

## National Exams May 2015

## 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.

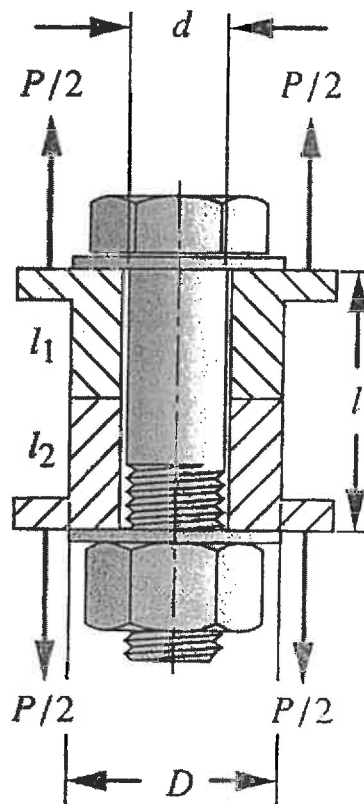
PART I

**Problem 1.** Briefly answer the following questions:

- (a) 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) What happens when the eccentricity ratio equals one in a journal bearing? (2 marks)

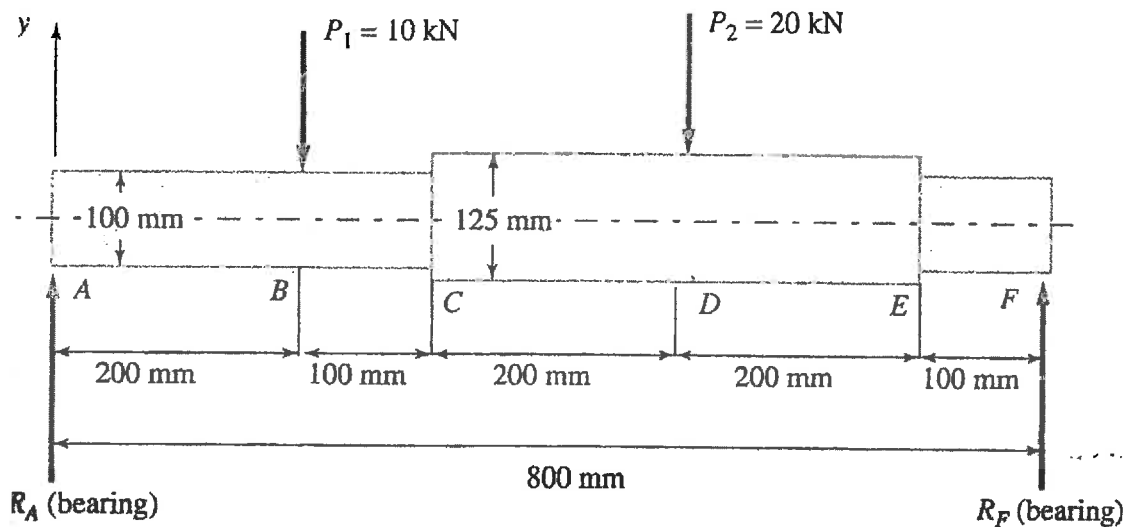
**Problem 2.** Design a suitable bolt size and preload for the joint shown in the following figure.

Find its safety factor against yielding and separation. Determine the optimum preload as a percentage of proof strength to maximize the safety factors. (30 marks)



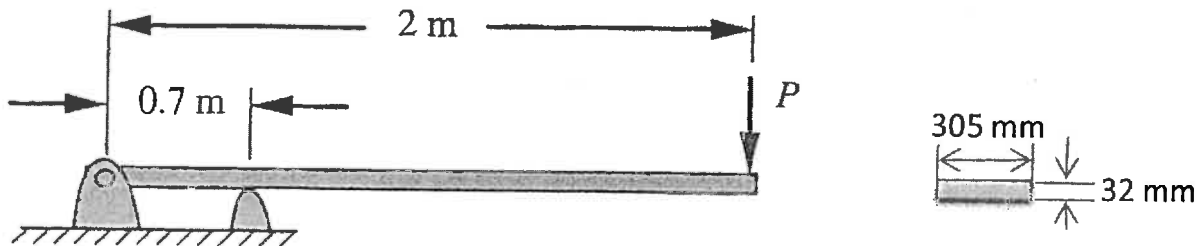
## Part II

**Problem 3.** 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 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.** 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 25 kg and deflects 8 cm statically when the person stands on it. (20 marks)



**Problem 6.** 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  $\theta = 30^\circ$ . 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)

