QUIZ [1]
SPRING 2011
(Thursday, 24th March 2011)
CIVE410 – STRUCTURES II
CLOSED BOOK, 70 MINUTES

Name: SOLUTION **ID#:**

NOTES

- 3 PROBLEMS – 8 PAGES.
- READ PROBLEM STATEMENTS CAREFULLY.
- ASSUME ANY MISSING DATA YOU MAY REQUIRE. WRITE YOUR COMMENTS BELOW.
- ALL YOUR ANSWERS SHOULD BE PROVIDED ON THE QUESTION SHEETS.
- WELL ORGANIZED AND SYSTEMATIC SOLUTION WILL BE CREDITED. NEATNESS COUNTS.
- ***TRY NOT*** TO USE THE BACK OF THE SHEETS FOR ANSWERS UNLESS YOU RAN OUT OF SPACE.
- NOTE THE PERCENTAGE OF POINTS ASSIGNED FOR EACH PROBLEM.
- CHECK BOXES ARE FOR YOU TO CONFIRM YOU HAVE SOLVED A QUESTION ☑

YOUR COMMENT(S)

DO NOT WRITE IN THE SPACE BELOW

MY COMMENT(S)

YOUR GRADE

Good Luck & Best Wishes
Dr. Hisham S. Basha

Problem I: ___ /25
Problem II: ___ /35
Problem III: ___ /40
Other: ___

Problem I: *(25 points)*

Check ***stability and determinacy*** for the structures shown in the accompanying Figures. Determine also the ***kinematic*** degrees of freedom for each structure.

Calculations and/or Diagrams:

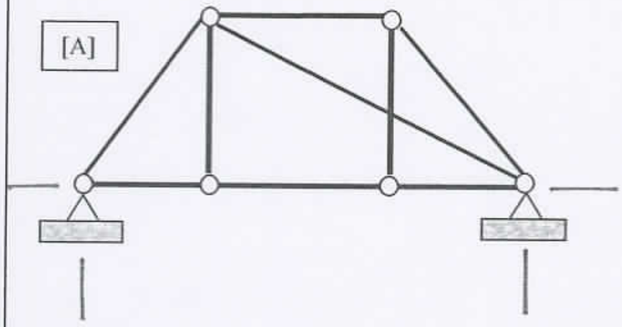
[A] $i = (m + r) - 2j$.

$$\left.\begin{array}{l} m = 9 \\ r = 4 \\ j = 6 \end{array}\right\} \Rightarrow \underline{\underline{i = 13 - 12 = 1}}.$$

Stable & indeterminate to the first degree (Once).

$k = 2j - r = \underline{\underline{8}}$ Kinem. degrees.

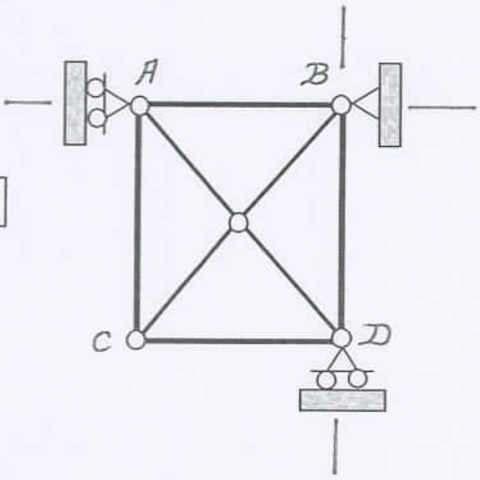
[A]



[B] By inspection, all reactions are concurrent at B.

⇒ Structure is $\underline{\underline{\text{Unstable}}}$.

[B]



[C] $i = (3m + r) - (3j + h)$.

$k = 3j - r$.

