MECHANICAL PROPERTIES PROPLEM SHEET

1. A tensile test uses a test specimen that has a gage length of 50 mm and an area = 200 mm^2. During the test the specimen yields under a load of 98,000 N. The corresponding gage length = 50.23 mm. This is the 0.2% yield point. The maximum load of 168,000 N is reached at a gage length = 64.2 mm. Determine (a) yield strength, (b) modulus of elasticity, and (c) tensile strength. (d) If fracture occurs at a gage length of 67.3 mm, determine the percent elongation. (e) If the specimen necked to an area = 92 mm2, determine the percent reduction in area.

2. A test specimen in a tensile test has a gage length of 2.0 in and an area = 0.5 in2. During the test the specimen yields under a load of 32,000 lb. The corresponding gage length = 2.0083 in. This is the 0.2 percent yield point. The maximum load of 60,000 lb is reached at a gage length = 2.60 in. Determine (a) yield strength, (b) modulus of elasticity, and (c) tensile strength. (d) If fracture occurs at a gage length of 2.92 in, determine the percent elongation. (e) If the specimen necked to an area = 0.25 in^2, determine the percent reduction in area.

3. During a tensile test in which the starting gage length = 125.0 mm and the cross-sectional area = 62.5 mm^2, the following force and gage length data are collected (1) 17,793 N at 125.23 mm, (2) 23,042 N at 131.25 mm, (3) 27,579 N at 140.05 mm, (4) 28, 913 N at 147.01 mm, (5) 27,578 N at 153.00 mm, and (6) 20,462 N at 160.10 mm. The maximum load is 28,913 N and the final data point occurred immediately before failure. (a) Plot the engineering stress strain curve. Determine (b) yield strength, (c) modulus of elasticity, and (d) tensile strength.
4. In Problem 3, determine the strength coefficient and the strain-hardening exponent in the flow curve equation. Be sure not to use data after the point at which necking occurred.

5. In a tensile test on a metal specimen, true strain =0.08 at a stress = 265MPa. When true stress = 325 MPa, true strain =0.27. Determine the strength coefficient and the strain-hardening exponent in the flow curve equation.

6. During a tensile test, a metal has a true strain = 0.10 at a true stress = 37,000 lb/in2. Later, at a true stress = 55,000 lb/in2, true strain = 0.25. Determine the strength coefficient and strain-hardening exponent in the flow curve equation.

7. In a tensile test a metal begins to neck at a true strain =0.28 with a corresponding true stress =345.0 MPa. Without knowing any more about the test, can you estimate the strength coefficient and the strain hardening exponent in the flow curve equation?

8. A tensile test for a certain metal provides flow curve parameters: strain-hardening exponent is 0.3 and strength coefficient is 600 MPa. Determine (a) the flow stress at a true strain = 1.0 and (b) true strain at a flow stress = 600 MPa.

9. The flow curve for a certain metal has a strain hardening exponent of 0.22 and strength coefficient of 54,000 lb/in2. Determine (a) the flow stress at a true strain = 0.45 and (b) the true strain at a flow stress = 40,000 lb/in2.

10. A metal is deformed in a tension test into its plastic region. The starting specimen had a gage length = 2.0 in and an area = 0.50 in^2. At one point in the tensile test, the gage length = 2.5 in, and the corresponding engineering stress = 24,000 lb/in2; at another point in the test before necking, the gage length = 3.2 in, and the corresponding engineering stress = 28,000 lb/in2. Determine the strength coefficient and the strain-hardening exponent for this metal.

11. A tensile test specimen has a starting gage length = 75.0 mm. It is elongated during the test to a length = 110.0 mm before necking occurs. Determine (a) the engineering strain and (b) the true strain. (c) Compute and sum the engineering strains as the specimen elongates from: (1) 75.0 to 80.0 mm, (2) 80.0 to 85.0 mm, (3) 85.0 to 90.0 mm, (4) 90.0 to 95.0 mm, (5) 95.0 to 100.0 mm, (6) 100.0 to 105.0 mm, and (7) 105.0 to 110.0 mm. (d) Is the result closer to the answer to part (a) or part (b)? Does this help to show what is meant by the term true strain?

