

Advanced Surveying (313321)

Model Question Paper — Set A · Model Answers

Q.1

a) Principle of tacheometry.

2 M

Principle: Tacheometry is based on the property of **similar isosceles triangles**: the ratio of the perpendicular distance from the apex to the base, to the length of the base, is constant. In a tacheometer the two stadia hairs (spacing i) subtend a constant angle at the outer focus (or at the anallatic point). Hence the **horizontal distance from the instrument to the staff is proportional to the staff intercept s** between the stadia hairs:

$$D = (f/i) s + (f + d) = K s + C$$

$K = f/i$ = multiplying constant (usually 100); $C = f + d$ = additive constant (zero with anallatic lens).

(Statement 1 M, formula with terms 1 M)

b) Simple circular curve and reverse curve.

2 M

Simple circular curve: A single arc of a circle of **constant radius** connecting two straights.

Reverse curve: A curve made of **two arcs bending in opposite directions**, with centres on opposite sides of the common tangent (point of reverse curvature P.R.C.).

(Each definition 1 M)

c) Relation between R and D.

2 M

Let R = radius of curve (m) and D = degree of curve, i.e. the angle subtended at the centre by an arc of 30 m.

$$R = 1718.9 / D \text{ (30 m arc)} \quad \text{or} \quad R = 1146 / D \text{ (20 m arc)}$$

where R = radius in metres and D = degree of curve (angle subtended at centre by a 30 m arc).

(Formula 1 M, terms 1 M)

d) Component parts of EDM.

2 M

1. Transmitter / oscillator
2. Modulator
3. Reflector (prism)
4. Receiver

(Any four, ½ M each)

e) Define remote sensing.

2 M

Remote sensing is the art and science of obtaining information about an object, area or phenomenon **without being in physical contact** with it, by recording the **electromagnetic energy reflected or emitted** by it, using sensors mounted on aircraft or satellites.

f) GIS software.

2 M

QGIS (open source), ArcGIS (Esri), GRASS GIS, MapInfo, Global Mapper, ERDAS / ENVI (for remote sensing). (Any two)

(Any two, 1 M each)

g) Merits of photogrammetry.

2 M

- **Quick** — large areas are covered in a short time.
- Suitable for **inaccessible** and difficult terrain.

(Any two, 1 M each)

Q.2

a) Situations where tacheometry is preferred.

4 M

- The ground is **hilly, undulating or broken**, so chaining is slow and inaccurate.
- There are **obstacles** like rivers, streams, ravines, swamps or standing crops.
- **Contour surveys** or topographic maps of large areas are required.
- **Preliminary location surveys** of roads, railways, canals, reservoirs.
- Small details have to be filled in quickly, or a rapid **check** on chained distances is needed.

(Any four, 1 M each)

b) Field method of determining tacheometric constants.

4 M

1. Select a fairly **level ground**. Set up the tacheometer at station O; centre and level it accurately.
2. Along a straight line from O, measure distances such as **30 m, 60 m, 90 m, 120 m** accurately with a steel tape and fix pegs P_1, P_2, P_3, P_4 .
3. Hold the staff **vertical** on each peg. Keep the **line of sight horizontal** (vertical circle reading $0^\circ 00'$).
4. Take the **top, middle and bottom** hair readings on each peg; staff intercept $s = \text{top} - \text{bottom}$.
5. For each peg write the equation $D = Ks + C$.
6. Solve the equations in pairs: $K = (D_2 - D_1)/(s_2 - s_1)$ and $C = D_1 - Ks_1$. Take the **mean** of the values obtained from different pairs.

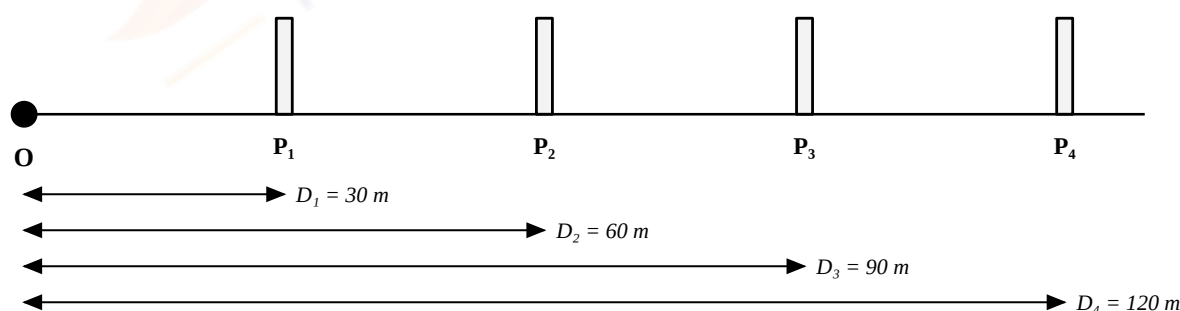


Fig.: Field determination of tacheometric constants (staff vertical, line of sight horizontal)

(Procedure 3 M, equations / sketch 1 M)

c) Sketch of simple circular curve with notations.

