ESC-S201

Friction

Block A weighing 1000 N rests over block B which weighs 2000 N as shown in Fig. Block A is tied to wall with a horizontal string. If the coefficient of friction between blocks A and B is 0.25 and between B and floor is 1/3, what should be the value of P to move the block (B), if

(a) P is horizontal.

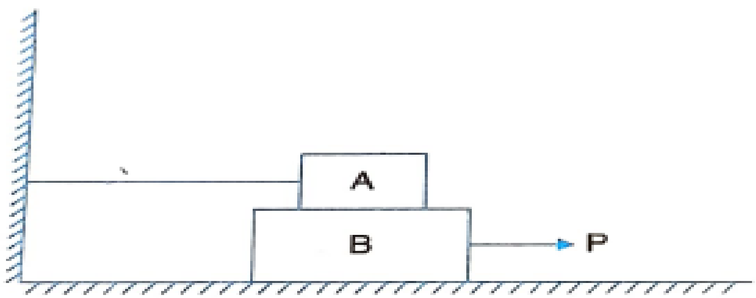
(b) P acts at 30° upwards to horizontal ?

Solution.

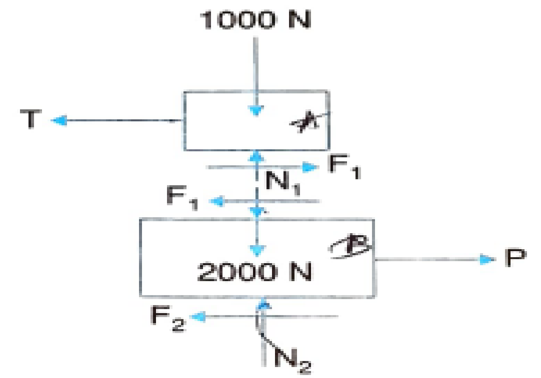
(a) When P is horizontal:

$$\Sigma V = 0 \rightarrow$$

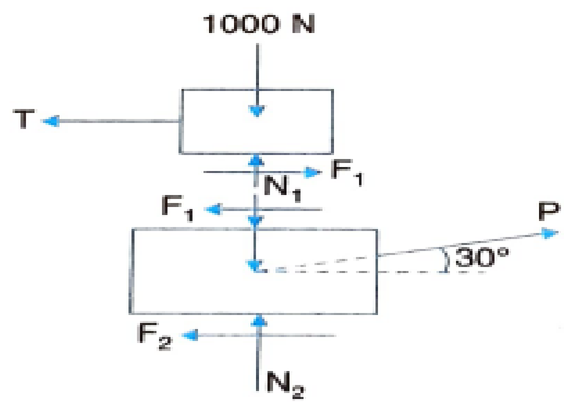
$$N_1 - 1000 = 0 \quad \text{or} \quad N_1 = 1000 \text{ N}$$



(a)



(b)



Since F_1 is limiting friction,

$$\frac{F_1}{N_1} = \mu = 0.25$$

$$F_1 = 0.25\,N_1 = 0.25 \times 1000 = 250 \text{ N}.$$

$$\Sigma H = 0$$

$$F_1 - T = 0$$

$$T = F_1 = 250 \text{ N}$$

Consider equilibrium of block B.

$$\Sigma V = 0 \quad \rightarrow$$

$$N_2 - 2000 - N_1 = 0$$

$$N_2 = 2000 + N_1 = 2000 + 1000 = 3000 \text{ N}$$

Since F_2 is limiting friction,

$$F_2 = \mu\,N_2 = \frac{1}{3} \times 3000 = 1000 \text{ N}$$

$$\Sigma H = 0 \quad \rightarrow$$

$$P - F_1 - F_2 = 0$$

$$\therefore \quad P = F_1 + F_2 = 250 + 1000$$

$$\therefore \quad \mathbf{P = 1250\ N} \quad \textbf{Ans.}$$

(*b*) When P is inclined:

Free body diagram for this case is shown in Fig. 5.5(*c*).

