29/06/2016

Friction

Friction

Static friction (f_s)
(tendency of Motion)

kinetic friction (f_k)
(Motion)

$$0 \leq f_s \leq (f_s)_{max}$$

$$(f_s)_{max} = \mu_s N$$

μ_s — Coeff. of friction

N — Normal rxn

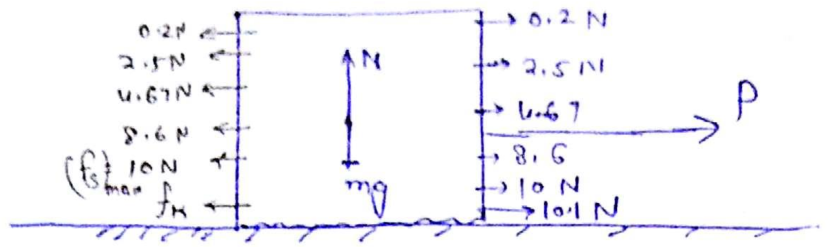
$$f_k = \mu_k N = \text{Const.}$$

μ_k — Coeff. of kinetic friction

$$(f_s)_{max} > f_k$$

$$\mu_s N > \mu_k N$$

$$\boxed{\mu_s > \mu_k}$$

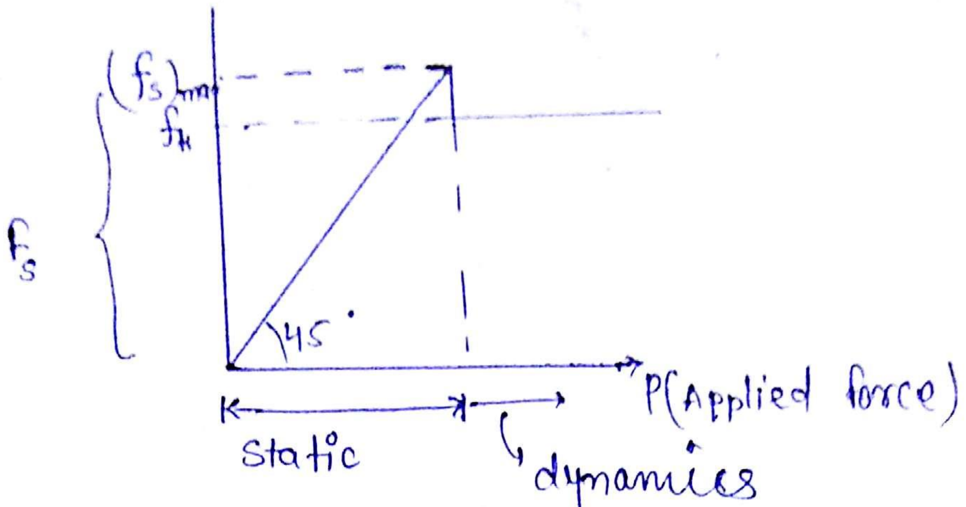


Static friction:- when two bodies trying to slide w.r.t to each other but they are not sliding then their exist a static friction whos value varies from 0 to a max. value $(f_s)_{max}$ depending on the value of applied force.

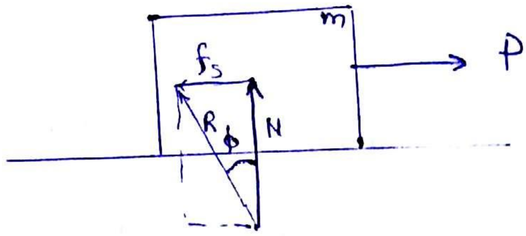
Note If the applied force is less than or equal to $(f_s)_{max}$ then the static friction force will be equal in mag. to the applied force and will act opposite to the applied force.

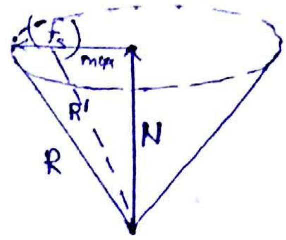
kinetic friction:- If the value of applied force is more than $(f_s)_{max}$ then their exists a kinetic friction whos value remains constant equal to $f_k = \mu_k N$, and acts opposite to relative motion

Remeber μ_k is always less then μ_s because of the lack of effective interlocking mechanism in b/w block and the surface.



