CIV100 - MECHANICS – QUIZ #2 – 90 MINUTES – DECEMBER 2, 2015

READ CAREFULLY THE RULES:

No aids are permitted.

Only one of the two specified non-programmable calculators are permitted:

- CasioFX991 - SharpEL520

Answers must include the appropriate units.

Draw a Free Body Diagram (FBD) for each problem.

Use 5 significant digits (two decimal points for angles) in the calculations and 3 significant digits in the answers.

Instructor: Prof. Grasselli Section

Family name: Given name: Student ID

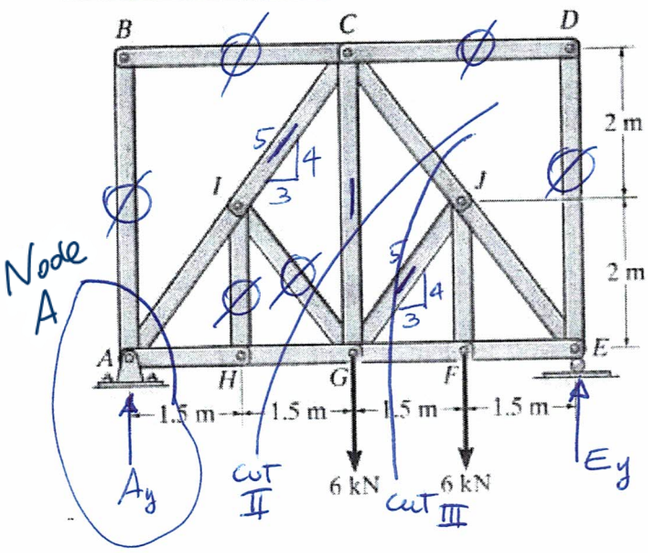
– YOU MUST REPORT ALL RESULTS IN THE SPACES PROVIDED –

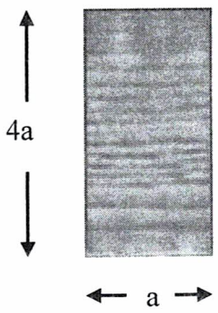
–ONLY THOSE REPORTED RESUTLS WILL COUNT TOWARDS THE QUIZ GRADE–

SOLUTIONS

A

Question #1 *[10 points]*





1 – List all zero force members. **[2 point]**

Zero force members are: AB, BC, IH, IG, CD, DE

2 - Determine the force in members **IC**, **GJ**, and **CG** of the truss and state if these members are in tension or compression.

IC= 5.625 **kN in** C	**GJ=** 3.75 **kN in** C	**CG=** 9.00 **kN in** T

[4 point]

3 – Assuming that the force in member **GF** is 5.625 kN in tension, calculate the minimum dimension for member **GF** knowing the cross section is rectangular as shown above. The maximum tensile strength for the wood is 12 MPa; the load factor is 2.0; and the side dimension ***a*** is only available in increments of 5 mm.

a= 15.3 mm	**Chosen cross section =** 20 X 80

[2 point]

4 – Assuming the member **AH**, having cross- sectional area is equal to 15x60 mm^2, to be subjected to a service load of 3.5 kN in tension, calculate its elongation. For the calculations assume the Young's modulus to be equal to 12 x 10^3 MPa.

Elongation = 0.486 **mm**

[2 point]

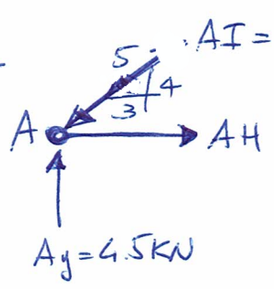
(2) Reaction forces

@ A ↻ $\Sigma M_A = -6 \cdot 3 - 6 \cdot 4.5 + E_y \cdot 6 = 0 \rightarrow E_y = 7.5$ KN

