

## National Exams May 2013

## Advanced Machine Design

## Notes

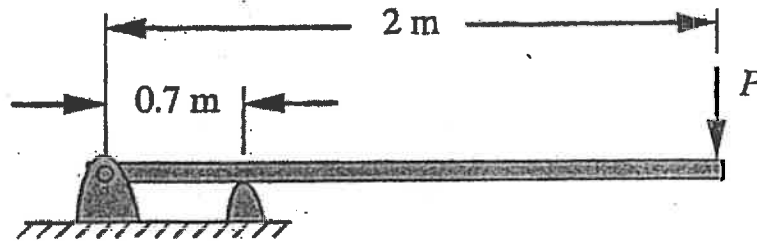
- Time: 3 hours.
- This is an open book exam.
- Answer all questions of Part I (i.e. Questions 1, 2), and only THREE questions from Part II of the examination.
- Make sure your answers are neat and clear.
- State all assumptions clearly. If doubt arises as to the interpretation of any question, write 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) What is  $\sigma_{0.2}$ ? (2 marks)  
(b) For an isotropic material, in biaxial stretching, which one will predict lower stresses at the onset of yielding; the Mises criterion, or the Tresca criterion? (2 marks)  
(c) Why is a hollow shaft preferred over a solid shaft? (2 marks)  
(d) For a plain (journal) bearing with the following data: 45-mm diameter, 200 mm long, eccentricity ratio  $\epsilon = 0.55$ , clearance ratio = 0.001, 2500 rpm, and ISO VG220 (SAE Engine 50) oil of 150°F, find the minimum film thickness. (4 marks)

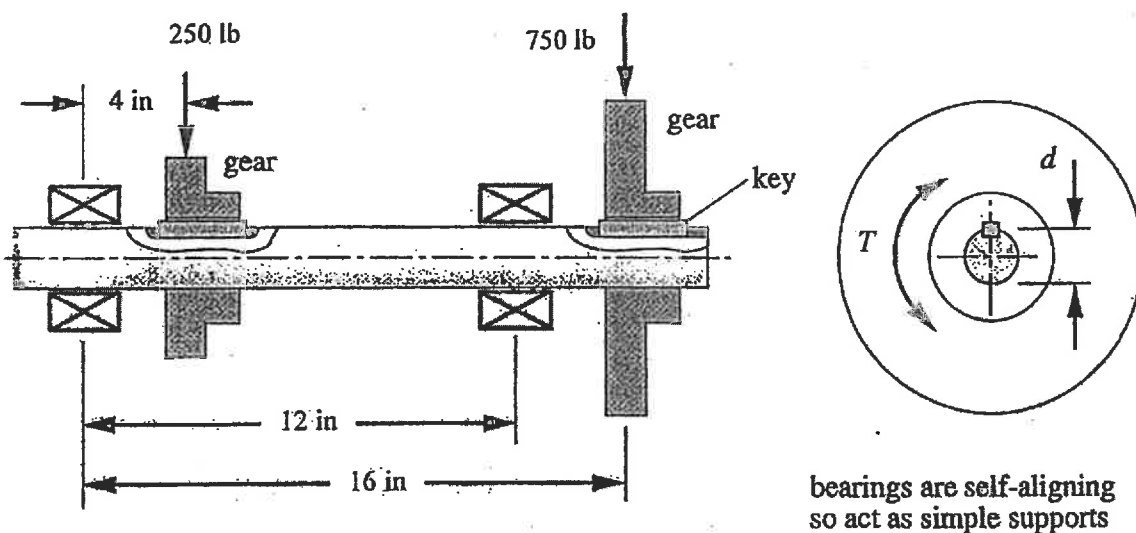
**Problem 2.** An overhung diving board is shown in the following figure with a cross-section of 305 mm x 32 mm. (a) Find the largest principal stress that will result when a 60-kg person jumps up 25 cm at the free end and lands back on the board. Assume that the board weighs 25 kg and deflects 10 cm statically when the person stands on it. (b) What is the static safety factor if the board material has an ultimate stress of 200 MPa in the longitudinal direction? (30 marks)