4 M

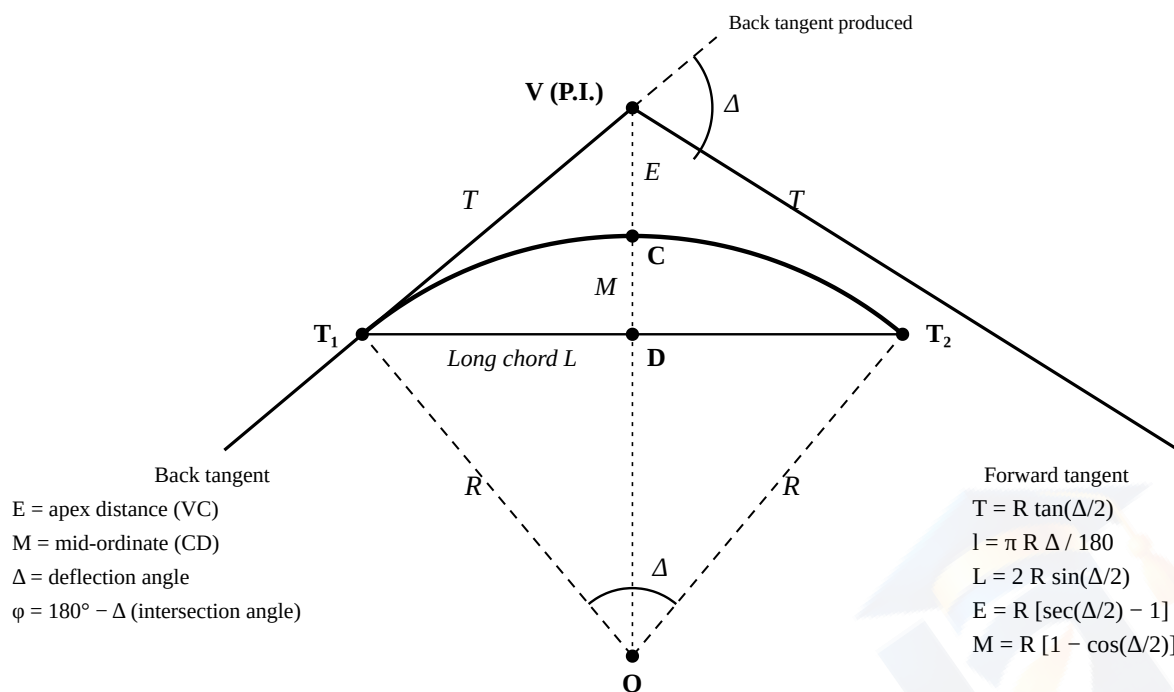


Fig.: Simple circular curve — notations

- **Tangent length** $T = T_1V = VT_2$ (distance from P.I. to tangent point).
- **Deflection angle** Δ — angle between the back tangent produced and the forward tangent (= central angle T_1OT_2).
- **Apex distance** $E = VC$ (from P.I. to mid-point of the curve).
- **Long chord** $L = T_1T_2$ (chord joining the two tangent points).

(Neat sketch 2 M, four notations $\frac{1}{2}$ M each)

d) Horizontal angle with digital theodolite.

4 M

1. **Set up** the digital theodolite over station **O** on the tripod; **centre** using the optical/laser plummet and **level** using the circular and plate levels (foot screws).
2. Switch **ON** the instrument; select the horizontal angle mode **HR** (right/clockwise reading).
3. Sight the left station **A**; bisect it accurately with the horizontal clamp and tangent screw.
4. Press **0SET** (twice) so that the display shows **HR 0°00'00"**.
5. Release the clamp, turn the telescope **clockwise** and bisect station **B** accurately.
6. Read the angle **HR** on the display = $\angle AOB$; record (or store) it.
7. Change face (transit the telescope) and repeat; the **mean** of face left and face right readings is the required angle.

(Correct sequence of steps 4 M)

Q.3

a) Curve elements: $\Delta = 38^\circ$, $R = 250$ m, P.I. at 1450.60 m.

4 M

Given: $R = 250$ m, $\Delta = 38^\circ$, chainage of P.I. = 1450.60 m.

Element	Formula / working	Value
Tangent length T	$R \tan(\Delta/2) = 250 \times \tan 19^\circ 00' 00''$	86.082 m
Length of curve l	$\pi R \Delta / 180 = \pi \times 250 \times 38 / 180$	165.806 m
Length of long chord L	$2 R \sin(\Delta/2) = 2 \times 250 \times \sin 19^\circ 00' 00''$	162.784 m
Chainage of T ₁	Chainage of P.I. – T = 1450.600 – 86.082	1364.518 m
Chainage of T ₂	Chainage of T ₁ + l = 1364.518 + 165.806	1530.324 m

Answer: T = 86.082 m; l = 165.806 m; L = 162.784 m; chainage of T₁ = 1364.518 m, of T₂ = 1530.324 m.

(Each element 1 M)

b) Principle of EDM.

