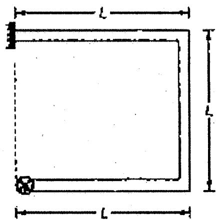
3
CHAPTER

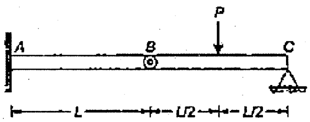
Shear Force and Bending Moment

Q.1 A concentrated force F is applied (perpendicular to the plane of the figure) on the tip of the 'U' bar as shown in the figure. The equivalent load at a section close to the fixed end is



(a) Force F
(b) Force F and bending moment FL
(c) Force F and twisting moment FL
(d) Force F, bending moment FL and twisting moment FL

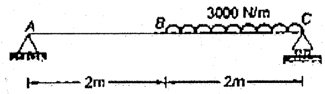
Q.2 A beam made up of two identical bars AB and BC is hinged at B. The end A is fixed and C is simply supported with load 'P' acting as shown. The bending moment at A is



(a) Zero
(b) $\frac{PL}{2}$
(c) PL
(d) $\frac{3PL}{2}$

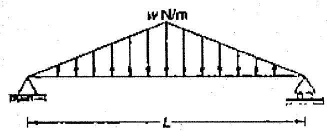
Q.3 The shape of the bending diagram for a uniform cantilever beam due to its self weight is
(a) straight line
(b) hyperbola
(c) parabola
(d) ellipse

Q.4 A beam has a loading pattern as shown in figure. The beam is considered to be weighless. The maximum BM occurs at



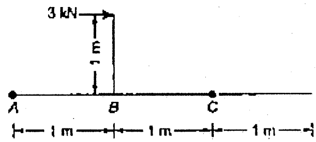
(a) at B
(b) at 2.675 m from A
(c) at 2.5 from A
(d) at 3.225 m from A

Q.5 A simply supported beam is subjected to a distributed loading as shown in figure below. What is the maximum SF in the beam



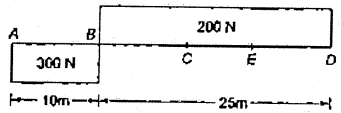
(a) $\frac{WL}{3}$
(b) $\frac{WL}{6}$
(c) $\frac{WL}{8}$
(d) $\frac{WL}{4}$

Q.6 A lever is supported on two hinges at A and C. It carries a force of 3 kN as shown in the figure. The BM at B will be

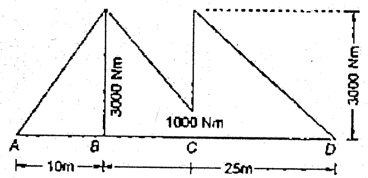


(a) 1.5 kNm
(b) 3 kNm
(c) 0 kNm
(d) 6 kNm

Q.7 Shear force and BM diagrams for a beam *ABCD* are shown in figure. It can be concluded that



SFD



BMD

(a) The beam has 3 supports
(b) End *A* is fixed
(c) A couple of 2000 Nm acts at *C*
(d) A uniformly distributed load is confined to *BC* only

Q.8 Consider the following statement.
If at a section distant from one of the ends of the beam, *M* represents the bending moment, *V* the shear force and 'w' the intensity of loading, then

1. $\frac{dM}{dx} = V$ 2. $\frac{dV}{dx} = w$

3. $\frac{dw}{dx} = y$

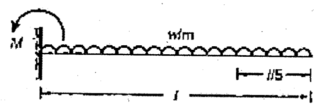
where *y* is the deflection of beam at the section
Which of the above statement(s) is(are) correct?
(a) 1 and 3 (b) 1 and 2
(c) 2 and 3 (d) 1, 2 and 3

Q.9 A beam of overall length *L* with equal overhangs on both sides carries a uniformly distributed load over the entire length. To have numerically equal bending moments at centre of the beam and at supports, the distance between the supports should be
(a) 0.277 *L* (b) 0.403 *L*
(c) 0.586 *L* (d) 0.707 *L*

Q.10 A prismatic beam of length *L* and fixed at both ends carries a uniformly distributed load. The distance of points of contraflexure from either ends is
(a) 0.207 *L* (b) 0.578 *L*
(c) 0.586 *L* (d) 0.25 *L*

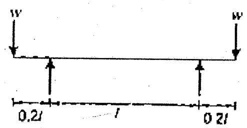
Q.11 A simply supported beam of length *L* carries a load varying uniformly from zero at left end to maximum at right end. The maximum bending moment occurs at a distance of
(a) $L/\sqrt{3}$ from left end
(b) *L*/3 from left end
(c) $L/\sqrt{3}$ from right end
(d) *L*/3 from right end

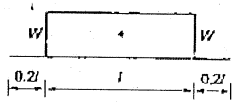
Q.12 In figure below, the maximum bending moment at the fixed end of the cantilever caused by the UDL is *M*.

