Chapter 5 - Newton's Laws (Page 152)

Isaac Newton

(1642-1727)

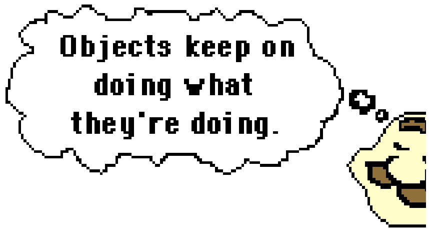
Frames of Reference

1. inertial -> frame of reference in which Newton's laws are valid
   -> frame of reference is at rest or has uniform motion

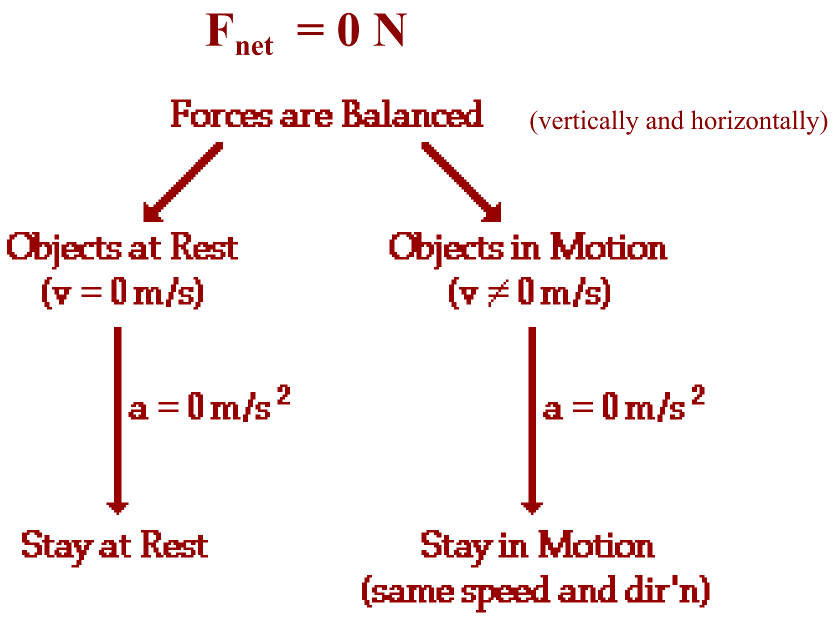
2. non-inertial -> frame of reference in which Newton's laws are not valid
   -> frame of reference is accelerating uniformly

Newton's First Law of Motion (The Law of Inertia)

An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.



The two parts of this law are summarized in the following diagram.



Newton's Second Law of Motion Pg 160

Newton's second law can be formally stated as:

The acceleration of an object produced by a net force is:

- directly proportional to the magnitude of the net force

$$a \propto F_{net}$$

$\propto$ -> proportional to

- inversely proportional to the mass of the object

$$a \propto \frac{1}{m}$$

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

$$\boxed{\vec{F}_{net} = m\vec{a}}$$

← Starting point for force problems involving acceleration.

$\vec{F}_{net}$ -> net force (N)
m -> mass (kg)
$\vec{a}$ -> acceleration (m/s^2)

Remember: The acceleration of an object has the same direction as the net force acting on the object.

Sample Problems

An object is accelerating at 2.0 m/s^2 east.

1. If the net force is tripled, what is the object's new acceleration?

$a = \frac{F}{m}$, if F×3 then a×3

So $a = 6.0$ m/s^2

2. If the net force is halved, what is the object's new acceleration?

F÷2 so a÷2

$a = 1.0$ m/s^2

3. If the net force is tripled and the mass is quadrupled, what is the object's new acceleration?

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

$\frac{F \times 3}{m \times 4}$ so $a \times \frac{3}{4}$

$a = 1.5$ m/s^2

What is the acceleration of a 12 kg cart under a constant force of 88 N?

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

$a = \frac{88 N}{12 Kg}$

$a = 7.3 m/s^2$

A force of 1200 N accelerates an object at 21 m/s^2. What is the mass of the object?

$F = ma$

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

$m = \frac{1200 N}{21 m/s^2} = 57 Kg$

What average force is required to accelerate a 33 kg mass at 4.6 m/s^2?

