Strength of Materials Math Worksheet Answers

1. Calculate the maximum tensile and compressive forces allowed for the cross-sectional area shown in Figure 1. The maximum tensile strength is 500 lb/in$^2$ (pounds per inches squared). The maximum compressive strength is 5,000 lb/in$^2$. Use the following equations to complete the problem. Show your work and calculations.

\[
\text{cross-sectional area} = (B) \times (L)
\]
\[
\text{maximum tensile force} = (\text{maximum tensile strength}) \times (\text{cross-sectional area})
\]
\[
\text{maximum compressive force} = (\text{maximum compressive strength}) \times (\text{cross-sectional area})
\]

**Answer:**

Cross-sectional area = (10 inches) x (20 inches) = 200 in$^2$

Maximum tensile force = (500 lb/in$^2$) x (200 in$^2$) = 100,000 lb

Maximum compressive force = (5,000 lb/in$^2$) x (200 in$^2$) = 1,000,000 lbs

![Figure 1: Cross-sectional area.](image)

2. Calculate the maximum tensile and compressive forces allowed for the following two cross-sectional areas shown in Figure 2. The maximum tensile strength is 3,750 lb/in$^2$. The maximum compressive strength is 4,850 lb/in$^2$. Use the following equations along with those in #2 to complete the problem. Show your work and calculations.

\[
\text{cross-sectional area} = \pi \times (\text{radius})^2
\]

\[
\pi = 3.14
\]

**Answer:**

Cross-sectional area of circle = 3.14 x (10 in)$^2$ = 314 in$^2$

Cross-sectional area of I-beam = (15 inches) x (2 inches) + (15 inches) x (2 inches) + (2 inches) x (20 inches) = 100 in$^2$

Maximum tensile force of circle = (3,750 lb/in$^2$) * (314 in$^2$) = 1,177,500 lb

Maximum compressive force of circle = (4,850 lb/in$^2$) * (314 in$^2$) = 1,522,900 lb

Maximum tensile force of I-beam = (3,750 lb/in$^2$) x (100 in$^2$) = 375,000 lb

Maximum compressive force of I-beam = (4,850 lb/in$^2$) x (100 in$^2$) = 485,000 lb

![Figure 2: Cross-sectional areas.](image)
3. Part 1: Calculate the compressive force for the cross-sectional area shown in Figure 3. The original length of the member was 100-in long. After applying the compressive force, the member was 99-in long. The modulus of elasticity for the material used in the cross section is 10,000 lb/in$^2$. Use the following equations along with those in #2 and #3 to complete the problem. Show your work and calculations.

Part 2: Calculate the tension force for the cross-sectional area shown in Figure 3. The original length of the member was 100-in long. After applying the tensile force, the member was 103-in long. The modulus of elasticity for the material used in the cross section is the same as in #2 above. Use the following equations along with those in #2 and #3 to complete the problem. Show your work and calculations.

\[ \sigma = E \cdot \varepsilon \]
\[ \varepsilon = \text{change in length} / \text{original length} \]
\[ E = \text{modulus of elasticity} \]

\[ \text{change in length} = (\text{length after force applied}) - (\text{original length}) \]

If the change in length is negative, take the absolute value to get a positive number.

force = \( \sigma \times \text{cross-sectional area} \)

**Part 1 Answer:**

Change in length = 99 inches - 100 inches = -1 inch
Taking the absolute value, change in length = 1 inch
\[ \varepsilon = \frac{1}{100} = 0.01 \]
\[ \sigma = (10,000 \text{ lb/in}^2) \times (0.01) = 100 \text{ lb/in}^2 \]
Cross-sectional area = (17 inches) x (39 inches) – (13 inches) x (33 inches) = 234 in$^2$
Force = (100 lb/in$^2$) x (234 in$^2$) = 23,400 lb

**Part 2 Answer:**

Change in length = 103 - 100 inches = 3 inches
\[ \varepsilon = \frac{3}{100} = 0.03 \]
\[ \sigma = (10,000 \text{ lb/in}^2) \times (0.03) = 300 \text{ lb/in}^2 \]
Cross-sectional area = (17 inches) x (39 inches) – (13 inches) x (33 inches) = 234 in$^2$
Force = (300 lb/in$^2$) x (234 in$^2$) = 70,200 lb