AA 210 Statics

Midterm #1 – Winter 2009

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

Version C

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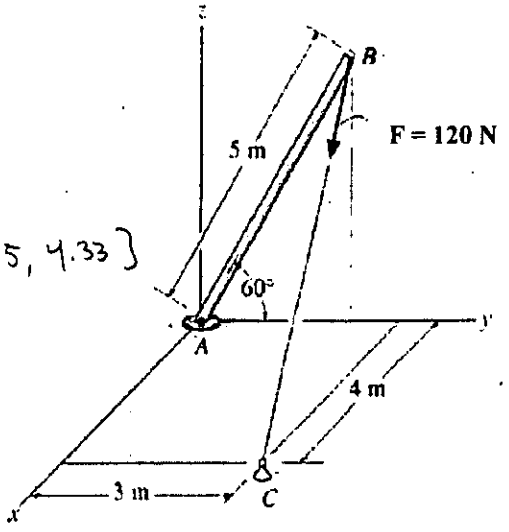
1. The 5m long boom AB lies in the y-z plane and the cable exerts a force of F = 120 N at B.
   a) Determine the moment vector (M_A) of the force F about point A. (12 pts)
   b) Determine the shortest distance between the cable and point A. (7 pts)
   c) Determine the moment vector of the force about the y-axis. (6 pts)



11/12 a) $B = (0, 2.5, 4.33)$

$C = (4, 3, 0)$

$r_{BC} = [4, 0.5, -4.33]$ $r_{AB} = [0, 2.5, 4.33]$

$e_{BC} = \dfrac{4i + 0.5j - 4.33k}{\sqrt{4^2 + .5^2 + 4.33^2}}$

$= .676i + .0845j - .732k$ ✓

$\vec{F} = |F| \cdot e$

$= 120(.676i + .0845j - .732k)$

$= 81.12i + 10.14j - 87.84k$

$M_A = r_{AB} \times \vec{F} = \begin{vmatrix} i & j & k \\ 0 & 2.5 & 4.33 \\ 81.12 & 10.14 & -87.84 \end{vmatrix} = \boxed{175.7i + 351.25j - 202.8k \ (N \cdot m)}$ ✗

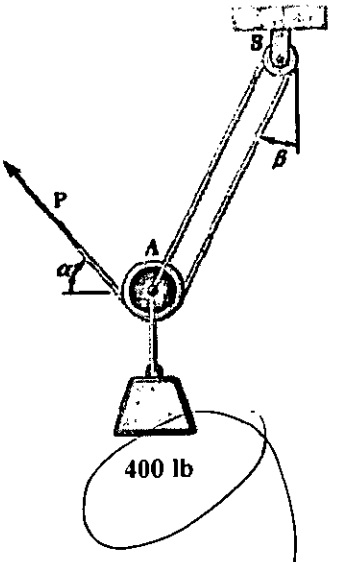
7/7 b) $d = \dfrac{|r_{BA} \times r_{BC}|}{|r_{BC}|}$ → $r_{BA} \times r_{BC} = \begin{vmatrix} i & j & k \\ 0 & -2.5 & -4.33 \\ 4 & 0.5 & -4.33 \end{vmatrix} = 13i + 17.32j - 10k$

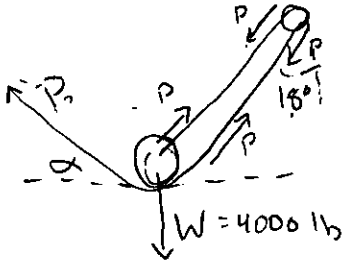
$d = \dfrac{\sqrt{(13)^2 + (17.32)^2 + (10)^2}}{\sqrt{4^2 + .5^2 + 4.33^2}} = \boxed{4.03 \text{ m}}$ ✓

6/6 c) The total moment about the y-axis is the y component of M_A:

$\boxed{\Sigma M_{y\text{ axis}} = 351.25 \ (N \cdot m)}$ ✓

2. A 400-lb load is supported by the rope-and-pulley arrangement shown. Knowing that $\beta = 18°$, determine the magnitude and direction (only consider $\alpha > 0$) of the force P which should be exerted on the free end of the rope to maintain equilibrium. Show the FBD. (25 pts)





