

THE UNIVERSITY OF BRITISH COLUMBIA

Department of Mechanical Engineering

Sessional Examination - December 2010

Mech 260 - Introduction to Mechanics of Materials - Sections 101 & 102

Instructors: C. W. de Silva (102) and F. Sassani (101)

Time: 2.5 hours

Closed book/notes. One 8.5"x11" fact sheet (double-sided)
prepared by student is allowed

This question paper
contains 3 pages

Non-programmable non-graphing calculators allowed. Alternatively, you may use only the "arithmetic mode" of a programmable calculator. **No communication devices are allowed.**

Draw a box around your answers and **clearly indicate** units. For each question, 1 bonus point will be given for orderly and neat presentation.

Question 1

(Total points: 20) The carriage arm of a machine is made of rigid metal parts and a synthetic rubber attachment piece, as shown in Figure 1. *Note:* All the components except the rubber attachment piece are assumed rigid. One side of the rubber piece is firmly glued to a rigid wall of the machine. The other side is firmly glued to the top end of the carriage arm. The metal arm is made of two pieces joined using a single bolt and nut, in double shear arrangement, as shown.

When a vertical load P is applied to the free end of the carriage arm, it moves vertically through 2 mm. The dimensions of the rubber attachment piece are 50mm×40mm×20mm as shown. The shear modulus of the rubber attachment piece is $G = 0.5\text{MPa}$.

- Determine the value of the load P in newtons. (12 points)
- If the diameter of the bolt is $d = 10\text{mm}$, determine the average shear stress in the X-section of the bolt. (8 points)

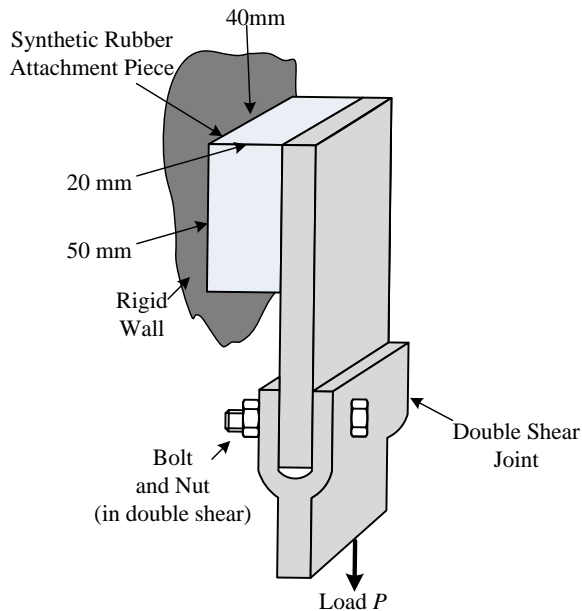


Figure 1 (a): Perspective View.

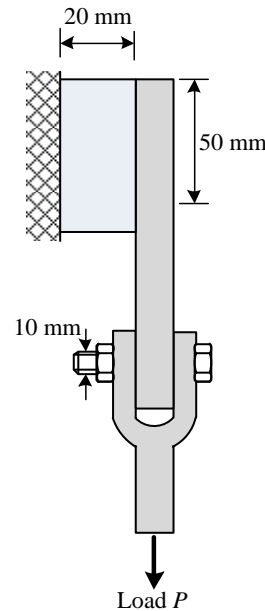


Figure 1 (b): Front View.

Question 2

(Total points: 25) At a temperature of 5°C , a 3-mm gap exists between two polymer bars and a rigid wall as shown in Figure 2. Bar (1) is 50 mm wide and 20 mm thick [$E_1 = 800 \text{ MPa}$; $\alpha_1 = 140 \times 10^{-6}/^{\circ}\text{C}$]. Bar (2) is 75 mm wide and 25 mm thick [$E_2 = 2.7 \text{ GPa}$; $\alpha_2 = 67 \times 10^{-6}/^{\circ}\text{C}$]. The supporting wall at C is also rigid.

