Newton's Laws

1. What net force is required to bring a 1500-kg car to rest from a speed of 100 km/h over a distance of 55 m?

v_o = 100 km/h = 28 m/s

v_f = 0

d = 55 m

1. The acceleration (a) which we assume to be constant

$v_f^2 = v_o^2 + 2a(x - x_o)$ **a =** $\frac{v^2 - v_o^2}{2(x - x_o)} = \frac{0 - (28m/s)^2}{2(55m)} = 7.1m/s^2$

2. The net force required $\Sigma F = ma = (1500\ \text{kg})(-7.1\ \text{m/s}^2)$

$= -1.1 \times 10^4$ N

2. The combined mass of a motorcycle and the rider is 275 kg. The cycle is slowing at a constant rate of 4.5 m/s/s. What is the magnitude of the net force on the bike?

m = 275kg

$F_{net} = ma = 275 \times 4.5 = 1237.5$ N

$a = -4.5\ \text{m/s}^2$

F_{net} = ?

3. A 1500-kg car is moving with an initial velocity of 20 m/s and comes to a stop in 5 seconds. What is the size of the net force acting on the car?

m = 1500 Kg

F_{net} = ma ⟶ need "a" first

a = ?

V_i = 20m/s

$a = \frac{v_f - v_i}{t}$

V_f = 0m/s

$F_{net} = (1500\ \text{Kg}) \times (-4\ /\text{s}^2)$ ⟵ a = -4 m/s2

t = 5 s

F_{net}= ?

$F_{net} = -6000\ \text{Kg m/s}^2$ ⟶ -6.00×10^3 N

The negative sign of the answer indicates that the force is directed in the opposite direction of the motion of the car.

4. A shot-putter exerts a net force of 140N on a shot. What is the mass of the shot if the shot accelerates at 19 m/s^2?

F_{net} = 140N

$a = 19 m/s^2$

m = ?

F_{net} = ma

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

$m = \frac{140\ (kg)(m/s2)}{19m/s2}$ = 7.37 kg

5. A pickup truck is accelerating from rest at a rate of 4 m/s^2.

a. If the mass of the empty pickup truck is 1200 kg, what is the magnitude of the net force acting on the pickup truck when it is accelerating?

$$\vec{F} = m \cdot \vec{a} = (1200\ kg) \times \left(4\ {}^{m}/_{s^2}\right) = 4800\ {}^{kg \cdot m}/_{s^2} = 4800\ N$$

b. If the pickup truck is carrying a load of bricks with mass 400 kg, what will be its acceleration?

$$Mass_{Tot} = 1200\ kg + 400\ kg = 1600\ kg$$

$$\vec{a} = \frac{\vec{F}}{m} = \frac{4800\ N}{1600\ kg} = \frac{4800\ {}^{kg \cdot m}/_{s^2}}{1600\ kg} = 3\ {}^{m}/_{s^2}$$

c. What is the net force acting on the truck if it is being driven along a straight road at a constant speed of 20 $^{m}/_{s}$?

If an object is moving with a constant speed in a straight line, the velocity is constant and therefore the acceleration is 0 $^{m}/s^2$. The net force acting on the truck must also be 0 N by Newton's first law.

6. A cliff diver of mass 65 kg jumps off a cliff 45 m high (v_o = 0 $^{m}/_{s}$) and falls freely (g = 10 m/s^2). He hits the surface of the water and stops 5.0 m below the surface.

a. What is the magnitude of the net force acting on the diver when he is in free fall?

$$\vec{F}_{net} = m \cdot \vec{a} = (65\ kg) \times \left(10\ {}^{m}/_{s^2}\right) = 650\ {}^{kg \cdot m}/_{s^2} = 650\ N$$

b. What is the velocity with which the diver hits the water?

