ENGR 20

Summer 2011

Exam # 2

June 2, 2011

Time: two hours

Open FE Statics notes, closed book and other notes
1. Given: The space diagram; support A is fixed.
   Required:
   a) Draw a free-body diagram of the system. (3)
   b) Determine the reactions at support A. (12)

   \[ \sum F_x = 0; \quad A_x + 400 \cos 30^\circ = 0 \]
   \[ \Rightarrow A_x = -346 \text{ N} \]

   \[ \sum F_y = 0; \quad A_y - 200 - 200 - 200 - 400 \sin 30^\circ = 0 \]
   \[ \Rightarrow A_y = 800 \text{ N} \]

   \[ \sum M_A = 0; \quad M_A - 2.5 \times (200) - 3.5 \times (200) - 4.5 \times (200 - 400 \sin 30^\circ) \]
   \[ - 2.56 \times 400 \cos 30^\circ = 0 \]
   \[ \Rightarrow M_A = 3900 \text{ N.m} \]
2. Given: The space diagram below; the weight is 200 lbs.
   Required:
   a) Draw a free-body diagram of the system (4)
   b) Determine the reaction at the ball-and-socket joint A and the tension in each of the wires. (15)

   \[
   \begin{align*}
   \vec{T}_{BD} &= \vec{T}_{ED} \\
   \vec{T}_{CD} &= \vec{T}_{BD} \left( -\frac{4}{5} \hat{j} + \frac{2}{5} \hat{k} \right) \\
   \vec{T}_{EF} &= \vec{T}_{EF} \\
   \vec{A} &= A_x \hat{i} + A_y \hat{j} + A_z \hat{k} \\
   \vec{W} &= -200 \hat{k} \\
   \end{align*}
   \]

   \[\text{Force vectors:}\]

   \[\text{Free body diagram:}\]

   \[\text{Force equilibrium:}\]

   \[
   \begin{align*}
   \Sigma F_x &= 0 \Rightarrow \Sigma i = 0; \quad A_x = 0 \\
   \Sigma F_y &= 0 \Rightarrow \Sigma j = 0; \quad -\frac{4}{5} \vec{T}_{CD} + A_y = 0 \Rightarrow A_y = 0 \\
   \Sigma F_z &= 0 \Rightarrow \Sigma k = 0; \quad \vec{T}_{BD} + \frac{3}{5} \vec{T}_{CD} + \vec{T}_{EF} + A_z - 200 \hat{k} = 0 \Rightarrow A_z = -30 \hat{k} \\
   \end{align*}
   \]
3. Given: the space diagram below.
Required:
   a) Draw the Free-Body Diagram of member (3)
   b) Get external reactions at supports A and C. (6)
   c) Use equilibrium to determine the internal forces just to the right of B. (9)

\[ \Sigma M_A = 0 \]
\[ -2.5 \times 10 \text{kN} \cdot \text{m} - 50 \text{kN} \cdot \text{m} + C_y (10 \text{m}) = 0 \]
\[ \Rightarrow C_y = 7.5 \text{N} \]

\[ \Sigma F_x = 0; \]
\[ A_x = 0 \]

\[ \Sigma F_y = 0; \]
\[ A_y - 10 \text{kN} + C_y = 0 \]
\[ \Rightarrow A_y = 2.5 \text{N} \]

\[ \Sigma M_B = 0 \]
\[ N_B \times 5 \text{m} + C_y = 7.5 \text{N} \]

\[ \Sigma F_x = 0; \]
\[ N_B = 0 \]

\[ \Sigma F_y = 0; \]
\[ V_B + 7.5 \text{N} = 0 \]
\[ \Rightarrow V_B = -7.5 \text{N} \]

\[ \Sigma M_B = 0; \]
\[ -M_B + 5 \text{m} (7.5 \text{N}) = 0 \]
\[ \Rightarrow M_B = 37.5 \text{N} \cdot \text{m} \]
4. Given: The system which is fixed at $O$.
Required: determine the internal forces and moments at section $H$, which is 5 ft from the ground along the pole. (15)

So, $V_{zh} = 0$, $M_{yh} = 0$, $M_{zh} = 0$

Equilibrium at 2-0 FBD:
\[ \Sigma F_x = 0, -80 + N_{zh} = 0 \Rightarrow N_{zh} = -80 \]  
\[ \Sigma F_y = 0, -V_{yh} + 120 \sin 45^\circ = 0 \Rightarrow V_{yh} = 84.8 \]  
\[ \Sigma M_{zh} = 0, M_{xh} + 80(3') - 120 \sin 45^\circ(9') = 0 \Rightarrow M_{xh} = 524 \text{ ft-lb} \]
5. Given: the truss below.
Required:
   a) Determine the force in members CD, HD, HG, GF, and JA. (15)
   b) List three assumptions used to analyze a truss. (3)

\[ \sum F_x = 0; \quad G F = 0 \]
\[ J A = -30 \text{kN} \]
\[ \sum F_y = 0; \quad J A = -30 \text{kN} \text{ or } 30 \text{kN} \]

Get reaction at E from global equilibrium:
\[ \sum M_A = 0; \quad -20(4) - 20(8) - 40(12) + E_y(16) = 0 \Rightarrow E_y = 45 \text{kN} \]

FBD of right of cut:
\[ \sum F_y = 0; \quad H G (40^2 - 40 \text{kN} + 45 \text{kN}) = 0 \Rightarrow H G = 45 \text{kN} \]
\[ \sum M_D = 0; \quad H G (4) + 45 (8) - C D (4) = 0 \Rightarrow C D = 50 \text{kN} \]

b) All members are two-force members (forces only applied at pins)
   - All pins are fixed (infinite)
   - All members are weightless.

Summary:
\[ GF = 0 \]
\[ JA = 30 \text{kN} \text{ C} \]
\[ HD = 7.07 \text{kN} \text{ C} \]
\[ HG = 45 \text{kN} \text{ C} \]
\[ CD = 50 \text{kN} \text{ T} \]
   Required:
   a) Draw a Free Body Diagram of each member in the pliers and pin B. (5)
   b) Use equilibrium to determine the clamping force at B. (10)

\[ \Sigma M_A = 0 \rightarrow 250 \text{mm} (100 \text{N}) + F_B (50 \text{mm}) = 0 \]
\[ \Rightarrow F_B = 500 \text{N} \]