Test

1. Levelling is the … of geodetic height using a levelling instrument and a level staff.

a) station;

b) test;

c) measurement;

d) system.

2. Common … instruments include the spirit level, the dumpy level, the digital level, and the laser level.

a) electronic;

b) direct;

c) levelling;

d) optical.

3. A typical procedure is to set up the instrument within … meters of a point of known or assumed elevation..

a) 26;

b) 13;

c) 16;

d) 100.

4. A rod or staff is held vertical on that point and the instrument is used manually or automatically to read the ...

a) final data;

b) rod scale;

c) main device;

d) second attempt.

5. The previous procedure is repeated as many times as need to cover the ... between the points.

a) distance;

b) beam;

c) measurement;

d) angle.

6. Since the equipotential surface is approximately ..., the effect of curvature is a function of the instrument-staff distance.

a) spherical;

b) oval;

c) vertical;

d) plane.

7. When the backsight and foresight distances are ..., the effect of curvature cancels out.

a) right;

b) equal;

c) correct;

d) real.

8. The ... has different optical properties everywhere.

a) air;

b) land;

c) surface;

d) angle.

9. A level … a telescope for looking at a leveling rod, which is a kind of ruler, and a pedestal for rotating the telescope horizontally.

a) needs;

b) directs;

c) rotates;

d) consists of.

10. The ... should be set up exactly in the middle between two points, thus the effect of curvature is the same for the backsight and foresight.

a) instrument;

b) material;

c) thing;

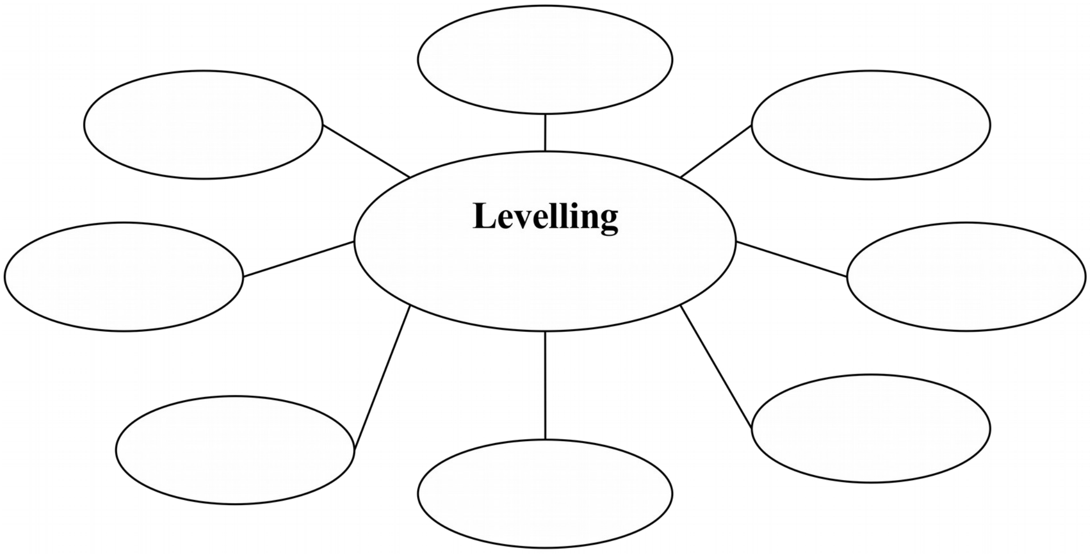
d) solution.

Answers:

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

Additional tasks

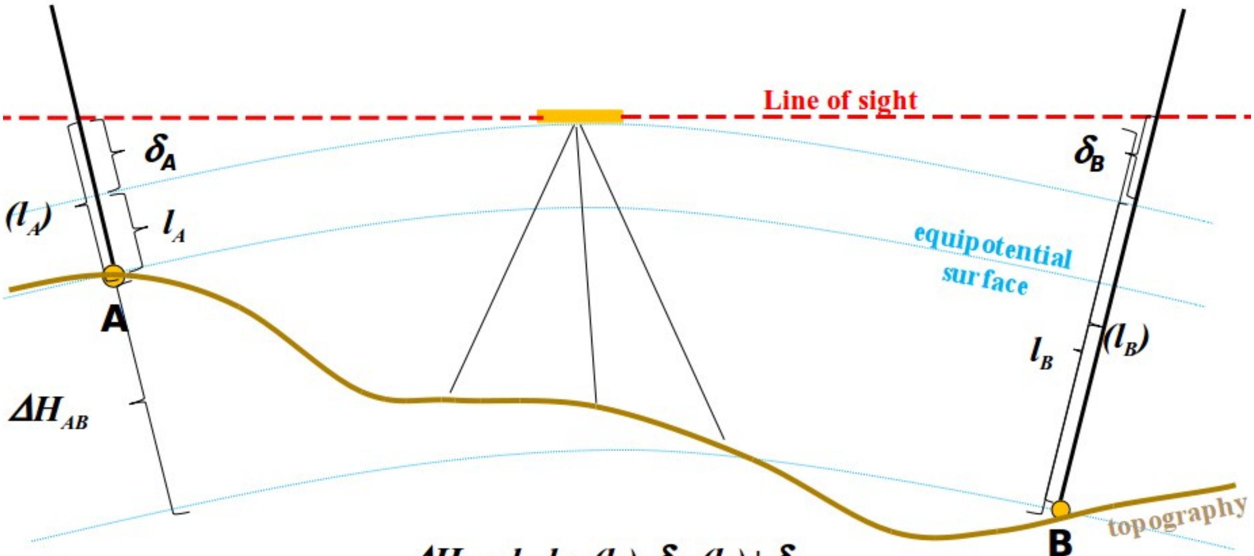
 **1. Fill in the spidergram with the words associated with levelling.**



 **2. Name these levelling instruments and talk about their peculiarities.**

3. Discuss with your groupmates. What are applications of levelling nowadays?

4. Discuss with your groupmates. What do you know about types of measurement with the help of levelling instruments nowadays?



$$\Delta H_{AB}=l_A-l_B=(l_A)-\delta_A-(l_B)+\delta_B$$

When $\delta_A=\delta_B$ (spherical approximation, equal distance to A and B)

$$\Delta H_{AB}=(l_A)-(l_B)$$

 **5. Discuss with your groupmates. What do you know about types of measurement with the help of levelling instruments nowadays?**

Refraction and curvature

The curvature of the earth means that a line of sight that is horizontal at the instrument will be higher and higher above a spheroid at greater distances. The effect may be significant for some work at distances under 100 meters.

The line of sight is horizontal at the instrument, but is not a straight line because of refraction in the air. The change of air density with elevation causes the line of sight to bend toward the earth.

The combined correction for refraction and curvature is approximately:

$\Delta h_{meters} = 0.067 D_{km}^2$ or $\Delta h_{feet} = 0.021 \left(\frac{D_{ft}}{1000}\right)^2$

For precise work these effects need to be calculated and corrections applied. For most work it is sufficient to keep the foresight and back sight distances approximately equal so that the refraction and curvature effects cancel out. Refraction is generally the greatest source of error in leveling. For short level lines the effects of temperature and pressure are generally insignificant, but the effect of the temperature gradient *dT / dh* can lead to errors.

Levelling loops and gravity variations

Assuming error-free measurements, if the Earth's gravity field were completely regular and gravity constant, leveling loops would always close precisely:

$$\sum_{i=0}^{n} \Delta h_i = 0$$

In the real gravity field of the Earth, this happens only approximately; on small loops typical of engineering projects, the loop closure is negligible, but on larger loops covering regions or continents it is not.

Instead of height differences, *geopotential differences* do close around loops:

$$\sum_{i=0}^{n} \Delta h_i g_i,$$

where g_i stands for gravity at the leveling interval *i*. For precise leveling networks on a national scale, the latter formula should always be used.

$$\Delta W_i = \Delta h_i g_i$$

should be used in all computations, producing geopotential values W_i for the benchmarks of the network.

Levelling instruments

Older instruments

The wye level is the oldest and bulkiest of the older style optical instruments. A low-powered telescope is placed in a pair of clamp mounts, and the instrument then leveled using a spirit level, which is mounted parallel to the main telescope.

The dumpy level was developed by English civil engineer William Gravatt, while surveying the route of a proposed railway line form London to Dover. More compact and hence both more robust and easier to transport, it is commonly believed that dumpy levelling is less accurate than other types of levelling, but such is not the case. Dumpy levelling requires shorter and therefore more numerous sights, but this fault is compensated by the practice of making foresights and back sights equal.

