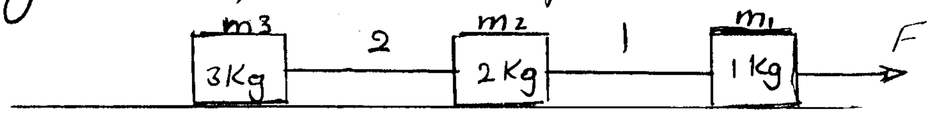
(1) Three blocks are connected, as shown in the figure, on a horizontal frictionless surface and pulled to the right with a force F. If the tension in string 1 is 10N, determine the force F (in N).



Solution:

If T on string 1 is 10N this means that the two blocks m_3 and m_2 have force acting on them equals 10N.

$$\Longrightarrow \quad T = (m_3 + m_2)\,a$$
$$T = (3 + 2)\,a$$
$$a = \frac{10}{5} = 2\ m/s^2$$

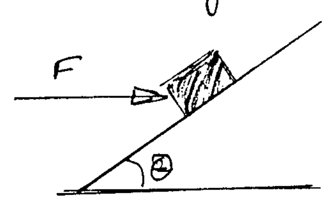
for the three blocks $F = (m_1 + m_2 + m_3)a$

But all block are accelerating with the same a

$$\therefore \quad F = (3+2+1)\,2 = 12\ N \quad //$$

---

(2) A block is pushed up a frictionless incline ($\theta = 30°$) by an applied horizontal force as shown in the figure. If $F = 30N$ and $m = 4kg$ what is the magnitude of the resulting acceleration (in m/s^2) of the block?



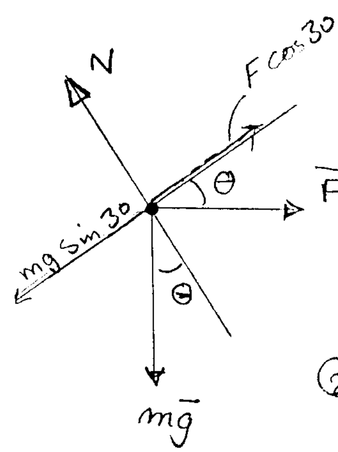
(1)

Solution: given: $F = 30N$, $m = 4\ kg$, $\theta = 30°$

Draw the free-body diagram shown (2)

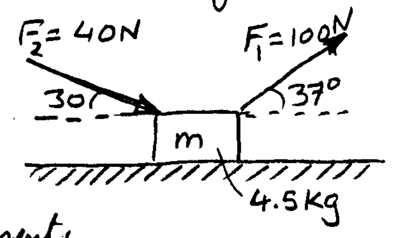
$$F_{net,x} = F\cos\theta - mg\sin\theta = ma$$
$$30\cos 30° - 4(10)\sin 30 = 4a$$
$$a = 1.49 \simeq 1.5\ m/s^2$$

\#

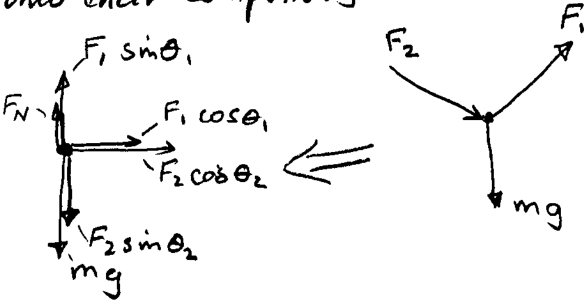


(2)

(3) from the figure determine the acceleration of the block if the surface is frictionless in (m/s^2).



Solution: draw the free-body diagram analysing force vectors into their components



we can see that the block will move horizontaly and not vertically.

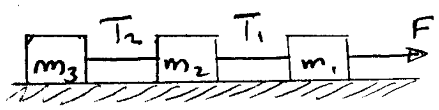
$\therefore$ $F_1 \cos 37 + F_2 \cos 30 = ma$

$$100 \cos 37 + 40 \cos 30 = ma$$

$$79.9 + 34.64 = ma$$

$$a = \frac{114.6}{4.5} \simeq 25 \quad \#$$

(4) From the shown figure $m_1 = 2\,kg$, $m_2 = 4\,kg$, $m_3 = 6\,kg$, $F = 60N$. The surface is smooth (frictionless). What is the net force acting on m_2 is (in N):



Solution:

Let us find the acceleration of all the system a because if one block is moving with a then all blocks are moving with the same a.