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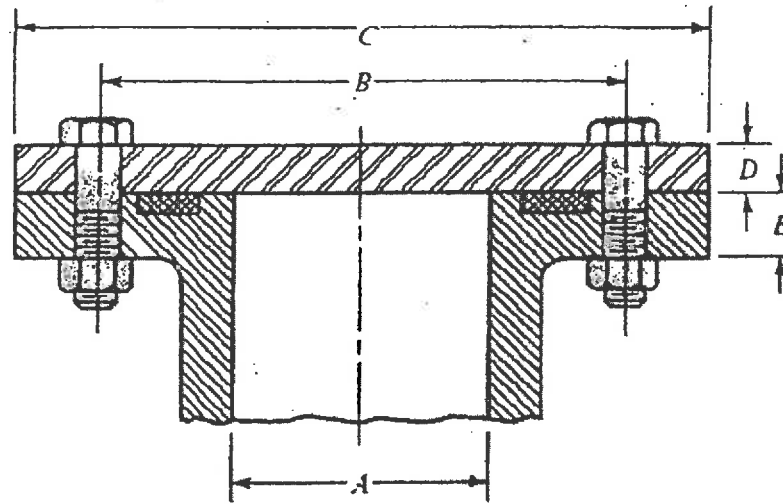
## Part II

**Problem 3.** A common shaft with two gears on it is shown in the following figure. Two constant radial forces of 250 lb and 750 lb are applied at the left and right gear, respectively. The shaft is subjected to a time-varying torque from the minimum of  $-200 \text{ lb}\cdot\text{in}$  to the maximum of  $400 \text{ lb}\cdot\text{in}$ . Find the diameter of shaft required to obtain a safety factor of 2 in fatigue loading if the shaft is steel of ultimate strength  $S_{ut} = 108 \text{ ksi}$  and yield strength  $S_y = 62 \text{ ksi}$ . What would be the maximum deflection in bending of the shaft? (20 marks)

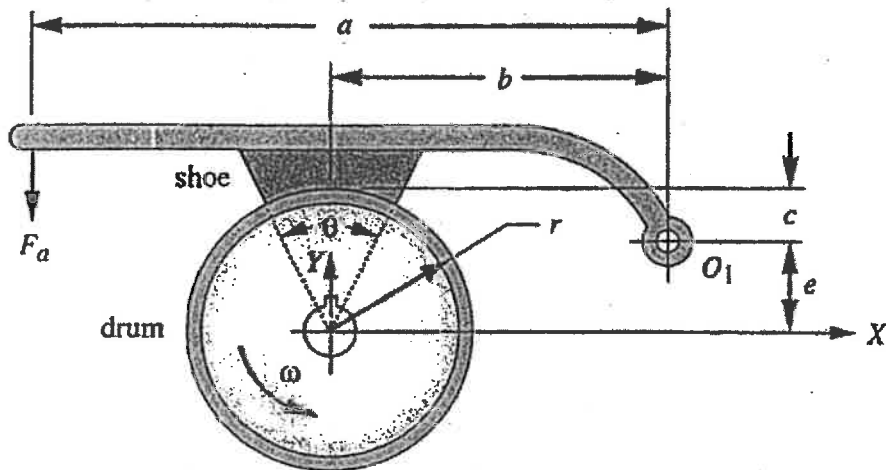


**Problem 4.** A journal and bearing are to be designed for a shaft that turns at 250 rpm. Suppose ISO VG100 (SAE Engine 30) is to be used as lubricant and the bearing length is to be equal to 1.2 times the diameter. If the no-load power loss is not to exceed  $2.5 \times 10^{-4}$  horsepower and the diametral clearance is 0.0045 times the diameter, estimate the maximum diameter that can be used for the journal, and the allowable temperature limit. (20 marks)

**Problem 5.** The figure below illustrates the connection of a steel cylinder head to a steel pressure vessel using 8 bolts and a confined-gasket seal. The effective sealing diameter is 150 mm. The other dimensions are:  $A = 100 \text{ mm}$ ,  $B = 200 \text{ mm}$ ,  $C = 300 \text{ mm}$ ,  $D = 20 \text{ mm}$  and  $E = 25 \text{ mm}$ . 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.** For a single short-shoe external 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  $\theta = 40^\circ$ . 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)



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