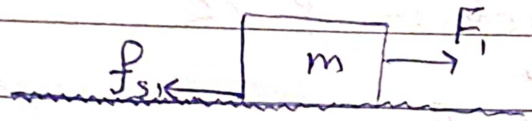
chapter 6: Force II

→ Friction force:

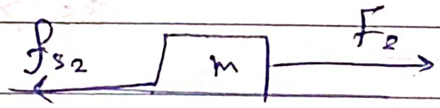
* 

No motion
static friction force

$\Sigma F = 0$ (No motion)

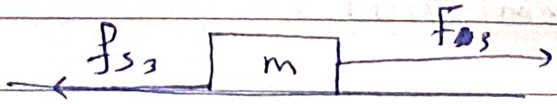
$F_1 - f_{s_1} = 0 \Rightarrow F = f_s$

* If we increase F but the body still not moving



No motion

$F_2 = f_s$, $f_{s_2} > f_{s_1}$

* 

about to move

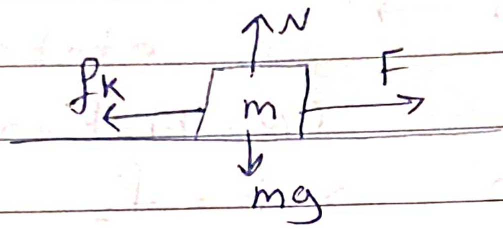
$f_{s_3} \equiv f_{sm}$: maximum static friction force.

$f_{sm} = \mu_s N$

μ_s : Coefficient of static friction

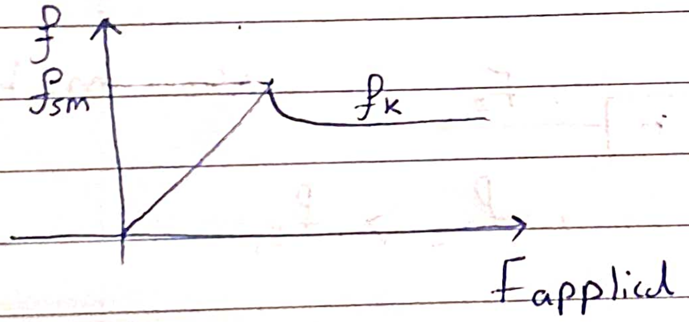
- If the body begins to slide along the surface, the magnitude of the frictional force rapidly decreases to a value f_k

f_k : kinetic friction force



$f_k = \mu_k N$

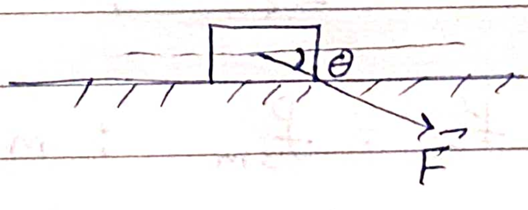
μ_k : Coefficient of kinetic friction.



$\mu_s > \mu_k$

sample problem 6.01 :

$F = 12\,N$, 30° under the horizontal

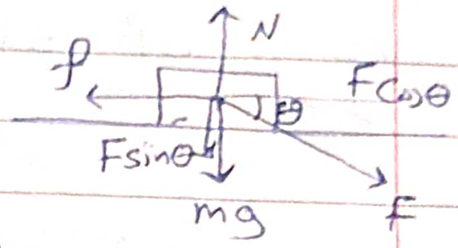


$m = 8\,kg$

$\mu_s = 0.7$

$\mu_k = 0.4$

→ Does the block move?



$\Sigma F_y = m a_y = 0$ (No motion on y-axis)

$N - mg - F\sin\theta = 0$

$N = mg + F\sin\theta$

$= 84.4\ N$

The block will move if $F_x > f_{sm}$

$f_{sm} = \mu_s N = 59\ N$

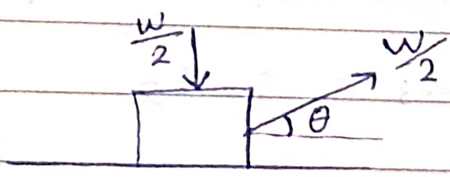
$F_x = F\cos\theta = 10.4\ N < f_{sm}$

its not moving.

