Final Exam

Continuing Education Course #274

What Every Engineer Should Know About Structures Part D - Bending Strength Of Materials

NOTE: The following question was revised on 15 August 2018

1. The moment of inertia of a beam is a measure of the stiffness of a beam.
   - ○ a. True
   - ○ b. False

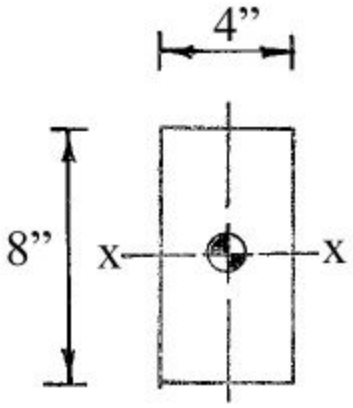
NOTE: The following question was revised on 30 January 2019

2. The moment of inertia is sometimes referred to by others as the:
   - ○ a. second moment of area
   - ○ b. area moment of inertia
   - ○ c. rectangular moment of inertia
   - ○ d. none of the above
   - ○ e. Answers a, b, & c above.

3. The moments of inertia of individual beams can be used to compare beams in an "apples to apples" sort of way.
   - ○ a. True
   - ○ b. False

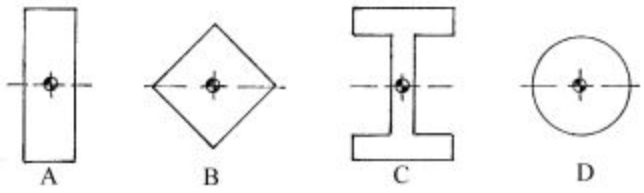
4. A beam cross section can be shaped to have a high moment of inertia by placing "Lot's of material _____ the centroidal axis.
   - ○ a. near
   - ○ b. below
   - ○ c. far away from
   - ○ d. none of the above
   - ○ e. all of the above

5. What is the moment of inertia about the x - x axis of the rectangular beam shown?



- a. 32 in^4
- b. 42.7 in^4
- c. 171 in^4
- d. 256 in^4

6. The drawing below shows four different beam cross sections. All cross sections have the same area. Which cross section has the highest moment of inertia about the x - x axis?

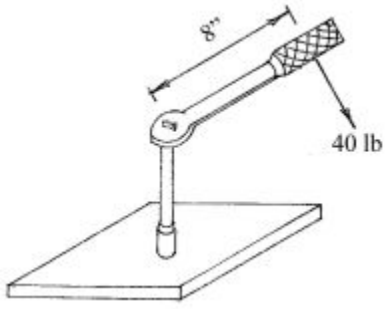


- a. beam cross section A has the largest moment of inertia
- b. beam cross section B has the largest moment of inertia
- c. beam cross section C has the largest moment of inertia
- d. beam cross section D has the largest moment of inertia

7. A torsional loading is called

- a. torque
- b. rotational moment
- c. twisting moment
- d. couple
- e. all of the above

8. A force of 40 pounds is applied to the socket wrench as shown below. What is the torque delivered to the shaft of the wrench?



- a. 20 lb-in
- b. 32 lb-in

○ c. 320 lb-in
○ d. 1,280 lb-in

9. The specifications for the installation of the bolts for an engine block call for a final torque of 15 lb-ft to be applied to the bolts. If the bolts are 1/2 inch in diameter, what is the maximum torsional shear stress in the bolt? Polar moment of inertia equals $J = \frac{\pi D^4}{32}$; Torsional shear stress equals $\tau = \frac{Tr}{J}$.

○ a. 0.611 ksi
○ b. 7.33 ksi
○ c. 9.87 ksi
○ d. 14.7 ksi

10. A 5 foot long, 3/4 inch diameter, aluminum rod is subjected to a 60 lb-in torque. What is the maximum twist, in degrees, of the rod?

- $\theta = \frac{TL}{JG}$
- The torsional moment of inertia of the rod is 0.0311 in^4
- The shear modulus of elasticity of aluminum is 3.75 x 10^6 psi
- π radians = 180 degrees

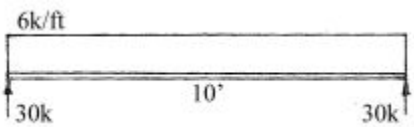
○ a. 0.0309 degrees
○ b. 0.15 degrees
○ c. 1.77 degrees
○ d. 21.2 degrees

11. In a horizontal beam supporting vertical loads, the internal forces are:
○ a. shear
○ b. bending moment
○ c. torsion
○ d. A and B above
○ e. all of the above.

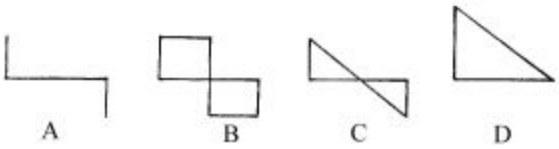
12. Beam diagrams are shown in what order?
○ a. loading diagram on top, moment diagram in the middle, shear diagram on the bottom
○ b. shear diagram on top, moment diagram in the middle, loading diagram on the bottom
○ c. loading diagram on top, shear diagram in the middle, moment diagram on the bottom
○ d. moment diagram on top, loading diagram in the middle, shear diagram on the bottom

13. When drawing beam diagrams, each diagram is derived from the one above (with the exception of the load diagram).
○ a. True
○ b. False

14. For the loaded beam shown, select the correct shear diagram.



Select from the following shear diagrams.



