Name ______________________________ SID ____

Introduction to Solid Mechanics
ME C85/CE C30

Midterm Exam 1

Fall, 2011

1. Do not open this exam until you are told to begin.
2. Put your name and SID on **every** page.
3. You may not use a calculator, but you may use a straightedge to help you draw figures.
4. You may use one 8-1/2 x 11 sheet of notes, but not your book or any other notes.
5. Store everything else out of sight.
6. Turn off cell phones.
7. There will be no questions during the exam. Write your concerns or alternative interpretations in exam margins.
8. Write all answers in the space provided on this exam.
9. Be concise and write clearly. Identify your answer to a question by putting a box around it.
10. You may use the backs of pages for "scratch" paper, but if there is work that we should see, be sure to point that out in the main body of the exam.

Problem	Possible	Score
1	25	25
2	20	20
3	25	25
4	30	28
Total	100	

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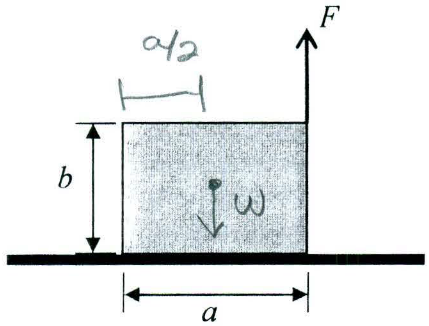
1. Consider a block of mass m resting on a rough horizontal surface. The coefficient of static friction between the block and the surface is μ_s. A vertical force F is applied at the upper right-hand corner of the block, and is slowly increased until the block begins to move.

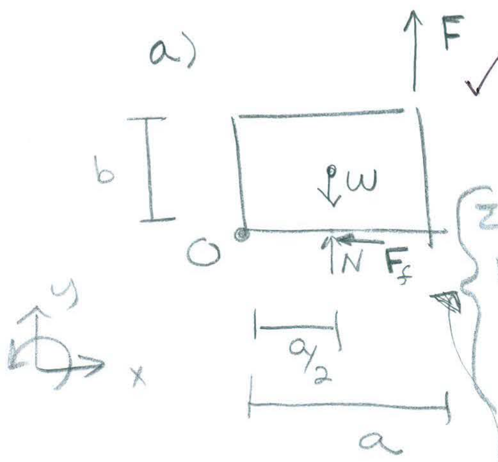
(a) (15 points) Determine the value of the force at which the block ceases to be in static equilibrium and begins to move.

(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.



Equilibrium Equations

a)



$\Sigma F_x = 0 : F_f = 0$ ✓

$W = mg$ ✓

$\Sigma M_O = 0 : (\frac{a}{2})W + (a)F = 0$

$\Sigma F_y = 0 : F + N - W = 0$ ✓

$F + N = W$

max $F \rightarrow N = 0$

$F_f = N\mu_s = 0\mu_s = 0$ ✓

$aF = -\frac{aW}{2}$

$F = -\frac{W}{2} = \frac{-mg}{2}$

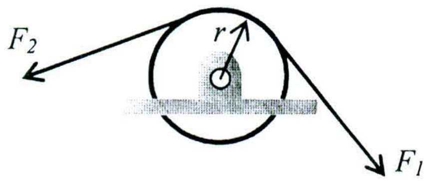
$\boxed{F = \frac{mg}{2}}$ ✓ (up)

b) Tipping will occur because the sum of the forces in the x direction will be zero as long as F is vertical. However, if $F > \frac{mg}{2}$, the sum of the moments $\neq 0$ so the block will tip ✓

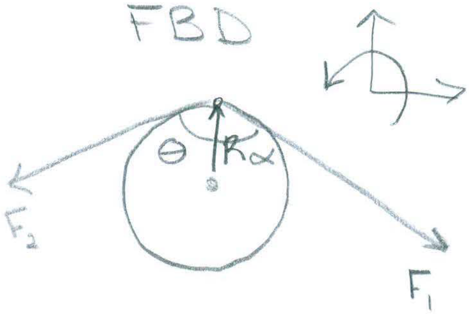
Problem 1 (continued)

Name 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.



