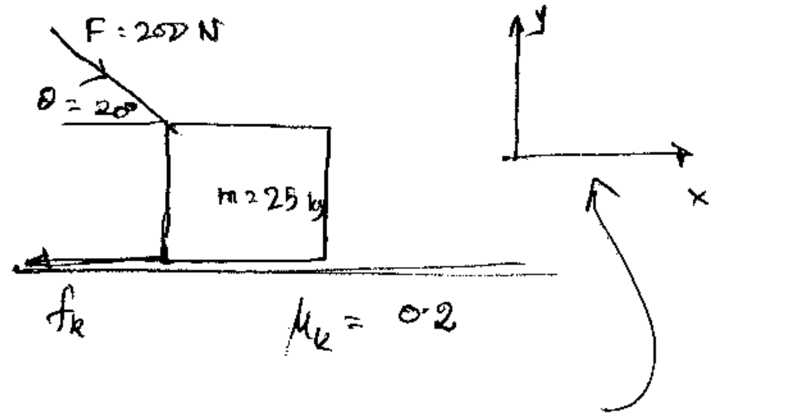
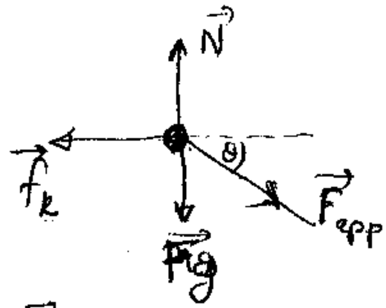
Exam 022 - major 1

Q14 → Q

(Q14)



1. Choose your axes (reference frame)
2. Free Body Diagram (FBD)



** Note that $\vec{F}_{app}$ is drawn with the tail end of the force vector coinciding with the body (dot). **

3. $\sum F_x = ma_x$

$$N\cos 90 + F_{app}\cos\theta + F_g\cos 270 + f_k\cos(180) = M(a)$$

$$0 + F_{app}\cos\theta + 0 - f_k = ma$$

$$f_k = (\mu_k N)$$

$$F_{app}\cos\theta - \mu_k N = ma \quad \text{——— (1)}$$

$$\sum F_y = ma_y$$

$$N - F_{app}\sin\theta - F_g + 0 = m(0)$$

$$N = F_g + F_{app}\sin\theta$$

$$N = mg + F_{app}\sin\theta \quad \text{——— (2)}$$

Substitute this in (1)

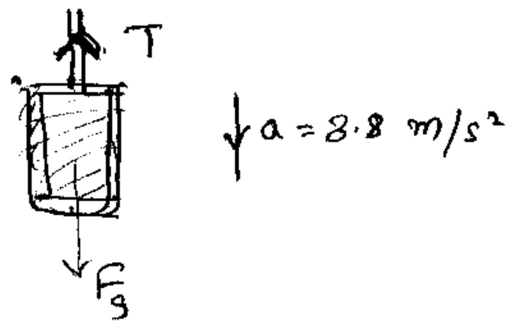
$$F_{app}\cos\theta - \mu_k(mg + F_{app}\sin\theta) = ma$$

$$a = \frac{F_{app}\cos\theta - \mu_k(mg + F_{app}\sin\theta)}{m}$$

$$= \frac{(200)(\cos 20) - 0.2(25(9.8) + 200\sin 20)}{25}$$

$$\boxed{a = 5.0 \ m/s^2}$$

(Q15)



