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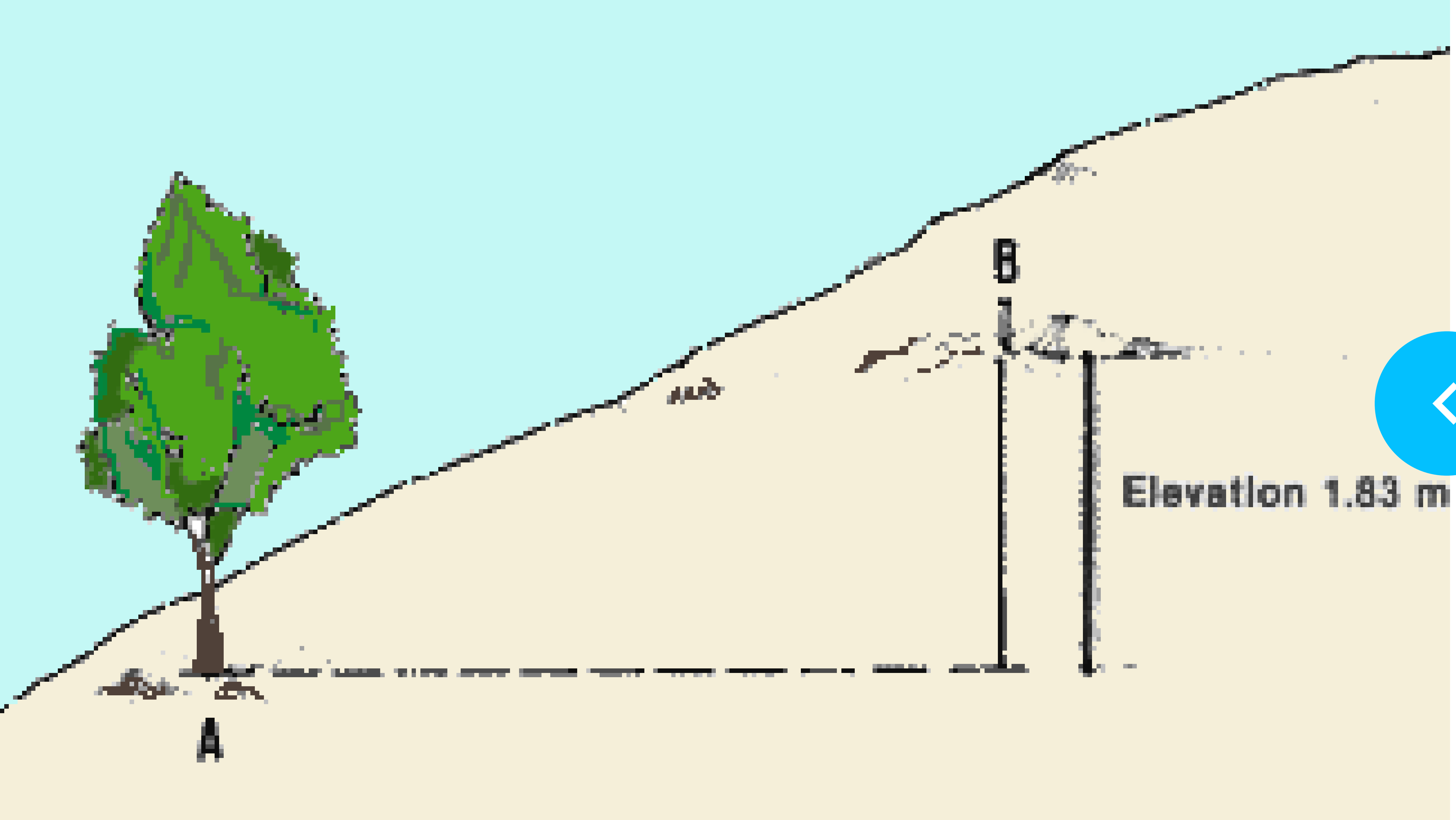


What are elevation and altitude?

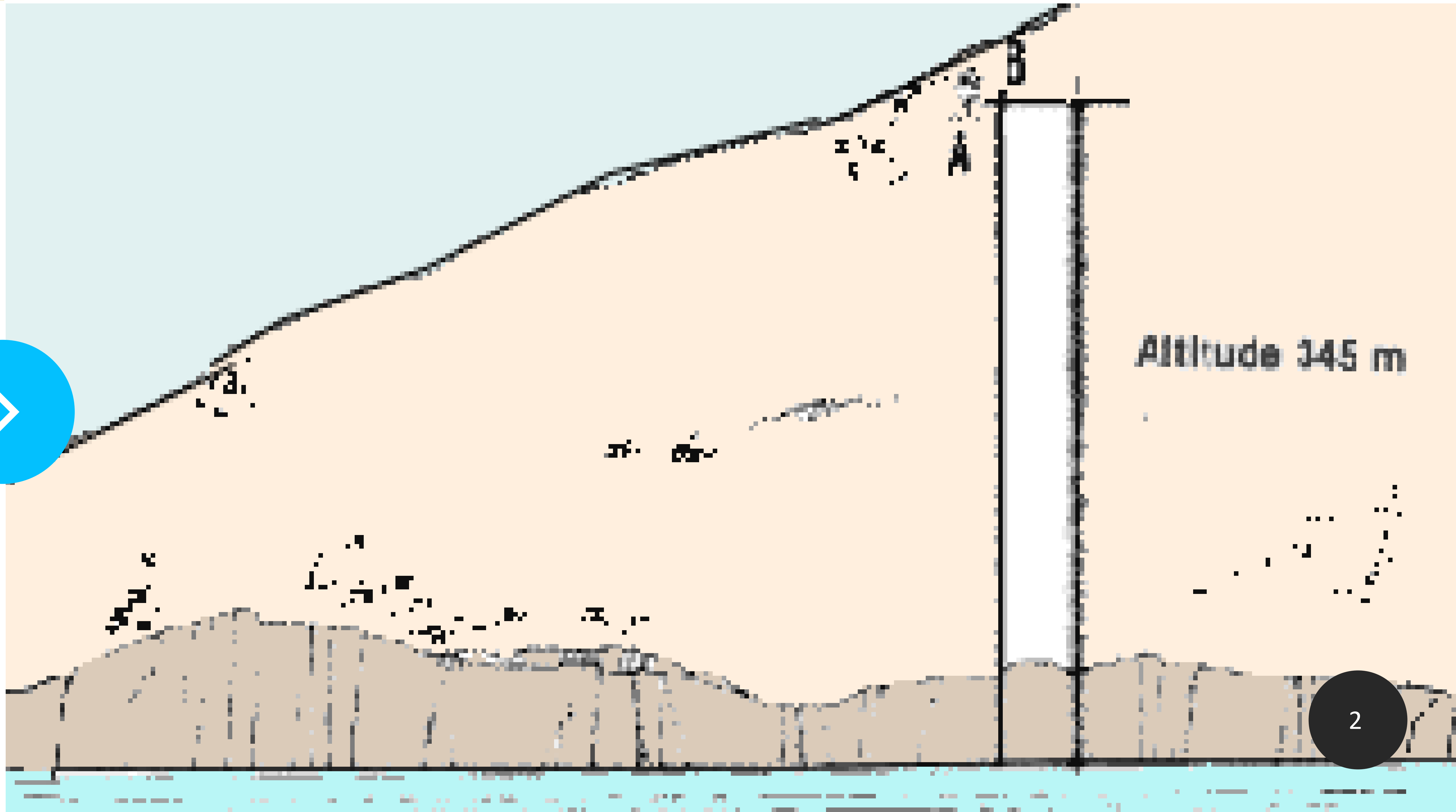
When the height of a point is its vertical distance above or below the surface of a reference plane you have selected, it is called the ***elevation*** of that point.

When the height of a point is its vertical distance above or below mean sea level (as the reference plane), it is called the ***altitude*** of the point.

The vertical distance between two points is called the ***difference in elevation***, The process of measuring differences in elevation is called ***levelling***.

Example

Elevation of a point above a selected ground mark A	1.83 m
Altitude of the same point above mean sea level (amsl)	345 m



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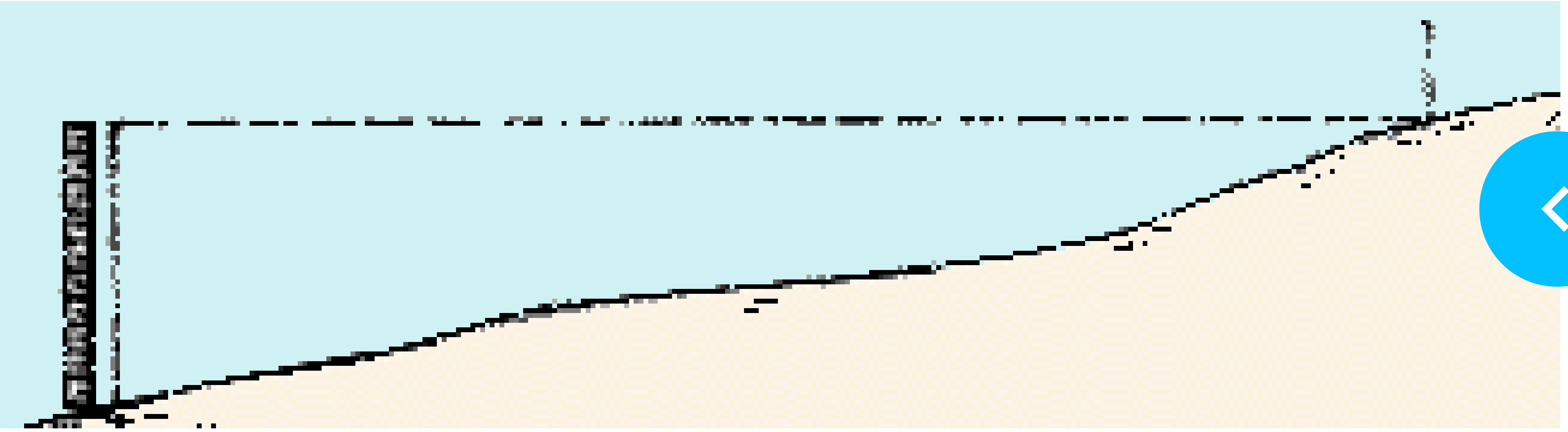
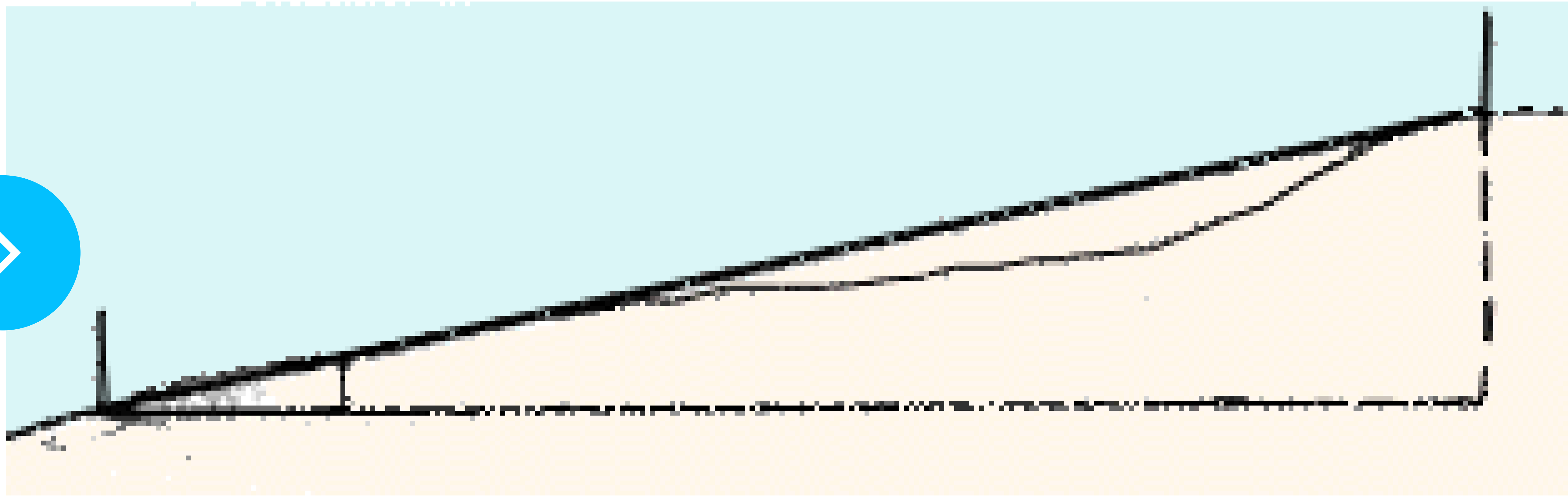
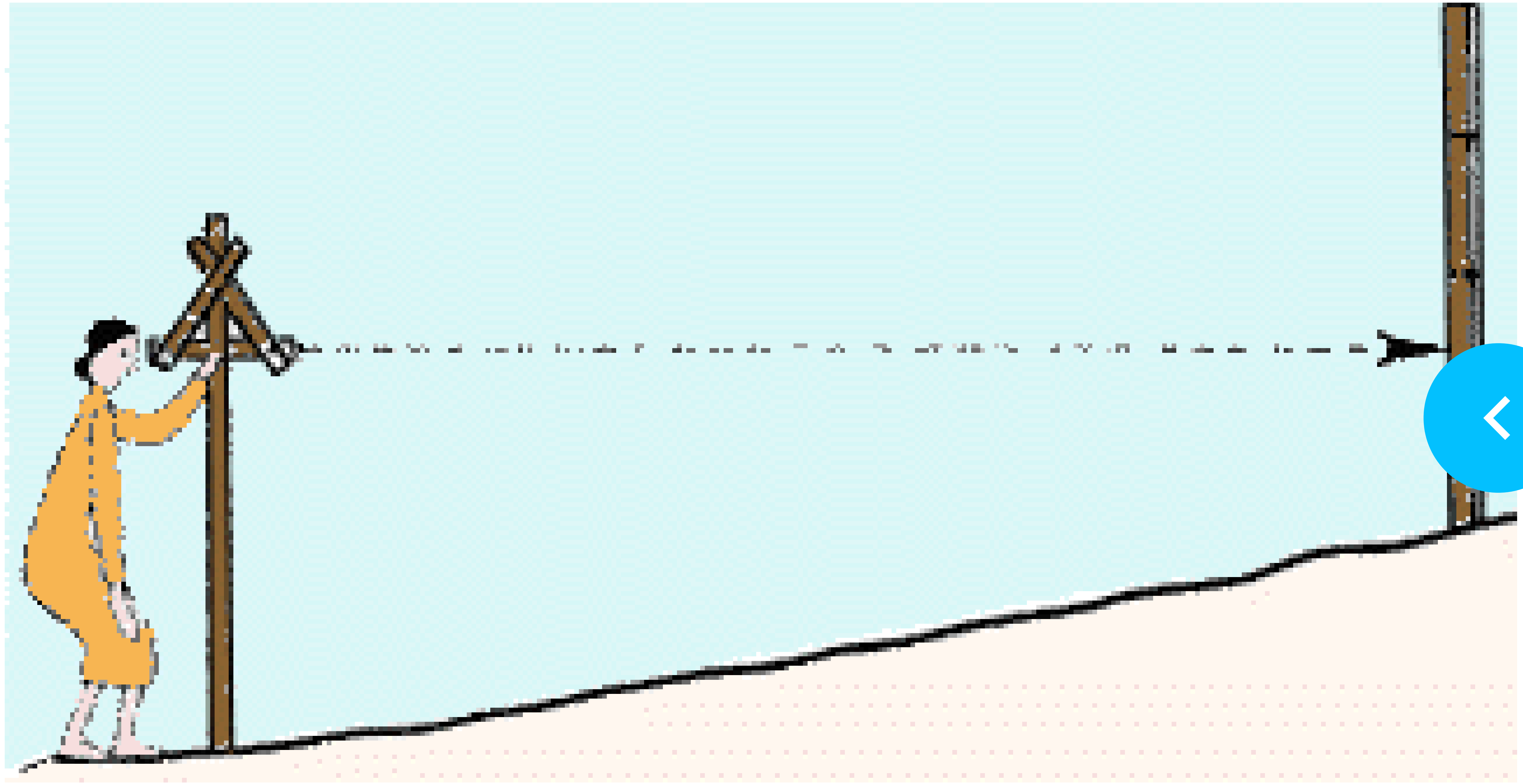
What are the main levelling methods?



