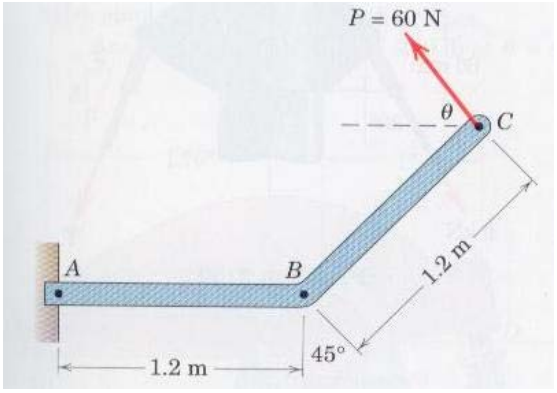
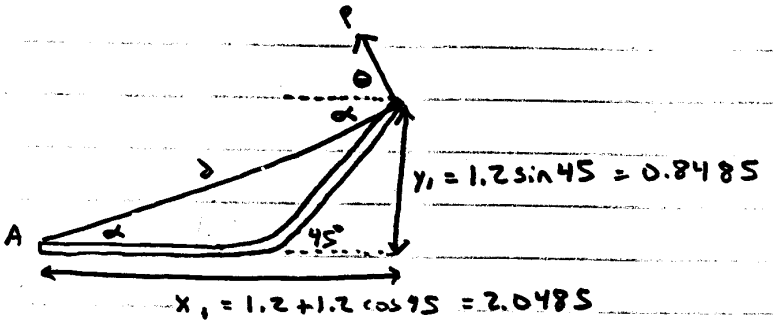
EGR 140 - Statics
File: N140T2J2S

Solution to Test #2

Instructions: Work 6 out of 7 problems on the test. Clearly mark OMIT on the problem to be omitted. If you do not mark OMIT on one of the problems, problem 7 will be automatically omitted.

1. (16.67 points) A 60-N force P is applied at point C of the bent bar shown. If θ = 45°, determine $\overline{M}_A$, the moment about point A due to force P (both magnitude and direction).





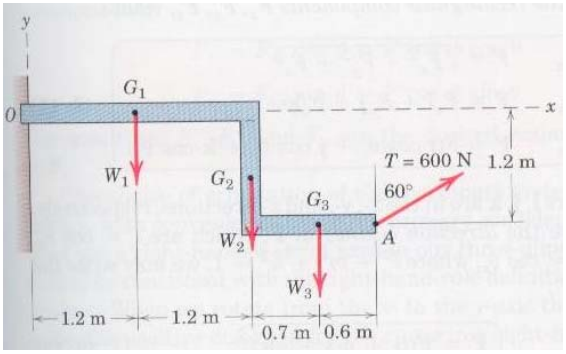
a) $P_x = 60\cos 45 = 42.43\ N$

$P_y = 60\sin 45 = 42.43\ N$

$\Sigma M_A = (42.43)(1.2 + 1.2\cos 45) + (42.43)(1.2\sin 45)$

$\boxed{\overline{M}_A = 122.9\ N\cdot m\ \circlearrowleft}$

2. (16.67 points) The structure shown is composed of bars of masses m_1 = 60 kg and $m_2 = m_3$ = 30 kg. The locations of the corresponding weights W_1, W_2, and W_3 are shown below. In addition, a force T = 600 N acts at point A.
   a. Determine $\overline{R}$, the resultant of the four forces (both magnitude and direction)
   b. Determine $\overline{M}_O$, the moment about point O due to the four forces (both magnitude and direction)
   c. Determine where the resultant should be placed. In particular, determine the x-coordinate of the point where the resultant intersects the x-axis.



$W_1 = (60\ kg)(9.81\ m/s^2) = 588.6\ N$

$W_2 = W_3 = (30\ kg)(9.81\ m/s^2) = 294.3\ N$

Original System:

$\overline{R} = \Sigma F = \overline{W}_1 + \overline{W}_2 + \overline{W}_3 + \overline{T}$

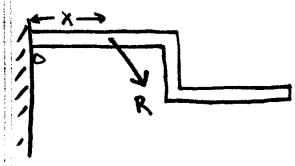
$\overline{R} = -588.6\,j - 294.3\,j - 294.3\,j + \underbrace{600\sin 60}_{519.6}\,i + \underbrace{600\cos 60}_{300}\,j$

$\boxed{\overline{R} = 519.6\,i - 877.2\,j\ N}$

$\Sigma \overline{M}_O = -(588.6)(1.2) - (294.3)(2.4) - (294.3)(3.1) + (300)(3.7) + (519.6)(1.2)$

