AA 210. F

AA 210 Statics

Final Exam – Winter 2009

(~~60~~ 100 min, Open Book & Open Notes; show all work and FBD's)

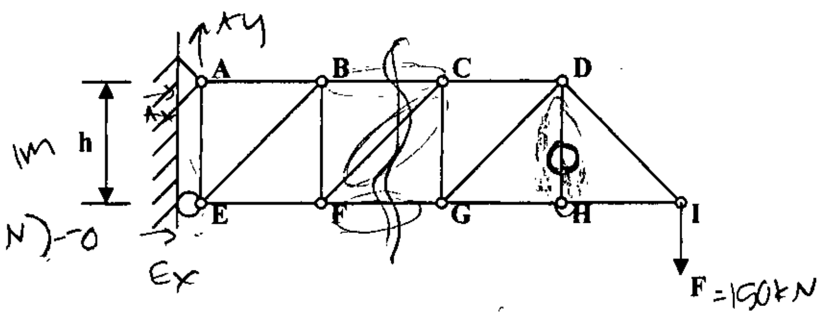
Version A

1. Every horizontal member in a truss, as shown below, is each 1 m in length. F is 150 KN and h is 1 m.
   (a) Determine the axial forces in members BC, CF, and FG and indicate whether they are in tension (T) or compression (C). (12 pts)
   (b) Is there any zero-force member in the truss? If there is, indicate what member is. (3 pts)

$\Sigma F_x = A_x + E_y = 0$

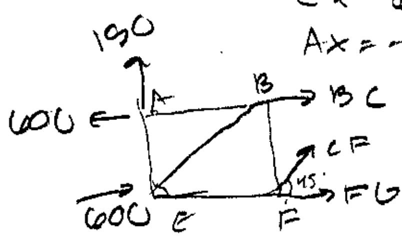
$\Sigma F_y = A_y - 150 = 0 \quad \boxed{A_y = 150}$

$\Sigma M_A = (1m)(E_x) - (4m)(150kN) = 0$



$E_x = 600$

$A_x = -600$



$\Sigma F_x = -600 + 600 + BC + FG + CF\cos 45 = 0$

$\Sigma F_y = 150 + CF\sin 45 = 0$

$CF = \dfrac{-150}{\sin 45} = -212.13\ (C)$

$\Sigma M_F = -(1m)(BC) - (1m)(150) + (1m)(600) = 0$

$BC = 450\ (T)$

$-600 + 600 + 450 + FG + (-212.13)(\cos 45) = 0$

$FG = -300\ (C)$

a.) CF = -212.13 kN (C)
BC = 450 kN (T)
FG = -300 kN (C)

b.) zero force members = $\boxed{DH}$

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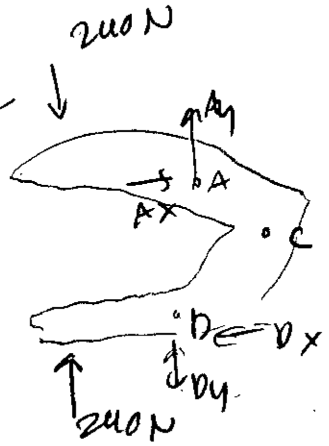
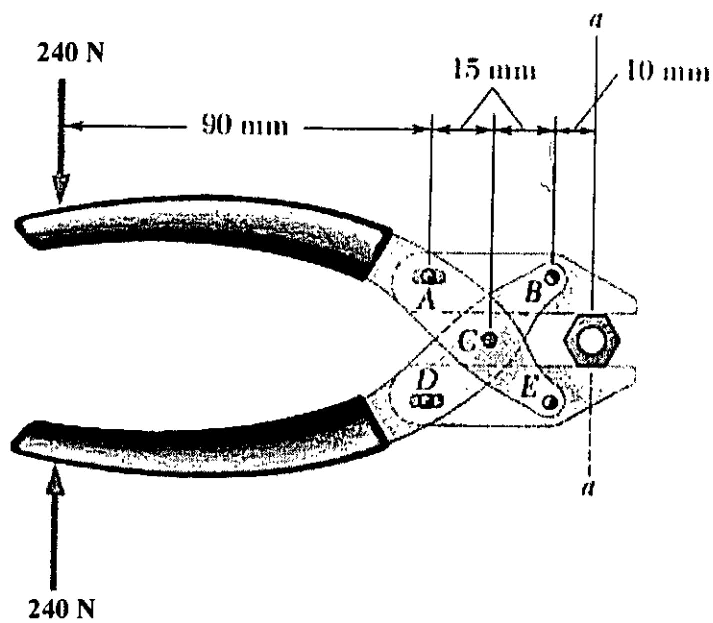
2. Assume that pins A and D slide freely (no friction) in slots cut in the jaws. Determine the magnitude of the gripping force exerted along line a-a on the nut when two 240-N forces are applied to the handles as shown. (15 pts)

