Hewitt/Lyons/Suchocki/Yeh

Conceptual Integrated Science

Chapter 3

NEWTON'S LAWS OF MOTION

Vectors

Vector

- a quantity whose complete description involves magnitude and direction
- represented by an arrow drawn to scale

Examples of a vector quantity:
velocity, force, acceleration

Vectors are represented by arrows.

Scalars

Scalar

- a quantity described only by magnitude

Examples of a scalar quantity:
mass, volume, speed

Vectors

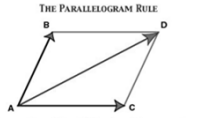
Working with Vectors

- Vectors in the same direction ⇒ add
- Vectors in the opposite direction ⇒ subtract
- Nonparallel vectors ⇒ use Parallelogram Rule. Original vectors are *components* of the final vector, or *resultant*.

The Parallelogram Rule

To apply the Parallelogram Rule:

1. Draw original vectors AB and AC
2. Draw lines BD and CD parallel to AC and AB, creating a parallelogram.
3. Draw a vector from A to D. This is the Resultant.
4. If done to scale, AD will be of the proper magnitude and direction.



Two motions AB and AC, acting at the same time, result in the diagonal motion AD.

Newton's First Law of Motion

http://www.cooperativeindividualism.org/calvin-on-scientific-law.gif

(Note: Don't Do This on the Exam!!!)

Newton's First Law of Motion

The law of inertia:

Every object continues in a state of rest or of uniform speed in a straight line unless acted on by a nonzero force.

Newton's First Law of Motion

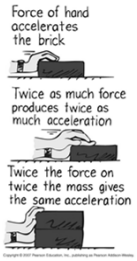
A different way of saying it:

"Objects at rest remain at rest; objects in motion at a constant velocity remain in motion in a straight line unless acted upon by a net force."

Newton's Second Law of Motion

The law of acceleration:

The acceleration produced by a net force on an object is directly proportional to the net force, is in the same direction as the net force, and is inversely proportional to the mass of the object.



Newton's Second Law of Motion

Equation for acceleration:

$$\text{Acceleration} = \frac{\text{net force}}{\text{mass}}$$

$$a = \frac{F}{m}$$

small net force, large mass ⇒ small acceleration

large net force, small mass ⇒ large acceleration

Newton's Second Law of Motion

When acceleration is *g*—free fall.

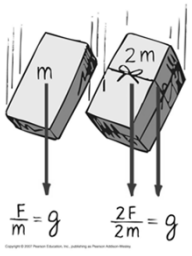
When the only force acting on a falling object is gravity, with negligible air resistance, the object is in **free fall**.

An object in free fall accelerates toward Earth at ~10 m/s per second (~10 m/s^2)

Newton's Second Law of Motion

When acceleration is *g*—free fall.

Twice the force on twice the mass ⇒ same acceleration as half the force on half the mass.



It does not matter what the mass is, all objects fall at the same rate!

Newton's Second Law of Motion
A situation to ponder…

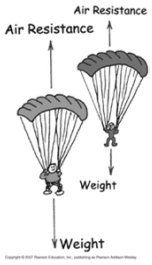
When an air-filled glass tube containing a coin and a feather is inverted, the coin falls quickly to the bottom of the tube while the feather flutters to the bottom.

Newton's Second Law of Motion

When acceleration is <u>less than *g*</u>—non-free fall.

There are two forces act on a falling object

- A force due to gravity acting downward
- Air resistance acting upward



Newton's Second Law of Motion

When acceleration is less than *g*—non-free fall.

The force exerted by the surrounding air increases with the increasing falling speed.

The force of air resistance may continue to increase until it equals the weight. At this point, net force is zero and no further acceleration occurs. The object has reached *terminal velocity* and continues to fall with no acceleration—at constant velocity.

Forces and Interactions

Force is something that can change the motion of an object.
Interaction occurs between one thing and another.

Example:
When you push against a wall, you're interacting with the wall.

Newton's Third Law of Motion

Law of action and reaction:
Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first.

Example:
When your hand presses on the wall, the wall simultaneously presses on your hand. Hand and wall press on each other with equal and opposite forces.

A soccer player kicks a ball with 1500 N of force. The ball exerts a reaction force against the player's foot of

✘ A. somewhat less than 1500 N.
✓ B. 1500 N.
✘ C. somewhat more than 1500 N.
✘ D. none of the above.

[MC Types]

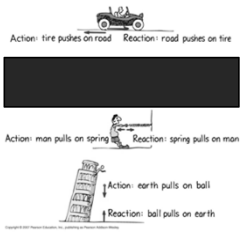
✓ [Default]

Newton's Third Law of Motion

Simple Rule to Identify Action and Reaction:

Action—
Object A exerts a force on object B.

Reaction—
Object B exerts a force on object A.

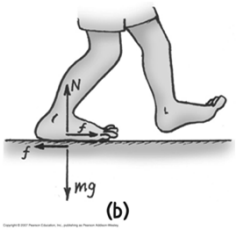


Newton's Third Law of Motion

Action and Reaction Forces:
Example – Walking

Balanced: Your weight (mg) and the normal force.

Unbalanced: Your foot pushes backwards on the floor; the floor pushes forward on you. Therefore – you go forward!



Newton's Third Law of Motion

Action and Reaction on Different Masses:
If the same force is applied to two objects of different masses,

greater mass object ⇒ small acceleration
smaller mass object ⇒ large acceleration

(This also involves Newton's Second Law!)