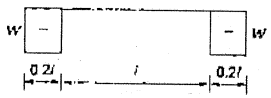


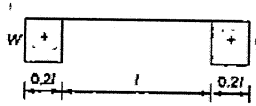
The bending moment at a section *l*/5 from the free end is
(a) 4% of *M* (b) 5% of *M*
(c) 10% of *M* (d) 20% of *M*

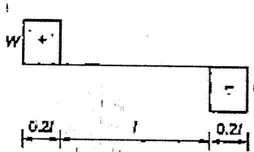
Q.13 Which one of the following represents the correct shear force diagram of the simply supported beam as shown in figure?



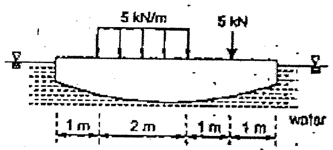
(a)


(b)


(c)


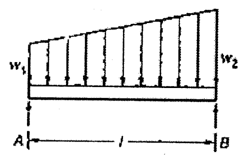
(d)


Q.14 A small narrow barge is loaded as shown in figure.



Maximum shear force in barge is
(a) 3 kN (b) 5 kN
(c) 4 kN (d) 7 kN

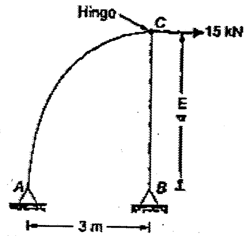
Q.15 A simply supported beam of span *l* is loaded (as shown) with a UDL of intensity w_1 per unit length at *A* and w_2 per unit length at *B*. The shear force at the support *B* is given by



(a) $\frac{(w_1 + w_2)l}{3}$ (b) $\frac{(w_1 + w_2)l}{6}$

(b) $\frac{w_1 l}{6} + \frac{w_2 l}{3}$ (d) $\frac{w_2 l}{3} + \frac{w_2 l}{6}$

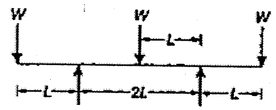
Q.16 Axial force in the member *BC* of the structure as shown in the given figure is

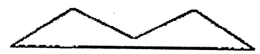


(a) 15 kN (b) 20 kN
(c) 25 kN (d) 30 kN

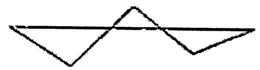
Q.17 A cantilever beam having 5 m length is so loaded so that it develops a shearing force of 50 *T* and a bending moment of 20 Tm at a section 2 m from the free end. Maximum shearing force and maximum BM developed under this load are 50T and 125 Tm respectively. The load on the beam is
(a) 25 T concentrated load at free end
(b) 20 T concentrated load at free end
(c) 5 T concentrated load at free and and 2 T/m load over entire length
(d) 10T/m UDL over entire length

Q.18 A loaded bēam is shown in the figure. The BM diagram of the beam is best represented by



(a)


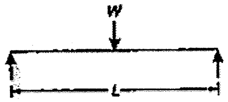
(b)

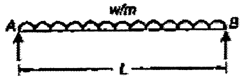

(c)


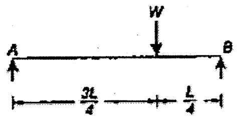
(d)

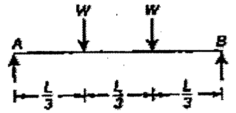

Q.19 Match List-I (Simply supported beams) with List-II (Shear force diagrams) and select the correct answer by using codes given below the lists:

List-I

A. 

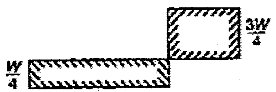
B. 

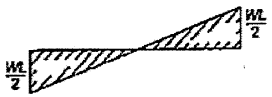
C. 

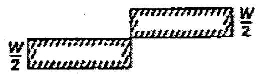
D. 

List-II

1. 