FBD



If the tension in the cables are equal, then the sum of the moments acting on the pulley = 0

$$\Sigma M_p = F_2 \times r - F_1 \times r = 0$$

$$\vec{F}_2 \times \vec{r} = \vec{F}_1 \times \vec{r}$$

However, b/c the cable is wrapped around the pulley & is taught, its force is exerted perpendicular to the radius. So r is the $\perp$ distance to either Force

$$F_2(d_\perp) = F_1(d_\perp)$$

$$\frac{F_2 \cancel{r}}{r} = \frac{F_1 \cancel{r}}{r}$$

$F_2 r - F_1 r = 0$

$$F_2 = F_1$$

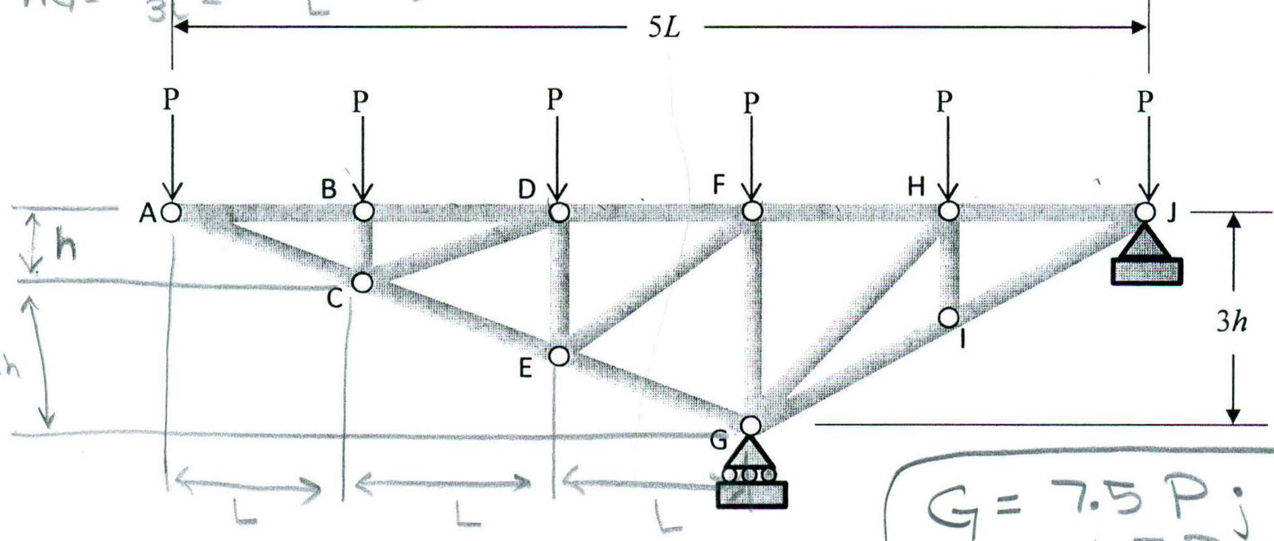
Problem 2 (continued)

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).

