

# **Ph.D. Qualifying Examination**

## ***Mechanics of Materials***

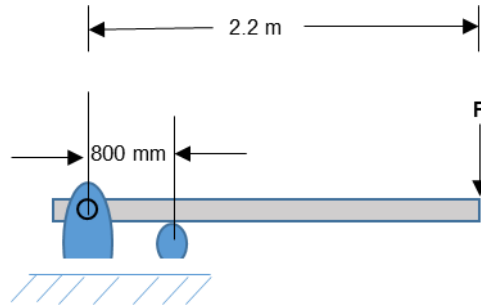
**Summer 2023**

### Notes:

- There are a total of 4 problems.
- Time allowed: 2.5 hours.
- Exam is closed book and closed-notes (one double-sided sheet of formulas is allowed)
- Problems count 25 points each (total=100 points).
- Show your work on these exam sheets. (Add additional sheets, if needed.)
- You may use a calculator.
- Laptops and cell phones are not allowed.

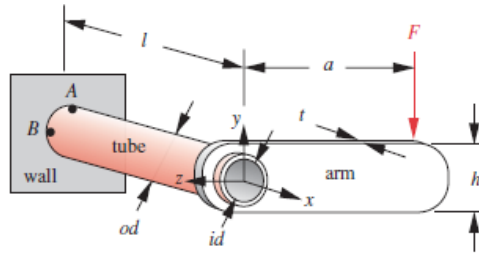
### **Problem 1**

Develop the shear-force and bending moment diagram and find the locations and magnitudes of the maximum moment and shear force in an overhung platform, shown in the figure below, when a 60 kg person stands at one end. Assume the cross-section is 300 mm x 30 mm, and find the largest principle stress in the platform. Consider acceleration due to gravity is  $9.81 \text{ m/s}^2$



## **Problem 2**

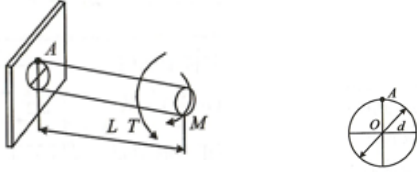
A mechanical structure is loaded with a force  $F$  at the tip of the arm, as shown in the figure below. The point of interests A and B are shown on the wall. At these points, assume the stress-concentration factor of 1.8 in bending and torsion. Calculate the magnitude of the bending and shear stresses acting on the stress elements A and B. Do not neglect transverse shear stress. Consider the parameters:  $F = 85 \text{ N}$ ,  $l = 70 \text{ mm}$ ,  $a = 200 \text{ mm}$ ,  $t = 6 \text{ mm}$ ,  $h = 80 \text{ mm}$ ,  $OD = 20 \text{ mm}$ , and  $ID = 6 \text{ mm}$ . (Maximum transverse shear stress for hollow, thin-walled round.  $\tau_{\max} = \frac{2V}{A}$ )



### **Problem 3**

A cantilever beam is fixed at one end, and a bending moment  $M$  and torque  $T$  are applied simultaneously at the free end. The beam has a length of  $L$  and its cross-section diameter is  $d$ .

Show that the maximum principal stress at point A is equal to  $\frac{16}{\pi d^3} (M + \sqrt{M^2 + T^2})$ .



#### **Problem 4**

Consider the triangular cross section shown below, with base  $b$  and height  $h$ . The moment of inertia about its base,  $I_y = \frac{1}{12}bh^3$ . Derive this relation, using the definition of the moment of inertia.

