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# SURVEYING

## CIVIL ENGINEERING

Date of Test : 30/04/2026

### ANSWER KEY >

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

## DETAILED EXPLANATIONS

1. (b)

2. (b)

For setting out right angles in chain surveying, the following instruments are generally used:

- (i) Cross staffs
- (ii) Optical squares
- (iii) Prism squares

Cross-staffs are of following types:

(i) Open cross-staff:

It is used for

- Finding the foot of a perpendicular offset.
- Setting out a right angle at a point of the chain line

(ii) French cross-staff

It is used for setting out right angles.

- It has the advantages that the lines can also be set out at angles of 45° and 135°. In that respect, a french cross-staff is superior to an open cross-staff.

(iii) Adjustable cross-staff

It is used to take offsets and to set out any desired angle from the chain line.

3. (c)

Temporal resolution refers to the precision of a measurement with respect to time in which, observations are made over the same area on different dates. This is useful during crop growth, deforestation, floods etc.

4. (c)

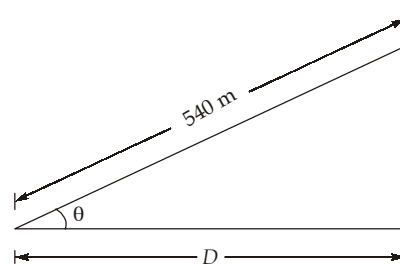
Sensitivity of a bubble tube,  $S = \frac{nl}{R}$

Now,  $n = 1$

$\therefore S = \frac{1 \times 10^{-3}}{0.8} = \frac{1}{800}$

5. (b)

6. (a)



$$\tan \theta = \frac{1}{6}$$

$$\Rightarrow \theta = 9.462^\circ$$

$$\therefore \text{Horizontal distance, } D = 540 \cos \theta$$

$$= 532.65 \text{ m}$$

Alternatively

$$\tan \theta = \frac{1}{6}$$

$$\therefore \sec^2 \theta = (1 + \tan^2 \theta) = \frac{37}{36}$$

$$\therefore \cos \theta = \frac{6}{\sqrt{37}}$$

$$\therefore D = 540 \cos \theta$$

$$= 540 \times \frac{6}{\sqrt{36}} = 532.65 \text{ m}$$

7. (a)

The length of the chain would have changed gradually during measurement and hence the average length of the chain must be used to find the true length.

$$\text{Average length of the chain} = \left( \frac{29.95 + 30.08}{2} \right) = 30.015 \text{ m}$$

$$\text{True length} = \text{Measured length} \times \frac{\text{Actual length}}{\text{Designated length}}$$

$$= 590.48 \times \frac{30.015}{30} = 590.78 \text{ m} \approx 591 \text{ m}$$

8. (d)

$$\text{Most probable error} = 0.6745 \times \text{standard deviation}$$

$$= 0.6745 \times 3$$

$$= 2.0235 \approx 2.024 \text{ seconds}$$

9. (b)

$$A_1 = 5 \times 4 = 20 \text{ m}^2$$

$$A_2 = 10 \times 8 = 80 \text{ m}^2$$

$$\text{Area at mid depth, } A_m = \left( \frac{5+10}{2} \right) \left( \frac{4+8}{2} \right) = 45 \text{ m}^2$$

$\therefore$  Volume of pit using Simpson's rule

$$V = \frac{h}{3} [A_1 + 4A_m + A_2]$$

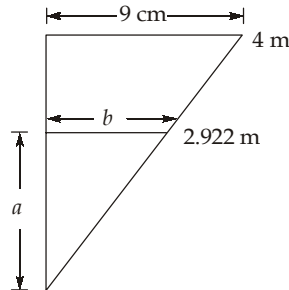
$$\Rightarrow V = \frac{5}{3} [20 + 4(45) + 80]$$

$$\Rightarrow V = 466.667 \text{ m}^3$$

10. (c)

$$\begin{aligned} \text{The height of rise} &= 0.0673 D^2 \\ &= 0.0673 \times (50)^2 \\ &= 168.25 \text{ m} \end{aligned}$$

11. (b)



$$\frac{b}{9} = \frac{2.922}{4}$$

$$\Rightarrow b = 6.5745 \text{ cm}$$

$$\begin{aligned} \therefore \text{Correct reading } (a) &= \sqrt{2.922^2 - (0.065745)^2} \\ &= 2.92126 \text{ m} \simeq 2.9213 \text{ m} \end{aligned}$$

