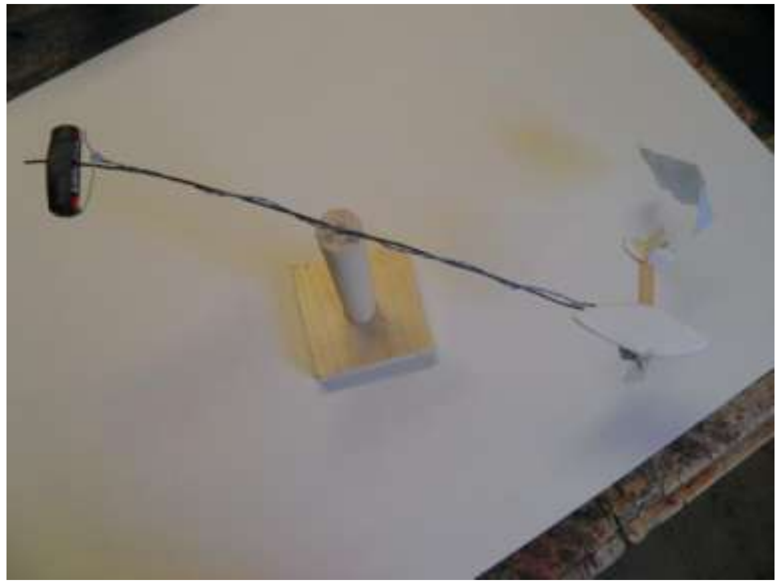
Motorized Balancing Toy

Category: Physics: Force and Motion, Electricity

Type: Make & Take



Rough Parts List:

1’	Coat hanger
1	Motor
2’	Electrical Wire
1	AA battery
1	Wide rubber band
1	Block of wood
1	Plastic bottle
	Foam core, popsicles sticks, paint, or other supplies to make and decorate a flying toy

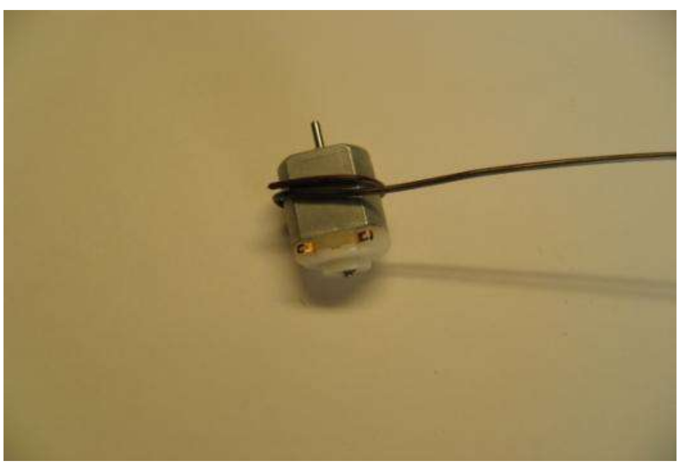
Tools List:

Scissors
Pliers
Hot glue gun
Small wood saw

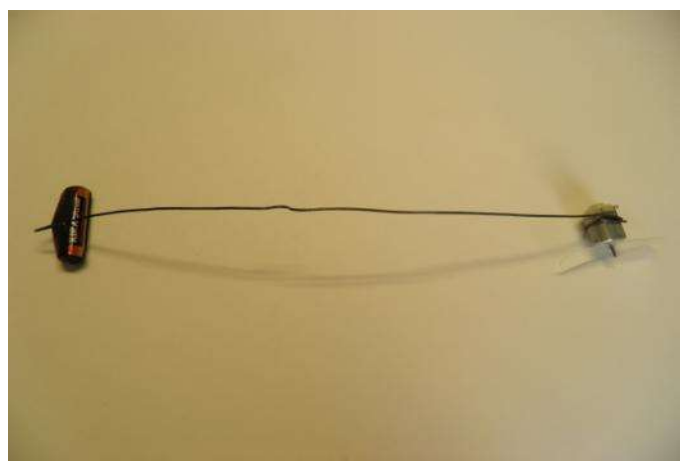
Video: http://www.youtube.com/watch?v=Puo1nSYvErM&feature=plcp