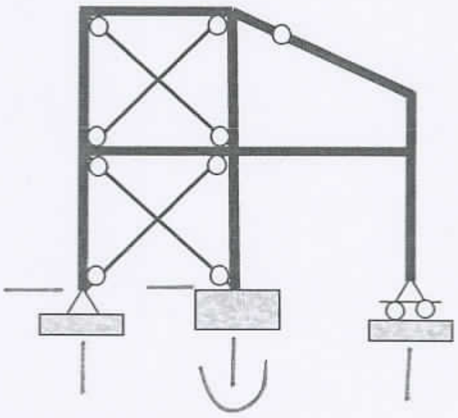
$$\left.\begin{array}{l} m = 15 \\ r = 6 \\ j = 10 \\ h = 9 \end{array}\right\} \begin{array}{l} \Rightarrow i = (3\times15 + 6) - (3\times10 + 9) \\ \quad = 51 - 39 = \underline{\underline{12}}. \\ \text{Stable \& indeterminate} \end{array}$$

to the 12th degree.

$k = 3(10) - 6 = \underline{24}$.

24th Kinematic degrees of freedom system.

[C]

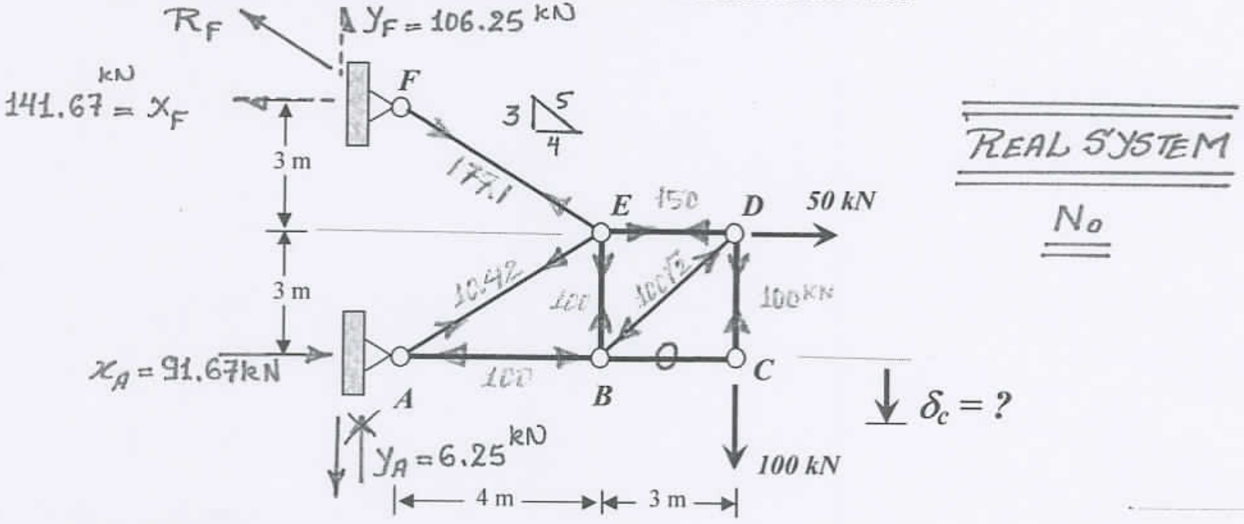


Problem II: *(35 points)*

[1] Determine the *vertical* displacement of joint ***C*** of the steel truss shown in the accompanying figure due to the given loads. (25*points*) ☐

[2] Remove all loads on the truss. Determine the *vertical* displacement of joint ***C*** of the steel truss shown in the accompanying figure due to an increase of temperature in member ***FE*** only of 60°C and a fabrication error in member BD being 7 mm too short. (*10points*) ☐

Use $\alpha=1.08(10^{-5})/^{\circ}C$ and $E=200GPa$ ($1GPa=10^6 kN/m^2$).
Take the cross-sectional area $A= 200\ mm^2$ for all members of the truss.



