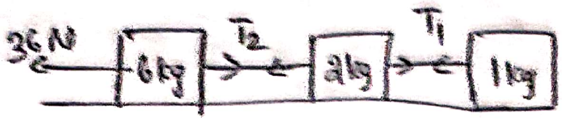
ws-10

connecting bodies

①, ②, ③



$F_{applied} = 36$ N. Total mass $= 6+2+1$

$= 9$ kg

Acceleration of the system $= \dfrac{F_{applied}}{\text{Total mass}} = \dfrac{36}{9} = 4\ m/s^2 \rightarrow A$

between 1 & 2 kg T_1 is contact force

Free body diagram for 1 kg

∴ Net force acting on 1 kg $= m_1 a$

$= 1 \times 4$

$\boxed{T_1 = 4\ N} \rightarrow C$

From Free body diagram for 6 kg

Net force acting on 6 kg is $36 - T_2 = m_3 a$

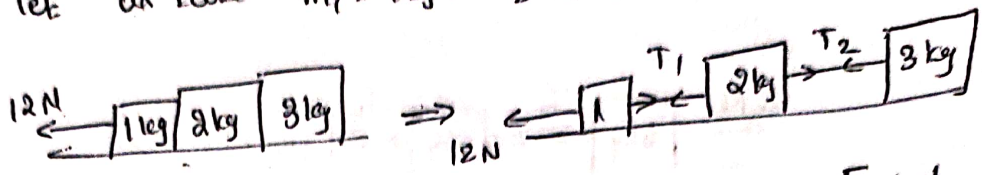
$\Rightarrow 36 - T_2 = 6 \times 4$

$\Rightarrow 36 - T_2 = 24$

$\Rightarrow T_2 = 36 - 24 = 12\ N \rightarrow B$

④, ⑤

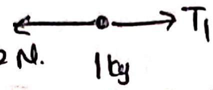
let us take $m_1 = 1kg$; $m_2 = 2kg$; $m_3 = 3 kg$



Acceleration of the system $a = \frac{F_{Total}}{\text{Total mass}}$

$$\Rightarrow a = \frac{12}{1+2+3} = \frac{12}{6} = 2\ m/s^2$$

let us take free body diagram for 1 kg.



Net force acting on 1 kg = $12 - T_1 = m_1 a$

$\Rightarrow 12 - T_1 = 1 \times 2.$

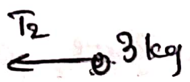
$\Rightarrow 12 - T_1 = 2$

$\Rightarrow \underline{T_1} = 12 - 2 = \underline{10\ N}$ in the $\to D$

contact force between 1 kg and 2 kg

Clearly from fig 'T_2' is the contact force between 2 kg & 3 kg.

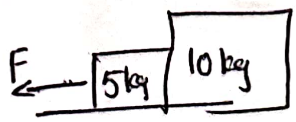
Take Free body diagram for 3 kg



Net force acting on 3 kg is $T_2 = m_3 a$.

$\Rightarrow \underline{T_2} = 3 \times 2 = \underline{6\ N} \to A$

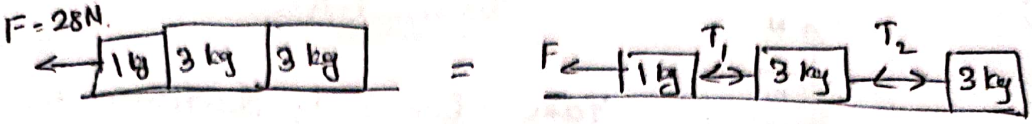
⑥



let $m_1 = 5kg$; $m_2 = 10 kg$ & $F = 45 N$.

$$\text{Acceleration} = \frac{F_{applied}}{\text{Total mass}} = \frac{45}{5+10} = \frac{\cancel{45}^{3}}{\cancel{15}} = 3\ m/s^2 \to B$$

(7)

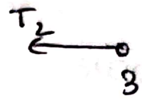


Acceleration of system $= \dfrac{F}{m_1+m_2+m_3}$

$$a = \frac{28}{1+3+3} = \frac{28}{7} = 4 \text{ m/s}^2$$

T_2 is contact force between 3 kg & 3 kg.