direct levelling, where you measure differences in elevation directly. This is the most commonly used method.

indirect levelling, where you calculate differences in elevation from measured slopes and horizontal distances.

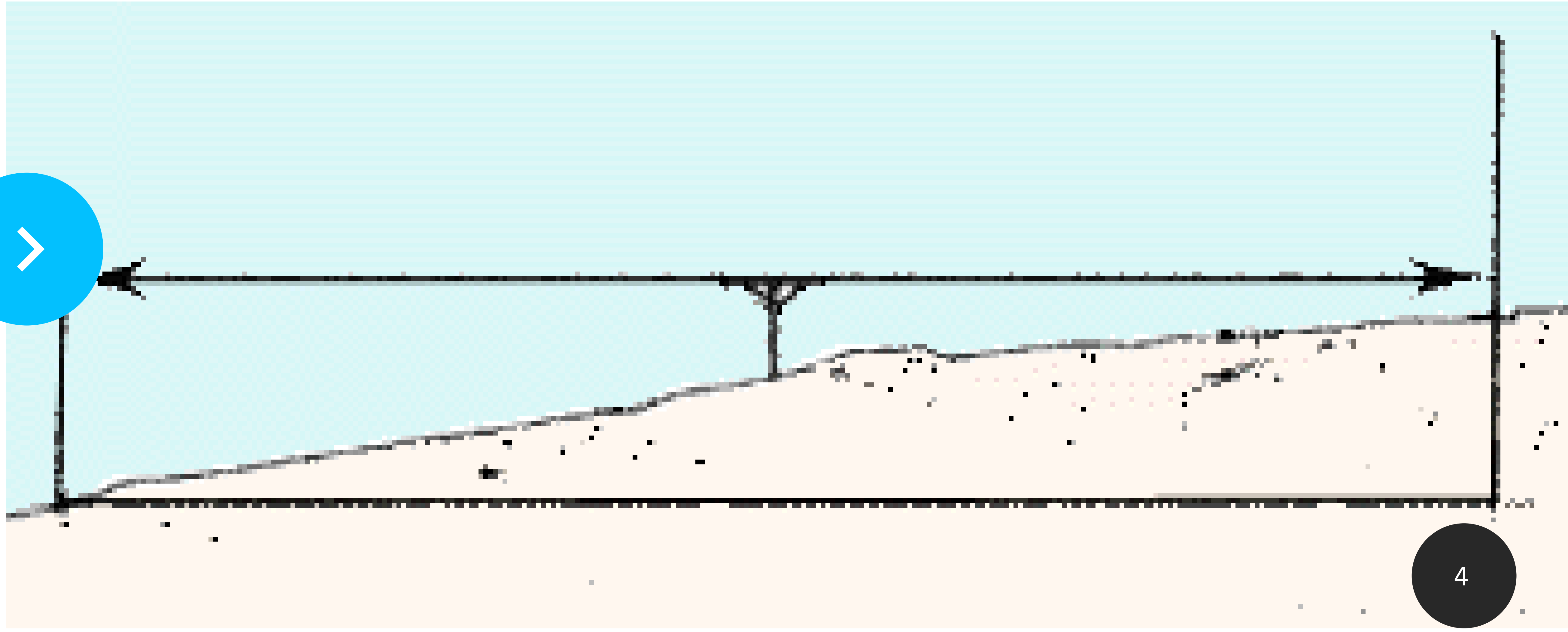




What are the kinds of direct levelling?

In ***differential levelling*** , you find the difference in elevation of points which are some distance apart . In the simplest kind of direct levelling, you would survey only two points A and B from one central station LS.

In ***profile levelling*** , you find the elevations of points placed at short measured intervals along a known line, such as the centre-line of a water supply canal or the lengthwise axis of a valley. You find elevations for cross-sections with a similar kind of survey



Main Parts of a Levelling System

The system is composed of

* differential level

* graduated staff.

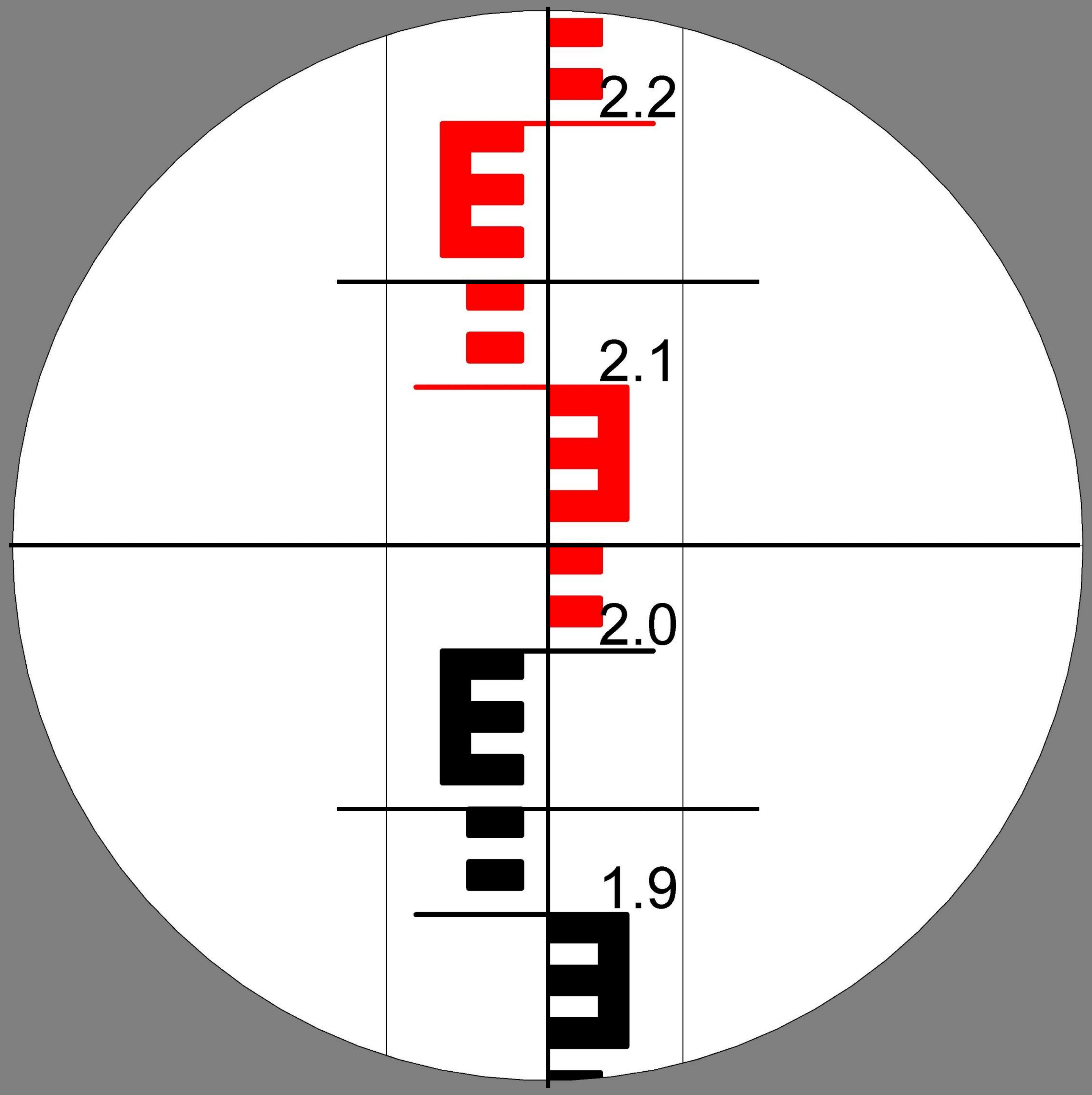
Differential Level components

The system is composed of

* Surveying Telescope
* A Spirit Level (also called Level Vial or Bubble Level).
* A Tribrach.
* A Tripod

Reading a Staff

2.04 m



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Types of Levels:

1- Dumpy Level (Old)
2- Tilting Level
3- Automatic Level
4- Digital Level
5- Laser Level

