

CARLETON UNIVERSITY

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88.302A  
FINAL EXAMINATION  
April 23, 2002

DURATION: 3 HOURS

No. of Students: 66

Department Name & Course Name: Mechanical and Aerospace Engineering 88.302A  
Machine Design and Practice

Course Instructor Professor X. Wang

AUTHORIZED MEMORANDA  
Calculator, Text Book and Course Notes Only

Students **MUST** count the number of pages in this examination question paper **before** beginning to write, and report any discrepancy immediately to a proctor. This question paper has 4 Pages.

This examination question paper May Be taken from the examination room.

Note:

- (a). Answer any five questions.
  - (b). All questions carry equal marks (20 marks).
- 1). A steel bar of 20-mm diameter as shown in Figure 1 is loaded by the forces  $F = 1$  kN,  $P = 8$  kN and torque  $T = 30$  N×m. For the steel, the yield strength  $S_y = 200$  MPa.
- a). Calculate the stresses acting on the elements  $A$  and  $B$ .
  - b). Represent the states of stresses on elements  $A$  and  $B$  with three-dimensional Mohr's circles.
  - c). Calculate the safety factor against yielding using the maximum-distortion-energy (Von Mises) yield theory at element  $A$ .

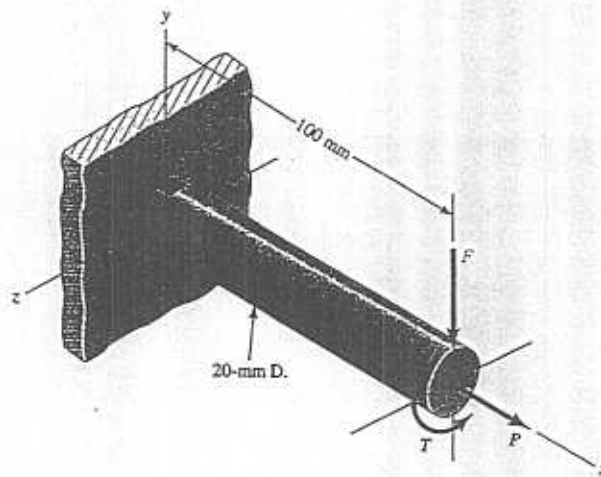


Figure 1

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- 2). A notched steel component consists of a bar 1.0 inch wide and 0.25 inch thick with two semi-circular notches, each of 0.1 inch radius. This gives the plate a width at the reduced section of 0.8 inch as shown in Figure 2. The component is subjected to a fully reversed load with an amplitude of  $8 \times 10^3$  lbf. The steel has an ultimate strength,  $S_u = 110$  ksi and yield strength  $S_y = 90$  ksi. The component has a fine-ground surface.
- (a). Estimate the  $S-N$  curve for the steel with 95% reliability. (Use gradient factor  $C_G = 0.9$ ).
- (b). Calculate the fatigue life of this component with 95% reliability. (Hint: use Figure 4.39 in the text to get stress concentration factor  $K_t$ )

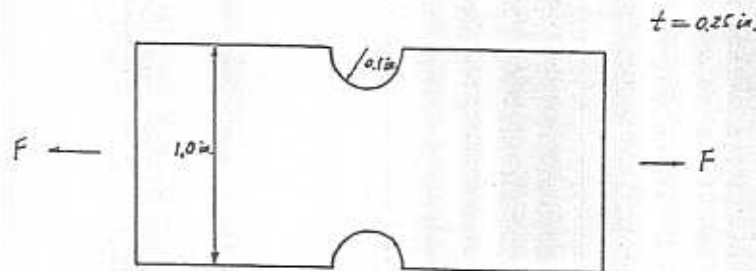


Figure 2

- 3). A series of bolted connections are arranged circumferentially around two flanges in a pressured cylinder, the cross-section is illustrated in Figure 3 (on the next page). The cylinder is made of cast iron while the bolts are of SAE grade 5, 3/4"-10 UNC. Assume the bolts are tightened to a standard 90% of its proof strength, and the stiffness of the clamped flanges is five times the stiffness of the bolts. During the operation, each bolt experiences an external separating force that fluctuates between 0 and  $P$ .
- (a). What is the initial bolt tension force  $F_i$ ?
- (b). Estimate the maximum value of  $P$  that would not cause leakage (joint separation).
- (c). Estimate the maximum value of  $P$  that would not cause eventual fatigue failure. Assume that the threads of the bolt are rolled, and therefore the fatigue stress concentration factor  $K_f$  is 3.0. To simplify your analysis, assume the point at the Goodman's diagram corresponding to the eventual fatigue failure is given in the Figure (next page).