2. 

3. 

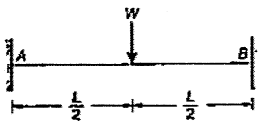
4. 

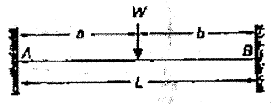
Codes:

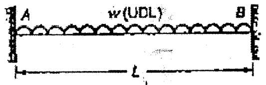
	A	B	C	D
(a)	4	3	2	1
(b)	1	2	3	4
(c)	2	4	1	3
(d)	1	3	2	4

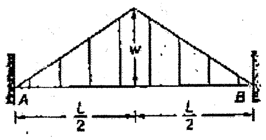
Q.20 Match List-I with List-II and select the correct answer by using codes given below the lists:

List-I

A. 

B. 

C. 

D. 

List-II

1. $M_A = \frac{Wab^2}{L^2}$
2. $M_A = -\frac{wL^2}{12}$
3. $M_A = -\frac{5wL^2}{96}$
4. $M_A = -\frac{WL}{8}$

Codes:

	A	B	C	D
(a)	4	1	2	3
(b)	1	2	3	4
(c)	3	2	1	4
(d)	1	4	2	3

Q.21 Match List-I (Beam/Column and loading) and List-II (Number of points of contraflexure) and select the correct answer using the codes given below the lists:

List-I

A. Propped cantilever beam under mid point loading
B. Fixed beam under uniformly distributed load
C. Fixed beam subjected to a moment at mid point
D. Simply supported column subjected to eccentric load at an intermediate point

List-II

1. Two
2. Three
3. One

Codes:

	A	B	C	D
(a)	3	2	1	3
(b)	3	2	3	1
(c)	2	3	3	1
(d)	2	3	1	3

Q.22 A beam of length L is fixed at left end and is propped at the right end, and carries a uniformly distributed load 'w' per unit length. Following points are drawn:

1. The maximum bending moment is $\frac{9}{128}wL^2$
2. The bending moment at the fixed end is $\frac{wL^2}{8}$
3. The maximum shear force at the fixed end is $\frac{5}{8}wL$
4. Shear force is zero at a distance $\frac{3}{8}L$ from propped end.

Which of these statements is/are correct?

(a) both 1 and 4
(b) 1, 2 and 4
(c) 2, 3 and 4
(d) 1, 2, 3 and 4

Q.23 A beam of channel cross-section with vertical web loaded with a concentrated load at midspan in a plane perpendicular to the plane of symmetry passing through the centroid is subjected to

1. bending moment
2. twisting moment
3. shear force
4. axial thrust

Which of these statements is correct?

(a) 2, 3 and 4
(b) 1, 2 and 3
(c) both 1 and 2
(d) both 1 and 3

Q.24 Consider the following statements with reference to sinking of an intermediate support of a continuous beam:

1. Reduces the negative moment at sinking support
2. Increases the negative moment at the centre of span
3. Reduces the positive moment at the centre of span
4. Increases the positive moment at the centre of span

Which of the above statements is correct?

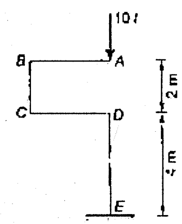
(a) both 1 and 4
(b) both 1 and 3
(c) both 2 and 3
(d) both 2 and 4

Q.25 Assertion (A): The maximum bending moment occurs where the shear force is either zero or changes sign.

Reason (R): If the shear force diagram outline between the two points is horizontal, the BM diagram outline is inclined. But if the SF diagram is inclined, the BM diagram is a parabola of second degree.

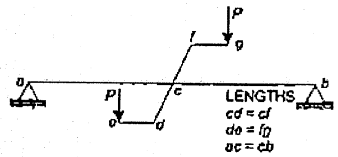
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.26 The bending moment at E for the structure shown in figure is



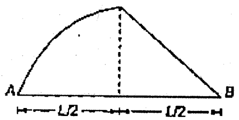
(a) zero
(b) 10 t-m
(c) 20 t-m
(d) 40 t-m

Q.27 A beam having a double cantilever attached at mid span is shown in figure. The nature of force in beam 'ab' is

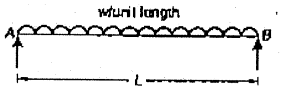


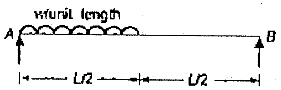
(a) bending and shear
(b) bending, shear and torsion
(c) pure torsion
(d) torsion and shear

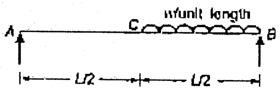
Q.28 The bending moment diagram for a simply supported beam is shown in figure below.