$\Sigma F_y = 2P\cos 18 - 4000\text{ lb} + P\sin\alpha = 0$

$\Sigma F_x = 2P\sin 18 - P\cos\alpha = 0$

$2P\sin 18 = P\cos\alpha$

$2\sin 18 = \cos\alpha$

$\alpha = 51.83°$ ✓

$P_1(2\cos 18° + \sin 51.83°) = 4000$ -3

$P = 1487.9\text{ lb}$

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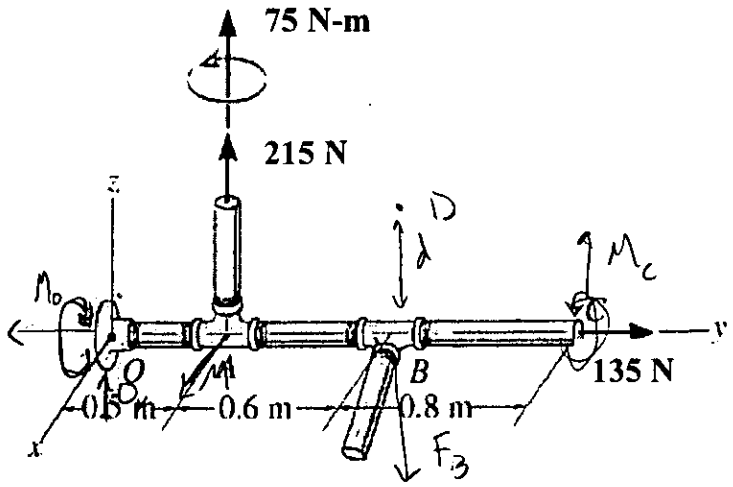
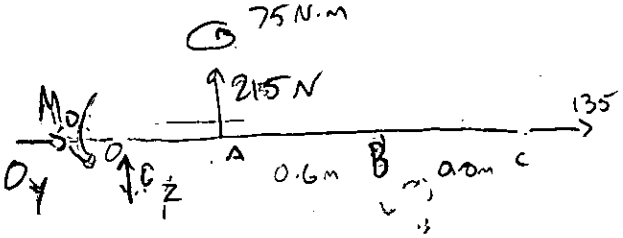
3. Replace the wrench and force acting on the pipe assembly by an equivalent force and couple moment at point O. (25 pts)





$\Sigma M_O = -75\ N\cdot m + 215(0.6) + F_{2D}(1.1) + 135(1) - F_{y_O}(d) = 0$

$\Sigma \vec{M}_O = (215\ N)(0.5\ m) + 75\ N\cdot m - M_{BO}(1.1) = 0$

$\Sigma \vec{F}_z = O_x + 215 = 0$

$\Sigma F_y = O_y + 135N = 0$

$O_z = -215\ N$

$O_y = -135\ N$ ✓

$M_O = +32.5\ N\cdot m$ −12

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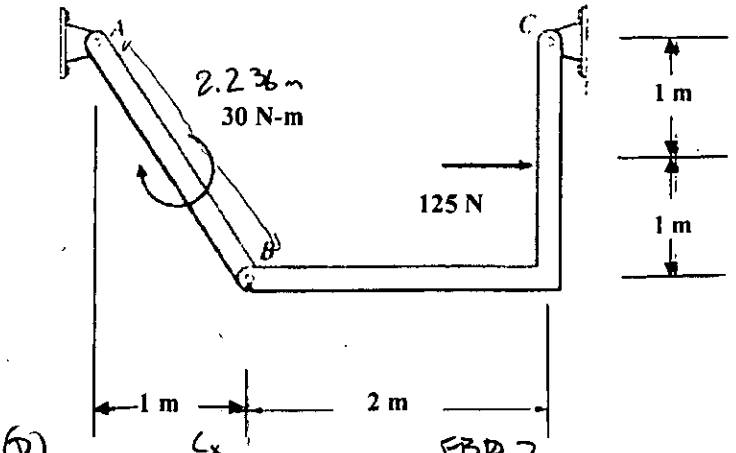
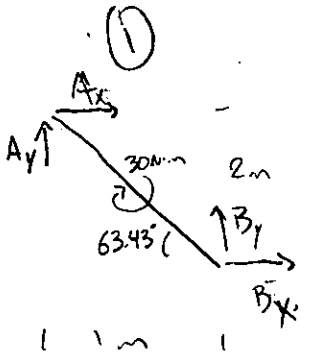
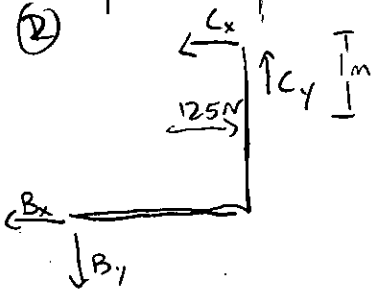
4. Determine the reactions at A and C. Show all FRD's used for solving this problem. (25 pts)







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FBD 2

$\Sigma M_C = (125)(1m) - B_x(2m) + B_y(2m) = 0$

FBD 1

$\Sigma M_A = -30\ N\cdot m + B_x(2m) + B_y(1m) = 0$

$\Sigma F_x = A_x + B_x = 0$

$125 - 2B_x + 2B_y = -30 + 2B_x + B_y$

$155 - 4B_x = -B_y$

$B_y = (4B_x - 155)$

$-30 + B_x(2m) + 4B_x - 155 = 0$

$B_x = 30.83\ N$

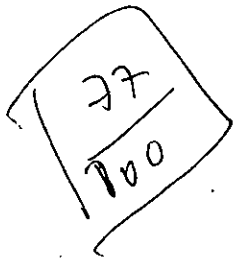
$B_y = -31.67$

$A_x = -B_x = -30.83$ ✗

$A_y = -B_y = 31.67$ ✓

$C_x = B_x = 30.83$ ✗

$C_y = B_y = -31.67$ ✓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