Calculations and/or Diagrams:

REACTIONS :~

- $\Sigma M_{/F} = 0 \Rightarrow 50*3 - 100*7 + X_A*6 = 0.$

$\Rightarrow \underline{X_A = 91.67\ kN} \rightarrow$

- $\Sigma M_{/E} = 0 \Rightarrow 100*3 + 4*y_A - 91.67*3 = 0.$

$\Rightarrow \underline{y_A = \ominus 6.25\ kN} \ \cancel{\uparrow} \downarrow$

opp. to assumed sense.

- $\Sigma X = 0 \Rightarrow X_F = 141.67\ kN \leftarrow$
- $\Sigma Y = 0 \Rightarrow Y_F = 106.25\ kN \uparrow$

$\Rightarrow R_F = \sqrt{X_F^2 + Y_F^2}$

$\Rightarrow \underline{R_F = 177.1\ kN}.$

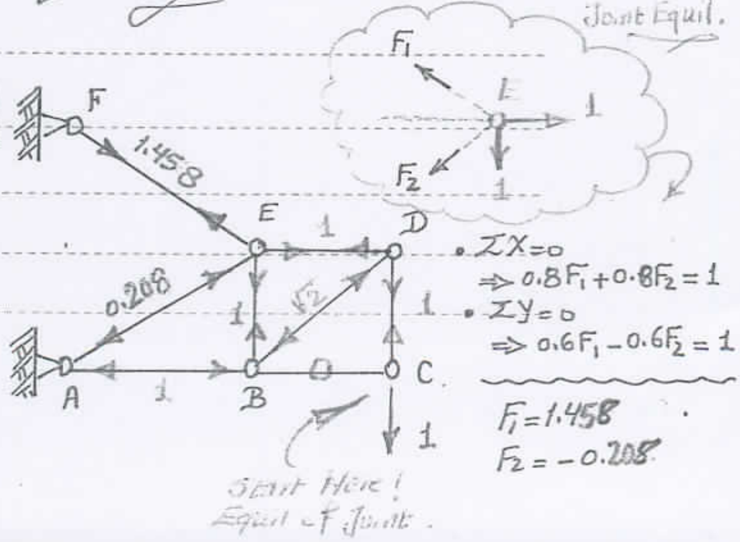
Check, $\Sigma M_{/D} = 0 \Rightarrow$ ok✓.

VIRTUAL SYSTEM

$\underline{N_1}$

$P.V.W \Rightarrow \Sigma W_{ext} = \Sigma W_{int}$

$$\Rightarrow 1*\delta_c = \sum_{i=1}^{8} \frac{N_o N_1 L}{EA}.$$



- $\Sigma X = 0$

$\Rightarrow 0.8F_1 + 0.8F_2 = 1$

- $\Sigma Y = 0$

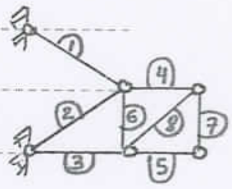
$\Rightarrow 0.6F_1 - 0.6F_2 = 1$

$F_1 = 1.458$

$F_2 = -0.208$

Calculations and Diagrams (cont'd):

Member	L (m)	N_o	N_1	$N_o.N_1.L$
1	5	177.1	1.458	1,291.06
2	5	10.42	-0.208	-10.84
3	4	-100	-1.0	+400
4	3	150	1.0	+450
5	3	0	0	0
6	3	100	1.0	+300
7	3	100	1.0	+3.00
8	$3\sqrt{2}$	$-100\sqrt{2}$	$-\sqrt{2}$	$+600\sqrt{2}$



$$\sum_{1}^{8} N_o.N_1.L = 3,578.75$$

$$\Rightarrow \delta_c = + \frac{3,578.75}{EA} \downarrow$$

$$EA = 200 \times 10^6 \frac{kN}{m^2} * \frac{200}{10^6} m^2$$

$$= 40,000 \text{ kN}.$$

$$\Rightarrow \delta_c = 0.0895 \text{ m} \downarrow = \underline{\underline{8.95 \text{ cm} \downarrow}}.$$

