MAE 101 Fall 2010

Midterm Examination #1

October 25, 2010

Instructor: Professor Gupta

DO ALL WORK ON THE EXAM

ATTTACH ADDITIONAL SHEETS AS NEEDED

WRITE YOUR NAME ON EVERY SHEET YOU USE

NOTE: *ALL* EQUATIONS OF EQUILIBRIUM MUST HAVE

ASSOCIATED FREE BODY DIAGRAMS

Problem 1 14

Problem 2 25

Problem 3 10

Problem 4 30

TOTAL (100) 79

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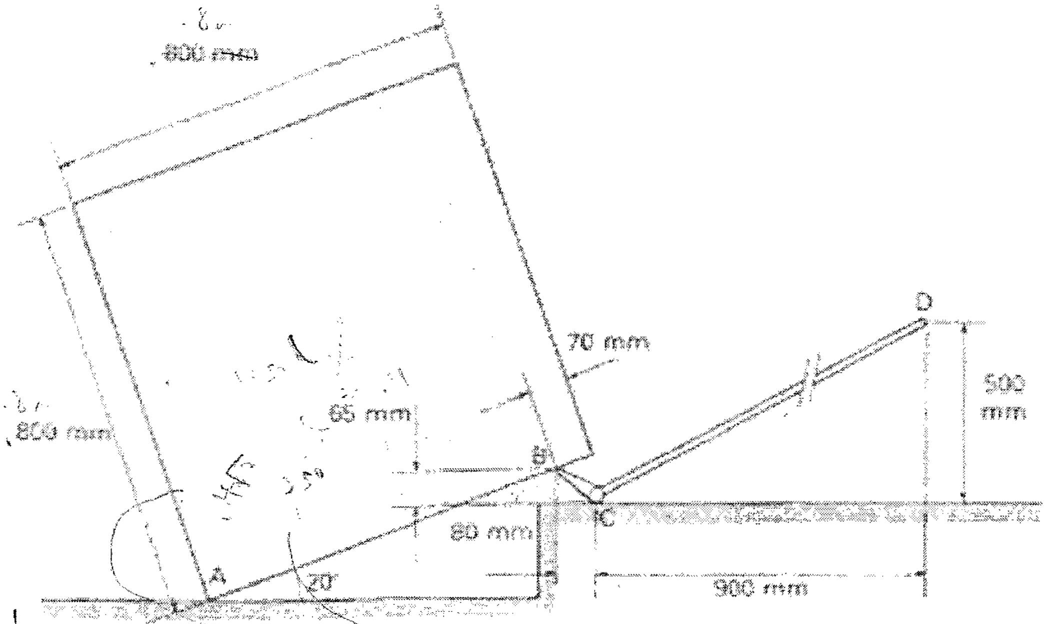
ID: 9027[illegible]

Problem 1: A packing case containing a machine tool and weighing a total of 1.7 kN is being maneuvered with the aid of a light crowbar as shown. Assume that the packaging case at point A rotates freely without slipping, that is, it acts like a pin joint, and the crowbar provides support at point B that is frictionless. The distribution of mass within the case is such that its center of gravity is at the center point. The crowbar rests on frictionless rollers at C, so there is no resistance as C slides along the horizontal direction over the floor. Find the magnitude and direction of the force which must be applied to end D of the crowbar to hold the packing case in equilibrium. (35 points)



$\vec{W} = 1.7$

$\sum F_y = 0$

$\sum M$

$= 0$

$B = $ $= .592$ kN

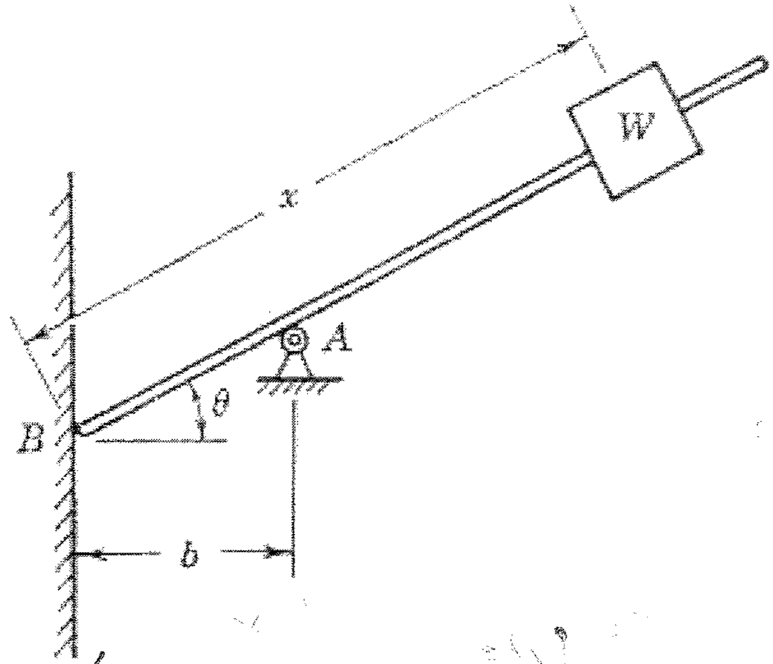
$= 0 = (.08) B - \sqrt{.9^2 + .5^2}\, D$

$D = \dfrac{.08 B}{\sqrt{\;}}$ $= .046$ kN

next page

25

Problem 2: A rigid rod with negligible weight and small radius carries a load W whose position is adjustable. The rod rests on a small roller at A and bears against the vertical wall at B. Determine the distance x for any given value of θ such that the rod will be in equilibrium. Assume that friction is negligible at contact points A and B. (25 points)