@ E ↻ $\Sigma M_E = 0 = 6 \cdot 1.5 + 6 \cdot 3 - A_y \cdot 6 = 0 \rightarrow A_y = 4.5$ KN

verify that $\Sigma F_y = 0 = 7.5 - 6 - 6 + 4.5 = 0$ ✓

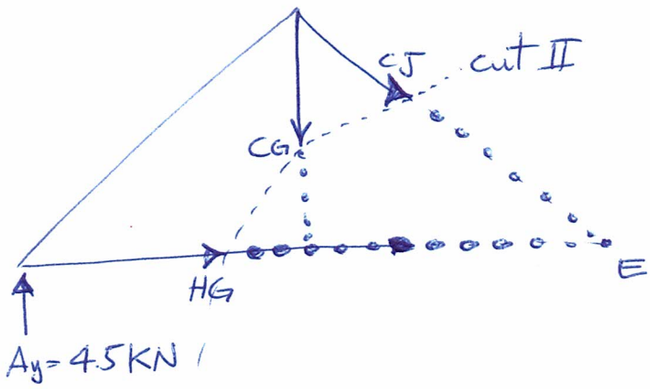
Node A



$\frac{4}{5} AI = AI_y = A_y$

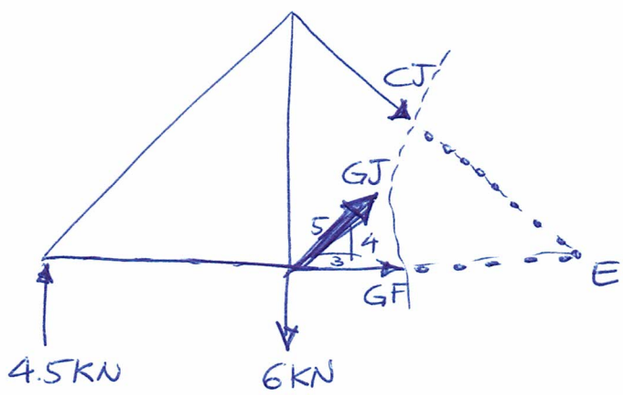
$AI = \frac{5}{4} \cdot 4.5 = 5.625$ KN (C)

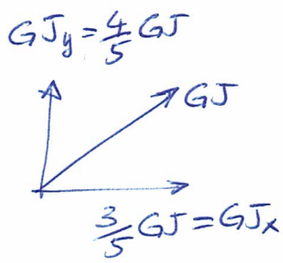
Cut II



$$@\ E \ \circlearrowleft^{+} \ \Sigma M_E = 0 = -4.5 \cdot 6 + CG \cdot 3 = 0 \Rightarrow \underline{CG = 9\,KN\,(T)}$$

Cut III





$$@\ E \ \circlearrowleft^{+} \ \Sigma M_E = 0 = -4.5 \cdot 6 - GJ_y \cdot 3 + 6 \cdot 3 \Rightarrow \underline{GJ = \frac{15}{4} = 3.75\,KN\,(C)}$$

(3)

$$Area = a \cdot 4a = 4a^2$$

$$\sigma_y = \frac{F \cdot LF}{Area} \rightarrow Area = \frac{F \cdot LF}{\sigma_y} \Rightarrow 4a^2 = \frac{5.625 \cdot 10^3 \cdot 2}{12}$$

$$a^2 = 234.375\ mm^2 \rightarrow \underline{a = 15.31\ mm}$$

$$\rightarrow \underline{\text{Section } 20 \times 80}$$

(4)