12. A tensile specimen is elongated to twice its original length. Determine the engineering strain and true strain for this test. If the metal had been strained in compression, determine the final compressed length of the specimen such that (a) the engineering strain is equal to the same value as in tension (it will be negative value because of compression), and (b) the true strain would be equal to the same value as in tension (again, it will be negative value because of compression). Note that the answer to part (a) is an impossible result. True strain is therefore a better measure of strain during plastic deformation.

13. Derive an expression for true strain as a function of D and Do for a tensile test specimen of round cross section, where D = the instantaneous diameter of the specimen and Do is its original diameter.

14. Show that true strain = ln(1-e), where e = engineering strain.

15. Based on results of a tensile test, the flow curve strain hardening exponent = 0.40 and strength coefficient = 551.6 MPa. Based on this information, calculate the (engineering) tensile strength for the metal.

16. A copper wire of diameter 0.80 mm fails at an engineering stress = 248.2 MPa. Its ductility is measured as 75% reduction of area. Determine the true stress and true strain at failure.

17. A steel tensile specimen with starting gage length = 2.0 in and cross-sectional area = 0.5 in^2 reaches a maximum load of 37,000 lb. Its elongation at this point is 24%. Determine the true stress and true strain at this maximum load.

18. A metal alloy has been tested in a tensile test with the following results for the flow curve parameters: strength coefficient = 620.5 MPa and strain hardening exponent = 0.26. The same metal is now tested in a compression test in which the starting height of the specimen = 62.5 mm and its diameter = 25 mm. Assuming that the cross section increases uniformly, determine the load required to compress the specimen to a height of (a) 50 mm and (b) 37.5 mm.

19. The flow curve parameters for a certain stainless steel are strength coefficient = 1100 MPa and strain-hardening exponent = 0.35. A cylindrical specimen of starting cross-sectional area = 1000 mm2 and height = 75 mm is compressed to a height of 58 mm. Determine the force required to achieve this compression, assuming that the cross section increases uniformly.

20. A steel test specimen (modulus of elasticity = 30 _ 106 lb/in2) in a compression test has a starting height = 2.0 in and diameter = 1.5 in. The metal yields (0.2% offset) at a load = 140,000 lb. At a load of 260,000 lb, the height has been reduced to 1.6 in. Determine (a) yield strength and (b) flow curve parameters (strength coefficient and strain hardening exponent). Assume that the cross sectional area increases uniformly during the test.

21. bend test is used for a certain hard material. If the transverse rupture strength of the material is known to be 1000MPa, what is the anticipated load at which the specimen is likely to fail, given that its width =15 mm, thickness = 10 mm, and length = 60 mm?

22. A special ceramic specimen is tested in a bend test. Its width = 0.50 in and thickness = 0.25 in. The length of the specimen between supports = 2.0 in. Determine the transverse rupture strength if failure occurs at a load = 1700 lb.

23. A torsion test specimen has a radius = 25 mm, wall thickness = 3 mm, and gage length = 50 mm. In testing, a torque of 900 N-m results in an angular deflection = 0.3_ Determine (a) the shear stress, (b) shear strain, and (c) shear modulus, assuming the specimen had not yet yielded. (d) If failure of the specimen occurs at a torque = 1200 N-m and a corresponding angular deflection = 10^0, what is the shear strength of the metal?

24. In a torsion test, a torque of 5000 ft-lb is applied which causes an angular deflection = 1 on a thin walled tubular specimen whose radius = 1.5 in, wall thickness = 0.10 in, and gage length = 2.0 in. Determine (a) the shear stress, (b) shear strain, and (c) shear modulus, assuming the specimen had not yet yielded.

(d) If the specimen fails at a torque = 8000 ft-lb and an angular deflection = 23^0, calculate the shear strength of the metal.

25. In a Brinell hardness test, a 1500-kg load is pressed into a specimen using a 10-mm-diameter hardened steel ball. The resulting indentation has a diameter = 3.2 mm. (a) Determine the Brinell hardness number for the metal. (b) If the specimen is steel, estimate the tensile strength of the steel.