4 M

Principle: EDM (Electronic Distance Measurement) works on the principle that the **distance is obtained from the time taken, or the phase difference, of an electromagnetic wave** travelling from the instrument to a reflector and back.

- The instrument at A transmits a **modulated carrier wave** (infrared, laser or microwave) towards a reflector (prism) at B.
- The reflected wave returns to A; the total path is **2D**.
- In the **phase-comparison** method, $2D = n\lambda + \Delta\lambda$, where n = number of whole wavelengths and $\Delta\lambda$ = fraction found from the phase difference. Hence **D = (nλ + Δλ)/2**.
- In the **pulse** method, $D = ct / 2$ (c = velocity of the wave, t = time of travel).

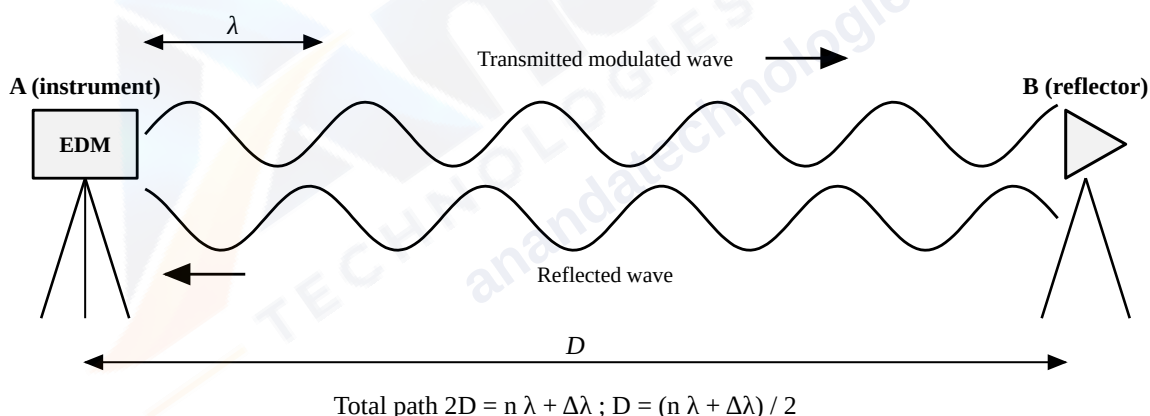


Fig.: Principle of EDM (phase comparison)

(Principle 2 M, sketch 2 M)

c) Function keys of total station.

4 M

Key	Use
POWER	Switches the instrument ON / OFF.
ANG	Angle measurement mode (HR / HL, V).
▲ (DIST)	Distance measurement mode — slope (SD), horizontal (HD), vertical (VD) distance.

⏏ (CORD)	Coordinate measurement mode — N, E, Z of the target point.
MENU	Opens programs — stake-out (layout), resection, area, REM, MLM, data collection.
ESC	Cancels the current operation / returns to previous screen.
ENT	Confirms data entry / accepts a measurement.
F1 – F4 (soft keys)	Perform the function shown above them on the display (e.g. 0SET, HOLD, MEAS, MODE).
★ (Star)	Illumination, display contrast, laser plummet, electronic level (tilt).

(Key names differ slightly from make to make.)

(Any four keys with use, 1 M each)

d) Active vs passive remote sensing.

4 M

Passive system	Active system
Uses natural energy of the Sun (reflected) or emitted thermal energy.	Has its own energy source; transmits energy and receives the back-scatter.
Works mainly in day time (except thermal sensing).	Works day and night.
Affected by clouds, haze, rain.	Microwave (RADAR) penetrates clouds; all-weather.
Less power required; simpler sensor.	Needs more power; complex and costly.
Examples: aerial camera, multispectral scanner (Landsat, IRS LISS).	Examples: RADAR / SAR, LiDAR, SONAR.

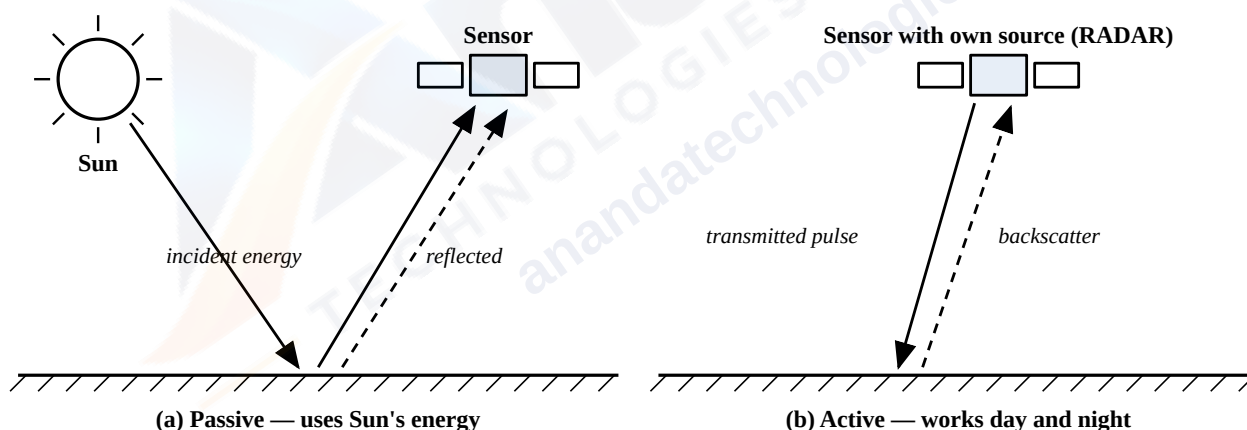


Fig.: Passive and active remote sensing systems

(Any four points, 1 M each)

Q.4

a) Essential characteristics of tacheometer.

