# National Exams December 2008

## 07-Mech-B1, Advanced Machine Design

## 3 hours duration

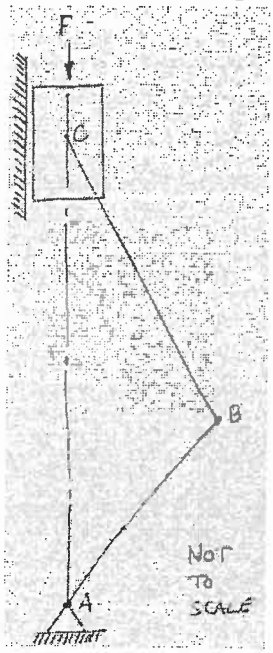
## Notes

1. Answer all questions of Part I (i.e., Questions 1 & 2) and only TWO questions from Part II of the examination.
2. Make 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. This is an OPEN BOOK EXAM.
5. Any non-communicating calculator is permitted.
6. Assume any missing data and make sure to properly state it in your answer.
7. The examination marks total 100.

# Part I

Questions 1 and 2 must be solved by all students.

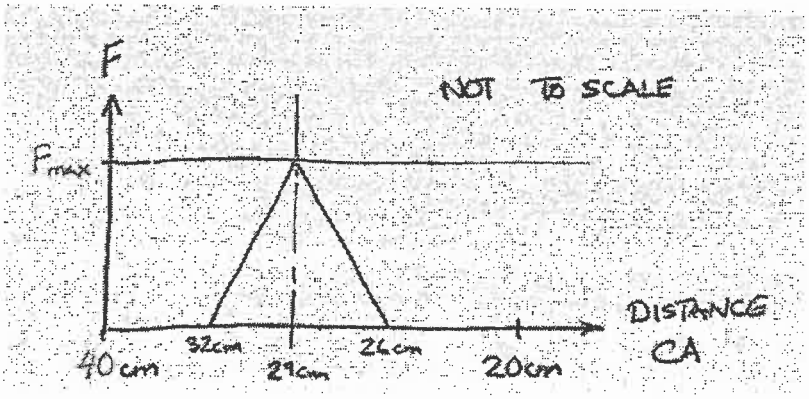
## Question 1 (25 points)




The above figure is a schematic representation of a slider-crank mechanism. Points *A*, *B*, and *C* are pinned joints. Links *AB* and *BC* are 10 cm and 30 cm long, respectively.

**a)** Write an expression for the torque at point *A* given in terms of the input force *F*. Document any assumptions.

**b)** Given the below function diagram for the force *F* in terms of the location of the piston at *C* compute: the maximum torque in terms of $F_{max}$ and compute the position of the piston at maximum torque.



## Question 2 (25 points)

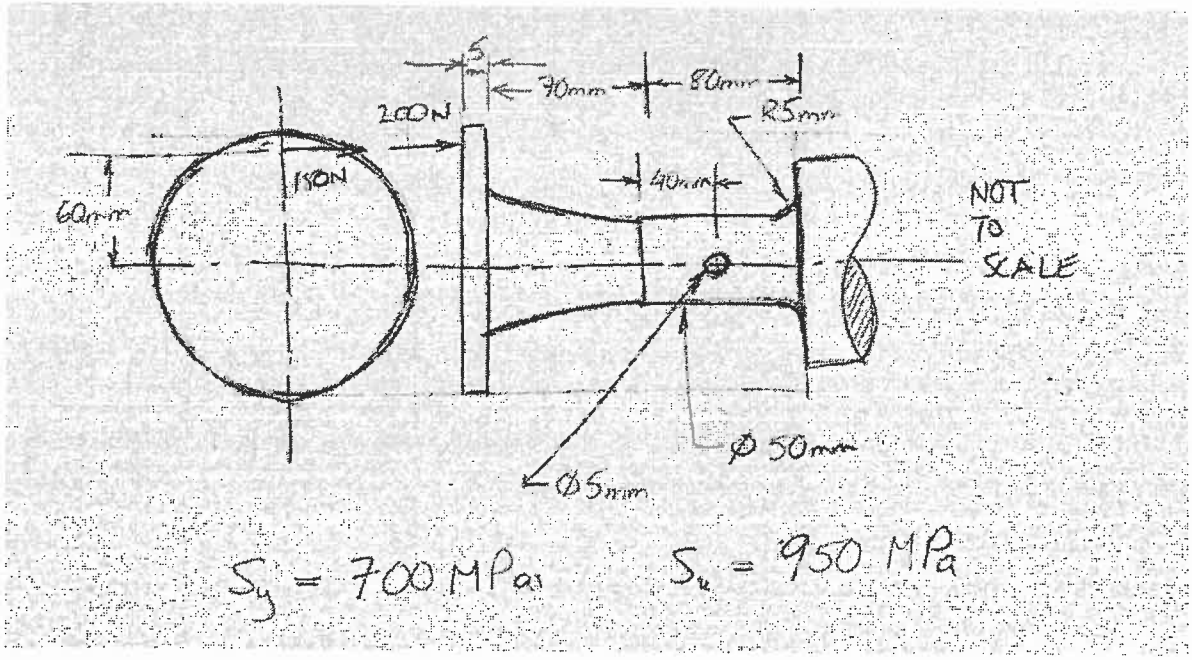
The function of spacer is to maintain a minimum clearance between two surfaces. It is required to maintain a minimum clearance of 250 mm under a negligible load at 26°C. The as-built spacer is 250 mm long tube with a known cross-sectional area of 625 mm$^2$. It was constructed from aluminum alloy (2024-T4). However, when subjected to an environment with a temperature of 250°C, the load increases at rate of 80 MN/mm (the spacer's thermal expansion is constrained by a structure with a stiffness of 80 MN/mm). When the temperature is again reduced to 26°C, it is noticed that the spacer has failed. Determine the cause of failure and then redesign the spacer to meet the dimensional and thermal requirements.

## Part II

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

## Question 3 (25 points)

In the figure below, a rotating disk is shown on the end of a shaft. It is made of steel having *Sy*=700 MPa and $S_u$=950 MPa. Fixed tangential and normal loads are shown. Estimate a safety factor for infinite fatigue life. Note, there is no discontinuity in the diameter at 80 mm from the shaft shoulder.




## Question 4 (25 points)

Design a double calliper disk brake using at least two circular pads. The centre of contact of each of pad must be at a distance of 148 mm from the centre of the rotor. The outside diameter of the disk is 400 mm. The generated brake torque must be at least 500 N·m. Limit the average pressure on the pads to 450 kPa. List your assumptions.

## Question 5 (25 points)

A single, square-threaded power screw lifts a load of 6,000 kg. The mean diameter of the screw is 25 mm with a pitch of 6 mm and a collar diameter of 45 mm. The coefficients of friction are estimated at .11. To move the nut at 50 mm/s what power must be provided? What is the von Mises stress at the thread root?