National Exams May 2011

07-Mec-B1, Advanced Machine Design

3 hours duration

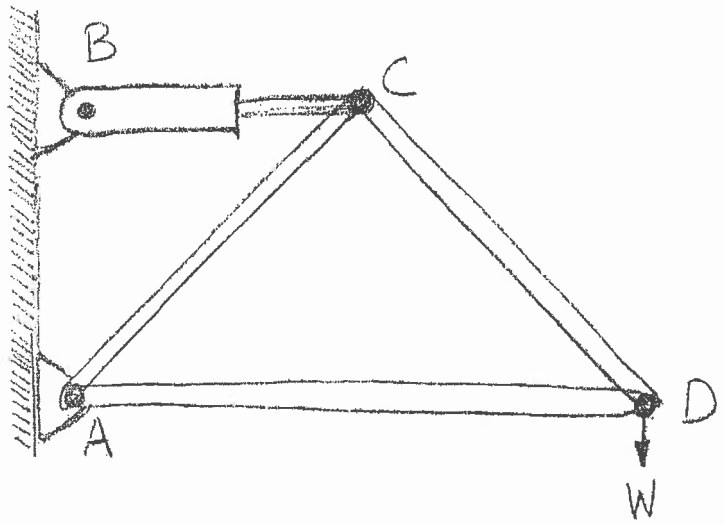
NOTES

1. Answer all questions of Part I (i.e., Questions 1 & 2) and only TWO questions from Part II of the examination.
2. FIVE (5) questions constitute a complete exam paper. The first five questions as they appear in the answer book will be marked.
3. Make your answers neat; write your equations in symbol form first and put intermediate and final results in boxes.
4. 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. Assume any missing data and make sure to properly state it in your answer.
5. All answers must be clearly annotated with a summary of the approach, method, and results written in clear and correct English.
6. This is an OPEN BOOK EXAM.
7. Any non-communicating calculator is permitted.
8. The examination marks total 100.
9. Each question is of equal value.
10. Failure to follow the above directions will result in the grade penalties.
11. Some questions may require an answer in essay format. Clarity and organization of the answer are important.

PART I

Questions 1 and 2 must be solved by all candidates.

Question 1 (25 points)



The above sketch represents a simple device used to lift a weight at point *D*. The hydraulic cylinder between points *B* and *C* is used to lift the weight over a small displacement. Assume:

- Link *AD* is horizontal in the above sketch and has a length of 1000 mm.
- Links *AB* and *BC* are 500 mm each.
- The weight (*W*) is 20 kN.
- The links are in-plane and made from AISI 1006 cold-drawn steel. The links have a square cross-section.
- The factor of safety used in the design is 1.5.

Answer the following questions:

a. What are the reaction forces at points *A* and *B*?
b. If the hydraulic cylinder retracts 10 mm, what will the vertical displacement be at point *D*?

Question 2 (25 points)

The tensile offset yield strength of AISI 1137 cold-drawn steel is reported histographically as follows. Assume a lognormal distribution.

S_y (kpsi)	93	95	97	99	101	103	105	107	109	111
f	22	26	37	18	11	9	4	3	4	1

For a safety factor of 1.5, estimate the percentage of components made of this material that plastically deform at a stress of 100 kpsi.

PART II

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

Question 3 (25 points)

An Acme thread power screw has a major diameter of 36 mm and a pitch of 6 mm with double threads. Assume $f = 0.14$, $f_c = 0.08$ and $d_c = 45$ mm..

a. At what force is the screw self-locking?
b. What is the combined efficiency of the screw and collar at this force?

Question 4 (25 points)

A 2 inch diameter bearing has a length of 3 inch and has a central annular oil groove 0.25 inch wide that is fed by SAE-10 oil at 120°F and 30 psi supply pressure. The average radial clearance is 0.0015 inch. The journal is rotating at 3500 rev/min and the average pressure is 600 psi over the projected area. Find the temperature rise, the minimum film thickness, and the maximum film pressure.

Question 5 (25 points)

Design a disk brake for a half-tonne hoist that lifts and lowers a payload attached to a cable. The cable is wrapped around the 0.5 m diameter drum. A constant speed centrifugal governor limits the lowering speed to 1 m/s. The drum weighs 100 kg and has a radius of gyration of 0.2 m. The multiple disk brake is mounted as shown below. The brake must bring the payload to a stop in 0.5 s and the axial actuating force on the brake must not exceed 10 kN. Design the disk brake system including number of disks, their diameter and thickness, the required actuating force, and temperature rise in the system.