Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Period\_\_\_\_\_\_\_\_\_\_

**Forces and Motion Simulation Lab**

Let’s investigate the relationship between mass, force and acceleration.

MC900391040[1]

**Equipment:**

* Forces and Motion: Basics Simulation from Phet: <http://phet.colorado.edu/en/simulation/forces-and-motion-basics>
* Stopwatch

**Discussion:**

Airplanes accelerate from rest on a runway until they reach takeoff velocity. Cars accelerate from a stop sign until they reach cruising velocity. And when they come to a stop, they accelerate negatively. How do mass and force affect these accelerations? And how does friction play a role in acceleration?

In this experiment you will accelerate various objects. First, you will apply the same force to carts of different masses. Then, you will apply varying forces to the same mass. A relationship between mass and acceleration should be found. Finally, you will find the effect that friction has in these situations.

**Procedure:**

Work in pairs, one computer for each pair of students. Open up the University of Colorado, PhET "Forces and Motion" simulation

<http://phet.colorado.edu/en/simulation/forces-and-motion-basics>

**Part 1: Balanced vs Unbalanced Forces**

1. Click on “Tug of War” on the top of the page. Then, check “Sum of Forces” and “Values”.

2. Follow the “Trial” column below for which sims (persons) you should put on each side. \*\*Make sure to hit “RETURN” after each trial.\*\*

Data Table A

|  |  |  |  |
| --- | --- | --- | --- |
| Trial # (do NOT calculate this #) | Blue side | Red Side | Net Force with color of side winning |
| 1  (1 blue adult & 1 red adult) |  |  |  |
| 2  (1 blue child & 1 red adult) |  |  |  |
| 3  (1 blue teen, 1 blue child & 1 red adult) |  |  |  |
| 4  (1 blue adult & 2 red children) |  |  |  |

**Analysis:**

1. Do balanced forces cause a change in motion?

2. Did it matter where you placed your characters on the rope? (For example, did you apply more force by putting your children at the front or back or neither.) Explain your results.

3. Now that you have had a chance to experiment with the simulation, go back to the question at the beginning of the investigation. What do you think would be the best way to divide up your friends for the game of tug-of-war? Be sure to explain your reasoning.

**Part 2: Constant Force, Changing Mass**  
\* Click on the “Friction” Tab and check all the boxes in the upper right-hand corner (Forces, Sum of Forces, Values, Masses, Speed). In the next three parts you will need a stopwatch.

* 1. Place one of the 50 kg boxes in the center of the track. Move the Friction bar to “None”. Set the Applied Force box by entering 100 Newtons. You will start the force at the same time you start the stopwatch.
  2. You will allow the crate to accelerate to 40 m/s of velocity, which is full scale for the speedometer. Stop the stopwatch when the speed equals 40 m/s. Practice accelerating the carts a few times to ensure proper timing.
  3. When you get a run that you think is accurate, find the acceleration based on the change in velocity Δv and the change in time Δt. (See the table at the bottom of this page.)
  4. Do the same procedure for masses of 100 kg (two crates), 200 kg (refrigerator) and 300 kg (fridge and two crates). Enter the results in Data Table B

Data Table B

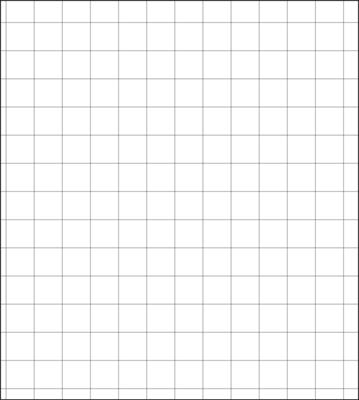
|  |  |  |  |
| --- | --- | --- | --- |
| Trial # (do not calculate this #) | Mass | Push Force | Acceleration (see table below) |
| 1 | 50 kg | 100 N |  |
| 2 | 100 kg | 100 N |  |
| 3 | 200 kg | 100 N |  |
| 4 | 300 kg | 100 N |  |

**This table is to assist you in finding the acceleration values for the above column.**

(v= 40 m/s for all trials, then divide by time= acceleration.)

