Newton's Third Law

Pre-Class Questions

Problem Set (due next time)
Ch 4 - 27, 28, 31, 42

Lecture Outline

1. Newton's Third Law - The Law of Action/Reaction
2. Free Body Diagrams

Newton's Third Law - The Law of Action and Reaction

"When one object exerts a force on a second object, the second object exerts an equal, but opposite force on the first object."

Two key ideas:

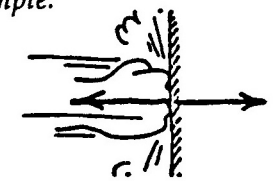
- Force is not a property of an object, it is a mutual interaction between two objects.
- If you examine a system that includes both objects, there will be no net force.

Concept-Development Practice Page 6-1

Newton's Third Law

1. In the example below, the action-reaction pair is shown by the arrows (vectors), and the action-reaction described in words. In (*a*) through (*g*) draw the other arrow (vector) and state the reaction to the given action. Then make up your own example in (*h*).

Example:

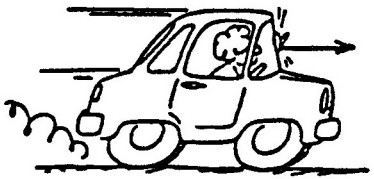


Fist hits wall.

Wall hits fist.

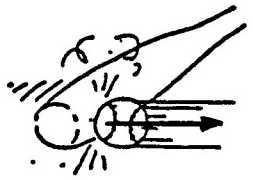
Head bumps ball.

(*a*)_____



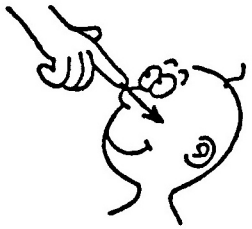
Windshield hits bug.

(*b*)_____



Bat hits ball.

(*c*)_____



Hand touches nose.

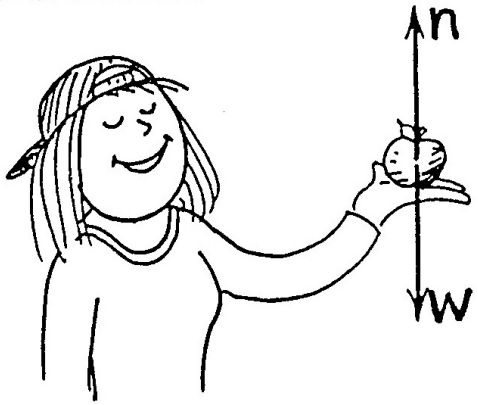
(*d*)_____

Hand pulls on flower.

(*e*)_____

Newton's Third Law

3. Nellie Newton holds an apple weighing 1 newton at rest on the palm of her hand. The force vectors shown are the forces that act on the apple.



a. To say the weight of the apple is 1 N is to say that a downward gravitational force of 1 N is exerted on the apple by

(the earth) (her hand).

b. Nellie's hand supports the apple with normal force **n**, which acts in a direction opposite to **W**. We can say **n**

(equals **W**) (has the same magnitude as **W**).

c. Since the apple is at rest, the net force on the apple is (zero) (nonzero).

d. Since **n** is equal and opposite to **W**, we (can) (cannot) say that **n** and **W** comprise an action-reaction pair. The reason is because action and reaction always

(act on the same object) (act on different objects),

and here we see **n** and **W**

(both acting on the apple) (acting on different objects).

e. In accord with the rule, "If ACTION is A acting on B, then REACTION is B acting on A," if we say *action* is the earth pulling down on the apple, *reaction* is

(the apple pulling up on the earth) (**n**, Nellie's hand pushing up on the apple).

f. To repeat for emphasis, we see that **n** and **W** are equal and opposite to each other

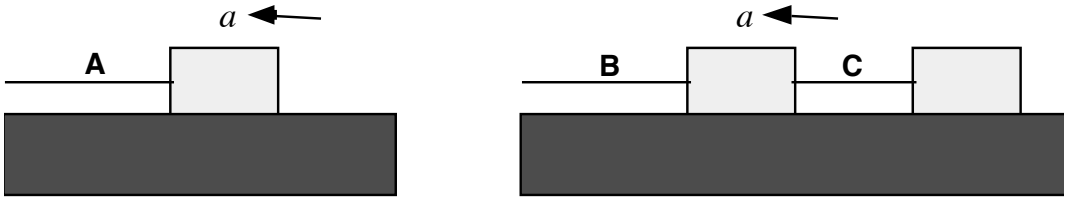
(and comprise an action-reaction pair) (but do *not* comprise an action-reaction pair).

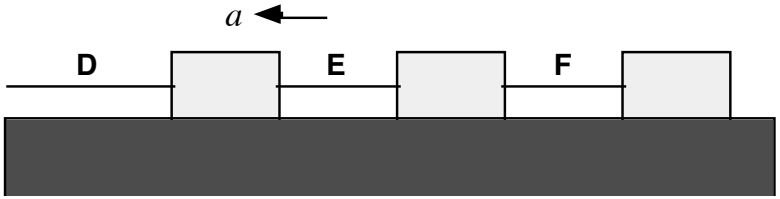
Example 1: For a block at rest on a table, (a)draw a free-body indicating all the forces on the object. (b)Use Newton's Second Law to find their magnitudes. (c)Describe the reaction force to each force acting on the block.

Example 2: A 20.0kg crate rests on top of a 30.0kg crate. (a)Draw the free-body diagram for the system as a whole, (b)the 20.0kg crate, and (c)the 30.0kg crate. Find (d)the normal force that the 30.0kg crate exerts on the 20.0kg crate and (e)the normal force that the ground exerts on the 30.0kg crate.

The figures below show boxes that are being pulled by ropes along frictionless surfaces, accelerating toward the left. All of the boxes are identical, and the acceleration is the same in each figure. As you can see, some of the boxes are pulled by ropes attached to the box in front of them.

Rank the ropes from greatest to least on the basis of the tension in the rope.





Greatest 1_____ 2_____ 3_____ 4_____ 5_____ 6_____ Least

Or, all of the tensions will be the same. _____

Please carefully explain your reasoning.

Lecture 10- Summary

Newton's First Law - The Law of Inertia
"Every object will move with a constant velocity unless a force acts on it."

Newton's Second Law - $\sum F=ma$
"The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass. The direction of the acceleration is in the direction of the net force."

Newton's Third Law - The Law of Action/Reaction
"When one object exerts a force on a second object, the second object exerts an equal, but opposite force on the first object."

Free-body Diagrams

1. Choose a system.
2. Draw the forces acting on the system from the outside.