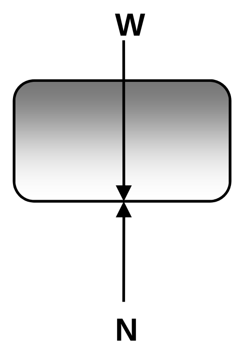
Statics SKMM1203

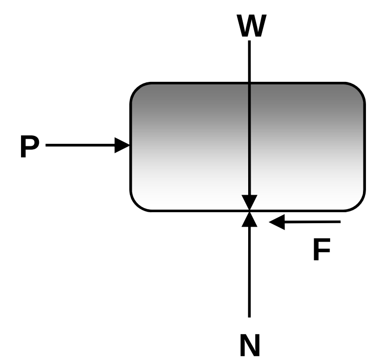
Friction

Faculty of Mechanical Engineering

Brief introduction to Friction

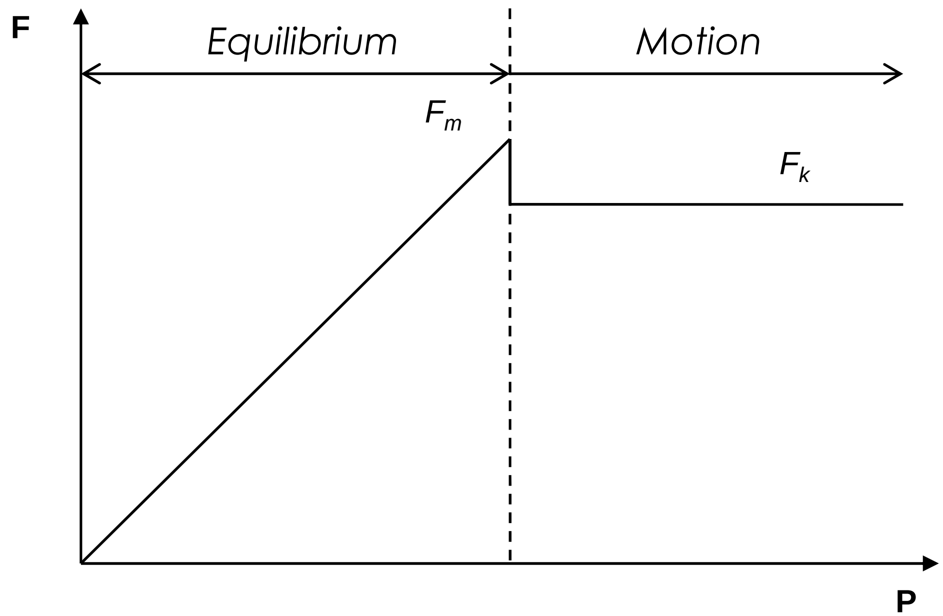
Principle of dry friction





N = W
No Friction, F = 0

N = W
$F = \mu_s N$ *if* $F < F_m$ *(body in equilibrium)*
$F = \mu_s N$ *if* $F = F_m$ *(motion impending)*
$F = \mu_k N$ *if* $F > F_m$ *(body in motion)*



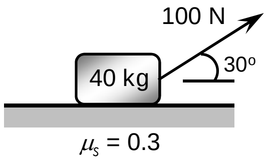
Relationship between applied force P and friction force F

where, F_m = *maximum static friction force*
F_k = *kinetic friction force*
μ_s = *coefficient of static friction*
μ_k = *coefficient of kinetic friction*
N = normal force

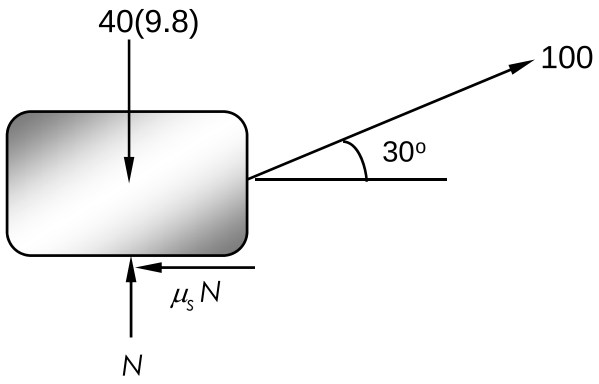
- *Friction force is independent of surface area of contact but dependent on the roughness of surface area in contact*
- *Static friction, F is directly proportional to the normal force, N.*

QUESTION 1

Determine magnitude and direction of the friction force.



