Theory of Structures (I) - BCE	May 29, 2016	Time: 3 Hours
Third Year	Final Exam – First Attempt	**Closed Book & Notes**

Answer 4 questions only. ثالث انشائية

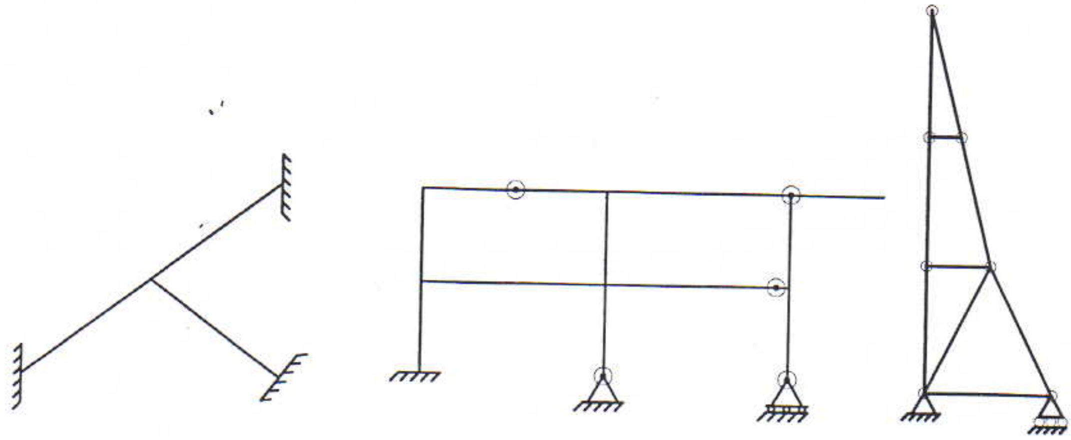
Q1:

a. Write briefly about the structural analysis and design; discuss safety, economy and serviceability for the structures and the main role of engineer to provide these requirements.

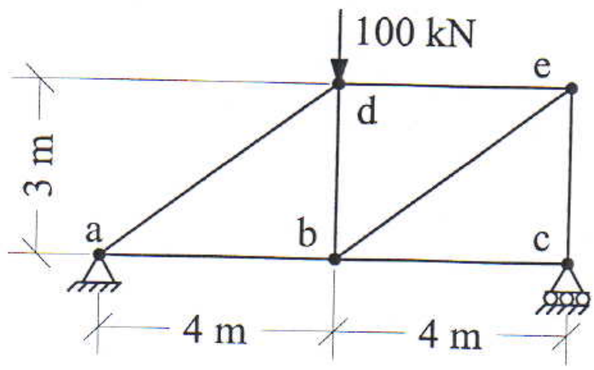
b. Sometimes it is important to use an inactive members in a truss, define inactive these members and why it should be used for?

c. What is the stiffness and flexibility mean for structural engineer?

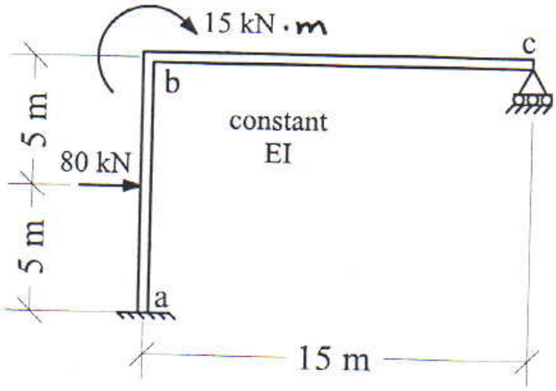
d. Discuss the stability and determinacy of the 3 structures shown:



Q2: For the structural truss shown, using the Unit Load Method, find the vertical deflection of joint B in terms of EA. EA = constant for all members.



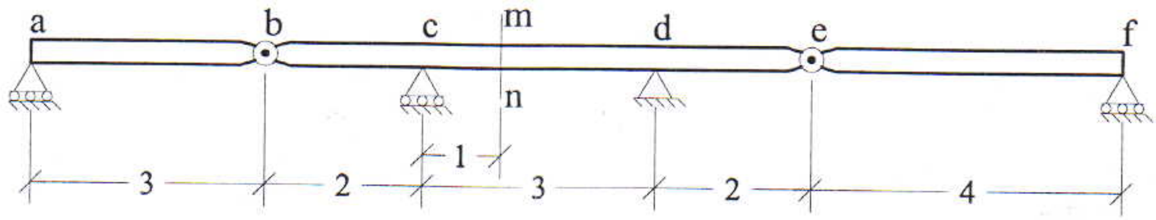
Q3: For the structural frame shown, using the Consistent Deformation Method, draw the bending moment diagram for member ~~cd~~ bc.