$\therefore$ Take free body diagram for 3 kg



Net force acting on 3 kg is $T_2 = m\,a$

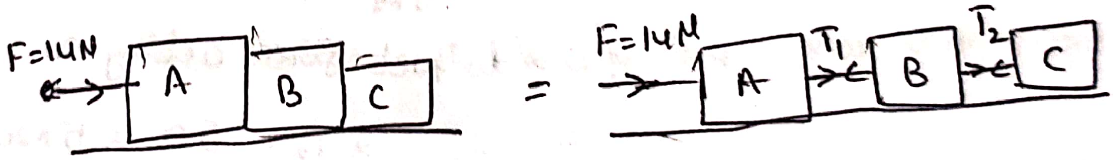
$= 3 \times 4$

$\underline{T_2 = 12\text{ N}} \rightarrow D$

(8)

let

$m_A = 4$ kg ; $m_B = 2$ kg ; $m_c = 1$ kg.

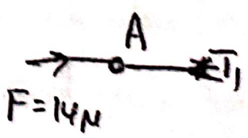


Total mass $M = m_A + m_B + m_c = 4+2+1 = 7$ kg

Acceleration $a = \dfrac{F}{M} = \dfrac{14}{7} = 2 \text{ m/s}^2$.

T_1 is the contact force between A and B.

Take free body diagram for A



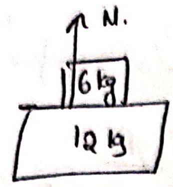
Net force on A $\Rightarrow$ $F - T_1 = m_A\,a$

$\Rightarrow 14 - T_1 = 4 \times 2$

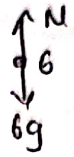
$\Rightarrow 14 - T_1 = 8$

$\Rightarrow T_1 = 14 - 8 = 6\text{ N} \rightarrow A$

(9)

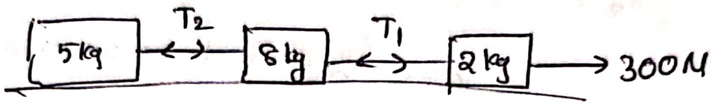


Take free body diagram for 6 kg



$\therefore N = 6g = 6 \times 10 = 60\,N$

(10)



Total mass $= 5 + 8 + 2 = 15$ kg

$F = 300\,N$. $\therefore$ Acceleration $a = \frac{F}{m} = \frac{300}{15}$

$\rightarrow a = 20\,m/s^2$.

T_2 is the tension in the string between 5 kg and 8 kg

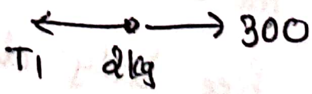
Take free body diagram for 5 kg

$\Rightarrow$ Net force acting on 5 kg is T_2

$\rightarrow \underline{T_2} = 5a = 5 \times 20 = \underline{100\,N}$

T_1 is the tension in the string between 2 kg and 8 kg.

Take free body diagram for 2 kg



$\rightarrow$ Net force acting on 2 kg is

$\rightarrow 300 - T_1 = 2a$

$\rightarrow 300 - T_1 = 2(20)$

$\rightarrow 300 - T_1 = 40$

$\rightarrow \underline{T_1} = 300 - 40 = \underline{260\,N}$

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Advanced

① The two bodies will exert an equal and opposite force on each other. that what says newton's third law.

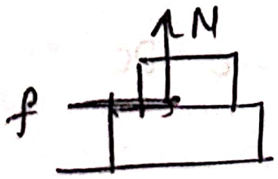
② Since the thrown three bodies are placed on smooth horizontal surface. so no friction is present.

m_1 & m_2 exerts an equal and opposite force (T_1) on each other. they cancel out

m_2 & m_3 also exert an equal and opposite (T_2) forces on each other, so they cancel out.

