STATICS = STUDY OF OBJECTS WHOSE ACCELERATION IS ZERO.

I. EQUILIBRIUM OF A PARTICLE

A. PARTICLE = A POINT MASS WITH ALL THE FORCES CONCENTRATED ON THAT POINT.

B. RECIPE:

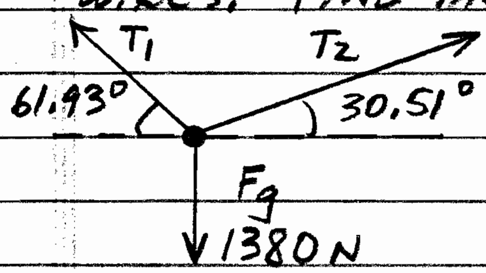
1. PUT A DOT ON THE CENTER OF THE OBJECT.
2. DRAW THE FORCES EMANATING FROM THAT DOT.
3. WRITE A NEWTON'S EQUATION FOR EACH AXIS.

$$ma_x = \Sigma F_x \qquad ma_y = \Sigma F_y.$$

RECALL, THEY ARE LOCAL THINKERS AND THEY ONLY KNOW THE FORCES WHICH DIRECTLY AFFECT THEM.

4. SET $a_x = 0$ AND $a_y = 0$ AND SOLVE FOR THE UNKNOWNS.

C. EXAMPLE: A 138 KG MASS HANGS FROM TWO WIRES. FIND THE TENSION. GIVEN:



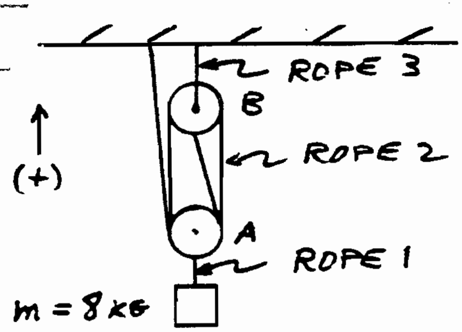
x: $0 = T_2 \cos 30.51 - T_1 \cos 61.93$

y: $0 = T_2 \sin 30.51 + T_1 \sin 61.93 - 1380$

SOLVE THE SIMULTANEOUS EQUATIONS.

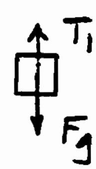
$T_2 = 650\ N \qquad T_1 = 1190\ N$

EXAMPLE:



FIND THE TENSION IN EACH ROPE.

ROPE 1:

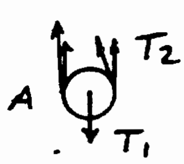


$0 = T_1 - F_g$

$0 = T_1 - 80$

$\boxed{T_1 = 80N}$

ROPE 2:

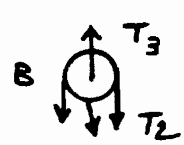


$0 = 4T_2 - T_1$

$0 = 4T_2 - 80$

$\therefore \boxed{T_2 = 20N}$

ROPE 3:



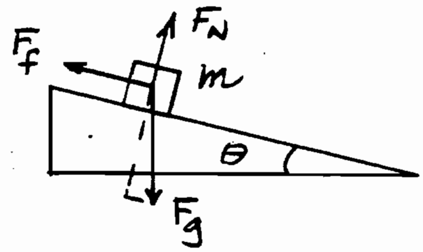
$0 = T_3 - 3T_2$

$0 = T_3 - 60$

$\therefore \boxed{T_3 = 60N}$

EXAMPLE:

FIND A FORMULA FOR THE MINIMUM VALUE FOR μ SO THAT THE BRICK WILL NOT MOVE.

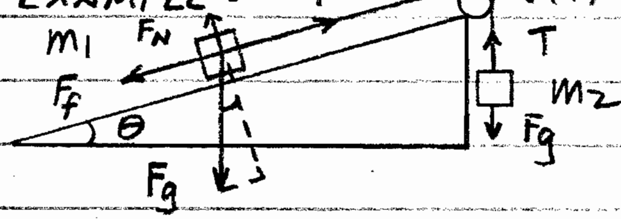


$$mA_x = F_g \sin\theta - F_f \qquad mA_y = F_N - F_g\cos\theta$$
$$0 = F_g \sin\theta - F_f \qquad 0 = F_N - F_g\cos\theta$$
$$F_f = F_g \sin\theta \qquad F_N = F_g\cos\theta$$

LEMMA: $F_f = \mu F_N$

$$(F_g \sin\theta) = \mu(F_g\cos\theta)$$
$$\sin\theta = \mu\cos\theta$$
$$\frac{\sin\theta}{\cos\theta} = \mu$$
$$\therefore \boxed{\mu = \tan\theta}$$

EXAMPLE:



a) FIND THE TENSION IN THE ROPE.

$$0 = F_{g2} - T$$
$$T = m_2 g$$

b) FIND THE MINIMUM VALUE OF m_1 SO THAT IT DOES NOT MOVE.

