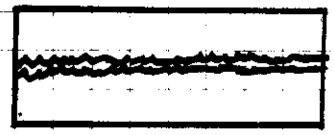
FRICTION & CIRCULAR MOTION

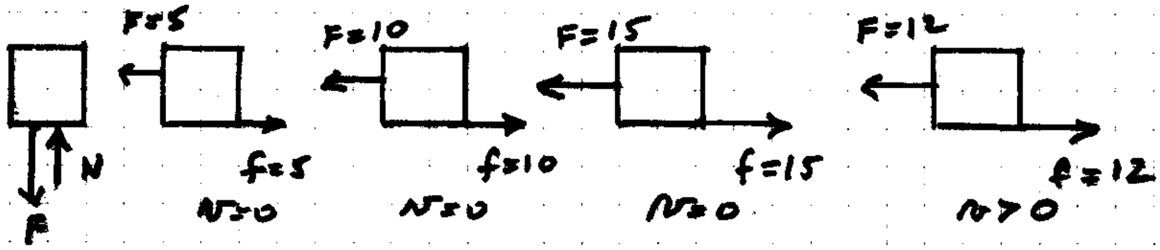
FRICTIONAL FORCES RESULT FROM THE ATTRACTION (INTERACTION) OF ATOMS IN ADJOINING SURFACES

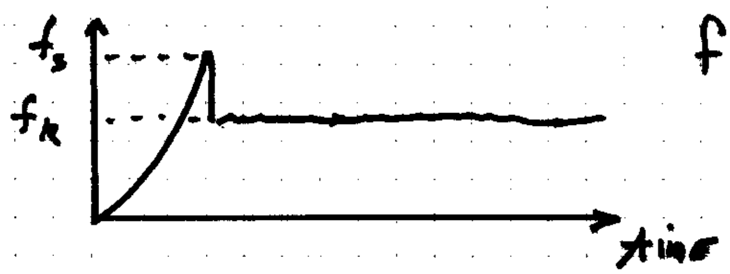


MOTION BETWEEN THE BLOCKS IS RESISTED BY THE INTERACTING PEAKS & VALLEYS

MACHINIST GUAGE BLOCKS ADHERE & ARE SEPARATED BY PULLING THEM APART

FRICTIONAL FORCES

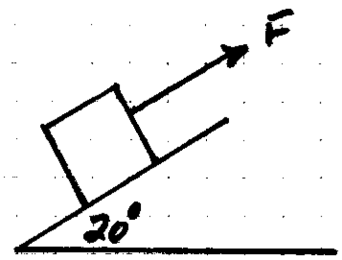




f - ALWAYS OPPOSES MOTION OR IMPENDING MOTION

FOR EQUILIB $f_s \leq \mu_s N$ DURING MOTION $f_k = \mu_k N$

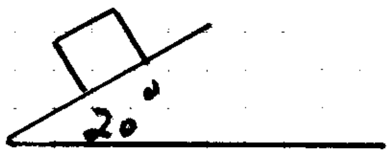
EXAMPLE I

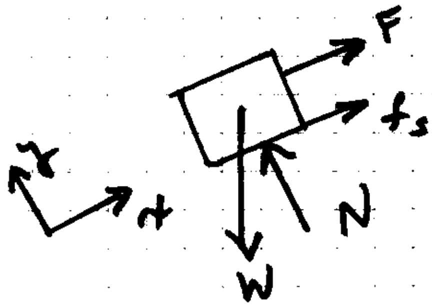


$W_{BLOCK} = 80\,N$

$f_s = .25$ $f_k = .20$

a) find the MINIMUM F TO KEEP THE BLOCK FROM SLIDING DOWN THE PLANE





$\Sigma F_x = 0$ $\quad F + f - 80 \sin 20 = 0$ $\quad \Sigma F_y = 0$

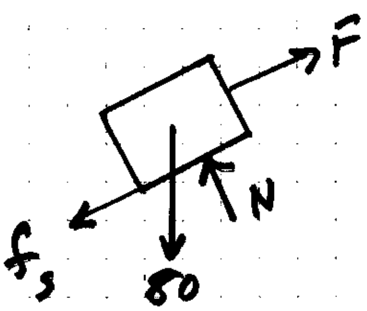
$F + \mu_s N = 80 \sin 20 = 27.4$ $\quad N = 80 \cos 20$

