1. The 20-ft pole is acted upon by an 840-lb force as shown. It is held by a ball and socket at A and by the two cables BD and BE. Neglecting the weight of the pole, determine the tension in each cable. **Full credit for this problem is given only if there is a correct Free Body Diagram (FBD).** The FBD may be a separate diagram or clearly marked and labeled forces/reactions superimposed on the figure given below.
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![Diagram](image)

\[ \overrightarrow{BD} = 12\hat{x} - 14\hat{y} - 12\hat{z} \quad \overrightarrow{BD} = 22 \]

\[ \overrightarrow{BE} = 12\hat{x} - 14\hat{y} + 12\hat{z} \quad \overrightarrow{BE} = 22 \]

\[ \overrightarrow{T_{BD}} = \frac{T_{BD}}{22} (12\hat{x} - 14\hat{y} - 12\hat{z}) = \frac{T_{BD}}{22} (4\hat{x} - 7\hat{y} - 6\hat{z}) \]

\[ \overrightarrow{T_{BE}} = \frac{T_{BE}}{22} (6\hat{x} - 7\hat{y} + 6\hat{z}) \]

\[ 2\overrightarrow{M_A} = 0 = 2(\overrightarrow{r} \times \overrightarrow{F}) = 2 \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix} \]

\[ 0 = \begin{vmatrix} -j & k \\ 0 & 20 & 0 \\ -840 & 0 & 0 \end{vmatrix} + \frac{T_{BD}}{22} \begin{vmatrix} -j & k \\ 0 & 14 & 0 \\ 6 & -7 & -6 \end{vmatrix} + \frac{T_{BE}}{22} \begin{vmatrix} -j & k \\ 0 & 14 & 0 \\ 6 & -7 & 6 \end{vmatrix} \]

\[ 0 = (20)(-840) + \frac{14T_{BD}}{22} \begin{vmatrix} -4\hat{x} - 6\hat{z} \\ 10 & 0 & 0 \\ 6 & -7 & -6 \end{vmatrix} + \frac{14T_{BE}}{22} \begin{vmatrix} 6\hat{x} - 6\hat{z} \\ 10 & 0 & 0 \\ 6 & -7 & 6 \end{vmatrix} \]

\[ 2 \text{ x coeff} = 0 = -6(14T_{BD}) + 6(14T_{BE}) \]

\[ T_{BD} = T_{BE} \] (Continued)
\[ 2k \text{ coeff} = 0 = (-20)(-840) - \frac{6(14)T_{BD} - (6)(14)T_{BE}}{11} \]

\[ 0 = 16,800 - T_{BD} \left[ \frac{(6)(14)}{11} + \frac{(6)(14)}{11} \right] \]

\[ T_{BD} = \frac{16,800}{\frac{11}{(6)(14) + (6)(14)}} \]

\[ T_{BD} = 1,100.00 \text{ lb} \]

\[ T_{BE} = 1,100.00 \text{ lb} \]

\[ \text{NOT REQUIRED, BUT FOR THE FUN OF IT, FIND REACTIONS AT A,} \]

\[ \sum F = 0 = -840 \overrightarrow{\text{c}} + \overrightarrow{T_{BD}} + \overrightarrow{T_{BE}} + \overrightarrow{A} \]

\[ 0 = -840 \overrightarrow{\text{c}} + \frac{1,100}{11} (6 \overrightarrow{\text{i}} - 7 \overrightarrow{\text{j}} - 6 \overrightarrow{\text{k}}) + \frac{1,100}{11} (6 \overrightarrow{\text{i}} - 7 \overrightarrow{\text{j}} + 6 \overrightarrow{\text{k}}) + A \overrightarrow{\text{x}} + A \overrightarrow{\text{y}} \]

\[ \sum \overrightarrow{\text{c}} = 0 = 840 + 600 + 600 + A \overrightarrow{\text{x}} \]

\[ A \overrightarrow{\text{x}} = 840 - 1200 = -360 = 360.00 \text{ lb} \]

\[ \sum \overrightarrow{\text{y}} = 0 = -700 - 700 + A \overrightarrow{\text{y}} \]

\[ A \overrightarrow{\text{y}} = 1400.00 \text{ lb} \uparrow \]

\[ \sum \overrightarrow{\text{z}} = 0 = -600 + 600 + A \overrightarrow{\text{z}} \]

\[ A \overrightarrow{\text{z}} = 0.00 \text{ lb} \]
1. The 20-ft pole is acted upon by an 840-lb force as shown. It is held by a ball and socket at A and by the two cables BD and BE. Neglecting the weight of the pole, determine the tension in each cable.

**Full credit for this problem is given only if there is a correct Free Body Diagram (FBD).** The FBD may be a separate diagram or clearly marked and labeled forces/reactions superimposed on the figure given below.

Using \( \vec{T}_{AE} = 12\hat{z} + 12\hat{k} \) although I would use \( \vec{T}_{AB} = 14\hat{y} \)

\( \vec{BE} = 12\hat{x} - 14\hat{y} + 12\hat{k} \)

\( \vec{C} = -840\hat{z} \)

\( \vec{T}_{AC} = 20\hat{y} \)

\( \Sigma M_{AD} = 0 = \frac{12(20)(840)}{16.97} \begin{vmatrix} 1 & 0 & -1 \\ 0 & 1 & 0 \\ -1 & 0 & 0 \end{vmatrix} + \frac{12(12)T_{BE}}{16.97(11)} \begin{vmatrix} 1 & 0 & -1 \\ 0 & 1 & 1 \\ 6 & 7 & 6 \end{vmatrix} \)

\[ 0 = (20)(840)(-1)(1) + \frac{12T_{BE}}{11} \begin{bmatrix} (1)(7) - (1)(-7) \end{bmatrix} \]

\[ (20)(840) = \frac{12T_{BE}}{11} [7 + 7] \]

\[ T_{BE} = \frac{(20)(840)(11)}{(12)(14)} = 1100, 000 \text{ lb} \]
2. Determine the total surface area of the body shown. Pappus & Guldinus theorems must be at least a part of your solution.
2. Determine the total surface area of the body shown.

