

2020

RANK *Improvement* **WORKBOOK**



**Answer key and Hint of
Objective & Conventional Questions**

Civil Engineering
Structural Analysis



MADE EASY
— Publications

1

Determinacy and Indeterminacy

LEVEL 1 Objective Questions

1. (a)
2. (d)
3. (a)
4. (9)
5. (2.6)
6. (a)
7. (3)
8. (3)
9. (c)
10. (b)
11. (d)
12. (8)
13. (b)
14. (a)

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LEVEL 2 Objective Questions

15. (d)
16. (b)
17. (a)
18. (a)
19. (c)
20. (a)
21. (a)
22. (d)
23. (b)
24. (11)
25. (a)
26. (d)

■ ■ ■ ■

2

Influence Line Diagram and Rolling Loads

LEVEL 1 Objective Questions

1. (d)
2. (c)
3. (b)
4. (b)
5. (d)
6. (240)
7. (22.5)
8. (c)
9. (1)
10. (a)
11. (b)
12. (c)
13. (a)

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LEVEL 2 Objective Questions

14. (1.783)
15. (a)
16. (c)
17. (c)
18. (b)
19. (b)
20. (d)
21. (a)
22. (d)
23. (195.488)

LEVEL 3 Conventional Questions**Solution : 1**

$$T = 60 \text{ kN}, \quad C = 135 \text{ kN}$$

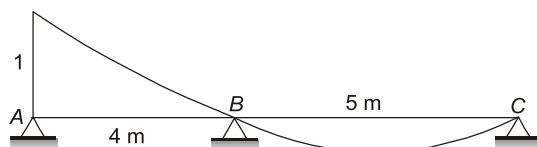
Solution : 2

$$250\sqrt{3} \text{ (tension)}$$

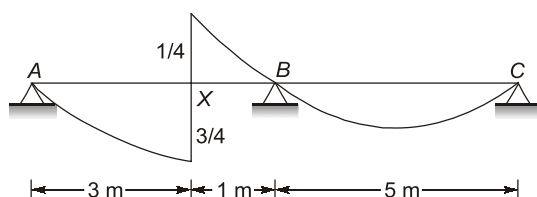
Solution : 3

Using Muller-Breslau Principle,

1. Influence line diagram for reaction at A, R_A



2. Influence line diagram for shear force at X

**Solution : 4**

$$26.44 \text{ t}$$

Solution : 5

$$207.9 \text{ kNm}$$

Solution : 6

$$\text{SF} = (-)79.37 \text{ kN}$$

$$\text{BM} = 293.76 \text{ kN}$$

Solution : 7

$$H = 587.5 \text{ kN and } M = 750 \text{ kNm}$$

Solution : 8

$$\text{SF} = +62.5 \text{ kN}, \quad 303.75 \text{ kNm}$$

Solution : 9

$$\text{SF} = +60 \text{ kN}, \quad M_{\max} = 590.7 \text{ kNm}$$

Solution : 10

$$60 \text{ kN and } 160 \text{ kNm}$$

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3

Arches and Suspended Cables

LEVEL 1 Objective Questions

1. (c)

2. (d)

3. (a)

4. (12.02)

5. (45.76)

6. (a)

7. (b)

8. (35.35)

9. (a)

10. (c)

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11. (c)

12. (c)

13. (b)

14. (c)

15. (c)

16. (b)

17. (d)

18. (a)

19. (a)

20. (b)

21. (b)

LEVEL 3 Conventional Questions**Solution : 1**

$$H = 0, \quad M = 0$$

Solution : 2

$$H_B = 9.77 \text{ t}$$

Solution : 3

$$H = \frac{WL}{8r}$$

Solution : 4

$$F = 2.017 \text{ kN}, \quad N = 3.188 \text{ kN},$$

$$M_{\max}(+) = 7.68 \text{ kNm}, \quad M_{\max}(-) = -2 \text{ kNm}$$

Solution : 5

$$H = 26.94 \text{ kN}, \quad M = -12.68 \text{ kNm}, \quad N = 28.89 \text{ kN}, \quad F = 7.12 \text{ kN}$$

