

Q5-18. Types of Friction at the foundation +
Track

Q

Given $m = 25 \text{ kg}$; $F = 122.5 \text{ N}$

Given the box just slides that

$$f = mg$$

$$\Rightarrow \mu mg = F$$

$$\Rightarrow \mu \times 25 \times 10 = 122.5$$

$$\Rightarrow \mu = \frac{122.5}{250} = 0.49 \approx 0.5$$

Q

Given initial velocity $u = 15 \text{ m/s}$; $v = 0$

distance $s = 25 \text{ m}$; $g = 10 \text{ m/s}^2$

From $v^2 - u^2 = 2as$ ($a = \mu g$)

$$\Rightarrow 0^2 - (15)^2 = 2 \mu g \times s$$

$$\Rightarrow \frac{15^2}{2 \times 5} = 2 \times \mu \times 10 \times 25$$

$$\Rightarrow \mu = \frac{9}{20} = 0.45 \approx 0.44$$

Q

Given $m = 12 \text{ kg}$; $\mu = 0.15$; $F = 5 \text{ N}$.

when a block placed on horizontal surface, the static frictional force $f = \mu mg = 0.15 \times 12 \times 10$

$$= 18 \text{ N}.$$



clearly frictional force > Applied force (5N)
so the block is at rest

$$\text{frictional force} = F_{\text{applied}} = 5N.$$

(4)

Given $\mu = 0.24$.

maximum acceleration $a = \mu g = 0.24 \times 10$
 $= 2.4 \text{ m/s}^2$

(5)

Given speed $u = 4.9 \text{ m/s}$; $\mu = 0.7$.

Final velocity $v = 0$.

From $v^2 - u^2 = 2as$

$$\Rightarrow (4.9)^2 - 0^2 = 2 \mu g s$$

$$\Rightarrow 4.9^2 \times 4.9 = 2 \times 0.7 \times 9.8 \times s$$

$$\Rightarrow 7 = 4s$$

$$\Rightarrow s = \frac{7}{4} = 1.75 \text{ m}$$

(6)

Given $m = 0.1 \text{ kg}$ $F_{\text{applied}} = 5N$; $\mu = 0.5$

magnitude of frictional force $= \mu mg$

$$= 0.5 \times 0.1 \times 10$$

$$\Rightarrow 0.5N$$

here frictional force < F_{applied}

so magnitude of frictional force = 5N.

7

Given $F_{app} = 1.2 \text{ kgf}$; $m = 1.5 \text{ kg}$; $\mu = 0.3$

magnitude of frictional force : μmg

$$= 0.3 \times 1.5 \times 9.8$$

$$= 4.4 \text{ N.}$$

$$F_{applied} = 1.2 \times 9.8 = 11.76 \text{ N}$$

$$\text{Net acceleration} = \frac{F_{app} - f}{m} = \frac{11.76 - 4.4}{1.5}$$

$$= 4.9 \text{ m/s}^2$$

8

Given initial velocity $u = 4 \text{ m/s}$; Final velocity $v = 0$

distance $s = 40 \text{ cm} = 40 \times 10^{-2} \text{ m} = 0.4 \text{ m}$

$$\text{From } v^2 - u^2 = 2as$$

$$\Rightarrow 0^2 - (4)^2 = 2 \mu \times g \times 0.4$$

$$\Rightarrow -16 \times 1 = 80 \mu$$

$$\Rightarrow \mu = \frac{-16 \times 1}{80}$$

$$\Rightarrow \mu = \frac{1}{2}$$

9

Given $v = 6 \text{ m/s}$; $\mu = 0.3$

acceleration $a = \mu g = 0.3 \times 9.8 = 3 \text{ m/s}^2$

$$\text{From } v^2 - u^2 = 2as$$

$$\Rightarrow (6)^2 - 0^2 = 2 \times 3 \times s$$

$$\Rightarrow 36 = 6s \Rightarrow s = 6 \text{ m}$$

(3)

(10)

Given $P = 0.98 \text{ kW}$; $m = 100 \text{ kg}$; $s = 4 \text{ m}$; $\mu = 0.3$

$$\text{Power} = \frac{W}{t} = \frac{F s}{t}$$

$$\Rightarrow 0.98 \times 10^3 = \frac{\mu m g s}{t}$$

$$\Rightarrow 980 = \frac{0.3 \times 100 \times 9.8 \times 4}{t}$$

$$\Rightarrow t = 0.3 \times 4 = 1.2 \text{ sec}$$

(16)