|  |  |  |  |
| --- | --- | --- | --- |
| Trial # (do not calculate this #) | Velocity / | Time (s) = | Acceleration (m/s2) |
| 1 | 40 m/s |  |  |
| 2 | 40 m/s |  |  |
| 3 | 40 m/s |  |  |
| 4 | 1. m/s |  |  |

5. Using graph paper, make a graph of acceleration (vertical axis) vs. force (horizontal axis).



**Analysis:**

1. Describe your graph of acceleration vs. mass. Is it a straight line or a curve?

2. How does increasing mass affect the system’s acceleration?

3. Using your data and graph from Steps 1-5, predict what mass on the cart would be needed to accelerate the cart by 0.75 m/s/s, using the same force. Write it here: \_\_\_\_\_\_\_ kg

**Part 3: Constant Mass, Changing Force**

1. Place the 50 kg box the center of the track. Move the friction bar to “None”. Set the Applied Force box by entering 100 Newtons. Again, you will start the force at the same time you start the stopwatch.
2. Again, you will allow the crate to accelerate to 40 m/s of velocity, which is full scale for the speedometer.
3. When you get a run that you think is accurate, find the acceleration. (See the table at the bottom of this page.)
4. Do the same procedure for the same masses, but forces of 200N, 300N and 400N. Enter the results in Data Table C

Data Table C

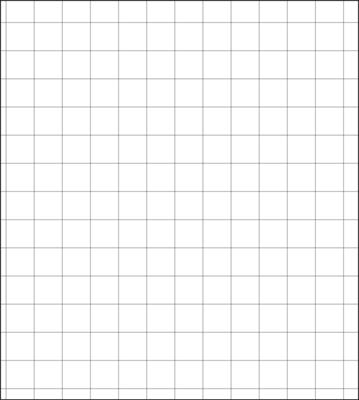
|  |  |  |  |
| --- | --- | --- | --- |
| Trial # (do not calculate this #) | Mass | Push Force | Acceleration (see table below) |
| 1 | 50 kg | 100 N |  |
| 2 | 50 kg | 200 N |  |
| 3 | 50 kg | 300 N |  |
| 4 | 50 kg | 400 N |  |

**This table is to assist you in finding the acceleration values for the above column.**

(v= 40 m/s for all trials, then divide by time= acceleration.)

|  |  |  |  |
| --- | --- | --- | --- |
| Trial # (do not calculate this #) | Velocity (m/s) / | Time (s) = | Acceleration (m/s2) |
| 1 | 40 |  |  |
| 2 | 40 |  |  |
| 3 | 40 |  |  |
| 4 | 40 |  |  |

5. Using graph paper, make a graph of acceleration (vertical axis) vs. force (horizontal axis).

****

**Analysis:**

1. Describe your graph of acceleration vs. force. Is it a straight line or a curve?

2. How does increasing force affect the system’s acceleration?

3. Find the slope of the graph. What does the slope represent?

**Part 4: Friction**

1. Place the 50 kg box in the center of the track. Move the friction bar to “Lots”. Set the Applied Force box by entering 350 Newtons. Again, you will start the force at the same time you start the stopwatch.
2. Again, you will allow the crate to accelerate to 40 m/s of velocity, which is full scale for the speedometer.
3. When you get a run that you think is accurate, find the acceleration. (See the last table on this page.)
4. Do the same procedure for the same masses and friction, but force of 450 N. Enter the results in Data Table D

Data Table D

|  |  |  |  |
| --- | --- | --- | --- |
| Trial # (do NOT calculate this #) | Mass | Push Force | Acceleration (see table below) |
| 1 | 50 kg | 350 N |  |
| 2 | 50 kg | 450 N |  |

**This table is to assist you in finding the acceleration values for the above column.**

(v= 40 m/s for all trials, then divide by time= acceleration.)

|  |  |  |  |
| --- | --- | --- | --- |
| Trial # (do not calculate this #) | Velocity (m/s) / | Time (s) = | Acceleration (m/s2) |
| 1 | 40 |  |  |
| 2 | 40 |  |  |

**Analysis:**

1. What force on the 50kg masses with no friction (Table C) gives the same acceleration as with 350 N and lots of friction (Table D)? What force on the 50kg masses with no friction gives the same acceleration as with 450 N and lots of friction?

2. How much do you think the force of friction must be? Why?