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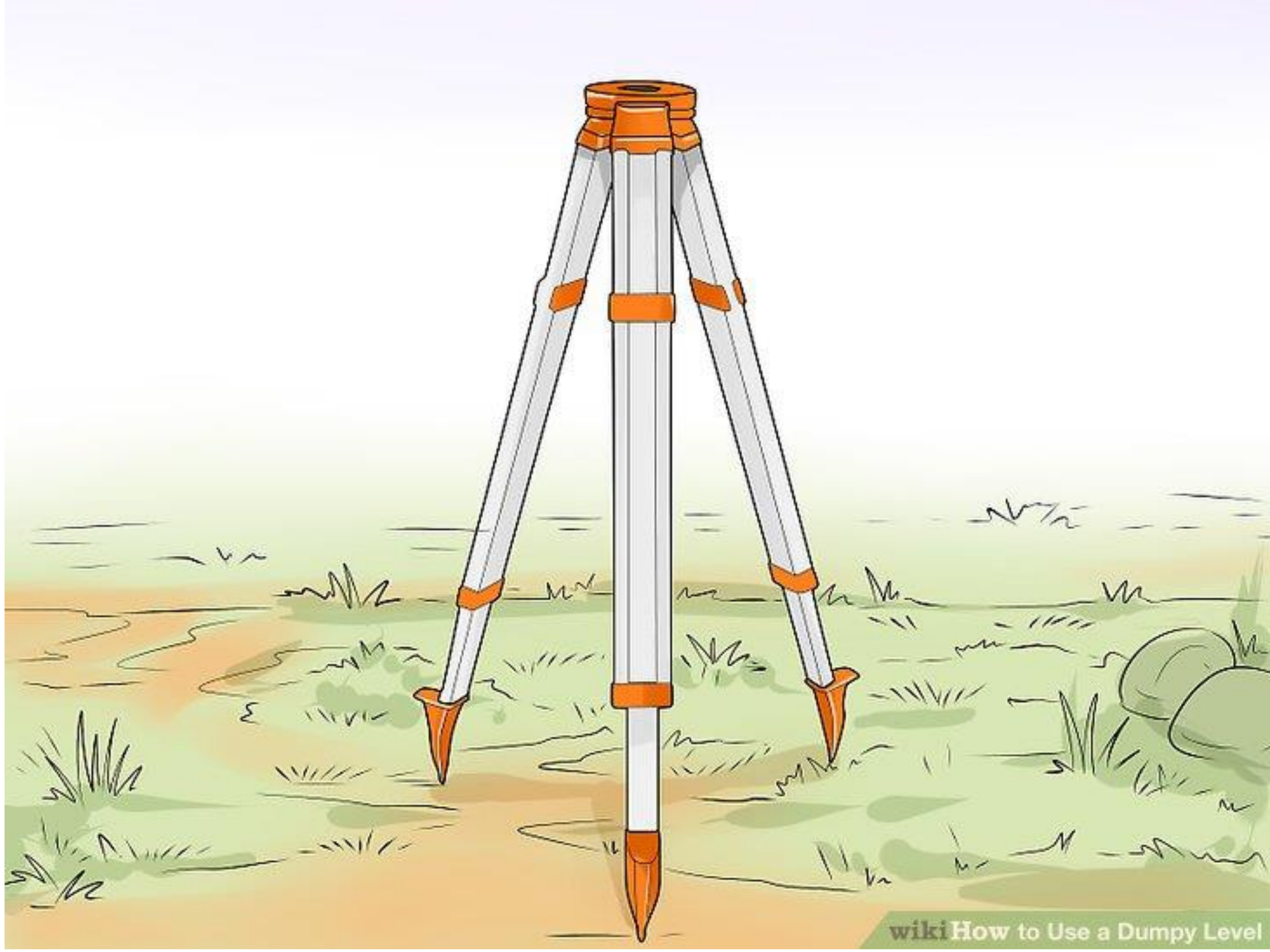
How to Use a Level

Find a benchmark location near the spot you want to measure.

How to Use a Level

Set your tripod up near the spot you want to measure. Place your tripod on a patch of flat, clear ground that sits between your benchmark location and the spot you want to measure. Then, undo the latches on your tripod's legs and extend each leg out. Adjust the legs until your tripod is completely level, then close each latch.



How to Use a Level

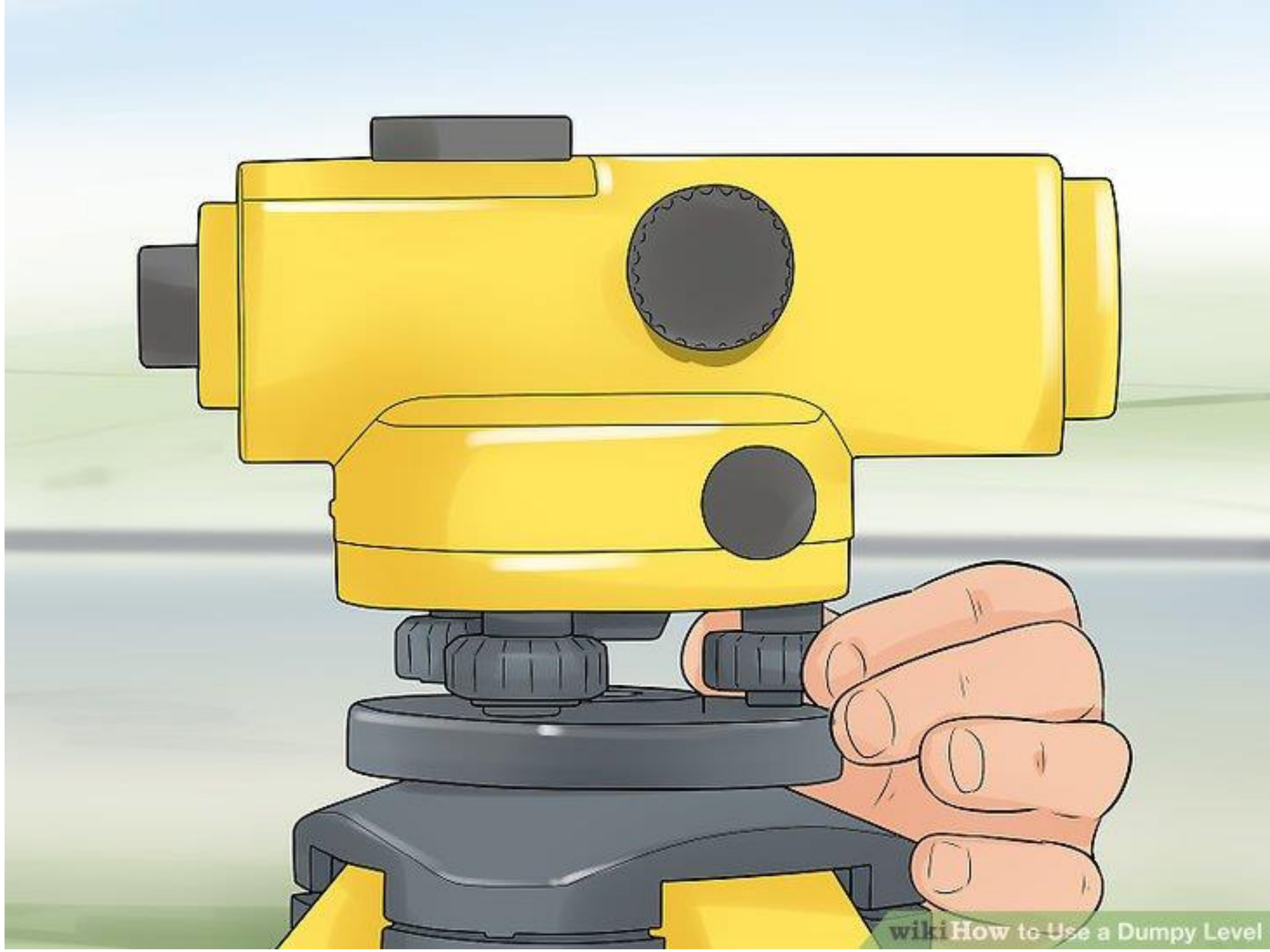
Connect your device to the tripod and position it over 2 levelling screws. Screw your dumpy level onto the tripod's base plate, then connect the base plate to the main tripod body. Once the instrument is securely attached, turn the dumpy level's telescope so that it sits parallel with 2 of the device's levelling screws.

How to Use a Level

Level the device by adjusting the 2 levelling screws. Look for a traditional bubble level located somewhere on your device. When you find it, grab the 2 levelling screws that are parallel to the device's telescope and twist them in opposite directions. Do this until the bubble sits in the exact centre of the level

How to Use a Level

Turn your telescope 90 degrees and adjust the third levelling screw. After adjusting your first 2 levelling screws, turn your telescope approximately 90 degrees so that it sits parallel to the device’s third levelling screw. Then, adjust this screw until the bubble once again sits in the centre of the level



How to Use a Level

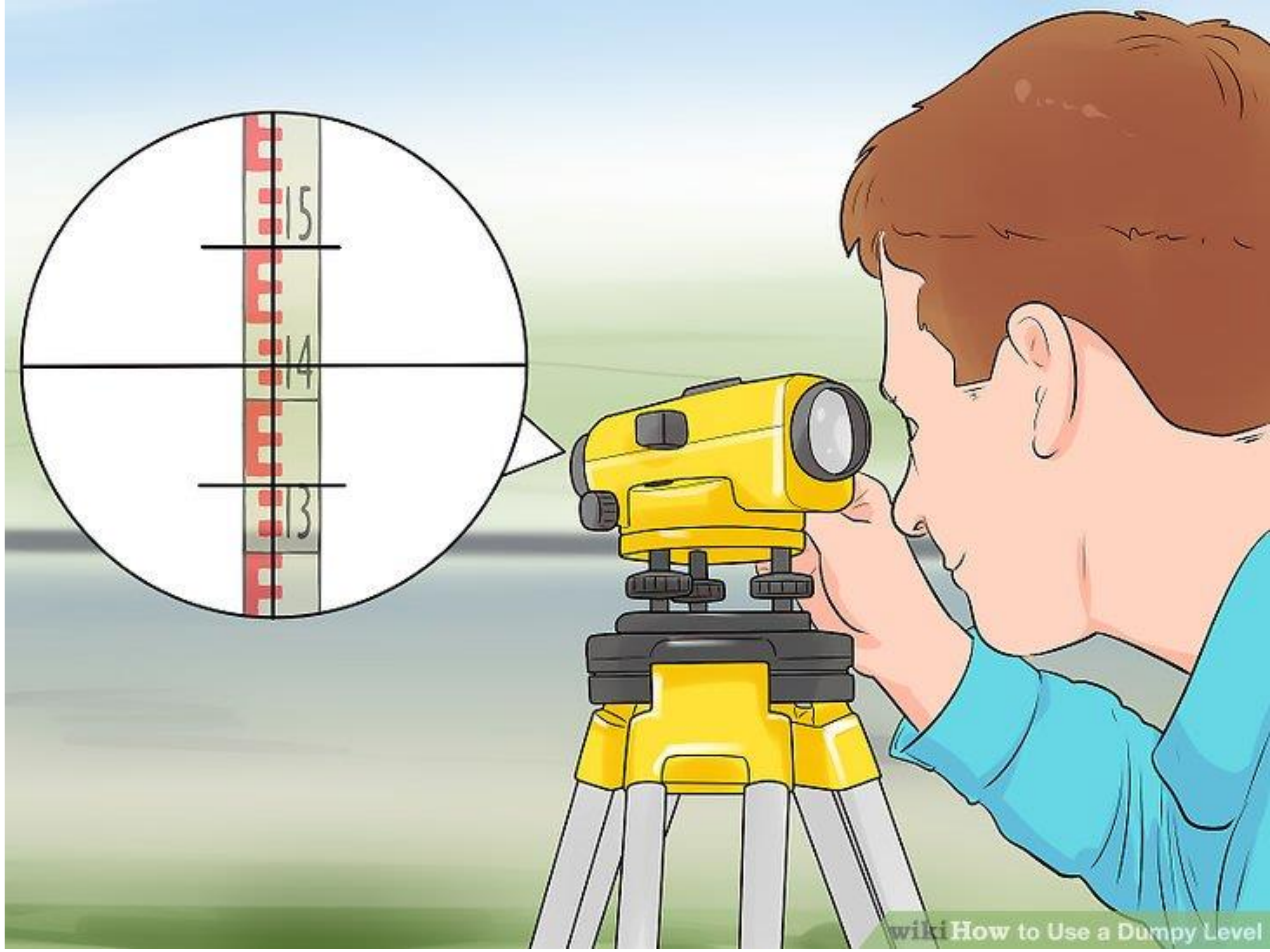
Check your level’s calibration by turning it 180 degrees. After making your initial levelling adjustments, return your telescope to its starting position and check that the bubble still sits in the centre of the level. If it does, turn the telescope 180 degrees and check the level again. You can focus the device once all 3 positions show the bubble in the centre of the level

How to Use a Level

Remove your dumpy level's lens cap. The lens cap protects your device's lens from unwanted dirt, grime, and debris. To avoid damaging your instrument, leave the lens cap on until you're ready to use the device

How to Use a Level

Adjust the eyepiece until you can see the device’s crosshairs. Place a sheet of paper or a similar object directly in front of your device’s lens to occupy its entire field of vision. Then, turn the eyepiece’s focusing knob until you can clearly see the dumpy level’s crosshairs