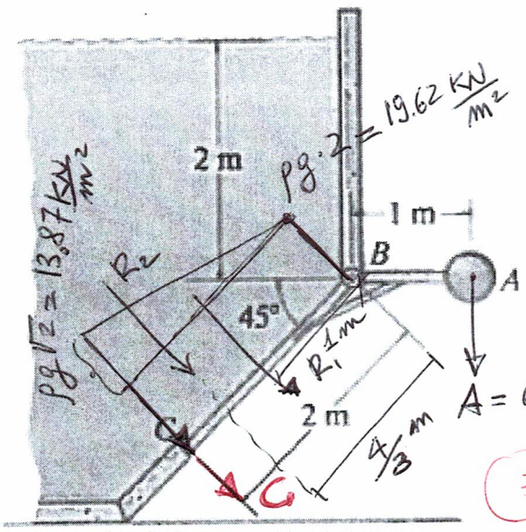
$$Area = 15 \cdot 60 = 900\ mm^2$$

$$L = 1.5\,m = 1500\ mm$$

$$\sigma = \frac{F}{Area} = \frac{3.5 \cdot 10^3}{900} = 3.889\ MPa$$

$$\sigma = E \cdot \frac{\Delta L}{L} \rightarrow \underline{\Delta L = \frac{\sigma \cdot L}{E} = \frac{3.889 \cdot 1500}{12 \cdot 10^3} = 0.486\ mm}$$

Question #2 *[5 points]*



If the mass of the counterweight at A is 6500 kg, determine the force the gate exerts on the smooth stop at C.

The gate is hinged at B and is 1 m wide.

The density of water is ρ_w = 1 Mg/m³

$A = 6.5 \cdot 10^3 \cdot 9.81 = 63.765\ KN$

3

Resultant force due to Water pressure =	53.11 **kN**	**C=**	3.02	**kN**

1 2

[5 point]

$$P_B = \rho g \cdot h_B = 1000 \cdot 9.81 \cdot 2 = 19.62\ \frac{KN}{m^2}$$

$$\Delta p = \rho g (h_c - h_B) = 1000 \cdot 9.81 \cdot \sqrt{2} = 13.87\ \frac{KN}{m^2}$$

$$P_c = P_B + \Delta p = 53.49\ \frac{KN}{m^2}$$

$$R_1 = P_B \cdot 2 \cdot 1 = 39.24\ KN$$

$$R_2 = \Delta p \cdot 2 \cdot 1 \cdot \frac{1}{2} = 13.87\ KN$$

$$R = R_1 + R_2 = 53.11\ KN$$

$$@B\ (+\circlearrowleft)\ \Sigma M_B = 0 = -63.765 + 39.24 \cdot 1 + 13.87 \cdot \frac{4}{3} + C_y \cdot 2$$

$$\rightarrow C_y = 3.02\ KN$$

Question #3 ***[10 points]***

1- Draw **NEATLY** the Shear and Bending Moment diagrams for the beam ABCDEF in the space provided below the beam. (Locate and indicate values at supports, loads, and local maxima and minima) **[2 point]**

2- Find the magnitude of the Maximum Bending moment.

Maximum Bending moment = **kN m**

[2 point]

3- Find the location, distance measured from A, where the bending moment is maximum.

Distance from A = **m**

[2 point]

5 - If the maximum bending moment is 15 kN m, for the given cross section below, calculate the value of the maximum stress due to the applied bending moment.