12. (a)

Height of instrument,

$$\begin{aligned} \text{HI} &= \text{RL of floor} + \text{Staff reading from floor} \\ &= 45.65 + 0.60 \\ &= 46.250 \text{ m} \end{aligned}$$

RL of bottom of beam,

$$\begin{aligned} &= \text{HI} + \text{Inverted staff reading taken from bottom of beam} \\ &= 46.250 + 3.242 \\ &= 49.492 \text{ m} \simeq 49.5 \text{ m} \end{aligned}$$

13. (c)

$$\begin{aligned} \text{Number of photographs per strip} &= \frac{\text{Length of area}}{(1 - P_l)S \times l} + 1 \\ &= \frac{20 \times 1000}{(1 - 0.7) \times 100 \times 0.25} + 1 = 2667.67 \simeq 2668 \end{aligned}$$

$$\begin{aligned} \text{Number of strips} &= \frac{\text{Width of area}}{(1 - P_w)S \times w} + 1 \\ &= \frac{15 \times 1000}{(1 - 0.35) \times 100 \times 0.25} + 1 = 924.08 \simeq 925 \end{aligned}$$

$$\therefore \text{Number of photographs required} = 2668 \times 925 = 2467900 = 246.79 \times 10^4$$

14. (c)

We know that,

$$\text{Least count} = \frac{s}{n}$$

Here, least count,

$$\text{LC} = 20''$$

$$s = \frac{1^\circ}{6} = \frac{(60 \times 60)''}{6} \quad [1^\circ = 60' = (60 \times 60)'']$$

$$\therefore 20 = \frac{10 \times 60}{n}$$

$$\Rightarrow n = 30$$

$\therefore$  In case of theodolite,  $n$  divisions of vernier scale are equal to  $(n - 1)$  divisions of main scale.

$\therefore$  (30) divisions of vernier scale are divided into (29) divisions of main scale.

15. (c)

First we correct the bearing for local attraction.

Correct back bearing of line  $AB$  should be equal to  $245^\circ 30' - 180^\circ = 65^\circ 30'$ 

$$\begin{aligned} \therefore \text{True back bearing of } AB &= \text{Magnetic bearing} - \text{West declination} \\ &= 65^\circ 30' - 3^\circ 15' \\ &= 62^\circ 15' \end{aligned}$$

$$\therefore \text{True back bearing of line } AB = \text{True bearing of line } AB = 62^\circ 15'$$

16. (a)

Combined correction due to curvature and refraction

$$\begin{aligned} C &= -0.0673 d^2 && \text{(where } d \text{ is in km)} \\ &= -0.0673 (0.425)^2 \\ &= -0.012156 \text{ m} \end{aligned}$$

$$\therefore \text{Corrected staff reading at B} = 1.950 - 0.012156 = 1.938 \text{ m}$$

$$\begin{aligned} [\text{RL}] \text{ of B} &= [\text{RL}] \text{ of A} + \text{HI} - \text{Staff reading at B} \\ &= 160 + 1.2 - 1.938 = 159.262 \text{ m} \end{aligned}$$

$$\therefore \text{Level difference} = (\text{RL})_A - (\text{RL})_B = 160 - 159.262 = 0.738 \text{ m}$$

17. (b)

Line	Length (m)	Bearing	Latitude (m)	Departure (m)
AB	30	$60.5^\circ$	14.77	26.11
BC	120	$300^\circ$	60	$-60\sqrt{3}$
CD	$l$	$270^\circ$	0	$-l$
DA	300	$\theta$	$300 \cos \theta$	$300 \sin \theta$

$$\therefore \Sigma L = 0$$

$$\text{And } \Sigma D = 0$$

$$\therefore \Sigma L = 0$$

$$300 \cos \theta = -74.77 \quad \dots(i)$$

$$\text{Similarly, } \Sigma D = 0$$

$$\Rightarrow 300 \sin \theta = 77.813 + l \quad \dots(ii)$$

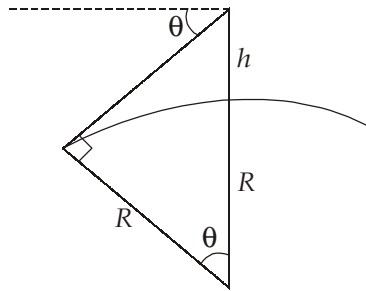
Squaring and adding eq. (i) and (ii)

