

Robotics Badges: *Designing Robots 1*

Model Tilt Sensor Instructions

Overview:

To understand how sensors and programming can be integrated into explorer robots, build a model of a sensor that can help robots get around rough terrain.

How Robots Know They are Tilted

- Robots use sensors to help them maneuver over rough terrain. An **accelerometer** can give the robot information about its speed and whether it's going along flat ground or up or down an incline. This is the same kind of sensor that rotates the image on a smart phone screen when you turn the phone sideways.
- A **tilt sensor** is a simple version of an accelerometer. It can tell a robot if it's pointed up, down, or to the side. Its programming could then direct the robot to give more power to the wheels in the front, the back, or on one side or the other to help it roll over an obstacle.
- A tilt sensor works by making an electrical connection when it is tilted. It is similar to an on/off switch, but instead of pushing a button, you let gravity do the work.

How the Model Tilt Sensor Works

- The Model Tilt Sensor you will build has different colored LED light bulbs to indicate which way it is tilted. On a real robot, the sensor would send different signals to the robot's "brain" so it could keep itself upright.
- The model Tilt Sensor is shaped like a bell. It is made from an upside-down plastic or paper cup. Instead of a clapper that bangs against the sides of the bell, it has a paperclip chain that swings and touches the inside of the cup at different spots.
- At the end of the chain, a battery acts as a weight. When the chain swings so that the battery touches a strip of metal foil connected to one of the LEDs, it closes the gap in the electrical circuit and makes the LED light up.



Finished Tilt Sensor

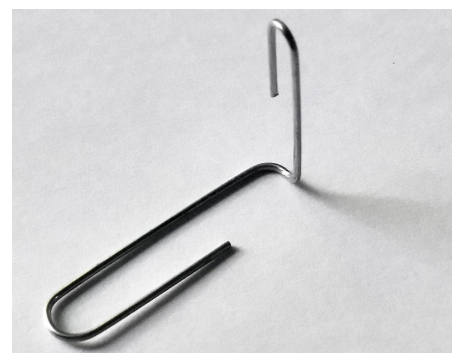
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Materials

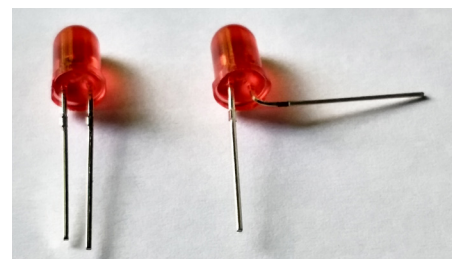
- Medium plastic or paper cup (16 ounce works well)
- Aluminum foil tape, cut into 2 small strips (1/2 inch by 2 inch) and 2 larger strips (1 inch by 1 foot); the foil tape is sold in duct-tape-size rolls in the heating duct aisle of hardware stores
- 2-4 LEDs in different colors, with the longer wire leg or lead around 1 inch long (available from hobbyist electronics/robotics parts retailers online)
- 3 volt (3V) coin battery (such as CR2032)
- 3 or more metal paperclips (metal must be visible, no paint or plastic covering)
- Clear tape
- Scissors
- Pen or pencils
- Paper
- **Optional:** craft knife, such as an X-Acto knife

Steps

1. First, take one of the paperclips and bend it open so that the big outer loop and the smaller inner loop are perpendicular (form an “L” shape).
2. Next, turn the cup over so the bottom is facing up. Use one point of the scissors or a craft knife to cut a slot in the bottom of the cup. It should be big enough for the smaller loop on the bent paperclip to slide in and out easily. That loop will serve as a hook to hang the paperclip chain “clapper” on the sensor’s “bell.”
3. Then, take the LEDs and the battery. Test each LED by sliding the two wire legs (also known as leads) over the sides of the battery. If it lights up, note which lead is touching the positive (+) side of the battery. It should be the longer lead. (If the LED doesn’t light up, turn it around.)
4. To prepare the first LED, take the positive wire leads and bend it out, perpendicular to the other lead. Repeat with the other LED(s).
5. Take a small strip of foil tape (about 1/2 inch by 2 inches). Hold all the LEDs by their negative (downward-pointing) wire leads as if they were a bunch of flowers. Add the bent paperclip with the smaller loop facing down. Make sure the wire leads are touching the paperclip and the bulbs are sticking up above the bend of the paperclip.



