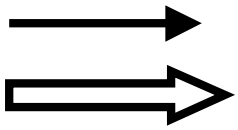
Chapter 12 - Forces and Motion

A. What is a force?

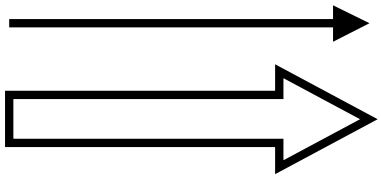
1. It is a push or pull.
2. Force can cause resting objects to move.
3. Force can cause acceleration by changing the object's speed or direction.
4. Newtons are used to measure force (N)
5. A newton is the amount of force needed to accelerate a 1 kg object at 1m per second every second.

$$N = \frac{kg * m}{sec^2}$$

6. Arrows can be used to represent force



Small force



Large force

B. Combining Forces

1. Forces in the same direction combine together.
   e.g. If you push on a rolling ball in the same direction that it is rolling, it will accelerate.
2. Forces in the opposite direction are subtracted.
   e.g. If you put your foot in front of a rolling ball, it will slow down.
3. Net force – the overall force acting on an object after all forces are combined

4. **Balanced force – when forces are balanced the net force is zero, therefore there is no change in the object's motion**
   e.g. Book resting on your desk

5. **Unbalanced forces acting on an object cause the object to accelerate by:**
   a. slowing it down
   b. speeding it up
   c. changing its direction (figure 4, p. 358)

C. Friction

1. **Friction is a force that opposes the motion of objects that touch as they move past each other.**
2. **Friction acts on objects that are touching each other.**
   e.g. Solid objects rubbing or objects moving through liquids or gases.
3. **Static friction - acts on objects that are not moving. It acts opposite of the force being applied to an object.**
4. **Sliding friction opposes the direction of motion of an object as it slides over a surface.**
5. **Sliding friction is always less than static friction; therefore less force is needed to keep an object going than to start an object moving.**
6. **Rolling friction - friction that acts on rolling objects**
7. **Rolling friction can be 100 to 1000 times less than static or sliding friction.**
   e.g. Ball bearings and wheels
8. **Fluid friction occurs when an object moves through a liquid or gas.**
9. **Air resistance is fluid friction acting on an object as it passes through air.**

D. Gravity – a force that acts between any two objects that pulls them together

1. Earths gravity acts downward.

2. Gravity causes objects to accelerate downward at a rate of 9.8m/sec^2.

3. Air resistance acts in the direction opposite the motion and reduces acceleration. The larger the surface area of an object, the more air resistance it will experience.

4. Terminal Velocity - when the upward force of air resistance becomes equal to the downward force of gravity, it can cause the object to no longer accelerate; it will then fall at a constant velocity.

5. Projectile Motion - curved motion of an object that is shot or thrown near the Earth's surface
    1. It is caused by two forces:
        a. Initial force
        b. Gravity

F. Aristotle, Galileo, and Newton

Aristotle: Greece
Born: 384 BCE Died: 322 BCE

1. **Incorrectly stated that force is required to keep an object moving at constant speed**
2. **This statement held back progress in the study of motion for almost 2000 years.**

Galileo: Italy
Born: 1564 Died: 1642

1. **Studied how gravity produces constant acceleration.**
2. **Galileo concluded that moving objects not subjected to friction or any other force would continue to move indefinitely.**

Newton: England
Born: 1642 (1643) Died: 1727

1. **Published the book *Principia***
2. **In *Principia*, Newton defined mass and force and introduced his laws of motion.**

G. Newton's 1st Law of Motion

1. **The state of motion of an object does not change as long as the net force acting on the object is zero.**

2. **An object at rest stays at rest or an object in motion stays in motion unless acted upon by an unbalanced force.**

3. Also known as the law of inertia – tendency of an object to resist a change in motion.

H. Newton's 2nd Law of Motion

1. The acceleration of an object is equal to the net force acting on it divided by its mass.

$A = \frac{F}{M}$ $F = M \times A$ $M = \frac{F}{A}$

A = acceleration F = force M = mass

Mass must be in kg.
Acceleration must be in m/s^2 .

I. Weight and Mass

WEIGHT AND MASS ARE NOT THE SAME THING!

1. Weight is the force (N) of gravity acting on an object.

weight = mass x acceleration due to gravity

e.g. $10kg \times 9.8m/sec^2 = 98N$

2. Mass is a measure of inertia in an object; its weight is a measure of the force of gravity acting on it.

J. Newton's 3rd Law of Motion

1. Whenever an object exerts a force on a

second object, the second object exerts an equal and opposite force on the first object.

2. Known as action and reaction forces.
3. They do not cancel each other out because they are not acting on the same object.
   e.g. While swimming your hand (action force) pushes on the water. The water pushes back on your hand.

K. Momentum
1. It is the product of an object's mass and its velocity.
2. Momentum = mass x velocity
3. The more mass a moving object has, the more momentum it has.
4. The faster an object moves, the more momentum it has.
   e.g. Train vs. Mini cooper

L. Conservation (constant value) of Momentum
1. Law of Conservation of Momentum - if no net force acts on a system, the total momentum does not change.
   (Fig 17, p. 376)
2. In a closed system, the loss of momentum in one object is equal to the gain of momentum in another object.

M. Electromagnetic Forces

1. **They are associated with charged particles.**
2. **Electric and Magnetic forces can both attract and repel.**
3. **Objects with LIKE electrical charges repel.**
4. **Objects with OPPOSITE electrical charges attract.**
5. **Magnetic forces can act on certain metals, on poles of magnets, and on moving charges.**
6. **The opposite poles of magnets attract.**
7. **The same poles repel.**

N. Nuclear forces (nucleus of an atom)

1. **The protons (+) of the atom are held together by strong nuclear forces and a weak nuclear force.**

2. **The *strong* nuclear force overcomes the repulsion of the protons. Its range of effectiveness is very small (size of a proton). However, it is stronger than the repulsion force between the protons.**
3. **The *weak* nuclear force is an attraction that occurs over very small distances.**

O. Gravitational Force

1. **Gravity is the weakest universal force but it is the most effective over large distances.**

2. **Gravitational force acts between any 2 objects.**
3. **Law of Universal Gravitation: every object in the universe attracts every other object**
4. **The farther apart the objects, the less attraction there is between them.**
5. **The more massive the objects, the greater the attraction between them.**
   (p. 380, Fig.21)
6. **Centripetal force - is a center directed force of an object to make it move in a circle.**
7. **Satellites in orbit only need the centripetal force provided by gravity and its inertia to maintain its orbit.**