How to Use a Level

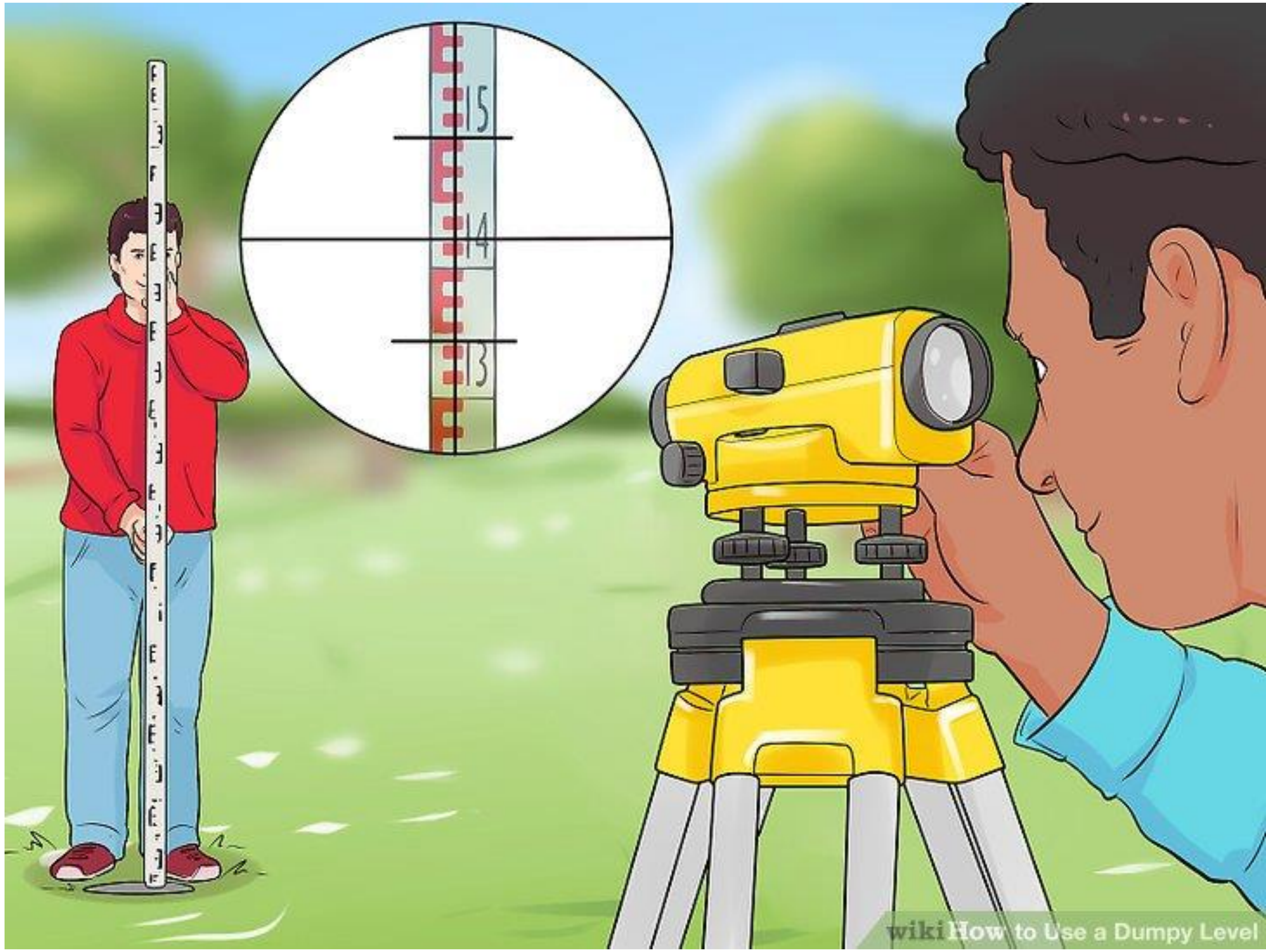
Twist the device's focusing knob until the image is clear. Once you can see the crosshairs, point your device's telescope toward your benchmark spot. Look for a large, distinct object in the area, such as a tree or hilltop, then twist your device's primary focusing knob until the object comes into focus

How to Use a Level

Position an E staff on top of your benchmark spot. Then, have a friend or colleague hold the staff on top of your benchmark spot

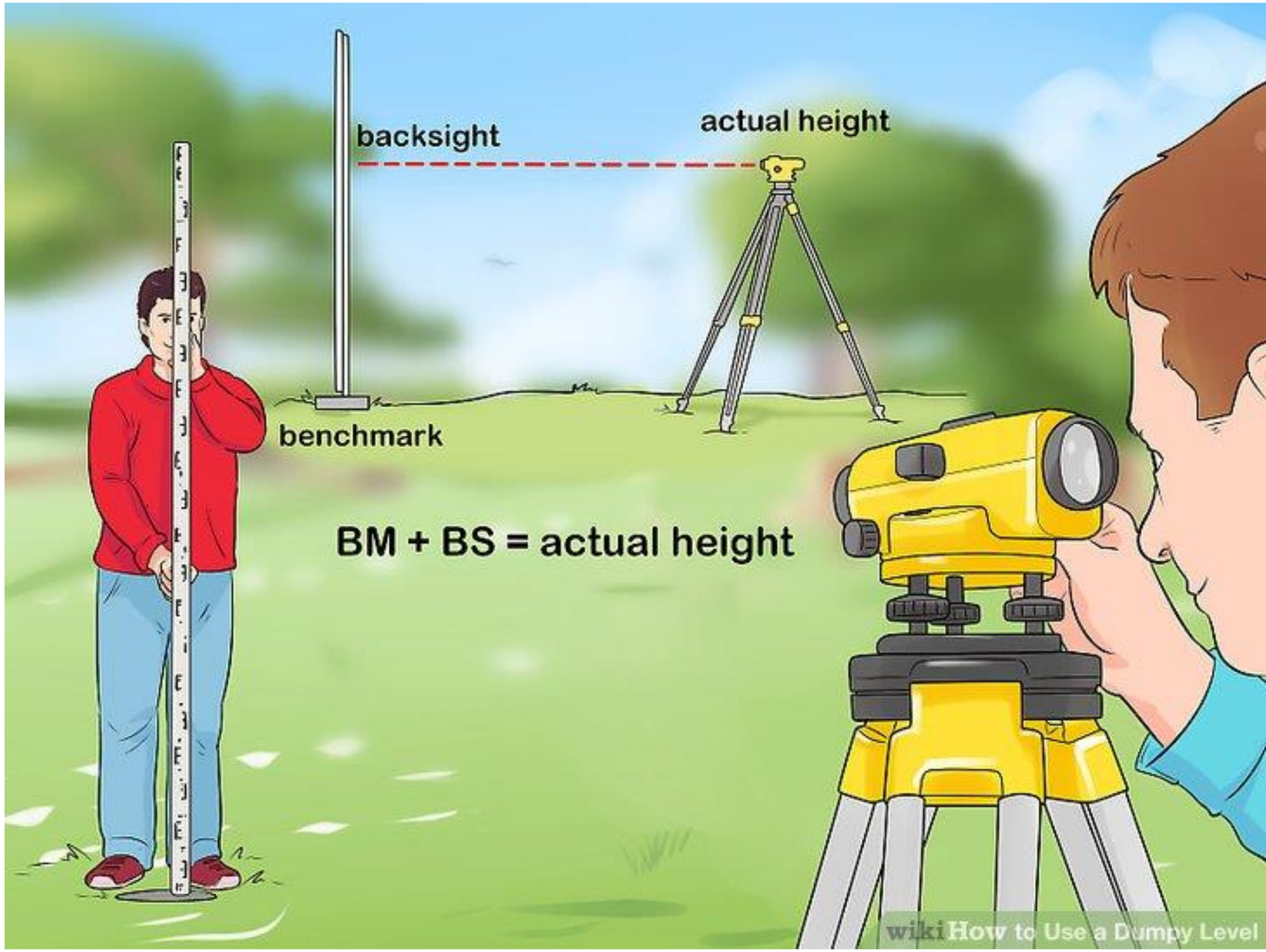
How to Use a Level

Find the height difference between your level and the benchmark spot. Look through your dumpy level's telescope and locate the E staff. Then, record the measurement indicated by your device's centre, horizontal crosshair



How to Use a Level

Calculate your level’s actual height using the benchmark height. Once you have your backsight measurement, add it to your benchmark location's actual height. This will give you the current height of your dumpy level’s telescope



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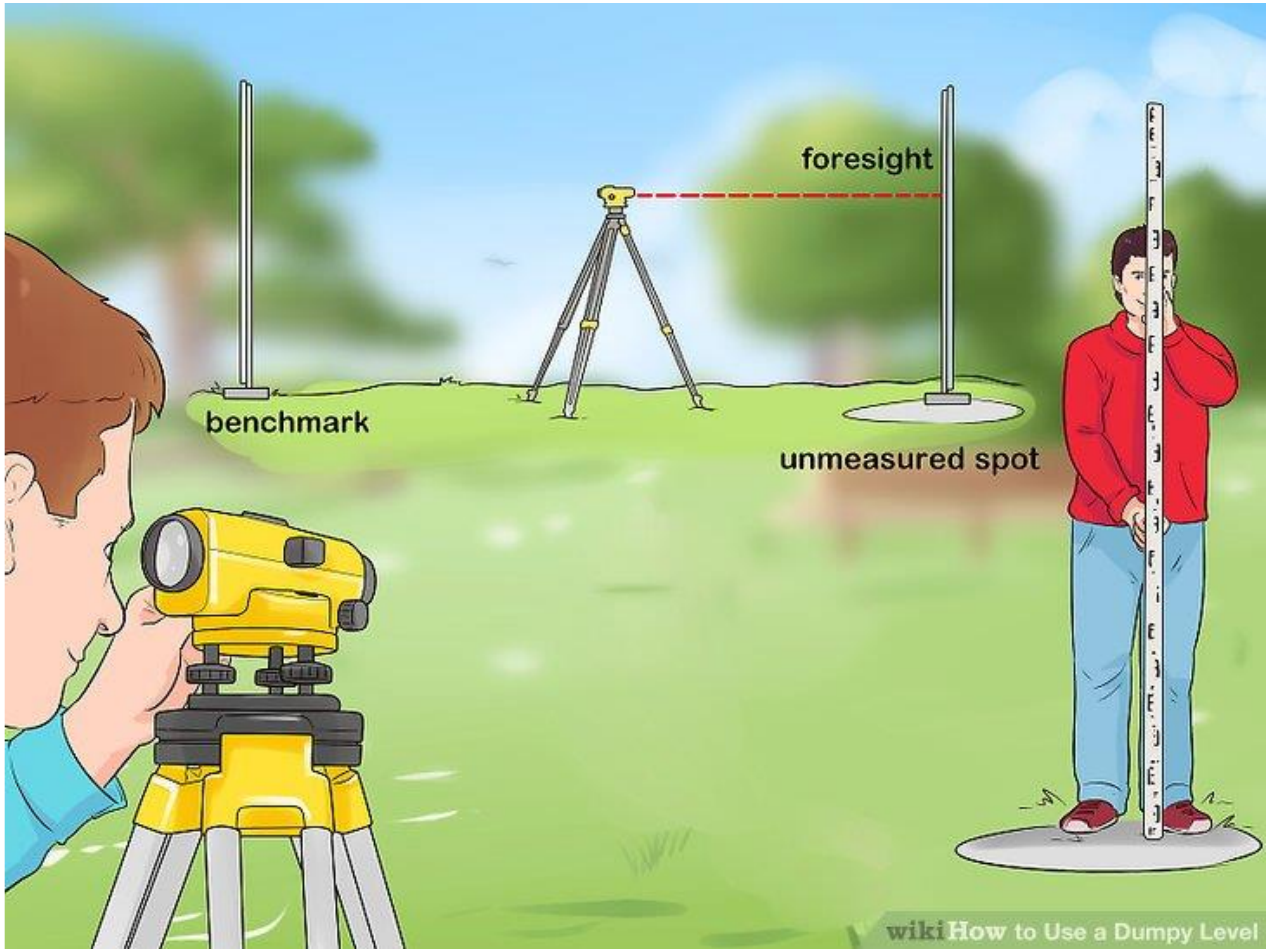
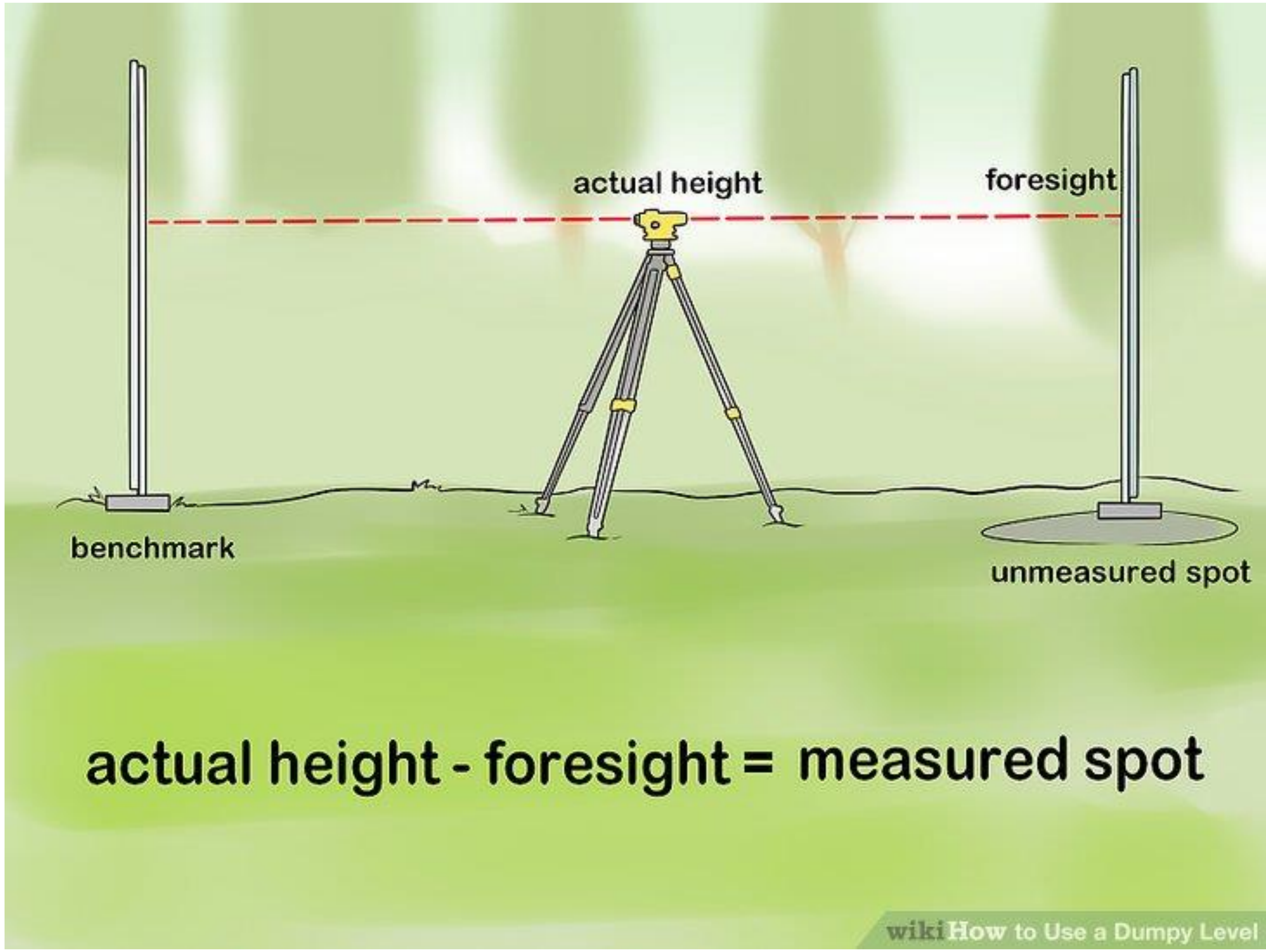
How to Use a Level

