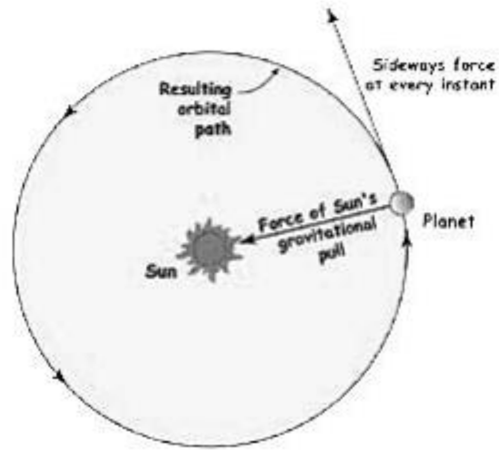
ASTRONOMY: PLANET ORBITING & SHAPES

Lesson Date: May 23, 2013



MATERIALS

- 3/8'' beveled Washers
- Lots of string/ribbon; cut into ~3ft length pieces
- Piece of paper
- Plastic Straws (1-2 per student)
- Planet shape template (1 per student)
- Heavy construction paper
- Tape
- Glue
- Scissors

ACTIVITY: REVIEW ORBITS (~5-10 minutes)

Q: Why do planets orbit the sun?

A: Gravitational attraction. The sun has the most mass in our solar system and thus the strongest gravitational pull. Draw the gravitational force on the board.

Q: What would happen if the gravitational force was no longer applied?

A: Accept all answers. Explain that we are going to model the orbit using the ball and string.

1. Tape an arm's length piece of string/thread to a piece of paper
2. Crumple the paper into the ball
3. Model an orbit by swinging the paper ball in a circle
4. Why does the paper ball moves in a circle?

Explain that orbit occurs because the paper ball has some initial speed (it is moving in some direction) and then it gets pulled toward the center by the string. This is a model f*or a space shuttle orbiting the earth where the ball is the space shuttle and the string is gravity*.

5. There are two ways you can show this "initial speed/direction"

a. When the ball is "orbiting" let go of the string and see where the ball goes. The thread should leave a trail behind the ball so you can see the direction that it was traveling.

b. Make a loop on the other end of the string and put that loop around a pencil. Flick the paper ball in an "initial direction" and (hopefully) the ball will be pulled by the string to make a circular path.

DISCUSSION:

Q: Where did the ball go?

A: Go inside and draw an arrow from the circle to represent the path of the ball when you released it.

Q: So none of the planets flew into you (i.e. the sun). Why don't planets spin into the sun, i.e. what keeps them far away?

A: Inertia of their orbit drives planets outward into deep space. The two forces from the gravitational pull and the planets inertia are balanced, keeping planets in a set orbit. Draw the sideways force on the planet.

ACTIVITY: ORBITING (~10 – 15 minutes)

1. Using the same string and ball, thread the end of the string through the straw and attach it to the washer.
2. Begin with lots of room. Holding the straw and washer assembly upright, pull the string until the bottom washer rests against the bottom of the straw.

(Image from: strachild.gsfc.nasa.gov)

3. Hold the straw with one hand with your arm fully extended in front of your body. By rapidly rotating the wrist of the extended arm, start spinning the string/washer assembly until the string is fully extended. **Note**: If the paper ball is difficult to rotate, you can flip it upside down and use the washer as a planet (but make sure the kids don't swing the washer toward each other!).
4. Continue spinning the system at a constant rate as you use your other hand to pull slowly down on the bottom washer. **Note:** The spinning ball should be going at a steady rate before students start to pull the string. If students' are having difficulty they can spin their 'planet' in a vertical circle. Make a special effort to help students pull the string slowly enough that the washer can make complete orbits at each radius before you pull the string more.
5. Q: What is a year? Discuss how a year on Earth is not the same as a year on Mars. Calculate age on different planets using the worksheet. (Ex: 10 years old, $10 \div 1.88 = 5.31\ Mars\ years$)