member ACO





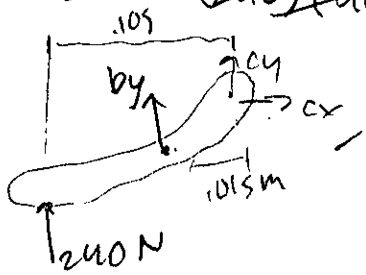
$\Sigma F_x = A_x - D_x = 0 \qquad \underline{A_x = D_x}$

$\Sigma F_y = -240 + 240 + A_y - D_y = 0$

$\underline{A_y = D_y}$

$\Sigma M_D = -(240)\cancel{(90mm)} + \cancel{(240)(90mm)} - d(A_x) = 0 \qquad A_x = 0N$

$D_x = 0\ N$



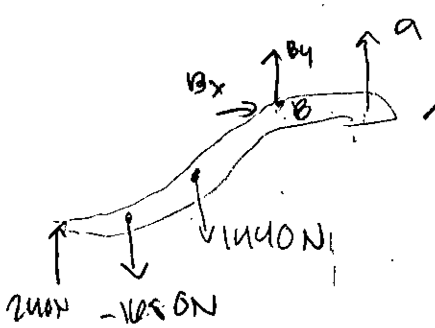
$\Sigma F_x = C_x = 0N$

$\Sigma F_y = C_y + D_y + 240 = 0$

$\Sigma M_c = -(.015m)(D_y) - (240N)(.105) = 0$

$D_y = -1680\ N$

$C_y = 1440\ N$



$\Sigma F_x = B_x = 0$

$\Sigma F_y = 240 - (-1680) - (1440) + B_y + a$

$= 480 + B_y + a$

$\Sigma M_B = (.01m)a + (.015m)(1440) + (.03)(-1680) - (.12)(240) = 0$

$\boxed{a = 9760N}$ ✗ -3

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$\frac{x}{2} = \sin 30$

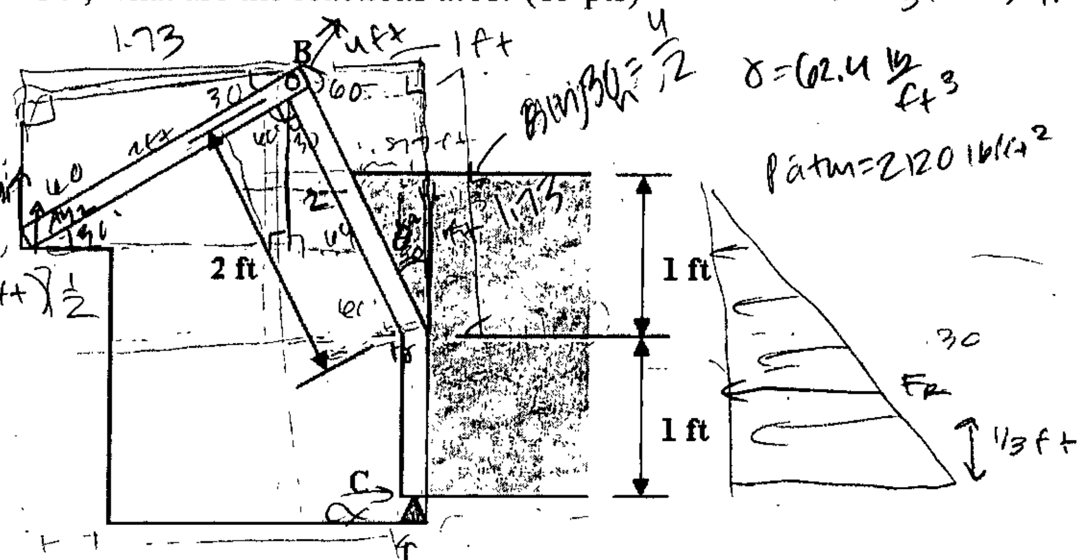
3. The water gate BC is jointed with a member AB which has one end, A, supported by the ground and is perpendicular to water gate at B. The width of the gate and member AB (the dimension into the paper) is 4 ft. The weight density of the water is γ = 62.4 lb/ft^3, and the atmospheric pressure patm = 2120 lb/ft^2. Neglect the weights of the gate and member, and the friction between the member and ground. Assume $\theta = 30^\circ$, what are the reactions at A? (15 pts)