Find the height difference between your level and the unmeasured spot. Move your E staff so it sits directly on top of the spot you want to measure. Use your device's telescope to find the staff, then record whatever number the device's center, horizontal cross hair sits over



How to Use a Level

Calculate the spot's actual height using your level's height. Unlike with your previous calculation, you'll need to subtract your foresight measurement from your dumpy level's actual height. This will give you the height of the spot you measured



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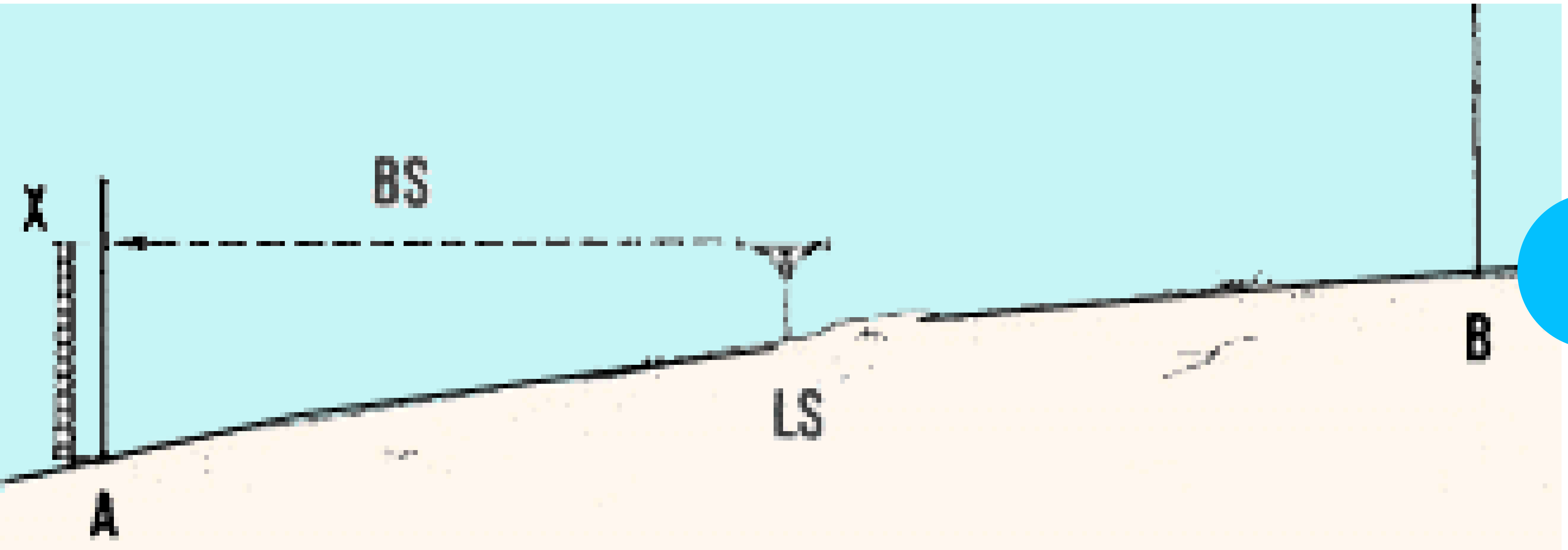
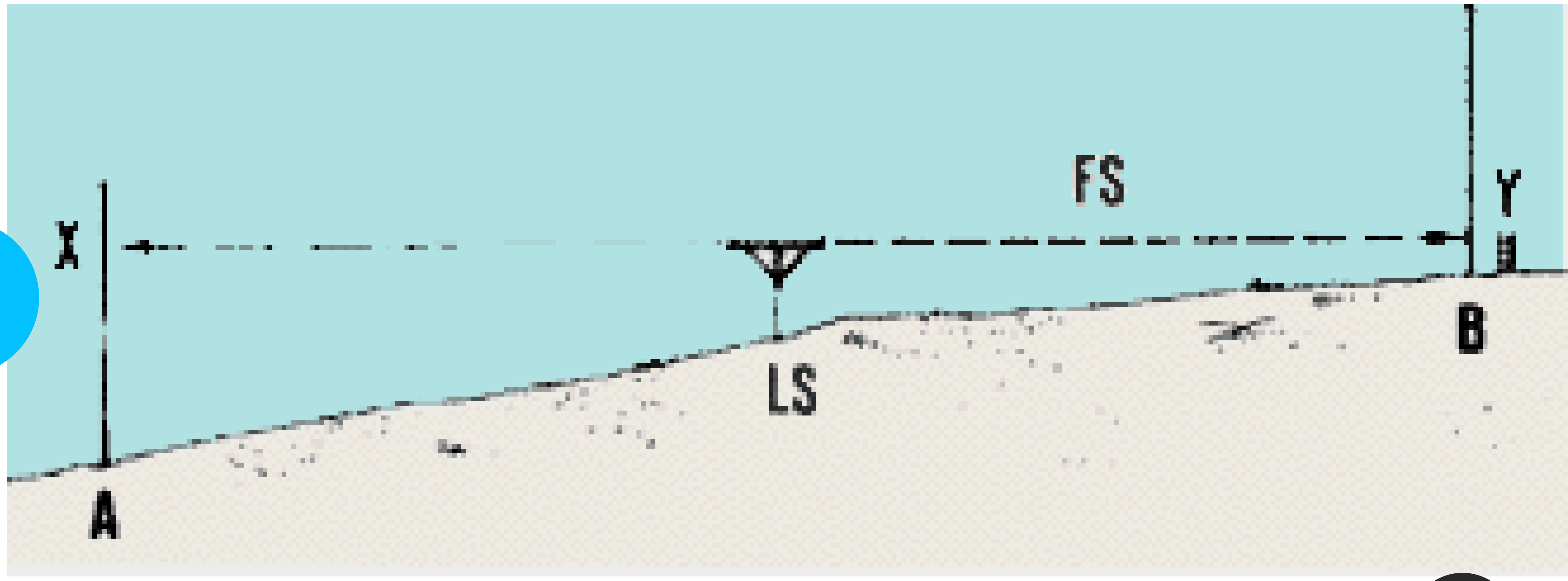
What is differential levelling?

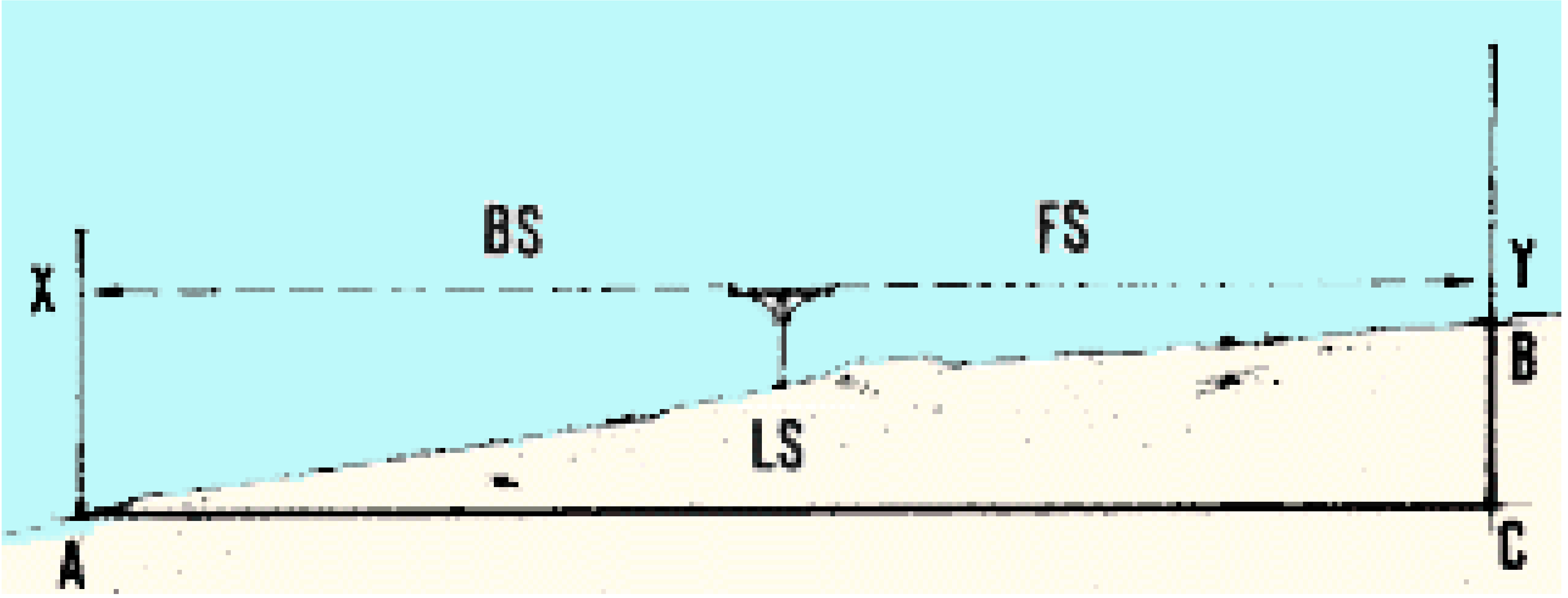


A and B , both you can see from one central levelling station, LS

- Sight with a level from LS at the levelling staff on point A. The point where the line of sight meets the levelling staff is point X. Measure AX. This is called a backsight (BS).