4 M

1. The **multiplying constant** f/i should be **100** (a round figure).
2. The **additive constant** $(f + d)$ should be **zero** — the telescope is fitted with an **anallatic lens**.
3. The telescope should be **powerful**, magnification about 20 to 30 diameters.

4. The object glass should have a **large aperture** (35–45 mm) so that the image is bright and staff readings can be taken at long distances.
5. The **diaphragm** should carry three horizontal hairs (two stadia + central hair) that are distinct and equally spaced.
6. The vertical circle should be accurate (read to 20" or better) for inclined sights.

(Any four, 1 M each)

b) Key components of GIS.

4 M

GIS (Geographic Information System): A computer-based system of hardware, software, data, people and methods used to **capture, store, analyse, manage and display spatially referenced (geographic) data** along with their attributes.

1. **Hardware** — computer, GPS receivers, digitiser, scanner, plotter/printer, servers.
2. **Software** — GIS packages for input, storage, analysis and display — e.g. QGIS, ArcGIS.
3. **Data** — spatial data (points, lines, polygons, raster images) and attribute (non-spatial) data in tables — the most important component.
4. **People** — GIS users, technicians, analysts and decision makers who operate and use the system.
5. **Methods / procedures** — well-designed rules, standards and procedures for data collection, analysis and output.

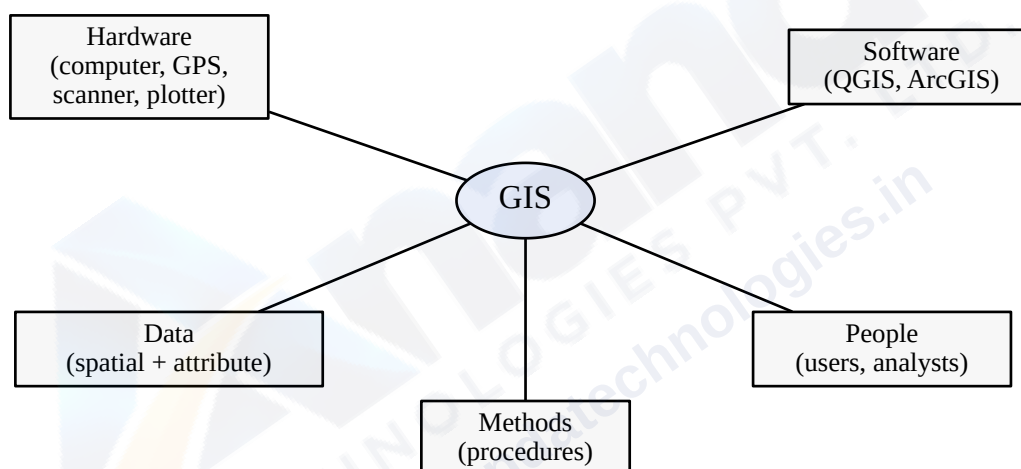


Fig.: Components of GIS

(Any four components with explanation, 1 M each)

c) GPS and its segments.

4 M

GPS (Global Positioning System): A satellite-based radio navigation system (NAVSTAR, USA) that gives the **three-dimensional position (latitude, longitude, height), velocity and time** of a receiver anywhere on the earth, 24 hours a day, in all weather.

1. **Space segment:** constellation of 24 or more satellites in six orbital planes at about 20,200 km altitude; they transmit radio signals with time and orbit data.
2. **Control segment:** master control station, monitor stations and ground antennas; they track the satellites and upload corrected orbit and clock data.
3. **User segment:** GPS receivers (handheld, DGPS, RTK) which receive the signals and compute position by trilateration (minimum four satellites for 3-D position and time).