SOLUTION



$(+\rightarrow)\ \Sigma F_x = 0$

$\mu_s N + 100\cos 30 = 0$ ………(1)

$(+\uparrow)\ \Sigma F_y = 0$

$N - 40(9.8) + 100\sin 30 = 0$ ……(2)

$N = 342N$

Substitute into (1) for friction force $F = \mu_s N$

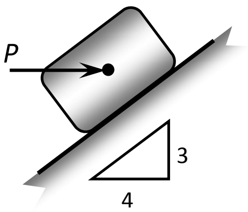
$F = (0.3)(342)$

$= 102.6N$

QUESTION 2

a. Determine the coefficient of statics friction μ_s if the minimum force required to stop the block from sliding down the inclined surface is P = 40 N

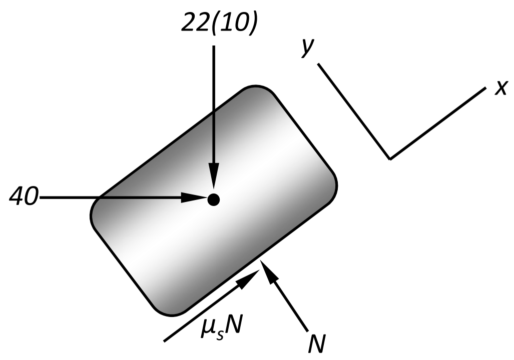
b. If the coefficients of statics and kinetics friction between the block and the surface are μ_s = 0.5 and μ_k = 0.4 respectively, and P = 200 N, determine the magnitude and direction of the friction force.



g = 10 m/s^2

SOLUTION

(a)



(+↗) $\Sigma F_x = 0$

$\mu_s N - 22(10)(3/5) + 40(4/5) = 0$ …..(1)

(+↖) $\Sigma F_y = 0$

$N - 22(10)(4/5) - 40(3/5) = 0$ ….(2)

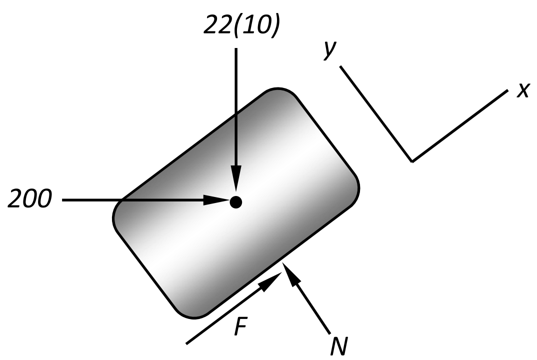
N = 200N

Substitute into (1)

$\mu_s(200) - 22(10)(3/5) + 40(4/5) = 0$

$\mu_s = 0.5$

(b)



Assume the direction of friction force F is in + x –dir

(+↗) $\Sigma F_x = 0$

F – 22(10)(3/5) + 200(4/5) = 0 .....(1)
F = - 28N (Actual direction is opposite to the assumption)

(+↖) $\Sigma F_y = 0$

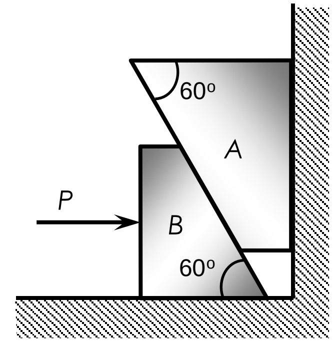
N -22(10)(4/5) – 200(3/5) = 0 ....(2)
N = 296N

Maximum static friction $F_m = \mu_s N$
$F_m = (0.5)(296)$
$= 148N$

Since $F < F_m$, *the object is in equilibrium. Thus the magnitude and direction of friction force is 28N* ↙ *(-x direction)*

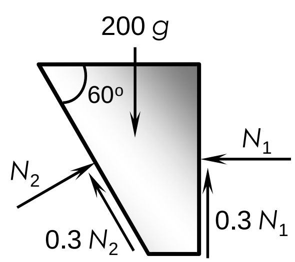
QUESTION 3

Two blocks *A* and *B* of mass 200 kg and 100 kg respectively are placed in contact with each other as shown. Determine the minimum force *P* required to maintain equilibrium if the coefficient of friction between all contacting surfaces is $\mu = 0.3$.