- Turn around and sight from LS at the levelling staff on point B. The point where the line of sight meets the levelling staff is point Y. Measure BY. This is called a foresight (FS).

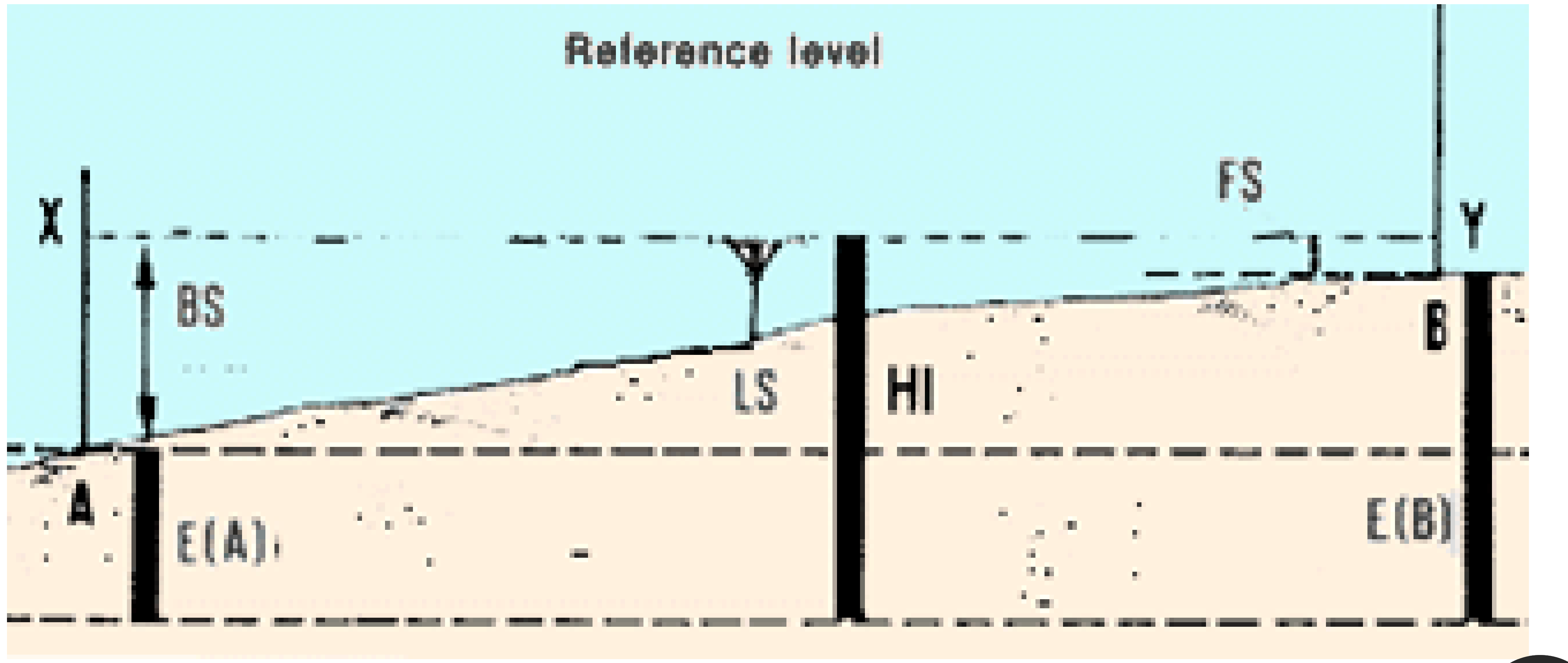




What is differential levelling?

- The difference in elevation between point A and point Be quals BC
- (AX- BY)
- (backsight BS - foresight FS).

- If you know the elevation of A, called E(A), you can calculate the elevation of B, called
- E(B)=BS -FS + E(A)
- The height of the instrument or the elevation of the line of sight directed from the level.
- BS + E(A) = HI



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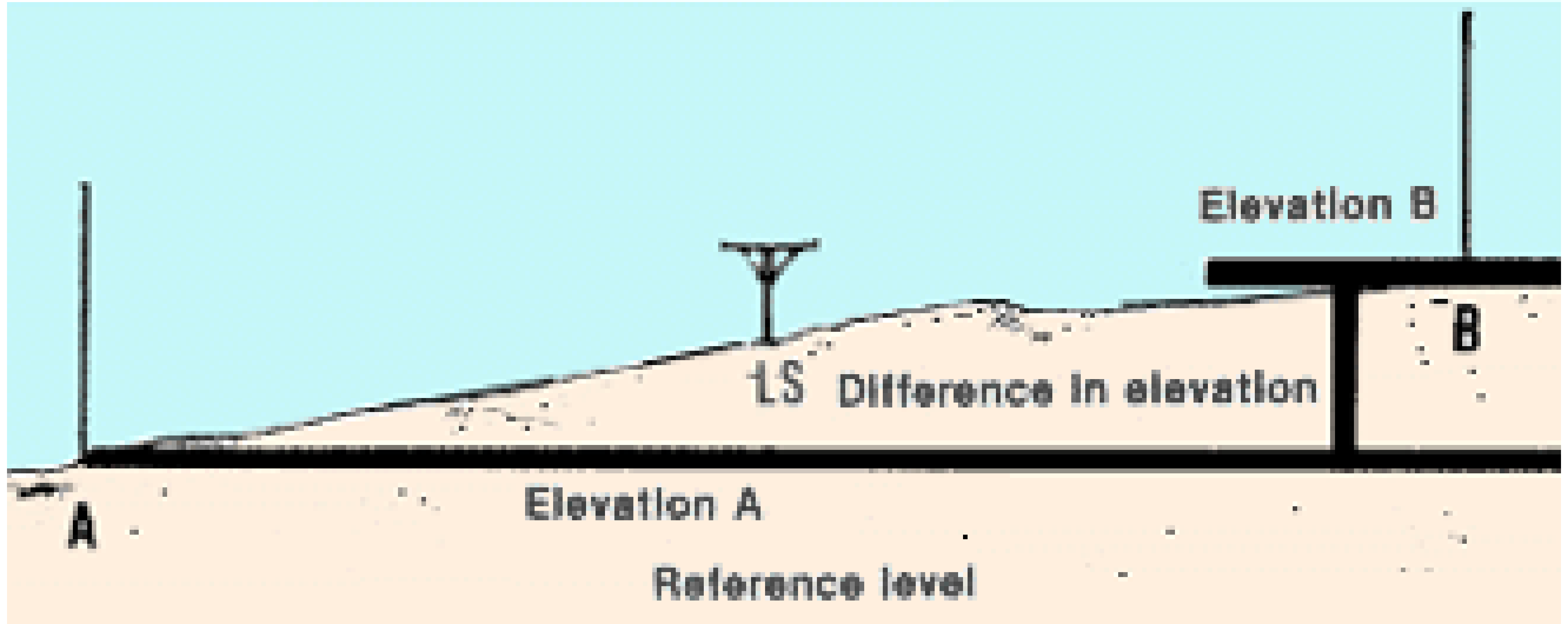
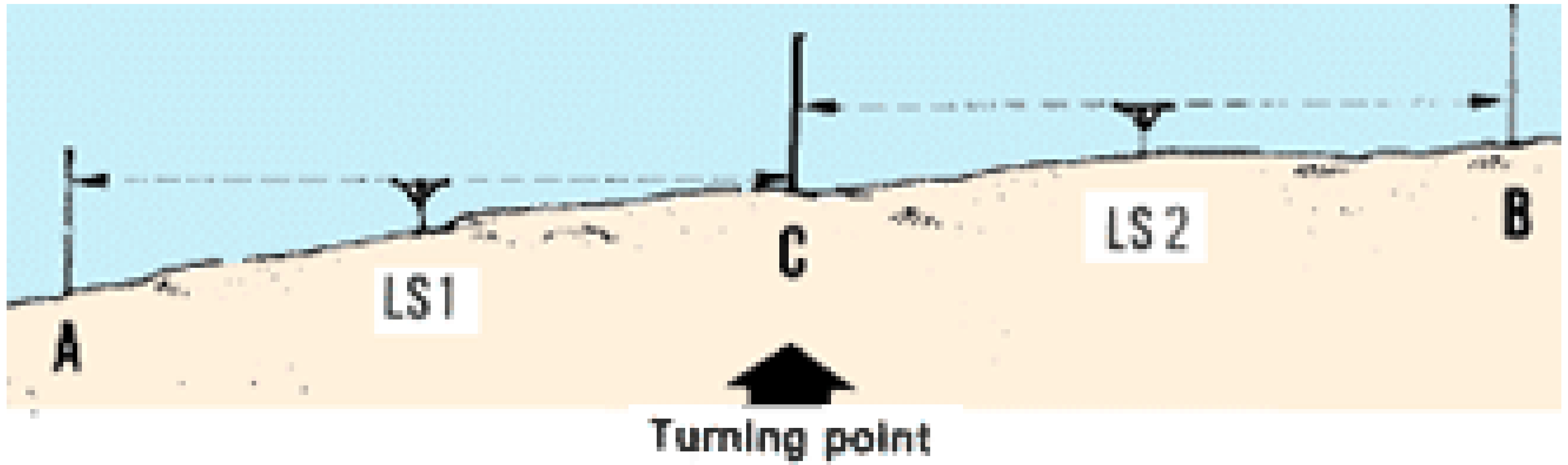


What is differential levelling?

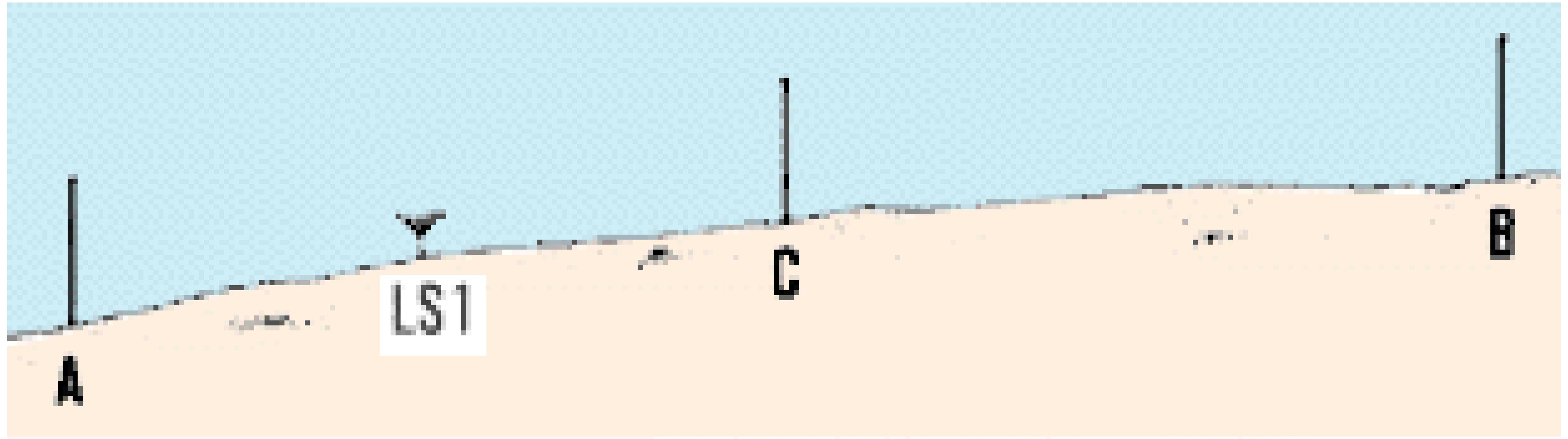
- the elevation at point B being equal to the height of the levelling instrument, minus the foresight.
- E(B) = HI - FS

