

**National Examinations - May 2003**

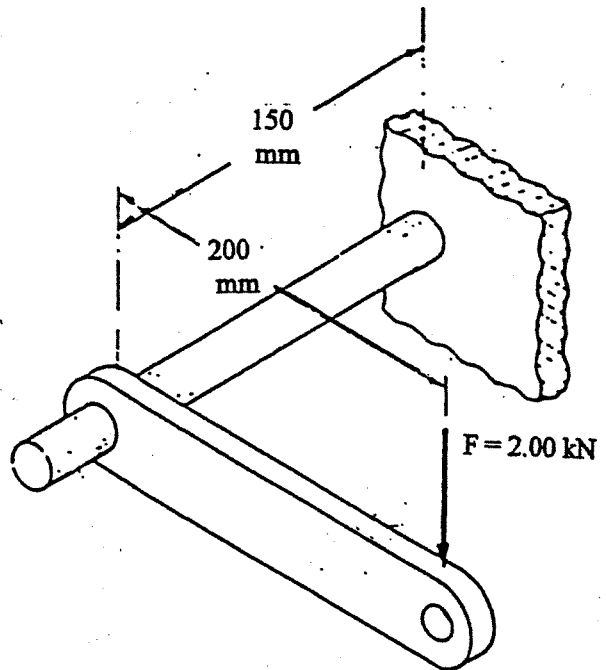
**98-Mec-A5, Design and Manufacture of Machine Elements**

**3 Hours Duration**

**Notes:**

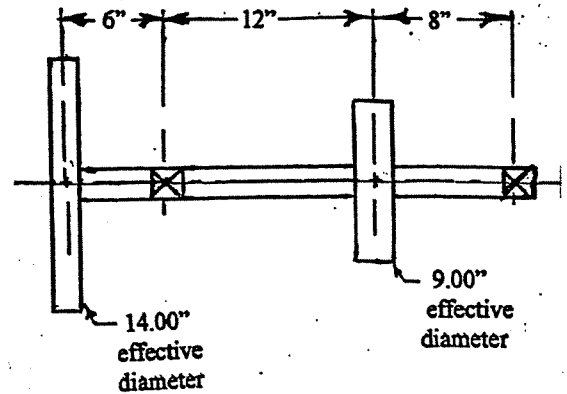
1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. Any non-communicating calculator is permitted. Write the name and model designation of the calculator on the first inside sheet of the exam work book.
3. This is an open book examination.
4. There are seven questions on the following 3 pages.
5. Any 5 (five) questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
6. All questions are of equal value (20%).

1. A lever subjected to a static force of 2.00 kN is attached to a 25.0 mm diameter solid round bar made from AISI 1050 (G10500) cold drawn steel. For this problem, consider the stresses near the wall, but ignoring stress concentrations due to attachment.



- a) List the stresses (no calculations) acting on a horizontal line through the middle of the bar at this location.
- b) For a point on the top of the bar at this location, using either Mohr's Circle or calculation, find:
- the maximum normal and shear stresses,
  - the factor of safety based on the maximum normal stress,
  - the factor of safety based on the maximum shear stress.
- c) Would you specify welding as an attachment method for this assembly? Why?
2. a) What manufacturing methods can be used to manufacture:
- internally-toothed gears?
  - externally-toothed gears?
  - Which one of the methods in (ii) is preferred for high volume production?
- b) Commercially-cut gears are heat-treated after machining. Precision gears are cut, hardened, then ground.
- What hardening method(s) can be used in gear manufacture?
  - Why do precision gears require grinding after hardening?
  - Why are all gears not ground after hardening?
- c) As a manufacturer of cast iron parts, you will expect the designers to follow good design practice for cast parts. Discuss some of these requirements, such as part complexity, transition areas, differing thickness, etc. Why are these points important?
- d) A flanged cup shape is to be deep-drawn.
- Would you specify a single-acting, or a double-acting die design? Why?
  - What steel(s) would you expect the designer to specify?
  - Why is springback a problem?
  - Why is draft angle important?

3. A countershaft transmits a steadily-applied, uniform 20.0 HP at 1200 RPM from one V-belt to another. To ease calculations, assume the tension ratio  $F_1/F_2$  (tight side to slack side) is 4 : 1 for both belts. All belt runs are assumed to be vertical. The bearings are self-aligning. Pulley weights are assumed to be small compared to the belt loads.

