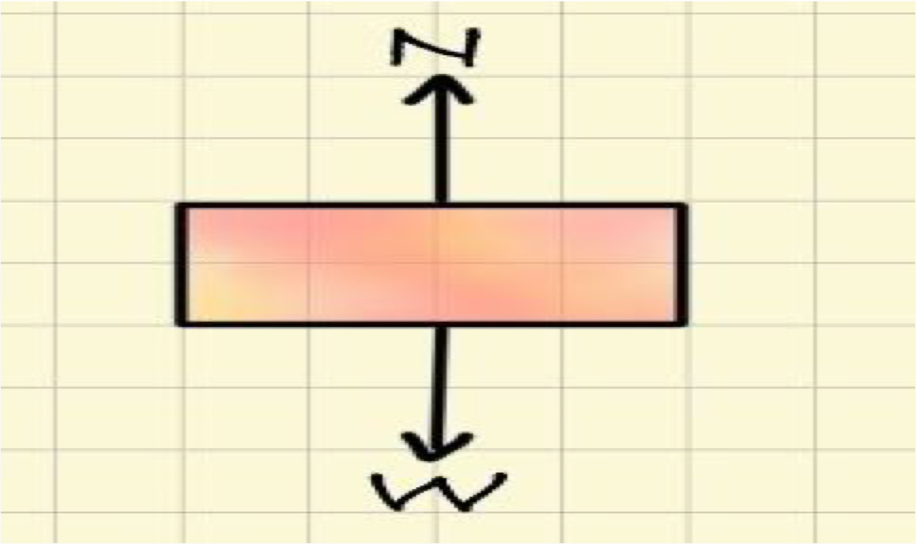
DONE BY :
BANDAR AL - SHWABKAH

Newton's laws of motion

- **Force** : any influence that cause the object to accelerate
- Newton's first law : an object at rest will remain at rest and an object in motion with constant velocity in a straight line will maintain that motion unless it experience a net external force
- Newton's second law : the acceleration of an object is directly proportional to the resultant force acting on it and inversely proportional to its mass $\Sigma\vec{f} = m\vec{a}$
- Newton's third law : to every action there is always an equal and opposite reaction $\vec{f}_{12} = \vec{f}_{21}$

- **Equilibrium** : an object is at equilibrium if the resulting forces on it are zero
- $\overrightarrow{\Sigma f} = 0$
- **Weight** : the force exerted by the earth on a body
- $\mathbf{W = mg\ ,\ g = 9.8\ m/s^2}$
- **Unit of force** : newton (N) , $1N = 1kg*m/s^2$
- **Example** : a woman has a mass of 60 kg , she is standing on a floor and remains at rest , find the normal force exerted on her by the floor ?