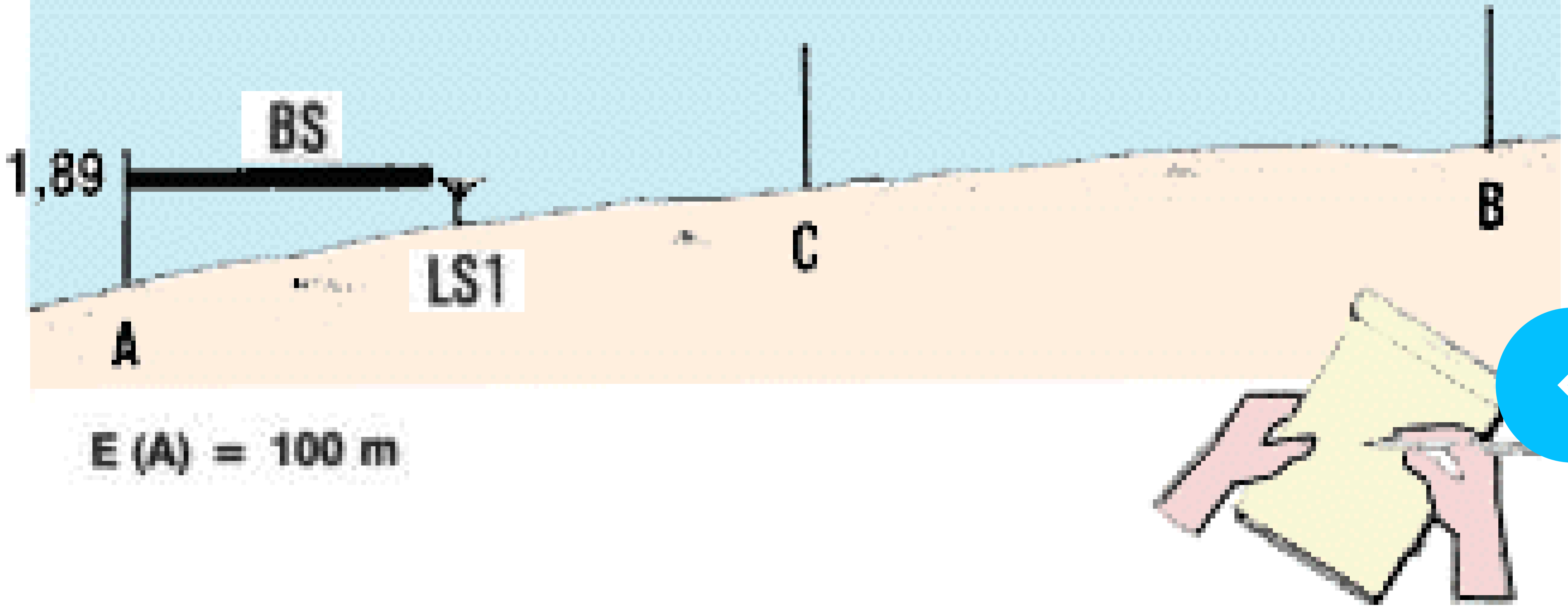
Surveying two points with one turning point

- Often you will not be able to see at the same time the two points you are surveying, or they might be far apart.
- In such cases, you will need to do a series of differential levellings . You will use intermediate temporary points called turning points (TP).



- You know the elevation of point A, E(A) = 100 m, and you want to find the elevation of point B, E(B), which is not visible from a central levelling station.
- Choose a turning point C about halfway between A and B. Then, set up the level at LS1, about halfway between A and C.

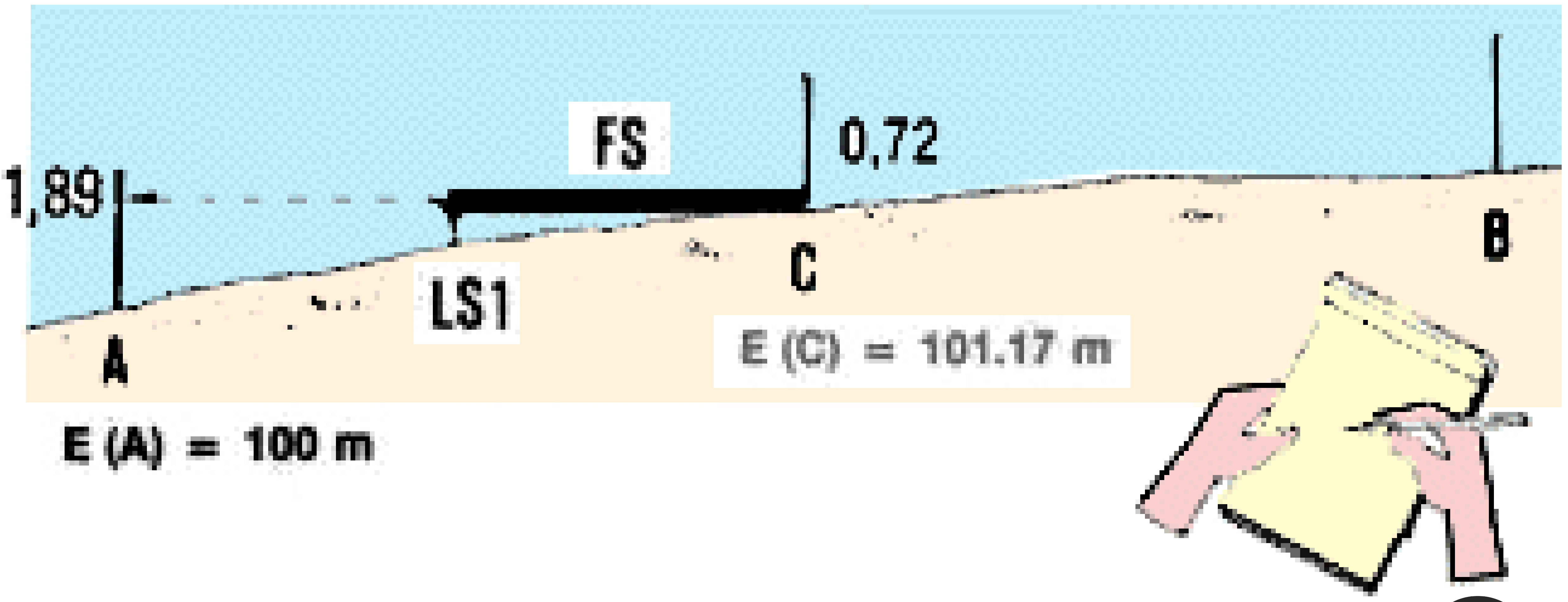


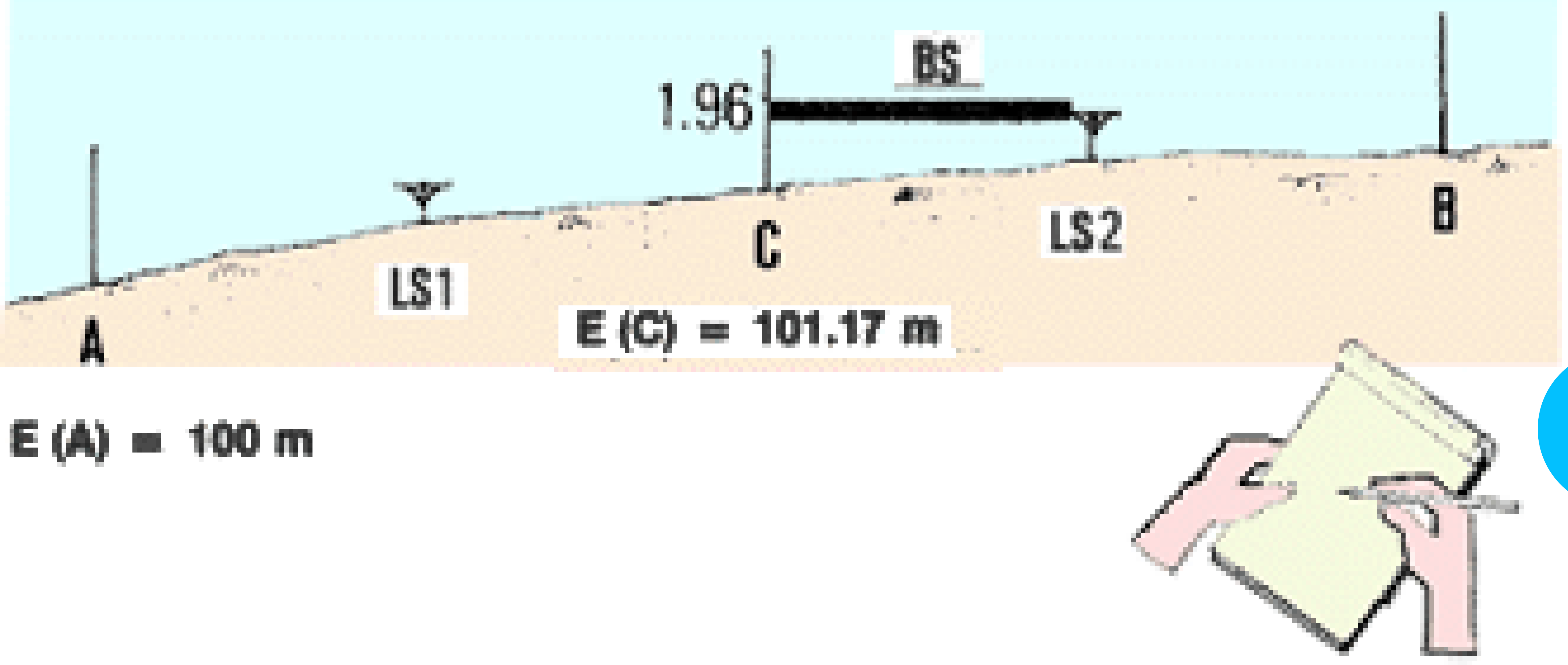


Surveying two points with one turning point

- Measure a backsight on A (for example, BS = 1.89 m).
- Measure on C a foresight FS = 0.72 m.

- Calculate Height of instrument
- HI = BS + E(A) = 1.89m + 100 m = 101.89 m.
- Find the elevation of turning point C as
- E(C)= HI-FS = 101.89 m - 0.72 m = 101.17 m.

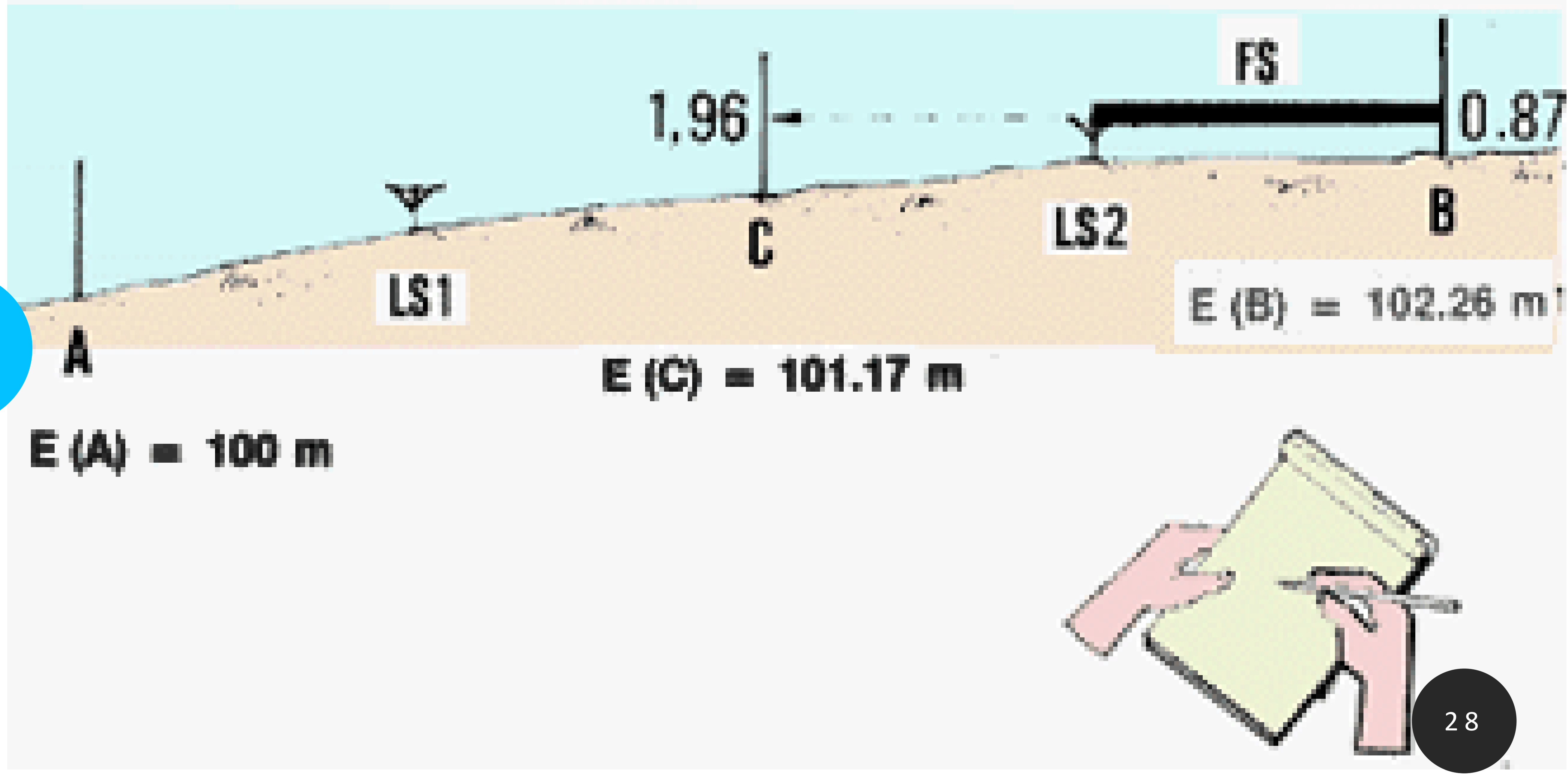




Surveying two points with one turning point

- Move to a second levelling station, LS2, about halfway between C and B.
- Set up the level and measure BS = 1.96 m, and FS = 0.87 m.

