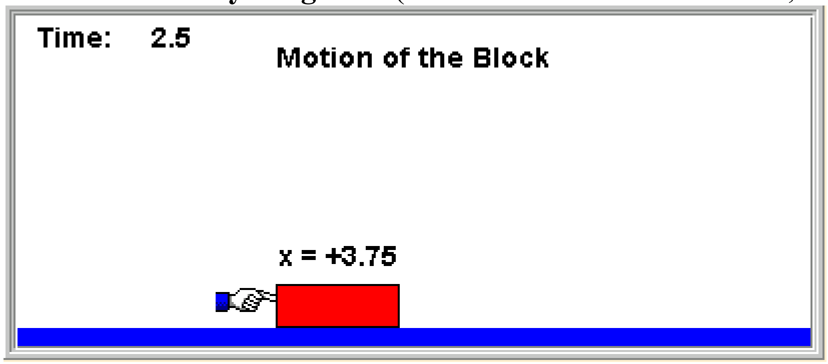
Worksheet: Newton's 3rd Law and Free Body Diagrams

Part I: Free Body Diagrams (modified from Illustration 4.1, *Physlet Physics*)



1. Press "play" and let the animation run. An 8-kg block is pushed across the floor (position is given in centimeters and time is given in seconds). Describe the motion:

2. Sketch a possible free-body diagram for the block:

3. What is the velocity of the block at t=2-seconds? _______ Show your work below: (Reminder: $v=\Delta x/\Delta t$ so, for example, measure the position of the block at t = 1.9 s and at t= 2.1 s and then calculate the velocity by taking the distance traveled during that short time and divide by the time interval)

4. What is the velocity of the block at t=4-seconds? _______ Show your work below:

5. What is the acceleration of the block? _______________ Show your work below: (Reminder: $a=\Delta v/\Delta t$)

6. Therefore, the net force (sum of all the forces) in the x-direction = __________ (Reminder: Net F = ma or $\Sigma F=ma$)

7. Similarly, the net force (sum of all the forces) in the y-direction = __________

8. Consider the forces in the x-direction (horizontal forces). Click each of the four possible diagrams. The length of the vector represents the magnitude of the force. Only one is a possible free-body diagram. For each animation, indicate why it is or is not a possible force diagram:

Horizontal components:

	Possible force diagram?	Reason:
Free-Body 1x		
Free-Body 2x		
Free-Body 3x		
Free-Body 4x		

Vertical components:

	Possible force diagram?	Reason:
Free-Body 1y		
Free-Body 2y		
Free-Body 3y		
Free-Body 4y		

9. Based on this, sketch a complete free-body diagram below:

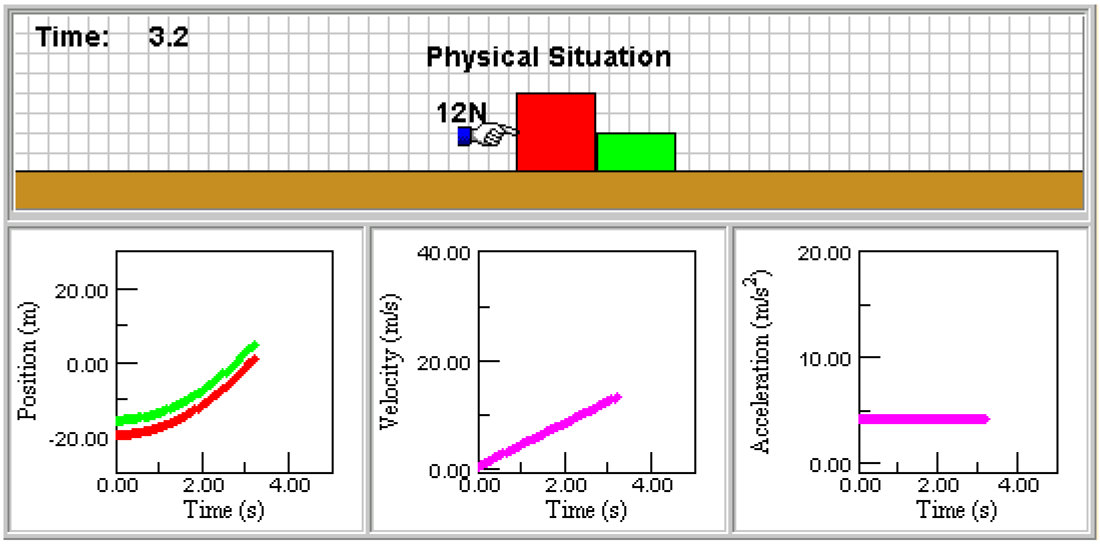
10. Explain any differences with your original sketch.