Find f_s?

$f_s = 10.4\ N$

problem 10:

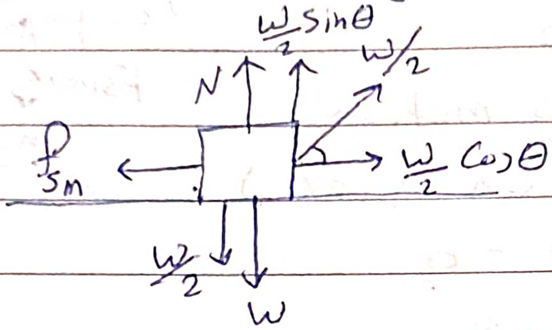


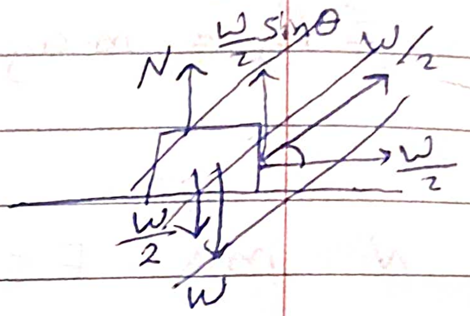
$F = \frac{w}{2}$, w: weight

$\theta = 30°$

→ what coefficient of static friction bt.

the block & the floor puts the block on the verge of sliding? (find $f_{sm} \Rightarrow \mu_s$)





$\Sigma F_x = 0$

$\frac{W}{2}\cos 30 - f_{sm} = 0$

$f_{sm} = \frac{W}{2}\cos 30 = \sqrt{3}\frac{W}{4}$

$\Sigma F_y = 0$

$N + \frac{W}{2}\sin 30 - W - \frac{W}{2} = 0$

$N = 5\frac{W}{4}$

$f_{sm} = \mu_s N = \frac{\sqrt{3}W}{4}$ (~~= 0.87~~)

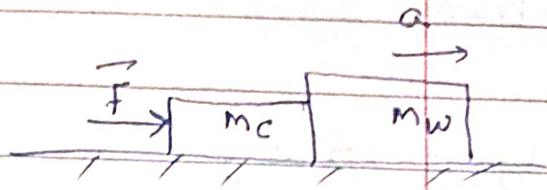
$\mu_s\left(\frac{5W}{4}\right) = \frac{\sqrt{3}W}{4}$

$\mu_s = 0.35$

Problem 20

$m_c = 1\ kg$

$m_w = 3\ kg$

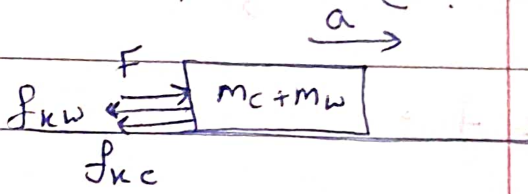


$f_{kc} = 2\ N$, $f_{kw} = 3.5\ N$

$\vec{F} = 12\ N$

Find the force on m_w from m_c ?

