National Exams December 2016

98-Mar-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:

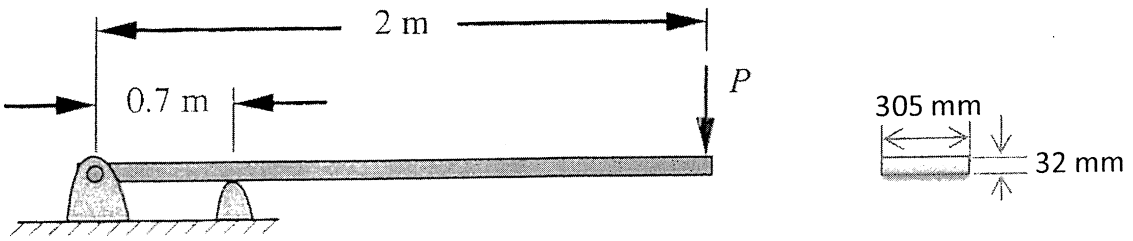
(a) What is $\sigma_{0.2}$ ? **(2 marks)**

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

(c) How does the mean stress affect the fatigue behavior of material? **(3 marks)**

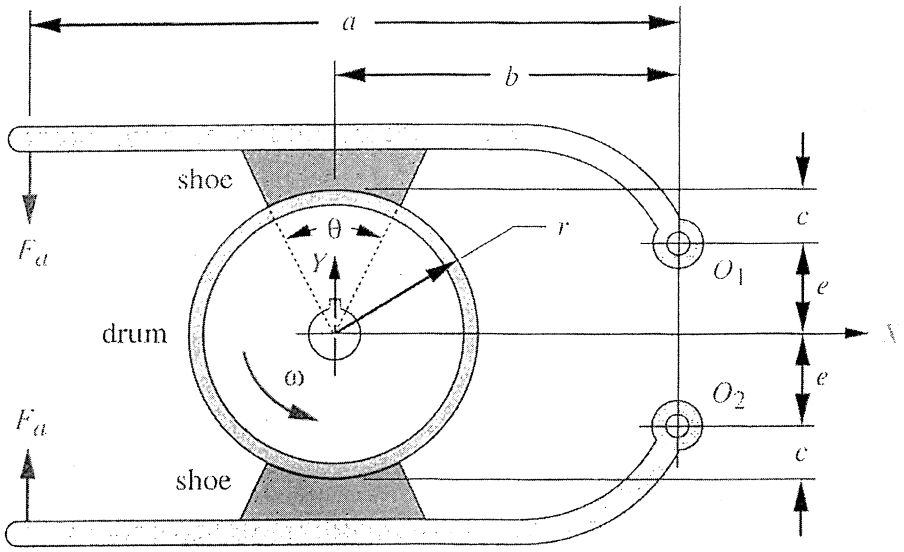
(d) In plane strain equi-biaxial tension, why does the material exhibit a higher load carrying capacity before yielding compared with uniaxial tension? **(2 marks)**

**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)**

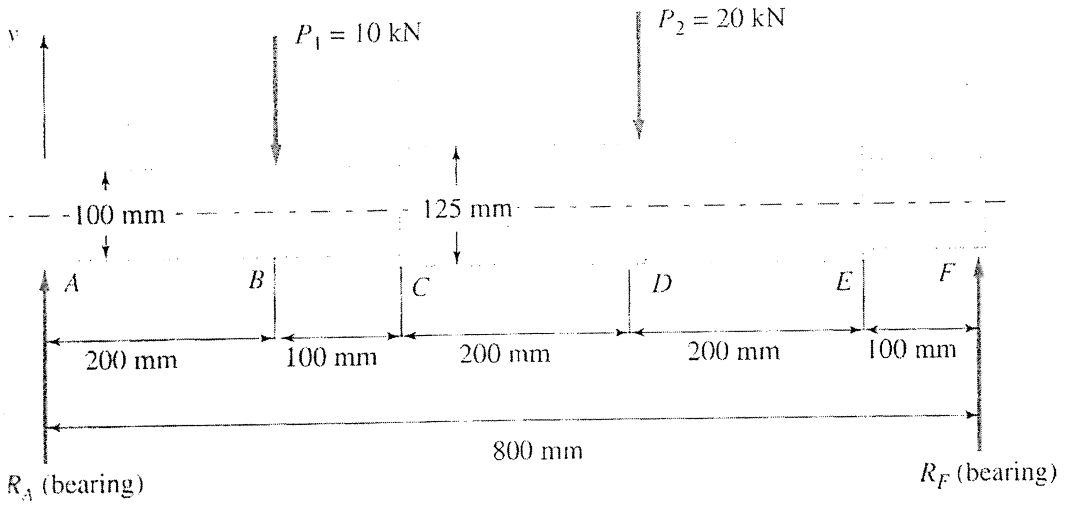


Part II

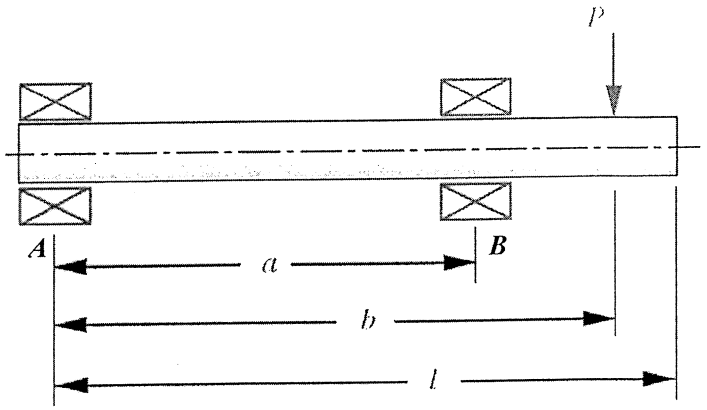
**Problem 3.** For a double short-shoe external drum brake with a drum width of 60 mm as shown in the following figure, find the torque capacity and required actuating force $F_a$ for $a = 90$ mm, $b = 80$ mm, $e = 30$ mm, $r = 40$ mm, and $\theta = 25^\circ$. What value of $c$ will make it self-locking? Assume the maximum allowable lining pressure is 1.3 MPa and the friction coefficient for the brake lining material is $\mu = 0.25$. **(20 marks)**

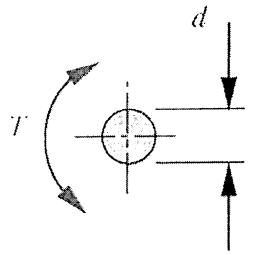


**Problem 4.** A stepped, round shaft is loaded as shown in the following figure. Find out (1) the maximum deflection and its location along the shaft, and (2) the fundamental critical rotating speed for the shaft. **(20 marks)**




**Problem 5.** A shaft is simply supported at $A$ and $B$ as shown. A constant magnitude transverse load $P$ is applied as the shaft rotates subjected to a time-varying torque from $T_{min}$ to $T_{max}$. If $l$ = 12 in, $a$ = 7 in, $b$ = 9 in, $P$ = 500 lb, $T_{min}$ = – 100 lb-in, $T_{max}$ = 600 lb-in. Find the shaft diameter required to obtain a safety factor of 2 in fatigue loading, and the corresponding maximum deflection of the shaft. Assume a machined surface, reliability of 99% and room temperature, use $S_{ut}$ = 108 ksi, $S_y$ = 62 ksi, and $E = 2.9 \times 10^4$ ksi. **(20 marks)**




assume bearings act as simple supports

**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)**