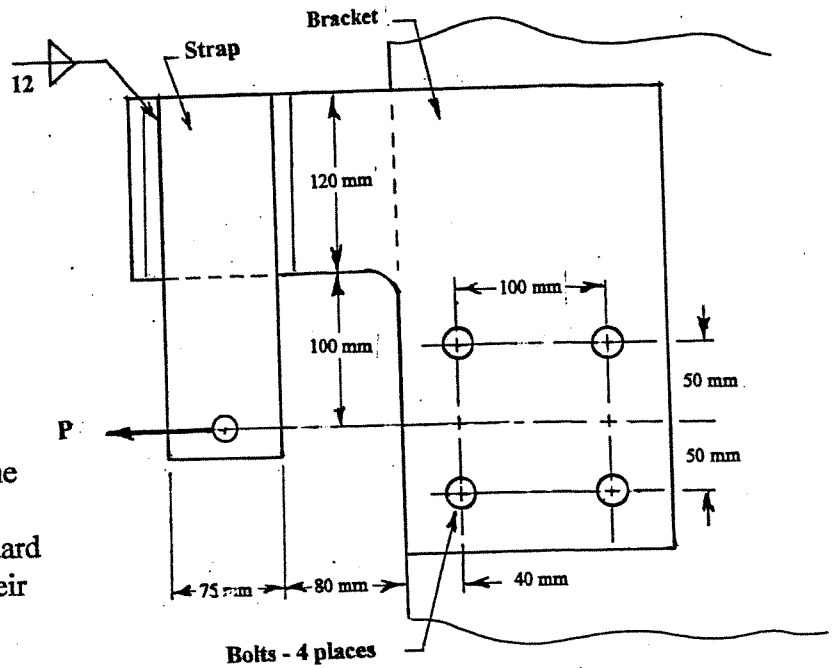


- (a) Draw a free body diagram of the shaft, and show complete shear and bending moment diagrams.
- (b) The shaft is AISI 1045 (UNS G10450) cold drawn steel. Due to keyways, etc., apply a stress concentration factor of 1.80. A factor of safety of 2.00 is to be used. Find the minimum shaft diameter. It is suggested that you use the modified Goodman line and maximum-shear-stress theory. However, you may use other theories, but must state clearly what theories you use.
4. a) Specify 2 plastic materials for each of the following room temperature applications. Which physical property(ies) did you consider in your selection in each case?
- a long slender rod having steady tensile loading,
  - a short member subjected to tensile impact loading,
  - a member which must undergo minimum dimensional change under load,
  - a member undergoing large elastic deflection.
- b) For a fibre-reinforced composite:
- Indicate 2 functions of the matrix material.
  - List 2 functions for the fibres.
  - Why is it important to have a good bond between the fibres and the matrix?
  - When would the designer specify oriented fibres, and when would random fibres be used?
- c) Briefly discuss the differences in mechanical properties among the following types of plastic materials:
- thermoplastics
  - thermosets
  - elastomers.

5. The steel strap is attached to this cable bracket by 12 mm fillet welds using E6010 electrodes. The bracket is bolted to its support structure with 4 equal sized bolts.

Assume that the strap and bracket are sufficiently strong, and experience no out-of plane stresses.

- Find the maximum magnitude of the gently-applied cable force  $P$ .
- Find the smallest diameter of standard M8.8 bolts to resist load  $P$ . Use their major diameter and a maximum allowable shear stress of 200 MPa.



6. A 500 rev/min shaft subjects a ball bearing to a radial load of 15.0 kN and an axial load of 12.5 kN. The bearing's inner race rotates with the shaft. The design life of the bearing is to be 10 years of 8 hour per day, 250 working day per year, operation. There is light vibration, and 99.5 % reliability is required.

Select a suitable single row, angular contact ball bearing in the 02 series.

- For energy-absorbing applications (i.e.: collision energy absorption members in the front end of a car), a metal which is "tough" is required. Sketch a stress-strain curve for mild steel, and indicate what parameter(s) produce toughness.

- When replacing a steel part with aluminum, many engineering properties must be considered. Compare these 2 metals with respect to:
  - toughness
  - rigidity
  - strength
  - endurance.

How would you adjust your aluminum design to compensate for a deficiency in the above properties (if any)?

- Stronger steels are produced by many methods. Four are:

- high carbon steels
- heat-treated steel
- high alloy steels
- HSLA (high strength, low alloy) steels.

Briefly discuss each, and indicate which one you would specify for the replaceable road-contacting segment of a blade for a snow plow or road grader.