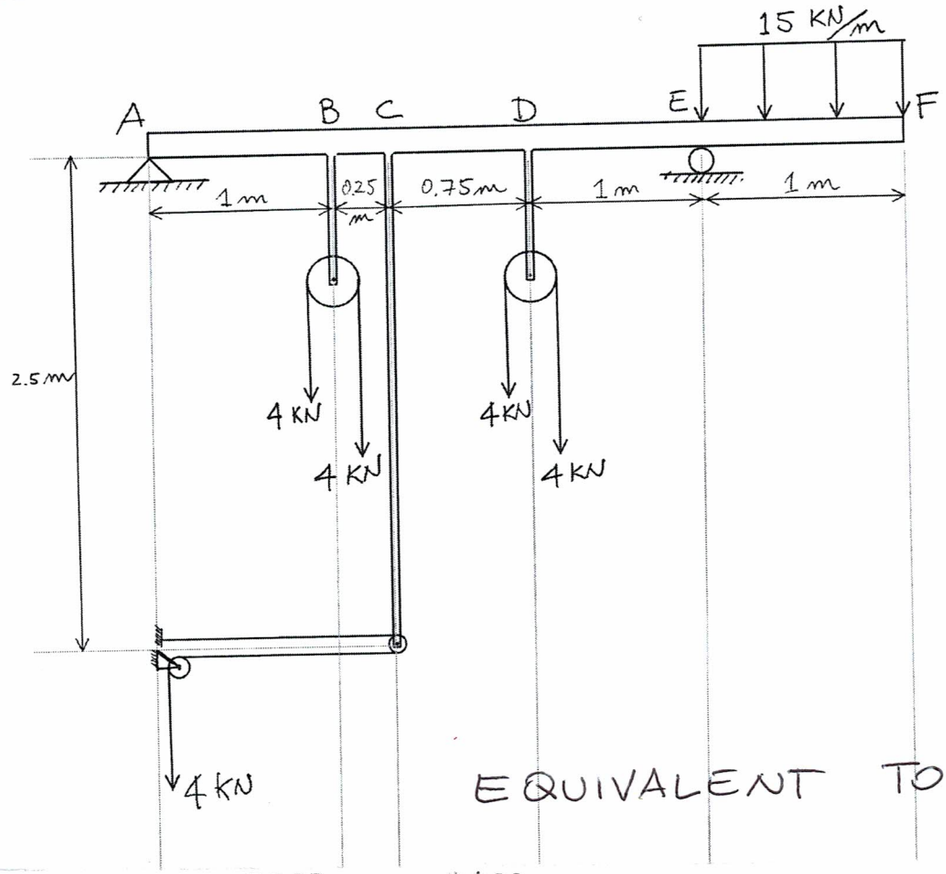
Maximum stress = **MPa**

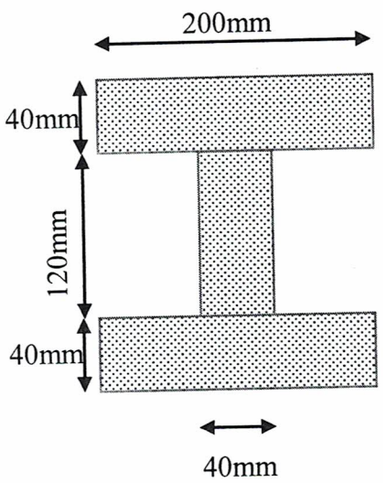
[2 point]

6 – If the yield stress for the material in the beam is 400 MPa, state if the beam is safe or not