11. Click on the "complete free body diagram" link. Sketch the free-body diagram shown in the animation below:

12. Does it agree with your sketch above? If not, explain why the animation (and not your drawing) shows the correct free-body diagram.

Note that in this case, there is a frictional force, but the form of the frictional force will be addressed later in this course.

Part II: Newton's 3rd Law (modified from Illustration 4.6, *Physlet Physics*)
The animation shows graphs of position, velocity and acceleration versus time for a 12-N force pushing a 2-kg red block in contact with a 1-kg green block on a **frictionless surface**. Click the show and play the physical situation link to show the animation.



1. Describe what you see.

2. What is the acceleration of the red block (you can click on the graph to read the value)? ________

3. What is the acceleration of the green block? ________

4. Sketch a free-body diagram for the two blocks (assuming that they together make one 3-kg mass system). Indicate the values for each of the forces in your diagram:

5. List your forces and determine whether they are long range or contact forces.

6. Sketch a free-body diagram for each block individually (again, show explicitly the values of each of the forces in your diagram):

7. How does this diagram differ (if at all) from the one you drew previously?

8. Use Newton's 2nd Law to solve for the value of the contact force on the 1-kg (green) block.

9. Which pair of forces is an action/reaction pair? Do they cancel out? Why or why not?

10. Specifically, what is the value of the contact forces between the two blocks:

Force of green on red = ____ N   Force of red on green = ____ N

Type these two values into the appropriate text boxes in the animation and then push the "set values and play" button. Describe what happens:

11. Did the motion (and the graphs) match the original animation? If not, you have not put in the correct values for the contact forces and you will need to rethink your diagram and your values for the contact forces (don't forget to use signs to indicate direction: a force pointing to the left requires a minus sign).

Correct value:

Force of green on red = [ ] **N** **Force of red on green =** [ ] **N**

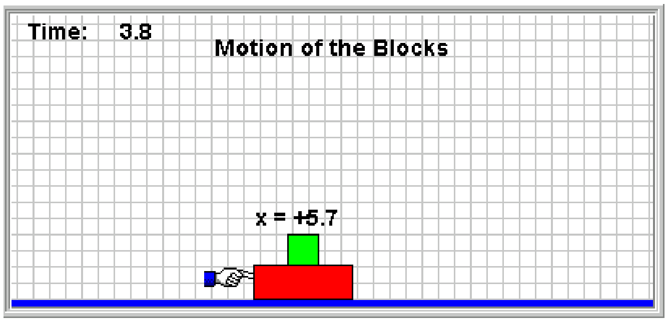
12. Additional help (if needed):
For the green block (1-kg) to have an acceleration of 4 m/s^2, what must the horizontal force be on the green block? __________ Note that this comes from the red block pushing on the green block.

For the red block (2-kg) to have an acceleration of 4m/s^2, what must the net force (sum of all the forces) be on it?_______ Since it has 12-N to the right, what must the force to the left be? _______ (Note that since this is a force that points to the left, you must include a minus sign when typing it into the text box in the animation.) The force should be equal and opposite (Newton's 3rd Law) to the force that the red block exerts on the green block. Is it?

What, then, are the correct values to type into the text boxes?

Force of green on red = [ ] **N** **Force of red on green =** [ ] **N**

Part III: Free-Body Diagrams and Newton's 3rd Law (Problem 4.1, *Physlet Physics*)
A red block is pushed and moves as shown in the animation. In addition, a green block sits on the red block and moves as well.



1. What is the acceleration of the two blocks? ________ How do you know?

2. Which free-body diagram is correct? Give reasons why the other three are incorrect:

	Correct free-body diagram?	Reason:
Free-Body 1		
Free-Body 2		
Free-Body 3		
Free-Body 4		

3. How would your answers to (2) change if the blocks did not move?