Precise level designs were often used for large leveling projects where utmost accuracy was required. They differ from other levels in having a very precise spirit level tube and a micrometer adjustment to raise or lower the line of sight so that the crosshair can be made to coincide with a line on the rod scale and no interpolation is required.

Automatic level

Automatic levels make use of a compensator that ensures that the line of sight remains horizontal once the operator has roughly leveled the instrument (to within maybe 0.05 degree). The surveyor sets the instrument up quickly and doesn't have to relevel it carefully each time he sights on a rod on another point. It also reduces the effect of minor settling of the tripod to the actual amount of motion instead of leveraging the tilt over the sight distance. Three level screws are used to level the instrument.

1. Gun sight
2. Circular level (pond bubble)
3. Levelling Screw
4. Base Plate
5. Objective Lens
6. Focusing Knob
7. Horizontal fine motion screw
8. Horizontal circle window
9. Horizontal circle setting ring
10. Reticle adjusting screw cover
11. Eyepiece

Setting up an automatic level

Set up the tripod at just above chest height. Make sure it is stable, and mount the level on the top. Adjust the leveling screws until the pond bubble is centralized. As long as the pond bubble is central, the automatic compensators are able to finely level the instrument. To ensure this is the case, whilst looking through the scope, gently tap the level. The view will waver for a few moments before steadying. If this does not happen, the instrument is not level enough for the compensators to cope, and needs adjustment.

Sighting

Sight is towards the staff using the gun sight. Look through the eyepiece and focus the reticle by gradually turning the reticle focusing ring anti-clockwise. Turn the focusing knob to focus on the staff. Turn the fine motion screw to center the staff in the field of view. Turn the focusing knob to eliminate parallax between the staff and reticle.

The levelling staff

Reading the staff

The staff starts at zero, on the ground. Every 10 cm is a number, showing (in meters to one decimal) the height of the bottom of what appears to be a stylized E (even numbers) or 3 (odd numbers), 5 cm high. The stems of the E or 3 and the gaps between then are each 10mm high. These 10mm increments continue up to the next 10 cm mark.

To read the staff, take the number shown below the reticle. Count the number of whole 10mm increments between the whole number and the reticle. Then estimate the number of mm between the last whole 10mm block and the center of the reticle. The diagram above shows 4 readings: - 1.950, 2.000, 2.035 and 2.087.

The person holding the staff should endeavor to hold it as straight as possible. The leveller can easily see if it is tilted to the left or right, and should correct the staff-holder. However, it cannot easily be seen that the staff is tilted towards or away from the leveller. In order to combat this possible source of error, the staff should be slowly rocked towards and away from the leveller. When viewing the staff, the reading will thus vary between a high and low point. The correct reading is the lowest value.

Digital levels electronically read a bar-coded scale on the staff. These instruments usually include data recording capability. The automation removes the requirement for the operator to read a scale and write down the value, and so reduces blunders. It may also compute and apply refraction and curvature corrections.

Laser level

Laser levels project a beam which is visible and/or detectable by a sensor on the leveling rod. This style is widely used in construction work but not for more precise control work. An advantage is that one person can perform the levelling independently, whereas other types require one person at the instrument and one holding the rod.

The sensor can be mounted on earth-moving machinery to allow automated grading.

(http://en.wikipedia.org/wiki/Levelling)

6. State whether the sentences are true or false. If true, add the information on the statement. If false, correct the sentence.

1. The curvature of the earth means that a line of sight that is horizontal at the instrument will be higher and higher above a spheroid at greater distances.	T	F
2. The effect may be significant for some work at distances under 200 meters.	T	F
3. The line of sight is horizontal at the instrument, but is not a straight line because of refraction in the air.	T	F
4. The change of air density with elevation does not cause the line of sight to bend toward the earth.	T	F
5. Refraction is generally the greatest source of error in	T	F

leveling.		
6. For short level lines the effects of temperature and pressure are generally significant, but the effect of the temperature gradient dT / dh can lead to errors.	T	F
7. The wye level is the oldest and bulkiest of the older style optical instruments.	T	F

7. Discuss with your groupmates and find peculiarities between these levelling instruments.