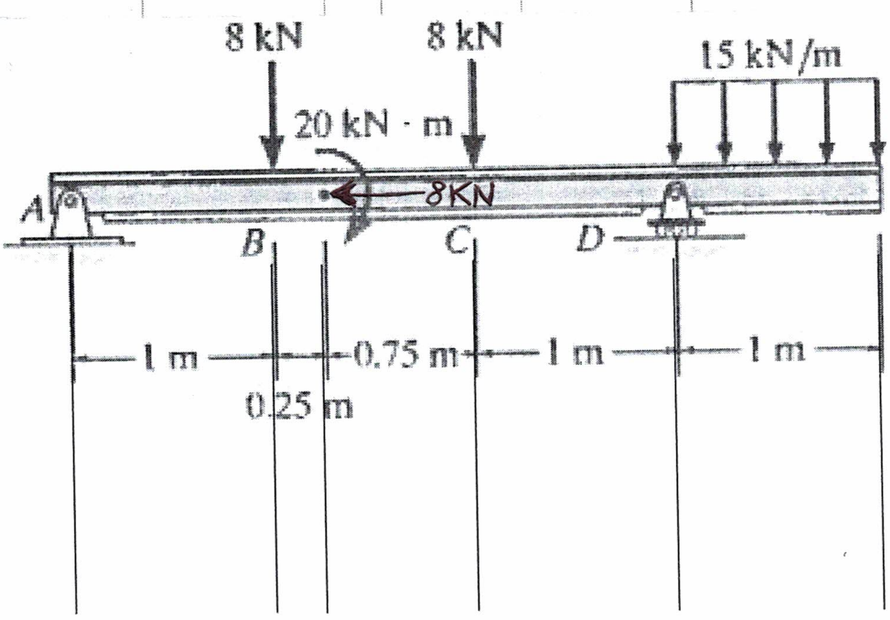
The beam is

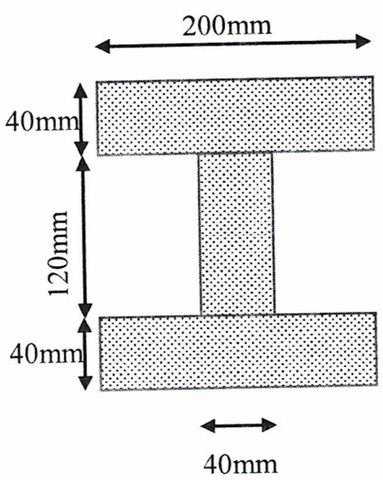
[2 point]





EQUIVALENT TO :





Question #3 *[10 points]*

1- Draw **NEATLY** the Shear and Bending Moment diagrams for the beam ABCDEF in the space provided below the beam. (Locate and indicate values at supports, loads, and local maxima and minima) **[2 point]**

2- Find the magnitude of the Maximum Bending moment.

Maximum Bending moment = 16.54 **kN m**

[2 point]

3- Find the location, distance measured from A, where the bending moment is maximum.

Distance from A = 1.25 **m**

[2 point]

5 - If the maximum bending moment is 15 kN m, for the given cross section below, calculate the value of the maximum stress due to the applied bending moment.