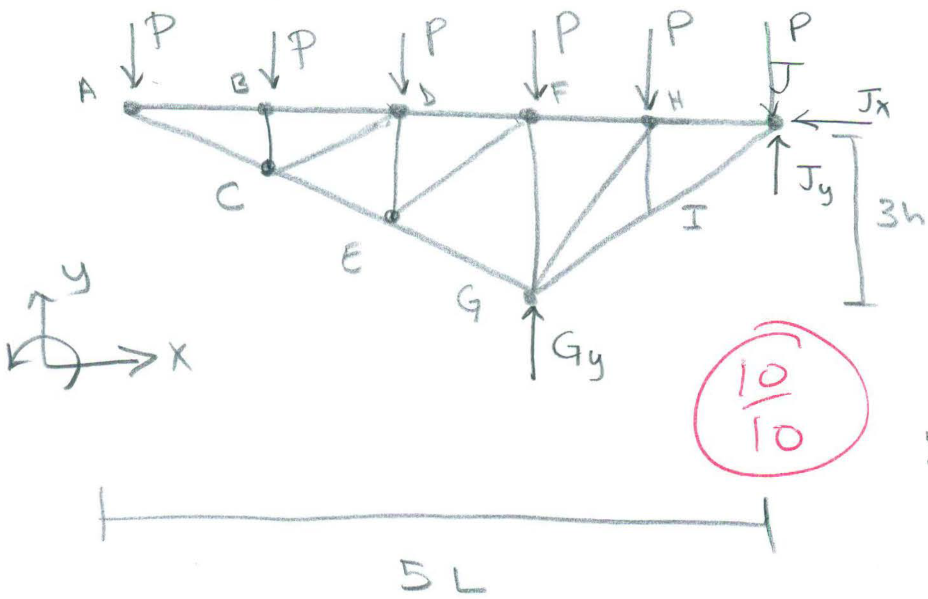
(b) (15 points) Determine the force in member DF. Be sure to indicate clearly whether it is in tension or compression.

Slope AG $= -\frac{3h}{3L} = -\frac{h}{L} \rightarrow$ $\underline{DE = 2h}$



$$\boxed{\begin{aligned} G &= 7.5P\,\hat{j} \\ J &= -1.5P\,\hat{j} \end{aligned}}$$

a) Equilibrium of entire structure



10/10

G:

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

$$P\cancel{L} + 2P\cancel{L} + 3P\cancel{L} + 4P\cancel{L} + 5P\cancel{L} = 2G_y\cancel{L}$$

$$15P = 2G_y$$

$$\frac{15}{2}P = G_y$$

$$\Sigma F_y = -6P + G_y + J_y = 0$$

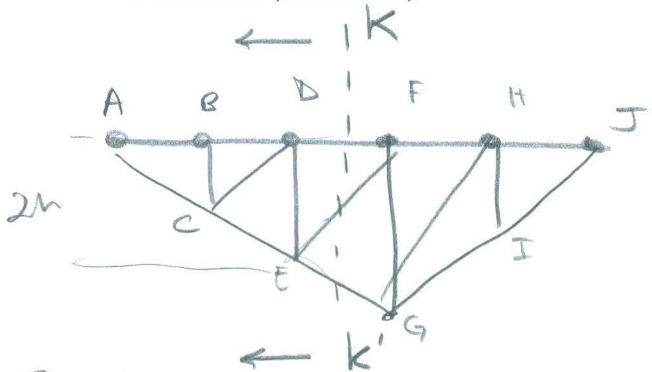
$$-6P + \frac{15}{2}P = -J_y$$

$$-6P + 7.5P = -J_y$$

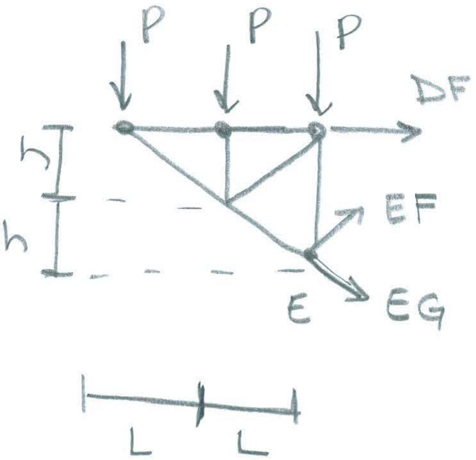
$$-1.5P = J_y$$

$$\Sigma F_x = 0: J_x = 0$$

Problem 3 (continued)



