**Practice Questions - Revision**

**Question 1:**

(a) The data from a survey, are shown below.

Use either the Rise and Fall method or the Height of Plane of Collimation (HPC) method to reduce the data.

Use arithmetic checks to support your answer.

<table>
<thead>
<tr>
<th>Station</th>
<th>Point</th>
<th>BS</th>
<th>IS</th>
<th>FS</th>
<th>Rise</th>
<th>Fall or HPC</th>
<th>RL</th>
<th>CH</th>
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Answer:

- Rise and Fall method

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<th>Point</th>
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<th>IS</th>
<th>FS</th>
<th>Rise</th>
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<td>0.781</td>
<td>(43.000-0.781)</td>
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<td>(0.802-2.311)</td>
<td>1.509</td>
<td>(42.219-1.509)</td>
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<td>(2.311-1.990)</td>
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<td>(40.710+0.321)</td>
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<td>(43.391-2.455)</td>
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Arithmetic checks:

1. \( LRl – FRl = 42.842 – 43.000 = - 0.158 \) m
2. \( \Sigma BS – \Sigma FS = 7.561 – 7.719 = - 0.158 \) m
3. \( \Sigma R – \Sigma F = 4.932 – 5.090 = - 0.158 \) m

THEREFORE OK
- Height of Plane of Collimation method

<table>
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<th>Station</th>
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<td>42.999</td>
<td>42.842</td>
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Arithmetic checks:

1. $\text{LRI} - \text{FRI} = 42.842 - 43.000 = -0.158 \text{ m}$
2. $\Sigma \text{BS} - \Sigma \text{FS} = 7.561 - 7.719 = -0.158 \text{ m}$

THEREFORE OK
(b) Plot the longitudinal profile using the height against the distance

Solution:

(c) On the same graph you plotted at (b), plot the profile of a proposed road which will start at Chainage 0 meters with Reduced Level of 41.100m. The road will end at Chainage 50m and Reduced Level of 42.300m. Indicate which areas will need to be excavated and which areas will need to be filled.

Answer:
(d) Find the slope of the above road.

**Answer:**

Slope = \( \tan \phi = 0.024 = 2.4\% \)

(e) What would the RL of the road be at a chainage of 60m?

**Answer:**

The RL at chainage of 60m is 42.540m
(f) We plan to build a different road which would start at a Chainage of 0 meters at an elevation of 42.000m. The road would have a slope of $+5^\circ$. What would the elevation of the road be at a chainage of 80m?

Answer:

The RL at chainage of 80m is 49.000m

Question 2:

An Electronic Distance Measurement (EDM) device measured a slope distance of 50.874m. The EDM is 1.60m above its station (point A) and the prism is at height 2.10m above point B. If the reduced levels of A and B are $RL_A=+27.000m$ $RL_B=+22.700m$, calculate the horizontal distance from A to B.

Answer:

$H = 50.732m$

Question 3:

A 30m steel tape, standardized at 20°C using a tensile force of 60N. Measured against a standard tape, the tested tape had a length of 29,994m. The 30m tape has a weight of 0,195N/m and a cross sectional area of 1,41mm². A field measurement ($L_f$) of 29,716m found at a temperature of 15°C using a tensile force of 50N.

The coefficient of linear thermal expansion $= 1.17x10^{-5}$ °C⁻¹

The Young’s Modulus of Elasticity $= 2.068x10^{11}$N/m²

Find the actual or true length. (25 marks)

$$C_s = -\frac{w^2L_f^3}{24P^2} \quad C_p = \frac{(P-P_s)L_f}{AE} \quad C_T = a(T-T_s)L_f \quad C_L = \frac{\Delta m}{m}L_f$$

Answer:

$C_T = -0.001738m$

$C_s = -0.0166m$

$C_p = -0.0010191m$
Question 4:

Give answers to the following using the correct number of significant figures:

- Sum of 3.36 and -2.2
- Product of 2218.26 and 7.2
- Sum of 12.0009, 0.000278 and 312
- Product of 2.45 and 4.567

Answer:

- Sum of 3.36 and -2.2
  \[ 3.36 - 2.2 = 1.2 \text{ (the answer 1.16 is rounded to 1.2 so that it has 1 decimal place)} \]

- Product of 2218.26 and 7.2
  \[ 2218.26 \times 7.2 = 1.6 \times 10^4 \text{ (the answer 15971.472 is rounded so that it has only 2 significant figures)} \]

- Sum of 12.0009, 0.000278 and 312
  \[ 12.0009 + 0.000278 + 312 = 324 \text{ (the answer 324.001178 is rounded so that it has no decimal places)} \]

- Product of 2.45 and 4.567
  \[ 2.45 + 4.567 = 11.2 \text{ (the answer 11.18915 is rounded so that it has only 3 significant figures)} \]

Question 5:

(a) What are systematic and what are random errors?

Answer:

Systematic errors: they are defined as the errors whose magnitude and algebraic sign can be determined. Systematic errors can be determined and therefore corrected. They result from factors that comprise the measuring system and include the environment, the instruments and the observer. As long as the measuring system remains constant, the systematic errors remain constant. If the conditions change, the magnitudes of the systematic errors will change. An example is the error due to the temperature effects which changes the length of a steel tape. If the temperature is known, the change in length of the steel tape (shortening or lengthening) can be determined.

Because systematic errors tend to accumulate, they are also called cumulative errors.
Random errors: they are the errors remaining after mistakes and systematic errors are eliminated. They are due to the eliminations of the observer and the instruments. Smaller errors occur more frequently than larger ones, while +ve and –ve errors are equally likely to occur and balance each other.