SOLUTION

block *A*



$(+\rightarrow)\ \Sigma F_x = 0$

$N_2 \sin 60^o - 0.3\, N_2 \cos 60^o - N_1 = 0$

$0.866\, N_2 - 0.15\, N_2 - N_1 = 0$

$N_1 = 0{,}716\, N_2$

$(+\uparrow)\ \Sigma F_y = 0$

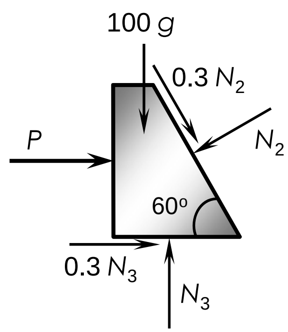
$N_2 \cos 60^o + 0.3\, N_2 \sin 60^o + 0.3\, N_1 - 100\, g = 0$

$0.5\, N_2 + 0.26\, N_2 + 0.3\, N_1 - 100\, g = 0$

$0.76\, N_2 + 0.3(0.716\, N_2) - 200\, g = 0$

$N_2 = 2012$ N

block *B*



$$(+\uparrow)\ \Sigma F_y = 0$$

$$N_3 - N_2 \cos 60^o - 0.3\, N_2 \sin 60^o - 100\, g = 0$$

$$N_3 - 1006 - 523 - 100\, g = 0$$

$$N_3 = 2510 \text{ N}$$

$$(+\rightarrow)\ \Sigma F_x = 0$$

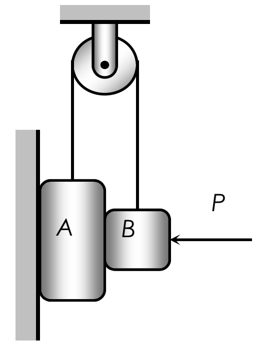
$$P + 0.3\, N_3 + 0.3\, N_2 \cos 60^o - N_2 \sin 60^o = 0$$

$$P + 753 + 302 - 1742 = 0$$

$$P = 687 \text{ N}$$

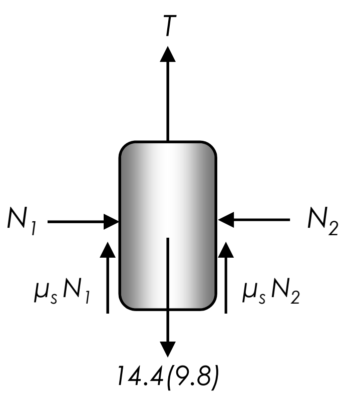
QUESTION 4

Blocks *A* of mass 14.4 kg and *B* of mass 7.2 kg are connected by a cable that passes over smooth pulley *C*. If the coefficient of static friction at all surfaces of contact are μ_s= 0.12, determine the smallest value of *P* for which equilibrium is maintained. Determine also the tension in the cable, *T*.



SOLUTION

block *A*



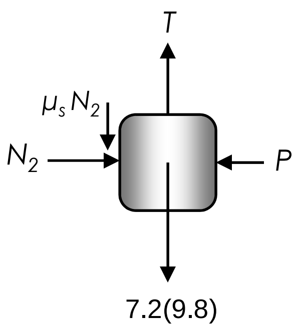
$(+\rightarrow)\ \Sigma F_x = 0$

$N_1 - N_2 = 0$ ....(1)

$(+\uparrow)\ \Sigma F_y = 0$

$\mu_s N_1 + \mu_s N_2 + T - 14.4(9.8) = 0$ ......(2)

block *B*



$(+\uparrow)\ \Sigma F_y = 0$

$T - \mu_s N_2 - 7.2(9.8) = 0$ ……..(3)

$(+\rightarrow)\ \Sigma F_x = 0$

$N_2 - P = 0$ ………(4)

(3) – (2)

$-\mu_s N_2 - 7.2(9.8) - \mu_s N_1 - \mu_s N_2 + 14.4(9.8) = 0$

From (1) $N_1 = N_2$, thus

$-\mu_s N_2 - 7.2(9.8) - \mu_s N_2 - \mu_s N_2 + 14.4(9.8) = 0$

$3\mu_s N_2 = 70.56$

$N_2 = 196\ N = N_2$

From (4), $P = N_2 = 196N$

From (3),

$T - \mu_s N_2 - 7.2(9.8) = 0$

$T = 0.12(196) + 7.2(9.8)$

$= 94.08N$