Activity 2.3c – More Engineering Problems

Purpose

In Principles of Engineering there is a need for word problems that cover the different aspects of the strength of materials. When solving these problems, 3.14 was used as an approximation for pi, and all "long running" decimals were rounded to the nearest thousandths place. Your answers may not exactly match the answers given; however, when you have rounded to the correct significant digit, you should be in agreement.

Procedure

To be a successful word problem solver, one must develop a strategy. There are a couple of simple, easy steps that you should follow to make your quest for a solution a bit easier. All the solutions given in this document follow these steps:

1) First, read the problem carefully.
2) Make a sketch of the information, even if a picture is already given. This gives the left side of your brain a chance to communicate with the right side of your brain. It also allows you to begin to organize and synthesize the given information. This is a clear illustration of the phrase that "a picture is worth a thousand words."
3) Make a list of what you know (the given information) and what you don't know (things you need to determine).
4) Using the information given, work towards the solution to the problem.

Use the previous assignment, Activity 6.2 Engineering Problems, as a guide to complete these problems.

Common Variable Names:

σ = stress
$\in$ = strain
δ = deformation
E = modulus of elasticity
Δ = the change in
P = axial force
A = cross section area
L = length
r = radius
d = diameter

Formulae you might use are:

$\sigma = P/A$
$\in = \delta/L$
$\delta = PL/AE$
$E = \sigma/\in$

$A=\Pi r^2$ (area of circle: radius)
$A= 0.7854d^2$ (area of circle: diameter)
1 kip = 1 000 pound-force

Section 1 - Problems Involving Tensile, Compressive and Shear Stress:

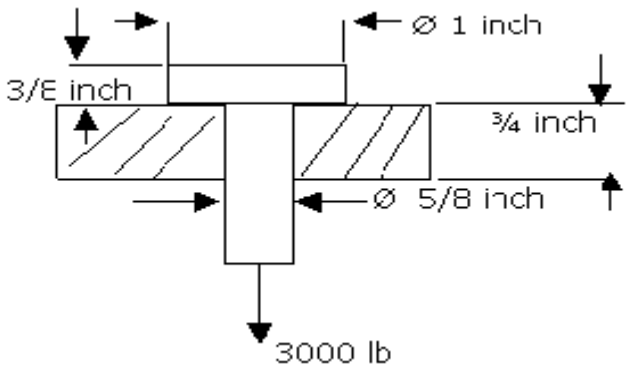
1. What is the compressive stress in a pressure treated wooden post 250 mm by 250 mm, if it supports a compressive load of 425 kN? **Answer in Pascals**

2. Steel rod suspenders support water pipes in an electric plant. The 3/8 in. diameter rods have an allowable axial tensile stress of 25,500 psi. What is the allowable axial tensile load in the rods? **Answer in lbs**

3. The following members are subjected to axial tensile loads of 35,000 lb. Determine the stress: (a) A square steel bar 3.5 inches on a side
(b) W14 x 90 (cross sectional area = 26.5 in^2)
(c) An eight-inch diameter wooden post (unfinished).

Answers in ksi

4. The figure shows a bolt passing through a plate. Calculate (a) the tensile stress in the bolt and (b) the shear stress in the head. **Answers in psi**



5. A punch press punches out round washers with an inside diameter of 5 mm and an outside diameter of 15 mm. If the stock that the washers are being punched out of is 2 mm thick and requires a force of 225 kN, what is the (a) compressive stress in the punch and the (b) shear stress in the plate? **Answers in Pascals**

6. A punch press punches out square washers with an outside dimension of 1 inch on a side and a circle in the center with a diameter of 3/8 inch. If the stock that the washers are being pressed out of is ¼ inch thick, and requires a force of 330 kips, what is the (a) compressive stress in the punch and the (b) shear stress in the plate? **Answers in ksi**

7. Compute the force required to punch a 1.25-inch diameter hole through a ½ inch boilerplate. The ultimate shear stress for the material is 42000 psi. **Answer in lbs**

Section 2 - Problems Involving Design and Factor of Safety

1) A rod supports an axial force of 45 kN. If the compressive stress in the bar is not to exceed 80 MPa, determine the diameter of the rod. **Answer in cm**

