National Exams December 2014

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:

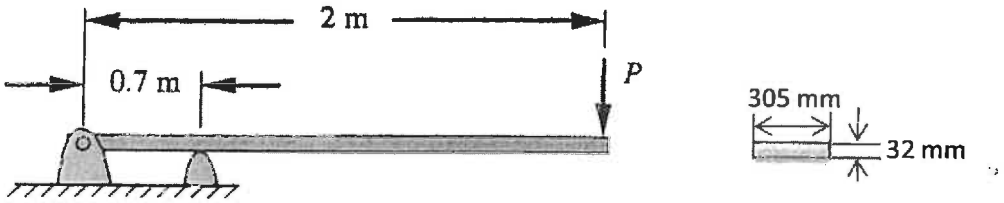
(a) If the three principal stresses are the same and equal to the yield strength of a material, will the material yield? Justify your answer briefly. **(3 marks)**

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

(c) To design a solid aluminum beam for pure bending load, which cross-section shape will need less material, a circular shape or a square? Justify your answer briefly. **(3 marks)**

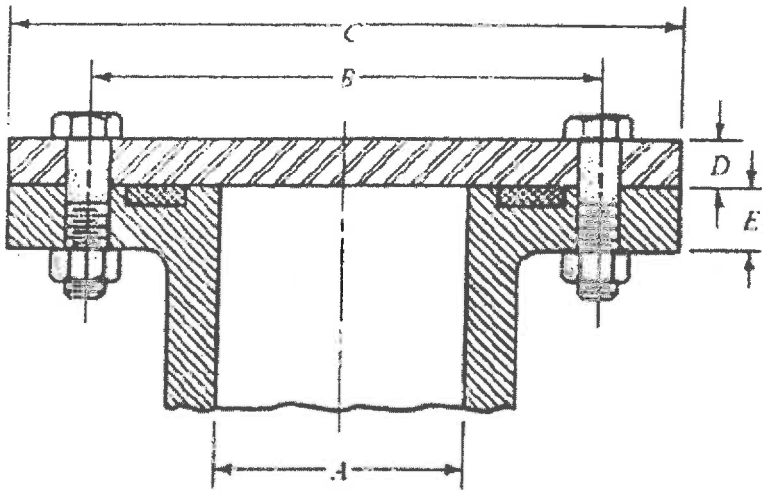
(d) How does the mean stress affect the fatigue behavior of material? **(2 marks)**

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 70-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 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. 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: $A = 100$ mm, $B = 200$ mm, $C = 300$ mm, $D = 20$ mm and $E = 25$ 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 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 2.5×10^{-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. 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 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 $\theta = 40°$. 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)**