

Department of Civil Engineering
McGill University

CIVE 207 Solid Mechanics Winter 2021
Final Assignment

Issued: Thursday 15 April 2021

Due date: Friday 30 April 2021 (by 12h00 AM)

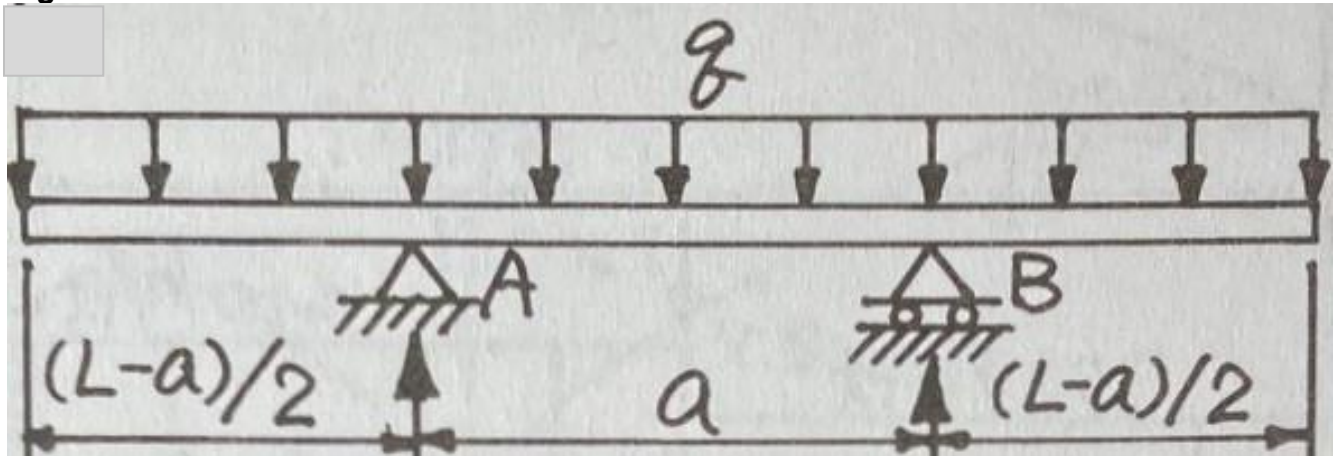
Total /100.

Problem 1 (15 marks)

Consider the simple beam with overhangs in Figure P1.

- Determine the optimal value of the distance between the two supports (distance a) such that the magnitude of the bending moment in the beam is the smallest.
- Sketch the corresponding V and M_f diagrams.
- Determine the deflection at the free end using superposition.
- Sketch the elastic curve of the deflected beam, indicating the degree of the polynomials describing the curve segments.

Figure P1

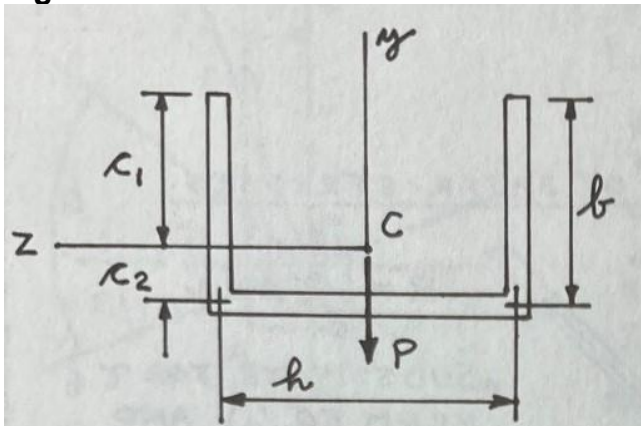


Problem 2 (20 marks)

The U-shaped cross section shown in Figure P2 is subjected to a downward force P of 20 kN.

- Calculate the maximum shear stress in the section.
- Sketch the shear stress distribution on the middle line of the cross section.
- Show that the stress resultants balance the applied load.
- Locate the shear centre of the U shape

