Forces and Dynamics

A **force** is any kind of push or pull that acts on an object. All forces can be loosely grouped into four categories, known as the **fundamental forces**:

Strong Nuclear Force

- attractive force that holds protons and neutrons in the nucleus of atoms
- strongest of the four forces
- only acts over very short distances $\left(10^{-15}\ m\right)$, so it can be ignored outside the nucleus

Weak Nuclear Force

- exerted between certain subatomic particles
- responsible for some types of nuclear decay
- second strongest of the four forces (a million times weaker than the strong force)
- a hundred times shorter in range than the strong force, so it can also be ignored outside the nucleus

Gravitational Force

- force between two objects because of their mass
- always attractive
- weakest of the four forces (only noticeable if one of the objects has a very large mass and is not too far away)
- acts over nearly unlimited distances

Electromagnetic Force

- forces that charged particles exert on each other
- can be attractive or repulsive
- acts over practically unlimited distances
- any force that is not one of the other three types, is considered to be electromagnetic

Force is a vector quantity, and thus has both a magnitude and a direction. In addition, all the usual rules for vector addition apply when combining forces.

Newton's Laws of Motion

Newton developed three laws to describe how forces cause motion:

Newton's First Law
Every object continues in its state of rest, or of uniform velocity in a straight line, as long as no net force acts on it.

The tendency of an object to maintain its state of rest or of uniform motion in a straight line is called inertia. Thus, Newton's first law is often called the **law of inertia**.

Implications:

- if the net force acting on an object is zero, then either
  - the object is at rest, or
  - the object is moving with a constant velocity

- if the net force on an object is not zero, then the object is accelerating (speeding up, slowing down, or changing direction)

- if an object is moving with a constant velocity, or at rest, then the net force acting on it must be zero

Weight
The weight of an object on Earth is the gravitational force exerted on it by the Earth. In other words,

$$Weight = F_g$$

The gravitational force acting on an object can be calculated using:

$$F_g = mg$$

where m is the mass of the object and g is the gravitational acceleration on Earth. Experiments have shown that

$$g = 9.8\ m/s^2$$

The value of g varies with both latitude (stronger at the poles than at the equator) and altitude (weaker as you move farther away from Earth's surface), but can be considered constant as long as we remain close to Earth's surface.

Example
What is the weight of a textbook whose mass is 1.85 *kg* ?

Forces Worksheet

1. Complete the following table about the properties of the four fundamental forces:

Property	Fundamental Force
Acts between charged particles	
Acts in the nucleus	
Has the shortest range of all the forces	
Has unlimited range	
The weakest force	
Acts between protons	
Due to the fact that objects have mass	
Can be attractive or repulsive	
Is only attractive	

2. Identify to which of the four fundamental forces each of the following belongs:

Force	Category
Weight	
Spring pulling a book	
Occurs between neutrons	
Occurs between particles smaller than protons	
Allows a balloon to stick to a wall	
Friction	
Bat hitting a ball	

3. Why is it particularly dangerous to drive on an icy highway?

4. Why do you lunge forward when your car suddenly comes to a halt? Why are you "thrown backward" when your car rapidly accelerates?

5. Why is your body pressed against the left side of the seat when the car you are riding in suddenly veers to the right?

6. What is the effect of friction on a moving object?

7. The speed of a ball increases as it rolls down an incline and decreases as it rolls up an incline. What happens to its speed on a smooth (frictionless), horizontal surface?

8. Does the law of inertia apply to moving objects, objects at rest, or both?

9. If you were in a spaceship and launched a cannonball into frictionless space, how much force would have to be exerted on the ball to keep it going?

10. If an elephant was chasing you, its enormous mass would be very threatening. But if you zigzagged, the elephant's mass would be to your advantage. Why?

11. What is the weight of $2\ kg$ of yogurt? ($19.6\ N$)

12. Forces of $10\ N$ and $15\ N$ are acting in the same direction on an object. What is the net force on the object? ($25\ N$)

13. If forces of $10\ N$ and $15\ N$ act in opposite directions on an object, what is the net force? ($5\ N$ in the direction of the $15\ N$ force)

14. If a woman has a mass of $50\ kg$, calculate her weight in newtons. ($490\ N$)

15. Susie Small finds she weighs $300\ N$. Calculate her mass. ($30.6\ kg$)