$$(300)^2 = (-74.77)^2 + (77.813 + l)^2$$

⇒

$$l = 212.72 \text{ m}$$

18. (d)



$$\text{Dip} = \theta = \cos^{-1} \left( \frac{R}{R+h} \right)$$

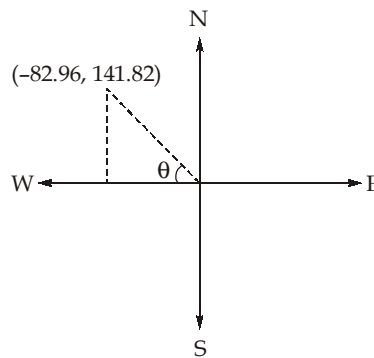
⇒

$$\theta = \cos^{-1} \left( \frac{6370}{6370 + 0.082} \right)$$

⇒

$$\theta = 0.2907^\circ = 17.44 \text{ minutes}$$

19. (a)



$$\tan \theta = \frac{141.82}{82.96} = 1.7095^\circ$$

∴

$$\theta = \tan^{-1} (1.7095) = 59.674^\circ$$

$$\text{WCB} = 270 + \theta = 270 + 59.674 = 329.674^\circ$$

$$= 329.674 \times \pi \text{ rad} = 5.75 \text{ rad}$$

20. (a)

Length of curve,

⇒

$$l = \text{PT} - \text{PC}$$

⇒

$$l = 2999.4 - 2658.3$$

$$l = 341.1 \text{ m}$$

We know,

$$\frac{l}{\Delta} = \frac{2\pi R}{360^\circ}$$

⇒

$$\frac{341.1}{50^\circ} = \frac{2\pi R}{360^\circ}$$

⇒

$$R = 390.87 \text{ m} \simeq 391 \text{ m}$$

21. (c)

**Correction for temperature:**

$$\begin{aligned} \text{For first half (1000 m, } T = 20^\circ\text{C), } C_f &= \alpha(T_m - T_0)L \\ &= 12 \times 10^{-6}(20 - 15) \times 1000 \\ &= + 0.06 \text{ m} \end{aligned}$$

For second half (1000 m,  $T = 26^\circ\text{C}$ )

$$C_f = 12 \times 10^{-6} \times (26 - 15) \times 1000 = + 0.132 \text{ m}$$

**Correction for pull:**

$$\begin{aligned} C_p &= \frac{(P_m - P_0)L}{AE} \\ &= \frac{(22 - 0) \times 2000 \times 10^{-4}}{3.75 \times 10^{-6} \times 2.11 \times 10^6} = + 0.556 \text{ m} \end{aligned}$$

**Correction for Sag:**

$$C_{\text{sag}} = \frac{W^2L}{24P^2}$$

$$\text{Weight of the tape} = \frac{7.7504 \times 10^{-3}}{10^{-6}} \times 3.75 \times 10^{-6} \times 50 = 1.4532 \text{ kg}$$

$$C_{\text{sag}} = -\frac{(1.4532)^2 \times 2000}{24 \times 22^2} = - 0.364 \text{ m}$$

$$\begin{aligned} \text{Total correction} &= 0.06 + 0.132 + 0.556 - 0.364 \\ &= + 0.384 \text{ m} \end{aligned}$$

$$\text{Corrected total length} = 2000 + 0.384 = 2000.384 \text{ m}$$

22. (c)

If  $l$  is the length of the offset, the linear error is  $\frac{l}{r}$ . Displacement due to angular error =  $l \sin \alpha$ . These two errors are to be equated.

$$\therefore l \sin \alpha = \frac{l}{r}$$

$$\Rightarrow r = \operatorname{cosec} \alpha = \operatorname{cosec} 4^\circ = 14.34 \approx 14$$

The accuracy in linear measurement required is 1 in 14.