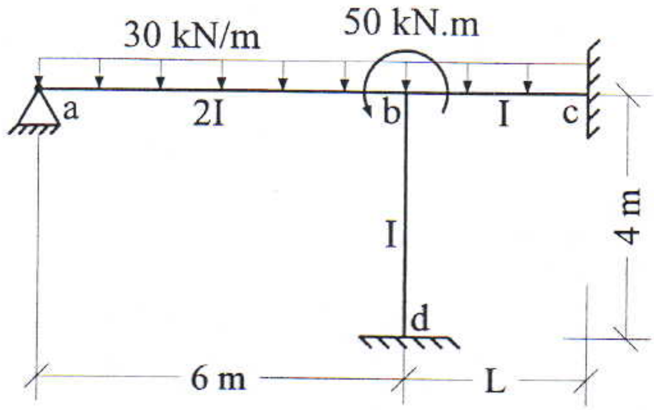
Q4:

a. For the structural beam shown below, draw the influence line for: Ra; Rc; Mc; Md, Vc_{right}, Mmn; Vmn, Vd_{left} and Ve.

b. Find the value of Mmn if the structural beam is subjected to infinite uniformly distributed load (w = 30 kN/m).



Q5: For the structural frame shown, use the Slope Deflection Method; find the span length (L) such that the rotation at joint (b) will not exceed 4.22° (in counterclockwise). The frame members have a modulus of elasticity (E) = 2×10^5 N/mm^2 and the moment of inertia (I) = 30×10^5 mm^4.



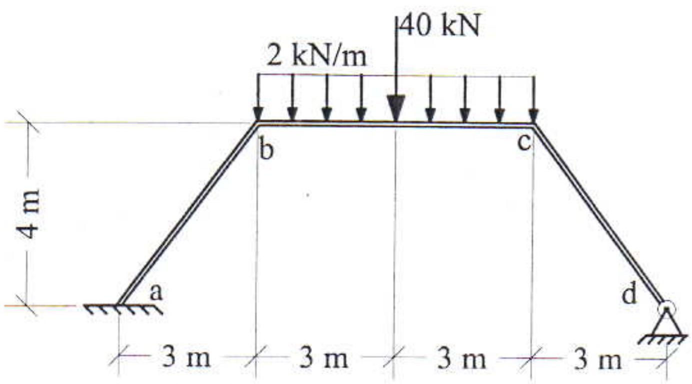
Notes:

- π rad. / 180° = 1.
- The fixed end moments (FEM) for the uniformly distributed load at the member ends equal $\pm w\ell^2/12$.
- Use iteration method to solve the equation, start with L = 1 m, L ≤ 3 m.

Q6: Using the Moment Distribution Method, find the reactions at support a (a_x & a_y) due to the applied loading shown. EI = constant. If it needed, try up to three cycles only.

Notes:

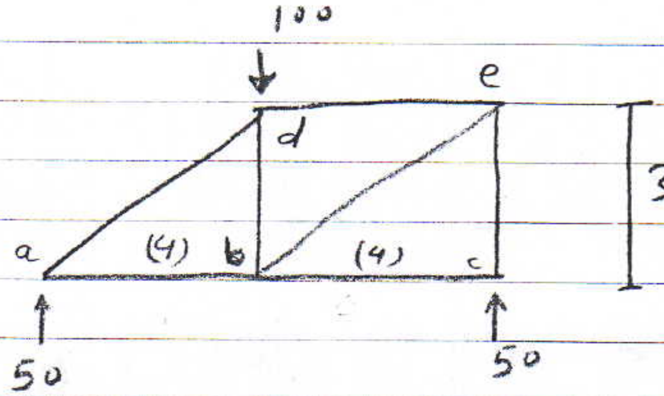
- The fixed end moments (FEM) for the uniformly distributed load at the member ends equal $\pm w\ell^2/12$.
- The fixed end moments (FEM) for the midspan concentrated load at the member ends equal $\pm p\ \ell/8$.