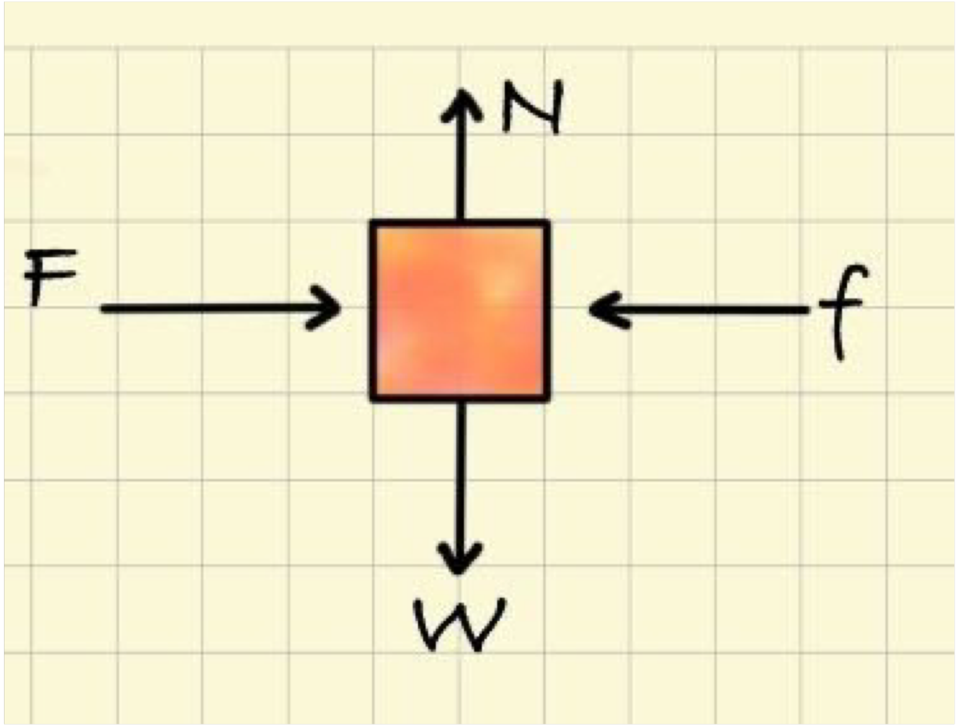


- **Solution** :
- **Equilibrium :**
- $\vec{N} + \vec{W} = 0$
- $\vec{N} = N\hat{K}$
- $\vec{W} = -W\hat{K}$
- $N = W = mg$
- $N = 60 * 9.8 = 588\ N$

- **Example** : an ice cream vendor exerts a force of 40N to overcome friction and push his cart at a constant velocity , the car has a mass of 150kg , find the forces acting on the cart ?

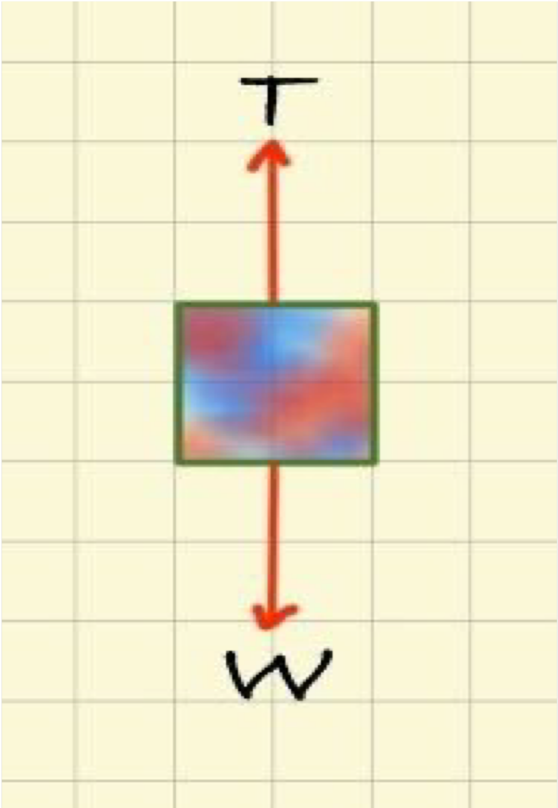
- **Solution** :

- The net forces are **zero**
- $\sum \vec{f}_i = \vec{F} + \vec{N} + \vec{f} + \vec{W} = 0$
- F = f = 40N
- N = W = mg = 150 * 9.8 = 1470N

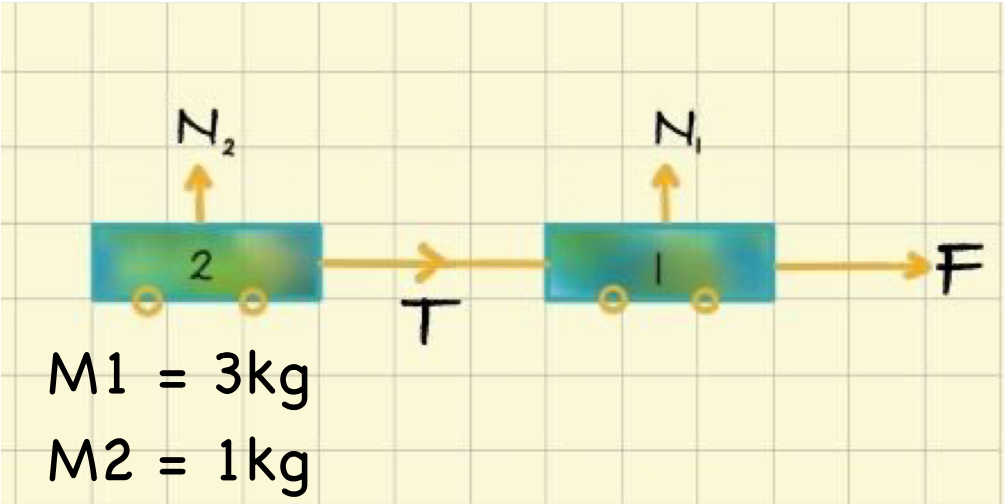


- **Example** : a child pushes a sled across a frozen pond with a horizontal force of 20N , assume friction is negligible .
- 1) if the sled accelerates at $0.5 m/s^2$, what is its mass ?
- 2) another child with a mass of 60kg sits on the sled , what acceleration will the same force produce now ?
- **Solution** :
- 1) $f = ma$
- $m = f/a = 20/0.5 = 40kg$
- 2) $a = f/(m_1 + m_2) = 20/(40+60) = 0.2\ m/s^2$