Section KK'



b) Force DF

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

$$2h\,DF = 3PL$$

$$DF = \frac{1.5\,PL}{h} \quad (T)$$

15/15

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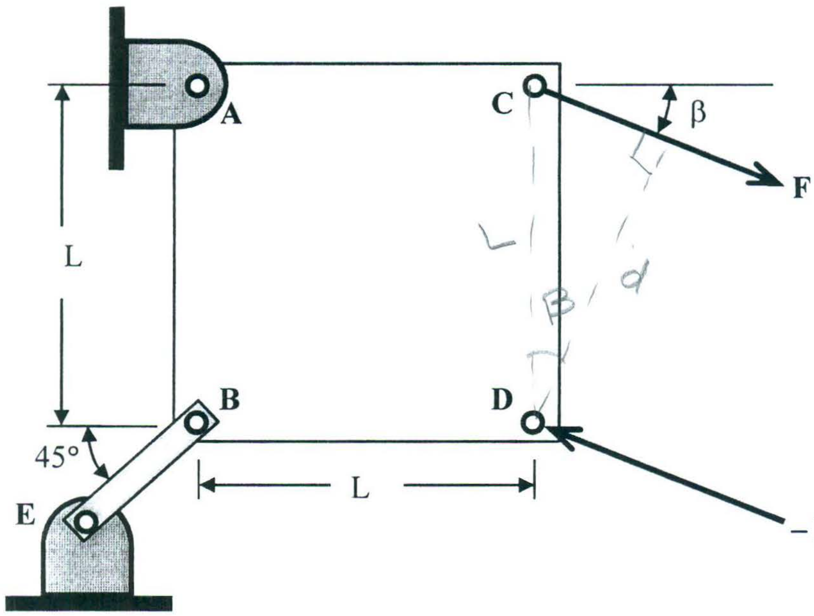
4. (30 points) The square plate shown below can be treated as massless. It is supported at points A and B by a pin and a short link, respectively. It is loaded by equal and opposite forces **F** and –**F** at points C and D.

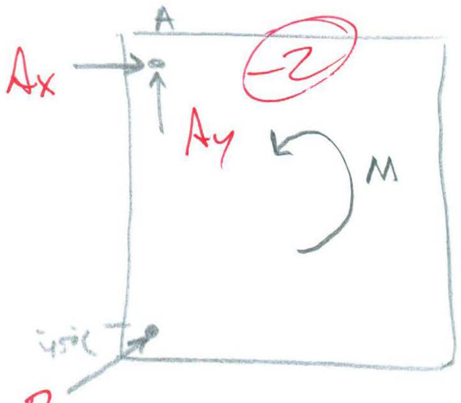
Determine the reaction forces acting on the plate at points A and B.



$d = L\cos\beta$

$M = Fd = FL\cos\beta$ (cw)

couple reduces to a moment



FBD

Equilibrium equations:

$\Sigma M_B = -M - A_x L = 0$

$-M = A_x L$

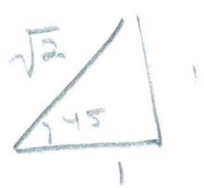
$-FL\cos\beta = A_x L$

$-F\cos\beta = A_x$

$\Sigma F_x = 0: \quad A_x + B_x = 0$

$-F\cos\beta = -B_x$

$F\cos\beta = B_x$



$B_x = B\cos 45°$

$\frac{B_x}{\cos 45°} = \frac{F\cos\beta}{1/\sqrt{2}} = F\sqrt{2}\cos\beta = B$

Problem 4 (continued)

$$\Sigma F_y = 0: \quad A_y + B \sin 45° = 0$$

$$A_y = -B \sin 45°$$

$$= -(F\sqrt{2}\cos\beta)\left(\frac{1}{\sqrt{2}}\right)$$

$$= -F\cos\beta$$

$$A: \quad A = \sqrt{A_y^2 + A_y^2}$$

$$= \sqrt{F^2\cos^2\beta + F^2\cos^2\beta}$$

$$= \sqrt{2}F\cos\beta$$

$A: \sqrt{2}F\cos\beta \; \measuredangle \; 45°$

$B: \sqrt{2}F\cos\beta \; \measuredangle \; 45°$