directly proportional : ↑↑ or ↓↓

invesly proportional : ↓↑ or ↑↓

Newton's Second Law

A non-zero net force F_{net} acting on an object causes acceleration a in direction of the net force, with magnitude inversely proportional to the mass of the object and directly proportional to the magnitude of the net force.

$$\vec{a} = \frac{\vec{F_{net}}}{m} = \frac{\Sigma \vec{F}}{m} \longrightarrow \vec{F}_{net} = m\vec{a}$$

- Units: Newton = $N = kg \times m/s^2$ $= kg \times m \times s^{-2}$

$\Sigma \vec{F} = 0N$

Forces are Balanced ⇒ object in equilibrium

$a = 0\ m/s^2$

Objects at Rest ($v = 0$ m/s) → Stay at Rest

Objects in Motion ($v \neq 0$ m/s) = constant velocity → Stay in Motion (same speed & dir'n)

$\equiv$

$\Sigma \vec{F} \neq 0N$

Forces are Unbalanced

There is an acceleration $a \neq 0\ m/s^2$

The acceleration depends directly upon the "net force"

The acceleration depends inversely upon the object's mass.

Example 1. Determine the accelerations that result when a 12-N net force is applied to a 3-kg (m_1) object and then to a 6-kg (m_2) object.

$$a_1 = \frac{F_{net}}{m_1} = \frac{12}{3} = 4\ m/s^2$$

$$a_2 = \frac{F_{net}}{m_2} = \frac{12}{6} = 2\ m/s^2$$

⇒ twice the mass, half the acceleration

Example 2. A net force of 15 N is exerted on an encyclopedia to cause it to accelerate at a rate of 5 m/s². Determine the mass of the encyclopedia.

F_{net} → a

$$F_{net} = ma \Rightarrow m = \frac{F_{net}}{a} = \frac{15}{5} = 3\ kg$$

$a = \frac{F_{net}}{m}$

$2 = \frac{F_{net_1}}{m_1}$ ← Before a

Example 3. Suppose that a sled is accelerating at a rate of 2 m/s². If the net force is tripled and the mass is doubled, then what is the new acceleration of the sled?

After → $a = \frac{3F_{net_1}}{2m_1} \Rightarrow a = \frac{3}{2} \cdot \frac{F_{net_1}}{m_1} = \frac{3}{2} \cdot \frac{2}{1} = 3 \text{ m/s}^2$

Example 4. Suppose that a sled is accelerating at a rate of 2 m/s². If the net force is tripled and the mass is halved, then what is the new acceleration of the sled? a

After: → $a = \frac{3F_{net_1}}{\frac{1}{2}m_1} \Rightarrow a = \frac{3}{0.5} \cdot \frac{F_{net_1}}{m_1} = (6)(a) = 12 \text{ m/s}^2$

Example 5. The direction of the net force is in the same direction as the acceleration. Thus, if the direction of the acceleration is known, then the direction of the net force is also known. Consider the two oil drop diagrams below for an acceleration of a car. From the diagram, determine the direction of the net force that is acting upon the car.

A: ····· →

B: · · · · · · · · · · ←

In conclusion, Newton's second law provides the explanation for the behavior of objects upon which the forces do not balance. The law states that unbalanced forces cause objects to accelerate with an acceleration that is directly proportional to the net force and inversely proportional to the mass.

6-8

Textbook: p. 93 #~~13~~, p. 97 #15-18 p. 101 #21, 23, 25, 26 Bonus for marks: p 100 Challenge Problem