Angle of friction ("ϕ")→





$$\tan\phi = \frac{(f_s)_{max}}{N} = \frac{\mu_s N}{N}$$

when friction force as its max. Value the angle b/w resultant ~~on~~ Contact force and Normal rxn is called angle of friction

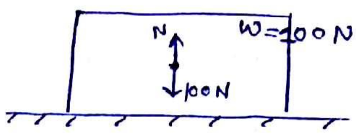
Cone of friction:-
when friction is at its max. value and the contact force is rotated round the normal rxn line, we get a cone called cone of friction
(if any contact force falls within this cone it means friction force is less then it max. Value, so the body will remain in rest)

- if $\mu_s = \mu_k = \mu$

i) $0 \le f_s \le (f_s)_{max} = \mu N = f_k$

ii) $\tan\phi = \mu$

Ques what will be the value of friction force at contact surface as shown in fig for the values of P equal 40 N, 50 N. and 60 N
Given $\mu_s = 0.5$, $\mu_k = 0.3$



Sol^n

$$N = 100\text{ N}$$

$$(f_s)_{max} = \mu_s N = 0.5 \times 100 = 50\text{ N}$$

(i) if $P = 40\text{ N}$

$$P < (f_s)_{max}$$

$$f_s = P = 40\text{ N}$$

(ii) if $P = 50\text{ N}$

$$P = (f_s)_{max} = 50\text{ N}$$

So body will be at verge of motion

(iii) if $P = 60\text{ N}$

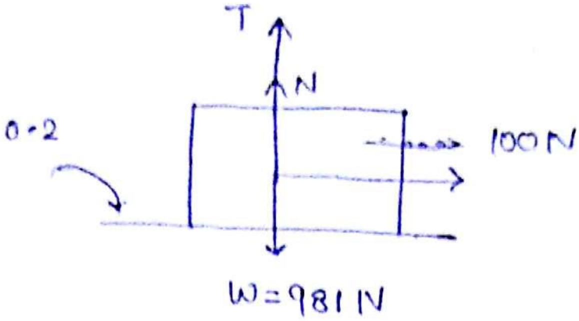
$$(f_s)_{max} = 50\text{ N}$$

$$P > (f_s)_{max} \xrightarrow{So} f = f_k = \mu_k N = 0.3 \times 100 = \underline{30\text{ N}}$$

f_k friction

Q 3.10

P.g.81

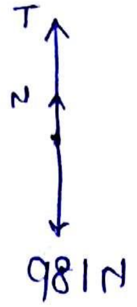


~~$f \geq \mu N$~~ $\qquad P = 100\ N$

~~$f = 0.2 \times 981$~~

~~$(f)_{max} = 196.2\ N$~~ $\qquad (f_s)_{max} = 100 = \mu N$

~~$(f) \geq P$~~ $\qquad$ ~~$\geq N = \frac{100}{0.2}$~~



$$100 = 0.2(981 - T)$$

$$T = 481\ N$$

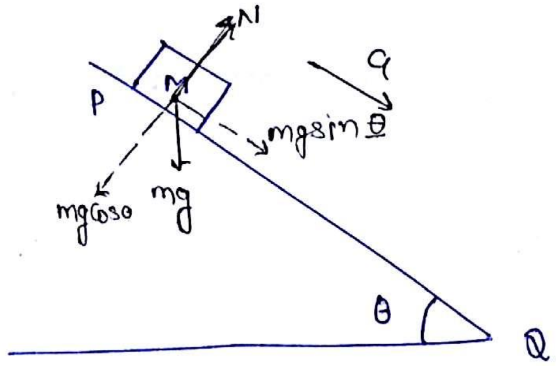
3.9

P.g.81

$\mu = 0$

$PQ = S$

$\mu < \tan\theta$



$$mg \sin\theta > (f_s)_{max} > \mu N$$

$$N = mg\cos\theta$$

$$mg\sin\theta > \mu mg\cos\theta$$

$$\mu < \tan\theta$$

$$mg\sin\theta - f_k = ma$$

$$mg\sin\theta - \mu mg\cos\theta = ma$$

$$a = g\cos\theta\,[\tan\theta - \mu]$$

$$s = ut + \frac{1}{2}at^2$$

$u = 0$

$$s = \frac{1}{2} g\cos\theta(\tan\theta - \mu)\,t^2$$

$$t = \sqrt{\frac{2s}{g\cos\theta(\tan\theta - \mu)}}$$

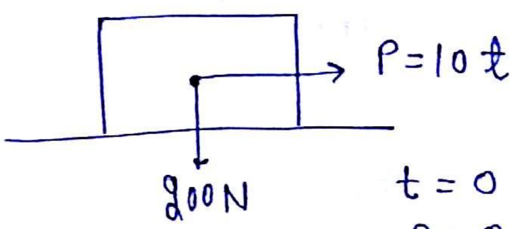
3.12

Q2

R.g.

