National Exams May 2018

16-Mec-B1, Advanced Machine Design

Notes

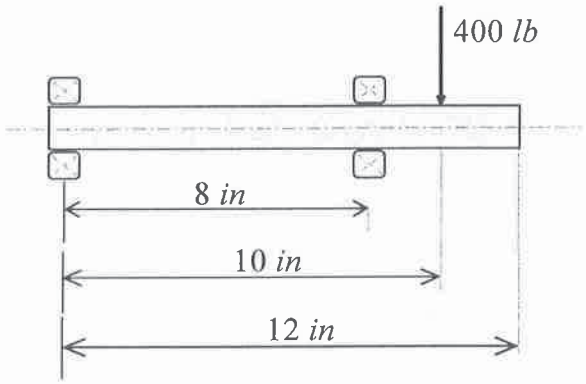
- Time: 3 hours.
- This is an open book exam.
- **Answer all questions of Part I (i.e. Questions 1, 2), and only THREE questions from Part II of the examination.**
- Make sure your answers are neat and clear.
- State all assumptions clearly. If doubt arises as to the interpretation of any question, write down a clear statement of any assumptions made.
- All answers must be clearly annotated with a summary of the approach, method, and results written in clear and correct English.
- Document your sources of information whenever you use a tabulated value or an equation.
- Any non-communicating calculator is permitted.
- Assume any missing data and make sure to properly state in your answer.
- The examination marks 100 in total.
- Failure to follow the above directions will result in grade penalties.

PART I

Problem 1. Briefly answer the following questions:

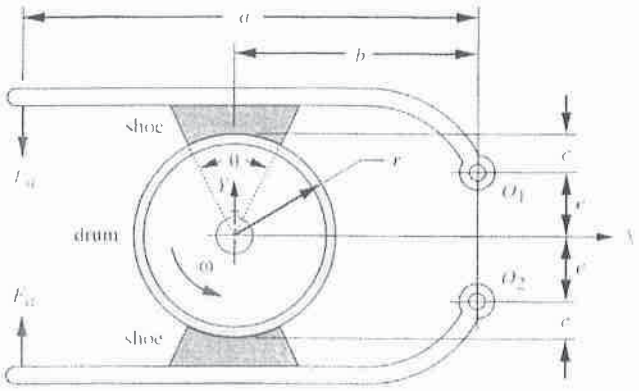
(a) In general, is von Mises' criterion more conservative in predicting yielding than Tresca's criterion? Explain your answer briefly. **(3 marks)**
(b) How does the mean stress affect the fatigue behavior of material? **(2 marks)**
(c) List a couple cases when solid film lubricants are used rather than liquid lubricants, and explain the reasons. **(3 marks)**
(d) What is fretting corrosion? **(2 marks)**

Problem 2. A simply supported shaft is shown in the following figure. A constant magnitude transverse load of 400 *lb* is applied as the shaft rotates subjected to a time varying torque that varies from -500 to 500 *lb.in.* Using ASME distortional energy elliptical theory, find the diameter of the shaft required to obtain a safety factor of 2 in fatigue loading for an infinite life if the shaft is steel with $S_{ut} = 108$ *kpsi*, and $S_y = 62$ *kpsi*. Assume no stress concentration and 50% reliability. **(30 marks)**

