Newton's Laws of Motion

Pre-Lecture Questions

Problem Set #10 (due next time)

Lecture Outline

1. Newton's First Law - The Law of Inertia
2. Newton's Second Law - $\sum F=ma$
3. Newton's Third Law – The Law of Action and Reaction

Pre-Class Summary:

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

Two key ideas:

- The "natural state" of motion is not rest, but any constant velocity.
- Force is defined to be the agent that causes velocity to change.

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

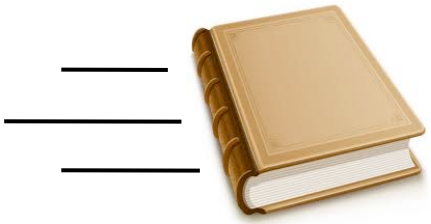
http://www.youtube.com/watch?v=vfnt8Sdj7cs

Newton's First Law

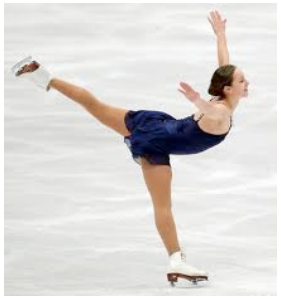
For each situation below draw the forces acting on the object and describe the motion in terms of Newton's First Law

A. A book at rest.

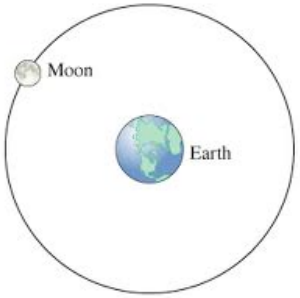
C. A book skidding to rest across a rough table.



B. An ice skater moving at constant speed across the ice.



D. The moon in orbit around Earth



Pre-Class Summary:

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."

Four key ideas:

- It is not an equation, but a set of instructions, designed to produce an equation to describe the motion of an object.
- It establishes the definition of mass as a measure of the inertia of an object.
- It establishes force as a vector quantity.
- It lets us be able to calculate the acceleration of an object if we know the forces that act upon it.

COMMENT ON PROBLEM SOLVING:

When you want to use the Second Law to attack a problem, use your sketch to identify the object to which you want to apply the Second Law. Then draw just the forces that **act on** this object due to other objects. Then choose a convenient coordinate system. Finally, use the Second Law to write an equation for the object.

CONCEPTUAL **Physics** PRACTICE PAGE

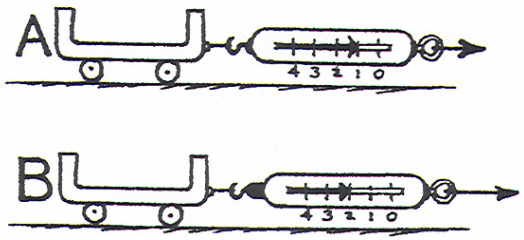
Chapter 4 Newton's Second Law of Motion

Racing Day with a = F/m

In each situation below, Cart A has a mass of **1 kg**. *Circle the correct answers* (A, B, or Same for both).

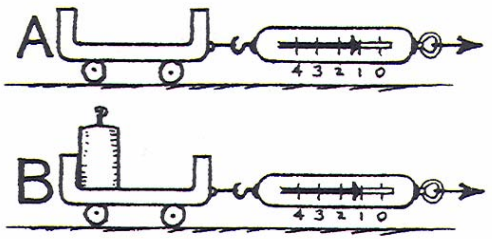
1. Cart A is pulled with a force of **1 N**.
   Cart B also has a mass of **1 kg** and
   is pulled with a force of **2 N**.
   Which undergoes the greater acceleration?

   [A] [B] [Same for both]



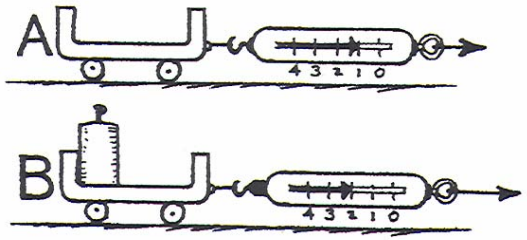
2. Cart A is pulled with a force of **1 N**.
   Cart B has a mass of **2 kg** and is
   also pulled with a force of **1 N**.
   Which undergoes the greater acceleration?