2) A square metal rod must support an axial compression load of 1550 N. The allowable stress in the rod is 175 MPa. Find the dimensions of the rod. **Answer in mm**

3) Calculate the required diameter of an aluminum rod subjected to an axial tensile load of 45.5 kN, if the allowable tensile stress is 135 MPa. **Answer in cm**

4) A steel column sits on a square steel base plate which in turn rests on a poured concrete footing. The steel column supports an axial compressive load of 85 kips. The allowable compressive stress in the steel is 15.5 ksi and the allowable bearing stress in the concrete footing is 725 psi. Determine the required cross sectional area of the column and the length of sides on the steel base plate. **Answer (a) in in^2 and (b) in**

5) A boilerplate has an ultimate shear strength of 290 MPa. Compute the force required to punch a 20 mm diameter hole, if the steel plate thickness is 15 mm. Assume that the shear stress is uniformly distributed. **Answer in Newtons**

6) A loading platform at a factory is to be supported by 9 concrete posts. The maximum estimated load expected is 150 tons. If the compressive strength of the concrete is 3500 psi, what diameter should the concrete posts be? Since concrete is a very brittle material, design your posts with a factor of safety of 15. (1 ton = 2000 lb) **Answer in inches**

7) A dual-tracked military vehicle is being designed to operate in desert sands. Data collected in the desert indicate the bearing pressure under the tracks cannot exceed 12 psi. The vehicle will weigh no more than 35 tons and each of the 2 tracks will be 22 inches wide. Determine the minimum required contact length for each of the 2 tracks. **Answer in feet**

Section 3 - Problems With Deformation, Stress, Strain, and Modulus of Elasticity

For the following problems, the modulus of elasticity for steel to be 30,000,000 psi (207 000 MPa) and the proportional limit to be 34,000 psi (234 MPa).

1) A short compression member with a cross sectional area of 22.3 in^2, and 7 inches long is subjected to a 45,000 pound compressive load. As a result, the length of the member is shortened to 6.45 inches. Find the strain in the member. **Answer in inches/inch**

2) A concrete test cylinder 12 inches in diameter and 15 inches high is loaded in compression. As a result of the load, the cylinder is shortened by 0.015 inches. Find the strain in the member. **Answer in inches/inch**

3) A 15 inch bar with a cross-sectional area of 1.5 in^2 is subjected to an axial load of 1 ton. Compute the stress (**answers in psi)**, the strain **(answers in inches/inch)**, and the total elongation **(answers in inches)** if the bar materials are: (a) steel, (b) aluminum (modulus of elasticity = E_{AL} = 10,000,000 psi) and (c) wood (modulus of elasticity = E_W = 1,500,000 psi).

4) A weight of 7500 N is to be suspended by a steel wire 8.25 m in length. The tensile stress in the wire must not exceed 145 MPa and the total elongation must not exceed 4.5 mm. Find the required diameter of the wire (ignore the weight of the wire itself). **Answer in mm**

5) A rectangular bar with dimensions of 20 mm by 85 mm elongates 3.25 mm in a length of 1.75 m when subjected to an axial load of 245 kN. The material has a proportional limit of 240 mPa. Determine (a) the axial stress **in MPa** the bar and (b) the modulus of elasticity (Young's modulus) **in units of Pa**.

6) A steel wire is suspended at one end from the ceiling of a warehouse. The wire is 375 feet long and has a diameter of 3/16 in. (The unit weight of steel is 490 pcf.) Find (a) the maximum tensile stress **in psi** due to the weight of the wire and (b) the maximum additional load **in lbs** that the wire could hold at the lower end of the wire. (Use the allowable tensile stress of 24,000 psi.)

Activity 6.2c – More Engineering Problems Answer Sheet

Section 1:

1) _____

2) _____

3a) _____

3b) _____

3c) _____

4a) _____

4b) _____

5a) _____

5b) _____

6a) _____

6b) _____

7) _____

Section 2:

1) _____

2) _____

3) _____

4a) _____

4b) _____

5) _____

6) _____

7) _____

4) _____

5a) _____

5b) _____

6a) _____

6b) _____

Section 3:

1) _____

2) _____

3)

	Stress	Strain	Total Elongation
Steel			
Aluminum			
Wood			