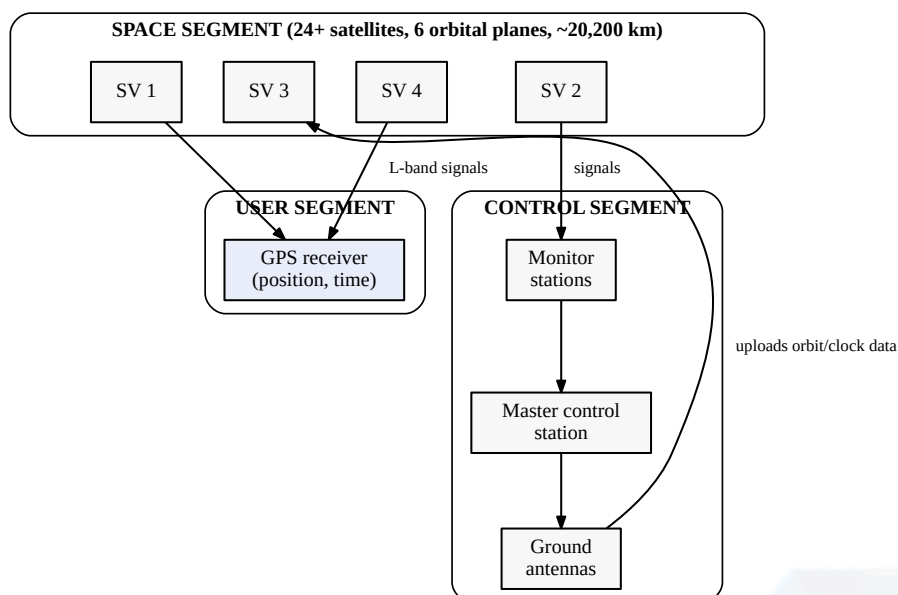


Fig.: Segments of GPS

(Definition 1 M, three segments 3 M)

d) DGCA classification of drones.

4 M

As per the **Drone Rules, 2021** (Ministry of Civil Aviation / DGCA), drones are classified by **maximum all-up weight including payload**:

Category	All-up weight
Nano drone	up to 250 g
Micro drone	more than 250 g up to 2 kg
Small drone	more than 2 kg up to 25 kg
Medium drone	more than 25 kg up to 150 kg
Large drone	more than 150 kg

By type, unmanned aircraft are also grouped as **aeroplane (fixed wing)**, **rotorcraft (multi-rotor)** and **hybrid**. Registration (UIN) and remote-pilot certificate requirements depend on the category and use.

(Classification with weight limits 4 M)

e) Applications of photogrammetry in civil engineering.

4 M

- Topographic mapping:** preparation of maps, contours and DEM for planning of projects.
- Route location:** selection of best alignment for highways, railways, canals and pipelines.
- Dams and reservoirs:** site selection, catchment and submergence area, reservoir capacity.
- Earthwork and volumes:** volumes of cutting, filling, stockpiles and quarries (drone photogrammetry).

(Any two explained, 2 M each)

Q.5

a) Distance OP and RL of P.

6 M

Given: $K = 100$, $C = 0$ (anallatic lens), RL of B.M. = 245.500 m. Staff held vertical, inclined sights.

Formulae (staff vertical): $D = K s \cos^2 \theta + C \cos \theta$; $V = K s (\sin 2\theta)/2 + C \sin \theta$

Quantity	Working	Value
Staff intercept s (B.M.)	$1.700 - 1.150$	0.550 m
V_1 (to B.M., $\theta = 6^\circ 20'$)	$100 \times 0.550 \times \sin 12^\circ 40' / 2$	6.030 m
RL of instrument axis	$\text{RL B.M.} - V_1 + h_1 = 245.500 - 6.030 + 1.425$	240.895 m
Staff intercept s (P)	$1.735 - 0.985$	0.750 m
Horizontal distance OP	$100 \times 0.750 \times \cos^2(4^\circ 10')$	74.604 m
V_2 (to P, $\theta = -4^\circ 10'$)	$100 \times 0.750 \times \sin 8^\circ 20' / 2$	5.435 m
RL of P	$\text{RL axis} - V_2 - h_2 = 240.895 - 5.435 - 1.360$	234.100 m

Answer: Horizontal distance OP = **74.604 m**; RL of P = **234.100 m**.

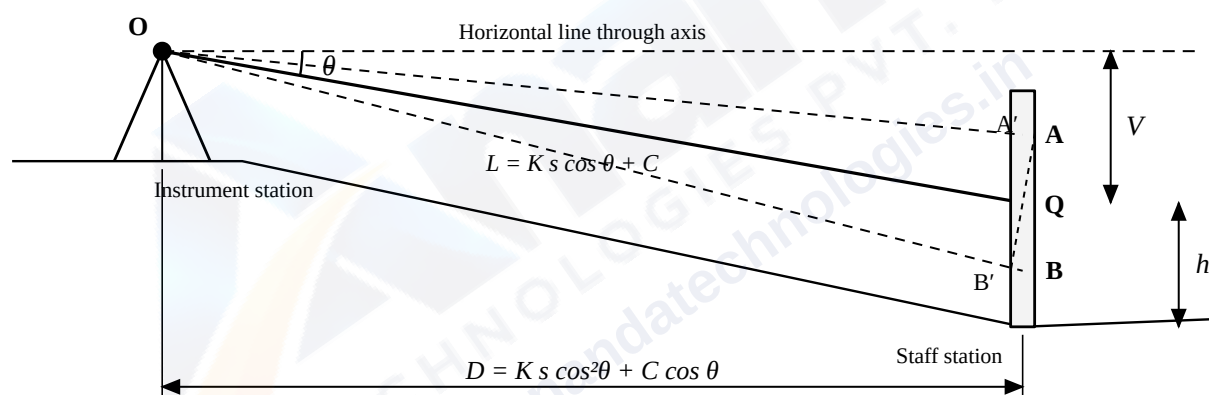


Fig.: Sight to P — angle of depression (RL P = RL of axis - V - h)

(V to B.M. and RL of axis 2 M, distance OP 2 M, RL of P 2 M)

b) Tacheometric constants.

