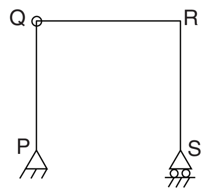
Structural Analysis Test 2

Number of Questions: 30 **Time: 75 min.**

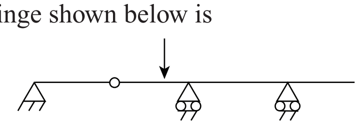
Directions for questions 1 to 30: Select the correct alternative from the given choices.

1. The frame shown below is



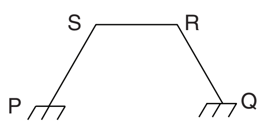
(A) statically indeterminate but unstable
(B) unstable
(C) determinate and stable
(D) none of the above

2. The static indeterminacy of a continuous beam with an internal hinge shown below is



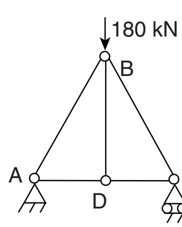
(A) zero (B) 1
(C) 2 (D) None

3. The degrees of freedom of the rigid frame with clamped ends at P and Q as shown in figure is



(A) 2 (B) 3
(C) 4 (D) zero

4. A truss, as shown in figure is carrying 180 kN at B. the force in member BD is



(A) 180 kN (Tensile)
(B) 180 kN (compressive)
(C) $180\sqrt{2}$ kN (Tensile)
(D) zero

5. Match List – I and List – II and select the correct answer using the code given below.

	List – I		List – II
a.	Column analogy method	1.	Stiffness
b.	Kanis rotation contribution method	2.	Force method
c.	Castiglianos theorem of minimum strain energy	3.	
d.	Moment distribution method	4.	

Codes:

	a	b	c	d		a	b	c	d
(A)	2	1	2	1	(B)	1	2	1	2
(C)	1	1	2	2	(D)	1	2	2	1

6. The cantilever beam AB of length 'ℓ' fixed at A and free at other end is subjected to a concentrated load W at its free end. The strain energy (U) stored in a beam is (EI const)

(A) $\dfrac{W^2\ell^2}{4EI}$ (B) $\dfrac{W\ell^3}{6EI}$

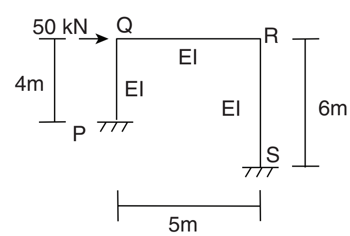
(C) $\dfrac{W^3\ell^3}{6EI}$ (D) $\dfrac{W\ell}{EI}$

7. The bending moment induced at fixed end of cantilever beam of span 'ℓ' if the free end undergoes a unit displacement without rotation is

(A) $\dfrac{3EI}{\ell^2}$ (B) $\dfrac{5EI}{\ell^2}$

(C) $\dfrac{6EI}{\ell^2}$ (D) $\dfrac{4EI}{\ell^2}$

8. The slope deflection equation at the end Q of member QR for the frame shown in the given figure below is



(A) $M_{QR} = \dfrac{2EI}{5}(2\theta_Q + \theta_R)$

(B) $M_{QR} = \dfrac{2EI}{5}(2\theta_Q - \theta_R)$

(C) $M_{QR} = \dfrac{2EI}{5}(2\theta_R - \theta_R)$

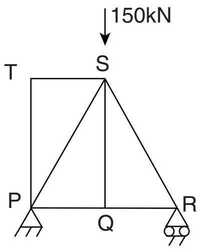
(D) $M_{QR} = \dfrac{EI}{5}(2\theta_Q + \theta_R)$

9. Which of the following cross sections has the highest shape factor?
(A) Rectangle (B) Diamond
(C) Triangle (D) Circle

10. The stiffness coefficient K_{ji} indicates
(A) force at j due to a unit deformation at i
(B) force at I due to a unit deformation at j

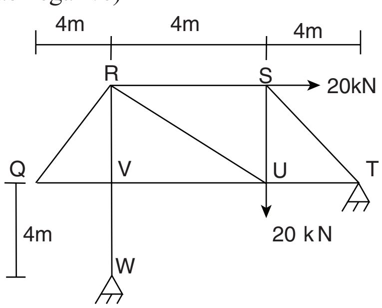
(C) deformation at j due to a unit force at i
(D) deformation at I due to a unit force at j