For m_1: $F - T_1 = m_1 a$

for m_2: $T_1 - T_2 = m_2 a$

for m_3: $T_2 = m_3 a$

we know that total mass $M = 2 + 4 + 6 = 12\,kg$.

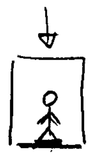
$$F = Ma \Rightarrow a = \frac{60}{12} = 5\,m/s$$

The net force acting on m_2 is

$$T_1 - T_2 = F_{net} = m_2 a = (4)(5) = 20N \quad \#$$

Just for your knowledge } $T_2 = m_3 a = (6)(5) = 30N \Rightarrow T_1 = 30 + 20 = 50N$

(5) A man of 800N stands on a spring scale (balance) in an elevator. The elevator started to accelerate down with acceleration $2 m/s^2$. Suddenly the cable of the elevator breaks. What would be the reading on the scale (in N)?



Solution: given weight = 800 N a (down) = $2 m/s^2$

$$w = m(g - g) = 0$$

---

(6) Two blocks A and B are pushed a horizontal force F = 24N on a horizontal frictionless surface. If $m_A = 4 Kg$ and $m_B = 8 Kg$ what is the net force on block B (in N)?

Solution: given $m_A = 4 kg$, $m_B = 8 kg$, $F = 24N$

let us find acceleration for all system

$$F_{net} = (m_A + m_B)a$$

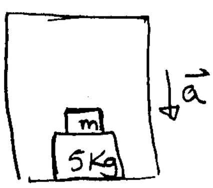
$$\Rightarrow a = \frac{24}{12} = 2 m/s^2$$

∴ net force on B is

$$F = m_B a = (8)(2) = 16 N \#$$

---

(7) A mass of 5 Kg sits on the floor of an elevator that has a downward acceleration of $1.0 m/s^2$. On the top of the 5 kg mass is an object of unknown mass m. The force of the elevator on the 5 Kg mass is 80N up. Determine the unknown mass (in Kg).



Solution:
$$N = M(g - a) \Rightarrow \text{where M is total weight}$$

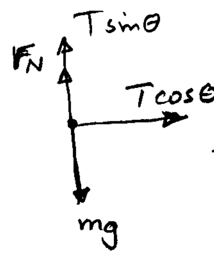
$$\Rightarrow M = \frac{80}{10-1} = 8.9$$

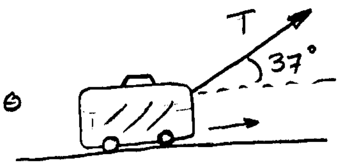
$$\Rightarrow m = 8.9 - 5 = 3.9 \text{ Kg}$$

(8) A string (cord) at an angle θ pulls on a suitcase (bag) on a smooth (frictionless) horizontal surface, as shown. The mass of the case is 20 Kg, $\theta = 37°$, and the acceleration is found to be $4\ m/s^2$. Find the normal force acting on the case. (Note: $\sin 37° = .6$, $\cos 37° = .8$, Hint: Find T first.

Solution:

free-body diagram:





$$F_{net} = ma$$

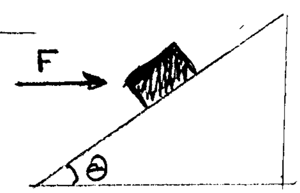
x-axis: $T\cos\theta = ma$

$$T = \frac{ma}{\cos\theta} = \frac{20(4)}{.8} = 100\ N$$

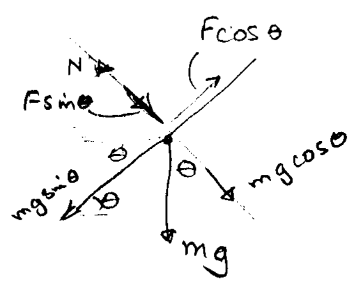
$$F_N = mg - T\sin\theta = 20(10) - 100(.6) = 140\ N$$

---

(9) A block of mass m, on a smooth incline of angle θ, is help at equilibrium by a horizontal force of magnitude F, as shown. Express this F as an equation.



