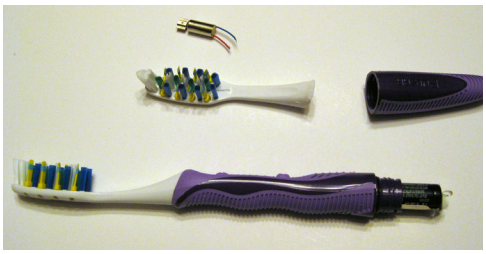

Figure 4—You can take apart an electric toothbrush to get to the vibrating motor.

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Now it's time to create a body for your robot. Some suggestions:

- Add to your robot's body with recycled containers or other items.
- On a spinning top-style robot, connect the motor to an old CD with the shaft poking through the center hole.
- Add legs to a robot made from craft sticks, straightened paper clips, or thin washable markers (for a drawing "artbot").
- Toothbrush bristles make good feet. Use a wire cutter to snip the head off a toothbrush.
- Create wheels using bottle caps or other items. One way is to remove the eraser from a pencil and push it onto the motor shaft. Glue the other end onto the inside of a bottle cap. To make an axle to hold the wheels, attach a drinking straw to the robot body. Cut a bamboo skewer to the length you want, then insert it into the straw. Glue bottle caps on the end of the skewer. To make the wheels and axle turn, wrap a rubber band around the outside of one wheel and connect it to the shaft of the motor, like a drive belt.

For robots to meet the "sense-think-act" definition, they need some way to respond to their environment. Even without an electronic controller, you can design a robot's body to affect the way it moves by changing the shape and weight distribution. This "programmable" body determines the way the robot reacts to conditions around it.

How can you program your motorized robot? Can you make it go in circles? In a straight line?

Want More Challenge? Try this!

- Design a switch that turns the robot off when it bumps up against something and use it as a touch sensor.
- Add additional motors to push the robot around in different directions.
- Add parts from an electronics kit such as Lego Robotics or littleBits to control a motor
- Add a microcontroller (such as micro:bit or Adafruit Circuit Playground Express) to control a motor with programming.