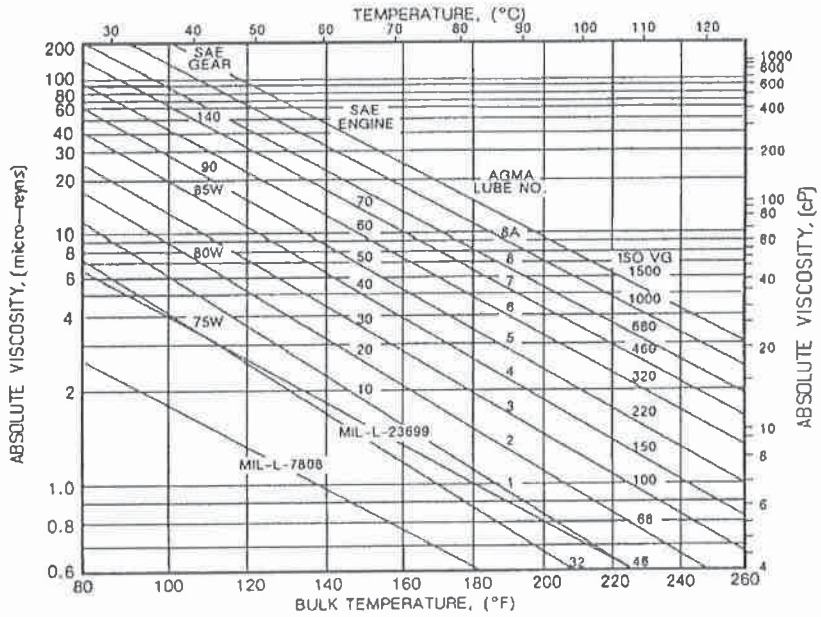


Part II

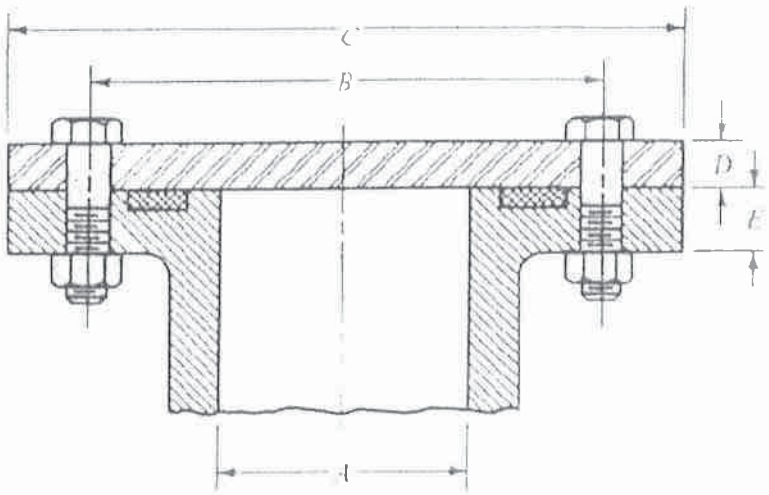
Problem 3. For a double short-shoe external drum brake with a drum width of 60 mm as shown in the following figure, find the torque capacity and required actuating force F_a for $a = 90$ mm, $b = 80$ mm, $e = 30$ mm, $r = 40$ mm, and $\theta = 30°$. What value of c will make it self-locking? Assume the maximum allowable lining pressure is 1.3 MPa and the friction coefficient for the brake lining material is $\mu = 0.3$. **(20 marks)**



Problem 4. A journal and bearing are to be designed for a shaft that turns at 250 rpm. Suppose ISO VG100 (SAE Engine 30) is to be used as lubricant and the bearing length is to be equal to 1.2 times the diameter. If the no-load power loss is not to exceed 0.0002 horsepower and the diametral clearance is 0.0045 times the diameter, estimate the maximum diameter that can be used for the journal, and the allowable temperature limit. Use the following figure for viscosity and temperature relation of the lubricant. **(20 marks)**



Problem 5. The figure below illustrates the connection of a steel cylinder head to a steel pressure vessel using 10 bolts and a confined-gasket seal. The effective sealing diameter is 150 mm. The other dimensions are: $A = 100$ mm, $B = 200$ mm, $C = 300$ mm, $D = 20$ mm and $E = 25$ mm. The pressure vessel is used to store gas at a static pressure of 6 MPa. Metric 12 mm diameter bolts are to be used as they give a reasonable bolt spacing. The factor of safety for separation is to be at least 1.5 and the factor of safety for yielding is to be at least 2. Determine the required bolt preload and select a suitable grade of bolt. **(20 marks)**



Problem 6. Two identical 3 in. power screws (single threaded) with Acme threads are used to raise and lower a 50 ton sluice gate of a dam. The quality of construction and maintenance (including lubrication) are good, resulting in an estimated friction coefficient of 0.1 for both screws. The collar bearings have an effective diameter of 5 in. and a coefficient of friction of 0.03, as roller thrust bearings are used. Friction of the sluice gate in its tracks adds 2 tons to its weight when raising and reduces its apparent weight by 2 tons when lowering. The gate is designed to move at a speed of 2 ft/min. Find: (a) the torque required to drive each screw to either raise or lower the sluice gate; (b) the rotation speed of the screws; and (c) the horse-power needed by each screw's motor to raise the gate (raising torque × angular velocity). Use the following tables for the sizes of the Acme threads. **(20 marks)**

Major Diameter (in)	Threads per Inch	Thread Pitch (in)	Pitch Diameter (in)	Minor Diameter (In)	Tensile Stress Area (In^2)
0.250	16	0.063	0.219	0.188	0.032
0.313	14	0.071	0.277	0.241	0.053
0.375	12	0.083	0.333	0.292	0.077
0.438	12	0.083	0.396	0.354	0.110
0.500	10	0.100	0.450	0.400	0.142
0.625	8	0.125	0.563	0.500	0.222
0.750	6	0.167	0.667	0.583	0.307
0.875	6	0.167	0.792	0.708	0.442
1.000	5	0.200	0.900	0.800	0.568
1.125	5	0.200	1.025	0.925	0.747
1.250	5	0.200	1.150	1.050	0.950
1.375	4	0.250	1.250	1.125	1.108
1.500	4	0.250	1.375	1.250	1.353
1.750	4	0.250	1.625	1.500	1.918
2.000	4	0.250	1.875	1.750	2.580
2.250	3	0.333	2.083	1.917	3.142
2.500	3	0.333	2.333	2.167	3.976
2.750	3	0.333	2.583	2.417	4.909
3.000	2	0.500	2.750	2.500	5.412
3.500	2	0.500	3.250	3.000	7.670
4.000	2	0.500	3.750	3.500	10.321
4.500	2	0.500	4.250	4.000	13.364
5.000	2	0.500	4.750	4.500	16.800