∴ only external force F is acting on three bodies, that's why they move with same acceleration

③ when two or more bodies kept in contact



Normal force is perpendicular to the contact surface and acts away from contact surface

friction is parallel to contact surface and acts in a direction opposite to the motion of a body

(4)

From diagram Total mass $= 10+20+30 = 60\,kg$

Given $T_3 = 60\,N$ is the external force acting on the system.

$\therefore$ Acceleration $a = \dfrac{\text{Total force [external]}}{\text{Total mass}}$

$\Rightarrow a = \dfrac{60}{60} = 1\,m/s^2$

Take Free body diagram for 10 kg

$$10\,kg \xrightarrow{T_1}$$

$\therefore$ Net force acting on 10 kg $= T_1$

$\Rightarrow T_1 = 10a = 10 \times 1 = \underline{10\,N}$

Take free body diagram for 20 kg

$$T_1 \longleftarrow \underset{20\,kg}{\bullet} \longrightarrow T_2$$

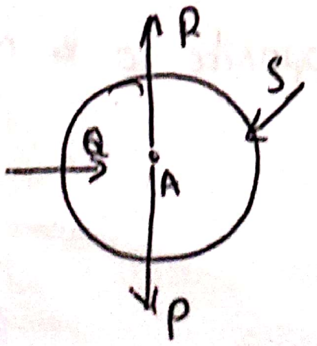
$\Rightarrow T_2 - T_1 = 20a$

$\Rightarrow T_2 - 10 = 20 \times 1$

$\Rightarrow T_2 - 10 = 20 \Rightarrow T_2 = 20 + 10 = 30\,N$

(5)

Take free body diagram for A



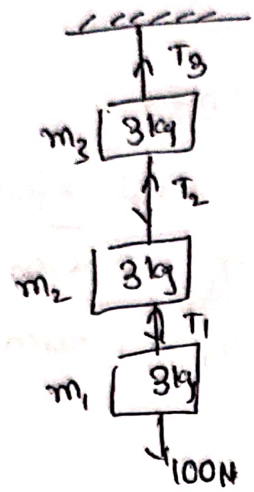
Q → Reaction or Normal force by wall

P → weight of A

R → Normal force by horizontal surface

S → Normal force by Ball B

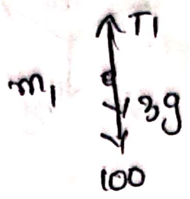
(6)



$m_1 = m_2 = m_3 = 3\ kg.$

Take free body diagram for m_1.

under equilibrium



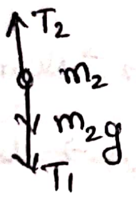
$\Rightarrow \quad T_1 = 3g + 100$

$= 30 + 100$

$\boxed{T_1 = 130\ N}$

Take free body diagram for m_2

under equilibrium



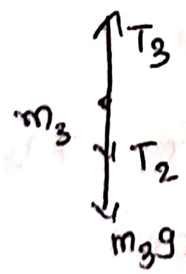
$\Rightarrow T_2 = T_1 + m_2 g \Rightarrow 130 + 3 \times 10$

$\Rightarrow T_2 = 130 + 30$

$\Rightarrow \boxed{T_2 = 160\ N}$

Take free body diagram for m_3.

under equilibrium



$\Rightarrow T_3 = T_2 + m_3 g$

$\Rightarrow 160 + 3 \times 10$

$\Rightarrow 160 + 30$

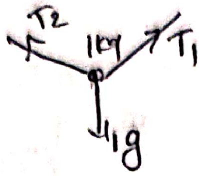
$\boxed{T_3 = 190\ N}$

L Task

CUQ's

(1)(2) (3)

(7) Take free body diagram

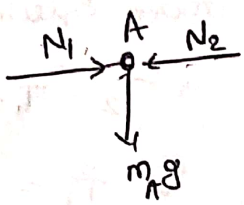


Total 3 forces → A

T_1 → Tension in Right string.

T_2 → Tension in left string

(8) Take free body diagram for A.



N_1 → Normal force by vertical line

N_2 → Normal force by B.

