Forces and Motion Script

Intro

Why are we here?

-2005 has been declared "World Year of Physics", being commemorated around the world
- Einstein published 3 great discoveries in this year

1. Explained how the motion of atoms could be seen.

2. Proved that light could be thought of as little "packets" or "particles"
3. Revolutionary idea that space and time are really the same thing

- Was awarded the Nobel Prize in Physics in 1921 for #2

Who are we? What is Fermilab?

- Employees at Fermilab, In Batavia IL

- Fermilab is a large laboratory that studies physics

- Physics is the study of the nature of the Universe. Tries to answer

1. What is the Universe made of?

2. How does it behave? => Study of forces and motion

- At Fermilab to study these questions we accelerate particles to close to the

- Fermilab houses one accelerator that is 2 miles around, and one that is 4 milles around.

- Give 2 sentences about what we do.

Transition: "Shall we get started?"

Tablecloth / Glass Demonstration

- What will happen when I pull the tablecloth out quickly?

- Why didn't the glasses fall off?

- Applied a force to the tablecloth, making it move. But didn't apply force to tableware. They stayed in place.

-Leads us to Newton's First Law: ASK if anyone knows why Newton is famous. For discovering gravity when an apple fell? Yes, but also for three laws of motion. First law was just demonstrated.

objects at rest stay at rest and objects in motion stay in motion, unless acted upon by a force

- We call this tendency "inertia" (resistance to change in motion/rest)

- Forces can be a pull or a push, but there can also be forces that act at a distance, like gravity, magnets, electric charge (think hair and balloon)

- Motion only happens because of unbalanced force. If I hold out a ball, force of gravity is balanced by force from my hand. The net force is 0, and the ball doesn't move. If I remove the force from my hand, then there is an unbalanced force from gravity, and the ball falls.

-Newton also had two other Laws

- F=ma, to accelerate (or speed up) a more massive object requires a larger force.

- Every action has an equal and opposite reacting force. I push on table. I apply a force on it, but it applies the same force back on me.

- Demonstrate this by putting two volunteers **sitting** on skateboards. Ask one to push on the other (on his/her knees, skateboard). They will both move back. Then swtich and ask the other child to push this time. Same results.

Newtonian Demonstrator

- What happens if I release the ball?

- Certain properties of motion are "conserved", which means that they remain the same

- In this case, "momentum" is conserved. We start with a ball with a 16 lb weight moving to right, and after the collision we have a 16 lb ball moving to the right.

-What happens if I release two balls?

- What if one ball on each side?

Gravity

Ramp plus skateboard

-Two volunteers.

-Release them and show that they hit ground at same time.

- Add bricks to one. Which one will arrive first? Repeat.

- Explain that gravitational force is larger on the one with bricks, but the inertia is larger. Requires a larger force to move it. These two things cancel out.

- Ramps with different slopes. Two new volunteers.

- Ask which one will reach first.

- Steeper one reaches first. Show force diagram.

- In the steeper case, ramp cancels out less of the gravitational force.

- Think of the case where the ramp is totally horizontal. Ramp cancels out all of gravitational force. In the case where the ramp is vertical, ramp cancels none of the gravitational force.

SUMMARY:

Mass doesn't matter, angle does.

Dropping Balls (or a box of paperclips and a single paperclip)

(Legend says Galileo did this from tower in Pisa, to disprove Aristotle.)

-Which ball will hit the ground first?

- They reach at the same time. Again, gravity causes objects to accelerate at the same rate. This doesn't depend on the mass.

An exception:

-If we were to drop a hammer and a feather on the Earth, the hammer hits the ground first, but this is due to air resistance, which is much larger for the feather. If we were in a vacuum, where there is no air, they would strike the ground at the same time. The surface of the moon is a vacuum. Astronauts on Apollo 15 did this on the Moon with a hammer and feather. They struck the lunar surface at the same time.

- Can find this on the Web.

Ramps with Rings

- get a volunteer to weigh steel and aluminum ring

- Then get them to release the rings

- Again, regardless of mass, they reach end at same time.

- Get volunteer to weight aluminum rod and ring, they have the same mass.

- Predict which one will reach the ground first.

- Do it.

- Can also do this with the disk and the rod, etc.

- Rods roll faster than rings. Mass is closer to center

- Summary: masses don't matter for rolling things, but how it is distributed does. (Show slide)

Turntable

-get a small volunteer

- Get them spinning on the turntable with their arms out, holding weights

- ask them to pull their arms in, Is there a difference?

- Easier to turn if mass is closer to the center, so spins faster.

- If we dropped them, they would hit the ground at the same time, but because they are rolling they behave differently.

- This is why figure skaters pull arms in on jumps and turns. (show slide)

Bicycle Wheel

- Ask volunteer to get the bicycle wheel to be vertical, holding only the rope.

- Demonstrate it

Sword Fight

- Have a volunteer challenge teacher to a sword fight. The must block themselves with wheel. Now spin it. It is hard.

- Once something is spinning, it resists changing direction. Again this is rotational inertia.

- This is why it is easier to keep your bike upright once the wheels are moving. It is very wobbly when the wheels aren't turning fast. (show Einstein slide)

Bicycle Wheel+Turntable

-Get a small volunteer on the turntable.

- Hand them a spinning wheel. Ask them to change axis of wheel.

- They recoil.

- Now hand them a non-moving wheel and ask them to spin it horizontal

- Just like in the Newtonian Demonstrator where momentum was conserved, something called angular momentum is conserved for spinning objects. If you try to flip which was the wheel is spinning, you start to spin the other way to conserve the angular momentum

Summary

- Moving objects stay moving

- Stationary Objects stay stationary (Resting objects stay resting?)

- Gravity accelerates all objects at the same rate, regardless of mass

- Rotating objects behave strangely

- Some properties of motion, like momentum or angular momentum remain the same, and this is useful

Physics is everywhere and explains how the world works. Fermilab has many interesting science attractions as well as miles of bike trails, fishing ponds, and bison. Consider a visit! If you think of questions later, your teacher can email us.