$$\sum F_y = ma_y$$

$$T - F_g = m(-a)$$

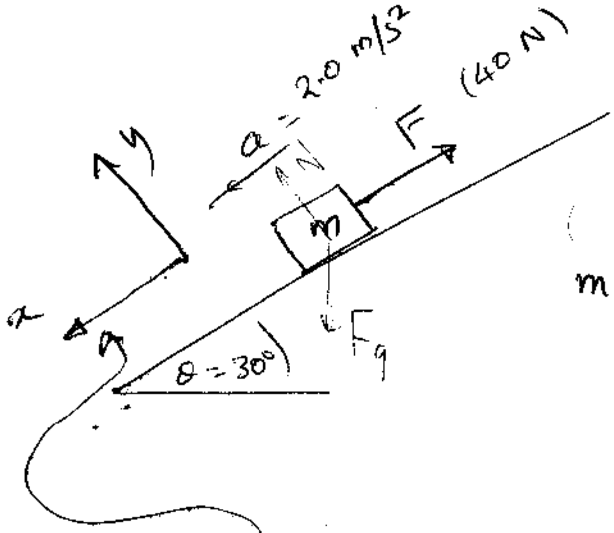
$(F_g = mg)$

$$T = mg - ma$$

$$T = m(g - a) = 700(9.8 - 3.8) = 4200$$

$$\boxed{T = 4.2\ kN}$$

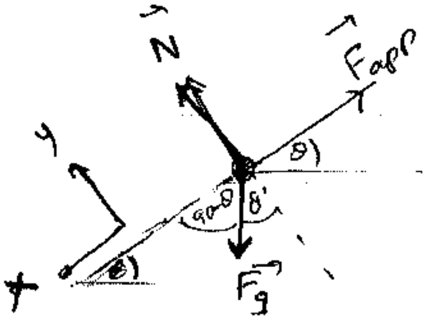
(Q16)



m ?

1. Choose your axes (reference frame) wisely

2. FBD



$$\Sigma F_x = m a_x$$

$$F_g \sin\theta - F_{app} + 0 = m a$$

$$m g \sin\theta - F_{app} = m a \qquad \{\theta = 30^\circ,\ F_{app} = 40\,N,\ a = 2.0\ m/s^2\}$$

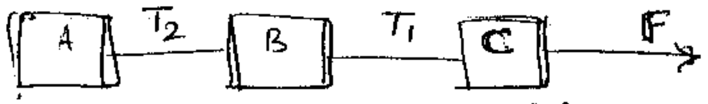
The only unknown here is 'm' !

$$m(g\sin\theta - a) = F_{app}$$

$$m = \frac{F_{app}}{g\sin\theta - a} = \frac{40}{9.8\sin 30 - 2} = 13.8\ kg \approx 14\ kg$$

(Q17)

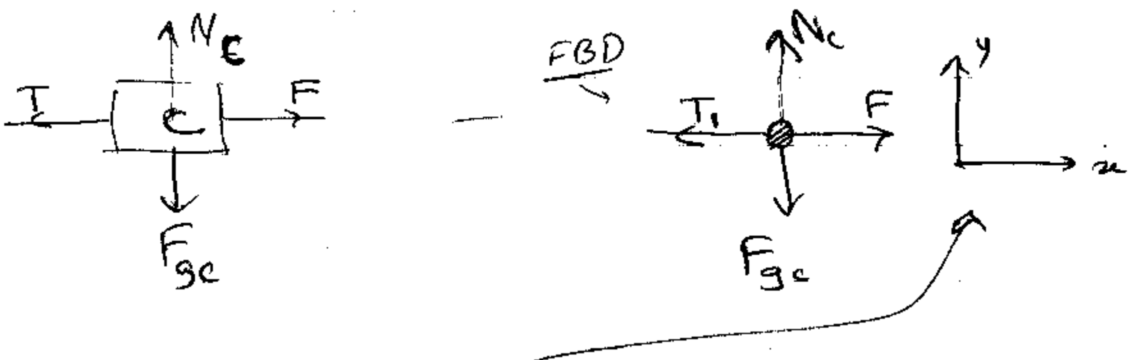
$m_A = m_B = m_C = M$



Find T_1? (in terms of F)

1. Know Your System!

We are asked to find T_1, the tension acting on block ~~B~~ C (and block B). But block B has an additional unknown force T_2 acting on it. So it is only a wise thing to ~~ch~~ choose "C" as our system & see:



2. Choose your axes wisely

* Note the direction of T_1; tension is directed AWAY from the body along the cord.

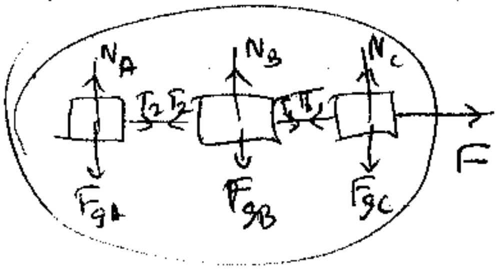
* Note the subscript ~~on N &~~ 'c' on N_c & F_{gc}, this avoid confusing with N & F_g from other blocks.

