TechLab: Pushing Things Around

a simulation of force, mass, and acceleration

PERIOD	1.		
	2.		
GROUP	3.		
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• Purpose •

In this activity, you will investigate the relationship between force and motion using the "Forces and Motion: Basics" PhET simulation.

• Apparatus •

___computer (MacBook or equivalent)

___"Forces and Motion: Basics" PhET simulation software (available at phet.colorado.edu)

• Setup •

1. Turn the computer on, log on and allow it to complete its start up cycle. Connect to The Internet.

2. Find and start the PhET simulation, "Forces and Motion: **Basics**". Ask your instructor for assistance if needed. Note: There is also a sim called "Forces and Motion". That is not the sim for this lab.

• Discussion •

There is an important relationship between force and motion. Using the simulation (sim), we will investigate the basics of this relationship.

• Procedure •

PART A. TUG OF WAR

The sim should open in the Tug of War tab. If it does not, click the tab to activate Tug of War. In this sim, a wagon (W) can be pulled by the

players of 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.

1. Even Steven.
If you arrange identical teams in the Tug of War, you'll get a tie. The net force is zero. The following are examples of identical teams.

A---W---A (Adult vs. Adult)

C-T---W---C-T

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

a. Describe three distinct ways to arrange the teams so that you get a tie even though the teams have **different numbers** of players. These are non-identical, balanced teams. (To show distinct arrangements, don't simply switch players on each side. For example, **A-C---W---T** and **T---W---A-C** are **not** distinct. (Nor do they produce a tie.)

i.

ii.

iii.

b. Complete this statement which relates part of Newton's First Law (the Law of Inertia) to these

observations: **A body** _____ _____ **will remain** _____ _____

unless acted on by a/an _____ **force.**

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2. The Electric Slide.

a. Arrange an unbalanced tug of war by placing only one player on the rope. One team will have an active player; the other team will be completely unmanned. Click the on-screen Go button, wait two full seconds, the click the on-screen Pause button. At this point, the wagon was moving and the one-player team was winning.

b. While the action remains paused, add player(s) to the other team so that the two teams are balanced (the net force is zero).

c. Prediction. While the action remains paused, predict what will happen when the sim is unpaused and action resumes with the newly balanced teams.

d. Observation. Now unpause the sim and record your observation of what happens.

e. Explain. Use the Law of Inertia to explain why this happens.

PART B: MOTION
Click the Motion tab to select the Motion activities.

1. PhET Girl vs. Massive Stack.

a. In the on-screen control panel, the Force checkbox should already be selected. Click the Speed checkbox to activate the speedometer. Set the PhET Girl on the skateboard. Use maximum Applied Force to get her up to speed as rapidly as possible.

i. What happens when she reaches maximum speed? (Discuss the pusher, the motion of the girl, and the grayed-out—unavailable—section of the Applied Force control.)

ii. Now apply a maximum force in the **opposite** direction until the pusher falls again. What happens during this push?

b. Take the girl off the skateboard and load the skateboard with two crates and the refrigerator. Repeat the maximum force one way, then the other way as was done with the PhET Girl.

What was different this time, and why?

PART C: ACCELERATION LAB
Click the Acceleration Lab tab. Activate the Speed and Acceleration displays. Set the Friction to None (ice).

1. Sloshy.

a. Set the translucent/transparent bucket on the track and push it for maximum acceleration. Record observations of the speedometer, accelerometer, and water in the bucket.

b. Remove the bucket to stop the action. Now stack a crate, refrigerator, and the bucket. Push again for maximum acceleration. Describe the differences compared to part a.

2. Numerical Ish.
Click the on-screen Reset All button. Set Friction to None. In the control panel, activate Forces: Values, Masses, Speed, and Acceleration.

a. Click the on-screen Pause button. Set one 50-kg crate on the track. Set the Applied Force to 200 N. (If the slider won't let you select 200 N exactly, type 200 N into the Applied Force value space). Unpause the sim for a second or to so that the acceleration registers on the accelerometer. The pause the sim. For the purposes of the questions below, we will consider this configuration to be the Original Arrangement.

i. From the Original Arrangement, what **single** change could double the acceleration?

ii. From the Original Arrangement, how could you **halve** the acceleration *without* changing the Applied Force?

b. Remove all items from the track to stop the action.

i. Click the on-screen pause button. Add two 50-kg crates to the track. Set the Applied Force to 250 N. Unpause the sim momentarily to register the acceleration.

ii. Make two changes to the arrangement so that the acceleration will **quadruple** when the sim is unpaused. Describe the changes.

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