National Exams December 2017

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) Why is a hollow shaft preferred over a solid shaft? What are the disadvantages of a hollow shaft? **(2 marks)**

(c) In plane strain tension, why the material exhibits a higher load carrying capacity before yielding compared with uniaxial tension? **(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 100-kg person jumps up 25 cm at the free end and lands back on the board. Assume that the board weighs 29 kg and deflects 131 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)**
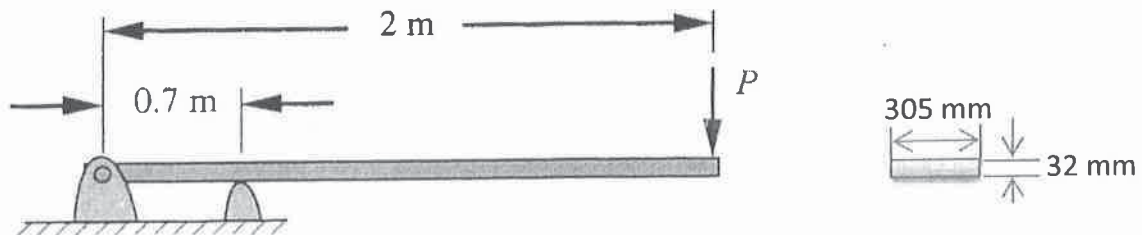
Part II

Problem 3. Design a single-surface disk clutch to transmit 100 N.m of torque at 750 rpm using a molded lining with a maximum pressure of 1.2 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 0.577. What is the power transmitted? **(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)**
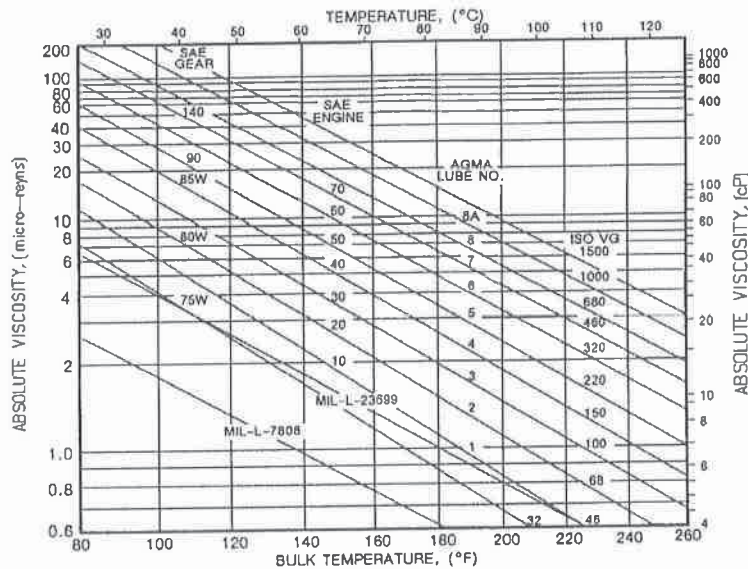

Figure 10-1

Absolute Viscosity Versus Temperature of Petroleum Lubricating Oils in ISO Viscosity Grades
Source: Extracted from AGMA Standard 2001-B88, *Fundamental Rating Factors and Calculation Methods for Involute Spur and Helical Gear Teeth* with the permission of the publisher, American Gear Manufacturers Association, 1500 King St., Suite 201, Alexandria, Va., 22314.

Problem 5. 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 $a = 110$ mm, $b = 70$ mm, $e = 25$ mm, $r = 35$ mm, and $\theta = 40°$. 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)**
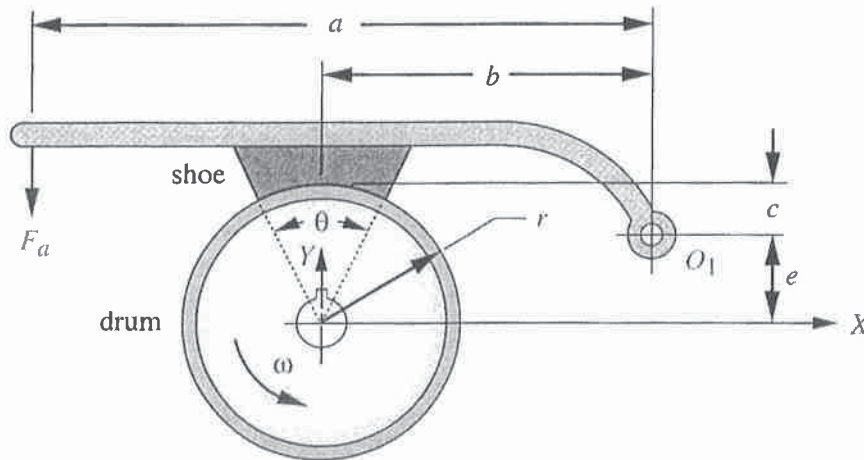
Problem 6. Design a suitable bolt size and preload for the joint shown in the following figure. Find its safety factor agianst yielding and separation. Determine the optimum preload as a percentage of proof strength to maximize the safety factors. The joint dimensions are $D = 1$ in, $l = 2$ in. The applied load $P = 2000$ lb. **(20 marks)**