$f_s = 0.4$

$f_k = 0.2$



$t = 0$

$P = 0$

$(f_s)_{max} = 0.4 \times 200 = 80\,N$

$(f)_k = \mu \times N$

$(f)_k = 0.2 \times 200 = 40\,N$

So $f = ma$

$\Rightarrow (10t - 40) = 20 \times a$

$\int 10t - 40 = 20\,\frac{dv}{dt}$

$v = \frac{1}{20}\left(\frac{10t^2}{2} - 40t\right)$ $\quad v_{t=10} = \frac{1}{20}\left(\frac{1000}{2} - 400\right)$

$(f_s)_{max} = \mu_s N = 0.4 \times 200 = 80\ N$

$(f_k) = \mu_k N = 0.2 \times 200 = 40\ N$

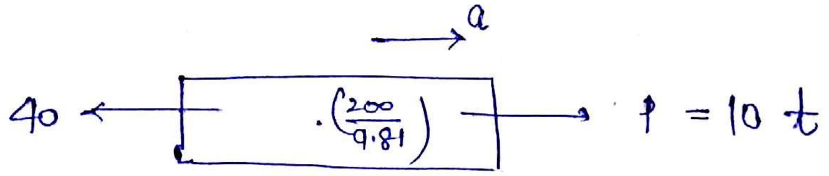
$P = 10t$

at $t = 8$ Sec. & $P = 80$ N

Block will be at verge of Motion

$V_{t=8s} = 0$

$t = 8s$ to $t = 10$ Sec.



1 to 10

$$\cancel{4000}\ (P - 40) = \frac{200}{9.81} a$$

$$\frac{dv}{dt} = \frac{10t - 40}{(200/9.81)}$$

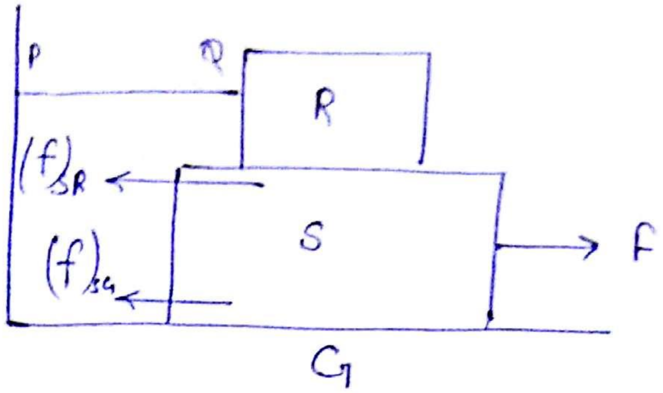
$$\int_8^{10} (10t - 40)\, dt = \frac{200}{9.81} \int_0^{V_f} dv$$

$$\left[\frac{10t^2}{2} - 40t\right]_8^{10} = 20.39\ V_f$$

$$\left(\frac{1000}{2} - 400\right) - \left(\frac{640}{2} - 320\right) = 20.39\ V_f$$

$$V_f = 4.9\ m/s$$

Q. 3.13
P.g. 82

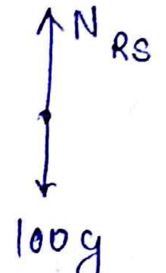


$M_R = 100$ kg
$M_S = 150$ kg
$\mu_s = 0.4$
$(F)_{min} = ?$

$$F_{min} = \left[(f_s)_{max}\right]_{SR} + \left[(f_s)_{max}\right]_{SG}$$

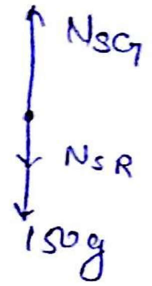
$$F_{min} = \mu_s (N)_{SR} + \mu_s (N)_{SG}$$

(R)



$N_{RS} = 100g$

(S)