[2] $\underline{(\Delta T)_{FE} = +60^\circ C \quad \& \quad (\delta L)_{BD} = -0.007 \, m.}$ __NO LOADS !__

$$P.V.W \Rightarrow 1 * \delta_c = \cancel{\sum_{i=1}^{8} \frac{N_o N_1 L}{EA}} + \sum N_1 . (\alpha . \Delta T . L)_{FE} + \sum (N_1 * \delta L)_{BD}.$$

No Loads.

$$\Rightarrow \delta_c = (1.458)(1.08 \times 10^{-5} * 60 * 5) + (-\sqrt{2} * -0.007)$$

$$= 0.004724 + 0.0098995 = 0.01462 \text{ m} \downarrow.$$

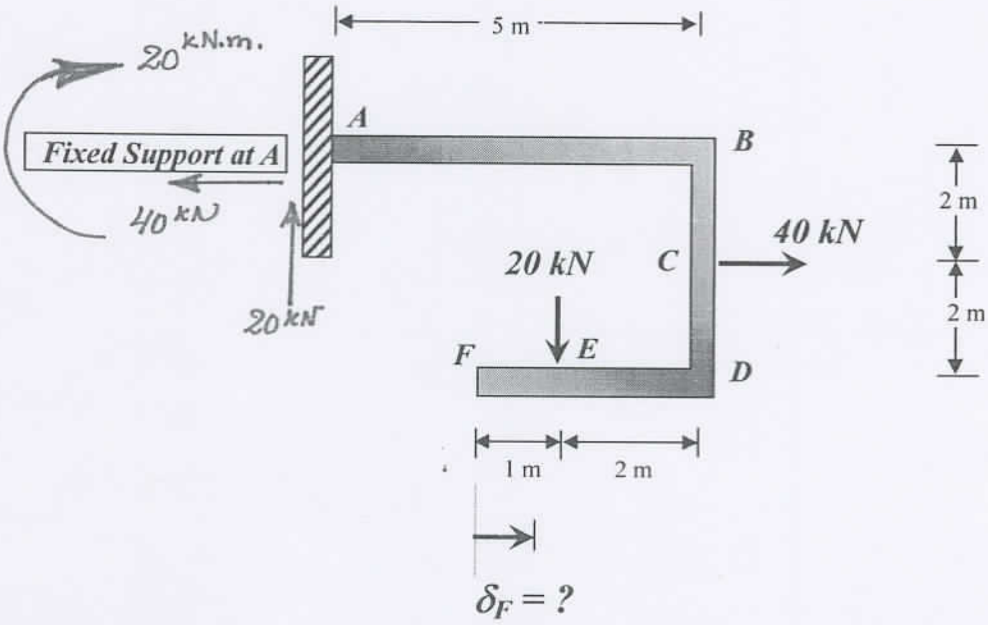
$$\Rightarrow \underline{\underline{\delta_c = 1.462 \text{ cm} \downarrow}}.$$ __Due to temp change & Fabrication Error__