$$v_f^{\ 2} - v_o^{\ 2} = 2\,a \cdot \Delta x$$

$$v_f^{\ 2} - \left(0\ {}^{m}/_{s}\right)^2 = 2\left(-10\ {}^{m}/_{s^2}\right) \cdot (-45\ m) = 900\ {}^{m^2}/_{s^2}$$

$$v_f = \sqrt{900\ {}^{m^2}/_{s^2}} = 30\ {}^{m}/_{s}$$

c. What is the acceleration and net force acting on the diver under water?

$$v_f^2 - v_o^2 = 2a \cdot \Delta x$$

$$\left(0\ {}^{m}\!/_{s}\right)^2 - \left(30\ {}^{m}\!/_{s}\right)^2 = 2(a)\cdot(-5\,m)$$

$$a = \frac{-900\ {}^{m^2}\!/_{s^2}}{-10\,m} = 90\ {}^{m}\!/_{s^2}$$

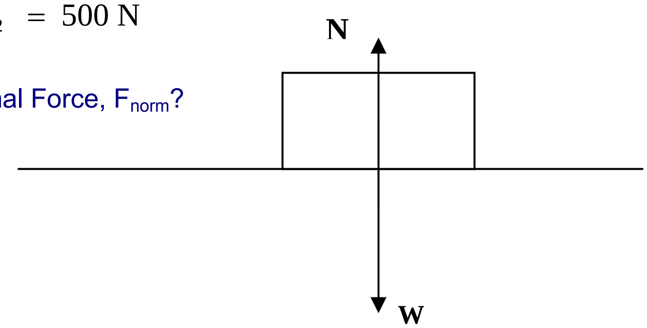
$$\vec{F}_{net} = m \cdot \vec{a} = (65\,kg)\cdot\left(90\ {}^{m}\!/_{s^2}\right) = 5850\ {}^{kg \cdot m}\!/_{s^2} = 5850\,N$$

7. A crate of mass 50 kg is at rest on a horizontal floor.

a. What is the magnitude of the net force acting on the crate?
$a = 0\ m/s^2$
$F_{net} = 0\ N$

b. What is the weight of the crate?

$$W = m \cdot g \quad 50\,kg \cdot 10\ {}^{m}\!/_{s^2} = 500\,N$$



c. What is the magnitude of the Normal Force, F_{norm}?

$F_{norm} – mg = 0\ N$
$F_{norm} = mg = 500\ N$

8. An elevator of mass 400 kg has an occupant of mass 100 kg and is suspended from a cable. The elevator is initially at rest ($g = 10\ m/s^2$).

a. What is the total mass of the elevator and occupant?

$M_{tot} = 400\ kg + 100\ kg = 500\ kg$

b. What is the total weight of the elevator and occupant?

$Wt_{tot} = M_{tot} \bullet g = (500\ kg) \bullet (10\ m/s^2) = 5000\ N$

c. What is the magnitude of the tension in the supporting cable?

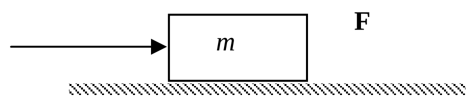
F_{net} = Tension - mg
0 N = T - 5000 N
T = 5000 N

d. If the elevator and occupant are accelerating upward at a rate of 2 m/s^2, determine the magnitude of the Net Force, the Weight, and the Tension in the supporting cable.

$F_{net} = M_{tot} \bullet a = (500\ kg) \bullet (2\ m/s^2) = 1000\ N$ Upward
$Wt_{tot} = M_{tot} \bullet g = (500\ kg) \bullet (10\ m/s^2) = 5000\ N$ Downward

F_{net} = Tension - Wt
1000 N = T - 5000 N
T = 6000 N

9. A 0.5-kg book is being pushed on a horizontal table. The force pushing the book is 6N and the frictional force between the book and the surface has magnitude f = 4N.



a. What is the weight of the book?

W = mg = (0.5)(9.8) = 4.9 N

b. What is the acceleration of the book?

Using Newton's second law, the net force acting on the book in the horizontal direction is

$F - F_{fr} = 6 - 4 = 2N$.

Since a = F/m,

$a = 4 m/s^2$.