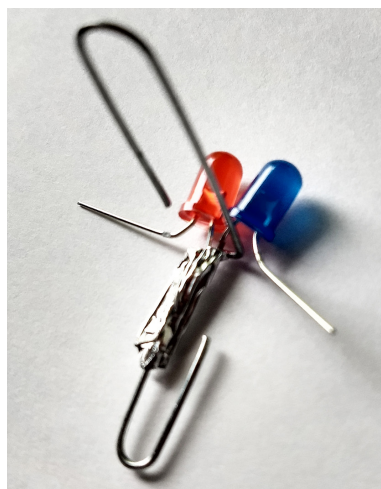
STEP 1: Bend the paperclip into an “L” shape.



STEP 4: Gently bend the longer lead (wire leg) of each LED so it sticks out perpendicular to the other lead.

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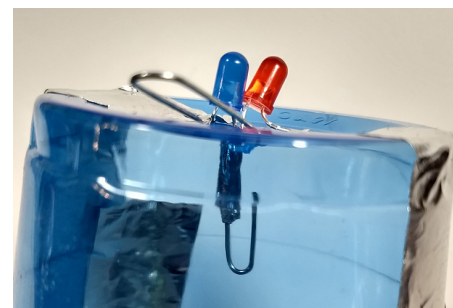
6. Now wrap the small foil strip around the LED wires and one side of the paperclip loop. Be sure to leave loop open because you will use it as a hook to hand the paperclip chain “bell clapper.” After it’s wrapped, squeeze the foil to make the bundle of wires as thin as possible.
7. Insert the paperclip with the LED wires attached back into the slot in the cup, as far as it can go.
8. To fasten the positive wire of the first LED to the surface of the cup, take a large strip of foil, about 1 inch by 1 foot. The length will depend on the size of the cup. Start to peel the end off the backing paper. Press the end of the foil over the positive wire, down the outside of the cup, around the lip, and up the inside of the cup. It should reach at least halfway up the inside. Do the same with the other LEDs.
9. To make the “clapper,” chain two paperclips together. Cut a piece of clear tape about the size of the battery. Tape the negative side of the battery flat against one end of the paperclip chain. Make sure the paperclip is only touching the negative side. To prevent short circuits, use additional pieces of clear tape to completely cover the negative side of the battery, trying not to cover the positive side with the tape.
10. To make sure the positive side of the battery can touch the strips of foil inside the cup no matter where they are, take the other small strip of foil, attach it to the positive side of the batter, and wrap it



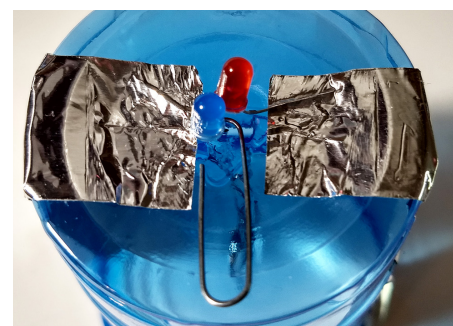
STEP 6: Tape the LEDs to the paperclip tightly, leaving the “hook” open.

To avoid short circuits, make sure:

- the paperclip is not connected to the positive side of the battery by the foil tape
- the upper loop of the bent paperclip is not touching the larger foil strips (if it is, cover the foil with clear tape to insulate it)



STEP 7: Insert the “hook” of the paperclip into the cup so the LEDs sit on top.



STEP 8: Tape the remaining leads of the LEDs to the top of the cup. Don’t let the foil tape touch the paperclip.



STEP 9: Use clear tape to attach the negative side of the battery to the paperclip chain. Cover the entire negative side of the battery with clear tape. Then wrap foil tape around the entire battery. Make sure the foil touches only the positive side of the battery. (The edge of the battery is part of the positive side.)

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horizontally around the middle of the battery, right over the clear tape. *Make sure the metal foil tape does not touch the metal of the paperclip!*

11. Finally, hang the paperclip chain from the hook inside the cup (the small loop of the bent paperclip).
12. To test the sensor, tilt the cup so the battery at the end of the chain is touching one of the strips of foil. The LED attached to that strip should light up. Tilt it another way to make the other LED(s) light up.

Troubleshooting Tips:

Remember that a circuit is made of conductive material - in this case, metal foil tape, metal paperclips, the positive and negative sides of the battery, and the positive and negative wires on the LEDs. If an LED isn't lighting up, check that:

- the foil is making good contact with the wire lead
- the paperclips are all touching each other
- the paperclip is making good contact with the negative side of the battery
- the sticky side of the foil tape is conductive; if it isn't, fold under one edge of the tape so the shiny side is making contact with the metal piece you are connecting it to



STEP 12: Tilt the cup so the battery touches the foil strip on one side to make the red LED light up. Tilt it the other way to make the blue LED light up.