DISCUSSION:
Q: What do you notice about the speed at which the spinning washer is traveling as the orbit it makes gets shorter and shorter?
A: The ball orbits faster as its orbit radius gets smaller.
Q: What are **two ways** that you can make the ball orbit faster or slower?
A: You can swing/pull it harder or you can make the orbit smaller. (We can say that pulling it harder is like a stronger gravitational force and making the string shorter is like making the orbit smaller)
Q: What does this have to do with planets orbiting the Sun?
A: The planets more distant from the Sun have a longer orbital path AND move slower around that path than the planets closer to the Sun. This results from distance and from differences in the effect of gravitational pull from the Sun. The amount of pull depends on the distance between the objects, just like you can feel with your string.
For tutors: $F = \frac{G m_1 m_2}{r^2}$
Therefore, the pull exerted on one body by another equals Newton's Constant times the mass of the first body times the mass of the second body divided by the square of the distance between the centers of the two bodies. Notice that in this equation, there is no distinction between which body is doing the pulling.
Q: In these examples we are looking at circular orbits, but do orbits have to be circles like in our model?
A: No – Earth's orbit is nearly a perfect circle, but most orbits are elliptical/eccentric. The orbits still result from gravitational forces, but these forces are not fixed in space/time.

ACTIVITY: SPINNING and PLANET SHAPE (~30 minutes)

Q: Why are planets rounded?

A: Again, gravity! Gravity pulls toward the center of the planet and into a spherical shape.

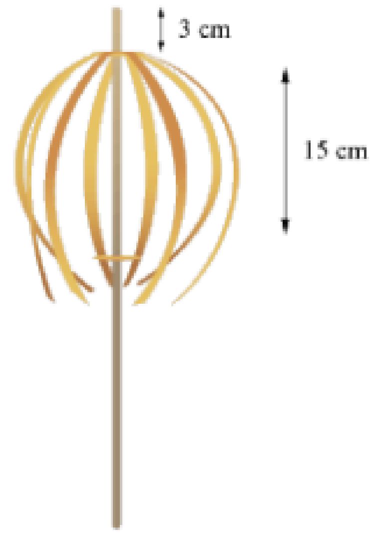
Q: What happens to the shape of planets as they spin about their own axis?

A: As planets spin they flatten out at the top and bottom, resulting in a bulge toward the equator.

Q: All planets do this, but do they flatten out the same way? What factors affect their shape?

A: Accept answers. Explain set-up and how we can test two changes – mass and rate of spinning.

Note: There should be enough materials for each student to make their own planet. But to start, your group can just focus on making two planets, one out of normal paper (lighter) and one out of construction paper (heavier)



1. Pass out 1-2 straws and “Planet shape” templates to each student. If using two straws, tape the straws together to make one long rod.
2. Cut out the circles and strips from the template (on the normal paper).
3. Make identical circles and strips out of the construction paper. (You can either trace a second copy from the first template OR cut a second planet shapes template and glue it to the construction paper)

Follow the remaining instructions for each planet:

4. Glue/tape one end of each of the 8 strips to one of the 4 cm circles. Try to get them evenly spaced around the circle.
5. Glue/tape this circle to the straw about 3 cm from one end.
6. Slide the small circle over the other end of the dowel rod and glue it about 15 cm from the circle already glued on the rod.
7. Now slide the remaining large circle over the free end of the rod and glue the strips to it. Again, try to make sure they (the strips) are evenly spaced.
8. Make sure that this end can still slide freely over the dowel rod.
9. Spin the planet and see what happens (diagramed below) – you should see the planet flatten.

Q: What happens to a planet that spins faster?
A: More flattened.
Q: What happens to a planet with more mass?
A: Less flattened, more ‘rigid’. If a planet were completely solid, like a pool ball, then it would not be deformed.