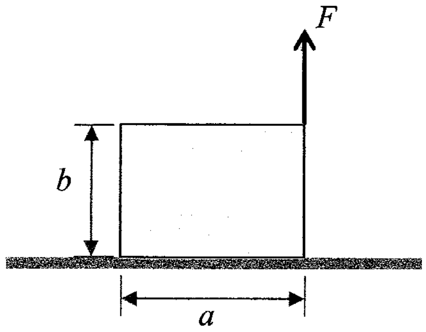
Name SOLUTION SID ____________

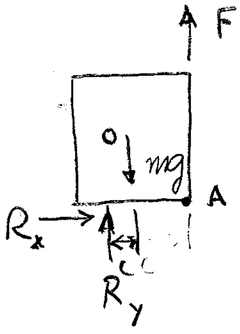
1. Consider a block of mass m resting on a rough horizontal surface. The coefficient of static friction between the block and the surface is μ_s. A vertical force F is applied at the upper right-hand corner of the block, and is slowly increased until the block begins to move.

(a) (15 points) Determine the value of the force at which the block ceases to be in static equilibrium and begins to move.

(b) (10 points) Determine what motion (sliding or tipping) will occur if the force is just above that determined in part (a), and provide the reasoning that supports your answer.



FBD



a) $\Sigma F_x = R_x = 0 \Rightarrow$ BLOCK CANNOT SLIDE

$\Sigma F_y = F + R_y - mg = 0 \Rightarrow R_y = mg - F$

$\Sigma M_O = \frac{Fa}{2} - R_y c = 0 \Rightarrow c = \frac{a}{2}\frac{F}{R_y}$

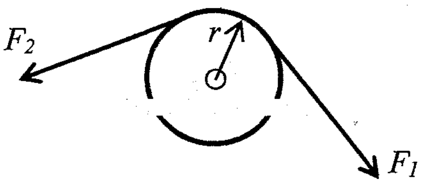
BLOCK WILL TIP WHEN $c \geq \frac{a}{2}$. THIS OCCURS WHEN $R_y = F$.

$R_y = F = mg - F \Rightarrow 2F = mg \Rightarrow \boxed{F = \frac{mg}{2}}$

b) THE BLOCK WILL TIP FOR $F \geq \frac{mg}{2}$ BECAUSE THE REACTION FORCE REQUIRED TO MAINTAIN EQUILIBRIUM MOVES BEYOND THE BASE OF THE BLOCK. IT CANNOT SLIDE BECAUSE THERE ARE NO HORIZONTAL FORCES.

Name SOLUTION SID ____________

2. (20 points) We have dealt with pulleys in several homework problems, and have made an *assumption* that the tension in the cable is the same on either side of the pulley. Prove that this assumption is correct for an ideal pulley by showing that $F_2 = F_1$. An ideal pulley is one that is able to rotate freely (without resistance) about its axis. The angle that the cable on either side of the pulley makes with some reference axis is arbitrary.



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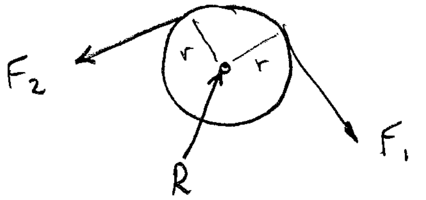


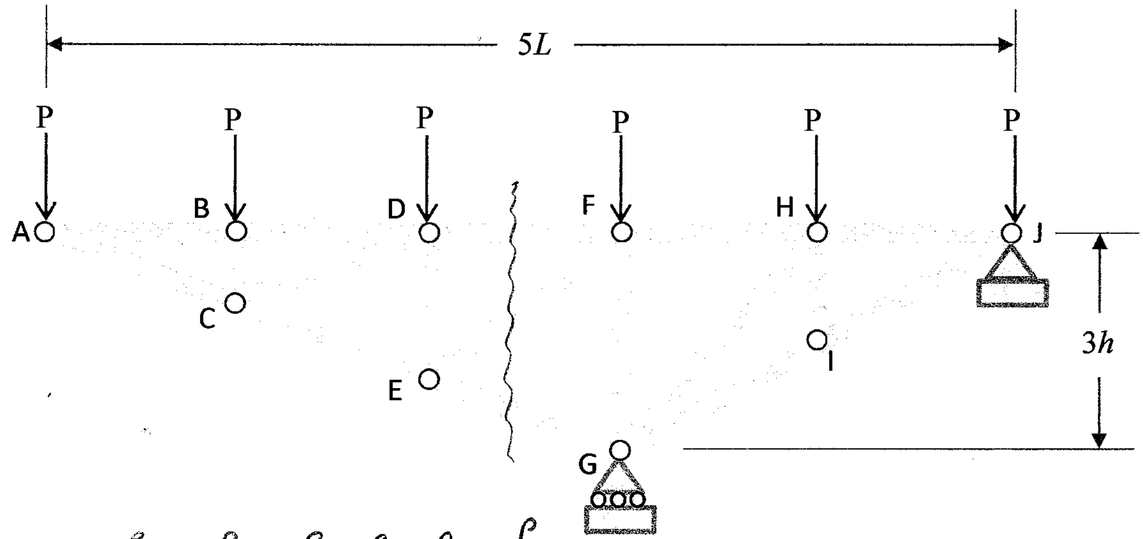
$$\Sigma M_o = F_2 r - F_1 r = 0 \Rightarrow F_2 = F_1$$

Name *SOLUTION* SID ____________

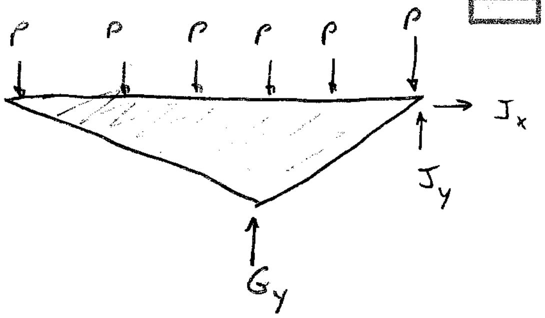
3. The truss shown below is loaded by vertical forces of magnitude P at each of the joints along the top. All of the horizontal members of the truss are of length *L*, and the vertical member BC has length *h*.