Solution : 6

$$T_{AC} = 26.4 \text{ N}$$

Solution : 7

$$T_{\max} = 950.3 \text{ kN}$$

$$(SF)_{\max} = 75 \text{ kN}$$

$$(M)_{\max} = 774 \text{ kNm}$$

Solution : 8

$$BM = -281.25 \text{ kNm}$$

$$N = 201.95 \text{ kN}$$

$$\text{Radial shear} = 0 \text{ kN}$$

Solution : 9

$$N = 11.86 \text{ kN}$$

$$F = 10.49 \text{ kN}$$

$$M = 31.7 \text{ kNm}$$

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4

Methods of Structural Analysis

LEVEL 1 Objective Questions

1. (5)
2. (a)
3. (b)
4. (d)
5. (5)
6. (a)
7. (17.8)
8. (0.67)
9. (c)
10. (a)
11. (d)
12. (b)
13. (d)
14. (4)
15. (0.87)
16. (50)
17. (0)
18. (b)

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LEVEL 2 Objective Questions

19. (1.0027°)
20. (60)
21. (c)
22. (c)
23. (1.4)
24. (b)
25. (0)
26. (a)
27. (c)
28. (c)
29. (c)
30. (b)
31. (c)

LEVEL 3 Conventional Questions**Solution : 1**

$$\theta_0 = \frac{Pa^2}{372EI}$$

Solution : 2

$$M_{12} = 17.97 \text{ kNm}$$

$$M_{23} = 52.94 \text{ kNm}$$

$$M_{34} = 41.42 \text{ kNm}$$

$$M_{21} = -52.94 \text{ kNm}$$

$$M_{32} = -41.41 \text{ kNm}$$

$$M_{43} = -9.29 \text{ kNm}$$

Solution : 3

Support reactions

at A,

$$H_A = 840 \text{ kgf} (\leftarrow); \quad V_A = 945 \text{ kgf} (\downarrow); \quad M_A = 1260 \text{ kgf-m} (\curvearrowright)$$

at D,

$$H_D = 840 \text{ kgf} (\rightarrow); \quad V_D = 3945 \text{ kgf} (\uparrow); \quad M_D = 840 \text{ kgf-m} (\curvearrowright)$$