Given $m = 60 \text{ kg}$; $\mu_s = 0.5$; $\mu_k = 0.4$

$$\text{Acceleration } a = (\mu_s - \mu_k) g$$

$$= (0.5 - 0.4) \times 9.8$$

$$= 1 \text{ m/s}^2 \text{ or } 0.98 \text{ m/s}^2$$

(17)

$$\text{Total mass} = m_A + m_B = 2 + 3 = 5 \text{ kg} \quad \therefore \mu = 0.1$$

$$F_{\text{applied}} = 45 \text{ N} \quad ; \quad \text{frictional force} = (m_A + m_B) \mu g$$

$$= 5 \times 0.1 \times 10$$

$$\Rightarrow 5$$

$$\therefore \text{Net acceleration} = \frac{F_{\text{app}} - \text{frictional force}}{\text{mass}}$$

$$\Rightarrow \frac{45 - 5}{5} = 8 \text{ m/s}^2$$

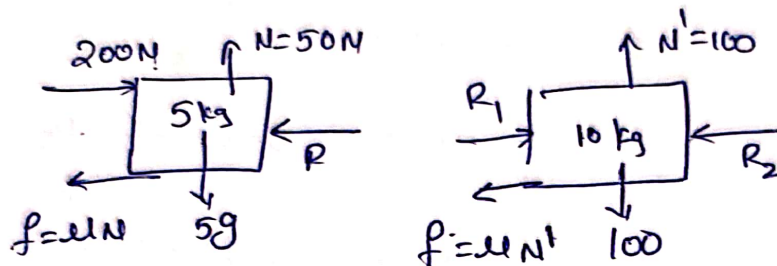


(18)

Given $m_A = 5 \text{ kg}$, $m_B = 10 \text{ kg}$, $\mu = 0.15$

Applied = 200 N

Free body diagram for A & B



$$\begin{aligned} R &= 200 - f \\ &= 200 - 0.15 \times 50 \\ &= 200 - 7.5 \\ &\Rightarrow 192.5 \text{ N} \end{aligned}$$

$$\begin{aligned} R_2 &= R_1 - f = R_1 - \mu N' \\ &= 192.5 - 0.15 \times 100 \\ &= 192.5 - 15 \\ &= 177.5 \text{ N} \end{aligned}$$

After removal of Partition, no reaction force is there

$$a = \frac{200 - f}{m_A + m_B} = \frac{200 - (m_A + m_B)g\mu}{m_A + m_B}$$

$$= \frac{200 - 15 \times 10 \times 0.15}{15} = \frac{200 - 22.5}{15} \approx 12 \text{ m/s}^2$$

If we take $g = 9.8 \text{ m/s}^2$ we will get 12.8 m/s^2

Task

(4)

Jee mains level

①

Given $m = 2 \text{ kg}$; $u = 6 \text{ m/s}$ $v = 0$; $t = 10 \text{ s}$

From $v = u + at$

$$\Rightarrow 0 = 6 - \mu g t$$

$$\Rightarrow 6 = 11 \times 10 \times 10$$

$$\mu = \frac{6}{100} = 0.06$$

$[a = -\mu g]$

Here 'a' is -ve because the body is in retardation

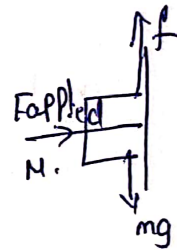
②

Given $F_{\text{applied}} = 10 \text{ N}$; $\mu = 0.2$.

Here the block is at rest

$$\therefore F_{\text{applied}} = N$$

$$\therefore f = \mu N \Rightarrow f = 0.2 \times F_{\text{applied}} = 0.2 \times 10 = 2 \text{ N}$$



③

Given $m = 1 \text{ kg}$ $a = 5 \text{ m/s}^2$; $\mu = 0.6$.

$$f = \mu mg$$

$$\Rightarrow 0.6 \times 1 \times 10$$

$$\Rightarrow 6 \text{ N}$$

$$\begin{aligned} F_{\text{pseudo}} &= ma \\ &= 1 \times 5 \\ &= 5 \text{ N} \end{aligned}$$

here frictional force $> F_{\text{pseudo}}$ so the body is in motion

$$\therefore f = 6 \text{ N}$$

④

Given $m = 10 \text{ kg}$; $\mu = 0.5$; $F = 100 \text{ N}$

frictional force $= \mu mg$

$$= 0.5 \times 10 \times 10 = 50 \text{ N}$$

$$\text{Net acceleration } a = \frac{F_{\text{app}} - f}{m} = \frac{100 - 50}{10}$$