(a) (10 points) Determine the reaction forces at points G (roller support) and J (pinned support).

(b) (15 points) Determine the force in member DF. Be sure to indicate clearly whether it is in tension or compression.



a) FBD



$\Sigma F_x = J_x = 0$

$\Sigma M_J = PL + P(2L) + P(3L) + P(4L) + P(5L) - G_y(2L) = 0$

$2G_yL = 15PL \Rightarrow \boxed{G_y = 7.5P}$

$\Sigma M_G = J_y(2L) - P(2L) - PL + PL + P(2L) + P(3L) = 0$

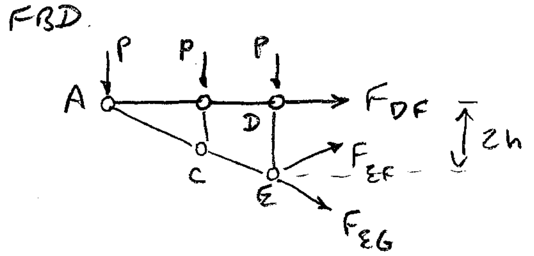
$2J_yL = -3PL \Rightarrow \boxed{J_y = -1.5P}$

$\Sigma F_y = G_y + J_y - 6P$

$J_y = 6P - G_y = \underline{-1.5P}$ ✓

b) Force in DF: Method of sections

FBD.



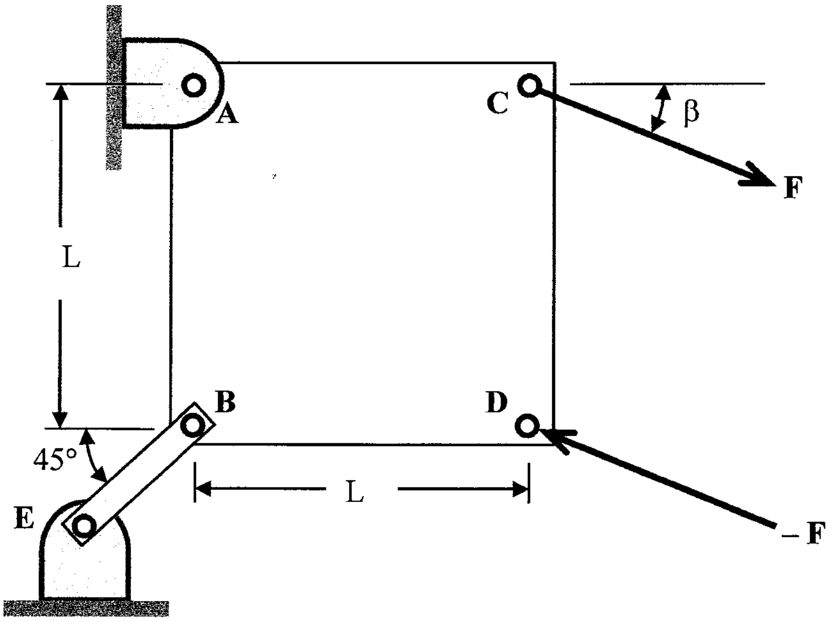
$\Sigma M_E = P(2L) + P(L) - F_{DF}(2h) = 0$

$\boxed{F_{DF} = \frac{3PL}{2h} \text{ (TENSION)}}$

Name Solution SID ____________

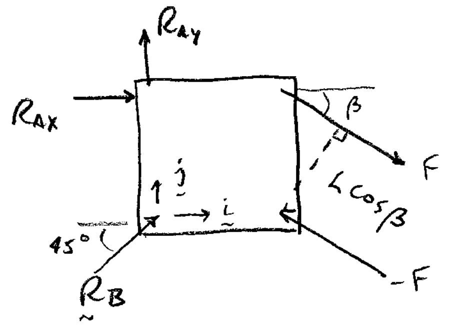
4. (30 points) The square plate shown below can be treated as massless. It is supported at points A and B by a pin and a short link, respectively. It is loaded by equal and opposite forces **F** and –**F** at points C and D.

Determine the reaction forces acting on the plate at points A and B.



NOTE: SHORT LINK BE IS A TWO FORCE MEMBER SO THE FORCE IT EXERTS ON POINT B IS IN THE DIRECTION OF THE LINK.

FBD:



THE TWO APPLIED FORCES FORM A COUPLE

$$M = -FL\cos\beta$$

$$\Sigma F_x = 0 = R_{AX} + R_{BX} \Rightarrow R_{AX} = -R_{BX}$$

$$\Sigma F_y = 0 = R_{AY} + R_{BY} \Rightarrow R_{AY} = -R_{BY} = -R_{BX}$$

$$\underset{\sim}{R}_B = R_{BX}\,\underset{\sim}{i} + R_{BY}\,\underset{\sim}{j}\ , \quad R_{BX} = R_{BY}$$

$$\Sigma M_A = 0 = -FL\cos\beta + R_{BX}L$$

$$\boxed{\begin{array}{l} R_{BX} = F\cos\beta\ , \quad R_{BY} = F\cos\beta \\ R_{AX} = -F\cos\beta\ , \quad R_{AY} = -F\cos\beta \end{array}}$$

$$\boxed{|\underset{\sim}{R}_B| = F\sqrt{2}\cos\beta}$$