$\Sigma F_x = ma$

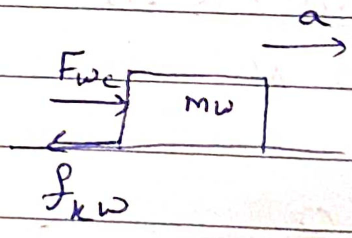


$F - f_{kw} - f_{kc} = (m_c + m_w) a$

$12 - 2 - 3.5 = 4\ a$

$a = 1.6\ m/s^2$

To find F_{wc}

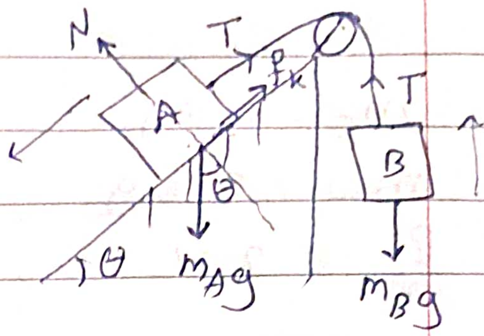


$F_{wc} - f_{kw} = m_w\ a$

$F_{wc} - 3.5 = 3(1.6)$

$F_{wc} = 8.3\ N$

problem 28 :



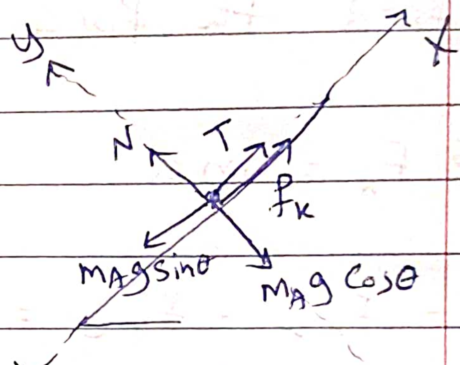
$m_A = 15$ kg

$\mu_k = 0.2$

$\theta = 30^\circ$

Block A slides with constant V

Find m_B ?



Block A :

$\Sigma F_y = 0$ (No motion along y-axis)

$N - m_A g \cos\theta = 0$

$N = 15 \times 10 \cos 30$

$= 130$ N

$\Sigma F_x = 0$ ($V = \text{Const} \Rightarrow a = 0$)

$T + f_k - m_A g \sin\theta = 0$

$T = m_A g \sin\theta - f_k$, $f_k = \mu_k N$

$= 15 \times 10 \sin 30 - 0.2 \times 130$

$= 49$ N

Block B :

$\Sigma F = 0$ (V is Const $\Rightarrow a = 0$)

