

Circular Motion Activity

Lesson Type: Module

Target Grade: Elementary

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Brief Overview

This lesson is a module based lesson focused on explaining circular motion (especially centripetal force) to students through various interactive demos (centripetal force chamber, egg detective) and discussions.

Teaching Goals

The main concepts you want the students to learn from this lesson (can be in bullet points)

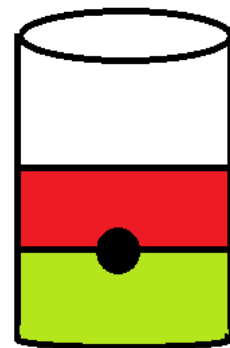
Ex:

- When forces on an object are balanced, it will not move
- When an object is moving in a circle, two forces act on it in the same plane as the circular motion it is performing: centripetal force (center-seeking) and centrifugal force.
- Hypothesis forming when we vary a parameter of the centripetal force chamber (reinforcing the Oobleck lesson)
- Application of material taught (Egg Detectives)

Before the Lesson

Preparing the Centripetal Force Chambers (CFGs)

- Using one color of the jello mixtures provided, make the jello according to the instructions on the box and pour the jello equally into as many plastic cups as your site will need. We recommend making 1 cup for every 2 students. Let the jello set in the fridge.
- Once the jello has set, divide the cups into two groups. For $\frac{3}{4}$ of the cups, gently press a small marble into the center of the jello, making sure that half the marble is in the jello. For the other $\frac{1}{4}$ cups



put in large marbles and do the same thing as with the small marbles.

- Now prepare the other color of the jello mixture and pour it in equal amounts into the prepared jello-cups-with-marbles-inside-them.
- You're almost done! Now, grab as many empty cups as the number of cups with jelly that you prepared. Attach two strings of length 2 feet each by stapling the string to the sides of the cup, close to the rim. Knot the free ends of the string.
- You make a CFG by placing the marble-in-jello-in-cup cups into the cups you just attached strings to. You twirl the cups round by holding the string and twirling the cups above your head (making sure not to hit anyone on the head). Then we will plate the jelly by covering the jelly filled cup with a paper plate and turning the cup upside down. You can try doing this yourself to see that everything works but if you follow the instructions on the box of jello you should be fine. If the jello is too firm, though, then you will have to improvise a bit (like making the string attachments extra secure so that the cups can be spun around faster).

Agenda

- Lecture on Balanced Forces (5 min)
- Demo on Balanced Forces and discussion (7 min)
- Disseminate CFGs which contain small marbles (1 for every 4 kids) (5 min)
- Let kids perform CFG demo and record observations (10 mins)
- Give kids a CFG with a variation (1 for every 4 kids). Ask them to form a hypothesis in groups and test hypothesis by repeating demo (10 mins)
- Egg Detectives (determining whether or not a egg is boiled or not using centripetal force)

Lesson Introduction

- An object will not move or continue moving with constant velocity when the forces acting on it on from all directions are equal to each other/net force is zero.
- When an object moves in a circle there is a force pushing the object outwards from the center of the circle it is moving about and another force pulling it inwards. Think of a roller coaster loop-de-loop. You feel like you're flying out of the circle (force pushing you out of the circle) but then the roller coaster rails prevent that from happening by providing a normal force in the opposite direction (the force pulling you into the circle).
- These forces are balanced as well, which is why you don't move radially outwards or inwards.

Module 1: Balanced Force

Introduction

- This module is about showing what makes a system that has balanced forces acting on it.

Materials

- Just a table/big box/rope with a knot tied in the middle
- 2 or more volunteers from the class

Material to Teach

- An object won't move if the forces acting on it from all directions are equal

Procedure for each Module

- Have two kids try to push on a table from opposite ends of the table/Tug on a rope from opposite ends. Let them figure out how much force they need to apply so that the table/knot in the middle of the rope does not move.
 - Mentors could try participating in this tug of war as well

Notes for Mentors

- Be careful that the kids don't push too hard that they start hurting each other
- Note that when the force applied by both kids were equal the table/knot did not move.
- Now ask, what if you were pushing against a wall which was made from something weak like say Styrofoam/sponge. Would the wall be able to support you leaning against it (provide a normal force) or would it break? Let the kids discuss this and then disseminate the CFGs

Module 2: CFGs

Introduction

- This module is going to show the kids the effect of the centrifugal force.

Materials

- The normal CFGs with small marbles in them and a string tied to each of them
- Groups of 4, but let two of the members perform this module. The other 2 will perform module 3

Material to Teach

- Teach this after the demo is completed. When you rotate the CFG, the marble will move outwards. This shows that there is a center fleeing force in circular motion. The marble moves outwards instead of staying stationary like the box/rope in the first example because the jelly at the bottom, which is supposed to provide the centripetal force, is not strong enough structurally to oppose the marble which wants to move outwards.

Procedure for each Module

- Split the class into groups of 4.
- Provide 1 CFGs to each group. Tell them to decide which 2 will perform this module and which 2 will perform the next module.
- Have the kids discuss which direction they think the marble will move in if the CFG is rotated 20 times slowly. How much more will it move if it is rotated quickly?
- Perform 20 rotations on the CFG, have them analyze the results and try to give reasons why they think the marble moved in that direction.
- Then do the “Material to Teach”

Notes for Mentors

- Try to space out the kids, we don’t want any heads getting banged

Module 3: CFGs again/hypothesis forming

Introduction

- This module is to reinforce the hypothesis forming/scientific method lesson we did last semester

Materials

- CFGs with large marbles and CFGs with longer/shorter strings
- Same Groups as before but the other 2 members will perform this module

Material to Teach

- Centripetal force is proportional to mass of object performing the circular motion, and inversely proportional to the radius of rotation (for the same velocity of rotation)

Procedure for each Module

- Disseminate the “new and improved” CFGs to the groups. Ask them to discuss what they think they will observe in the new CFGs.
- Write down their hypotheses at the front of the class in a table like this one:

Group 1	Longer string	(expected outcome 1)
Group 2	Bigger Marble	(expected outcome 2)
...

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- Encourage the other groups to give their opinion on whether or not they agree with the predictions being made. Ask for their reasons.
- Perform the 20 rotations just like in Module 2.
- Observe the results and discuss.

Module 4: Egg Detectives

Introduction

- This module is to apply what we learned about circular motion and the forces to determine (only using concepts of circular motion) whether or not an egg is boiled or fresh without having to peel it open/shake it to hear the sloshing of the yolk or lack of.

Materials

- Boiled and fresh eggs
- One egg (selected at random) per 2 kids

Material to Teach

- Teach after running the module. In a fresh egg, much like the marble in the CFG, the yolk will move outwards from the center of rotation when the egg is spun. This makes the rotation not balanced since the center of mass of the egg is changing so the egg will wobble and stop spinning. The boiled egg, however, has a fixed center of mass so once it starts spinning it won't wobble and will spin longer.

Procedure for each Module

- Have the kids try to figure this out on their own. Mentors should go to the groups and talk to the kids, asking the kids questions that will lead them to realize that all they need to do is spin their egg around and observe it.

Notes for Mentors

- Lining the tables with newspapers might be a good idea
- Tell the kids not to spin the eggs close to the edge of the table

References

- <http://writinghome.net/wp-content/uploads/2008/07/Centripetal-Force-Lab.pdf>

Summary Materials Table

Material	Amount per Group
Green Jello	
Red Jello	
String	
Small marbles	
Large marbles	
Transparent Plastic Cups	
Eggs	