Problem 1a) (10 points) Using the theorem of Pappus/Guildinus, determine the final total surface area exposed on a solid body generated by revolving the shaded area shown through an angle of 90 degrees about the horizontal axis A-A.

Note: Not to scale!

\[
\frac{2R}{\pi} = \frac{2(6)}{\pi}
\]

Problem 1b) (10 points) Determine the total volume for the body of problem 1a.

\[
V = \pi (6)^2 \left( \frac{4(6)}{3\pi} \right) + 2'' + 10'' + 3'' + 6'' \int \frac{2\pi}{4} = \\
\frac{4R}{3\pi} = \frac{4(6)}{3\pi} = \\
(2'') \int 1'' + 10'' + 3'' + 6'' \int \frac{2\pi}{4} = \\
(4'')(10'') \int 5'' + 3'' + 6'' \int \frac{2\pi}{4} = \\
\left( \frac{1}{2} \right)(4'')(3'') \int 2'' + 6'' \int \frac{2\pi}{4} = \\
= 1877.2 \text{ in}^2
\]

\[
S = \pi (6) \left( \frac{2(6)}{\pi} + 2'' + 10'' + 3'' + 6'' \int \frac{2\pi}{4} \right) \\
+ 2(2'') \int 1'' + 10'' + 3'' + 6'' \int \frac{2\pi}{4} \\
+ 2(10'') \int 5'' + 3'' + 6'' \int \frac{2\pi}{4} \\
+ 2(\sqrt{2''^2 + 3''^2}) \int 1.5'' + 6'' \int \frac{2\pi}{4} \\
+ 2(\pi)(6'') \frac{2}{2} \\
+ 2(2'')(12'') \\
+ 2(4'')(10'') \\
+ 2\left( \frac{1}{2} \right)(4'')(3'') = 3800.6 \text{ in}^2
\]
Problem 2

Exam Form 1

\[ T \]
\[ \theta = 22^\circ \]
\[ \beta = 40^\circ \]
\[ 850 \text{N} \]

\[ A_x = 300 \text{N} \]
\[ A_y \]

\[ B \]
\[ 200 \text{N} \]

\[ C \]
\[ \text{Not to scale} \]

\[ \tan 40^\circ = \frac{h}{200} \]
\[ h = 200 \tan 40^\circ = 251.7 \text{ mm} \]

\[ T_x = T \cos 22^\circ \]
\[ T_y = T \sin 22^\circ \]

\[ \sum M_A = 0 \Rightarrow T \sin 22^\circ (300) + T \cos 22^\circ (251.7) - 850 (500) = 0 \]

\[ T = \frac{1229.2 \text{ N}}{1} \]

\[ \sum F_x = 0 \Rightarrow A_x - T \cos 22^\circ \]
\[ A_x = 1139.7 \text{ N} \]

\[ \sum F_y = 0 \Rightarrow A_y + T \sin 22^\circ - 850 = 0 \]
\[ A_y = 389.5 \text{ N} \]
Problem 3) (20 points) Pulleys 1 and 2 of the rope and pulley system shown are welded together and rotate as a unit. The radius of pulley 1 is 100 mm and that of pulley 2 is 200 mm (not drawn to scale.) Rope A is fastened to pulley 1 at point A'. Rope B is fastened to pulley 2 at point B'. Rope C is continuous over pulleys 4 and 3. Determine the tension T required to hold body W in equilibrium in the mass of body W is 225 kg.

\[ W = 225 \text{ kg} \times 9.81 \text{ m/s}^2 = 2207 \text{ N} \]

From FB#1
\[ \sum F_v = 0 = -T - T + F_1 \]
\[ F_1 = 2T \]

From FB#2
\[ \sum M_{center} = 0 = +2T(100\text{ mm}) - F_2(200\text{ mm}) \]
\[ F_2 = \frac{(2T)(100)}{200} = T \]
\[ \sum F_v = 0 = -2T - T + F_3 \text{ (who cares?)} \]

From FB#3
\[ \sum F_v = 0 = +3T - 2207 \text{ N} \]
\[ \therefore T = 736 \text{ N} \]
Problem 4) (20 points) Solve for the forces in members GF, GB, and CE. Note whether the forces are in tension or compression.

\[ \Sigma M_B = 0 = -12^k(80\text{ft}) - 20^k(160\text{ft}) + GF_H(120\text{ft}) \]

So $GF_H = 34.67^k$

Slope of GF:

\[ \frac{GF_H}{40} = \frac{GF}{\sqrt{40^2 + 90^2}} \]

So $GF = \frac{34.67(98.49)}{40}$

= 85.36 kips

From FB\#2

GB = zero force member

From FB\#3

\[ \Sigma F_V = 0 \]

\[ = -12^k + CE \]

So $CE = 12^k$ Tension
Problem 5) (20 points) Solve for the horizontal and vertical components of reactions at “a” and “b”. Show these forces on a free body.

\[ \sum M_A = 0 = (4 \text{ kN/m})(12 \text{ m})(\frac{1}{2})[3m+8m+\frac{2}{3} \cdot 12m^2] - B_V \cdot 11m^2 \]

So, \( B_V = 41.45 \text{ kN} \)

\[ \sum F_V = 0 = -A_V + 41.45 - 24 \text{ kN} \]