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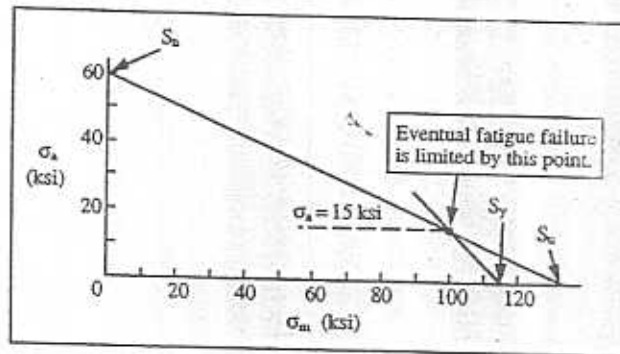
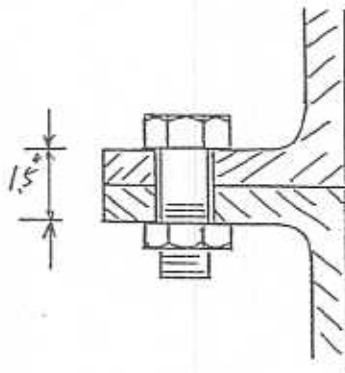


Figure 3

- 4). A helical coil compressive spring is made of cold drawn steel ( $S_u = 900\text{Mpa}$ ,  $G = 80\text{GPa}$ ) and has a wire diameter of 10 mm. The spring must resist a maximum load of 1500N. It is loaded with primarily static loading. The spring constant  $k$  should be  $18 \times 10^3 \text{ N/m}$ . The ends of spring are shown in Figure 4 and presetting is not used.
- (i). Accounting for 10% clash allowance, find (a) the coil diameter, (b) the total number of active coils, (c) the free length of the spring and (d) the length corresponding to spring-solid condition.
- (ii). Will the spring buckle under the worst possible load condition?



Figure 4

- 5). Figure 5 shows a printing roll driven by the gear to which the force  $F$  is applied. The bottom surface of the roll is in contact with an idler roller that applies a uniform (upward) loading. There is also axial direction load  $P$  applied. From the force analysis, the radial and thrust forces are found as follows. At location  $A$ ,  $F_r = 10.5$  kN and  $F_t = 5$  kN, and at location  $B$ ,  $F_r = 15.5$  kN and  $F_t = 2$  kN. Select two identical radial ball bearings (200 series) for  $A$  and  $B$  to provide two years of continuous operation at 300 rpm with 98% reliability. Assume there is moderate impact ( $K_a = 1.5$ ).

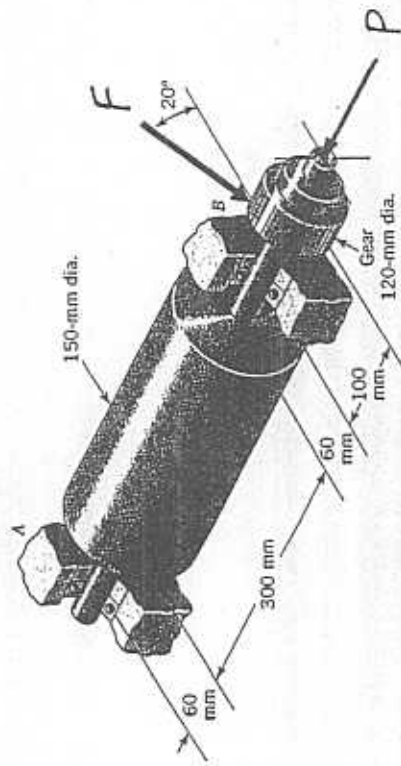


Figure 5

- 6). A 24-tooth pinion with a diametral pitch of 6 teeth per inch drives a 120-tooth gear in a high precision machine. The gears have face width of 2 inch and a pressure angle of 20 degree. Both gears are fabricated from AISI 4340 steel ( $S_u = 95$  ksi,  $S_y = 60.5$  ksi). If the gear set operates at a constant pitch line velocity of 800 feet per minute. Use a reliability of 95% and a safety factor of 1.5, estimate the maximum allowable horsepower that can be transmitted for infinite fatigue life, based only on bending fatigue.
- Assume
- The source of power is uniform and there is moderate shock in the machine.
  - The mountings are accurate.
  - There is no load sharing among gear teeth.