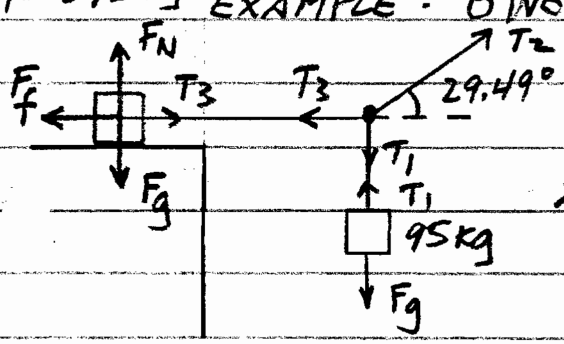
$$ma_x = T - F_f - F_g\sin\theta \qquad ma_y = F_N - F_g\cos\theta$$
$$0 = m_2 g - \mu m_1 g\cos\theta - m_1 g\sin\theta \qquad 0 = F_N - m_1 g\cos\theta$$

#3   #1 $\quad F_N = m_1 g\cos\theta$

$$m_1 = \frac{m_2}{(\sin\theta + \mu\cos\theta)} \qquad F_f = \mu F_N$$

#2 $\quad F_f = \mu m_1 g\cos\theta$

$m = 672$ kg EXAMPLE: GIVEN: FIND μ SO THAT IT IS STATIONARY.



PUT BRAIN ON DOT.

Y: $0 = T_2 \sin 29.49 - 950 \qquad T_2 = 1930$ N

X: $0 = 1930\cos 29.49 - T_3 \qquad T_3 = 1680$ N

PUT BRAIN IN BRICK. $F_f = T_3 = 1680$ N

$F_f = \mu F_N \qquad 1680 = \mu(6720)$

$\mu = .25$

II. EQUILIBRIUM OF A SOLID OBJECT

RECIPE: 1. DRAW A FORCE DIAGRAM.

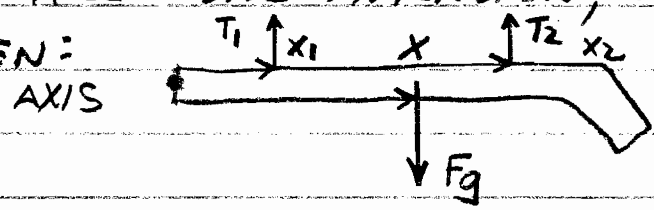
2. PICK AND LABEL AN AXIS FROM WHICH TO MEASURE LEVERAGE DISTANCES.

3. $ma_x = \Sigma F_x$ $ma_y = \Sigma F_y$ $I\alpha = \Sigma \tau$

RIGHT (+)   UP (+)   CLOCKWISE (+)

EXAMPLE: ONE DIMENSION, PURE VECTORS

GIVEN:



$T_1 = 2\ N$ $x_1 = 12\ cm$

$T_2 = 6\ N$ $x_2 = 32\ cm$

FIND THE WEIGHT OF THE HOCKEY STICK AND THE LOCATION OF ITS CENTER OF MASS.

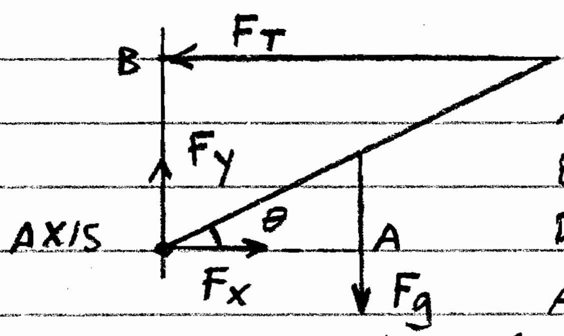
Y: $0 = T_1 + T_2 - F_g$ τ: $0 = -(12)(2) - (32)(6) + x(8)$

$0 = 2 + 6 - F_g$ $x = 27\ cm$

$F_g = 8\ N$ $m = .8\ kg$

EXAMPLE: TWO DIMENSIONS, PURE VECTORS

A HORIZONTAL WIRE HOLDS A POLE AT ANGLE 23.575°. GIVEN: $m = 48\ KG$ $L = 4\ m$



FIND THE TENSION IN THE ROPE AND THE FORCE EXERTED ON THE POLE BY THE WALL.