Solution:



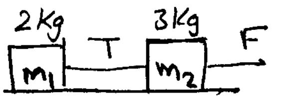
We know that the system is at equilibrium اتزان
this means that $F_{net} = $ zero.

∴ at the x-axis $F\cos\theta = mg\sin\theta$

$$F = mg\frac{\sin\theta}{\cos\theta} = mg\tan\theta$$

---

(10) Two masses m_1 and m_2 connected by a string are pulled on a horizontal, smooth plane by an external force F as shown. Let the tension $T = 8N$, $m_1 = 2kg$ and $m_2 = 3kg$. Find the force F.



Solution:

for $m_2 \rightarrow F - T = m_2 a$ ---- (1)

for $m_1 \rightarrow T = m_1 a$ ---- (2)

We can solve this problem into two methods :-

divide (1) by (2)

$$\frac{F-T}{T} = \frac{m_2 a}{m_1 a} = \frac{m_2}{m_1}$$

$$(F-T) = T\frac{m_2}{m_1}$$

$$F = T\frac{m_2}{m_1} + T$$

$$F = \frac{Tm_2}{m_1} + \frac{Tm_1}{m_1}$$

$$F = T\left(\frac{m_2+m_1}{m_1}\right)$$

$$= \frac{2+3}{2}(8)$$

$$= 20N$$ #

from (2) $a = \frac{T}{m_1}$

$\therefore F - T = m_2\left(\frac{T}{m_1}\right)$

$$F = m_2\frac{T}{m_1} + T$$

$$= \frac{m_2 T}{m_1} + \frac{Tm_1}{m_1}$$

$$= T\left(\frac{m_2+m_1}{m_1}\right)$$

$$= 20\ N$$ #

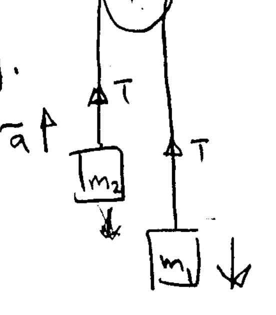
also $a = \frac{T}{m_1} = \frac{8}{2} = 4\ m/s^2$

$F = m_2 a + T = 3(4) + 8$

$= 20\ N$ #

---

(11) In the figure shown (Atwood machine), if $m_1 = .6kg$ and $m_2 = .4\ Kg$, What is the magnitude of the acceleration of the system? frictionless and massless pulley.



Solution:

We can see that $m_1 > m_2$ $\therefore \vec{a}$ is downword as shown

for m_1 $\quad m_1 g - T = m_1 a$ ---- (1)

for m_2 $\quad T - m_2 g = m_2 a$ ---- (2)

from (1) $\quad T = m_1 g - m_1 a$

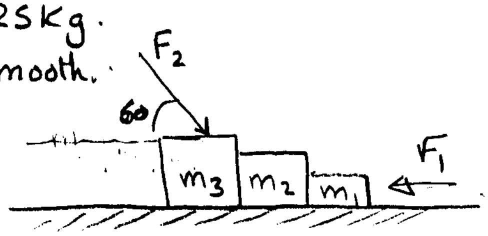
substitude in (2) $\quad (m_1 g - m_1 a) - m_2 g = m_2 a$

$\Rightarrow m_1 g - m_2 g = m_1 a + m_2 a$

$g(m_1 - m_2) = a(m_1 + m_2)$

$$a = g\left(\frac{m_1 - m_2}{m_1 + m_2}\right) = 10\left(\frac{0.2}{1}\right) = 2\ m/s^2$$ #

(11) In the figure $m_1 = 5$ kg, $m_2 = 15$ kg, $m_3 = 25$ kg. Also $F_1 = 50$ N and $F_2 = 280$ N. The surface is smooth. Find the net force acting on m_3.
Hint: First find the acceleration a.