$T - m_B g = 0$

$m_B = \frac{T}{g} = \frac{49}{10} = 4.9\,kg$

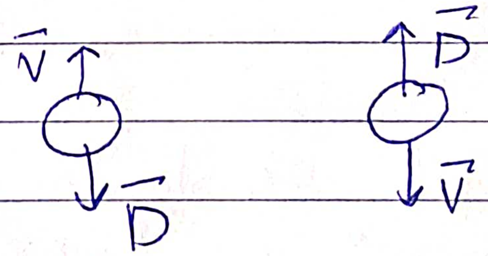
Drag Force : قوة احتكاك داخل الموائع

solid in Fluid Medium

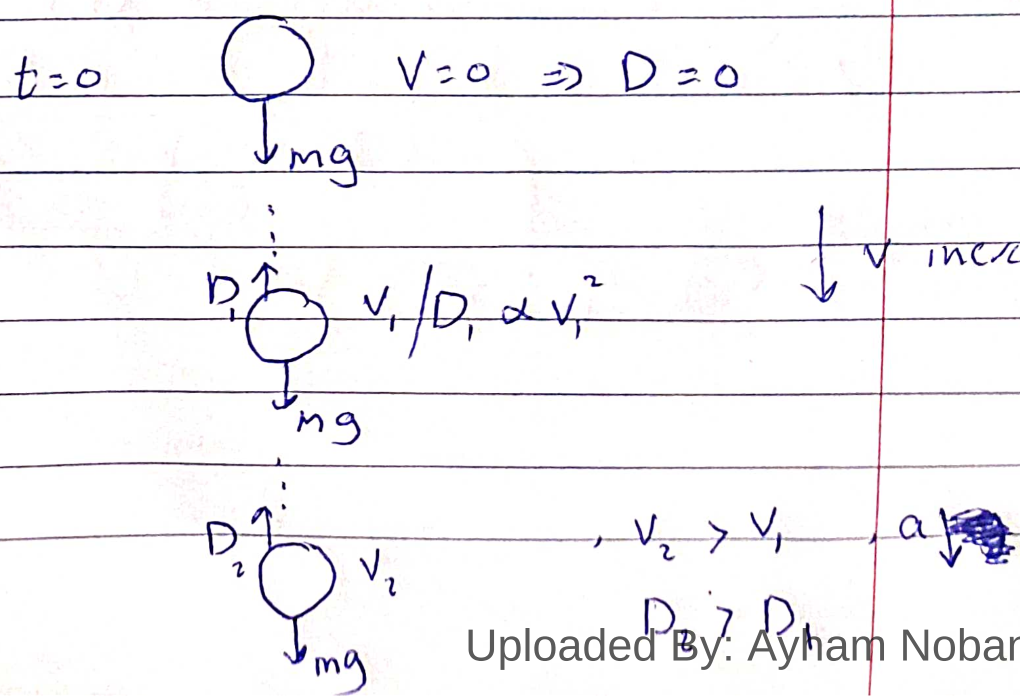
$$D = \frac{1}{2} C \rho A V^2$$

C : drag coefficient
ρ : density of air
A : effective cross-sectional area
V : velocity of the object

$\vec{D}$: opposes the relative motion of the body



Falling :



D still increase untill D = mg

$\Rightarrow D - mg = 0 \Rightarrow a = 0$

$\Rightarrow V = Const$

$V_{terminal}$ السرعة الحدية

اعلى سرعة يتحركها

الجسم

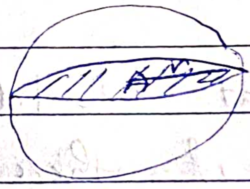
$D = mg$

$\frac{1}{2} C \rho A V_t^2 = mg$

$$V_t = \sqrt{\frac{2mg}{C \rho A}}$$

$V_t \propto \frac{1}{A}$ A : Cross-sectional area

for sphere $A = \pi r^2$



sample problem 3 :

Terminal speed of falling raindrop

$R = 1.55\ mm$

$\rho_w = 1\ g/cm^3 = 1000\ kg/m^3$

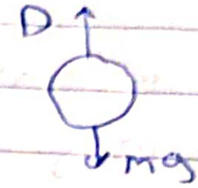
$C = 0.6$

$\rho_a = 1.2\ kg/m^3$

$h = 1200\ m$

a) Find the terminal speed ?

$$V_t = \sqrt{\frac{2mg}{C \rho_a A}}$$



$$m_{drop} = \rho_w V_{drop} = 1000 \times \left(\frac{4}{3}\pi R^3\right)$$

$$= 1000 \times \left(\frac{4}{3}\pi\right)\left(1.55 \times 10^{-3}\right)^3$$

$$=$$

$$A = \pi R^2 = \pi \left(1.55 \times 10^{-3}\right)^2$$

$$\Rightarrow V_t = \sqrt{\frac{2g \times 1000 \times \left(\frac{4}{3}\pi\right)\left(1.55 \times 10^{-3}\right)^3}{0.6 \times 1.2 \times \pi \left(1.55 \times 10^{-3}\right)^2}}$$

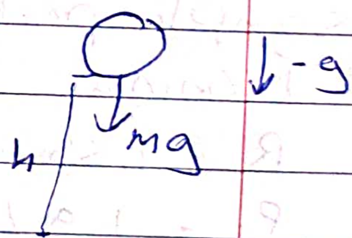
$$= 7.4 \text{ m/s}$$

b) what would be the drop's speed just before impact if there were no drag force?

