

National Exams May 2010
07-Mec-B1, Advanced Machine Design
3 hours duration

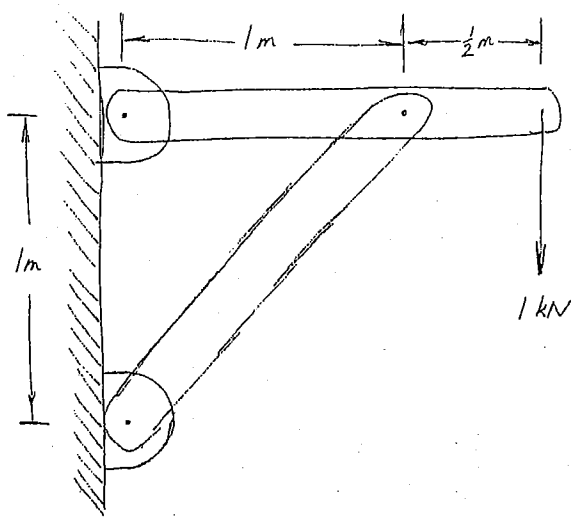
NOTES

1. Answer all questions of Part I (i.e., Questions 1 & 2) and only TWO questions from Part II of the examination.
2. Make your answers neat; write your equations in symbol form first and put intermediate and final results in boxes.
3. State all assumptions clearly. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
4. All answers must be clearly annotated with a summary of the approach, method, and results written in clear and correct English.
5. This is an OPEN BOOK EXAM. One textbook of your choice is permitted plus notes.
6. Any non-communicating calculator is permitted.
7. Assume any missing data and make sure to properly state it in your answer.
8. The examination marks total 100.
9. Failure to follow the above directions will result in the grade penalties.

PART I

Questions 1 and 2 must be solved by all candidates.

Question 1 (25 points)



For the two bar linkage shown above, select a material, method of manufacture, and cross-section. The design objectives are safety and economy. State your objectives, constraints, and metrics for the objectives. For buckling in the plane of the linkage, assume the link is pinned at both ends. Assume the ends are fixed for out-of-lane buckling. Justify your decisions.

Question 2 (25 points)

Select the material and wall thickness for a cylinder subject to an internal pressure of 30 MPa. The cylinder must have an inner diameter of 350 mm. Furthermore, the cylinder must be able to operate with a radial crack in the longitudinal direction of depth 12.5 mm. The crack may not exhibit uncontrollable growth.

PART II

Solve only two questions of the following three questions (3, 4, and 5).

Question 3 (25 points)

Journal bearing specifications:

- 75 mm shaft diameter
- unilateral tolerance -0.02 mm

Bushing specifications:

- bore diameter 75.1 mm
- unilateral tolerance 0.06 mm
- 36 mm length
- supports load of 2 kN

For the minimum clearance assembly and SAE 20 lubricant operating at an average film temperature of 60 C, find the journal speed at which heat loss is 60 W.

Question 4 (25 points)

A power screw used to resist a vertical load uses a 5/8 inch-6 Acme thread. The frictional coefficients are 0.05 for the threads and the collar. The collar has a friction diameter of 7/16 inch.

- Find the minimum vertical load at which the load will lower itself without any external effort.
- Determine the torque required to raise this load.
- Find the von Mises stress and maximum shear stress at the root.

Question 5 (25 points)

The following are histogrammic results from tensile testing of a batch of steel components.

| | | | | | | | | | | | | | | | |
|------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Tensile Strength (MPa) | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 |
| Frequency | 3 | 7 | 11 | 16 | 21 | 13 | 13 | 6 | 2 | 0 | 4 | 3 | 0 | 0 | 1 |

| | | | | | | | | | | | | | |
|-----------------------|------|------|------|------|------|------|----|------|------|------|------|------|------|
| Elongation in 2 in, % | 29.4 | 29.5 | 29.6 | 29.7 | 29.8 | 29.9 | 30 | 30.1 | 30.2 | 30.3 | 30.4 | 30.5 | 30.6 |
| Frequency | 1 | 4 | 3 | 2 | 12 | 24 | 18 | 12 | 11 | 3 | 4 | 5 | 1 |

Assuming lognormal distributions, estimate the modulus of elasticity for which 95% of the components will be stiffer.