26. One of the inspectors in the quality control department has frequently used the Brinell and Rockwell hardness tests, for which equipment is available in the company. He claims that all hardness tests are based on the same principle as the Brinell test, which is that hardness is always measured as the applied load divided by the area of the impressions made by an indentor. (a) Is he correct? (b) If not, what are some of the other principals involved in hardness testing, and what are the associated tests?

27. A batch of annealed steel has just been received from the vendor. It is supposed to have a tensile strength in the range 60,000 to 70,000 lb/in2. A Brinell hardness test in the receiving department yields a value of HB = 118. (a) Does the steel meet the specification on tensile strength? (b) Estimate the yield strength of the material.
28. Cylinder specimen is compressed to its 1/3 height, given initial height and diameter ho=20 mm and Do=30 mm. The material follows $\sigma = 160\ \varepsilon\ 0.25$ MPa. Calculate;
    a. The final diameter D ?
    b. True stress at the end of the deformation?
    c. Nominal stress at the end of the deformation?
    d. Total ideal work?
29. The following data were reported from tension test:

Load (N)	11500	16400	17000	20800	20600
Elongation (mm)	0.5	5.0	15.0	21.5	25.5

The speciamen has wire gauge length of 50.5 mm and wire gauge diameter of 7 mm. Determine:
    a. The cross-section area at amximum load?
    b. The true stress at maximum load?
    c. The ultimate tensile strength?
    d. The strain hardening exponent n and strength coefficient K ?
    e. The ideal plastic work required to stretch the specimen to instability?
30. Estimate the plastic work necessary to stretch a tensile specimen to instability. The initial cross section area is 40.8 mm2 and initial length 50.8 mm. The

material follows: σ = 1200 ε 0.35 MPa. Determine the ultimate tensile strength (UTS) ?

31. The following data were reported from tension test having rectangular cross-section area:

Load(N)	11500	16400	17000	20800	20700
Length(mm) l_f	63.0	68.0	75.0	80.0	85.0
Thickness (mm) t_f	4.8	4.6	4.3	4.1	3.9
Width (mm) w_f	19.84	19.18	18.6	18.29	18.1

Initial strip length l_o=60.0 mm, Initial strip thickness t_o=5.0 mm, Initial strip width *wo*=20.0 mm,

The material flow: $\bar{\sigma} = K\bar{\varepsilon}^n$

Determine the following:

a. The cross-section area at maximum load.
b. The true stress at maximum load.
c. Effective strain at maximum load.
d. The ultimate strength.
e. The value of K and n.
f. The plastic work necessary to stretch the specimen to instability.

32. The following data were reported from tension test having rectangular cross-section area:

Load(N)	11500	16400	17000	20800
Length(mm) l_f	61.0	65.5	76.0	82.0
Thickness (mm) t_f	4.8	4.6	4.3	4.0
Width (mm) w_f	19.8	19.7	19.5	w_f

Initial strip length l_o: 60.0 mm
Initial strip thickness t_o: 5.0 mm
Initial strip width w_o : 20.0 mm
The material flow: $\bar{\sigma} = K\bar{\varepsilon}^n$
Determine the following:

a. The strip width at maximum load.
b. The true stress at maximum load.
c. Effective strain at maximum load.
d. The ultimate strength.

e. The value of K and n.
f. The plastic work necessary to stretch the specimen to instability.

33. 6 The following data were obtained from a standard tensile test on a specimen of Rene 41 (heated 4 h at 1950 °F, air cooled, aged 16 h at 1400 °F and air cooled):

- specimen diameter, d_o = 0.505 in;
- gage length, l_o = 2.000 in;
- yield strain, ε_y = 0.007;
- yield load, P_y = 30,500 lb;
- ultimate load, P_u = 41,500 lb;
- ultimate length, l_u = 2.160 in;
- final length, l_f = 2.300 in;
- final diameter, d_f = 0.453 in.

Calculate the following:

(a) yield strength

(b) true stress at yield load

(c) tensile strength

(d) true stress at maximum load

(e) true strain at yield load

(f) Young's modulus of elasticity

(g) true strain at maximum load

(h) true strain at fracture load

(i) percent area reduction

(j) percent elongation.