Solution : 4

$$H_A = 840 \text{ kgf} (\leftarrow)$$

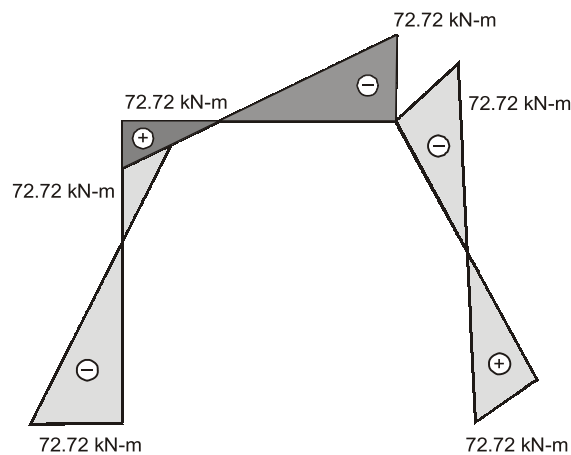
$$V_A = 945 \text{ kgf} (\downarrow)$$

$$M_A = 1260 \text{ kgfm}$$

$$H_D = 840 \text{ kgf} (\rightarrow)$$

$$V_D = 3945 \text{ kfg} (\uparrow)$$

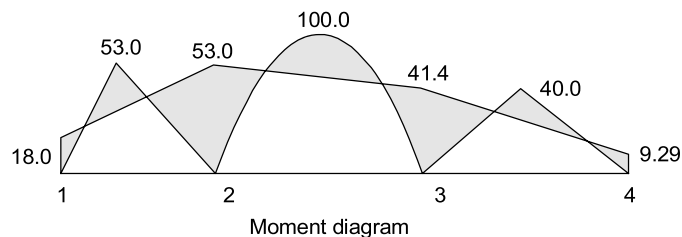
$$M_D = 840 \text{ kgfm}$$

Solution : 5

Bending Moment Diagram

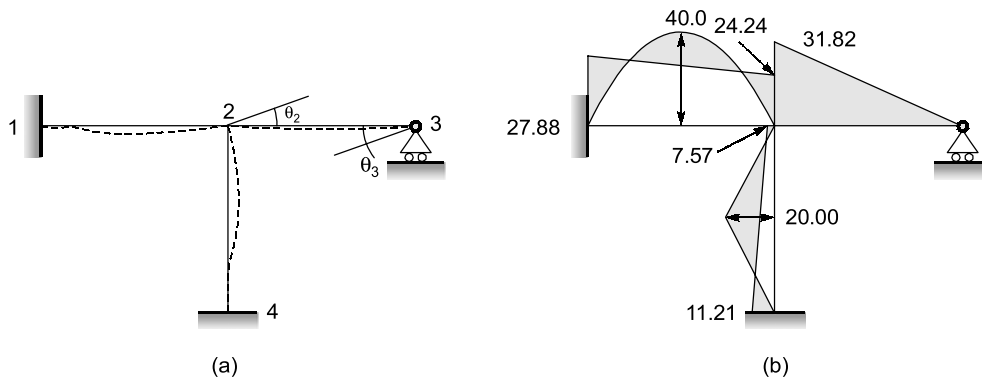
Solution : 6

The moment diagram is shown in figure below.



Solution : 7

The deflected shape and the moment diagram are shown in figure below.



(a) Deflected shape, (b) Moment diagram

Solution : 8

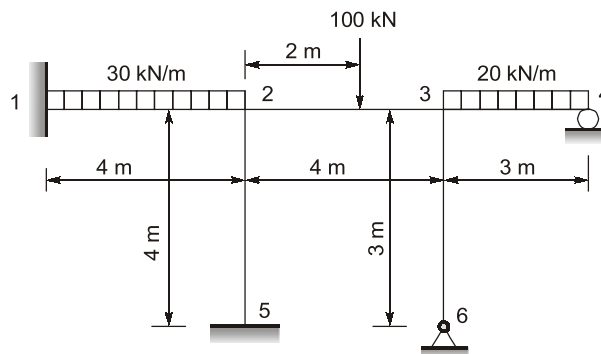


Fig. Frame and loading

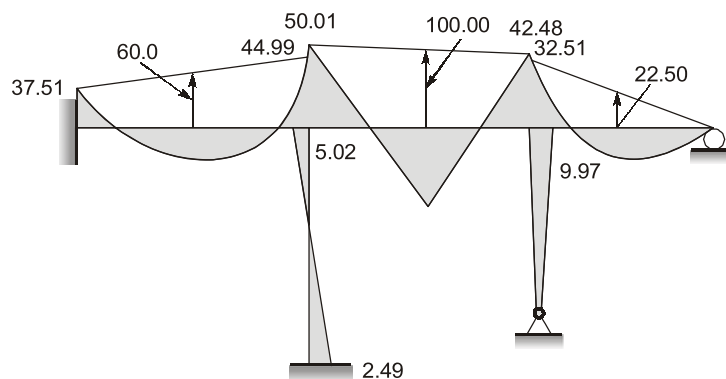
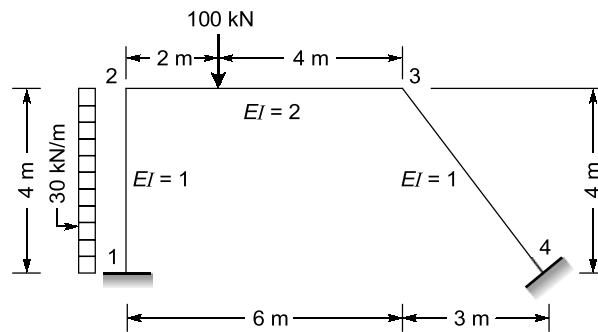