11. The force in the member QS of the truss shown in the figure is;



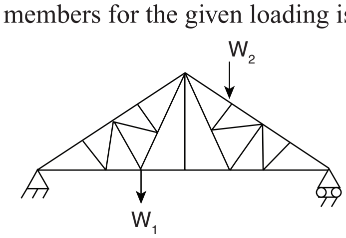
(A) 150 kN
(B) $\dfrac{150}{\sqrt{2}}$ kN
(C) zero
(D) 35.5 kN

12. The pin jointed 2-D truss is loaded with a horizontal force of 20 kN at joint 'S' and another 20 kN vertical force at joint 'U' as shown. Find the force in the member RS (in kN). (taking tension as positive and compression as negative)



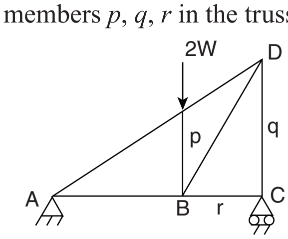
(A) zero
(B) 20 kN
(C) 40 kN
(D) −20 kN

13. For the plane truss shown in the figure, the number of zero force members for the given loading is



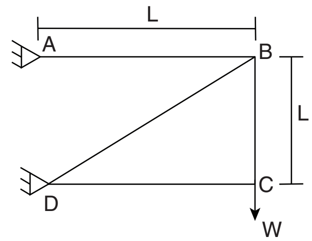
(A) 8
(B) 4
(C) 11
(D) 13

14. The force in members p, q, r in the truss shown



(A) $2W$, W, 0
(B) $2W$, W, W
(C) $\dfrac{W}{2}$, W, 0
(D) $\dfrac{W}{2}$, $\dfrac{W}{2}$, 0

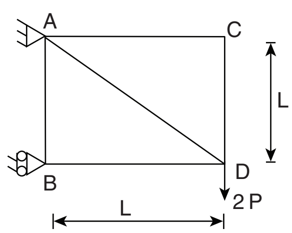
15. For the truss shown in the figure, the force in member AB is



(A) W
(B) $\dfrac{W}{2}$
(C) zero
(D) None

16. Which of the following statements is true with regard to the flexibility method of analysis?
(A) the method is used to analyse determinate structures.
(B) the method is used only for manual analysis of indeterminate structures
(C) the method is used for analysis of flexible structures.
(D) the method is used for analysis of indeterminate structures with lesser degree of static indeterminacy.

17. The strain energy stored in the member AB of the pin jointed truss shown below. A and E is same for all members.

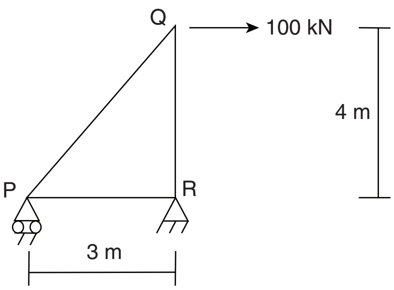


(A) $\dfrac{4P^2L}{2AE}$
(B) zero
(C) $\dfrac{P^2L}{AE}$
(D) $\dfrac{2P^2L}{3AE}$

18. The unit load method used in structural analysis is
(A) applicable only to indeterminate structures.
(B) derived from castigliano's, theorem
(C) another name for stiffness method
(D) none

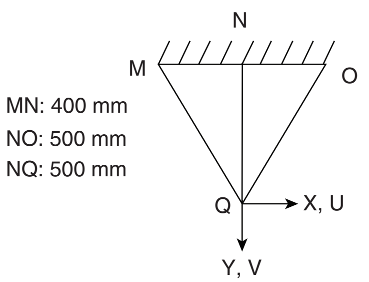
19. For linear elastic systems, the type of displacement function for strain energy is
(A) quadratic
(B) linear
(C) cubic
(D) quartic

20. The right triangular truss is made of members having equal cross sectional area of 1500 mm^2 and young's of $10^5 \times W^5$Mpa. The horizontal deflection at join Q is



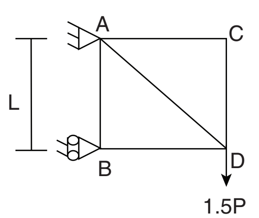
(A) 7.79 mm (B) 4.60 mm
(C) 8.20 mm (D) none

21. In a redundant joint model, three bar members are pin connected at Q as shown in figure. Under some load placed at Q, the elongation of the members MQ and OQ are found to be 40 mm and 25 mm. then the horizontal displacement 'U' and vertical displacement 'V' of the node Q_1 in mm will be respectively,