6 M

Line of sight horizontal, staff vertical: $D = K s + C$, where $K = f/i$ (multiplying constant), $C = f + d$ (additive constant).

Obs.	D (m)	Stadia readings (m)	$s = \text{top} - \text{bottom} \text{ (m)}$	Equation
1	50	1.152, 1.400, 1.648	$1.648 - 1.152 = 0.496$	$50 = 0.496 K + C \dots (1)$
2	150	0.852, 1.600, 2.348	$2.348 - 0.852 = 1.496$	$150 = 1.496 K + C \dots (2)$

$$(2) - (1): 100 = (1.496 - 0.496) K = 1.000 K \Rightarrow K = 100.00$$

$$\text{From (1): } C = 50 - 0.496 \times 100.00 = 0.400 \text{ m}$$

Answer: Multiplying constant $K = 100.00$ (≈ 100), additive constant $C = 0.40$ m.

(Intercepts 1 M, equations 2 M, K 1.5 M, C 1.5 M)

c) Ordinates from long chord: $R = 280$ m, $L = 120$ m, 10 m interval.

6 M

Given: $R = 280$ m, long chord $L = 120$ m, $L/2 = 60$ m, interval = 10 m (measured from the mid-point D of the long chord).

Mid-ordinate (versed sine): $O_0 = R - \sqrt{R^2 - (L/2)^2} = 280 - \sqrt{280^2 - 60^2} = 6.504$ m

Ordinate at distance x from mid-point of long chord: $O_x = \sqrt{R^2 - x^2} - (R - O_0)$, where $R - O_0 = 273.496$ m

x (m)	Ordinate	Working	Value (m)
0	O_0	$\sqrt{280^2 - 0^2} - 273.496$	6.504
10	O_{10}	$\sqrt{280^2 - 10^2} - 273.496$	6.325
20	O_{20}	$\sqrt{280^2 - 20^2} - 273.496$	5.789
30	O_{30}	$\sqrt{280^2 - 30^2} - 273.496$	4.892
40	O_{40}	$\sqrt{280^2 - 40^2} - 273.496$	3.632
50	O_{50}	$\sqrt{280^2 - 50^2} - 273.496$	2.004
60	O_{60}	$\sqrt{280^2 - 60^2} - 273.496$	0.000

The curve is symmetrical about the mid-point, so the same ordinates are set out on the other half. Ordinate at the tangent points T_1 and T_2 ($x = L/2$) is zero — check.