$\boxed{\Sigma \overline{M}_O = -591.4\ N\cdot m \quad \text{or} \quad 591.4\ N\cdot m\ \circlearrowright}$

Equivalent System:

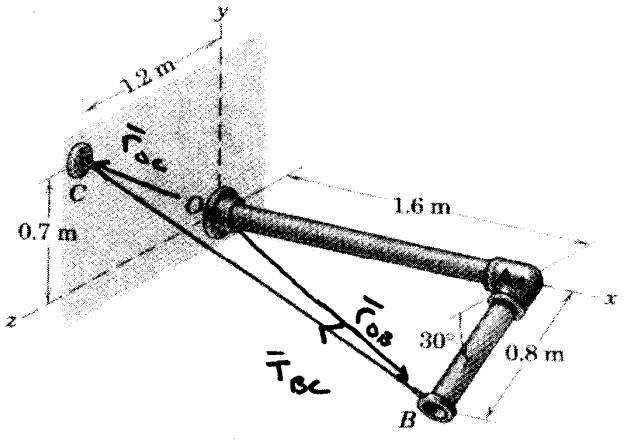


only the y-component of $\overline{R}$ produces a moment, so

$\Sigma \overline{M}_O = -591.4 = -(877.2\ N)(x)$

$\boxed{x = 0.674\ m}$

3. (16.67 points) Cable BC exerts a 750-N force on the right-angle pipe OAB. Determine $\overline{M}_O$, the moment produced about point O due to the force in cable BC.



$\bar{M}_o = \bar{r}_{OC} \times \bar{T}_{BC} = \bar{r}_{OB} \times \bar{T}_{BC}$

$\bar{r}_{OC} = 0.7j + 1.2k$

$\bar{r}_{OB} = 1.6i - 0.8\sin 30 j + 0.8\cos 30 k$

$\bar{r}_{OB} = 1.6i - 0.4j + 0.693k$

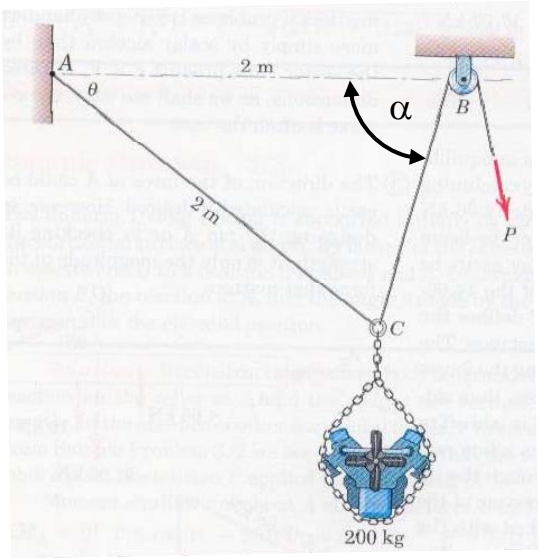
$\bar{T}_{BC} = 750 \cdot \lambda_{BC} = 750 \cdot \text{unit}\vec{V}[-1.6,\ 0.7+0.8\sin 30,\ 1.2-0.8\cos 30]$

$= 750 \cdot \text{unit}\vec{V}[-1.6,\ 1.1,\ 0.5072]$ $(BC = 2.007)$

$\bar{T}_{BC} = -597.9i + 411.1j + 189.5k$ N

$\bar{M}_o = \bar{r}_{OC} \times \bar{T}_{BC} = \bar{r}_{OB} \times \bar{T}_{BC} = -360.7i - 717.5j + 418.5k$ N·m

4. (16.67 points) Determine the force P required to maintain the 200-kg engine in the position for which θ = 30°. The diameter of the pulley at B is negligible. (Line AB is horizontal.)



Law of cosines:

$BC^2 = 2^2 + 2^2 - 2(2)(2)\cos(30°)$

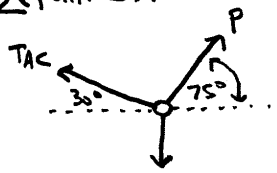
$BC = 1.035$ m

Law of sines:

$\frac{\sin\alpha}{2} = \frac{\sin 30}{1.035}$

$\alpha = 75°$

FBD (point C):