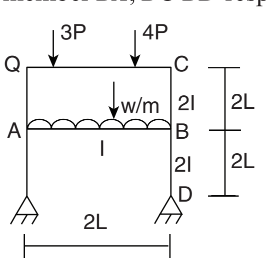
(A) 8.84 mm, 44.20 mm (B) 5 mm, 20 mm
(C) 0 mm, 44.20 mm (D) 7 mm, 35 mm

22. The strain energy started in the member AB of the pin jointed truss shown aside when E and A are same for all members is



(A) $\frac{1.5P^2L}{AE}$ (B) $\frac{P^2L}{AE}$
(C) zero (D) $\frac{2P^2L}{AE}$

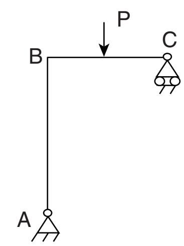
23. In the portal frame shown below, what are the distribution factors for member BA, BC BD respectively?

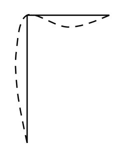
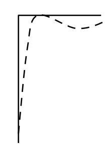


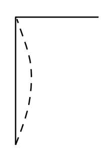
(A) 1/5, 2/5, 2/5 (B) 2/5, 1/5, 1/5
(C) 1/3, 1/3, 1/3 (D) none

24. A propped cantilever beam PQ with fixed edge 'P' is propped at 'Q' and carries a UDL of w/m over the entire span. If the prop displaces upward by 2 mm, which one of the following is true? (if prop reaction = R_Q moment at $P = M_P$)
(A) both R_Q and M_P increase
(B) R_Q increases, and M_P decreases
(C) R_Q decreases and M_P increases
(D) both R_Q and M_P decreases

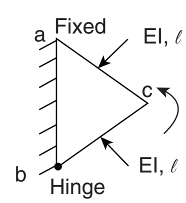
25. Identify the correct deflection diagram corresponding to the loading in the plane frame



(A)  (B) 

(C)  (D) None

26. Rotational stiffness coefficient, K_{11} at joint 'C' for the frame having two members of equal $\frac{EI}{\ell}$ is given by



(A) $\frac{7EI}{\ell}$ (B) $\frac{5EI}{\ell}$
(C) $\frac{4EI}{\ell}$ (D) $\frac{6EI}{\ell}$

27. A propped cantilever beam of span 'L' is loaded with UDL of intensity w/unit length, all through the span. Bending moment at fixed end is _____

(A) $\frac{WL^2}{8}$ (B) $\frac{WL^2}{2}$
(C) $\frac{WL^2}{12}$ (D) $\frac{WL^2}{24}$

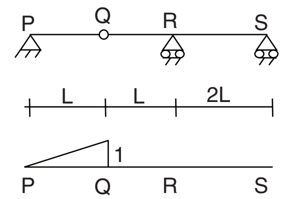
28. Influence lines for redundant structures can be obtained by
(A) Castigliano;s theorem
(B) Muller Berslau principle
(C) Unit load theorem
(D) Maxwell-Betti reciprocal theorem

29. A homogeneous, simply supported prismatic beam of Width B, depth D and span 'L' is subjected to a con-concentrated load of magnitude P. The load can be placed anywhere along the span of beam. The maximum flexural stress developed in the beam is

(A) $\frac{3}{4}\frac{PL}{BD^2}$ (B) $\frac{4}{3}\frac{PL}{BD^2}$

(C) $\frac{3}{2}\frac{PL}{BD^2}$ (D) $\frac{2}{3}\frac{PL}{BD^2}$

30. Consider the beam $PQRS$ and the influence line as shown below. The influence line pertains to



(A) Reaction of P, R_P
(B) Shear force Q, V_Q
(C) Shear force on left of Q, V_Q^-
(D) Shear force on right of Q, V_Q^+

Answer Keys

1. B	**2.** A	**3.** B	**4.** D	**5.** A	**6.** C	**7.** C	**8.** A	**9.** C	**10.** A
11. C	**12.** A	**13.** A	**14.** A	**15.** A	**16.** D	**17.** B	**18.** B	**19.** B	**20.** A
21. A	**22.** C	**23.** A	**24.** B	**25.** A	**26.** A	**27.** A	**28.** B	**29.** C	**30.** B