As in the previous case here also,

$$N_1 = 1000\ \text{N}$$

ι $F_1 = 250$ N. Consider the equilibrium of block B.

$$\Sigma V = 0 \quad \rightarrow$$

$$N_2 - 2000 - N_1 + P \sin 30° = 0$$

$$N_2 + P \sin 30° = 2000 + N_1$$

$$N_2 + 0.5\,P = 2000 + 1000$$

$$\therefore \quad N_2 = 3000 - 0.5P$$

From law of friction,

$$F_2 = \frac{1}{3} N_2 = \frac{1}{3} (3000 - 0.5P)$$

$$= 1000 - \frac{0.5}{3} P$$

$$\Sigma H = 0 \quad \rightarrow$$

$$P \cos 30° - F_1 - F_2 = 0$$

$$P \cos 30° - 250 - \left(1000 - \frac{0.5}{3} P\right) = 0$$

$$P\left(\cos 30° + \frac{0.5}{3}\right) = 1250$$

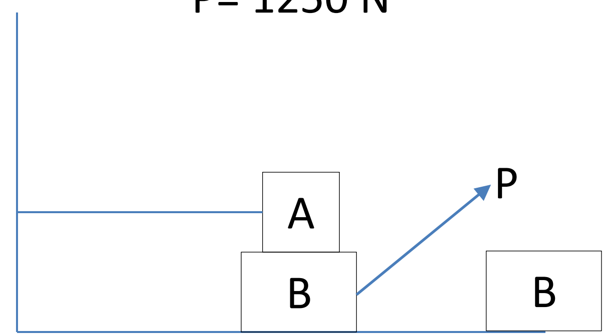
P = 1210.43 N Ans.

Friction problem

5. Block A weighing 1000 N rests over block B which weighs 2000 N. Block A is tied to wall with a horizontal string. If the coefficient of friction between A and B is ¼ and between B and the floor is 1/3, what should be the value of P to move the block B if a) P is horizontal? b) P acts 30^0 upwards to horizontal?

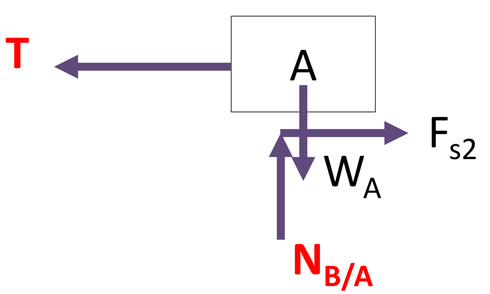
Case: B
P= 1210.43 N

Case: A
P= 1250 N



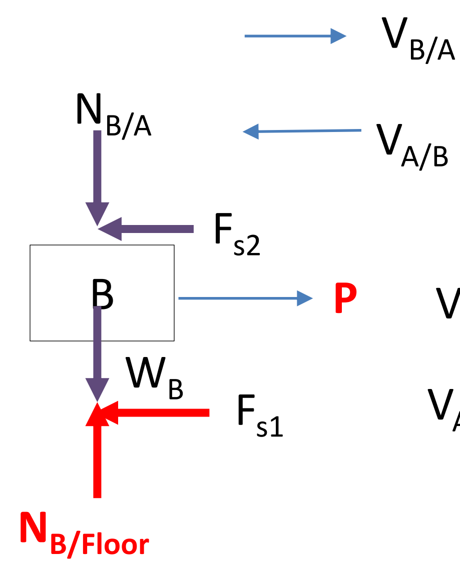
Case (a) P is horizontal

FBD- Block A



$$F_{s2} = \mu_{A/B} * N_{B/A}$$

FBD- Block B



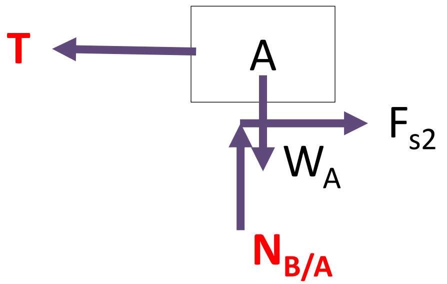
$$F_{s1} = \mu_{B/floor} * N_{B/Floor}$$

$$V_{B/A} = V_B - V_A$$

$$V_{A/B} = V_A - V_B = - V_{B/A}$$

W_A	= 1000 N
W_B	= 2000 N
$\mu_{A/B}$	= 0.25
$\mu_{B/floor}$	= 0.33

Friction problem



a) Force equilibrium in horizontal direction.

$T = F_{s2} = 250$ N

b) Force equilibrium in vertical direction.

