National Exams December 2018

07-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:

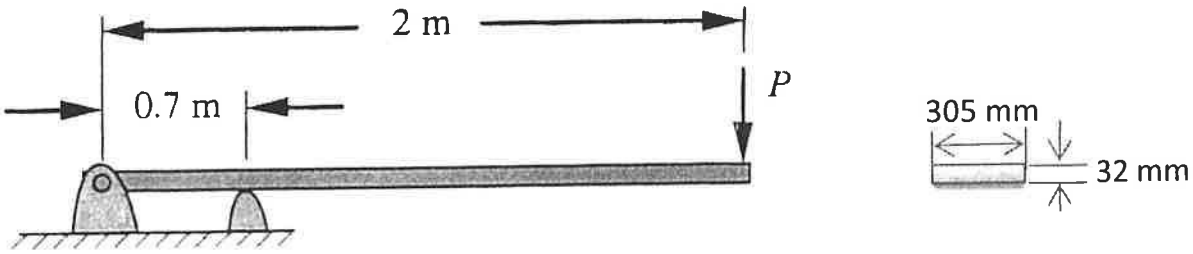
(a) In plane strain tension, why the material exhibits a higher load carrying capacity before yielding compared with uniaxial tension? **(3 marks)**

(b) Name five green design criteria. **(2 Marks)**

(c) Why is a hollow shaft preferred over a solid shaft? What are the disadvantages of a hollow shaft? **(3 marks)**

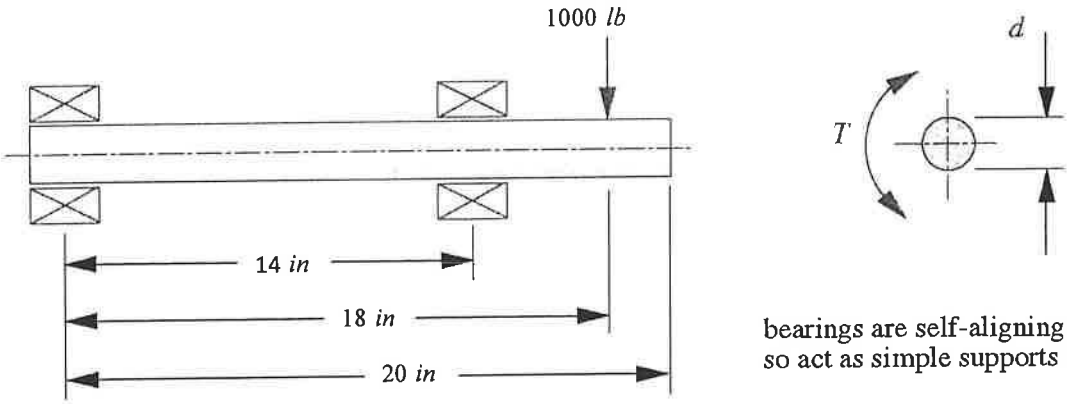
(d) In hydrodynamic lubrication of a journal bearing, how is the minimum oil film thickness related to the viscosity of the lubricant? **(2 marks)**

Problem 2. An overhung diving board is shown in the following figure with a cross-section of 305 mm x 32 mm. Find the largest principal stress that will result when a 60-kg person jumps up 25 cm at the free end and lands back on the board. Assume that the board weighs 20 kg and deflects 100 mm statically when the person stands on it. What is the static safety factor if the material has an ultimate stress of 130 MPa in the longitudinal direction? Take the diving board as a beam in your calculation. **(30 marks)**

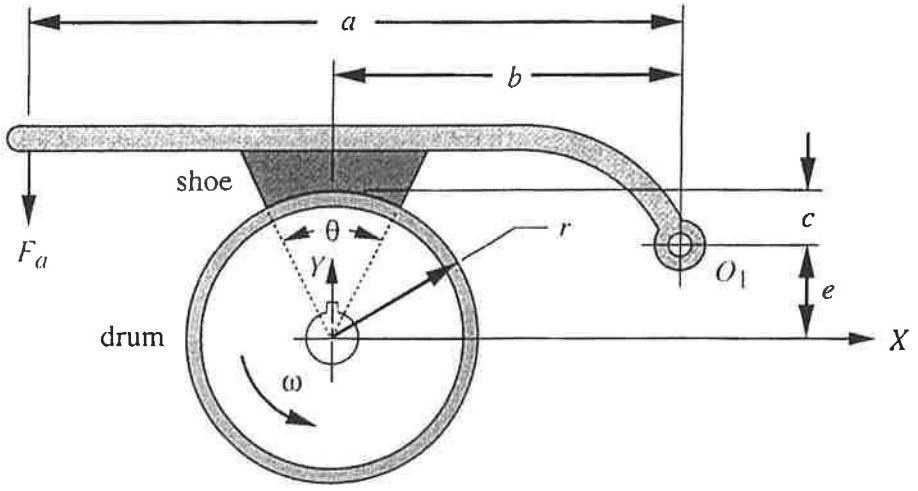


Part II

Problem 3. A simply supported shaft is shown in the following figure. A constant magnitude transverse load of 1000 *lb* is applied as the shaft rotates subjected to a time varying torque that varies from 0 to 2000 *lb-in*. Find (1) the diameter of the shaft required to obtain a safety factor of 2 in fatigue loading if the shaft is steel with $S_{ut} = 108$ *ksi*, and $S_y = 62$ *ksi*., and (2) the corresponding maximum deflection in torsion and in bending. Assume no stress concentration. **(20 marks)**



Problem 4. For a single short-shoe drum brake with a drum width of 40 mm as shown in the following figure, find the torque capacity and required actuating force F_a for $a = 120$ mm, $b = 70$ mm, $e = 20$ mm, $r = 35$ mm, and $\theta = 50^\circ$. 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 5. Design a single-surface disk clutch to transmit 120 N-m of torque at 850 rpm using a molded lining with a maximum pressure of 1.5 MPa and friction coefficient of 0.25. Assume uniform wear. Find the outside and inside diameters required using an inside to outside diametral ratio of 0.6. What is the power transmitted? **(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