$(200\text{ kg})(9.81\text{ m/s}^2) = 1962$ N

$\Sigma F_x = 0 = -T_{AC}\cos 30 + P\cos 75$

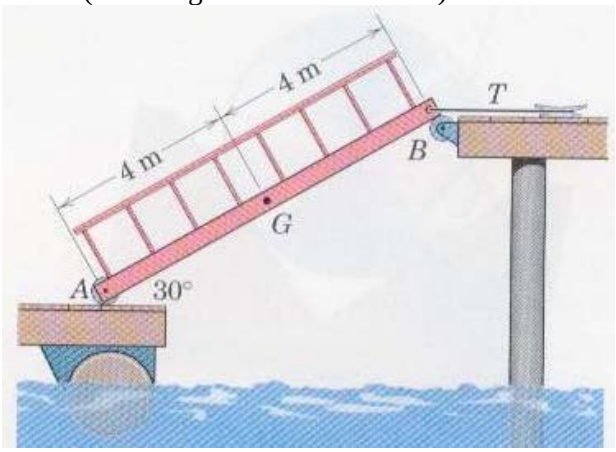
$\Sigma F_y = 0 = T_{AC}\sin 30 + P\sin 75 - 1962$

solving ① & ② yields:

$T_{AC} = 525.7$ N

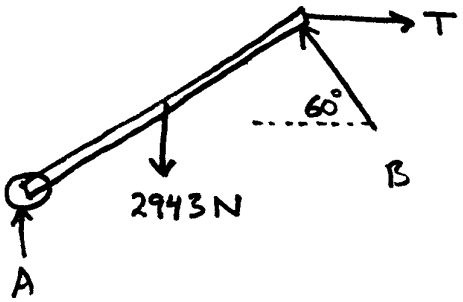
$P = 1759.1$ N

5. (16.67 points) To accommodate the rise and fall of the tide, a walkway from a pier to a float is supported by two rollers as shown. If the mass center of the 300-kg walkway is located at G, determine the reactions at A and B (both magnitude and direction) and the tension T in the horizontal cable which is tied to a cleat.



FBD: $W = (300\ kg)(9.81\ m/s^2)$

$W = 2943\ N$



$\Sigma M_B = 0 = -(A)(8\cos 30) + (2943)(4\cos 30)$

$\Sigma F_y = 0 = 1472 - 2943 + B\sin 60$,

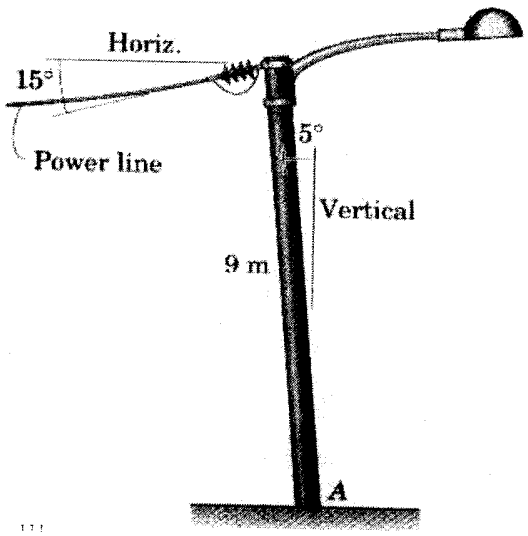
$\Sigma F_x = 0 = T - 1699\cos 60$,

$\overline{A} = 1472\ N \uparrow$

$\overline{B} = 1699\ N \angle 60^o$

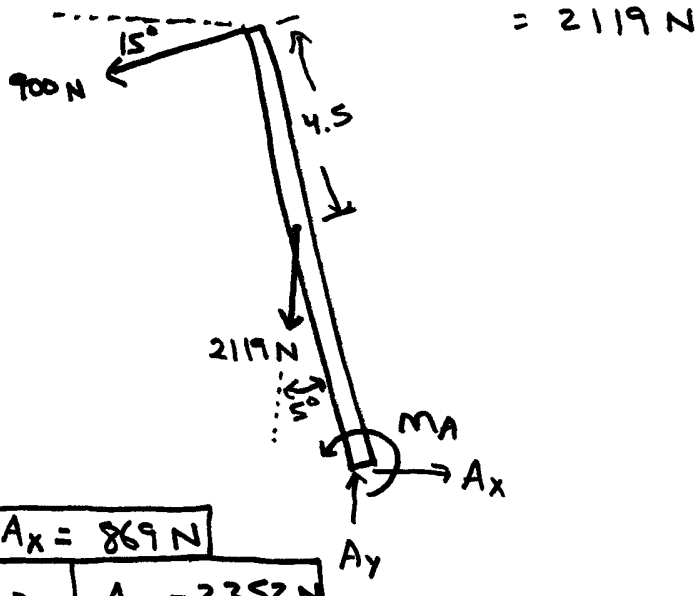
$T = 849.5\ N$

6. (16.67 points) Because of the long-term loading from the 900-N tension in the power line, the uniform 216 kg utility pole has developed a 5° lean. If the mass of the lamp fixture is negligible, determine the reaction at the ground support A. Box your results.