(.342) (.939)

$F = 27.4 - \mu_s (75.2) = 8.6\,N$ $\quad N = 75.2$

(μ_s = .25; $\mu_s(75.2)$ = 18.8)

b) FIND THE MIN F TO START THE BLOCK MOVING UP THE PLANE



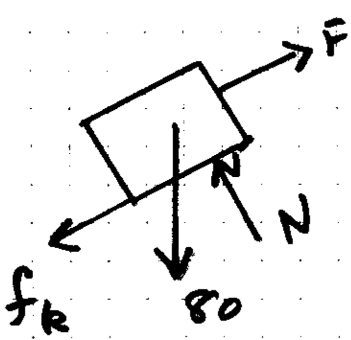
$\Sigma F_x = 0$

$F - 80 \sin 20 - f_s = 0$

$F = 80(.342) + .25(75.2) = 46.2\,N$

(27.4) (18.8)

c) WHAT FORCE IS REQ'D TO MOVE THE BLOCK UP THE PLANE AT CONSTANT VELOCITY



$\Sigma F_x = 0$

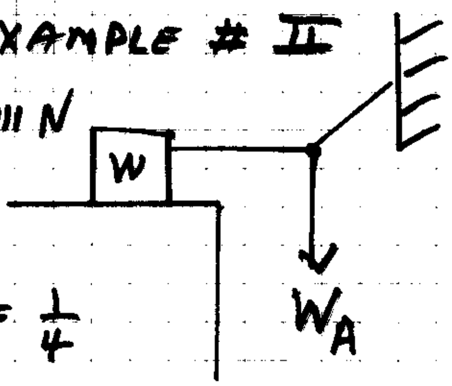
$F = W \sin 20 + \mu_k N$

$= 27.4 + 0.2(75.2) = 42.4\,N$

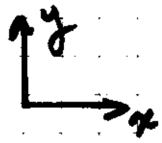
(15.0)

EXAMPLE # II

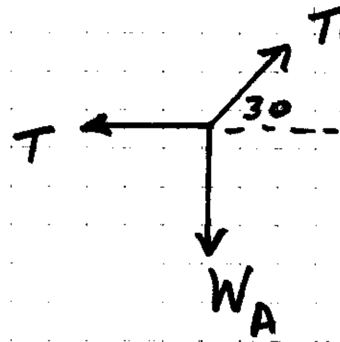
$W = 711\ N$

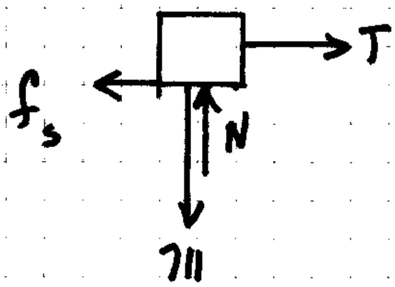


$\mu_s = \frac{1}{4}$



FIND THE MAX WEIGHT A FOR EQUIB.