$$V_f^2 = V_o^2 - 2gD$$

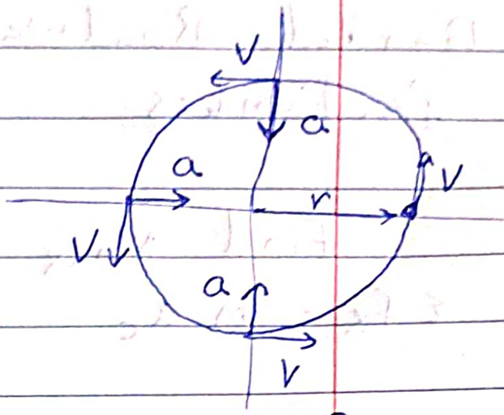
$$V_f^2 = -2g(-h)$$

$$V_f = \sqrt{2gh} = \sqrt{2g\,1200}$$



$$= 153 \text{ m/s} \simeq \text{speed of bullet}$$

* Uniform circular Motion



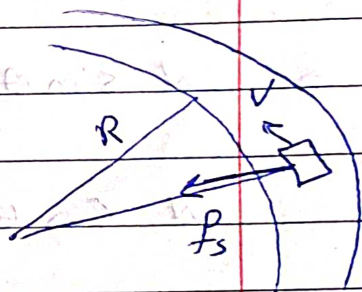
$$V = \frac{2\pi r}{T}$$

$$a_c = \frac{V^2}{r}$$ Centripital acc.

$$F_c = m a_c = m\frac{V^2}{r}$$ Centripital force "not a new kind of force"

EX:

"The only horizontal force acting on the car is a frictional force"



$$\Rightarrow \quad F_c = f_s$$

R = 100 m

$\mu_s = 0.75$

Find V_{max} ??

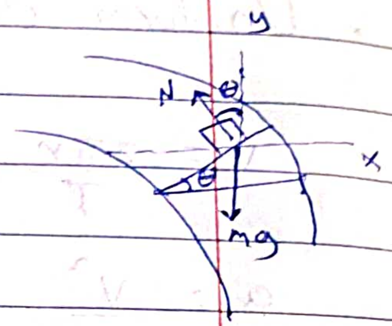
$$\frac{m V_m^2}{R} = f_{sm}$$

$$\frac{m V_m^2}{R} = \mu_s (mg)$$

$$V_m = \sqrt{\mu_s R g} = \sqrt{0.75(100)(9.8)}$$

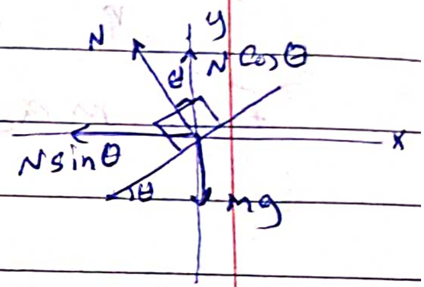
$$= 27.1 \text{ m/s}$$

* Banked Roadway:
frictionless



Find V_{max} ??

$\Sigma F_x = m a_c$



$-N\sin\theta = m\left(\frac{-V^2}{R}\right)$ ... ①

$\Sigma F_y = 0$

$N\cos\theta - mg = 0$ ... ②

$\Rightarrow N\sin\theta = m\frac{V^2}{R}$ — ①

$N\cos\theta = mg$ — ②

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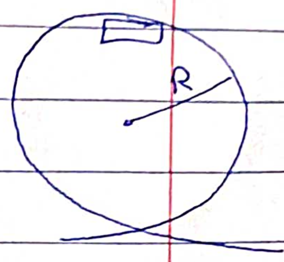
$\tan\theta = \frac{V^2}{Rg}$

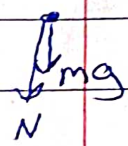
$V_{max} = \sqrt{Rg\tan\theta}$

Sample problem 6.04



$R = 2.7$ m

what is the least speed V at the top of the loop to remain in contact with it?



$\Sigma F = m a_c$

$-N - mg = m\left(\frac{-V^2}{R}\right)$

"it's on the verge of losing contact $\Rightarrow N = 0$" !!

$mg = m \frac{V_{min}^2}{R} \Rightarrow V_{min} = \sqrt{gR}$

$= 5.1$ m/s