Figure P2



$$h = 225 \text{ mm}$$

$$b = 90 \text{ mm}$$

$$t = 20 \text{ mm (thickness)}$$

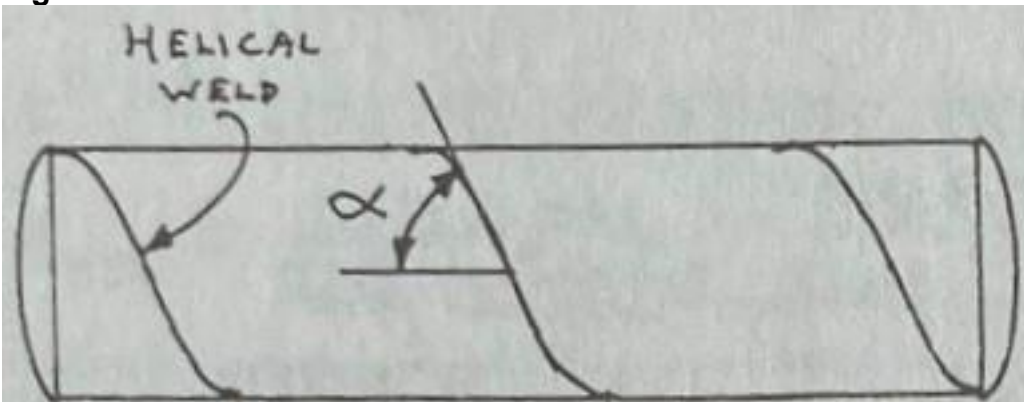
Perform calculations on the middle lines and neglect the higher order terms in t .

Problem 3 (15 marks)

A cylindrical pressure vessel of 1 m diameter and 15 mm thickness is constructed by welding the edges a thin steel strip helically wound around a drum as shown in Figure P3. The angle of the weld α is 60 degrees from the axial direction and the nominal internal pressure is 2.4 MPa.

- Determine the stress state in the cylindrical portion of the vessel and represent it on a Mohr's circle. Clearly state your axis convention and use the standard sign conventions.
- What is the maximum shear stress?
- Using Hooke's law and accounting for Poisson's effect, calculate the circumferential (hoop) and longitudinal (axial) strains in the cylindrical portion of the vessel. Take $E = 200 \text{ MPa}$ and a Poisson's ratio of 0.3 for steel.
- Calculate the stress state on the weld and represent it on the Mohr's circle found in a). Also show the stresses on a rotated element with respect to the axial direction.

Figure P3



Problem 4 (15 marks)

A cantilever beam of T-section is loaded as shown in Figure P4a and its cross-sectional dimensions are indicated in Figure P4b.

- Determine the plane stress states at points A and B located on the axis of symmetry of the shape at the fixed end.
- Sketch the Mohr's circles representing these two stress states and clearly indicate the diameters corresponding to the following orientations: x-y; principal directions; direction of maximum in-plane shear.
- Also represent the stress states in b) on rotated elements with respect to the longitudinal axis, x.

Figure 4a

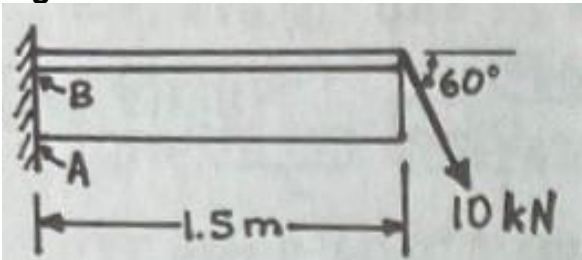
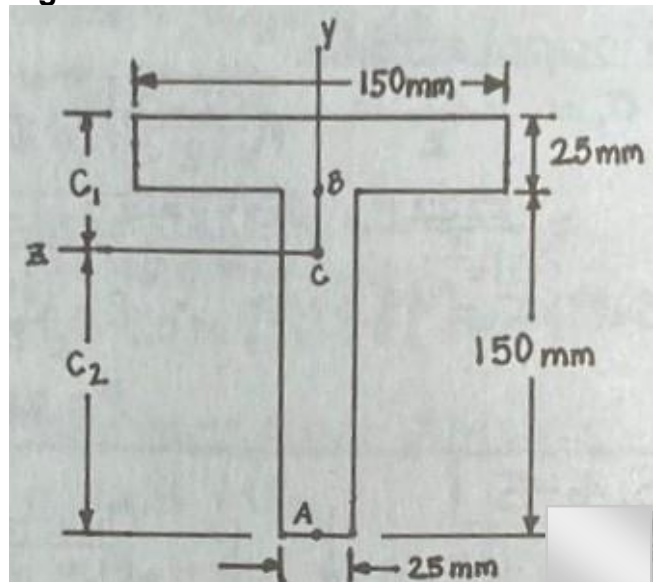