Good Luck

Final Exam – First Attempt, 2016 – Solution:

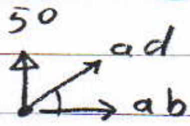
Q2:



memb	L/EA	S (kN)	u	SuL/EA
ab	4/EA	+66.67	0.667	1600/9EA
bc	4/EA	0	0	0
ad	5/EA	−83.33	−0.833	3125/9EA
de	4/EA	−66.67	−0.667	1600/9 EA
be	5/EA	83.33	0.833	3125/9EA
ce	3/EA	−50	−0.5	75/EA
bd	3/EA	−50	0.5	−75/EA

$$\therefore \sum \frac{SuL}{EA} = \boxed{\frac{1050}{EA} = \Delta_b}$$

S: ⊛ joint a:

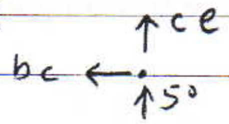


$\theta = \arctan(3/4) = 36.87°$ $\quad \Sigma F_y = 0 \Rightarrow 50 + ad \sin\theta = 0$

$ad = -83.33$ kN

$\Sigma F_x = 0 \Rightarrow ad\cos\theta + ab = 0 \Rightarrow ab = +66.67$ kN

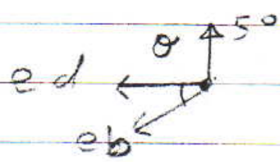
⊛ joint c:



$\Rightarrow \Sigma F_x = 0 \Rightarrow bc = 0$ and $\Sigma F_y = 0$

$ce = -50$ kN

⊛ joint e:

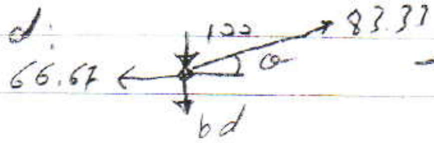


$\Sigma F_y = 0 \Rightarrow 50 = eb\sin\theta$

$eb = 83.33$ kN

$\Sigma F_x = 0 \Rightarrow ed + eb\cos\theta = 0 \Rightarrow ed = -66.67$

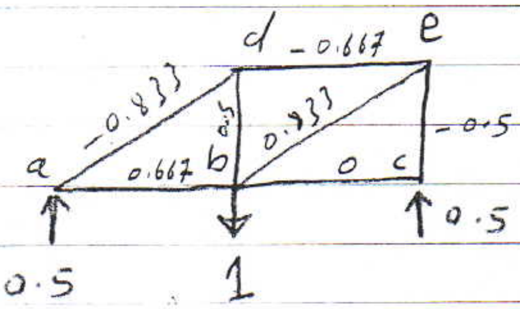
⊛ joint d:



$\longrightarrow \Sigma F_y = 0 \Rightarrow 100 + bd = 83.33\sin\theta$

$bd = -50$ kN

U:



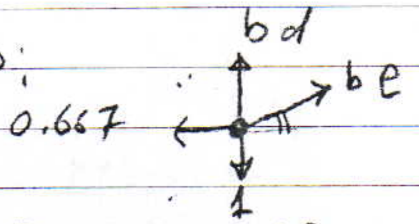
* Joint a:

$\Sigma F_y = 0$

$0.5 + ad \sin\theta = 0 \Rightarrow ad = -0.833$

$\Sigma F_x = 0 \Rightarrow +0.833 \cos\theta = ab \Rightarrow ab = 0.6667$

* joint b:

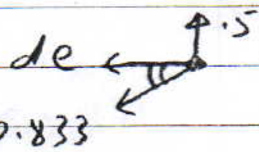


$\Sigma F_x = 0 \Rightarrow be \cos\theta = 0.667$

$be = 0.833$

$\Sigma F_y = 0 \Rightarrow 1 = 0.833 \sin\theta + bd \Rightarrow bd = +0.5$

* joint e:

