

Pendulum Painting

Background Information

- **What is a pendulum and how does it work?** A pendulum is an object, hung from a fixed point, that swings freely back and forth because of the force of gravity. A pendulum works by converting energy back and forth. When the object is at its highest point, it has the most stored energy (gravitational potential energy). As the object moves and accelerates down towards its lowest point, its potential energy is converted to kinetic energy or the energy of motion. Then the object has the energy to move back up again to potential energy. As the object swings back and forth changing position from high to low and back to high, it repeatedly converts its energy back and forth between potential (position) and kinetic (motion).
- **How does a pendulum stop moving?** If it weren't for friction or drag (air resistance), a pendulum would keep on moving forever! With each swing of the pendulum, friction & drag take a bit more energy from the pendulum causing it to slow down & eventually it will gradually come to a stop.
- **What is Newton's First Law of Motion?** Newton's First Law of Motion is also known as the Law of Inertia. This physical law states that an object at rest will stay at rest and an object in motion will stay in motion with the same speed and direction unless it is acted on by a greater, unbalanced force. How is the law of inertia evident in a pendulum?

Materials

Pencil

Ruler

10 oz. Plastic Cup (1)-to make pendulum painting cup

Thumbtack

Washers (6)

Large Paper clip (1)

Masking Tape-to "cap off" pendulum painting cup until ready to use

String

Tempera Paint

Dixie Cup-to mix paint to correct consistency

Duct Tape-to attach pendulum painting cup to table

Plastic Table Cloth (or old sheet, old towel, newspaper that can get dirty)

Butcher Paper (or other large paper)

Set-Up

1. Pre-make a pendulum paint cup. Using a thumbtack, puncture the center of the bottom of the cup to make a hole about the size of a ballpoint pen. Then use the thumbtack to poke two holes on opposite sides near the top lip of the cup. Make a "W" shape out of the paperclip and slide a washer onto the center arch of the "W." Stick the ends of the paperclip through the holes near the top of the cup. Cover the hole on the bottom of the cup with a piece of masking tape on the outside of the cup.
2. Prep your paint - the paint should be the consistency of ink. With the tempera paint it takes a little more than a 1:1 ratio of water to paint.
3. Prep an area with a table for your pendulum painting. Place a large plastic table cloth or other protective material underneath your pendulum area.
4. Cut 3 pieces of butcher paper or other paper on hand to roughly 2' x 2' squares or equivalent rectangles. Label one CONTROL, one MASS and the third LENGTH.

Directions

1. Using your ruler, measure the distance of the bottom of the pendulum paint cup to the floor so that the bottom of the cup is 4" from the floor. Use string to measure a length that can hang your pendulum paint cup from the bottom of the table so it hangs 4" from the floor. Attach the string to the cup by tying your string in a knot around the washer.
2. Use duct tape to tape the string to the bottom of the table at the appropriate length so that the pendulum paint cup is 4" above the floor.
3. Test your pendulum paint cup EMPTY first to see how it works and make sure your tape will hold. Hold the cup at varying angles to see the time it takes for one swing of the pendulum and observe the patterns of the swinging motion from different angles.
4. You will be performing 3 trials today with pendulum painting. The first trial will use the paper labeled CONTROL. The second trial will use the paper labeled MASS. The third trial will use the paper labeled LENGTH.
5. Constraints for reliable results: Make sure your measurements are accurate. Try to release your pendulum paint cup at the same height and angle for each trial. Practice your swing before you put the paint in the pendulum paint cup and before you release your swing with the paint, check your position (i.e. height and angle)
6. Trial 1: CONTROL. Use a pencil to draw the pattern you predict the pendulum will make on the paper labeled CONTROL using the observations you made during your practice swings. Add the paint to your cup. Lift the pendulum paint cup to the height and angle you want to release from. Remove the masking tape from the bottom of your cup. Release the pendulum paint cup. Observe the patterns. When the pendulum paint cup stops moving, replace the tape to the bottom of the paint cup.
7. Trial 2: MASS. Change to your next piece of paper. Add 5 washers to your paint cup by removing the tape where the string is attached to the table and slide the extra washers onto the string. Reattach the tape and string to the table. Make sure your pendulum paint cup bottom is still 4" from the floor. Use a pencil to draw the pattern you predict the pendulum will make on the sheet labeled MASS. Add more paint to your

pendulum paint cup if needed. Lift the cup to the height and angle you want to release from. Remove the masking tape from the bottom of your paint cup. Release the pendulum paint cup. Observe the patterns. When the pendulum paint cup stops moving, replace the tape to the bottom of the paint cup.

8. Trial 3: LENGTH. Change to your next piece of paper. Remove the 5 extra washers you added to your paint cup by removing the tape where the string is attached to the table and sliding the washers off the string. Reattach the tape and string to the table BUT this time adjust the string length and make sure your paint cup bottom is 8" from the floor instead of 4". Use a pencil to draw the pattern you predict the pendulum will make on the sheet labeled LENGTH. Add more paint to your pendulum paint cup if needed. Lift the paint cup to the height and angle you want to release from. Remove the masking tape from the bottom of your paint cup. Release the cup. Observe the patterns. When the pendulum paint cup stops moving, replace the tape to the bottom of the paint cup.

Activity Conclusion

- Place all the paintings next to each other on the floor and make observations of the similarities and differences in your 3 paintings.
- What are some of your observations between the paintings...What are some of the differences? What are some of the similarities? What are some things that could have affected your experiment?
- What do you think made the biggest difference - mass or string length? The only thing that would greatly affect the swing of the pendulum is the length of the string because it changes the swing time of the pendulum and gravity is not affected by changes in mass. The pendulum would slow down at the same rate because gravity is consistent.

Comparison to the Wave Pendulum Exhibit

What did you notice about the wave pendulum (exhibit or video) that's different from the spherical pendulum paint cup you built? The wave pendulum swings in patterns because the time period of each "string and bob" swing is different due to the varying lengths of the string. They are all dropped at the same time and they all weigh the same amount. Our exhibit has "bobs" filled with 3 pounds of sand and metal rods of varying length. The garage door opener and magnets used to pull up and release the bobs ensures that they are all released at the same time.

Activity Extension

- You can make more than one pendulum painting cup and use different colors of paint. Try all 3 of the above variations on the same piece of paper, but use a different color of paint each time. Or instead of changing mass or length of the pendulum, start each painting cup at a different height or angle before letting it go!
- Send us pictures of your awesome pendulum paintings or better yet a video of the pendulum in action to Programs@sciencemill.org or tag us on social media.