23. (d)

BS	IS	FS	Rise	Fall	RL	Comment
1.135	-	-	-	-	90.000	-
1.08	-	0.368	0.767	-	90.767	-
1.155	-	1.844	-	0.764	90.003	-
-	2.632	-	-	1.477	88.526	-
-	1.196	-	1.436	-	89.962	-
-	-	0.976	0.22	-	90.182	-

(All values in m)

So, the value of  $Y = 89.962 \text{ m}$ .

24. (c)

$$(2.724 + c) - 1.425 = 2.504 - (1.429 + c)$$

$$\Rightarrow 2c = -0.224 \text{ m}$$

$$\Rightarrow c = -0.112 \text{ m}$$

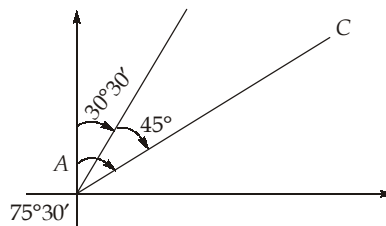
$$\therefore \text{Error} = +0.112 \text{ m}$$

$$\begin{aligned} \text{Error due to curvature and refraction} &= +0.0673(1.15)^2 \\ &= +0.089 \text{ m} \end{aligned}$$

$$\therefore \text{Error due to collimation} = 0.112 - 0.089 = +0.023 \text{ m (inclined upwards)}$$

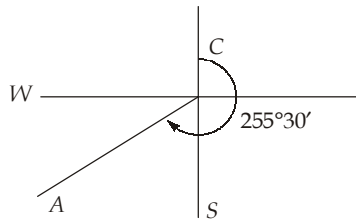
$$\text{Collimation error per 150 m} = \frac{0.023 \times 150}{1150} = 0.003 \text{ m}$$

25. (b)



$$\text{Fore bearing of AC} = 75^\circ 30'$$

$$\begin{aligned} \text{Back bearing of AC} &= \text{Fore bearing of CA} = 75^\circ 30' + 180^\circ \\ &= 255^\circ 30' = S75^\circ 30' W \end{aligned}$$



26. (c)

For staff at P,

$$S_1 = 1.365 \text{ m}, S_2 = 1.920 \text{ and } S_3 = 2.475 \text{ m}$$

$$\therefore (S_2 - S_1) = 0.555 \text{ m}$$

$$(S_3 - S_2) = 0.555 \text{ m}$$

$\therefore$  Staff is perpendicular to LOS.

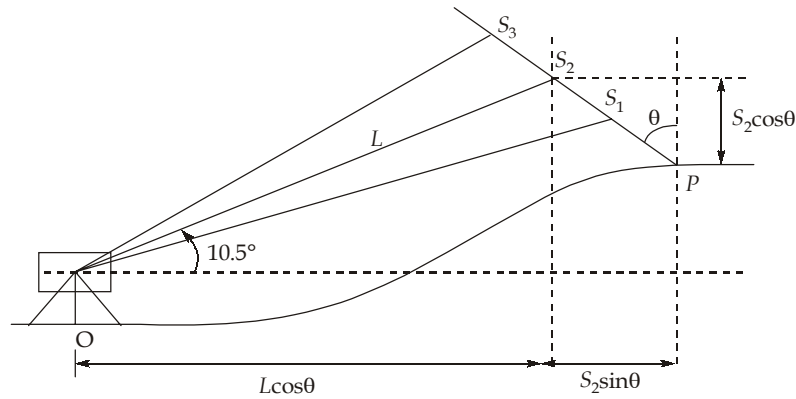
For staff at Q,

$$S_1 = 1.06 \text{ m}, S_2 = 1.88 \text{ m}, S_3 = 2.705 \text{ m}$$

$$\therefore (S_2 - S_1) = 0.82 \text{ m}$$

$$(S_3 - S_2) = 0.825 \text{ m}$$

$\therefore$  Staff is kept vertical.



