Newton's Second Law of Motion

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

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

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

$F_{net} = ma$

$$\boxed{\vec{F}_{net} = m\vec{a}}$$ ← 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 x3 then a x3

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?

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

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

$a = 7.3\ m/s^2$

$F = ma$

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?

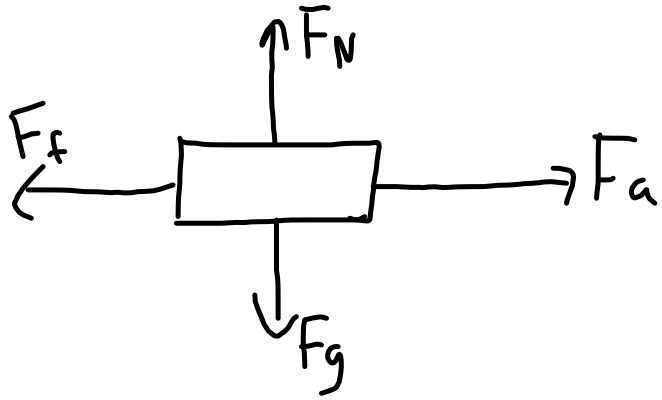
$F = ma$

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

$F_{avg} = 152\,N$

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) $F_{net} = F_a + F_f$

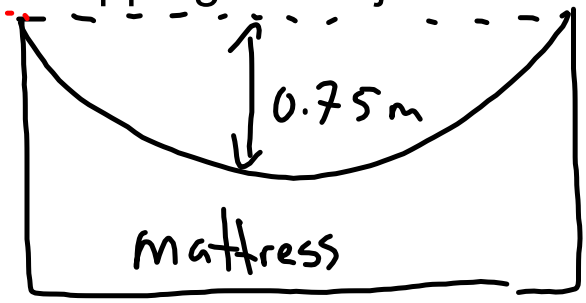
$F_{net} = 50 - 10$ ← opposite motion

$F_{net} = 40\,N$

(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?



$m = 2.5\,kg$

$v_o = -19\,m/s$

$d_f = -0.75\,m$

$d_o = 0.0\,m$

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

$v_f = 0.0\,m/s$

+ ↑ coordinate system ↓ −

$F_{net} = ?$

$F_{net} = ma$ ← Calculate

$$v_f^2 = v_o^2 + 2\vec{a}(\vec{d}_f - \vec{d}_o)$$

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

$$0 = 361 - 1.5a$$

$$-361 = -1.5a$$

$$\frac{-361}{-1.5} = \vec{a}$$

$$241\,m/s^2 = \vec{a}$$

$$F_{net} = ma$$

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

$$F_{net} = 602\,N$$