$N_{SG} = N_{SR} + 150g$

$N_{RS} = N_{SR} = 100$

$N_{SG} = 250g$

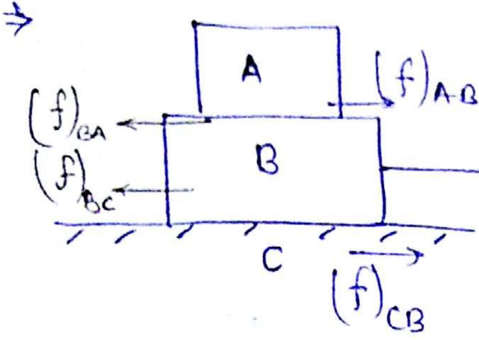
$$F_{min} = 0.4[100g + 250g]$$

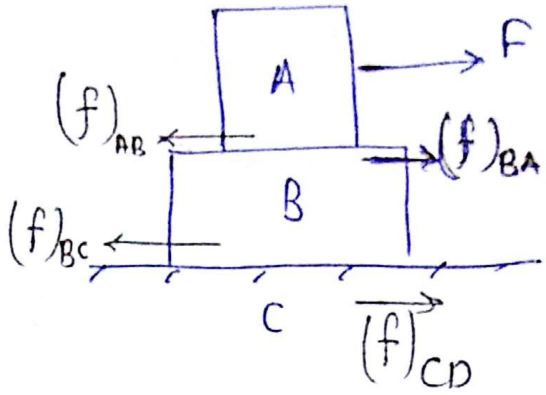
$F_{min} = 1373.4$ N

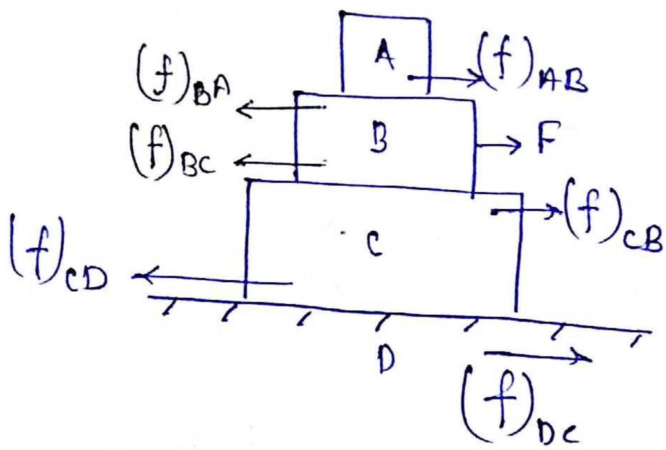
$F_{min} = 1.37$ kN

Note:-

→



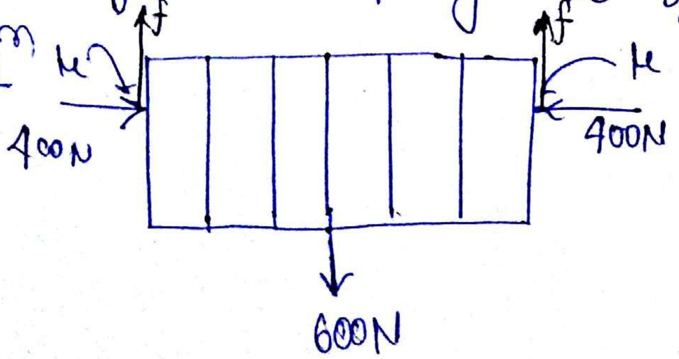




Always start with the block on which force is applied and then follow the nature of friction and Newton's 3rd law to find the dirn of friction

Ques: Six identicle book each weighing 100 N each are lifted by hand by appling a comp. force of 400 N. if book are on the verg on sleeping μ b/w books and hand is?

Soln



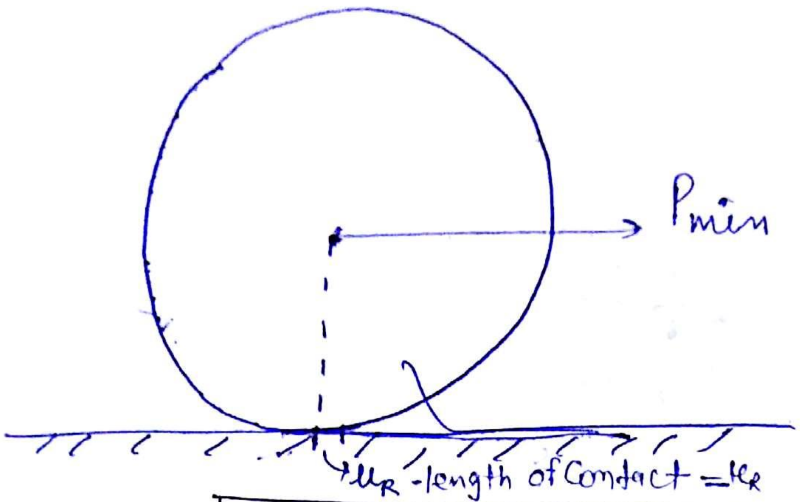
$2f = 600$

$f = 300N = \mu N$

$300 = \mu \times 400$

$\mu = 0.75$

Rolling Friction:-



$$\boxed{P_{min} = \frac{\mu_R W}{R}}$$

μ_R - Coeff. of rolling resistance (mm)

W - weight of roller

R - Radius of Roller.

Ques:

$D = 600$ mm $\quad W = 800$ N

$\mu_R = 0.3$ mm

Sol^n

$$P_{min} = \frac{\mu_R W}{R} = \frac{0.3 \times 500}{300} = 0.5 \text{ N}$$