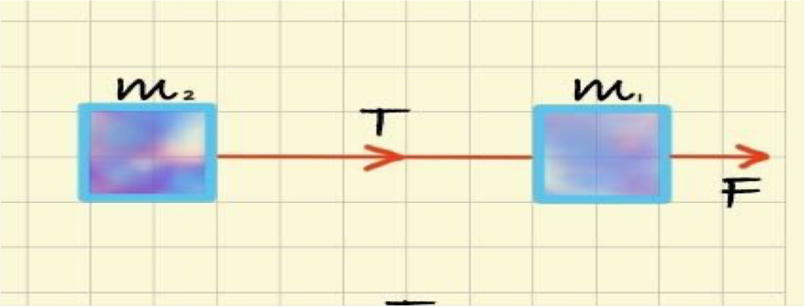
- **Example** : an elevator has a mass of 1000kg , find :
- 1) it accelerates upward at $3 m/s^2$, what is the force T exerts by the cable on the elevator ?
- 2) what is the force T if the acceleration is $3 m/s^2$ downward ?
- **Solution** :
- 1) $T - mg = ma$
- $T = mg + ma = m(g + a) = 1000 * (9.8 + 3) = 12800N$
- 2) $T - mg = -ma$
- $T = mg - ma = m(g - a) = 1000 * (9.8 - 3) = 6800N$



- **Example** : a child pulls a train of two cars with a horizontal force of 10N , if we neglect the mass of the string and friction :
- 1) find the normal forces exerted on each car by the floor
- 2) what is the acceleration of the train ?
- 3) what is the tension in the string ?

