THE UNIVERSITY OF BRITISH COLUMBIA

Department of Mechanical Engineering

Sessional Examination - December 2011

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

Instructors: C. W. de Silva (101) and F. Sassani (102) *Time: 2.5 hours*

Closed book/notes. One 8.5"x11" fact sheet *(double-sided) prepared by student is allowed* *This question paper contains* ***4 pages***

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

Clearly state all your assumptions and show all your steps of the derivations/calculations. Define any new variables or parameters that you use, which are not given in the problem. Draw a box around your answers and ***clearly indicate*** *units. For each question, 1 bonus point may be given for orderly and neat presentation.*

Question 1

(Total 25 points) A rigid stepped beam is supported at its ends, as shown in Figure 1, by two steel rods having a modulus of elasticity of $E = 30 \times 10^3$ ***ksi***. The rods have the diameter of $d_{AB} = 0.5$ ***in.*** and $d_{BC} = 0.3$ ***in***. If the allowable tensile stress for the steel is $\sigma_{allow} = 16$ ***ksi***, determine:

(a) the location, ***x***, and ***(15 points)***

(b) the magnitude of the force, ***P***, on the beam. ***(10 points)***

so that the beam remains horizontal position after it is loaded.

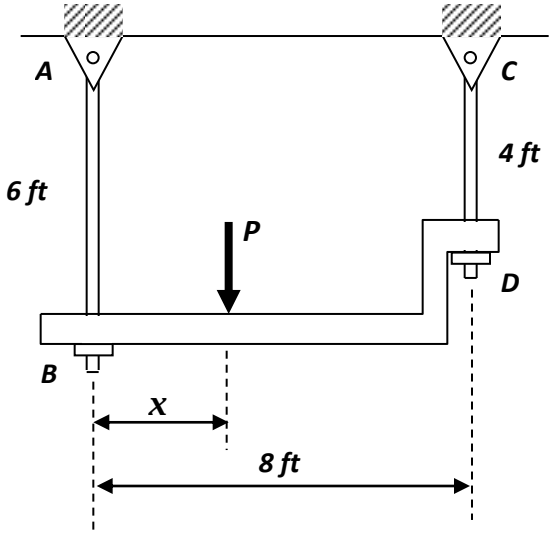

Figure 1: Loaded stepped beam.

Question 2

(Total 25 points) A vertical load ***P = 20 kN*** is supported by a rigid structure using a device as shown in Figure 2. In the device, a flexible rectangular piece (synthetic rubber) of height ***h = 100 mm***, width ***b* = 50 mm**, and thickness ***t*** is firmly glued between two rigid metal plates in order to absorb shock and vibration. The device is attached to the structure using steel bolts and nuts of shank diameter ***d = 10 mm*** and allowable shear stress $\tau_{allow} = 25$ ***MPa***.

(a) If the vertical movements δ at the point of application of the load ***P*** is to be limited to ***5 mm***, determine a suitable thickness ***t*** for the flexible piece. Shear modulus of the flexible piece ***G = 10 MPa***. ***(10 points)***

(b) Determine how many bolts would be needed . ***(15 points)***

Note: Assume that the load is equally distributed among all the bolts.

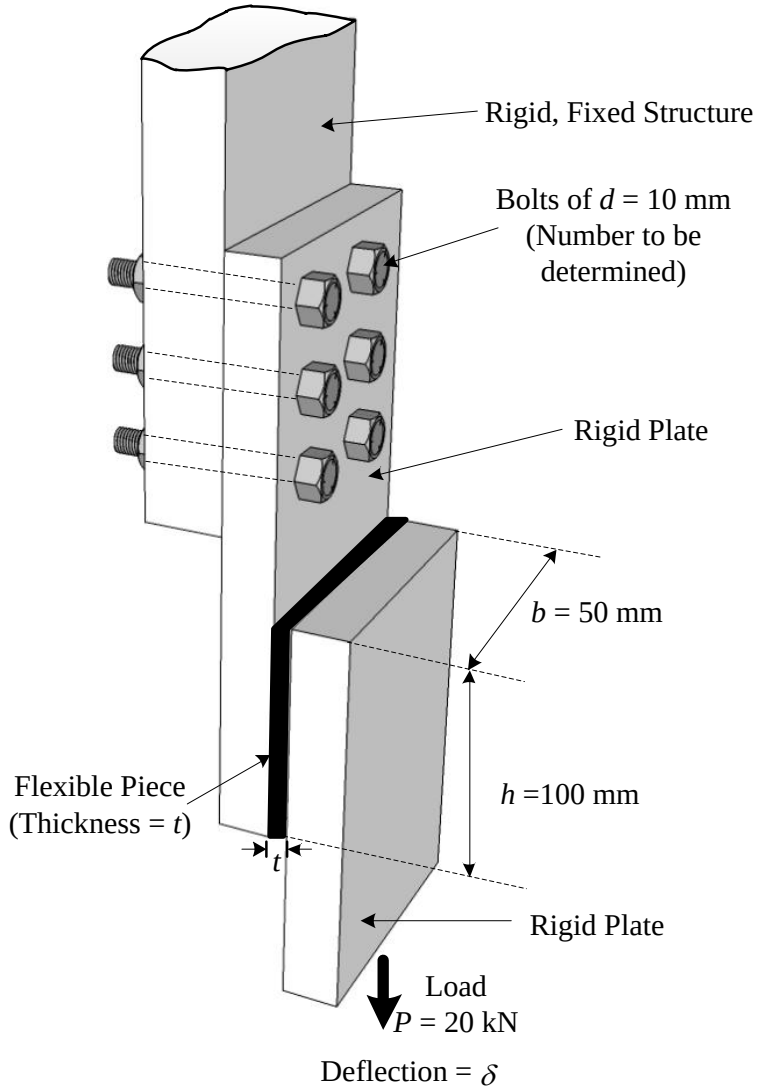

Figure 2: A load supported on a rigid structure through a shock absorber.