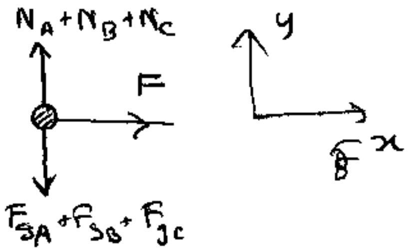
$$\sum F_x = m a_x$$

$$F - T_1 = M a \qquad \text{— (1)}$$

We cannot solve for T_1 ~~becau~~ from (1) because we have an additional unknown 'a'!
What do we do?

Think of another system (can consist of more than one block, moving in the same direction) where we can solve for 'a', and it is the whole:





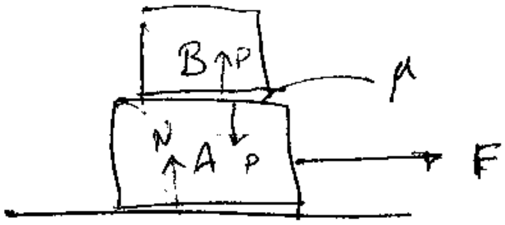
$$\sum F_x = m a_x$$

$$F = (3M)\, a \quad \Rightarrow \quad a = \frac{F}{3M}$$

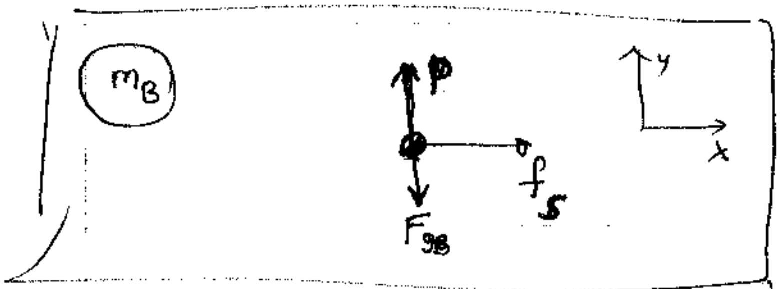
$$F - T_1 = M\left(\frac{F}{3M}\right)$$

$$T_1 = F - \frac{1}{3}F = \frac{2}{3}F$$

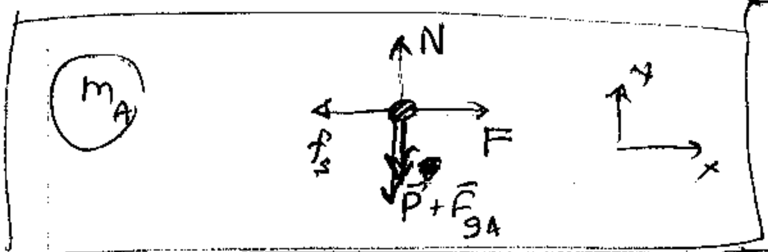
(Q18)



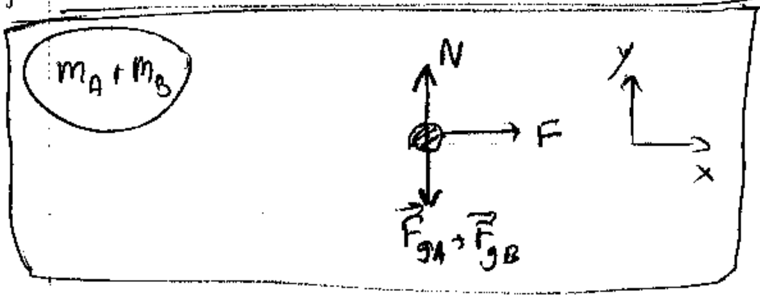
$m_A \quad m_B \ , \mu$



the block B can slip to the left only; this means the static friction, f_s, that opposes this is to the RIGHT



f_s is N's 3rd Law force-pair. Block A is trying to 'slip' to the right relative to the block B; f_s to the LEFT



m_B

$$\sum F_x = m a_x$$

$$f_s = m_B (a)$$

~~[illegible]~~

when it is about to slide f_s is at its maximum.

$$\Rightarrow f_s = f_{s,max} = \mu_s P$$

(the normal force in question here is P.

