Bobbing Eyeballs

As the head bobs one way, the eyeballs bob the other.

Parts:

1	Baseboard
2”	1x2 piece of wood
16”	Dowel, 5/16”
1	Nail, small with head
1	Paint paddle
1	Styrofoam plate
2	Film can lids (gray)
	Weights (large nuts, 3/8” or so)
2	Beads
2	Large paperclips
2	Tacks (big head if possible)
2	Pennies

Extra Tools:

Drill Drill platform 19/64” bit for drill Nail bit, small for paint paddle hole Nail bit, tiny for block
Duct tape
Pipe cleaners and decorative stuff

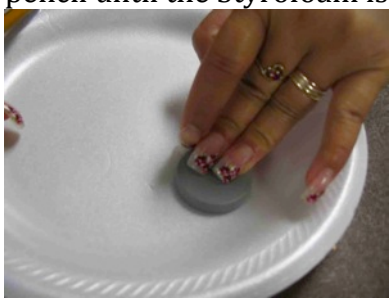
How To Build:

Drill a 19/64” hole on the baseboard. Cut a piece of 1x2 about 2” long and drill a 19/64” hole in the center of it. Cut about 16” of a 5/16” dowel. Hammer it through the hole in 1x2 piece of wood.



Hammer the other end of the dowel through the hole on the wood base.

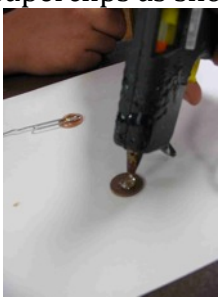
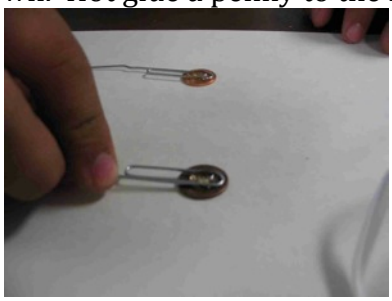

Put the film can lid the plate and push it down to make an indentation. Trace around the circle with a pencil until the Styrofoam is cut through.



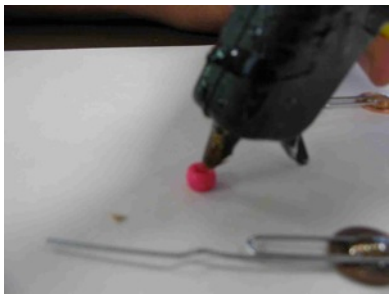
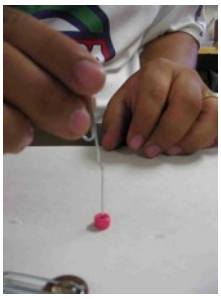
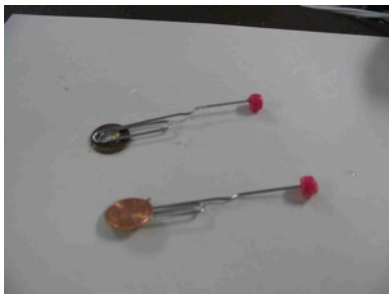

Repeat the process for the second eye.


Glue one end of the paint paddle about one inch in past the rim of the base of the Styrofoam plate. Put the hot glue on the wood to avoid melting too much of the Styrofoam.

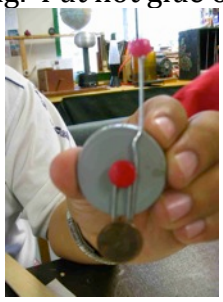

Unbend one end of the two paperclips as shown. Hot glue a penny to the far end that is still bent

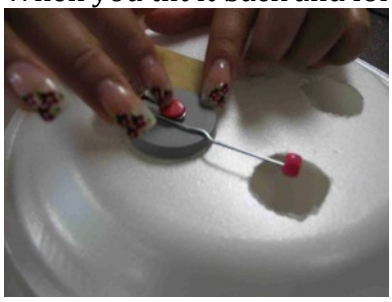
Hot glue beads to the unbent part of the paperclip.

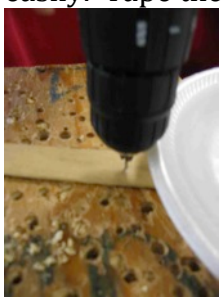
Tack the paperclips to the top of the film can lids. Push the tack in just far enough that the paperclip is still free to swing. Put hot glue on the

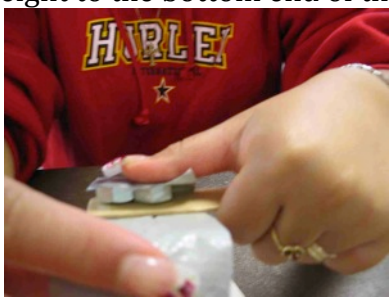




Stick the film can lids to the back of the Styrofoam plate so that the bead is visible through the eyehole. When you tilt it back and forth they eyes should bob.