Question 3

(Total 20 points) A circular shaft is made of a solid segments ***AB***, and a hollow segment ***BC***. The two are joined at ***B*** and are of the same material with a shear modulus of ***G = 25 GPa***. Segment ***AB*** has a diameter of ***20 mm***, and the segment ***BC*** has an ***outer diameter of 20 mm*** and ***an inner diameter of 10 mm***. The total length is ***L= 675 mm***. For an external torque of ***T=50 Nm*** (as shown), if the angle of twist of point ***C*** with respect to point *A*, $\varphi_{A/C} = 5^{\circ}$, determine

(a) the lengths of segments ***AB*** and ***BC***. ***(20 points)***

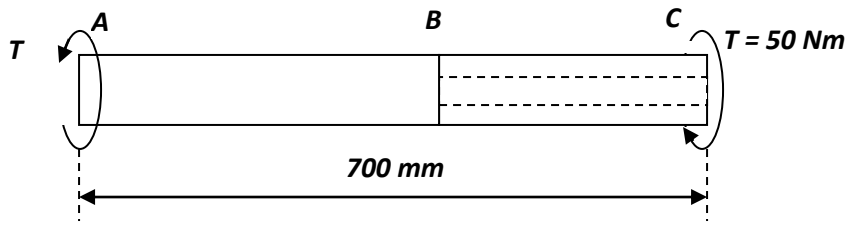

Figure 3: Composite shaft loaded by a torque.

Question 4

(Total 30 points) A horizontal cantilever beam ***AB*** of length ***L = 2 m*** is rigidly clamped at end **A** and a vertical load ***P = 10 kN*** is applied at the free end **B** (Figure 4- top). The beam has an I-section which is fabricated by seam welding two identical rectangular steel plates (flanges) of X-sectional ***width 100 mm*** and ***thickness 10 mm*** to the top and bottom sides of another rectangular steel plate (web) of X-sectional ***height 100 mm*** and ***thickness 20 mm*** (Figure 4- bottom). Determine:

(a) The complete location (i.e., along the beam and on the X-section) and the value of the maximum normal stress σ_{max} due to bending. ***(10 Points)***

(b) The location and the value of the maximum shear stress τ_{max} in the beam cross-section. ***(15 Points)***

(c) The combined axial force supported by the welded seam joints of a side plate (top plate or bottom plate) per unit length of the beam. ***(5 Points)***

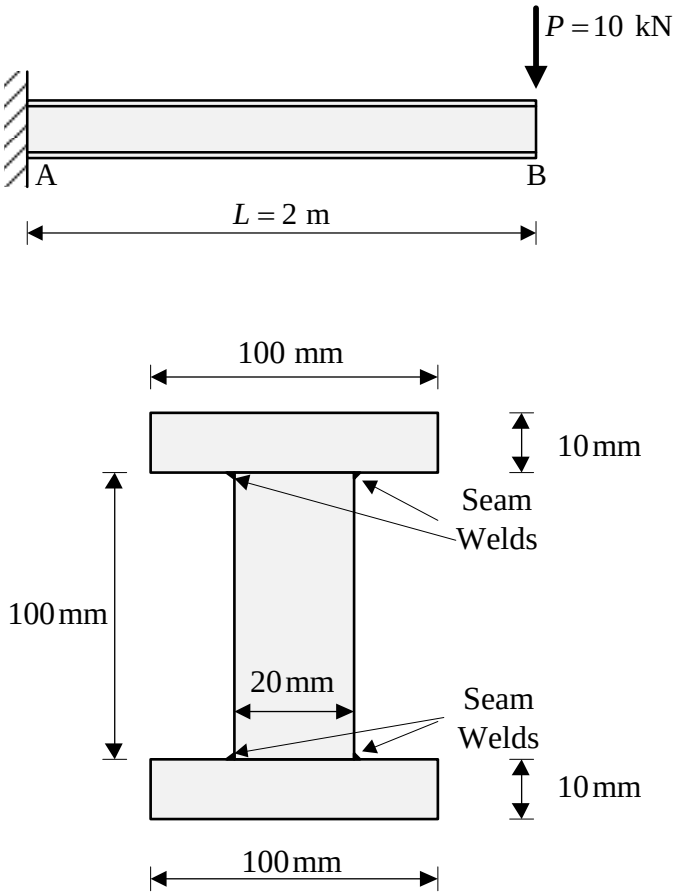

Figure 4. Top: A uniform cantilever beam of I-section;

Bottom: The cross-sectional geometry of the beam.