Blog Link: www.oaklanddiscovery.blogspot.com

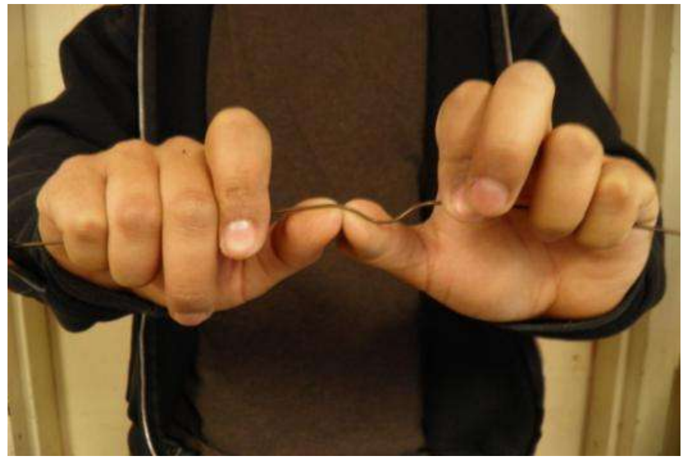
How To:



Wrap one end of a 14” piece of coat hanger around the motor. Make sure that it is secure!

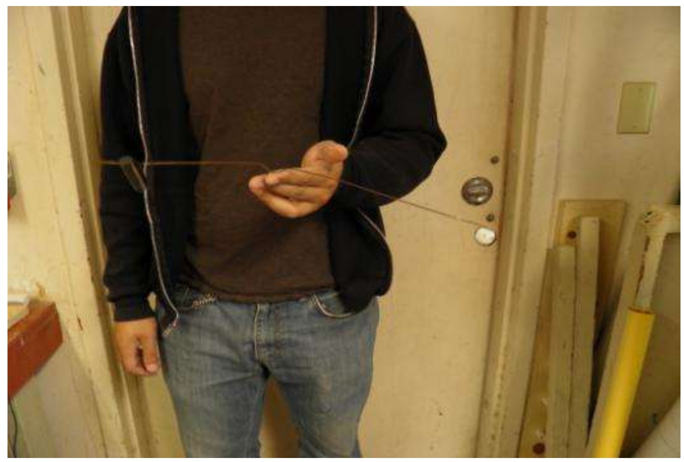


Attach a battery to the other end of the coat hanger wire with a thick rubber band.



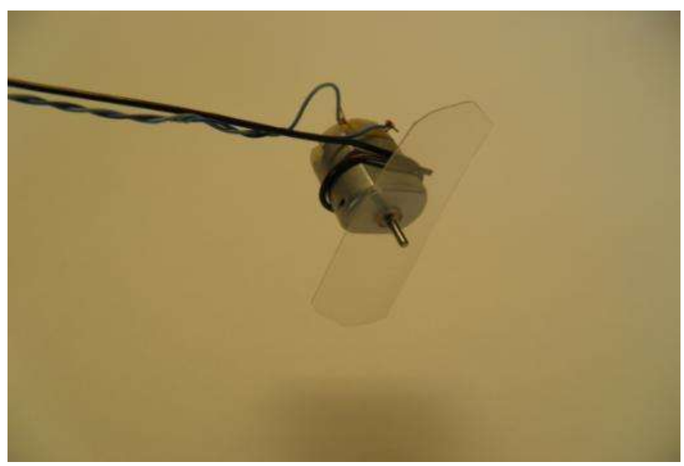
Balance the wire on your finger.
You have just found the balancing point!

Use your thumbs to bend a shallow "V" into the wire at the balancing point.