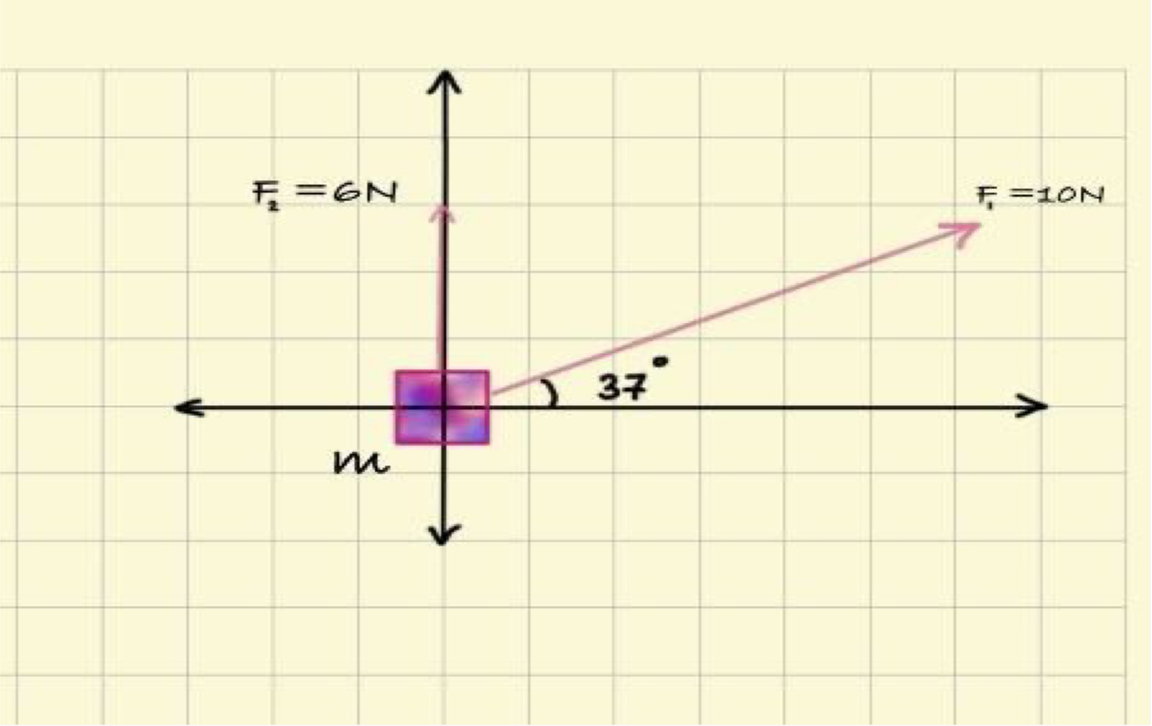


- **Solution** :
- 1)
- $N_1 = m_1 g = 3 * 9.8 = 29.4$ N
- $N_2 = m_2 g = 1 * 9.8 = 9.8$ N
- 2)
- $F = (m_1 + m_2) * a$
- $a = F/(m_1 + m_2) = 10/(3+1) = 10/4 = 2.5\ m/s^2$



- 3)
- $T = m_2 a = 2.5$ N

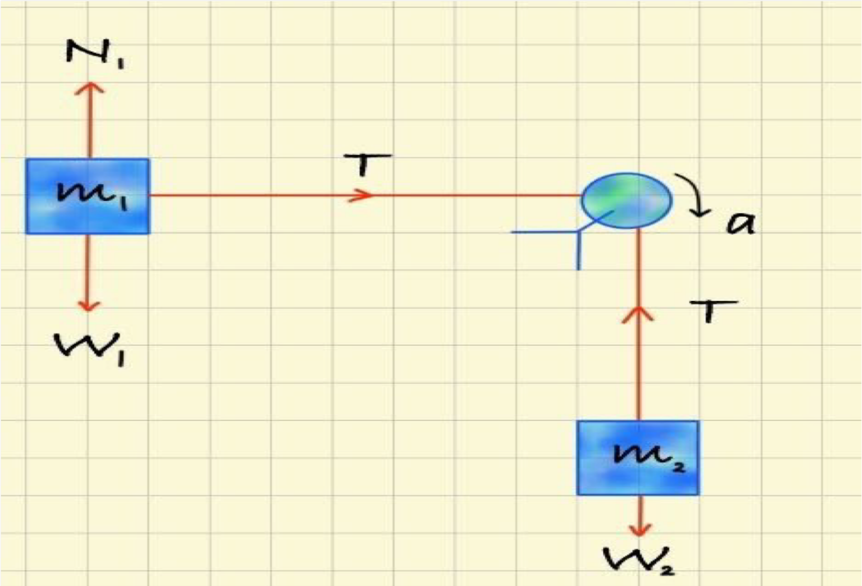
- **Example** : two forces F_1 and F_2 acting on an object of mass 2kg in the directions shown in the figure , find :
- 1) the acceleration of the object
- 2) the third force that causes the object to be in equilibrium



- **To be continued…..**

- **Solution** :
- 1)
- $\vec{\Sigma f} = m\vec{a}$
- $\Sigma f_x = ma_x$
- $(F_1 * \cos 37) + (f_2 * \cos 90) = ma_x$
- $10 * 0.8 + 0 = 2a_x$ ….. $a_x = 4\ m/s^2$
- $\Sigma f_y = ma_y$ …… $(F_1 * \sin 37) + (F_2 * \sin 90 = ma_y) = (10 * 0.6) + 6 = 2a_y$ ….. $A_y = 6 m/s^2$
- $A = \sqrt{a_x{}^2 + a_y{}^2} = \sqrt{16 + 36} = 7.2\ m/s^2$
- $\theta = \tan^{-1} a_y/a_x = \tan^{-1} 6/4 = 56.3^{\circ}$
- 2)
- $\vec{F_3} = -(\vec{F_1} + \vec{F_2})$, ***but*** $(\vec{F_1} + \vec{F_2}) = m\vec{a} = 2(4\hat{x} + 6\hat{y}) = 8\hat{x} + 12\hat{y}$
- $\vec{F_3} = -8\hat{x} - 12\hat{y}$
- $|\vec{F_3}| = \sqrt{(-8)^2 + (-12)^2} = 14.4\ N$