Figure 4b

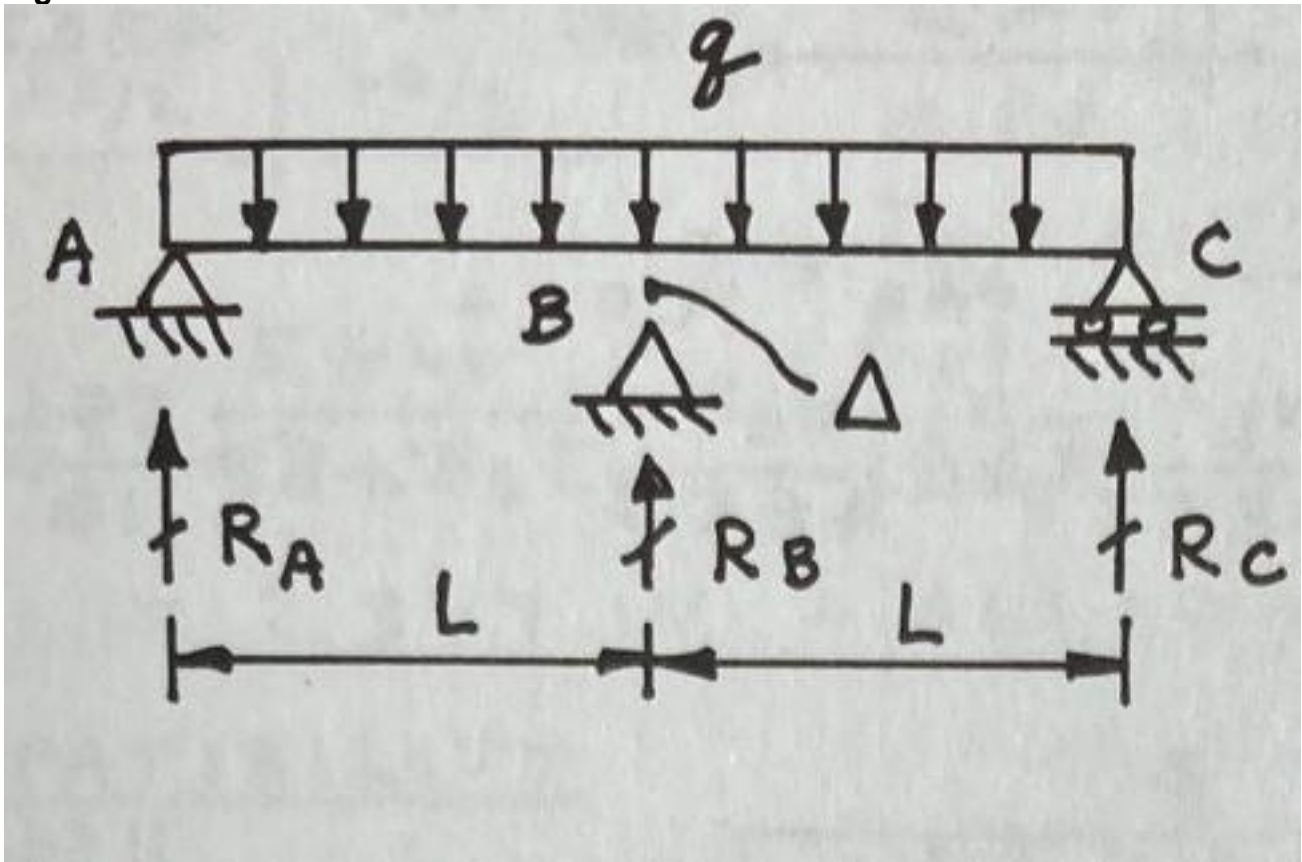


Problem 5 (20 marks)

The beam loaded as shown in Figure P5 is resting on a middle support with a gap, Δ .

- Determine the value of the minimum load $q = q_0$ necessary to close the gap.
- Determine the maximum bending moment in the beam as a function of the magnitude of the applied load q . Consider three scenarios: i) q less than q_0 , ii) $q = q_0$ and iii) q exceeding q_0 .
- Plot the function M_B vs q for the numerical example with a gap of 0.4 in., a span of 40 in. and $EI = 4 \times 10^8$ lb-in². (A bit of practice with imperial units).

Figure P5



Problem 6 (15 marks)

Consider the L-shaped tubular bracket shown in Figure P6.

- Determine the stress state at point A located at the fixed end and centered on the top face, and represent it on a Mohr's circle.
- Calculate the principal stresses and the maximum shear and identify the corresponding diameters on the Mohr's circle.
- Represent all of the above stress states on properly oriented elements.

Figure P6