Solution:

from forces on x-axis → $F_2 \cos 60 = 140$ N ⇒ 140 N > F_1

therefore $\vec{a}$ will be in the direction opposite to F_1

$\therefore \quad F_2 \cos 60 - F_1 = Ma$ where M is total mass

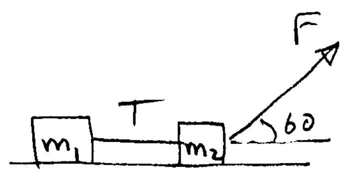
$$140 - 50 = (m_1 + m_2 + m_3)a$$

$$a = \frac{90}{45} = 2 \text{ m/s}^2$$

$\therefore$ force on m_3 is $m_3 a = (25)(2) = 50$ N #

---

(12) Two blocks m_1 and m_2 are connected by a light cord and pulled along a frictionless surface by a force F as shown in the figure. If $m_1 = 10$ kg, $m_2 = 40$ kg and $F = 100$N, find the tension (in N) in the connecting cord.



Solution

$$F \cos\theta - T = m_2 a \quad \text{---- (1)}$$

$$T = m_1 a \quad \text{---- (2)}$$

from (1) and (2) $\quad F\cos\theta - m_1 a = m_2 a$

$$F\cos\theta = m_1 a + m_2 a$$

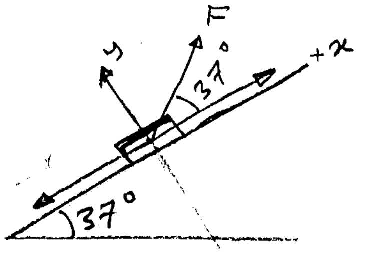
$$F\cos\theta = a(m_1 + m_2)$$

$$a = \frac{F\cos\theta}{m_1 + m_2} = \frac{100(.5)}{10+40} = 1 \text{ m/s}^2$$

from (2) $\quad T = m_1 a = 10(1) = 10$ N #

(14) A force of magnitude $F = 100N$ pulls a 20 Kg block along a frictionless plane that makes an angle $\theta = 37°$ with the horizontal. The acceleration of the block (shown in Fig.) is:

(a) $2\ m/s^2$ **(b) $-2\ m/s^2$** (c) $10\ m/s^2$ (d) $-10\ m/s^2$



Solution

$$F_{net,x} = m a_x$$

$$F\cos 37° - mg\sin 37° = ma \quad --- ①$$

$$F_{net,y} = m a_y$$

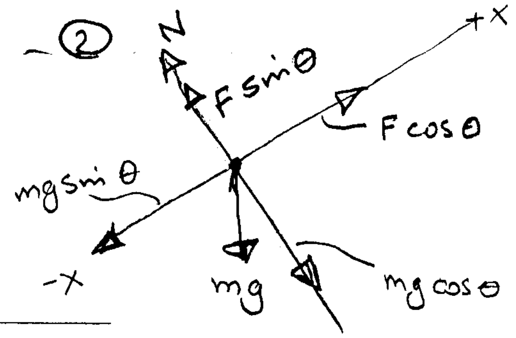
$$N + F\sin 37° - mg\cos 37° = 0 \quad --- ②$$

from equation ①

$$a = \frac{F\cos 37 - mg\sin 37°}{m}$$

$$= \frac{100(.8) - 20(10)(.6)}{20}$$

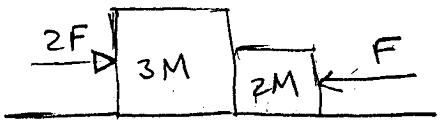
$$= -2\ m/s^2 \quad \#$$



(15) Two objects of masses 2M and 3M slide on a frictionless surface under the effect of two forces F and 2F as shown in Fig. If $F = 60N$ and $M = 1Kg$, the magnitude of the force exerted on the large block by the small block is:

(a) 12 N (b) 120 N (c) 228 N **(d) 84N** (e) other

Solution:



- Consider that the two block are one single block of Mass $= M_t = 3M + 2M = 5M$

$\therefore F_{net} = M_t$

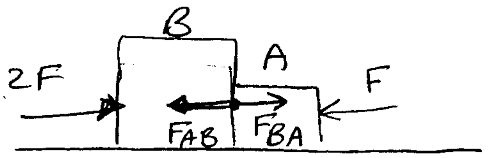
$\therefore 2F - F = 5Ma \quad ---- ①$

- Net Forces acting on the small block

$F_{BA} - F = 2Ma \quad ------ ②$

- Net forces acting on the Large block

$2F - F_{AB} = 3Ma \quad ----- ③$



from equation ① $F = 5Ma \Rightarrow a = \frac{F}{M} = \frac{60}{5} = 12\ m/s^2$

$\therefore$ this acceleration is for both blocks.

using equation ③

$$2F - F_{AB} = 3Ma \Longrightarrow (120) - F_{AB} = (3)(1)(12)$$

$$F_{AB} = 84N$$

another method

$2F - P = 3Ma$

$P - F = 2Ma$ add the two equ.

$2F - F = 5Ma \Rightarrow a = \frac{60}{5} = 12\ m/s^2$

$P = F_{AB} = 2(1)(12) + 60 = 84N \quad \#$

(16) The true weight of a man is 1000N. If his weight while standing in a moving elevator is 800 N, then the elevator's acceleration is:
(a) 0 m/s^2 (b) $-2\ m/s^2$ (c) $2\ m/s^2$ (d) $9.2\ m/s^2$ (e) other

Solution

True weight means that $a=0$

and $1000 = mg \Rightarrow m = \frac{1000}{10} = 100\ kg$

. The elevator is moving with acceleration then

$$N' - mg = ma \Rightarrow N' = mg + ma$$

But $N' = 800N$ and $mg = 1000\ N$

so $800 = 1000 + (100)a$

$$\Rightarrow a = \frac{-200}{100} = -2\ m/s^2 \quad \#$$

---

(17) At an instant when a 4Kg object has an acceleration equal to $(5\hat{i} + 3\hat{j})\ m/s^2$, one of the two forces acting on the object is known to be $(12\hat{i} + 22\hat{j})$ N determine the magnitude of the other force acting on the object (in Newtons).
(a) 2 (b) 13 (c) 18 (d) 17 (e) 12.8 (f) others

Solution:

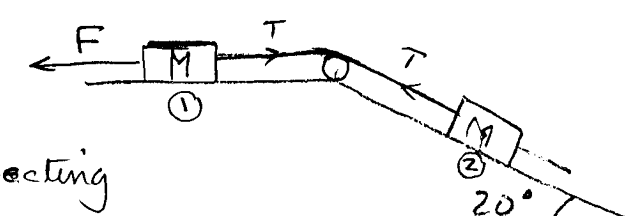
$$\Sigma F = \vec{F}_1 + \vec{F}_2 = m\vec{a}$$

$$\Sigma F_x = F_{1x} + F_{2x} = ma_x \Rightarrow 12 + F_{2x} = 4(5) \Rightarrow F_{2x} = 8N$$

$$\Sigma F_y = F_{1y} + F_{2y} = ma_y \Rightarrow 22 + F_{2y} = 4(3) \Rightarrow F_{2y} = -10N$$

$$\vec{F}_2 = 8\hat{i} - 10\hat{j} \Rightarrow F_2 = \sqrt{(8)^2 + (10)^2} = 12.8\ N \quad \#$$

(18) If F = 8N and M = 1.5Kg of two identical blocks.
What is the tension in the connecting string assuming all surfaces are frictionless?



Solution: for block ① $Ma = T - F$

for block ② $Ma = Mg\sin 20 - T$

if eqn ① = ② i.e $T - F = Mg\sin 20 - T$

$$\Rightarrow T = \frac{1}{2}[Mg\sin 20 + F]$$

$$= \frac{1}{2}[15\sin 20 + 8]$$

$$T = 6.57\ N \quad \#$$