Problem III: *(40 points)*

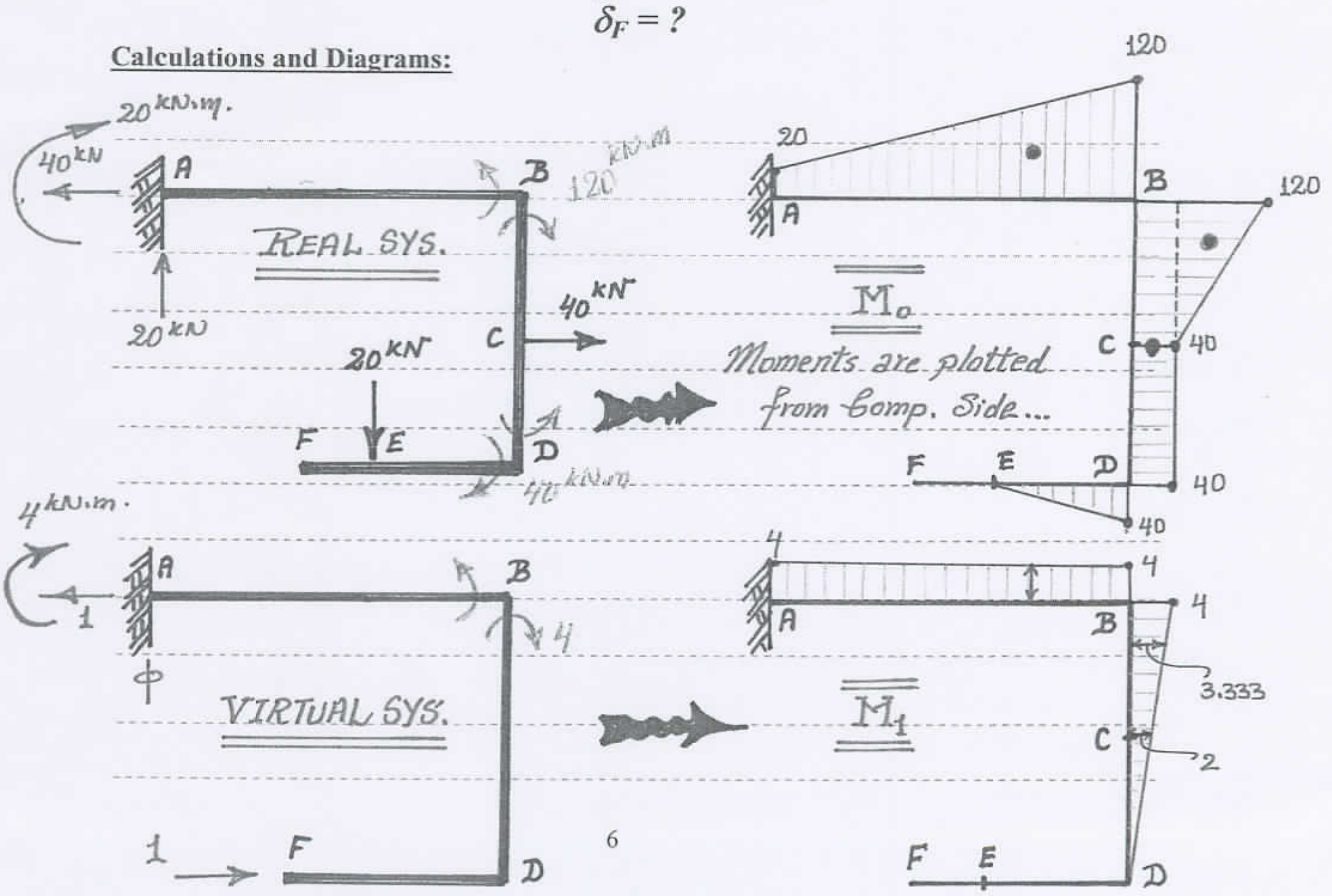
[1] The frame ABDF shown in the accompanying figure is fixed at A and free at F. Determine the *horizontal* displacement δ_F at the free end F due to the given loads (30 *points*) ☐

[2] In order to bring the horizontal displacement at F to zero an additional horizontal force P was applied at F. Determine the value and the direction of the *horizontal force P*. (10 *points*) ☐

Neglect axial and shear deformation. Use EI= 2.133×10^5 kNm^2.



