Safety on the Docks: An Engineering Design Challenge

Engineers often use computer simulations to solve problems. To create such a simulation physical laws must first be expressed mathematically, and then programmed into a computer. It is then possible to quickly perform a number of “if…then” experiments, which provide results that are similar to what will happen in the real world.

In this design challenge you will use a computer simulation of forces and motion to arrive at some safety rules for dockworkers. The simulation will allow you to make some decisions without having to put real dockworkers at risk. Begin by going to the following website.


This simulation is one of many excellent free simulations developed by researchers at the University of Colorado, Boulder (some of which you may have already used in this course). To start, click on Motion. You will see a robot next to a wooden crate on a skateboard. You can tell the robot to push the cart by moving the slider underneath the skateboard. Play with the simulation for a while by pushing the crate forward and backward, hard and light, and so forth to get a feeling for how the simulation functions.

Notice that the robot will only stop pushing when you move the slider back to zero.
You can always reset the simulation by clicking the orange button with a circular arrow.

Reset the simulation. In this mode there is no friction.

1. **Short Push.** Move the slider briefly to the right, then back to the center again. Notice that the robot stops pushing. What happens to the crate on the skateboard?

   Why does it move that way? Is it necessary for a force to be exerted to keep the cart rolling?

2. **Long Continuous Push.** Click reset. Then exert the same amount of force as before, but this time do not let the robot stop pushing. How does the motion of the crate on the skateboard change?
3. **Push Back.** Click reset, and then have the robot exert a very brief force on the cart. Now figure out what you need to do to stop the cart from rolling. What did you have to do to stop the cart?

When you figure out how to do that, explain why it works.

4. **Mass.** Click reset. Notice the other objects that can be placed on the skateboard. Drag these to the skateboard. Try pushing each of these using the same force. Notice the position of the robot as it tries to push heavier and heavier objects. Record your observation below.

5. **Friction.** Now it’s time to make the simulation more realistic. Click on the *Friction* icon at the bottom of the simulation. Notice the skateboard disappears and a “friction” slider at top right. Try doing the same things you did before, but this time with friction. What happens if you use a little friction versus lots of friction?

What direction is the force of friction acting when the object is moving? What is the direction when the object is *not* moving, despite the force the robot exerts on it?
**Develop Safety Rules**

Notice that the robot’s position changes as it exerts more pressure to get things moving. That’s because heavy objects also exert a force on the robot (recall Newton’s Third Law). For a dockworker, that force can cause serious health problems. (Also, heavier objects are just harder to get moving quickly than lighter objects, even in a frictionless environment.)

Make up three rules for conditions under which a dockworker must have the option of choosing to ask others for assistance, or otherwise changing working conditions. Consider how the various forces combine to make certain tasks much more difficult than others.

**Rule 1:**

**Rule 2:**

**Rule 3:**