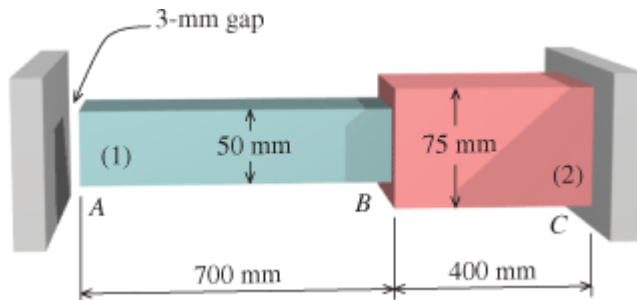


Figure 2: The Two-bar Arrangement.

Determine:

- the lowest temperature at which the 3-mm gap is closed. (5 points)
- the normal stress in the two bars at a temperature of 60°C . (15 points)
- the normal strain in the two bars at 60°C . (5 points)

Question 3

(Total points: 25) An electric motor drives a water pump (see Figure 3). The motor outputs a torque of 160 N-m. The 0.5 m long shaft joining the motor to the pump is made of steel and has a maximum allowable shear stress, τ_{allow} , of 82 MPa and shear modulus, G , of 80 GPa.

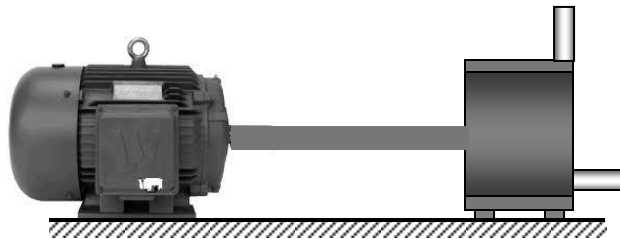


Figure 3: An Electric Motor Driving a Pump through a Shaft.

- What is the minimum required diameter of the shaft? (7 points)
- What will be the angle of twist in the shaft of this diameter? (6 points)
- It is proposed to replace the solid shaft by a hollow shaft of the same material whose inner diameter is one-half of its outer diameter. Determine the minimum required outer diameter. (6 points)
- Comparing your results from parts (a) and (c), what conclusions can you draw? Also, what is the ratio of the weight of the solid shaft to the hollow shaft? (6 points)

Question 4

(Total points: 30) A uniform beam of box section and length L (m) is clamped at one end and carries a uniform transverse load of $\frac{P}{L}$ (N/m) along it (see Figure 4(a)). The outer dimensions of the box section are $2a \times 2a$ (m \times m) and the inner dimensions are $a \times a$ (m \times m), as shown in Figure 4(b).

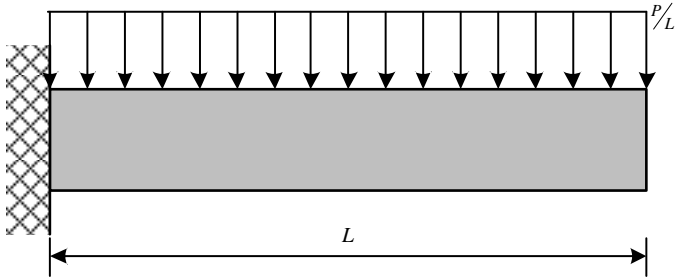


Figure 4 (a): Clamped Uniform Beam.

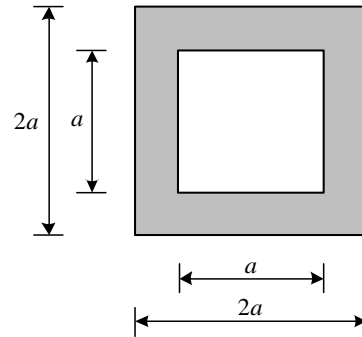


Figure 4 (b): Beam X-Section.

- Sketch the shear diagram and the moment diagram of the beam and mark the key values of internal shear force and internal bending moment on the two curves. (10 points)
- Determine the maximum bending (normal) stress on the beam X-section and its location. (10 points)
- Determine the maximum transverse shear stress on the beam X-section and its location. (10 points)

Note: Express the stresses in terms of the given quantities only (P , a and L).

General Instructions (for All Four Questions):

- Clearly state all your assumptions
- Give all your steps of derivations/computations
- Define any new variables/parameters/symbols that you may use