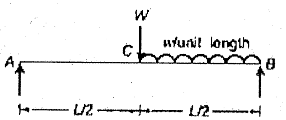


Which one of the following figure shows the corresponding loading on the beam?

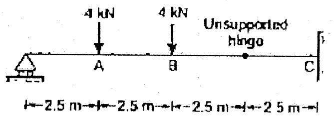
(a)


(b)


(c)


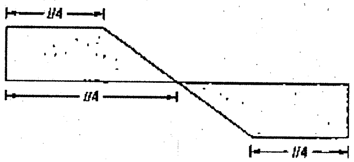
(d)


Q.29 The bending moment at points *A*, *B* and *C* of the beam as shown in the given figure will be



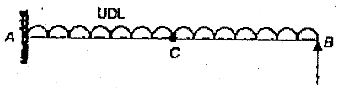
(a) 10 kNm, 10 kNm and 10 kNm
(b) 10 kNm, 10 kNm and −10 kNm
(c) 20 kNm, 10 kNm and −10 kNm
(d) 10 kNm, −10 kNm and 20 kNm

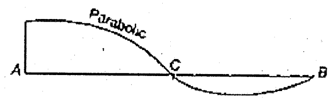
Q.30 The shear force diagram shown in the figure is that of a

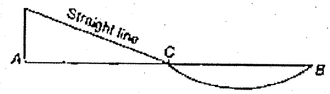


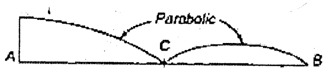
(a) freely supported beam with symmetrical point load about mid-span
(b) freely supported beam with symmetrical uniformly distributed load about mid-span
(c) simply supported beam with positive and negative point loads symmetrical about the mid-span
(d) simply supported beam with symmetrical varying load about mid-span

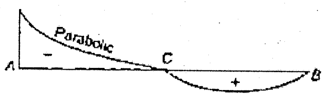
Q.31 A propped cantilever beam as shown in the figure is having internal hinge at its mid-span. Which one of the following is the shape of bending moment diagram for the given loading?



(a)


(b)


(c)


(d)


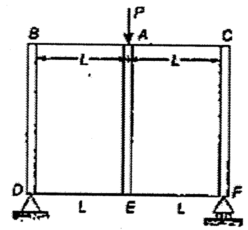
Q.32 Assertion (A): A beam subjected only to end moments will be free from shearing force.
Reason (R): The bending moment variation along the beam length is zero.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.33 Assertion (A): The change in BM between two cross-sections of a beam is equal to the area of the shearing froce diagram between two sections.
Reason (R): The change in the shearing force between two cross-sections of beam due to distributed loading is equal to the area of the load intensity diagram between the two sections.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.34 Assertion (A): In a simply supported beam carrying a concentrated load at midspan, both the shear force and BM diagram are triangular in nature without any change in sign.
Reason (R): When the shear force at any section of a beam is either zero or changes sign, the BM at that section is maximum.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.35 The BM diagram for a simply supported beam is a rectangle over a larger portion of the span except near the supports. The type of loading the beam is carrying is
(a) A UDL symmetrically loaded over a larger portion of the span except near the supports
(b) A concentrated load at mid span
(c) Two identical loads equidistant from the mid span and close to support.
(d) A moment at the mid span.

Q.36 Find the bending moment at *A* for frame shown in figure. Each vertical member has infinite moment of inertia



(a) $\frac{PL}{2}$
(b) $\frac{PL}{4}$
(c) $\frac{PL}{8}$
(d) $\frac{PL}{16}$

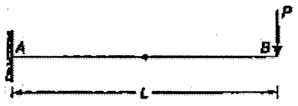
■■■■

Answers Shear Force and Bending Moment

1. (c)	2. (b)	3. (c)	4. (c)	5. (d)	6. (b)	7. (c)	8. (b)	9. (c)	10. (b)
11. (a)	12. (a)	13. (d)	14. (a)	15. (c)	16. (b)	17. (d)	18. (a)	19. (a)	20. (a)
21. (b)	22. (d)	23. (d)	24. (a)	25. (b)	26. (a)	27. (a)	28. (b)	29. (b)	30. (b)
31. (d)	32. (a)	33. (b)	34. (d)	35. (c)	36. (b)				