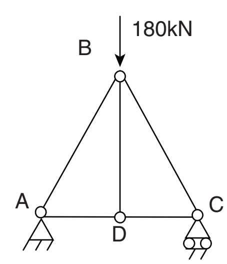
Hints and Explanations

1. Given rigid jointed plane frame with internal hinge at Q
$D_s = (3m + r) - 3J - C$
Where m number of members = 3
r : no of reactions = 2 + 1 = 3
J : number of joints = 4
C : number of releases = (2 – 1) = 1
$\therefore$ $D_s = [3(3) + 3] - 3(4) - 1$
$= 12 - 12 - 1 = -1$
$\Rightarrow$ $D_s < 1$
The given frame is unstable Choice (B)

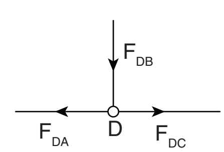
2. Degree of static indeterminacy = $D_s = D_{si} + D_{se} - C$
D_{se} : external indeterminacy
r : – 2 [since only vertical loading so '2' equilibrium equations]
r : number of reactions = 3
$D_{se} = 3 - 2 = 1$
D_{si} = Internal indeterminacy = 0
C : number of releases = 1
[Due to the presence of internal hinge, we get an additional equation since it does not allow moment from one part to other]
$\therefore$ $D_s = D_{se} + D_{si} - C$
$= 1 + 0 - 1$
$D_s = 0$ Choice (A)

3. Kinematic indeterminacy/Degrees of freedom $D_K = NJ - C$
Where N : number of degrees of freedom of each joint = 3 [since rigid plane frame]
J : number of joints = 4
C : number of restraints = 3 + 3 = 6
$\therefore$ $D_K = (3)(4) - 6 = 12 - 6$
$D_K = 6$ [with axial deformations]
$D_K = 6 - 3 = 3$ [neglecting axial deformation]
Choice (B)

4.



At joint D

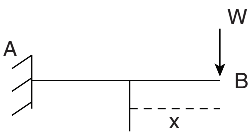


If two forces are in same line the force in third member is equal to zero when three forces are acting at a joint
$\therefore$ $F_{BD} = 0$ Choice (D)

5. These are basic method of structural analysis to analyse statically indeterminate structures.
Column analogy method and castiglianos theorem of minimum strain energy comes under force method/flexibility method/equilibrium method and kanis rotation

contribution method and moment distribution method comes under compatibility method/stiffness coefficient method/displacement method. Choice (A)

6.



Strain energy (U) is given by

$$U=\int_{O}^{L}\frac{M_X^2 d_X}{2EI}$$

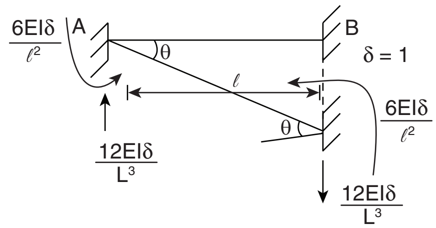
Where M_x : moment at a section (x)

$= -wx$ where x varies from o to L

$$U=\int_{O}^{L}\frac{(-W_X)^2 d_X}{2EI}$$

$$=\int_{O}^{L}\frac{W^2X^2}{2EI}=\left[\frac{W^2X^3}{6EI}\right]_{O}^{L}=\frac{W^2\ell^2}{6EI}$$ Choice (C)

7. Given free end undergoes unit displacement and without rotation so the beam can be shown as



∴ Moment at $A=\frac{6EI\delta}{\ell^2}$

Where $\delta = 1$

$M_A=\frac{6EI}{\ell^2}$

[Due to sinking of support B; rotations develop at A & B; but fixed end does not allow rotations and hence fixed end moments of magnitude $\frac{6EI\delta}{\ell^2}$ develops]

Choice (C)

8. $M_{QR}=\frac{2EI}{L}(2\theta_Q+\theta_R-\frac{3\delta}{L})+M_{FQR}$

$\delta = 0$; $M_{FRQ} = 0$

∴ $M_{QR}=\frac{2EI}{L}(2\theta_Q+\theta_R)$ Here $L = 5$m Choice (A)

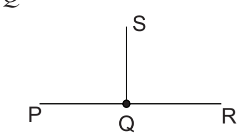
9.