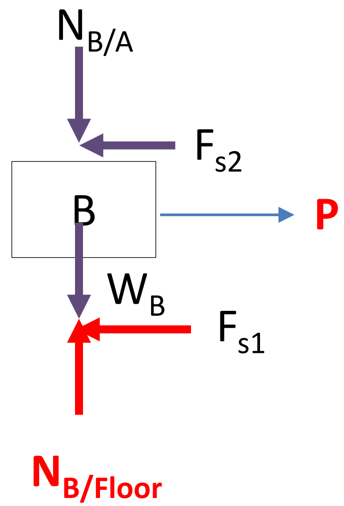
$N_{B/A} = W_A$

$N_{B/A} = 1000$ N

$F_{s2} = 0.25 \times 1000$ N

$= 250$ N

$F_{s2} = \mu_{A/B} * N_{B/A}$



a) Force equilibrium in horizontal direction

$P = F_{s1} + F_{s2}$

$= F_{s1} + 250$ N

b) Force equilibrium in vertical direction

$N_{B/floor} = N_{B/A} + W_B$

$N_{B/floor} = 1000 \text{ N} + 2000 \text{ N}$

$N_{B/floor} = 3000$ N

$F_{s1} = \mu_{B/floor} * N_{B/Floor}$

$= (1/3) * 3000$ N

$= 1000$ N

$P = F_{s1} + 250$ N

$= 1000 \text{ N} + 250 \text{ N}$

$P = 1250$ N

$W_A = 1000$ N

$W_B = 2000$ N

$\mu_{A/B} = 0.25$

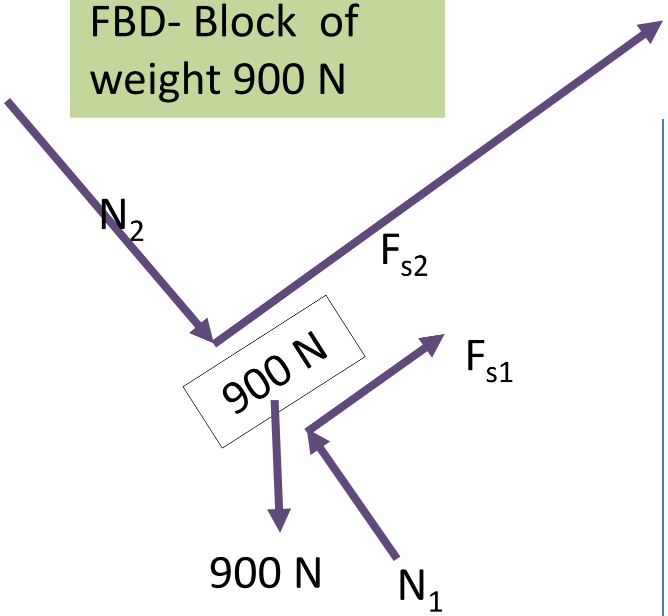
$\mu_{B/floor} = 1/3$

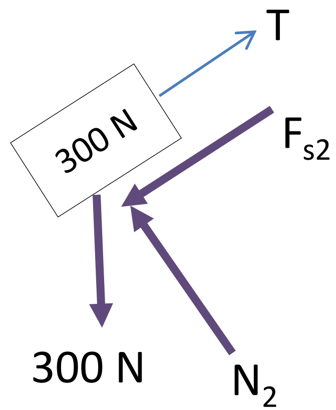
$F_{s1} = \mu_{B/floor} * N_{B/Floor}$

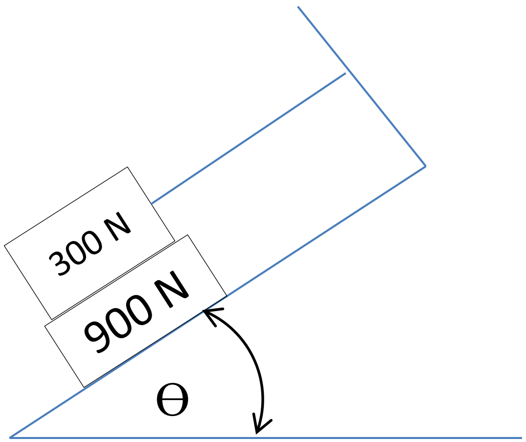
Friction problem

6. What should be the value of Θ in which will make the motion of 900 N block down the plane to impend? The coefficient of friction for all contact surfaces is 1/3.

FBD- Block of weight 900 N







$F_{s1} = \mu * N_1$

$F_{s2} = \mu * N_2$

Answer

Θ =29.05 degree