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Force, Mass, and Acceleration PhET Simulation

1. Click on the following link [PhET Force and Motion Basics and click "Net Force"]
    a. If you cannot access the link then type the following web address into your browser: https://phet.colorado.edu/
    b. In the search bar at the top of the page type in "Forces and Motion Basics" and press enter. Select the first simulation that is listed "Forces and Motion: Basics (HTML5)".
2. Click "play" to launch the simulation.

Part A: Forces

1. When the simulation starts click on the first simulation that says "Net Force" to start the tug of war simulation.
2. In this simulation, the wagon (W) can be pulled by the players of the two teams. Both Blue Team and Red Team have four players, one adult (A), a teenager (T), and two children (C). The adult is the largest player; the children are the smallest players.
3. In the upper right hand corner check both boxes "Sum of Forces" and "Values" and make sure they stay checked after you reset the teams.
4. Drag and drop the players onto the rope line arranging the teams so that they are even in their game of tug of war. Try the scenarios listed below:

    A ----W----A   or   C – T---W---T- C

    a. When the teams are even, we call this a balanced force. What do you observe about the movement of the wagon?

    ____

    ____

    b. What is the force of red team on right side of the rope?

    ____

    c. Is it the same as the blue team?

    ____

    d. What is the Sum of the Forces?

    ____

5. Next, let's drag and drop different team players onto the rope that are not the same on both sides. Can we still get a balanced force? Try the scenarios listed below:

    A---W---C-C-T   and   T---W---C-C

    a. Did both of the scenarios listed above show a balanced situation?

    ____

    b. Which one was balanced?

    ____

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c. What was the Sum of the Forces when it was balanced?

____

d. Which one was not balanced?

____

e. What was the Sum of the Forces when it was not balanced?

____

A **force** is a push or a pull. When the forces are equal an object doesn't move; the object is in a state of equilibrium. When the forces are unequal or unbalanced it causes the object to accelerate in the direction it is being forced.

f. When the forces were unbalanced which direction did the wagon accelerate?

____

g. Why? ____

____

6. Now it's your turn. Make a combination or two of team members for a fun game of tug of war.
   a. Who is pulling on the Blue Team?

   ____

   b. Who is pulling on the Red Team?

   ____

   c. Before hitting go, what do you predict will happen and why?

   ____

   d. What happened? (Use scientific language!)

   ____

   ____

   ____

Part B: Motion

1. Before beginning the simulation make sure to check all the boxes in the upper right hand corner and any time you reset the simulation make sure you check the boxes again.
2. Now, we said that a force is a push or a pull, but so far we have only observed a pull from the game of tug of war.
3. What is the mass of the crate on the skateboard?

   ____

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4. At the bottom it says "Applied Force" click the arrow on the right until it reads 200 Newtons. A Newton is a measurement of force needed to accelerate a mass of one kilogram of an object one meter per second per second.
   a. What is happening to the speed?

      ____

   b. What happened to the guy pushing the crate? Why?

      ____

      ____

Velocity of an object indicates its speed and its direction. It does not describe speed because two objects can have the same speed but be traveling in two different directions.

   c. Describe the velocity of the crate: (Use direction words like left and right).

      ____

      ____

Acceleration is the rate at which velocity changes over time.

   d. Using scientific words describe the change in acceleration of the crate:

      ____

      ____

   e. What happens when the guy pushing the cart falls down?

      ____

      ____

5. Next put the trashcan on top of the crate. The crate has a mass of 50 kg, and the trash can a mass of 100 kg.
   a. What is their total mass together on the skateboard?

      ____

6. Now have the guy push on the two objects with the same Applied Force of 200 Newtons.
   a. Because we increased the mass, but are applying the same force, what happened?

      ____

      ____

7. Reset the simulation where the skateboard is still and trashcan is resting on top of it. Now we are going to increase the force our guy uses to push the two objects to 300 Newtons.
   a. Because we increased the force what happened?