$\Sigma F_y = 0$

$N = 711$

$\Sigma F_x = 0$

$T = f_s = \frac{1}{4}(N)$

$T = \frac{711}{4}$

$\frac{711}{4} = 1.732 W_A$

$\boxed{W_A = 103\ N}$

$\Sigma F_x = 0$

$T = T_U \cos 30 = .866 T_U$

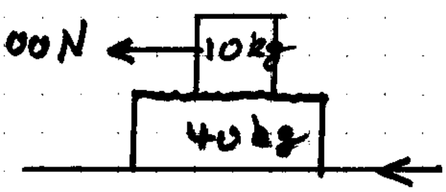
$\Sigma F_y = 0$

$W_A = T_U \sin 30 = \frac{T_U}{2}$

$T = .866(T_U) = .866(2W_A)$

$T = 1.732 W_A$

EXAMPLE III $F = 100\ N$



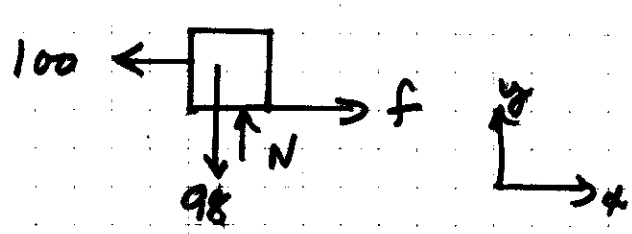
$\mu_k = 0.4$

$\mu_s = 0.6$

find THE ACCEL. OF THE BLOCK & SLAB

$f_k = 0.4\ N$

$f_s = 0.6\ N$



$f_k = 0.4(98) = 39.2$

$f_s = 0.6(98) = 58.8$

$\Sigma F_y = 0 \quad N = 98$

IF $F < 58.8$ WE WOULD HAVE NO MOTION

If $F = 39.2$ we would have sliding at constant speed

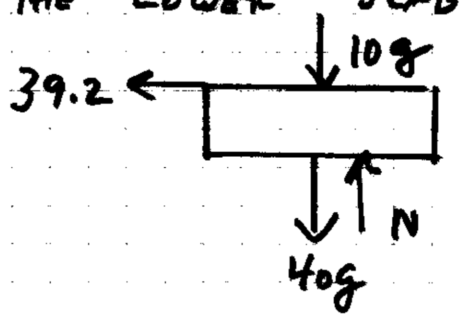
But $100 \gg 39.2$ so we have accel.

For the upper block $\quad \Sigma F_x = m a_x$

$$100 - 39.2 = 10\, a_x$$

$$a_x = 6.1\, m/s^2 \leftarrow$$

For the lower slab



Notice the frictional force is an action-reaction pair

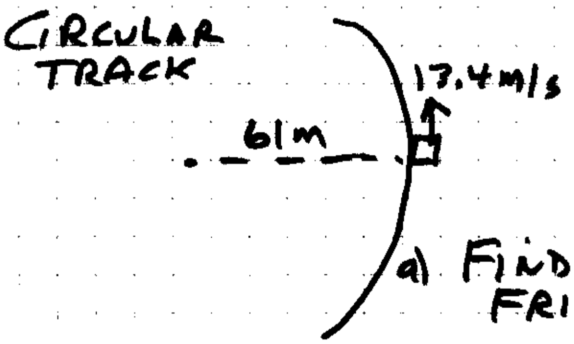
$\Sigma F_x = m a_x \qquad 39.2 = 4\, a_s$

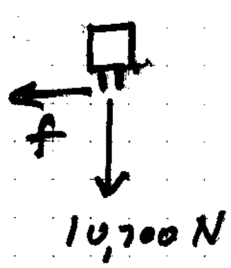
$$a_s = \frac{39.2}{40} = 0.98\, m/s^2 \leftarrow$$

Uniform Circular Motion

$$a_R = \frac{v^2}{R} \qquad F = \frac{m v^2}{R}$$

Example IV





$$f = m\frac{v^2}{R} = \frac{\left(\frac{10{,}700}{9.8}\right)(13.4)^2}{61} = 3214\ N$$

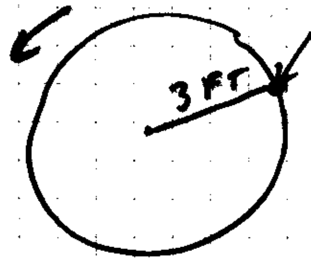
a) Find the req'd frictional force

b) IF $\mu_R = 0.35$ DOES THE CAR STAY ON THE TRACK

$$f_{REQ'D} = 3214\ N \qquad f_{MAX} = \mu N = .35(10,700)$$

$$= 3745\ N \quad \text{OK}$$

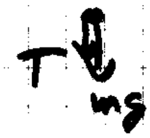
EXAMPLE V STONE ROTATING IN A VERTICAL CIRCLE



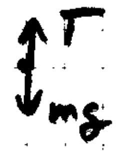
T_{MAX} IN STRING $= 9\#$

$W_{STONE} = 0.82\#$

(AT THE TOP FBD)