C/S sections	Shape factors values
(a) Rectangle	1.5
(b) Diamond	2.0
(c) triangle	2.34
(d) circle	1.7

Choice (C)

10. Choice (A)

11. Consider joint Q



Three forces are acting at joint Q. two of them are in same line; the force in third member (QS) to be zero form equilibrium of joint. Choice (C)

12. $\Sigma Fy = 0$

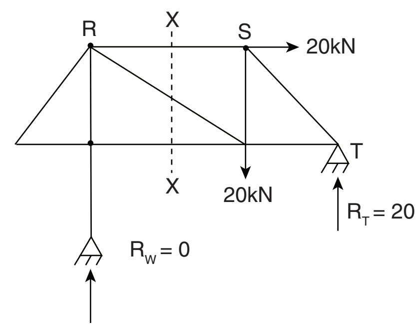
$R_W + R_J = 20$kN

$\Sigma M_T = 0$

$(R_W)8 + (20)(4) - (20(4) = 0$

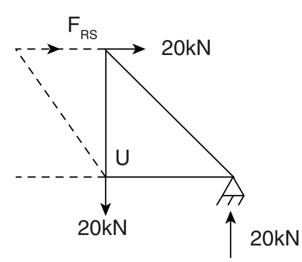
$R_W = 0$

$R_T = 20$kN



Draw a section (X) – (X) passing through (RS)

Taking equilibrium of right hand side

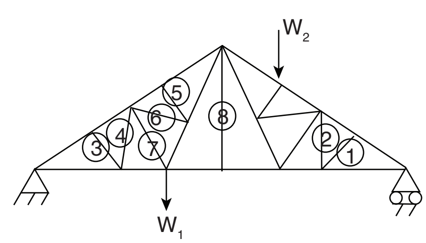


Taking moments about U

$(F_{RS})(4) + (20)4 - 20(4) = 0$

$(F_{RS}) = 0$ Choice (A)

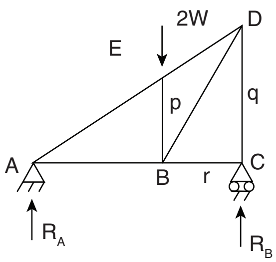
13.



Using the principle : If three forces act at a joint and two of them are in same line; the force in third member will be zero.

∴ Total number of zero forces = 8 Choice (A)

14.



$R_A + R_B = 2W$

Due to symmetry $R_A = R_B = \dfrac{2W}{2} = W$

R_B and q are in same line at joint C

$\therefore$ $R_B = q = W$

so the value of $r = 0$

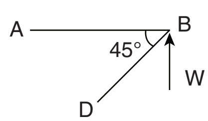
at joint E;

$2W$ and p are in same line

So, $p = 2W$ Choice (A)

15. At joint C; the force W and F_{BC} are in same line so the force in member DC will be zero

At joint B:



$\Sigma F_X = 0$

$F_{AB} = F_{BD} \cos 45°$

$\Sigma F_Y = 0$

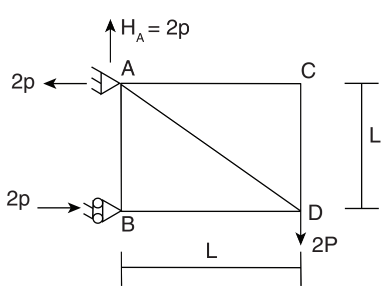
$F_{DB} \sin 45° = W$

$F_{DB} = W\sqrt{2}$

$F_{AB} = W\sqrt{2} \cos 45°$

$F_{AB} = W$ Choice (A)

17.



At joint B;

Reaction $2p$ and force in BD are in same line

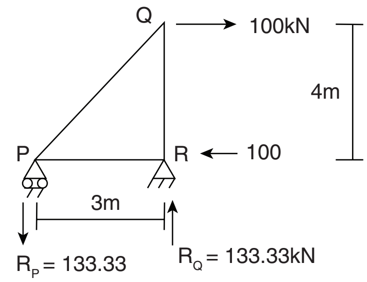
Therefore force in member $AB = 0$

Strain energy $= \dfrac{P^2L}{2AE}$

$p = 0$;

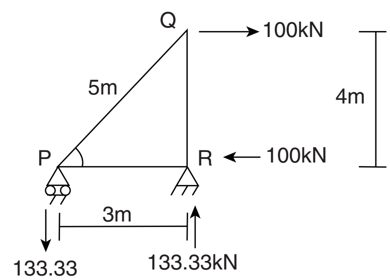
$_{UAB} = 0$ Choice (B)

20.