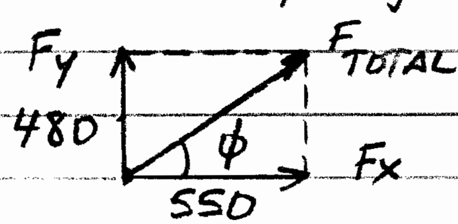
DISTANCE LEMMAS: $A = (2 \cos 23.575°)$

$A = 1.833$ $B = 4 \sin 23.575° = 1.6$

τ: $0 = A(F_g) - B(F_T) = (1.833)(480) - 1.6\ F_T$ $F_T = 550$

X: $0 = F_x - F_T$ $F_x = F_T$ $F_x = 550$

Y: $0 = F_y - F_g$ $F_y = F_g$ $F_y = 480$

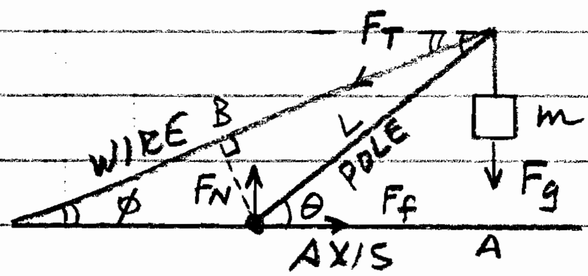


$F_{\substack{TOTAL\\WALL}} = \sqrt{F_x^2 + F_y^2} = 730$

$\phi = \tan^{-1}\left|\frac{F_y}{F_x}\right| = 41.11°$

EXAMPLE: TWO-DIMENSIONS, MIXED VECTORS

A WIRE SUPPORTS A MASSLESS POLE WHICH HAS A MASS HANGING FROM ITS END. FIND FORMULAS FOR FORCES ACTING ON THE POLE. DISTANCE LEMMAS:



$A = L\cos\theta$

$B = L\sin(\theta - \phi)$

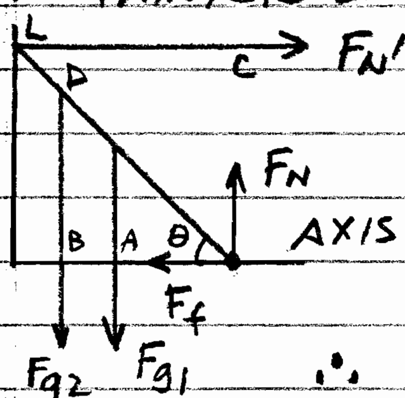
τ: $0 = (A)(F_g) - (B)(F_T)$

x: $0 = F_f - F_T\cos\phi$

y: $0 = F_N - F_T\sin\phi - F_g$

EXAMPLE: LADDERS PURE VECTORS.

A UNIFORM LADDER OF LENGTH L AND MASS m_1 LEANS AGAINST A FRICTIONLESS WALL AT ANGLE θ. THE FLOOR HAS COEFFICIENT OF FRICTION μ. FIND THE DISTANCE D TO WHICH A PAINTER OF MASS m_2 MAY SAFELY HIKE.



DISTANCE LEMMAS:

$A = (L/2)\cos\theta$ $\quad C = L\sin\theta$

$B = D\cos\theta$

τ: $0 = (C)(F_N') - (A)(m_1 g) - (B)(m_2 g)$

x: $0 = F_N' - F_f$ $\quad y$: $0 = F_N - F_{g_1} - F_{g_2}$

$\therefore F_N = (m_1 + m_2)g$

$F_f = \mu F_N = \mu(m_1 + m_2)g = F_N'$

τ: $0 = (L\sin\theta)(\mu(m_1+m_2)g) - (L/2)(\cos\theta)(m_1 g) - (D\cos\theta)(m_2 g)$

SOLVE FOR D.

$$D = \frac{(2L\sin\theta)\mu(m_1+m_2) - (L m_1\cos\theta)}{2m_2\cos\theta}$$

$$D = \mu L\left(\frac{m_1+m_2}{m_2}\right)\tan\theta - \left(\frac{m_1}{m_2}\right)\left(\frac{L}{2}\right)$$