AT THE BOTTOM FBD



THE SPEED OF THE STONE IS INCREASED UNTIL THE STRING BREAKS

a) WHERE IS THE STONE WHEN THE STRING BREAKS

AT THE TOP $T + mg = \frac{mv^2}{R}$

AT THE BOTTOM $T - mg = \frac{mv^2}{R}$

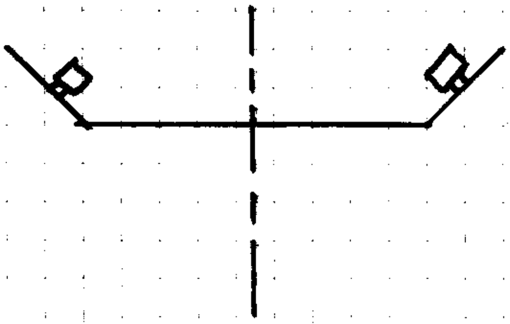
$$T_{MAX} = \frac{mv^2}{R} + mg$$

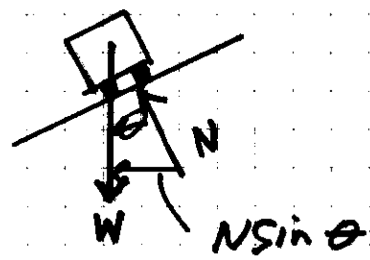
b) WHAT IS THE SPEED OF THE STONE WHEN THE STRING BREAKS

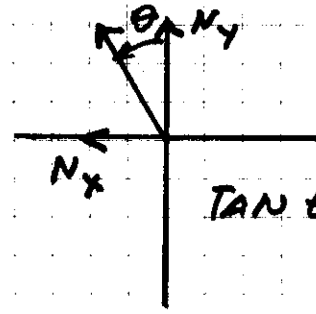
$g = 32\ FT/SEC^2$ $\quad v = \sqrt{\left(\frac{T - mg}{m}\right)R} = \sqrt{\left(\frac{9 - .82}{.82/32}\right)3}$

$$= 30.9\ m/s$$

EXAMPLE VI - A BANKED CIRCULAR HIGHWAY is designed for 60 km/HR. THE RADIUS IS 200 m. ON A RAINY DAY TRAFFIC MOVES AT 40 km/HR. find the minimum COEFFICIENT OF FRICTION TO ALLOW CARS TO STAY ON THE ROAD







$$\tan\theta = \frac{N_X}{N_Y}$$

$$N_X = \begin{Bmatrix} \text{RADIAL} \\ \text{FORCE} \end{Bmatrix} = N \sin\theta = \frac{m v^2}{R}$$

$$v = 60 \frac{km}{HR} \times \frac{1000\,m}{1\,km} \times \frac{1\,HR}{3600\,sec}$$

$v = 16.6\ m/s$

$R = 200\ m$

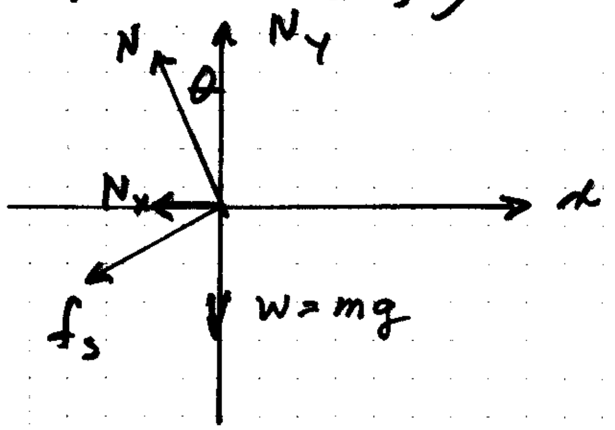
$g = 9.8$

$$mg \sin\theta = m\frac{v^2}{R}$$

$$\theta = \sin^{-1}\left(\frac{v^2}{gR}\right)$$

$$\theta = 8.14^\circ$$

NOW TRAVELING SLOWER AT 40 km/HR find THE REQ'D μ



$\Sigma F_x = 0$

$$-\underbrace{N \sin\theta}_{N_X} - f_s \cos\theta = m v^2/R \quad ①$$

$\Sigma F_y = 0$

$$N \cos\theta - f_s \sin\theta - mg = 0 \quad ②$$

$$\mu = 0.202$$