$\bar{x}_{w1} = \frac{1}{3}(.577) = .1923$

$\gamma = 62.4 \frac{lb}{ft^3}$

$p_{atm} = 2120\ lb/ft^2$

$(2)(2\gamma)(8)$



$w_1 = [(1\gamma)(.1 ft)(1 ft)(4 ft)]\frac{1}{2}$
$= 124.8$ lbs

$\cancel{W_2 = (2 ft)(2\gamma)(4)}$
$\cancel{= 998.4 lbs}$

$F_R = (2 ft)(2\gamma)(4)(\frac{1}{2})$
$= 499.2$ lbs ✓

$\Sigma F_x = -499.2 + C_x + AB\cos 30 = 0$

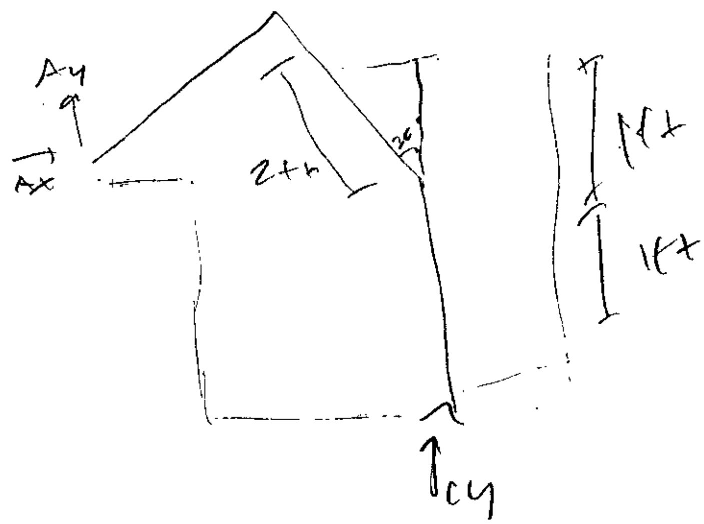
$\Sigma F_y = -124.8 + AB\sin 30 + C_y = 0$

$\Sigma M_C = -(.385)(124.8) - (2.73)(AB\sin 30°) - (2.73)(AB\cos 30°) = 0$

$= (48.048) - AB(2.73\sin 30 - 2.73\cos 30) = 0$

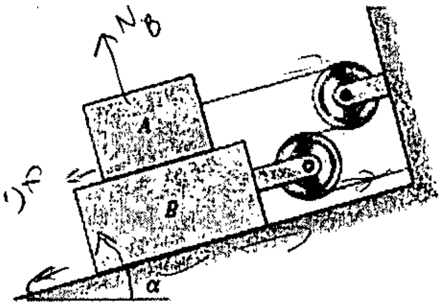
$AB = -48.1$ lbs ✗

$\frac{10}{15}$



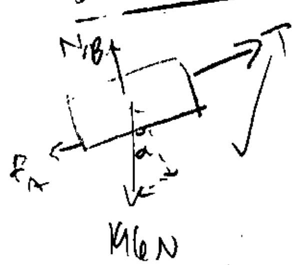
Ay
Ax
2ft
30°
1ft
1ft
Cy

4. The masses of crates A and B are 20 kg and 25 kg, respectively. The coefficient of static friction (μ_s) between all contacting surfaces is 0.34. What is the largest value of α for which the crates will remain in equilibrium? (20 pts)



$\frac{18}{20}$

Block A

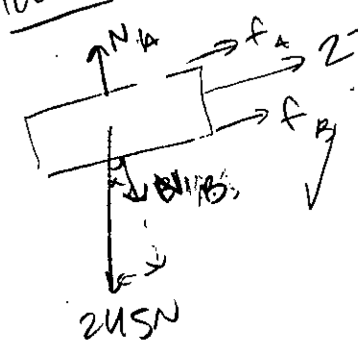


$\Sigma F_x = -f_A + T - 196\sin\alpha = 0$ (1)

$\Sigma F_y = N_B - 196\cos\alpha = 0$

$f_A = (N_B)(.34) = (196\cos\alpha)(.34) = 66.64\cos\alpha$

Block B



$\Sigma F_x = f_A + f_B + 2T - 245\sin\alpha = 0$ (2)

$\Sigma F_y = N_A - N_B - 245\cos\alpha = 0$

$= (196\cos\alpha)(.34) - N_B - 245\cos\alpha = 0$

$f_B = (N_B)(.34) -$

$= (66.64)(\cos\alpha) - 245\cos\alpha = f_B$

(2) $\Sigma F_y = \underbrace{66.64\cos\alpha}_{f_A} + \underbrace{66.64\cos\alpha - 245\cos\alpha}_{f_B} + 2T - 245\sin\alpha = 0$