Fig. Moment diagram

Solution : 9

(e) Frame and loading

$$M_{12} = 32.51 \times 0.715 = 23.24 \text{ kN.m}$$

$$M_{21} = -M_{23} = 35.12(0.715) = 25.11 \text{ kN.m}$$

$$M_{34} = -M_{32} = 41.99(0.715) = 30.92 \text{ kN.m}$$

$$M_{43} = 47.68(0.715) = 34.09 \text{ kN.m}$$

Solution : 10

$$M_{12} = +73.88 \text{ kNm}$$

$$M_{21} = 12.77 \text{ kNm}$$

$$M_{23} = -12.77 \text{ kNm}$$

$$M_{32} = -40 \text{ kNm}$$

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LEVEL 1 Objective Questions

1. (a)
2. (c)
3. (c)
4. (a)
5. (0.56)
6. (3.33)
7. (c)
8. (d)
9. (0.13)
10. (b)
11. (b)

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LEVEL 2 Objective Questions

12. (3.33)
13. (c)
14. (d)
15. (d)
16. (2.25)
17. (12)
18. (b)
19. (c)
20. (b)
21. (d)
22. (b)
23. (c)
24. (0.084)
25. (33.33)
26. (a)
27. (b)

LEVEL 3 Conventional Questions**Solution : 1**

Member	AO	AB	OB	BC	OC	OD	OE
Forces	20.71 kN	-54.11 kN	41.41 kN	-54.11 kN	-58.58 kN	41.41 kN	20.71 kN

Solution : 2

$$F_{lk} = 142.16 \text{ kN (C)}$$

Solution : 3

$$F_{5-6} = 75 \text{ kN (T)} \quad F_{5-8} = \frac{25}{\sqrt{2}} \text{ kN (T)}$$

$$F_{5-7} = \frac{25}{\sqrt{2}} \text{ kN (C)} \quad F_{5-4} = 100 \text{ kN (T)}$$

Solution : 4

$$F_{CB} = 10 \text{ kN (T)}, \quad F_{BE} = 10 \text{ kN (C)}, \quad F_{EF} = 30\sqrt{2} \text{ kN (C)}$$

Solution : 5

$$\delta_C = 0.335 \text{ mm}$$

Solution : 6

$$F_{2-3} = 66.67 \text{ kN (C)} \quad F_{7-3} = 41.67 \text{ kN (C)}$$

$$F_{7-12} = 41.67 \text{ kN (T)} \quad F_{11-12} = 66.67 \text{ kN (T)}$$

$$F_{2-7} = 50 \text{ kN (T)} \quad F_{7-11} = 0 \text{ kN}$$

Solution : 7

Members	AC	CD	DE	EB	BD	BA	AD	BC
Forces (kN)	-8.75	-6.56	-15	0	11.25	-6.56	-14.06	10.94

