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.

- cross-sectional area = (B) x (L)
- maximum tensile force = (maximum tensile strength) x (cross-sectional area)
- maximum compressive force = (maximum compressive strength) x (cross-sectional area)

   \[
   \text{B = 10 inches, L = 20 inches}
   \]

   \[
   \text{Answer: Cross-sectional area = (10 inches) \times (20 inches) = 200 in}^2
   \]
   \[
   \text{Maximum tensile force = (500 lb/in}^2\text{) \times (200 in}^2\text{) = 100,000 lb}
   \]
   \[
   \text{Maximum compressive force = (5,000 lb/in}^2\text{) \times (200 in}^2\text{) = 1,000,000 lbs}
   \]

   \[
   \text{Figure 1: Cross-sectional area.}
   \]

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.

- cross-sectional area = \( \pi \times (\text{radius})^2 \)
- \( \pi = 3.14 \)

   \[
   \text{B = 15 inches, B = 2 inches, L = 2 inches, L = 20 inches, Radius = 10 inches}
   \]

   \[
   \text{Answer: Cross-sectional area of circle = 3.14 \times (10 inches)^2 = 314 in}^2
   \]
   \[
   \text{Cross-sectional area of I-beam = (15 inches) \times (2 inches) + (15 inches) \times (2 inches) + (2 inches) \times (20 inches) = 100 in}^2
   \]
   \[
   \text{Maximum tensile force of circle = (3,750 lb/in}^2\text{) \times (314 in}^2\text{) = 1,177,500 lb}
   \]
   \[
   \text{Maximum compressive force of circle = (4,850 lb/in}^2\text{) \times (314 in}^2\text{) = 1,522,900 lb}
   \]
   \[
   \text{Maximum tensile force of I-beam = (3,750 lb/in}^2\text{) \times (100 in}^2\text{) = 375,000 lb}
   \]
   \[
   \text{Maximum compressive force of I-beam = (4,850 lb/in}^2\text{) \times (100 in}^2\text{) = 485,000 lb}
   \]

   \[
   \text{Figure 2: Cross-sectional areas.}
   \]
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/in². 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.

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

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

---

**Figure 3: Cross-sectional area.**

**Part 1 Answer:**

Change in length = 99 inches - 100 inches = -1 inch

Taking the absolute value, change in length = 1 inch

\[ \varepsilon = \frac{1\ \text{inch}}{100\ \text{inches}} = 0.01 \]

\[ \sigma = (10,000 \ \text{lb/in}^2) \times (0.01) = 100 \ \text{lb/in}^2 \]

Cross-sectional area = \((17\ \text{inches}) \times (39\ \text{inches}) - (13\ \text{inches}) \times (33\ \text{inches}) = 234\ \text{in}^2 \)

Force = \((100 \ \text{lb/in}^2) \times (234 \ \text{in}^2) = 23,400\ \text{lb} \)

**Part 2 Answer:**

Change in length = 103 - 100 inches = 3 inches

\[ \varepsilon = \frac{3\ \text{inches}}{100\ \text{inches}} = 0.03 \]

\[ \sigma = (10,000 \ \text{lb/in}^2) \times (0.03) = 300 \ \text{lb/in}^2 \]

Cross-sectional area = \((17\ \text{inches}) \times (39\ \text{inches}) - (13\ \text{inches}) \times (33\ \text{inches}) = 234\ \text{in}^2 \)

Force = \((300 \ \text{lb/in}^2) \times (234 \ \text{in}^2) = 70,200\ \text{lb} \)