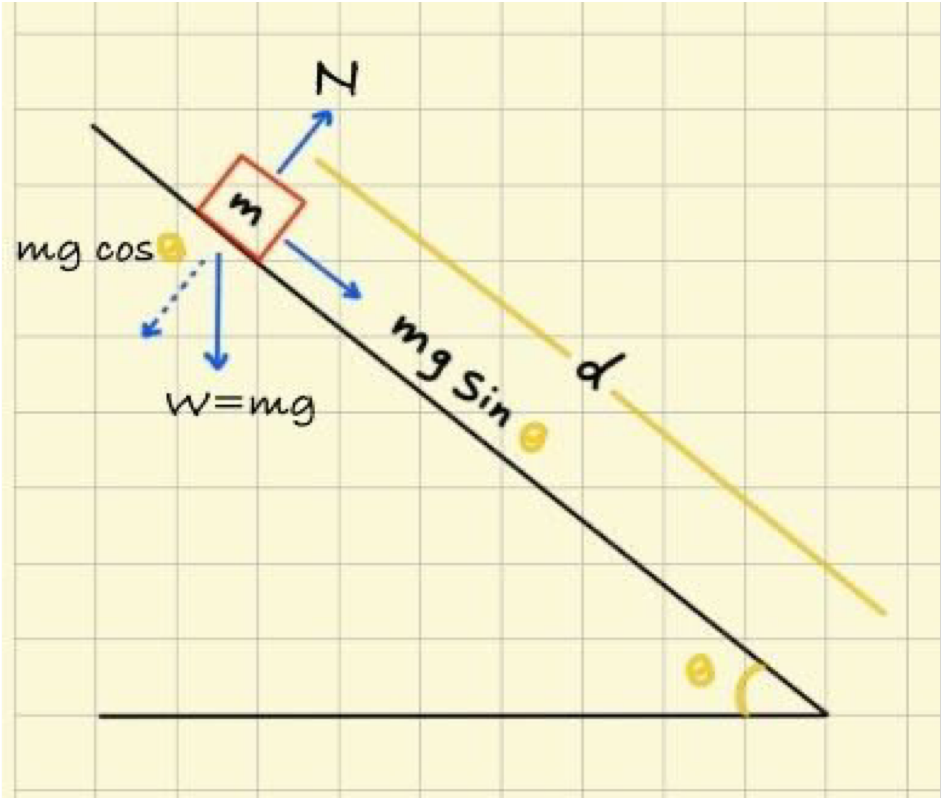
- **Example** : a block of mass $m_1 = 20kg$ is free to move on a horizontal surface , a rope : which passes over a pulley , attaches it to a hanging block of mass $m_2 = 10kg$ assuming for simplicity that the pulley and rope masses are negligible and that there is no friction , find :
- 1) the forces on the blocks
- 2) their acceleration
- 3) if the system is initially at rest , how far has it moved after 2s ?



- **to be continued …..**

- **Solution** :
- 1)
- $N_1 = m_1 g = 20 * 9.8 = 196\ N$
- $W_1 = N_1 = 196\ N$
- 2)
- *$T = m_1 a$ …….. (1)* *$T - W_2 = -m_2 a$ …… (2)*
- (1) – (2) :
- $W_2 = (m_1 + m_2) * a$
- $a = w_2/(m_1 + m_2) = m_2 g/(m_1 + m_2)$
- $a = 10*9.8/(20 + 10) = 3.27\ m/s^2$
- 3)
- $\Delta x = v_0 t + ½\ at^2$
- $= 0 + ½ * 3.7 * 2^2 = 6.54\ m$

- **Example** : a block of mass ***m*** is placed on a smooth inclined plane of angle ***θ*** and length ***d*** :
- 1) determine the acceleration of the block after its released
- 2) how long does it take the block to reach the bottom ?
- 3) what is the speed as it gets their ?



- **To be continued …..**

Solution :

1)

$\Sigma f_x = ma_x$

$mg * \sin\theta = ma_x$

$a_x = g * \sin\theta$

$\Sigma f_y = 0$

$N - (mg * \cos\theta) = 0$

2)

$\Delta x = d = v_{0x}t + (\frac{1}{2} a_x t^2)$

$d = 0 + (\frac{1}{2} g * \sin\theta * t^2)$

$t = \sqrt{2d/g*\sin\theta}$

3)

$V^2 = v_0^2 + 2a_x * \Delta x$

$= 0 + 2g*\sin0 * d$

$V = \sqrt{2d * g*\sin\theta}$