Revolve 3 lines 180°

\[ L_1 = 50 \]
\[ L_2 = \sqrt{60^2 + 70^2} \]
\[ L_2 = 92.20 \]
\[ L_3 = \sqrt{60^2 + 20^2} \]
\[ L_3 = 63.25 \]

\[ SA = \frac{2 \pi \Sigma \bar{x} \times L}{2} = \frac{\pi \times \Sigma \bar{x} \times L}{2} \]
\[ = \pi \left[ (65)(50) + (55)(92.20) + (30)(63.25) \right] \]
\[ = 10,218.12 \pi \]
\[ = 32,101.16 \text{ mm}^2 \]

This gives total area of II, III, & 5

Area of end triangles is \[ 2 \left[ \frac{1}{2} (50)(60) \right] = 3,000 \text{ mm}^2 \]

Total \[ SA = 32,101.16 + 3,000 = 35,101.16 \text{ mm}^2 \]

OR \[ \sqrt{50} \approx 92.20 \]

From \[ A = \sqrt{s(s-a)(s-b)(s-c)} \] where \[ s = \frac{1}{2}(a+b+c) \]
\[ A = \sqrt{2,250,282.18} \]
\[ A = 1500.99 \]
\[ 2A = 3000.19 \]
3. **DO EITHER 3A OR 3B**

3A. Determine by direct integration $\bar{x}$ of the area shown.

![Diagram of a region with equation $y = b \left(1 - kx^3\right)$]

3B. A thin homogenous wire is bent to form the perimeter of the figure indicated. Locate the center of gravity of the wire figure thus formed.

![Diagram of a wire figure with dimensions 20 mm, 30 mm, 36 mm, and 24 mm]
3. **DO EITHER 3A OR 3B**

3A. Determine by direct integration $x$ of the area shown.

\[ y = b \left(1 - kx^3\right) \]

\[
\begin{align*}
\bar{x} \sum L &= \frac{\sum x L}{\sum L} = \frac{10 \times 200 + 35 \times 160.15 + 24 \times 1050 + 12 \times 480 + 0 \times 200 + 30 \times 1800}{200.86} \\
&= \frac{3,570.15}{200.86} = 17.77 \text{ mm}
\end{align*}
\]

\[
\begin{align*}
\bar{y} \sum L &= \frac{\sum y L}{\sum L} = \frac{5,976.18}{200.86} = 29.75 \text{ mm}
\end{align*}
\]

3B. A thin homogenous wire is bent to form the perimeter of the figure indicated. Locate the center of gravity of the wire figure thus formed.

\[
\begin{align*}
\bar{x} \sum L &= \frac{\sum x L}{\sum L} = \frac{3,570.15}{200.86} = 17.77 \text{ mm}
\end{align*}
\]

\[
\begin{align*}
\bar{y} \sum L &= \frac{\sum y L}{\sum L} = \frac{5,976.18}{200.86} = 29.75 \text{ mm}
\end{align*}
\]
3A. Determine by direct integration $\bar{x}$ of the area shown.

\[ @ y = 0, x = 2 \]
\[ 0 = b(1 - k\alpha^3) \]
\[ 1 - k\alpha^3 = 0 \]
\[ k = \frac{1}{\alpha^3} \]

\[ \therefore y = b \left( 1 - \frac{x^3}{\alpha^3} \right) \text{ is our equation.} \]

\[ dA = y \, dx \]

\[ \bar{x} \int dA = \int \bar{x} \, dA \quad \text{and} \quad \bar{x} = \frac{\int_{0}^{\alpha} x \, y \, dx}{\int_{0}^{\alpha} y \, dx} \]

\[ \bar{x} = \frac{\int_{0}^{\alpha} x \, b \left( 1 - \frac{x^3}{\alpha^3} \right) \, dx}{\int_{0}^{\alpha} b \left( 1 - \frac{x^3}{\alpha^3} \right) \, dx} = \frac{\int_{0}^{\alpha} x \left( 1 - \frac{x^3}{\alpha^3} \right) \, dx}{\int_{0}^{\alpha} \left( 1 - \frac{x^3}{\alpha^3} \right) \, dx} \]

\[ \bar{x} = \frac{\int_{0}^{\alpha} x \, dx - \int_{0}^{\alpha} \frac{x^4}{\alpha^3} \, dx}{\int_{0}^{\alpha} \, dx - \int_{0}^{\alpha} \frac{x^3}{\alpha^3} \, dx} = \frac{x^2 \int_{0}^{\alpha} - \frac{x^5 \int_{0}^{\alpha}}{\alpha^3}}{\frac{x^2 \int_{0}^{\alpha} - \frac{x^4 \int_{0}^{\alpha}}{\alpha^3}} \frac{4\alpha^3}{4} = \frac{3\alpha^2}{10} \]

3B. A thin homogenous wire is bent to form the perimeter of the figure indicated. Locate the center of gravity of the wire figure thus formed.

\[ @ x = 0, y = b \]
\[ b = b \left[ 1 - k(\alpha^3) \right] \]
\[ b = b \quad \text{YEP}, \]

\[ \text{but we learn nothing of the constant from this.} \]