Explanations Shear Force and Bending Moment

2. (b)



$$M_A = \frac{P}{2}L = \frac{PL}{2}$$

4. (c)

$R_A + R_C = 3000 \times 2 = 6000$ N

$R_A \times 4 - 3000 \times 2 \times 1 = 0$

$\Rightarrow R_A = 1500$ N

For M_{max} SF = 0

∴ SF equation at x distance from A is span BC

$R_A - 3000 \times (x-2) = 0$ For $x > 2$ m

$\Rightarrow x = 2.5$ m

5. (d)

Total load $= \dfrac{WL}{2}$

SF_{max} occurs at $x = 0$

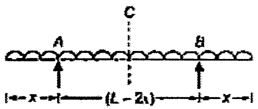
$$SF_{max} = \frac{WL}{4}$$

7. (c)

The vertical increment in moment at a point entails a point moment acting at the point.

Similarly a vertical increase in SF diagram entails a point load.

9. (c)



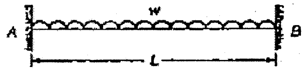
$M_A = M_C$

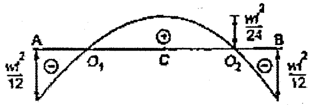
$\Rightarrow x = 0.207\,L$

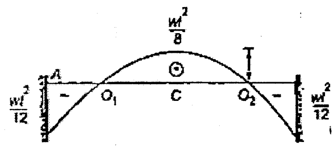
$\therefore (L - 2x) = 0.586\,L$

Value of $M_B = M_A = M_C = \dfrac{wx^2}{2} = \dfrac{wL^2}{46.7}$

10. (b)







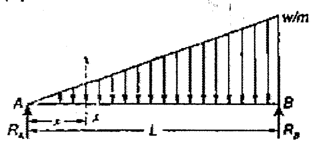
$$M_C = \frac{wl^2}{8} - \frac{wl^2}{12} = \frac{wl^2}{24}$$

$AO_1 = BO_2 = 0.211\,L$

$O_1O_2 = 0.578\,L$

Distance between points of contraflexure = 0.578L

11. (a)



$$R_A + R_B = \frac{1}{2}w \cdot L$$

$$\Sigma M_B = 0$$

$$\Rightarrow R_A \times L - \frac{1}{2} \times w \times L \times \frac{L}{3} = 0$$

$$\Rightarrow R_A = \frac{wL}{6}$$

The equation of BM at a distance 'x' from end A is

$$M_x = R_A \times x - \frac{1}{2} \times x \times \frac{w}{L}(x) \times \frac{x}{3}$$

$$\Rightarrow M_x = \frac{wLx}{6} - \frac{wx^3}{6L}$$

For maximum BM, $\dfrac{dM}{dx} = 0$

$$\therefore \frac{wL}{6} - \frac{3wx^2}{6L} = 0$$

$$\Rightarrow \frac{wL}{6} = \frac{wx^2}{2L}$$

$$x^2 = \frac{L^2}{3}$$

$$\Rightarrow x = \frac{L}{\sqrt{3}} \text{ from left end}$$

12. (a)

BM at fixed end $= M = \dfrac{wl^2}{2}$

BM at a section 'x' from the free end

$$= \frac{wx^2}{2}$$

∴ BM at section $\dfrac{l}{5}$ from free end

$$= \frac{w}{2}\left(\frac{l}{5}\right)^2 = \frac{wl^2}{50}$$

$$\therefore \frac{wl^2/50}{wl^2/2} \times 100 = 4\% \text{ of } M$$

14. (a)

udl at bottom $= \dfrac{5 \times 2 + 5}{5} = 3$ kN/m

Maximum shear force = 3 × 1 = 3 kN

(At 1 m distance from left end of barge).

16. (b)

$H_B = 0$ [As $M_c = 0$]

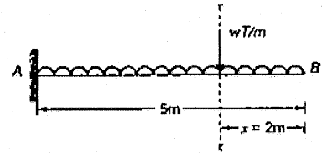
$H_A = 15$ kN

$R_A \times 3 = 15 \times 4$

$R_A = 20$ kN (↑)

$R_B = 20$ kN (↓)

17. (d)



Consider load to be UDL.