$b \tan\theta$

$\Sigma M_{(\text{about } B)}: A(b \sec\theta) - x \times W = 0$

$= A b \sec\theta - x W \sin(90-\theta) = A b \sec\theta - x W \cos\theta = 0$

$\Sigma F_x: B - A \sin\theta = 0$

$\Sigma F_y: A\cos\theta - W = 0$

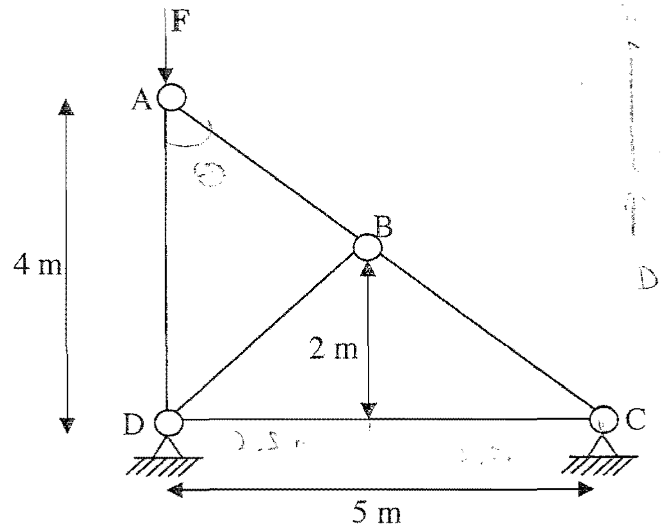
$x = \frac{A b \sec\theta}{W \cos\theta} = \frac{A b}{W\cos^2\theta}$

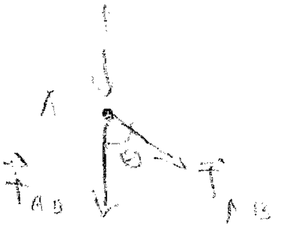
$A = W \sec\theta$

$B = A \sin\theta = W \sec\theta \sin\theta = W \tan\theta$

$x = \frac{A b}{W \cos^2\theta} = \frac{W \sec\theta\, b}{W \cos^2\theta} = \frac{b}{\cos^3\theta}$

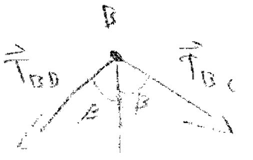
Problem 3: Find the force in member BD of the truss shown below, and indicate whether it is in tension or in compression. (10 points)





$\Sigma F_y: -F - T_{AB} \ldots = 0$

$\Sigma F_x: T \ldots = 0$



$\beta = \tan^{-1}\left(\ldots\right)$

$\Sigma F_x: T_{BC} \sin\beta - T_{BD} \sin\beta = 0$

$\Sigma F_y: -T_{BD} \cos\beta - T_{BC} \cos\beta = 0$

$T_{BC} = T_{BD}$

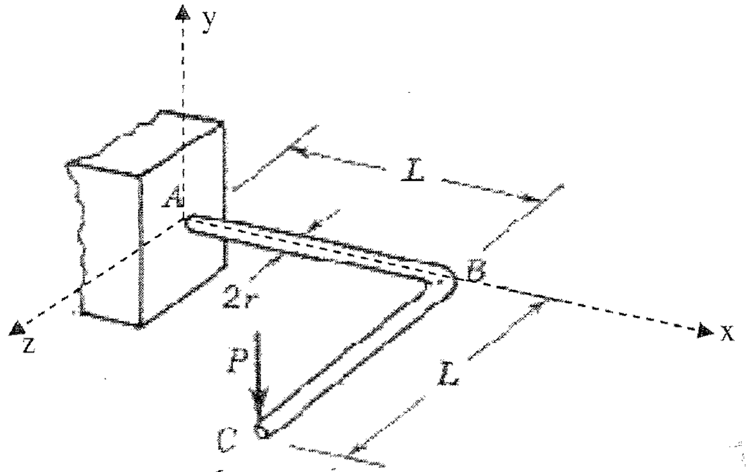
$\Sigma F_y: -T_{BD} \cos\beta - T_{BD} \cos\beta = 0$

10

neither tension nor compression

30

Problem 4: A straight bar of radius r is bent at B to form an L-shaped member ABC so as to form two straight legs AB and BC. It is built-in at A and lies in a horizontal plane when it is unloaded. Find all reactions at A that are necessary for the structure to be in equilibrium for any <u>given</u> value of the applied load P in the vertically downward direction (that is, -y direction). (30 points)

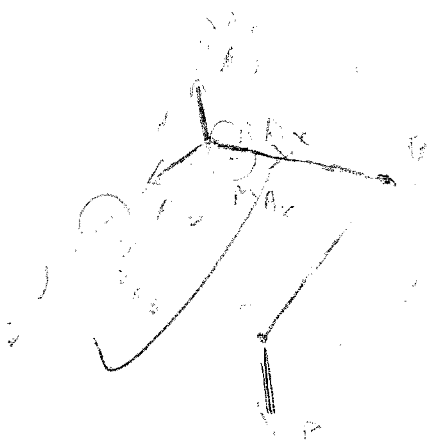


$r(L,0,1)$

$\sum F_x: A_x = 0$

$\sum F_y: A_y - P = 0$

$\sum F_z: A_z = 0$



$\sum M_{(\text{about }A)_x}: M_{A_x} + LP = 0$

$\sum M_{(\text{about }A)_y}: M_{A_y} = 0$

$\sum M_{(\text{about }A)_z}: M_{A_z} - LP = 0$

(moment ...)

$A_x = 0$

$A_y = P$

$A_z = 0$

$M_{A_x} = -LP$ (clockwise direction)

$M_{A_y} = 0$

$M_{A_z} = LP$ (counterclockwise direction)