$\frac{2T}{2} = \frac{-66.64\cos\alpha - 66.64\cos\alpha + 245\cos\alpha + 245\sin\alpha}{2}$

$T = -33.32\cos\alpha - 33.32\cos\alpha + 122.5\cos\alpha + 122.5\sin\alpha$

(1)

$\underbrace{-66.64\cos\alpha}_{f_A} + \underbrace{33.32\cos\alpha - 33.32\cos\alpha + 122.5\cos\alpha + 122.5\sin\alpha}_{T} \underbrace{-196\sin\alpha}_{W_x} = 0$

$-10.78\cos\alpha + 122.5\sin\alpha - 196\sin\alpha = 0$

$-10.78\cos\alpha = -122.5\sin\alpha + 196\sin\alpha = 0$

$-10.78\cos\alpha = 73.5\sin\alpha$

$\frac{-10.78}{73.5} = \tan\alpha$

$\alpha = -8.34°$

(next pg) $\Longrightarrow$

Block A:

f_A

$\Sigma F_x = -.34 N_B + T - 196 \sin\alpha = 0$ ✓

$\Sigma F_y = N_B - 196 \cos\alpha = 0$ ✓

$N_B = 196 \cos\alpha$ $\quad f_A = 66.64 \cos\alpha$

$-66.64 \cos\alpha + T - 196 \sin\alpha = 0$

Block B

$\Sigma F_x: 66.64 \cos\alpha + f_B + 2T - 245 \sin\alpha = 0$ ✓

$\Sigma F_y: N_A - 196 \cos\alpha - 245 \cos\alpha = 0$ ✓

$(N_A)(.34)$ $\quad N_A = 196 \cos\alpha + 245 \cos\alpha$

$f_B = 66.64 \cos\alpha + 83.3 \cos\alpha = 0$

$66.64 \cos\alpha + 66.64 \cos\alpha + 83.3 \cos\alpha + 2T - 245 \sin\alpha = 0$

$T = -33.32 \cos\alpha - 33.32 \cos\alpha - 41.65 \cos\alpha + 122.5 \sin\alpha = 0$

$- 216 \cos\alpha + 122 \sin\alpha$

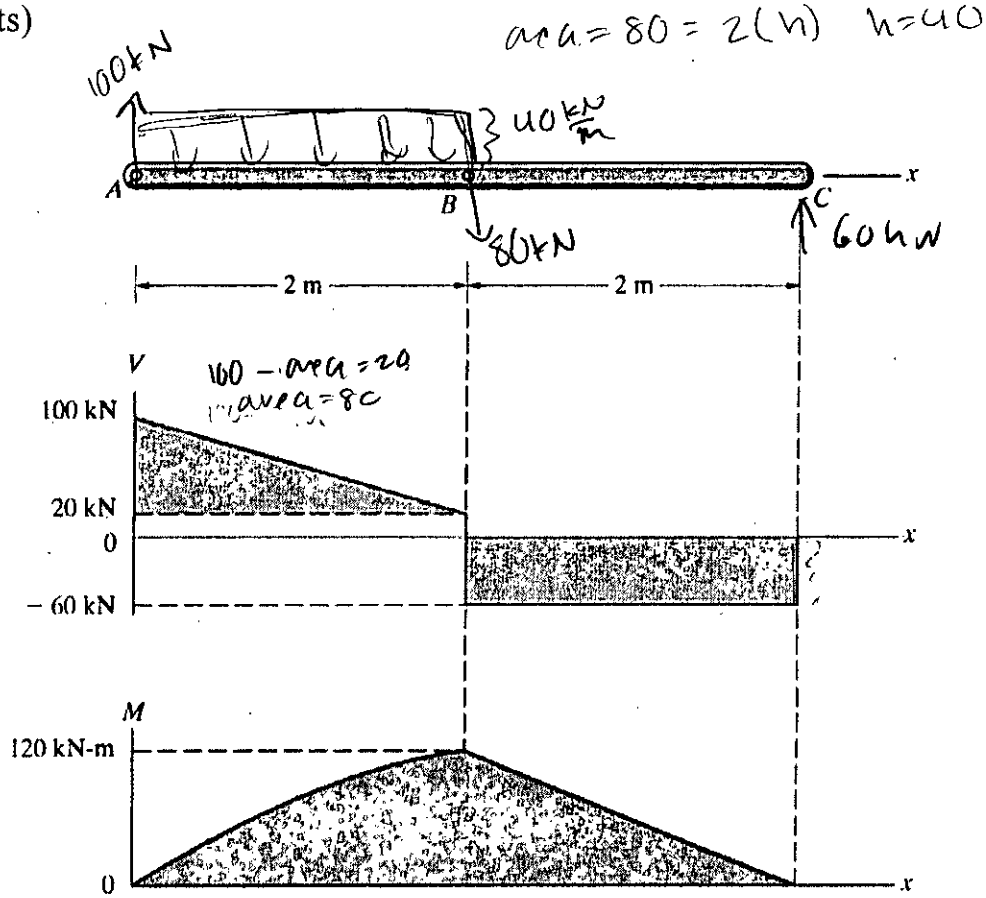
$-66.64 \cos\alpha - 33.32 \cos\alpha - 33.32 \cos\alpha - 41.65 \cos\alpha + 122.5 \sin\alpha - 196 \sin\alpha = 0$