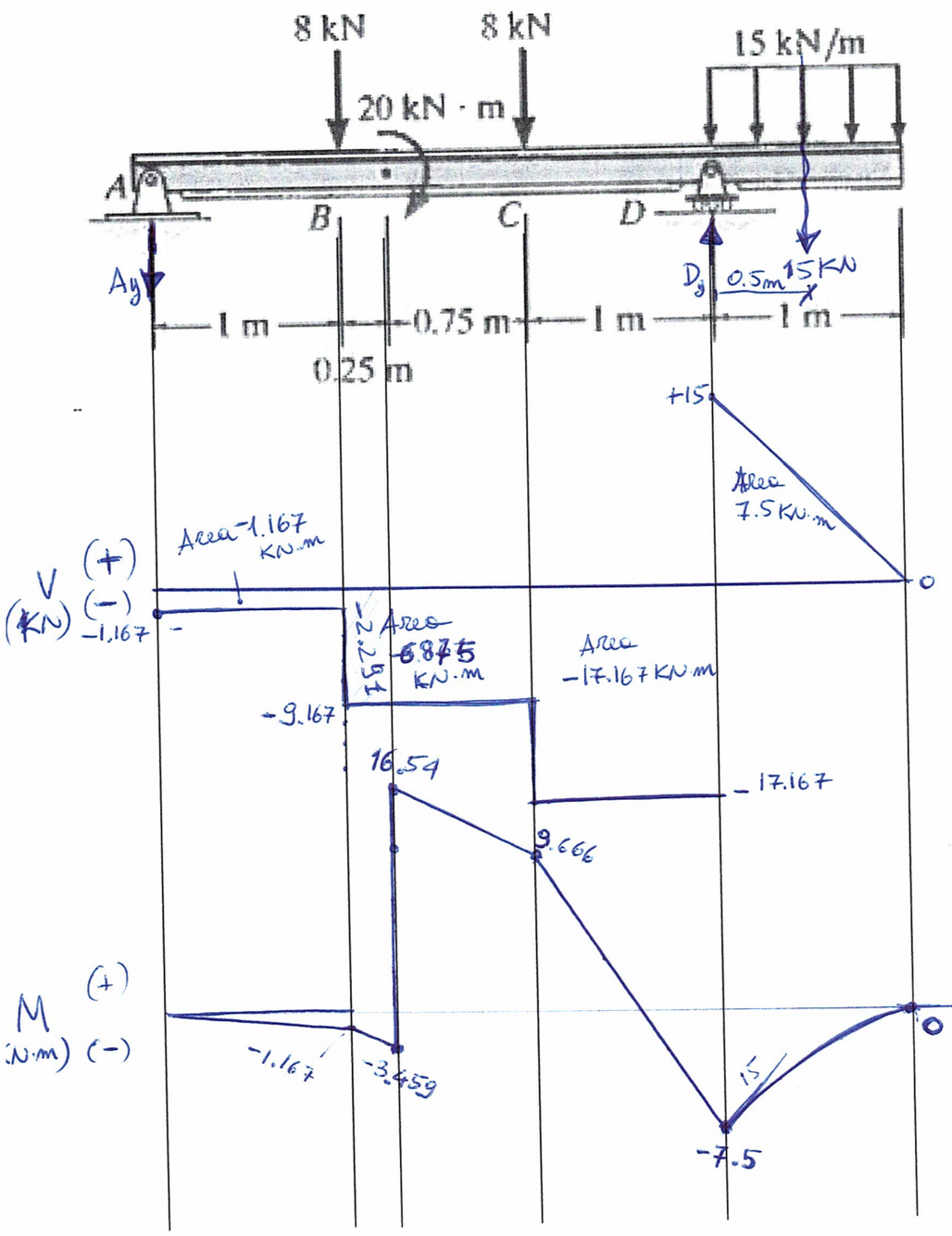
Maximum stress = 13.6 **MPa**

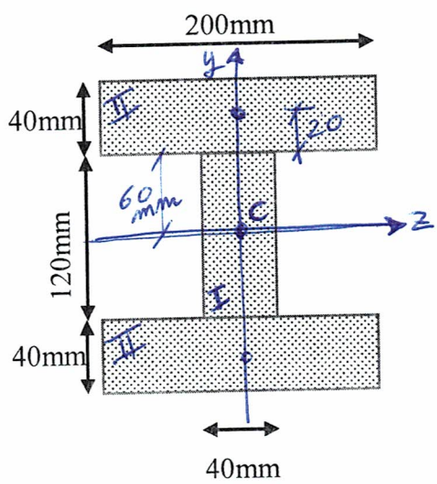
[2 point]

6 – If the yield stress for the material in the beam is 400 MPa, state if the beam is safe or not

The beam is SAFE

[2 point]





(1) @A $\circlearrowleft$ $M_A = 0 = -20 - 8 \cdot 1 - 8 \cdot 2 - 15 \cdot 3.5 + D_y \cdot 3$

$$D_y = 32.167\,KN(\uparrow)$$

@D $\circlearrowleft$ $M_D = 0 = -15 \cdot 0.5 + 8 \cdot 1 + 8 \cdot 2 - 20 + A_y \cdot 3$

$$A_y = 1.167\,KN(\downarrow)$$

Check: $+\uparrow \Sigma F_y = -1.167 - 8 - 8 + 32.167 - 15 = 0$ ✓

(5) $M_{z_{max}} = 15\,KN.m$ $\qquad \sigma = \dfrac{M_{z_{max}} \cdot y_{max}}{I_z}$

$y_{max} = 100\,mm$

Part	I_z	d_y (mm)	A (mm²)	d^2A	$I_z + d^2A$ (mm⁴)
I	$\frac{1}{12} \cdot 40 \cdot 120^3$	∅	4800	∅	$5.76 \cdot 10^6$
2× II	$\frac{1}{12} 200 \cdot 40^3 = 1.067 \cdot 10^6$	80	8000	$512 \cdot 10^6$	$52.267 \cdot 10^6 \times 2$

$I_z = 110.294 \cdot 10^6\,(mm^4)$

$$\sigma = \frac{15 \cdot 10^6 \cdot 100}{110.294 \cdot 10^6} = 13.6\,MPa$$

(6) $\sigma = 13.6\,MPa < 400\,MPa \Rightarrow$ Safe!