$m_A g$ → weight of A

Total forces 3 → A

~~Th~~ Jee main's level

(1), (2), (3)

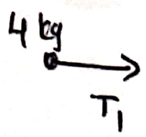
Total mass = 4 kg + 2 + 1 = 7 kg

External force = F = 28 N

acceleration of system $= \frac{F}{m} = \frac{28}{7} = 4\ m/s^2$

From fig T_1 is the contact force between 2 kg and 4 kg.

Take free body diagram for 4 kg



Net force on 4 kg body $= T_1$

$\Rightarrow T_1 = 4a$

$\Rightarrow T_1 = 4 \times 4 = 16N$

(1)(2) (3) continuation

From fig T_2 is the contact force between 2kg & 1kg

Take free body diagram for 1 kg

$T_2 \longleftarrow \underset{1kg}{\circ} \longrightarrow 28N$

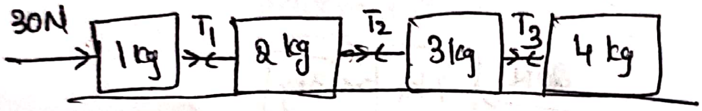
Net force on 1kg $= 28 - T_2$

$\Rightarrow 1 \times a = 28 - T_2$

$\Rightarrow 1 \times 4 = 28 - T_2 \Rightarrow T_2 = 28 - 4 = 24N$

(4), (5), (6)

we can make given arrangement like



Total mass $= 1+2+3+4 = 10$ kg

external force force $= 30N$.

Acceleration $= \frac{F}{m} = \frac{30}{10} = 3\ m/s^2$

T_1 is the contact force between 1 kg & 2 kg is

$\overset{30N}{\rightarrow} \underset{1kg}{\circ} \overset{T_1}{\rightarrow}$ Net force on $T_1 =$ ~~Fp~~ $30 - T_1$

$\Rightarrow 1 \times a = 30 - T_1$

$\Rightarrow 1 \times 3 = 30 - T_1$

$\Rightarrow T_1 = 30 - 3$

$\Rightarrow T_1 = 27N \rightarrow A$

T_3 contact force between 4 kg and 3 kg is

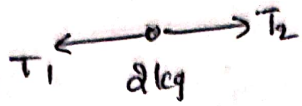
Take free body diagram for 4 kg

$\underset{4kg}{\circ} \longrightarrow T_3$ $\therefore T_3 = 4a$

$\Rightarrow T_3 = 4 \times 3 = 12N \rightarrow C.$

(5) T_2 is contact force between 2 kg and 3 kg

Take free body diagram for 2 kg



Net force on 2 kg $\Rightarrow T_1 - T_2$

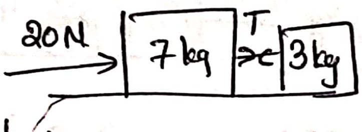
$\Rightarrow 2a = 27 - T_2$

$\Rightarrow 2 \times 3 = 27 - T_2$

$\rightarrow T_2 = 27 - 6 = 21\ N \rightarrow B$

(7)

we can make given arrangement like

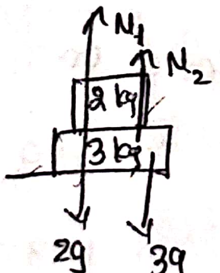


Total mass $= 7 + 3 = 10$ kg.

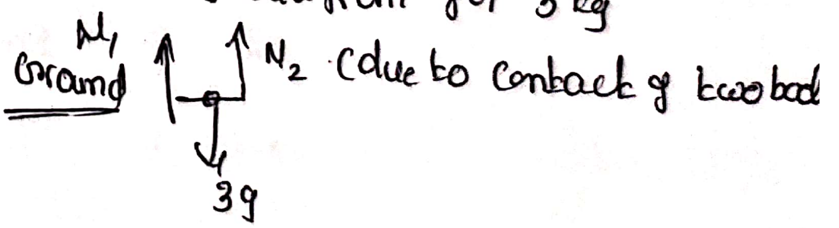
acceleration $a = \frac{20}{10} = 2\ m/s^2$

Net force on 3 kg $= T = 3a = 3 \times 2 = 6$ N.