Random errors are also called accidental errors.

(b) Give examples of mistakes in distance measurements (tape) and in levelling.

Answer:

Distance measurement (tape)

A common mistake is when you record a measured distance as 682.38 instead of 862.38. Another mistake is when you transport a number maybe from a field book to a ‘clean’ paper and instead of the correct number which is 85.96 you write 85.69.

Levelling

1. Instrument not correctly levelled.
2. Telescope not correctly focused.
3. The wrong cross-hair reading recorded (e.g. top instead of middle).
4. Staff incorrectly read or not held vertical.
5. Staff incorrectly booked.

Question 6:

(a) Define the terms accuracy and precision.

Answer:

Accuracy is the absolute proximity of the observed value to the ‘true’ measurement. In other words, it shows how close a measurement is, to the true value.

Precision is the degree of refinement of the measuring process and the ability to repeat the same measurement with consistently small variations i.e. how close is one measurement to another.

(b) Three groups carried out a levelling survey. The measurements of the elevation of the same point are shown in the following tables for each group. The true elevation of the point measured is +50.000m. Describe the results of each group in terms of accuracy and precision.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>49.991</td>
<td>46.004</td>
<td>48.050</td>
</tr>
<tr>
<td>49.997</td>
<td>46.009</td>
<td>53.300</td>
</tr>
<tr>
<td>50.003</td>
<td>45.900</td>
<td>46.200</td>
</tr>
</tbody>
</table>
Answer:

Group 1:  High precision
          High accuracy

Group 2:  High precision
          Low accuracy

Group 3:  Low precision
          Low accuracy

Question 7:

Describe how you will bring a perpendicular (offset) from a survey line. Use a sketch to support your answer.

Answer:

- Take any point on the survey line and mark it as P. Measure equal distances on the survey line to the left and to the right of point P. Mark these two points as A and B (AP = PB). Strike arcs from A and B with equal radii. At the point of intersection, mark point Q. Make a line from point Q to point P. Angle APQ = 90°.

Question 8:

Describe how you will bring a perpendicular (offset) from a point to a survey line. Use a sketch to support your answer.

Answer:

- With the free end of the tape (zero reading) at point P, form an arc with the tape. The tape cuts (crosses) the survey line at two points, A and B. Find the centre of the line AB and mark it with point Q. Bring a line to connect point P with point Q. The angle PQA = 90°.

OR

- With the free end of the tape (zero reading) at point P, cross the survey line at any point A. Bring a line from point P to point A. Find the centre of line AP and mark it as B. From B, strike an arc with radius BA. Where it cuts survey line mark point Q. Make a line from point P to point Q. Angle PQA = 90°.
Question 9:

Points A and B are visible to each other and are located on opposite sides of a lake. Explain how you will measure the distance between these two points using a tape. Use a diagram to support your answer.

**DISTANCE MEASUREMENT WHEN OBSTACLES ARE PRESENT BUT POINTS ARE VISIBLE**

1. ![Diagram 1]

   Distance AB is required.
   Solution: On a survey line outside lake drop perpendiculars at points C and D as shown.
   Then measure CD (= AE). Measure distance BE and calculate AB using Pythagoras
   \[ AB = \sqrt{(AE)^2 + (BE)^2} \]
   OR

2. ![Diagram 2]

   Distance AB is required.
   Solution: Drop a perpendicular at C, lying on extension line from A (rods can be used). Extend AB and from any point (in this case E) drop a perpendicular on the extension of BC (point D).
   Measure distances CB, EB and DB.
   \[ \frac{AB}{EB} = \frac{CB}{DB} \]
   Note that the two triangles are similar but not necessarily with equal sides (i.e., no need to have DB = BC).
   OR

3. ![Diagram 3]

   Distance AB is required.
   Solution: Extend AB to F (any point)
   Drop verticals from C, D to B, F so that AF=DF is a straight line (use of rods or by eye). Drop perpendicular to DF from C (at E) Measure BC, CE, ED.
   Using similar triangles
   \[ \frac{AB}{BC} = \frac{CE}{ED} \Rightarrow AB = \frac{CE \times BC}{ED} \]

The same methods can be used for similar problems. All the above can be solved in more than one way using simple geometry.
Question 10:

Describe the Peg Test.

Answer:

The purpose of the Peg Test is to check that the line of sight – **Plane of Collimation** – through the level is horizontal (i.e parallel to the axis of the bubble tube).

To perform the peg test, the surveyor first places two staffs at a distance of 60 to 90 m apart. The level is set up midway (paced) between the two staffs (adia) and readings are taken at both locations.

If the line of sight through the level is not horizontal, the errors in readings $\Delta e_1$ at both point A and B will be identical because the level is halfway between the points. Because the errors are identical, the calculated difference in elevation between points A and B (difference in readings) will be the true difference in elevation.

The level is then moved to one of the points (A) and set up so that the eyepiece of the telescope just touches the staff as it is being held at point A. The staff reading (a2) can be determined by sighting backward through the objective lens at a pencil point that is being moved slowly up and down the staff. The pencil can be centered precisely, even though the cross hairs are not visible, because the circular field of view is relatively small. Once that reading has been determined, the staff is held at B. If the surveyor cannot look backward through the telescope, the instrument is set up at 2m away from A with the staff read normally. Any error generated over that short distance will be relatively insignificant.
Question 11:

There are two points on a road axis, A and B. The length between these two points was measured to be 40.226m. If the slope of the road is -4% from point A dropping to point B, what is the horizontal distance between these two points? What is the difference in height between A and B?

Answer:

Height difference = 1.608m

Horizontal distance = 40.194m