Solution : 8

Members	BC	CE	ED	DA	AC	CD	BD
Forces (kN)	26.66	0	0	26.66	-33.33	20	-33.33

Solution : 9

$$H_D = 400 \text{ kN}, \quad V_b = 100 \text{ kN}$$

$$(a) \quad x = -43.4 \text{ m}$$

$$(b) \quad x = 0$$

$$(c) \quad x = 44.3 \text{ kN}$$

Solution : 10

$$\Delta = 15.168 \text{ mm}, \quad \theta = 3.326^\circ$$



6

Matrix Method of Structural Analysis

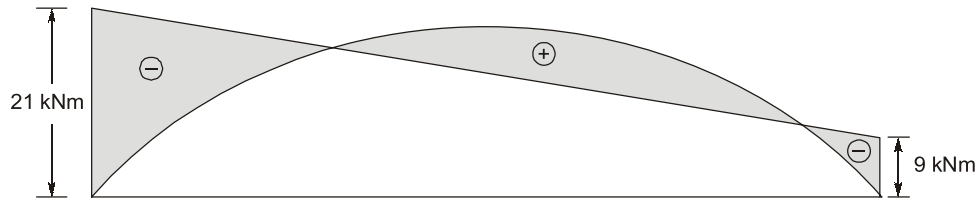
LEVEL 1 Objective Questions

1. (d)
2. (a)
3. (a)
4. (d)
5. (c)
6. (d)
7. (b)
8. (d)
9. (b)
10. (a)

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LEVEL 2 Objective Questions

11. (b)
12. (c)
13. (a)
14. (906.48)
15. (a)
16. (a)
17. (a)
18. (a)
19. (c)
20. (c)
21. (c)
22. (133.93/EI)
23. (b)
24. (c)

LEVEL 3 Conventional Questions**Solution : 1****Bending Moment Diagram****Solution : 3**

$$K' = \frac{EA}{L} \begin{bmatrix} \cos^2 \alpha & \cos \alpha \sin \alpha & -\cos^2 \alpha & -\cos \alpha \sin \alpha \\ \cos \alpha \sin \alpha & \sin^2 \alpha & -\cos \alpha \sin \alpha & -\sin^2 \alpha \\ -\cos^2 \alpha & -\cos \alpha \sin \alpha & \cos^2 \alpha & \cos \alpha \sin \alpha \\ -\cos \alpha \sin \alpha & -\sin^2 \alpha & \cos \alpha \sin \alpha & \sin^2 \alpha \end{bmatrix}$$

Solution : 4

Members	OA	OB	OC	OD
Forces	42.33 kN (T)	36.10 kN (T)	3.78 kN (T)	38.08 kN (T)

Solution : 5

$$K = \begin{bmatrix} \frac{12EI_1}{l_1^3} & \frac{-6EI_1}{l_1^2} \\ \frac{-6EI_1}{l_1^2} & \frac{4EI_1}{l_1} + \frac{3EI_2}{l_2} \end{bmatrix}$$

Solution : 6

$$M_A = -34.5 \text{ kNm}$$

$$M_D = 28.5 \text{ kNm}$$

$$M_B = -27.1 \text{ kNm}$$

$$M_E = 26.4 \text{ kNm}$$

$$M_C = 0$$

Solution : 7

$$M_1 = -170.3 \text{ kNm}$$

$$M_2 = -73.4 \text{ kNm}$$

Solution : 8

$$M_{AB} = -58.65 \text{ kNm}$$

$$M_{BA} = 85.20 \text{ kNm}$$

$$M_{BC} = -85.20 \text{ kNm}$$

$$M_{CB} = +158.04 \text{ kNm}$$

$$M_{CD} = +158.04 \text{ kNm}$$

$$M_{DC} = 0$$

Solution : 9

$$M_{AB} = -111.5 \text{ kNm}$$

$$M_{BC} = -72 \text{ kNm}$$

$$M_{BA} = +72 \text{ kNm}$$

$$M_{CB} = 0$$

Solution : 10

$$M_{AB} = 0$$

$$M_{BC} = -660 \text{ kNm}$$

$$M_{BA} = 660 \text{ kNm}$$

$$M_{CB} = -330 \text{ kNm}$$

Solution : 11

$$M_{AB} = 3.28 \text{ kNm}$$

$$M_{BC} = -9.93 \text{ kNm}$$

$$M_{CD} = -7.7 \text{ kNm}$$

$$M_{DC} = -5.55 \text{ kNm}$$

$$M_{BA} = 9.93 \text{ kNm}$$

$$M_{CB} = 30.23 \text{ kNm}$$

$$M_{CE} = -22.5 \text{ kNm}$$

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