\( A_V = 41.45 - 24 = 17.45 \text{ kN} \)

\[ \sum M_C = 0 = (41.45 \text{ kN})(8m) - (B_H)(2m) \]

\( B_H = 165.8 \text{ kN} \)
Problem 1) (20 points) Pulleys 1 and 2 of the rope and pulley system shown are welded together and rotate as a unit. The radius of pulley 1 is 200 mm and that of pulley 2 is 300 mm (not drawn to scale.) Rope A is fastened to pulley 1 at point A'. Rope B is fastened to pulley 2 at point B'. Rope C is continuous over pulleys 4 and 3. Determine the tension T required to hold body W in equilibrium in the mass of body W is 325 kg.

\[ T_2 = 1.33 \times T \]
\[ T_2 = 1.33 \times 957.4 = 325 \times 3.183 \]
\[ T_2 = 1273.3 \text{ N} \]

\[ T + T + 1.33T = 325 \times 3.183 \]
\[ T = 957.4 \text{ N} \]

\[ T_3 = 1.5 \times 1273.3 = 1910 \text{ N} \]
Problem 2  Solve for forces in $BC$, $BE$, and $FD$

**FBD 1**

1. $\sum F_x = 0$
   - $A_x = 0$

2. $\sum M_c = -A_y(80) - 20(80) - 12(160) = 0$
   - $A_y = -44k$ or $44\downarrow$

3. $\sum F_y = A_y + C_y - 20 - 12 = 0$
   - $C_y = 20 + 12 - (-44)$
   - $C_y = 76k \uparrow$

**FBD 2**

1. $\sum F_x = 0$
   - $FD - 20 = 0$
   - $FD = 20 \text{kips}$ (T)

**FBD 3**

1. $\sum M_G = 0$
   - $-20(80) - 12(160) - \frac{4}{\sqrt{a^2}}(120) \text{BC} = 0$
   - $\text{BC} = -72.3k = 72.3k$ (C)
Problem 3: Solve for horizontal and vertical components of reactions at "a" and "c".

**FBD 1**

\[ \sum M_A = -36(14) + C_y(10) = 0 \]

\[ C_y = 50.4 \text{ kN} \]

\[ \sum F_y = A_y + C_y = -36 = 0 \]

\[ A_y = 36 - 50.4 \]

\[ A_y = -14.4 \text{ or } 14.4 \text{ kN} \]

\[ \sum F_x = A_x + C_x = 0 \]

\[ A_x = 134.4 \text{ kN} \]

**FBD 2**

\[ \sum M_A = 50.4(8) + C_x(3) = 0 \]

\[ C_x = 134.4 \text{ or } 134.4 \text{ kN} \]

\[ A_y = 14.4 \text{ kN} \]

\[ C_y = 50.4 \text{ kN} \]
Problem 4a) (10 points) Using the theorem of Pappus/Guildinus, determine the final total surface area exposed on a solid body generated by revolving the shaded area shown through an angle of 90 degrees about the horizontal axis A-A.

Note: Not to scale!

Problem 4b) (10 points) Determine the total volume for the body of problem 4a.

\[ \frac{4 \pi}{3 \pi} = \frac{4 (5)}{3 \pi} = 3.82 \text{ Area} \]

\[ \frac{16 (6)}{3 \pi} = 16.6 \text{ Area} \]

\[ \frac{54}{3 \pi} = 17.265 \text{ Area} \]

\[ \frac{31.82 \text{ Area}}{3 \pi} = 7.182.5 \]

\[ \frac{\sum A_i y_i - 7182.5}{\sum A_i} = 25.1 \]

\[ V_1 = \frac{\pi}{2} (25.1)(286.2) = 11284.0 \text{ m}^3 \]
\( \frac{21.4}{11} = 5.73 \)

\( 119 = 28.22 \)

\( 25 \)

\( 7.5 \)

\( 4.24 \)

\( 17 \)

\( 26.5 \)

\( 33.73 \)

\( \overline{L_i} \quad \overline{Y_w} \quad \overline{L_i Y_w} \)

\[
\begin{array}{ccc}
1 & 28.22 & 33.73 & 951.9 \\
2 & 6 & 26.5 & 159 \\
3 & 12 & 25 & 300 \\
4 & 32 & 17 & 544 \\
5 & \frac{8.49}{86.7} & 7.5 & \frac{63.7}{2018.6} \\
\end{array}
\]

\[
\overline{y}_{\text{lines}} = \frac{2018.6}{86.7} = 23.3
\]

\[
S.A. = \frac{\pi}{2}(23.3)(86.7) + 2(286.2) = 3745.61 \text{m}^2
\]
Problem 5) (20 points) Determine the forces exerted on member ABC of the structure shown. Show these forces on a free body diagram of member ABC.

\[ \sum M_A = 0 \]

\[ -950(400) + 927T(335.6) + 375T(140) = 0 \]

\[ 0.4611T = 665 \]

\[ T = 1442.2 \]

\[ 927T = 1336.9 \]

\[ 375T = 540.8 \]

\[ \sum F_x = 0 \]

\[ A_x - 1336.9 = 0 \]

\[ A_x = 1336.9 \]

\[ \sum F_y = 0 \]

\[ A_y + 540.8 - 950 = 0 \]

\[ A_y = 409.2 \]