   [A] [B] [Same for both]



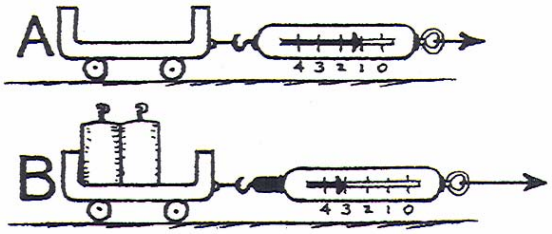
3. Cart A is pulled with a force of **1 N**.
   Cart B has a mass of **2 kg** and is
   pulled with a force of **2 N**.
   Which undergoes the greater acceleration?

   [A] [B] [Same for both]



4. Cart A is pulled with a force of **1 N**.
   Cart B has a mass of **3 kg** and is
   pulled with a force of **3 N**.
   Which undergoes the greater acceleration?

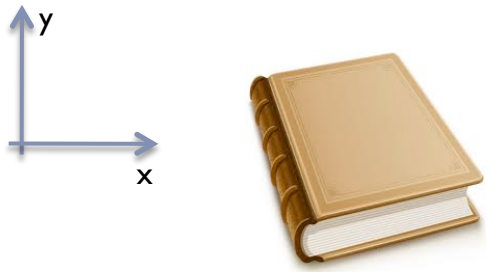
   [A] [B] [Same for both]



Newton's Second Law

For each situation below use your sketch of the forces acting on the object to write an equation for the acceleration of the object using Newton's Second Law.

A. A book at rest.



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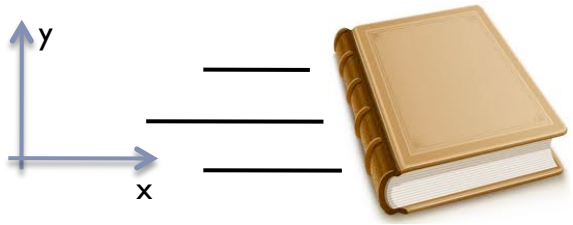

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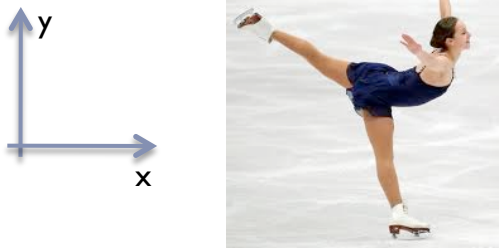

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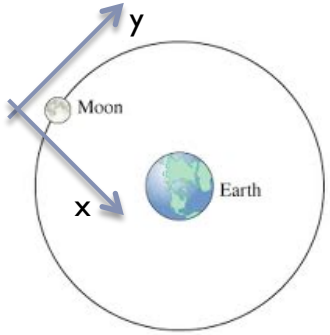


Pre-Class Summary:

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

"When one object exerts a force on a second object, the second object exerts and equal and opposite force back upon the first object."

Two key ideas:

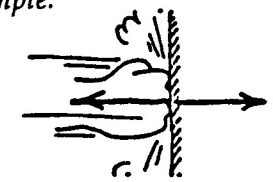
- Force is not a property of an object, it is a mutual interaction between two objects.
- The motion of an object is determined only by the forces that act on the object and not by forces the object exerts back on other objects.

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:

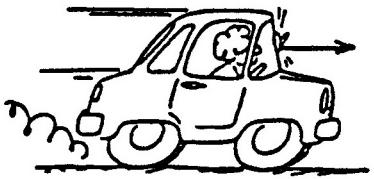


Fist hits wall.

Wall hits fist.

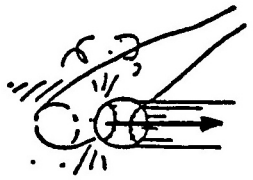
Head bumps ball.

(*a*)_____



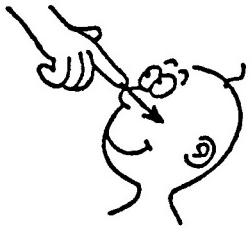
Windshield hits bug.

(*b*)_____



Bat hits ball.

(*c*)_____



Hand touches nose.

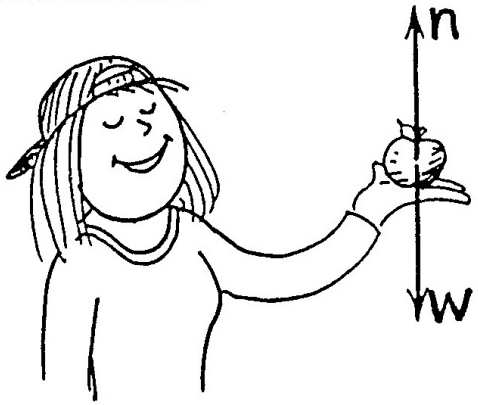
(*d*)_____

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).

Lecture 10 - Summary

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