$F = ma$

$F_{avg} = (33 Kg)(4.6 m/s^2)$

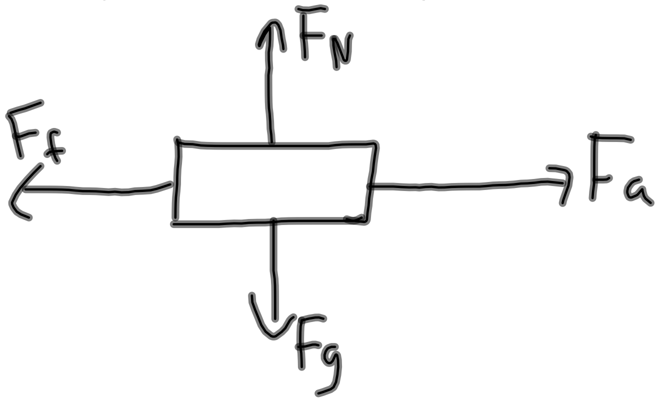
$F_{avg} = 152 N$

An applied force of 50 N is used to accelerate an object to the right across a frictional surface. The object encounters 10 N of friction. The weight of the object is 80 N.

(a) Calculate the objects mass. (8.2 kg)

(b) Calculate the net force. (40 N to the right)

(c) Calculate the object's acceleration. (4.9 m/s^2 to the right)



(a) $F_g = 80\ N = mg$

$80 = m(9.81)$

$m = 8.2\ kg$

(b) $F_{net} = F_a + F_f$

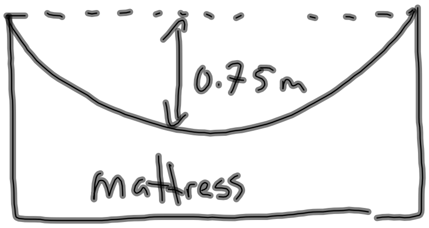
$F_{net} = 50 - 10$

$F_{net} = 40\ N$

(c) $F = ma$

$a = \frac{F}{m} = \frac{40}{8.2} = 4.9\ m/s^2$

A 2.5 kg object falls on an air mattress. Just as it hit it was traveling 19 m/s. The air mattress depressed 0.75 m before coming to a stop. What was the average force stopping the object?



Choose coordinate system up ↑ +, down ↓ −

Known variables:

$m = 2.5\ kg$

$v_0 = -19\ m/s$ (downward)

$v_f = 0\ m/s$ (stopped)

$d = -0.75\ m$ (downward)

$g = -9.81\ m/s^2$

Want:

$F_{avg} = ?$

$F_{avg} = ma$

Calculate "a" first

*check motion formulas: $v_f^2 = v_0^2 + 2a\vec{d}$

Solving for acceleration:

$(0)^2 = (-19)^2 + 2a(-0.75)$

$0 = 361 - 1.5a$

$-361 = -1.5a$

$241\ m/s^2 = a$

extreme acceleration, person probably died :(

↑ positive answer (directed upwards)

$F_{avg} = ma$

$F_{avg} = (2.5)(241)$

$F_{avg} = 603\ N$

positive (upwards)

Newton's Third Law of Motion

"For every action there is an equal and opposite reaction ."

"Forces come in equal and opposite reaction pairs ."

If object A exerts a force on object B, then object B will exert an equal but opposite force on object A.

Examples

If I push down on the Earth, the Earth pushes up on me.

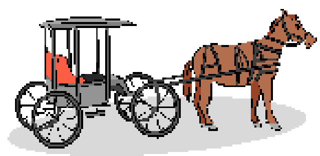
If a hockey stick applies a force to the puck, the puck applies the same amount of force back on the stick.

One of the most important conceptual questions of physics is:

"***If each action force causes an equal but opposite reaction force, then how can anything ever accelerate***?"

Horse and Cart Scenario

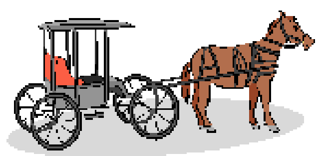
force of cart on horse ← → force of horse on cart



Each force acts on a different body.
The forces don't cancel each other.

a-r pair

force of cart on horse ← → force of horse on cart



force of ground on horse → ← force of horse on ground

a-r pair