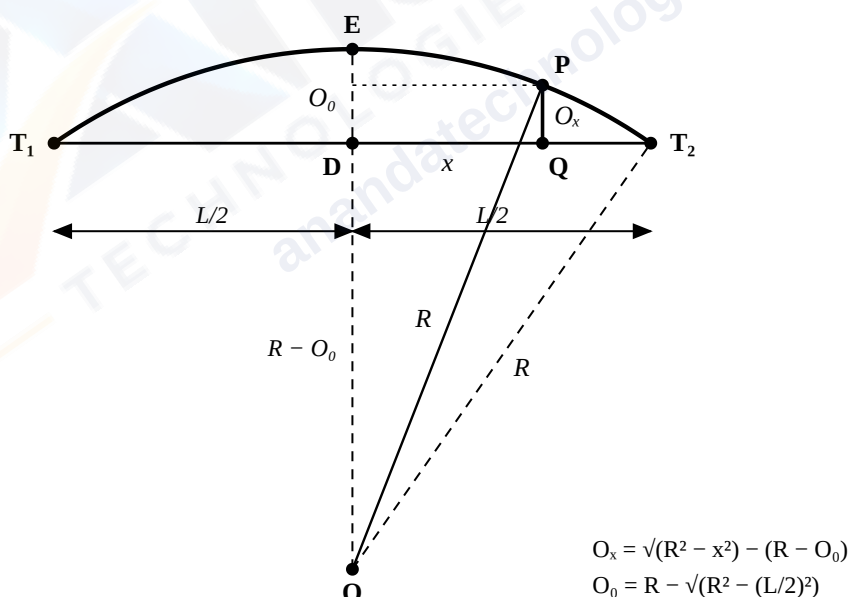


Fig.: Ordinates from the long chord

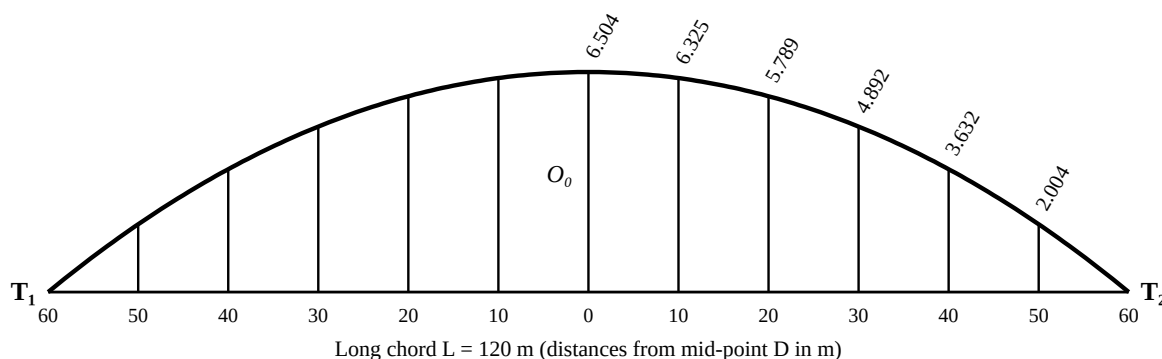


Fig.: Ordinates (m) from long chord, $R = 280$ m (vertical scale exaggerated)

(O_0 1 M, ordinates 3 M, sketch 2 M)

Q.6

a) Contouring with total station.

6 M

1. **Reconnaissance:** walk over the area, fix control stations with known coordinates and RL (from a benchmark).
2. Set up the total station on a control station; centre, level; enter station coordinates, RL, instrument height and reflector height.
3. **Orient** it on a backsight station (known coordinates / bearing).
4. Select the **data collection (coordinate) mode**; hold the prism at **grid points** or at **spot levels** — all breaks of slope, ridges, valleys, edges of roads and streams.
5. Measure each point; the instrument stores **point no., N, E, Z (RL) and code**. Shift the station when needed.
6. **Download** the data to a computer; using contouring software (e.g. AutoCAD Civil 3D, Surfer, QGIS) form a TIN / grid and **interpolate contours** at the chosen interval.
7. Edit, label contour values and plot the contour map.

Illustration: spot levels observed at 10 m grid with a total station and contours at 0.5 m interval interpolated from them:

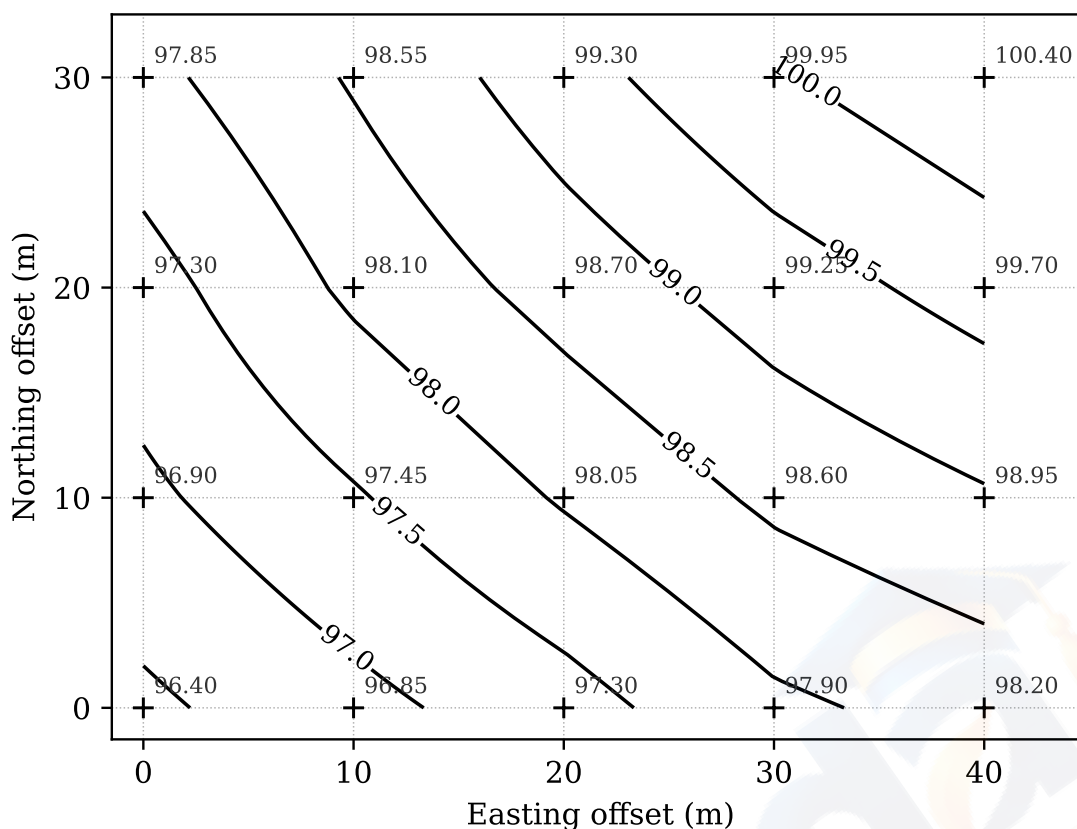


Fig.: Contours (0.5 m interval) interpolated from total-station spot levels (+)

(Steps 4 M, sketch 2 M)

b) Applications of remote sensing in civil engineering.