Calculations and Diagrams:



Calculations and Diagrams (cont'd):

P.V.W $\Rightarrow \sum W_{ext} = \sum W_{int}$

$\Rightarrow 1 * \delta_F = \int \frac{M_0 M_1 \, dx}{EI}$ ---- (Axial & Shear Deformation are neglected).

$$\Rightarrow \delta_F = \int_A^B \frac{M_0 M_1 \, dx}{EI} + \int_B^D \frac{M_0 M_1 \, dx}{EI} + \cancel{\int_D^F \frac{M_0 M_1 \, dx}{EI}}_{0}$$

$$= \frac{1}{EI}\left[\underbrace{\left(\frac{20+120}{2}\right) * 5}_{A \text{ of } ▭} * 4\right] + \frac{1}{EI}\left[\underbrace{40 \times 4}_{A \text{ of } ▭} * 2\right] + \frac{1}{EI}\left[\underbrace{\frac{80 \times 2}{2}}_{A \text{ of } ◺} * 3.333\right].$$

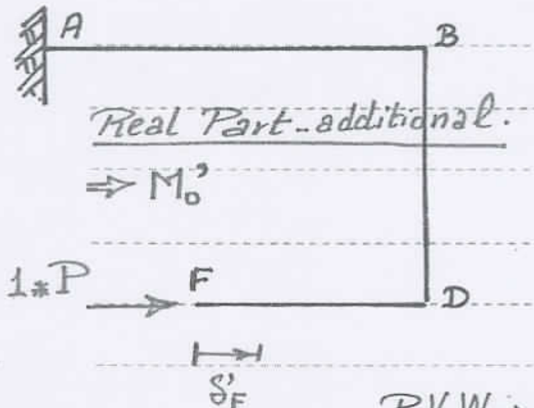
$$= \frac{1}{EI}\left\{1{,}400 + 320 + 266.67\right\} = \boxed{\frac{1{,}986.67}{EI}}$$

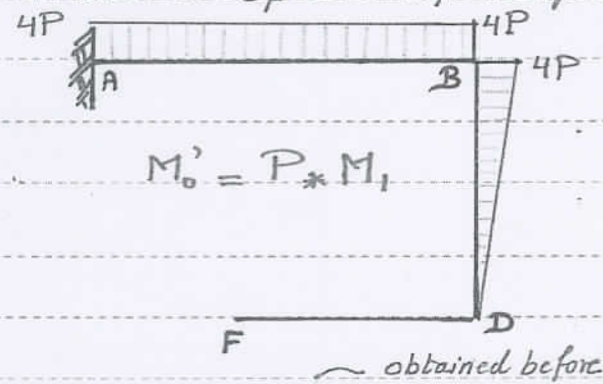
Knowing that $EI = 2.133 \times 10^5 \ kN.m^2 \Rightarrow \delta_F = +0.009314 \ m \mapsto$

$$\Rightarrow \boxed{\delta_F = 9.314 \ mm \longrightarrow}$$

[2] P = ?

The additional force P applied horiz. at F will bring the structure to zero horiz. displacement at F $\Rightarrow$ Effect of P alone without the applied loads considered in [1] will result in $\delta_F' = -\delta_F$ (computed in [1]).





$M_0' = P * M_1$

$$\text{P.V.W} \Rightarrow 1 * \delta_F' = \int \frac{M_0' * \overset{\text{obtained before.}}{\widetilde{M_1}} \, dx}{EI} = P \int \frac{M_1 M_1 \, dx}{EI}.$$

Now, $\delta_F' + \delta_F = 0$

$$\Rightarrow \delta_F + P \int \frac{M_1 M_1 \, dx}{EI} = 0 \Rightarrow P = -\frac{\delta_F}{\int \frac{M_1 M_1 \, dx}{EI}} = -\frac{9.314}{0.475}$$

$$* \int \frac{M_1 M_1 \, dx}{EI} = \frac{1}{EI}\left[(4 \times 5 \times 4) + \frac{4 \times 4}{2} * \frac{2}{3} * 4\right]$$

$$= +\frac{101.333}{EI} = 0{,}0004\overset{7}{7}5 \ m$$

$$= \underline{0.475 \ mm}.$$

$\Rightarrow P = -19.61 \ kN.$

$\Rightarrow \underline{\underline{P = 19.61 \ kN \longleftarrow}}$