- a. shear diagram A is the correct shear diagram
- b. shear diagram B is the correct shear diagram
- c. shear diagram C is the correct shear diagram
- d. shear diagram D is the correct shear diagram

NOTE: The following question was revised on 15 August 2018

15. Which of the following **rules for creating beam diagrams** apply to all beam diagrams?

- a. Each diagram is derived from the one above (with the exception of the load diagram).
- b. The slope of a line at any point is equal to the value of the diagram directly above.
- c. Align all diagrams vertically. Put all diagrams for a single problem on the same page.
- d. All of the above

16. Bending stress is the stress created in a beam to resist the applied external bending moments that occur along a beam.

- a. True
- b. False

17. Bending stresses in a simple beam with a uniformly distributed load are zero at the _____ .

- a. centroid of the cross section
- b. center of gravity of the cross section
- c. neutral axis of the beam
- d. all of the above

18. The maximum bending stress in a beam with a known bending moment can be calculated with the following formula(s):

- a. $\sigma = \frac{Mc}{I}$
- b. $\sigma = \frac{M}{S}$
- c. $\sigma = \frac{My}{I}$
- d. $\sigma = \frac{M}{\frac{I}{c}}$
- e. all of the above

19. If the bending moment at 6 feet from the end of a steel I-beam is 29 kip-ft, what is the maximum bending stress at that point? The steel I-beam has the following properties:

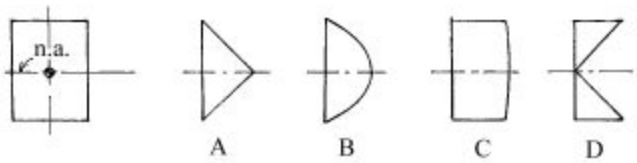
- I = 1,000 in^4
- E = 29 x 10^6 psi
- S = 100 in^3
- A = 16 in^2

- h = 20 in
- $c = \frac{h}{2} = \frac{20\text{in}}{2} = 10\text{in}$

○ a. 0.12 ksi
○ b. 2.9 ksi
○ c. 3.48 ksi
○ d. 290 ksi

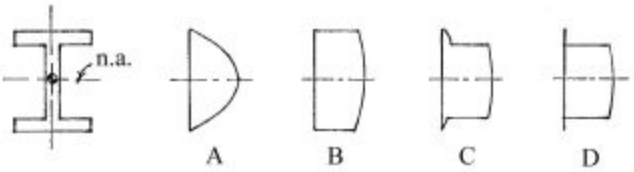
20. Horizontal shear stress is zero at the top and bottom of a beam and it is maximum at the neutral axis of a beam.
○ a. True
○ b. False

21. From the drawings below, select the one that most nearly represents the values of the horizontal shear stresses over a beam with a rectangular cross section



○ a. A most nearly represents the values of the horizontal shear stress
○ b. B most nearly represents the values of the horizontal shear stress
○ c. C most nearly represents the values of the horizontal shear stress
○ d. D most nearly represents the values of the horizontal shear stress

22. From the drawings below, select the one that most nearly represents the values of the horizontal shear stresses over a beam with an I-shaped cross section



○ a. A most nearly represents the values of the horizontal shear stress
○ b. B most nearly represents the values of the horizontal shear stress
○ c. C most nearly represents the values of the horizontal shear stress
○ d. D most nearly represents the values of the horizontal shear stress

23. Using the maximum horizontal shear stress formula for a rectangular wooden beam, what is the maximum horizontal shear stress in a 4" by 12" wood beam if the vertical shear force is 1,500 pounds.
○ a. 31.3 psi
○ b. 46.9 psi
○ c. 125 psi
○ d. 1,500 psi

Use the following beam properties and beam diagrams to answer questions No. 24 and No. 25.

Beam Properties
A = 8.84 in^2
beam depth (h) = 10.47 in
web thickness = 0.300 in

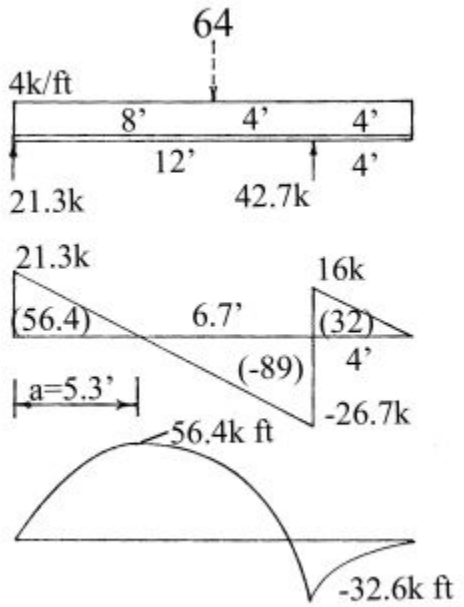
A_{web} = (10.47 in) (0.300 in) = 3.141 in^2

I = 170 in^4

S = 32.4 in^3

E = 29 x 10^6 psi

Beam Diagrams



24. Using the simplified maximum horizontal shear stress formula for a steel I-beam, calculate the maximum horizontal shear stress in the steel I- beam. Determine the maximum vertical shear force from the beam diagrams. Use either the maximum positive value or the maximum negative value (whichever is larger) to calculate the maximum horizontal shear stress in the steel I-beam.

- a. 5.1 ksi
- b. 6.8 ksi
- c. 8.5 ksi
- d. 10.4 ksi

25. Calculate the maximum bending stress in the steel I-beam. Hint: Use the value of the maximum bending moment from the beam diagrams to calculate the maximum bending stress in the steel I-beam.

- a. 1.0 ksi
- b. 1.7 ksi
- c. 12.1 ksi
- d. 20.9 ksi