(8)



Take free body diagram for 3 kg



$\therefore\ N_1 = N_2 + 3g \Rightarrow$ Total Normal force $= N_1 + N_2$

$N_1 = 3g;\ N_2 = 2g$

$= 3g + 2g$

$= 5g$

$= 50\ N$

9, 10

Total mass of the system = 20 kg + 80 kg
= 100 kg.

Force = 400 N.

Acceleration of system = $\frac{\text{Force}}{\text{mass}} = \frac{400}{100} = 4\ m/s^2$.
A

(?)

Take free body diagram for 'A'

$\xleftarrow{} T$
20kg

Tension $T = 20\,a$
$= 20 \times 4$
$= 80\ N$

Advanced

2, 5

Here contact force b/w m_1 and m_2 is equal and opposite so they cancel with each other.

Also between m_2 & m_3 the contact force is equal and opposite. so they cancel with each other.

$\therefore$ only applied force the force on all three bodies.

(3)

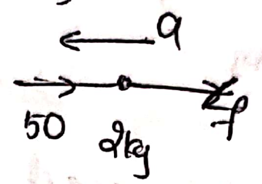
All the ~~three~~ bodies move with same acceleration and Tensions in the strings are different let $m_1 = 1\,kg$; $m_2 = 4\,kg$; $m_3 = 2\,kg$.

Net force acting on the system $= 120 - 50$
$= 70\,N$.

Acceleration $a = \dfrac{\text{Net force}}{\text{Total mass}} = \dfrac{70}{m_1 + m_2 + m_3}$

$a = \dfrac{70}{1+4+2} = \dfrac{70}{7} = 10\ m/s^2$

FBD for 2 kg

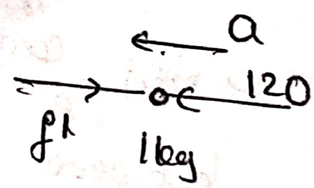


f is contact force bet 2 kg & 4 kg.

$\Rightarrow$ $2a = \cancel{50}\ f - 50$ $[f > 50]$

$\Rightarrow$ $2 \times 10 = f - 50 \Rightarrow f = 20 + 50 = \underline{70\,N}$

FBD for 1 kg



$120 > f'$

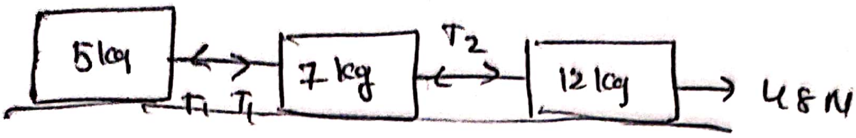
f' is contact force betwee 1 kg and 4 kg

$\Rightarrow$ $1 \times a = 120 - f'$

$\Rightarrow$ $10 = 120 - f'$

$\Rightarrow$ $f' = 120 - 10 = \underline{110\,N}$

7 7



Total force $= 48$ N.

Total mass $= 5 + 7 + 12 = 24$ kg

Acceleration $= \frac{\text{Force}}{\text{mass}} = \frac{48}{24} = 2\,m/s^2. \rightarrow c$

T_1 is the contact force between 5 kg and 7 kg.

Take free body diagram for 5 kg

$\underset{5kg}{o} \longrightarrow T_1 \quad \Rightarrow T_1 = 5a$

$T_1 = 5 \times 2 = \underline{10\ N}$

T_2 is the contact force between 12 kg and 7 kg.

Take FBD for 12 kg $T_2 \longleftarrow \underset{12}{o} \longrightarrow 48$

$\Rightarrow 12a = 48 - T_2$

$\Rightarrow 12 \times 2 = 48 - T_2$

$\Rightarrow 24 = 48 - T_2 \Rightarrow T_2 = 48 - 24 = \underline{24N} - c$

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