$$\therefore \quad \mu_s P = m_B a \quad \text{--- (1)}$$

m_B

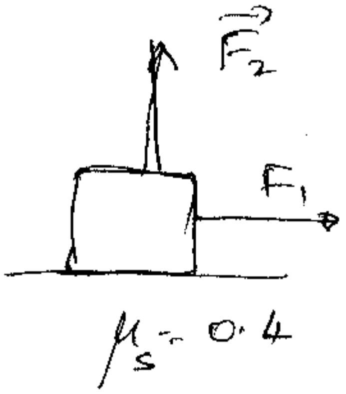
$$\underset{\downarrow}{\sum F_y} = m a_y$$

$$P - F_{g_B} = 0 \quad \Rightarrow P = m_B g$$

$$\Rightarrow \quad \mu_s (\cancel{m_B} g) = \cancel{m_B} a$$

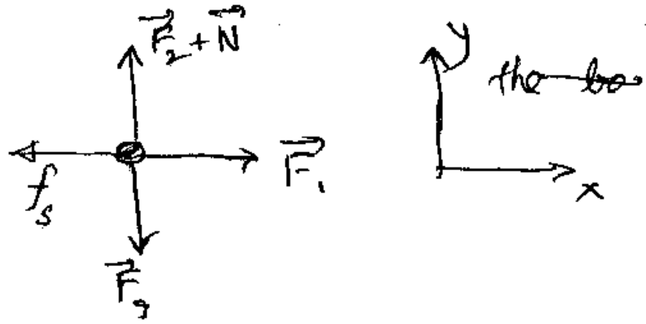
$$\boxed{a = \mu_s g}$$

Q19



$F_1 = 10$ N
$F_2 = ?$
$\mu_s = 0.4$
$mg = 50$ (N)

~~E~~ FBD



the box is not moving $\Rightarrow f = f_s$ static friction. & it is about to move $\Rightarrow$
$f_s = f_{s\,max} = \mu_s N$.

$\underline{\sum F_x} = m a_x$

$\downarrow$

$F_1 - f_s = m(0)$

$F_1 - \mu_s N = 0$ —— (1)

$\underline{\sum F_y} = m a_y$

$\downarrow$

$F_2 + N - \underset{mg}{F_g} = m(0)$

$N = mg - F_2$ —— (2)

(1) & (2) $\Rightarrow$ $F_1 - \mu_s(mg - F_2) = 0$

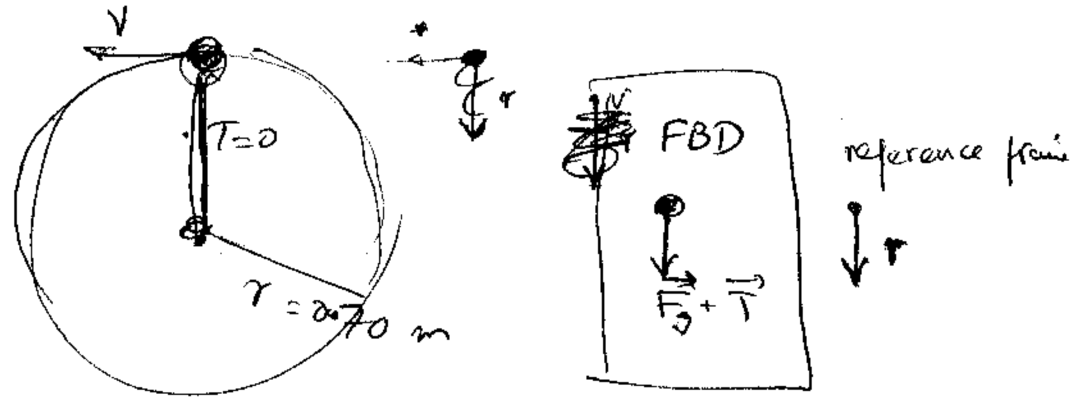
$$F_1 - \mu_s mg + \mu_s F_2 = 0$$

$$F_2 = \frac{\mu_s (mg) - F_1}{\mu_s} \quad (mg = 50)$$

$$= \frac{(0.4)(50) - 10}{0.4}$$

$$F_2 = \frac{20 - 10}{0.4} = \frac{10}{0.4} = \boxed{25\ N}$$

Q20



$$\sum F_r = m a_r$$

$$mg + T = m \frac{v^2}{r}, \quad T = 0$$

$$v^2 = g r$$

$$v = \sqrt{g r} = \sqrt{(9.80)(0.70)} = \boxed{2.6\ m/s}$$