∴ Max BM $= \dfrac{wl^2}{2}$

Max $SF = wl$

$\Rightarrow 50 = w \times 5$

$\therefore w = 10$ T/m

$$\frac{wl^2}{2} = \frac{10 \times 5^2}{2} = 125 \text{ Tm}$$

$SF_{x=2m} = wx = 10 \times 2 = 20T$

$$BM_{x=2m} = \frac{wx^2}{2} = \frac{10 \times 2^2}{2} = 20\text{Tm}$$

18. (a)

BM at support $= W \times L$

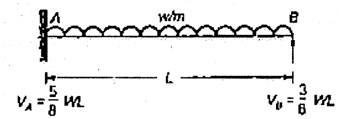
BM at middle $= W \times 2L - \dfrac{3W \times L}{2}$

$= 0.5\,WL$

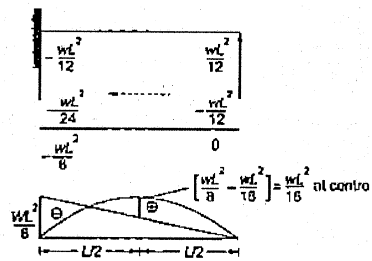
BM at free end of overhang = 0

Hence (a) is correct answer.

22. (d)



Solving by moment distribution method.



Reactions,

$$V_a = \frac{5}{16}wL,\ V_b = \frac{3}{8}wL$$

- Bending moment $= -\dfrac{wL^2}{8}$ at fixed end.

(at the support A)

- Maximum shear force $= \dfrac{5}{8}wL$ at support A
- Shear force at x from support B

$$S_x = \frac{-3}{8}wL + xw$$

$$S_x = 0 \Rightarrow x = \frac{3L}{8} \text{ from } B$$

i.e. shear force is zero at $x = \dfrac{3L}{8}$ from B.

- Maximum bending moment occurs where shearforce is zero

i.e. maximum $= +\dfrac{3}{8}wLx - \dfrac{Wx^2}{8}$

$$= +\frac{3}{8}wL \times \frac{3L}{8} - \frac{w}{2} \times \left(\frac{3L}{8}\right)^2$$

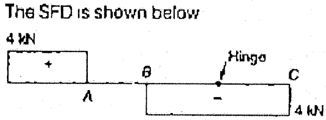
$$= +\frac{1}{2} \times \frac{9}{64}wL^2 = +\frac{9}{128}wL^2$$

26. (a)

The line of action of the load passes through E and hence lever arm is zero.

29. (b)

The SFD is shown below



∴ BM at $A = 4 \times 2.5 = 10$ kN-m

BM at $B = 10 + 0 = 10$ kN-m

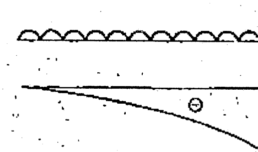
BM at $C = 10 - 4 \times 5 = -10$ kN-m

31. (d)

Due to hinge at C the part CB of beam behaves as simply supported beam. Thus reaction at B will be in upward direction and equals half of the load in span BC.

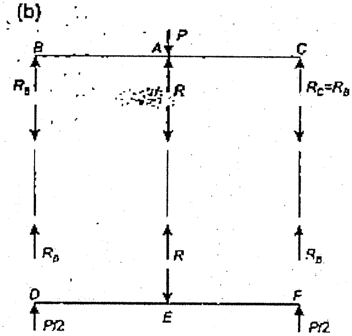
Span CA behaves as a cantilever beam. Therefore $B.M.D.$ will be sagging in BC and hogging in AC and it will be parabolic.

For a cantilever $B.M.D.$ will be as shown below.



Combining all the arguments answer will be (d) which is given with BM plotted on tension side.

36. (b)



$$\Delta_A = \Delta_E$$

$$\frac{(P-R)(2L)^3}{48EI} = \frac{R \times (2L)^3}{48EI}$$

$$\Rightarrow P - R = R$$

$$\Rightarrow \quad R = \frac{P}{2}$$

Also $2R_B + R = P$

$$\Rightarrow \quad R_B = \frac{P-R}{2} = \frac{P}{4}$$

$$\therefore \quad M_A = R_B L = \frac{PL}{4}$$