Now,

⇒

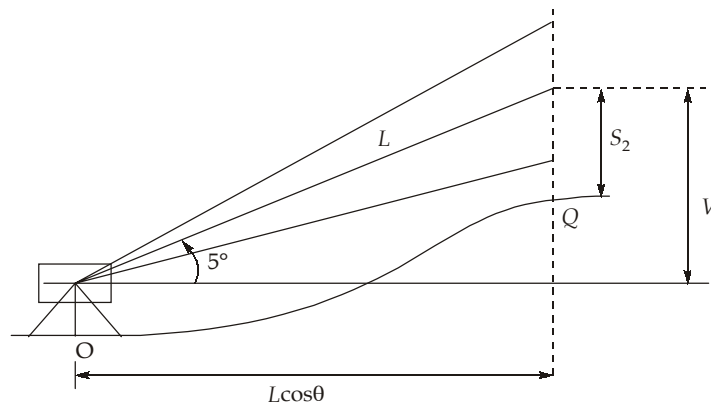
$$L = kS + C$$

$$L = 100(2.475 - 1.365) + 0 = 111 \text{ m}$$

$$\begin{aligned} D_{OP} &= L \cos \theta + S_2 \sin \theta \\ &= 111 \cos 10.5^\circ + 1.920 \sin 10.5^\circ \\ &= 109.491 \text{ m} \end{aligned}$$

$$V = L \sin \theta = 111 \sin 10.5^\circ = 20.228 \text{ m}$$

$$\begin{aligned} \text{RL of } P &= \text{H.I.} + V - S_2 \cos \theta = \text{H.I.} + 20.228 - 1.920 \cos 10.5^\circ \\ &= \text{H.I.} + 18.34 \end{aligned}$$

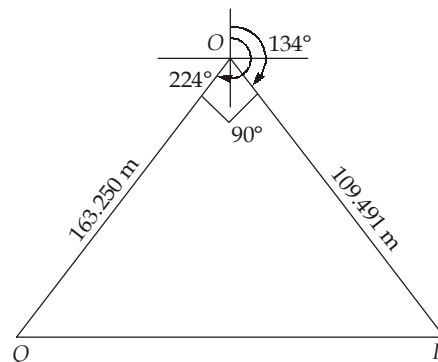


$$\begin{aligned} L &= kS \cos \theta + C = 100(1.645) \cos 5^\circ + 0 \\ &= 163.874 \text{ m} \end{aligned}$$

$$D_{OQ} = L \cos \theta = 163.874 \cos 5^\circ = 163.250 \text{ m}$$

$$V = L \sin \theta = 163.874 \sin 5^\circ = 14.283 \text{ m}$$

$$\begin{aligned} \text{RL of } Q &= \text{H.I.} + V - S_2 = \text{H.I.} + 14.283 - 1.88 \\ &= \text{H.I.} + 12.403 \end{aligned}$$





28. (d)

$$\Delta h = \frac{(H - h_{\text{bottom}})^2 \Delta p}{(H - h_{\text{bottom}}) \Delta p + b_m H}$$

⇒

$$H - h_{\text{bottom}} = 3000 - 200 = 2800 \text{ m}$$

$$\Delta p = 20 \text{ mm}$$

$$b_m = 110.5 \text{ mm}$$

∴

$$\Delta h = \frac{(2800)^2 \times 20}{(2800 \times 20) + (110.5 \times 3000)} = 404.65 \text{ m}$$

29. (b)

$$\text{Scale of the photograph} = \frac{0.1135}{1000}$$

∴

$$\frac{f}{H - h_a} = \frac{0.1135}{1000}$$

⇒

$$\frac{0.21}{H - 685} = \frac{0.1135}{1000}$$

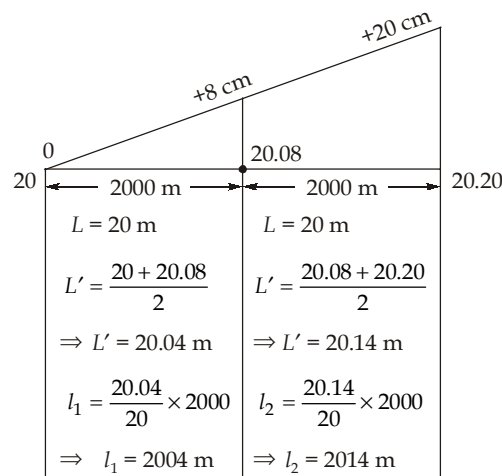
⇒

$$H = 2535.22 \text{ m}$$

∴

$$\text{The scale at 900 m elevation} = \frac{0.21}{2535.22 - 900} \approx \frac{1}{7787}$$

30. (a)



∴

$$l = l_1 + l_2 = 2004 + 2014 = 4018 \text{ m}$$