      ____

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8. Predict what would happen if we decreased the mass, but keep the force the same 300 Newtons.

   ____

   ____

9. Now play around with the objects and then write a brief description of what you did and any observations you may have made about playing with the force, mass and the acceleration.

   ____

   ____

   ____

   ____

   ____

   ____

Part C: Friction

1. Next let's start the Friction simulator located at the bottom menu of your screen.
2. When you click it what object disappears from the simulation?

   ____

3. On the right hand side of the screen make sure all the boxes are checked.
4. The crate is the same mass as it was in part B. Also in part B we applied 200 Newtons of force by clicking the arrow on the right. Do that again and make an observation:
   a. Does the crate accelerate as quickly as it did on the skateboard?

      ____

   b. What could be one possible explanation for this difference?

      ____

Friction is an opposing force on an object occurring between two surfaces. We also called this an applied force involving direct contact.

5. Now let's add the 100 kg trash can like we did in part B and set the Applied Force at 200 Newtons again.
   a. What is the total mass of the crate and trashcan?

      ____

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b. Applied Force is the force the guy is pushing on the crate. The Friction Force is the force at which the crate is pushing back on the guy. Are these forces unbalanced or balance?

____

c. How do you know?

____

d. Increase the Applied Force to 400 Newtons, double the force. What happened?

____

e. What was the amount of Applied Force to overcome the Friction Force exerted by the trashcan and crate?

____

The **sum of the forces**, also known as the **Net Force**, is the combination of all forces acting on an object. In this simulation is the difference between the Applied Force and the Friction Force because they are pushing in opposite directions. If they were pushing in the same direction the two forces would be added together.

f. What is the sum of the forces, or Net Force, being applied on the crate?

____

6. Reset the simulation, but make sure to check all the boxes in the right hand corner.
7. Once again have the guy push with 200 Newtons of Applied Force on the crate. Let the crate's speed increase a bit and then in the box in the right hand corner increase the friction slowly until the Sum of the Forces = 0. Now let's make some observations.
   a. What happens to the speed?

   ____

   b. What happens to the crate?

   ____

   c. What happens to the size of the Friction Force arrow?

   ____

8. Next let's see if we can guestimate the mass of the unknown gift. Remove the crate and place the gift next to the guy and start increasing the Applied Force until it starts to move.
   a. What was the Applied Force from the guy?

   ____

   b. What was the Friction Force from the present?

   ____

9. Next remove the gift and substitute the girl.
   a. What was the Applied Force from the guy?

   ____

   b. What was the Friction Force from the present?

   ____

10. Next remove the girl and substitute the man.

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a. What was the Applied Force from the guy?

____

b. What was the Friction Force from the present?

____

11. Can you guestimate the mass of the package?

____

Part D: Acceleration

1. Next, click on the simulation that says "acceleration" in the bottom menu.
2. What new feature has popped up in the simulation?

____

3. Click all the boxes on the right hand side.

Remember: **Acceleration** is the rate at which velocity changes over time. Or the rate at which speed and direction changes over time. Think of it as how fast something is traveling and where it's going. Unbalanced forces will cause an object to accelerate in the direction the greater force is pushing or pulling it.

Not only does acceleration depend on force, but also mass. As we saw in Part B (#6) if we increased the mass, what happened to the acceleration of the cate?

____

4. Now have the guy push the crate at an Applied Force of 400 Newtons.
   a. What happens to the acceleration as you are adding the Applied Force?

____

5. Let the simulation go until the guy falls down pushing the crate.
   a. What happens to the acceleration?

____

   b. Why? (Hint: Look at the forces).

____

____

6. Reset the simulation and check all the boxes. Place the bucket of water on the crate and have the guy push the two objects at the same 400 Newtons of Applied Force.
   a. How is the acceleration different from #5?

____

   b. What could be the cause for this change in acceleration?

____

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