FBD, pole: $W = (216\ kg)(9.81\ m/s^2)$

$= 2119\ N$



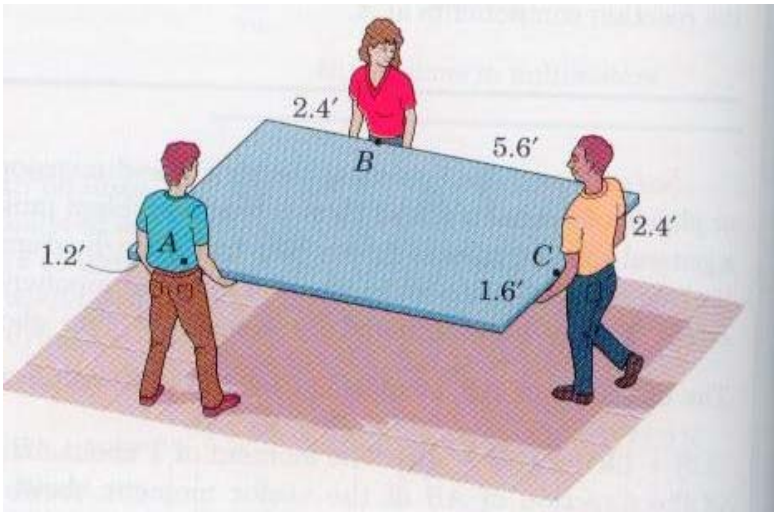
$\Sigma F_x = A_x - 900\cos(15) = 0 \rightarrow$ **$A_x = 869\ N$**

$\Sigma F_y = 0 = -2119 - 900\sin(15) + A_y \rightarrow$ **$A_y = 2352\ N$**

$\Sigma M_A = M_A + (2119)(4.5\sin 5^\circ) + (900\cos 15)(9\cos 5) + (900\sin 15)(9\sin 5)$

$M_A = -8808\ N\cdot m = 8808\ N.m$ ↺

7. (16.67 points) Three workers are carrying a 4-ft by 8-ft panel in the horizontal position shown. If the workers exert vertical forces at points A, B, and C, determine F_A, F_B, and F_C, the forces exerted by each worker, if the panel weighs 100-lb.



$\bar{A} = A\,j$

$\bar{B} = B\,j$

$\bar{C} = C\,j$

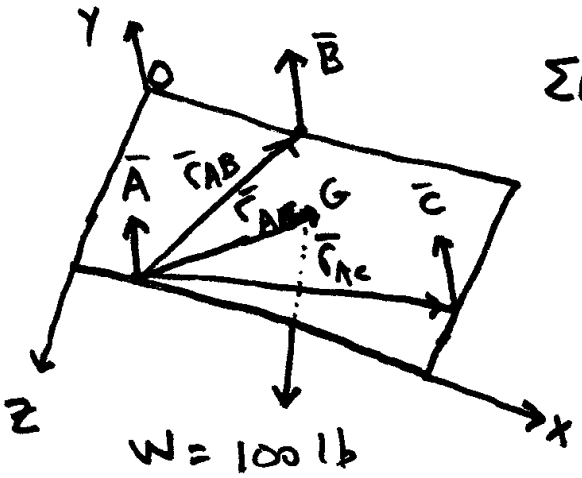
$\bar{r}_{AB} = 1.2i - 4K$

$\bar{r}_{AC} = 6.8i - 1.6K$

$\bar{r}_{AG} = 2.8i - 2K$

$\bar{W} = -100\,j$

FBD:



$\Sigma m_A = 0 = \bar{r}_{AB} \times \bar{B} + \bar{r}_{AC} \times \bar{C} + \bar{r}_{AG} \times \bar{W}$

$\Sigma m_A = 0 = (1.2i - 4K) \times (B\,j) + (6.8i - 1.6K) \times (C\,j) + (2.8i - 2K) \times (-100\,j)$

$\Sigma m_A = 1.2BK + 4Bi + 6.8CK + 1.6Ci - 280K - 200i$

$\Sigma m_x = 0 = 4B + 1.6C - 200$

$\Sigma m_z = 0 = 1.2B + 6.8C - 280$

$\Sigma f_y = 0 = A + B + C - 100$ so

$4B + 1.6C = 200$

$1.2B + 6.8C = 280$

$\rightarrow$ $B = 36.1$ lb, $C = 34.8$ lb

A 29.1 lb