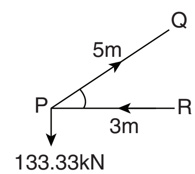


$R_P \times 3 = 100 \times 4$

$R_P = 100 \times 4/3 = 133.33$kN



At joint (P):



$\cos\theta = \dfrac{3}{5}$; $\sin\theta = \dfrac{4}{5}$

$F_{PQ} \sin\theta = 133.33$ KN

$F_{PQ} = \dfrac{133.33}{\sin\theta} = \dfrac{133.33}{(4)15}$

$F_{PQ} = 166.66$kN

$F_{PQ} \cos\theta = F_{PR}$

$F_{PR} = (166.66)(315)$

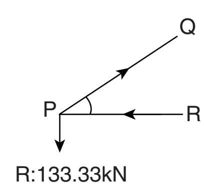
$F_{PR} = 99.99$kN

$F_{RQ} = 133.33$kN

$R \times 3 = 1 \times 4$

$R = 4/3 = 1.33$ kN

At joint P:



$F_{PQ} \sin\theta = 1.33$

$F_{PQ} = \dfrac{1.33}{\sin\theta} = \dfrac{1.33}{415}$

$F_{PQ} = 1.662$ kN

$F_{PQ} \cos\theta = F_{PR}$

$F_{PR} = 1.662 \times \frac{3}{5} = 0.9975$ kN

$F_{RQ} = 1.33$ kN

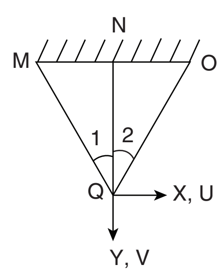
Member	P	K	ℓ
PQ	166.66	1.662	5
QR	133.33	1.33	4
PR	99.99	0.9975	3

$$\delta_H = \frac{\Sigma PKL}{AE}$$

$$= \frac{166.66 \times 1.662 \times 5 + (133.33)(1.33)(4) + (99.99)(0.9975)(3)}{1500 \times 200}$$

$\delta_H = 7.978$mm Choice (A)

21.



MN: 400mm

NO: 500mm

NQ: 500mm

$$\sin\theta_1 = \frac{400\text{mm}}{\sqrt{400^2 + 500^2}} = 0.624$$

$$\cos\theta_1 = \frac{500}{\sqrt{400^2 + 500^2}} = 0.780$$

$$\sin\theta_2 = \frac{500}{\sqrt{500^2 + 500^2}} = 0.707$$

$$\cos\theta_2 = \frac{500}{\sqrt{500^2 + 500^2}} = 0.707$$

By resolving the displacements along *OQ*;

$-U \sin\theta_2 + V \cos\theta_2 = 25$ - (1)

Along member *MQ*;

$U \sin\theta_1 + V \cos\theta_1 = 40$ - (2)

$U = 8.84$mm

$V = 44.20$mm Choice (A)

22. At joint *B*;
Reaction at *B* and force in member *CD* are in same line.
Therefore the force in member $AB = 0$

$F_{AB} = 0$

$U = \frac{P^2 L}{AE} = 0$ Choice (C)

23.

Joint	Members	Relative stiffness(k)	Σk	Distribution factor $\left(\frac{K}{\Sigma K}\right)$
B	BA	I/2L	5I/2L	1/5
	BC	2I/2L		2/5
	BD	2I/2L		2/5

Choice (A)

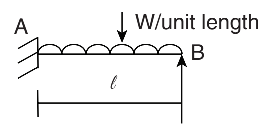
24. Choice (B)

25. Choice (A)

26. Rotational stiffness at joint = Sum of rotational stiffness of each member

$$= \frac{4EI}{\ell} + \frac{3EI}{\ell} = \frac{7EI}{\ell}$$ Choice (A)

27.



Initial FEM	$\frac{-WL^2}{12}$	$\frac{WL^2}{12}$
Balancing	$\frac{-WL^2}{12}$	$\frac{-WL^2}{12}$
Carry over	$\frac{-WL^2}{24}$	
Final FEM	$\frac{-WL^2}{8}$	0

Choice (A)

29. To get maximum *BM* place load at enter of beam,

Maximum bending stress $f = \frac{M_{max}}{Z}$

$$= \frac{\frac{PL}{4}}{\frac{BD^2}{6}} = \frac{3}{2}\frac{PL}{BD^2}$$ Choice (C)

30. ILD shown is for shear force at Q, V_Q Choice (B)