CARLETON UNIVERSITY

MECH 3002A

FINAL EXAMINATION

April 19, 2013

DURATION: 3 **HOURS** No. of Students: 95

Department Name & Course Name: Mechanical and Aerospace Engineering MECH 3002 A 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 not** Be taken from the examination room.

Note: BOOKLETS REQUIRED

(a). Answer any five questions.

(b). All questions carry equal marks (20 marks).

1). Figure 1 shows a cantilever plate loaded by a horizontal force of 67,500N, and a vertical force of 36,000N. The plate is made of an aluminum alloy with yield strength $S_y = 30$ MPa.

a). Calculate the stresses acting on the element at point *A*.

b). Represent the state of stress on the element at point *A* with three-dimensional Mohr's circles.

c). Calculate the safety factor against yielding at point A using the maximum distortion energy (Von Mises) yield theory.

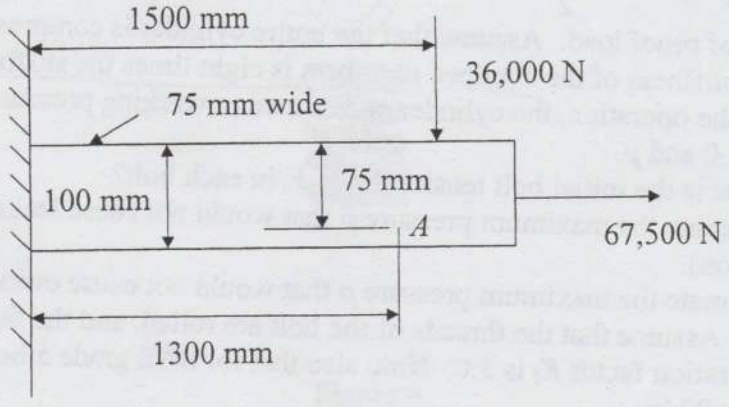

Figure 1

2). Figure 2 shows stepped steel plate subjected to a bending moment load fluctuating between 1,250Nm and 2,500Nm. The dimensions are: $D = 75$mm and $d = 50$mm. The steel has an ultimate strength, $S_u = 1100$MPa and yield strength $S_y = 900$MPa. The component has a machined surface.

(a). Estimate the *S-N* curve for unnotched specimen with 95% reliability; specify the values for both S_n, and S_{10^3}. (Use gradient factor $C_G = 0.9$).

(b). Calculate the safety factor against infinite fatigue life with 95% reliability at the fillet (use extrapolation if necessary when using Figure 8.24 in the text book).

(c). Will local yielding occur at the critical location?

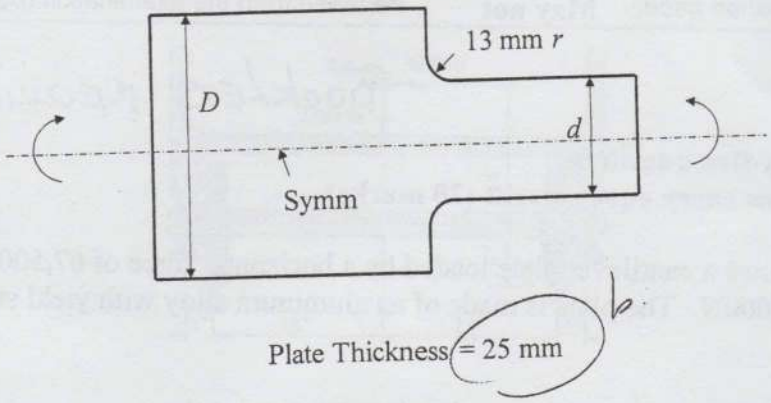

Figure 2

3). Figure 3 (on next page) shows a hydraulic cylinder in which $D = 4$ in, $t = 3/8$ in, $L = 12$ in, and $w = 3/4$ in. Both brackets as well as the cylinder are made of steel. Eight SAE grade 5, $\frac{1}{2}$ in-13 UNC bolts are used, and they are tightened to 90 percent of proof load. Assume that the entire cylinder is compressed uniformly, and the stiffness of the clamped members is eight times the stiffness of the bolts. During the operation, the cylinder experiences a working pressure that fluctuates between 0 and p.

(a). What is the initial bolt tension force F_i in each bolt?

(b). Estimate the maximum pressure p that would not cause leakage (joint separation).

(c). Estimate the maximum pressure p that would not cause eventual fatigue failure. Assume that the threads of the bolt are rolled, and the fatigue stress concentration factor K_f is 3.0. Note also that for SAE grade 5 bolts, $S_u = 120$ ksi and $S_y = 92$ ksi.

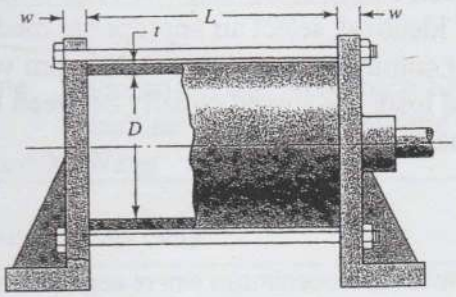

Figure 3

4). A helical coil compressive spring is to be designed for 10^4 cycles fatigue life. The spring is subjected to a load that fluctuates between 100 and 300 lbf. Steel spring wire having S_{us} (ultimate strength for shear stress) of 160 ksi, and a zero-maximum torsional 10^4 cycles fatigue strength of 140 ksi is to be used. No presetting is applied. The material's shear modulus G = 11.5×10^3 ksi.

(a). For a value spring index C = 8, determine the wire diameter and coil diameter.

(b). The number of the active turns is 10, the ends of the spring are fixed-fixed and they have the geometries as shown below. What is the spring constant K, and what is the spring-solid length, L_s, obtained in (a)?

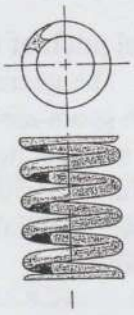

Figure 4

5). Consider Figure 5 below, showing the two bearings required to transmit constant in-service loads between a railway car and one of its axles. Assuming that the two bearings must be identical, select an appropriate medium radial ball bearing to provide one year of continuous operation at 300 rpm with 90% reliability. Assume that the thrust loads are shared equally between the two bearings, and there is moderate impact.

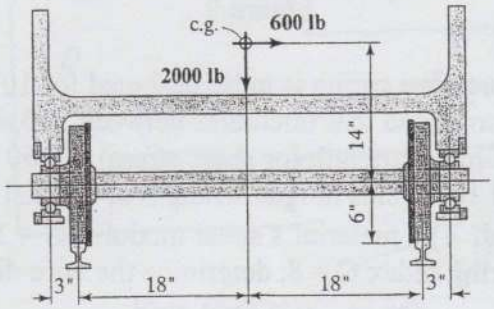

Figure 5

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, using a reliability of 50% and a safety factor of 2, estimate the maximum allowable horsepower that can be transmitted for infinite fatigue life, based only on bending fatigue.

Assume

i). The source of power is uniform and there is moderate shock in the machine.

ii). The mountings are accurate.

iii). There is no load sharing among gear teeth.