$-108.29 \cos\alpha = (-122.5 + 196) \sin\alpha$

$\boxed{\alpha = -55.83}$ X

5. A beam's shear force and bending moment diagrams are shown as below. $V_A = 100$ KN, $V_{B-} = 20$ KN, $V_{B+} = -60$ KN, and the maximum bending moment M_{max} is 120 KN-m. Determine values of the applied loads (point forces, point couples, or distributed loads) acting on the beam which result in these diagrams and draw them on beam ABC. (20 pts)

area = 80 = 2(h)   h=40



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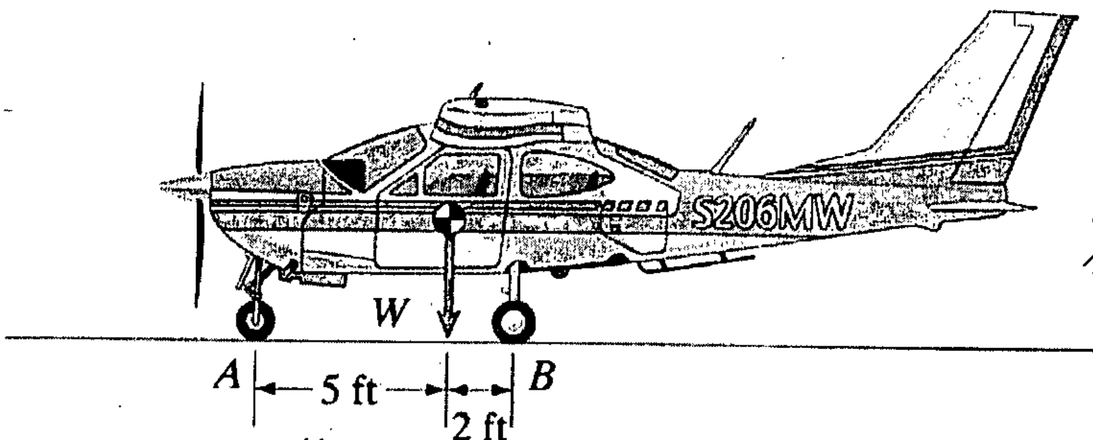
6. The empty airplane shown below has weight 2200 lb and center of gravity location 5 ft right to the point A.
   (a) For maintenance purpose, the engine has to be removed from the airplane. If the engine weighs 500 lb and has a center of gravity 0.25 ft right of point A, where will the airplane's center of gravity be in relation to A once the engine has been moved. (8 pts)
   (b) Now the airplane (complete with engine) is ready for flight. 240 lb of fuel are loaded. The fuel alone has a center of gravity 6 ft to the right of A. Also, two passengers board. They have a combined weight of 340 lb and a center of gravity 4.5 ft right of point A. Where is the center of gravity of fully loaded airplane located in relation A? (7 pts)



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a.)

	w	$\bar{x}$
airplane w/ engine	2200	5ft
engine	-500	.25ft

$$\bar{x} = \frac{(2200\text{ lbs})(5ft) - (500\text{ lbs})(.25ft)}{2200-500}$$

$\boxed{\bar{x} = 6.39\text{ ft (from A}}$ ✓

b.)

	w	$\bar{x}$
airplane w/ engine	2200 lbs	5ft
fuel	240 lbs	6ft
passengers	340 lbs	4.5ft

$$\bar{x} = \frac{(2200)(5ft) + (240)(6ft) + (340)(4.5ft)}{2200+240+340}$$

$= \boxed{5.03\text{ ft (from A)}}$ ✓

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