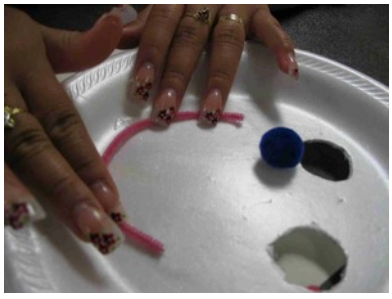


Use the nail bit to drill a hole in the paint paddle just below the Styrofoam plate.
This hole has to be slightly larger than the nail you'll use to fasten the head to the stand so it can swing easily. Tape the nuts or other weight to the bottom end of the paint paddle on the same side as the plate.



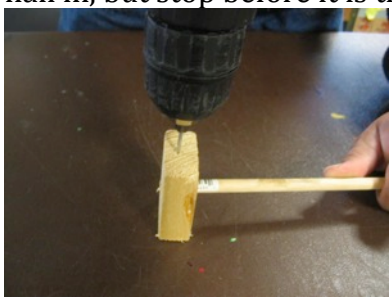


Make the rest of the face.




Lay the baseboard with the dowel on the table so the front of the 1x2 is facing up. Drill a hole in the front of the 1x2 with the tiny nail bit. This is a pilot hole, so that the block does not split and the nail is easy to

put in gently. Lay the paint paddle so that its hole is lined up with the hold in the 1x2. Gently hammer the nail in, but stop before it is tight.




Stand it up and rock it back and forth. You may have to bend the paper clips: make sure they don't hit anything and that the beads are visible through the eyeholes as they bob back and forth.

Concepts:

- The pennies are weights that make the paper clips stay in a vertical position.
- The pendulum goes back and forth because of gravity (which pulls down) and momentum (which keeps it swinging back up.)
- A simple pendulum is just a weight on a string. A complex pendulum has a top that moves back and forth the opposite direction as the weight.

Focus Questions:

1. Why do the eyeballs swing one way when the head swings the other way?
2. How could you make the eyeballs swing the same direction as the head?
3. How do you think those little dolls work with the eyes that close when you lay them down?
4. What happens to the eyes if you turn the head upside down?

Elaboration:

If a pendulum's weight swings on a stick instead of a string, and the stick extends up past the point of pivot, it is a complex pendulum. The part of the pendulum above the pivot point goes in the opposite direction of the part below. This toy has three complex pendulums: the head itself and the two eyes.

To answer the big question here – Why do the eyes bob right when the head bobs left? – you need to think about frames of reference. The frame of reference of the observer (you) is the same as the frame of

reference of the baseboard, dowel and 1x2. Another frame of reference is that of the plate, weight and paint paddle. This frame of reference tilts back and forth. The tacks attached to the film can lids go back and forth along with the head. So the tacks and film can lids have the same frame of reference as the head.

Each paper clip though is free to move, and they move so that the heavy penny is always down. Keep your eye on a penny as the head bobs. It always hangs near the lowest point, making the paper clip always vertical. If you were a small bug sitting on top of the penny, you'd be in the final frame of reference. You would see yourself going back and forth on the same arc as the head, but while the head tilts right and left, you would always sit straight up and down.

The popular carnival ride called the Zipper has a similar principle. A few people get in each of a set of small cars that go around a vertical oval track. If the car were fastened tightly to the track, the people would go upside down once each round. But the people in the car can lock it tight or let it swing so that the heavy bottom goes down. A person's frame of reference will be different whether in a car, on the ground, or on the track frame.

You may have seen a dial or meter in the hub of the wheel on a large truck. If you look closely, the dial is always right side up while the wheel turns around it so the bottom of the dial must be heavier than the top. This dial is an odometer to measure the number of times the wheels turns, which can then be translated into the miles that wheel has traveled. The same set up is used to make the eyes on a baby doll close when you lay it down.

If you glued the bead eyeballs onto the bottom of the paperclip, together with the penny, and mounted the film can lids above the eyeholes, the beads would swing in the same direction as the head. If you turn the head upside down, your pennies may show through the eye socket holes, but they will still appear to move in the direction opposite the head!

Links to k-12 California Content Standards:

Grades k-8 Standard Set Investigation and Experimentation

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.

Grades k-12 Mathematical Reasoning:

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:
2.1 Use estimation to verify the reasonableness of calculated results.
2.2 Apply strategies and results from simpler problems to more complex problems.
2.3 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.

Grade 2 Standard Set 1. Physical Sciences:

The motion of objects can be observed and measured.
1.a Students know the position of an object can be described by locating it in relation to another object or to the background.
1.b Students know an object's motion can be described by recording the change in position of the object over time.
1.c Students know the way to change how something is moving is by giving it a push or a pull. The size of the change is related to the strength, or the amount of force, of the push or pull.
1.d Students know tools and machines are used to apply pushes and pulls (forces) to make things move.

Grade 3 Standard Set 1. Physical Sciences (Energy & Matter)

1.d Students know energy can be carried from one place to another by waves, such as water waves and sound waves, by electric current, and by moving objects.

Grade 8 Standard Set 2. Forces:

Unbalanced forces cause changes in velocity.
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 an object are unbalanced, the object will change its velocity (that is, it will speed up, slow down, or change direction).