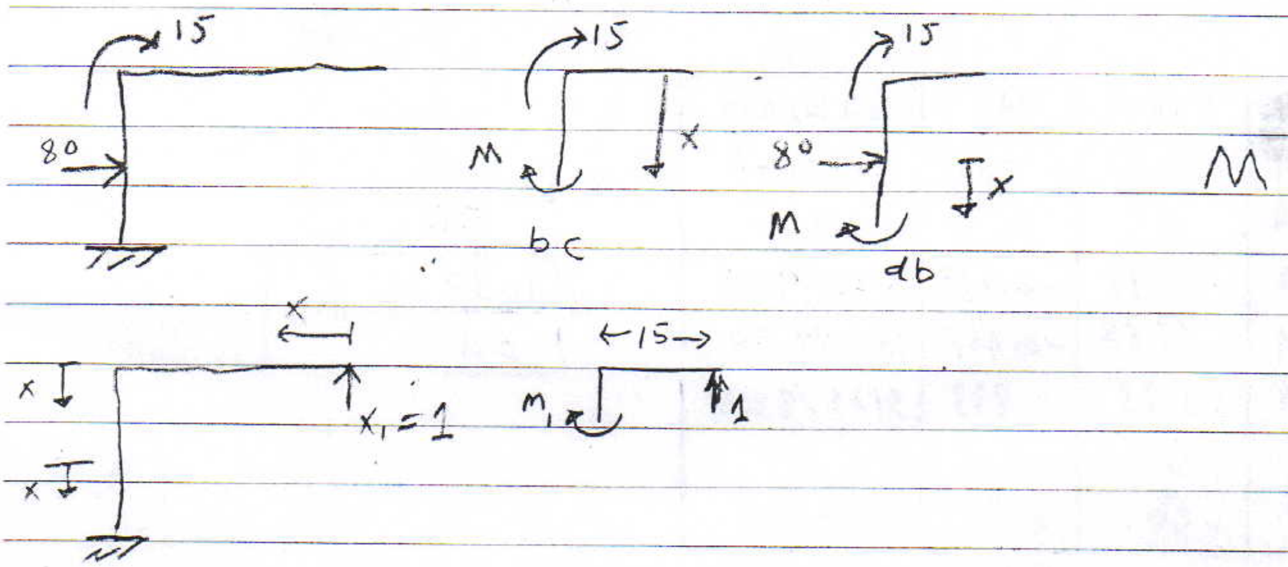


$\Rightarrow \Sigma F_x = 0 \Rightarrow 0.833 \cos\theta = -de$

$\therefore de = -0.667$

Q3:

memb.	EI	orig.	limit	M	m_1	Mm_1	m_1^2
ab	1	b	0-5	$-15-80x$	x	$-15x-80x^2$	x^2
bc	1	c	0-5	-15	15	-225	225
cd	1	d	0-15	0	15	0	225



$$\Delta_1 = \Delta_1' + \delta_{11} X_1$$

$$\Delta_1' = \int \frac{M m_1 dx}{EI} = \left[\int_0^5 (-15x - 80x^2)dx + \int_0^5 (-225)dx + 0\right]\frac{1}{EI}$$

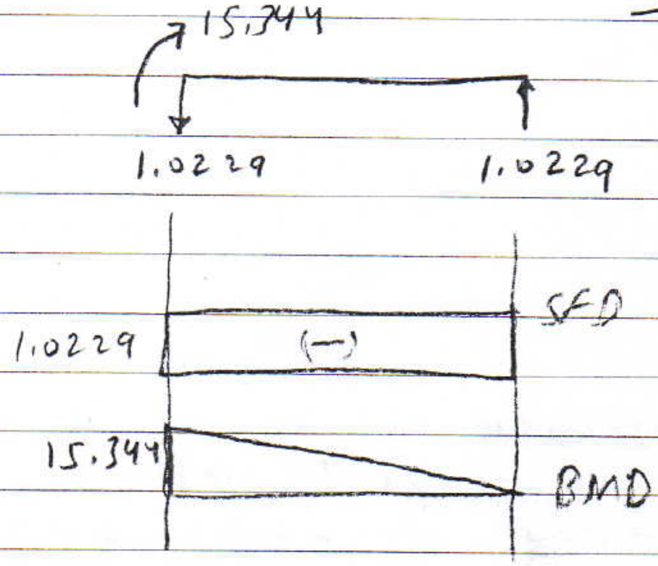
$$\Delta_1' = \frac{1}{EI}\left[-3520.833 - 1275\right] = \frac{-27875}{6EI} = -4645.833/EI$$

$$\delta_{11} = \int \frac{m_1 m_1 dx}{EI} = \left[\int_0^5 (x^2 + 225)dx + \int_0^{15} (225)dx\right]\frac{1}{EI}$$

$$= \frac{13625}{3EI} = 4541.666/EI$$

$$\therefore \frac{13625}{3EI} X_1 = \frac{27875}{6EI} \Rightarrow X_1 = 1.0229 \text{ kN} \uparrow$$

member cd



not required