6 M

- Land use / land cover mapping:** classifies built-up area, agriculture, forest, water bodies, wasteland; used for town planning and master plans.
- Site selection:** for dams, reservoirs, bridges, airports and industries using terrain, geology and drainage information.
- Route alignment:** of roads, railways, canals and pipelines — best route avoiding steep slopes, water bodies and forests.
- Water resources:** watershed management, surface water mapping, groundwater potential zones, irrigation command areas.
- Disaster management:** mapping of floods, landslides, earthquakes; damage assessment and planning of relief.

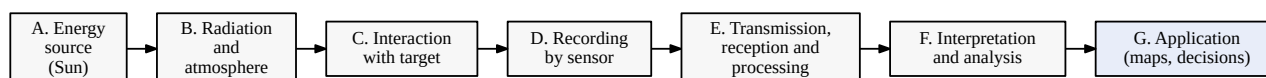


Fig.: Process (elements) of remote sensing

(Any three applications explained, 2 M each)

c) Rankine's method of deflection angles.

6 M

- Locate the point of intersection V, measure the deflection angle Δ ; compute T, length of curve and chainages of T_1 and T_2 . Fix T_1 and T_2 by measuring T from V along the two tangents.

2. Calculate the length of the first sub-chord, normal chords (20 m/30 m) and last sub-chord, and the **deflection angles $\delta = 1718.9 c / R$ minutes**; tabulate the **total deflection angles $\Delta_n = \Delta_{n-1} + \delta_n$** .
3. Set up the theodolite at T_1 , centre and level it. Set the vernier to $0^\circ 00' 00''$ and bisect V (the P.I.); clamp the lower plate.
4. Release the upper clamp and set the vernier to Δ_1 . Hold the zero of the tape at T_1 and swing a length c_1 until the arrow is bisected by the line of sight; fix peg 1.
5. Set the vernier to Δ_2 ; from peg 1 swing a length c_2 (chord) till it is bisected by the line of sight; fix peg 2. Repeat for all pegs.
6. The last peg must fall on T_2 (check). If the closing error is large, the curve is set out again. (For a left-hand curve, set $360^\circ - \Delta_n$.)

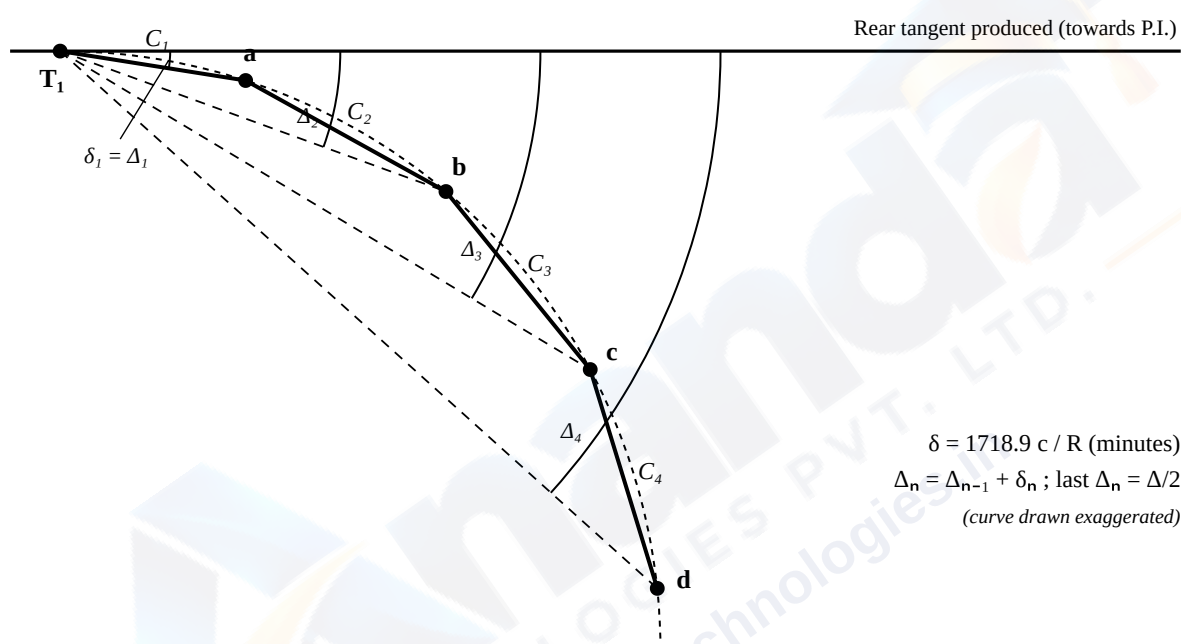


Fig.: Rankine's method of tangential (deflection) angles

(Procedure 4 M, sketch 2 M)

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