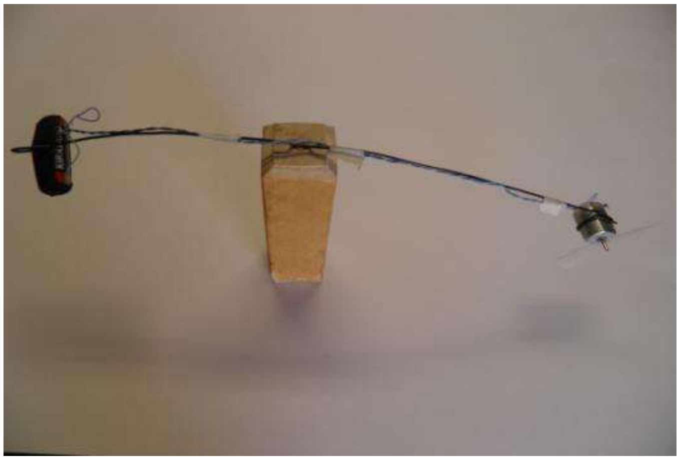
Your wire should look like this. The point of the "V" will be the pivot point for your toy.

Try balancing the wire at the pivot point. You might need to move the battery or bend the wire a little bit.

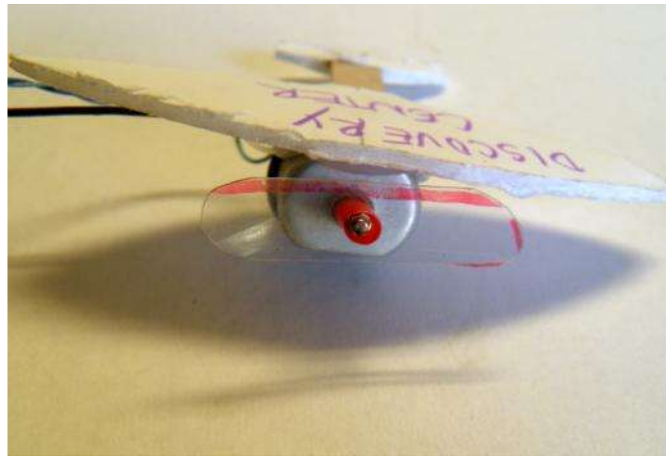


Trace and cut an oval out of a plastic bottle or cup. This will be your propeller. Poke a hole in the middle to attach to the motor shaft.

Twist the stripped ends of electrical wire onto the motor terminals. Wrap the wires around the coat hanger until they reach the battery, slip them under the rubber band and connect them to the battery. The motor should start spinning!



Create a stand for your toy to balance on and spin around. Use a screw driver to carve out a shallow dip in the top of the stand. Place the pivot point in the dip and watch your toy fly around.



Decorate the motor end of the toy. Some foam board and popsicle sticks can make a cool plane!

Fine Points:

→ Cut your propeller diagonally from the bottle. The curve of the bottle is utilized this way to create the most effective propeller.
→ If your airplane wants to go backward, try reversing the two wires going to the motor, or to the battery. To go forward, the fan should be blowing backward across the plane.
→ Tape your electrical wire to the coat hanger wire to keep things neat.
→ Once you decorate your toy, you might need to balance everything again. Try sliding the battery outward or adding some small weights such as washers.
→ Add a base to your toy for stability. You can decorate the base and create an entire animated scene.
→ Your toy might spin too quickly at first. Think about ways to slow the spinning and create a more stable system.

Concepts Involved:

- In order for this toy to work, it is important to find the center of mass of this system of objects. The center or mass is the weighted average location of all the different masses in this object (the motor, the battery, the wire itself, and any decorations or additions).
- This toy is essentially a beam, which results in torque on the battery and the motor. Torque is a when an object receives a force at a distance from its center. Torque can be thought of as a twist.

Focus Questions:

1. Which is heavier, the battery or the motor? Which one is closer to the pivot point? Why?
2. How could you change the propeller to make your toy spin more slowly? More quickly?
3. Move the battery further outward and add weights to the motor side to balance it. Did this change the spinning speed?
4. Think about the motor and battery on the outer edges of the wire compared to a point close to the center. Which one is spinning more quickly? Which one is spinning in a larger circle? Is one making more rotations per minute than the other? It might help to think about sitting on the outer chair of a carnival swing ride while your friend sits next to you in a chair closer to the center.

