

National Exams December 2010

07-Mec-B1, Advanced Machine Design

3 hours duration

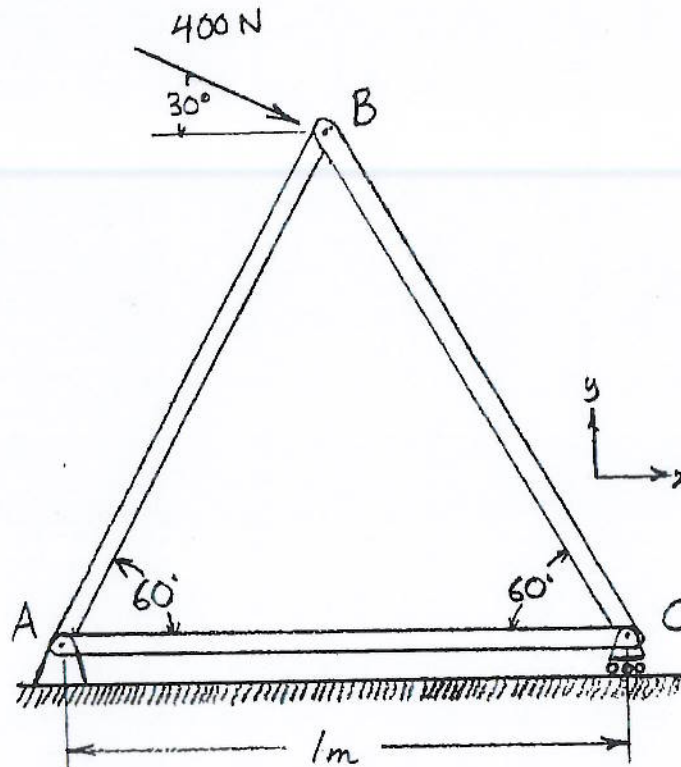
NOTES

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.
 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.
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PART I

Questions 1 and 2 must be solved by all candidates.

Question 1 (25 points)



Design the above three bar linkage to sustain a force of 400 N at point B while maintaining a maximum deflection of 1 mm at point C in the x direction. Use stock materials and cross-sections. Lower is cost is better. Assume the mechanism is planar. State your objectives, constraints, and metrics for the objectives. Justify your decisions.

Question 2 (25 points)

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

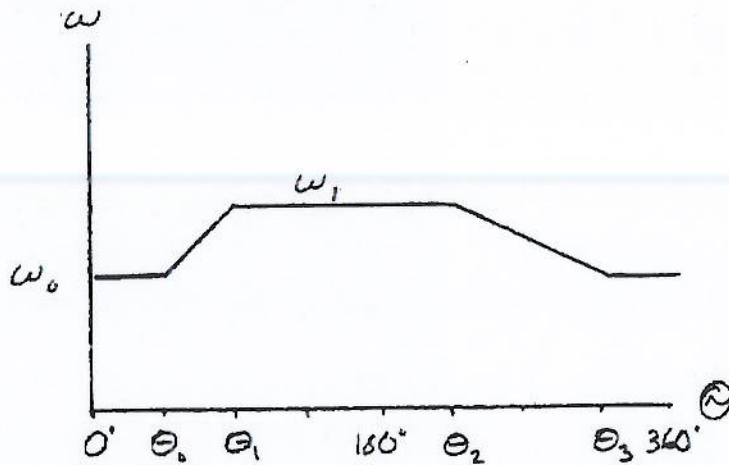
S_y (kpsi)	93	95	97	99	101	103	105	107	109	111
f	22	26	37	18	11	9	4	3	4	1

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)



Design a flywheel to halve ω_1 where $\omega_0 = 200$ rad/s. The figure above shows a shaft that undergoes an input of power at a torque of 3000 lbf·in over 45° of its rotation every cycle (from ϑ_0 to ϑ_1). From ϑ_2 to ϑ_3 , the shaft dissipates that power to return to the same angular velocity. Specify the flywheel's material, rim inside diameter, outside diameter, width, energy transfer, coefficient of speed fluctuation, and peak power.

Question 4 (25 points)

Design a single square thread power screw to use 30 N·m of input torque at 1.5 rev/s to produce 10 kN of output force and a displacement of a minimum of 5 mm per revolution. Specify the thread depth, thread width, pitch diameter, minor diameter, lead, and material. Assume $f=f_c=0.1$.

Question 5 (25 points)

Design a full journal bearing with the following parameters:

- $l/d = 1$
- SAE 10 oil
- $\mu = 20 \text{ mPa}\cdot\text{s}$
- $T_s = 50^\circ\text{C}$
- $d = 100 \text{ mm}$
- $b = 100.1 \text{ mm}$
- $W = 4000 \text{ N}$

Specify the journal speed, coefficient of friction, temperature rise, volume flow rate of oil, and minimum film thickness.