$$= 5 \text{ m/s}^2$$

⑤

Given initial velocity $u = 20 \text{ m/s}$

$\mu = 0.5$ Final speed $v = 0$

and the car is in retardation so $a = -ve$

$$\text{From } v^2 - u^2 = 2as$$

$$a = \mu g$$

$$\Rightarrow 0^2 - 20^2 = -2a \times s$$

$$= 0.5 \times 10$$

$$\Rightarrow 5$$

$$\Rightarrow -400 = -2 \times 5 \times s$$

$$\Rightarrow s = 40 \text{ m}$$

⑥

Given $m = 60 \text{ kg}$; $S = 0.9 \text{ m}$; $\mu = 0.15$

work done against friction $= w = f s$

$$= \mu mg s$$

$$\Rightarrow 0.15 \times 60 \times 10 \times 0.9$$

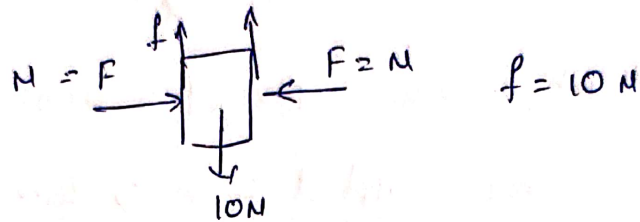
$$\Rightarrow \approx 80 \text{ J}$$



⑦

Given weight of box $= 10 \text{ N} = mg$

$$F_{\text{applied}} = 25 \text{ N}$$



$$\therefore \text{Frictional force} = \mu N \times 2$$

$$\mu f = \mu \times 25 \times 2$$

$$\Rightarrow 10 = \mu \times 25 \times 2$$

$$\mu = \frac{10}{2 \times 25} = \frac{5}{25} = \frac{1}{5} = 0.2$$

⑧

$$F_{\text{applied}} = 10 \text{ N}$$

$$\text{Pulling force } F = 5 \text{ N}$$

when 10 N applied on the body, then it starts moving
so the limiting friction is 10 N . As we apply 5 N force
which is less than the limiting friction. Therefore, the
force of friction that will come into play is equal to 5 N

⑨

$$\text{Here force of friction } f = mg$$

$$\mu N = mg$$

$$\therefore N = \frac{mg}{\mu} = \frac{60 \times 10}{0.5} = 1200 \text{ N}$$

(15)

Given $m = 4 \text{ kg}$; $F = kt$ [$k = 2 \text{ N/s}$] ; $t = 5 \text{ sec}$; $\mu = 0.2$

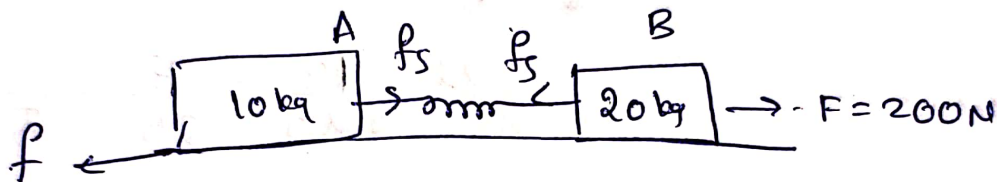
$$f_{\max} = \mu mg = 0.2 \times 4 \times 10 = 8 \text{ N}$$

At $t = 5 \text{ sec}$ $F = kt = 2(5) = 10 \text{ N}$

Since applied force $>$ force of friction

$\therefore$ the frictional force $= 8 \text{ N}$.

(16)



$$\mu = 0.1 \quad ; \quad a = 12 \text{ m/s}^2$$

For A :-

$$F_s - f = m_A a$$

$$\Rightarrow kx - \mu m_A g = 10(12)$$

$$\Rightarrow kx - 0.1 \times 10 \times 10 = 120$$

$$\Rightarrow kx = 130$$

For B :-

$$200 - kx - \mu m_B g = m_B a$$

$$\Rightarrow 200 - 130 - 0.1 \times 20 \times 10 = 20 a$$

$$\Rightarrow a = 2.5 \text{ m/s}^2$$

(17), (18), (19)

Given $M = 4 \text{ kg}$; $S = 20 \text{ m}$
 $m = 0.01 \text{ kg}$ $\mu = 0.25$

Force of friction $f = \mu_k N$

Since the system is on horizontal surface $N = (M+m)g$

$$\Rightarrow N = (4 + 0.01) \times 10 = 40.1 \text{ N} \approx 39.29 \text{ N}$$

$$\therefore f_k = \mu_k N = 0.25 \times 40.1 = 10.025 \text{ N} \approx 9.8 \text{ N}$$

$$\therefore a = \frac{f_k}{m+M} = \frac{10.025}{4.01} \approx 2.5 \text{ m/s}^2$$

For calculating speed $v^2 - u^2 = 2as$ [$a = -ve$
 $= -2.5 \text{ m/s}^2$]

$$\Rightarrow 0^2 - v^2 = -2 \times 2.5 \times 20$$

$$\Rightarrow v^2 = 100 \Rightarrow v = 10 \text{ m/s}$$

According to law of conservation of linear momentum

$$mu = (M+m)v$$

$$\Rightarrow 0.01 u = (4 + 0.01) \times 10$$

$$\Rightarrow u = 4010 \text{ m/s}$$