Elaboration:

Locating the center of mass is essential to making this toy balance and spin properly. There are many everyday instances when we find the center of mass of an object without even thinking about it! Have you ever balanced a spoon on your nose or a book on your head? It usually takes a few adjustments to get it right, but eventually you find the center of mass of that object. Center of mass is the place in a body where the weight is evenly dispersed and all sides are in balance. Where would the center of mass be in a basketball? The center of mass would be in the center as long as the ball's skin is uniform. An oddly shaped object such as a shovel would have an off-center center of mass. Since the shovel head weighs more than the handle, the center of mass would be off-center and closer to the head.

In the case of this toy, you are actually finding the center of mass of a group, or system, of bodies. The weight of the motor, toy, wire, and any additions all contribute to the center of mass. If you've ever balanced with a friend on a seesaw you have! With a single object like a spoon or book, the center of mass is located inside the object. But where is the center of mass in the system of you and your friend on a seesaw? It's somewhere in the middle between the two of you, outside of your bodies.

Imagine trying to balance on a seesaw with someone twice your size. Would you be sitting at equal distances from the center? Position is just as important as mass when trying to find the center of mass in a system of objects. The center of mass is that average of the masses multiplied by their distances from a reference point.

Another important concept in this project is torque. Torque when a force twists or turns an object. It can be described as the force applied to a lever multiplied by the distance from the lever's fulcrum (lever arm). The hanger wire in the project acts as a lever. The pivot point in the center is the fulcrum, the support about which a lever pivots.

The torque in this toy comes from the propeller, so the size and shape of the propeller are determining factors. A smaller propeller may produce less torque, and thus a more slowly spinning toy. The propeller places a torque on the entire toy that is determined by the pushing force (determined by the motor and propeller) and the distance the propeller is from the pivot point on the wire (lever arm). If you add extra weight to the motor so it balances closer to the pivot point in regards to the battery, you are decreasing the lever arm and thus the torque. As a result, you will get a more slowly spinning toy.

If on the other hand you put the motor far from the pivot point where it will have more torque, it also has to move through a longer distance to go around once. It is a complex relationship, and you can learn a lot about rotational motion by changing the distances, predicting what will happen and then trying it out. You can even time how many times it goes around in 10 seconds to get its rotational velocity.

Links to k-12 CA Content Standards:

<u>Grades k-8 Standard Set Investigation and Experimentation:</u>
Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other strands, students should develop their own questions and perform investigations.

<u>Grades k-12 Mathematical Reasoning:</u>
1.0 Students make decisions about how to approach problems:
1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
1.2 Determine when and how to break a problem into simpler parts.

2.0 Students use strategies, skills, and concepts in finding solutions:
1.1 Use estimation to verify the reasonableness of calculated results.
1.2 2.2 Apply strategies and results from simpler problems to more complex problems.
1.3 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.
2.5 Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.

3.0 Students move beyond a particular problem by generalizing to other situations:
3.1 Evaluate the reasonableness of the solution in the context of the original situation.
3.2 Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.
3.3 Develop generalizations of the results obtained and apply them in other circumstances.

<u>Grade 2 Standard Set 1. Physical Sciences:</u>
The motion of objects can be observed and measured.
1.c Students know the way to change how something is moving by giving it a push or a pull. The size of the change is related to the strength or the amount of force or the push or pull.

<u>Grade 4 Standard Set 1. Physical Sciences:</u>
1.a Students know how to design and build simple circuits and parallel circuits by using components such as wires, batteries, and bulbs.
1.g Students know electrical energy can be converted to heat, light, and motion.

<u>Grade 8 Standard Set 2. Forces:</u>
2.c Students know when the forces on an object are balanced, the motion of the object does not change.
2.e Students know that when the forces on a object are unbalanced, the object will change its velocity (that is, it will speed up, slow down, or change direction).

<u>Grades 9-12 Standard Set 1. Forces:</u>
1.b Students know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law).
1.g Students know circular motion requires the application of a constant force directed toward the center of the circle.