- Calculate Height of instrument
- HI = BS + E(C) = 1.96 m + 101.17 m = 103.13 m
- Find the elevation of turning point B as
- E(B) = HI- FS = 103.13 m - 0.87 m = 102.26 m



Surveying two points with one turning point

- You can make the calculations more easily if you record the field measurements in a table.
- You will not make any intermediate calculations. All BS's and all FS's must be added separately.
- The sum FS is subtracted from the sum BS to find the difference in elevation from point A to point B.
- A positive difference means that B is at a higher elevation than A.
- A negative difference means that B is at a lower elevation than A.

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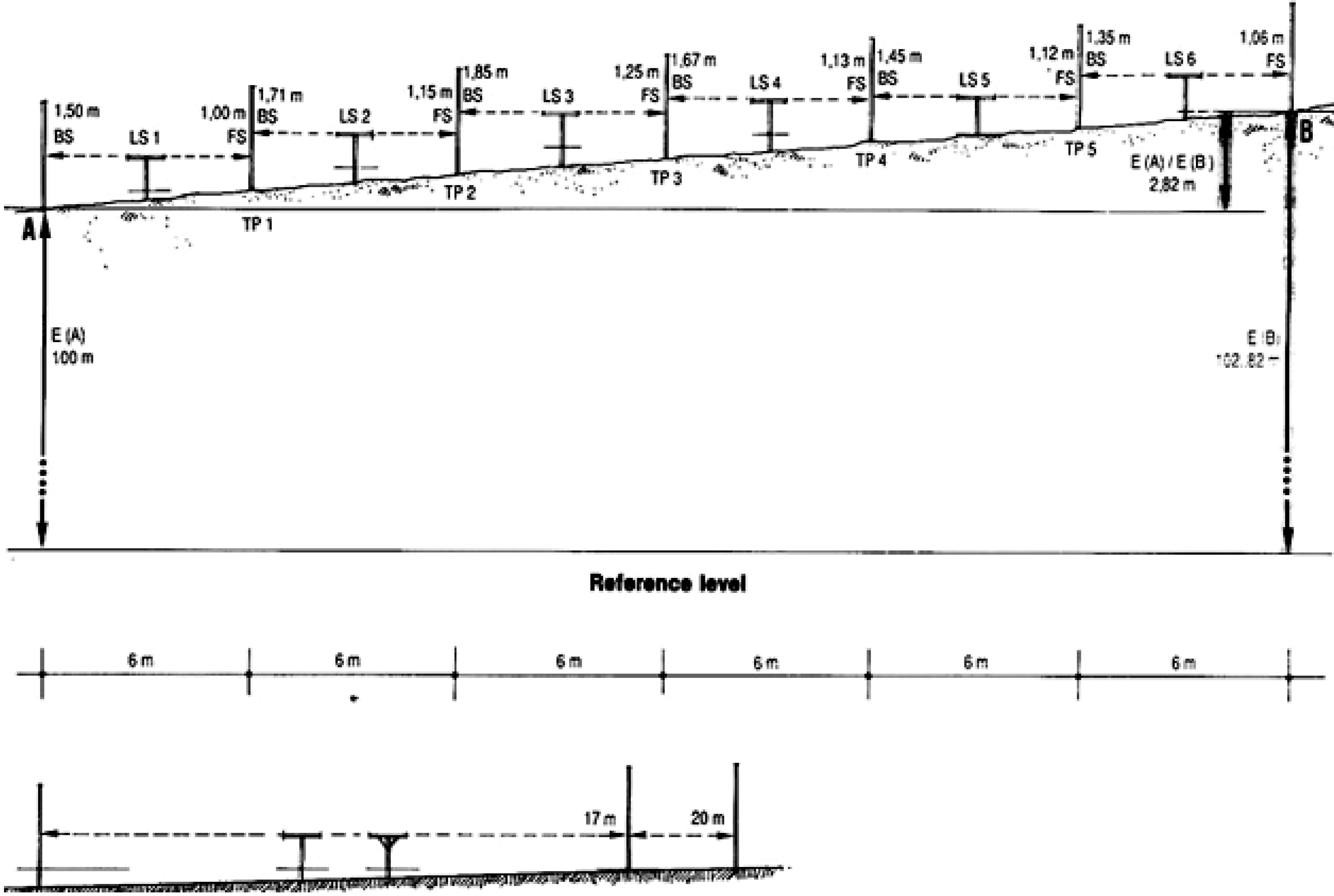
STAFF STATION	BR	IR	FR	R , F	RL	REMARKS
A	1.89				100.00	BM
C	1.96		0.72	1.17	101.17	TP
B			0.87	1.09	102.26	LAST
SUM	(3.85)		(1.59)	(2.26)	100.00	
CHECK	2.26			2.26	2.26	OK

STAFF STATION	BR	IR	FR	HI	RL	REMARKS
A	1.89			101.89	100.00	BM
C	1.96		0.72	103.13	101.17	TP
B			0.87		102.26	LAST
SUM	(3.85)		(1.59)		(100.00)	
CHECK	2.26				2.26	OK

Surveying two points using several turning points



Knowing the elevation of point A, you need to find the elevation of B. To do this, you need for example five turning points, TP1 ... TP5, and six levelling stations, LS1 ... LS6.

Surveying two points using several turning points

Points	BS	FS	(BS – FS)		Elevations	Remarks
	(+)	(–)	+	–	(m)	
A	1.50	–	–	–	100.00	Assumed elevation
TP1	1.71	1.00	0.50		100.50	Gate to farm
TP2	1.85	1.15	0.56	–	101.06	Paths' junction
TP3	1.67	1.25	0.60	–	101.66	Corner of maize field
TP4	1.45	1.13	0.54	–	102.20	Centre of path
TP5	1.35	1.12	0.33	–	102.53	Foot of large tree
B	–	1.06	0.29	–	102.82	Rock along path
Sums	9.53	6.71	2.82			
FS(–)	–6.71					
D(E)	+ 2.82					

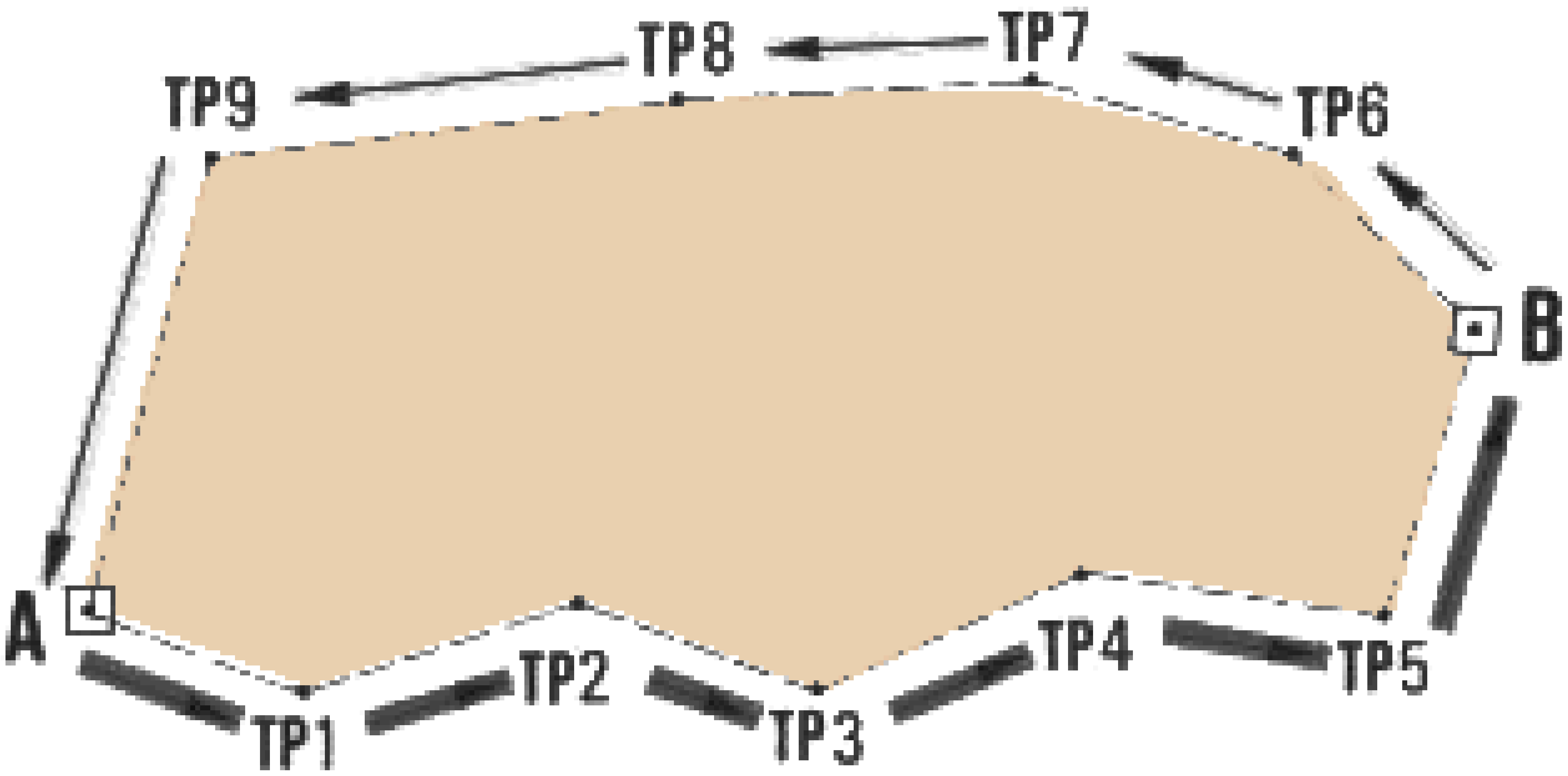
These two values should be the same

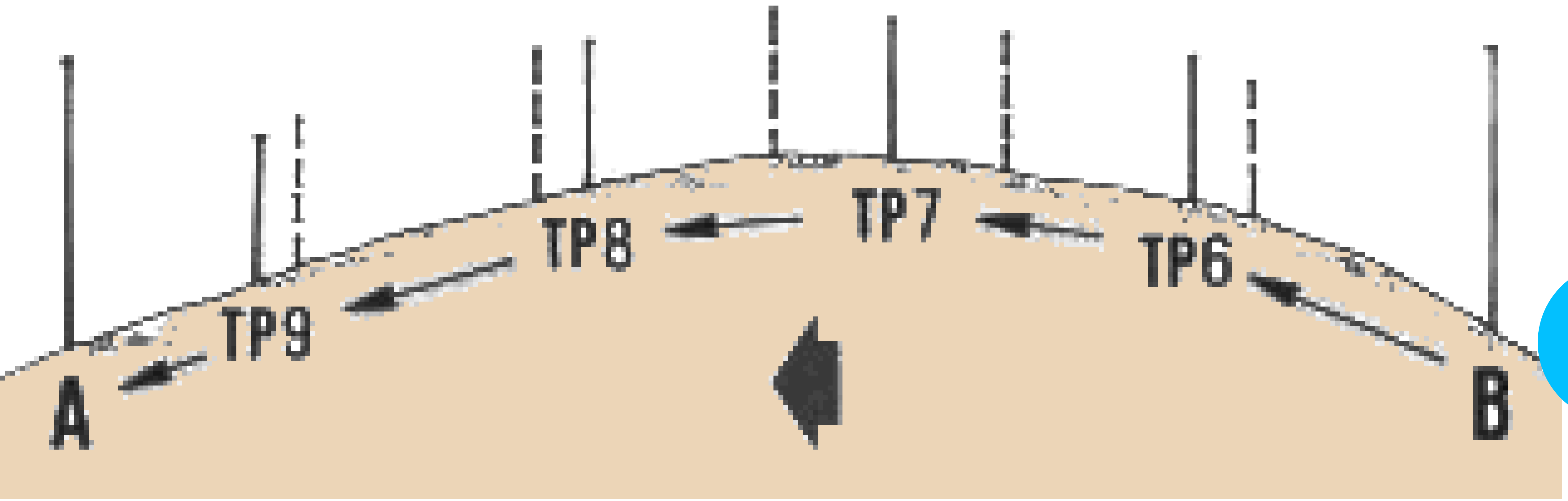
for each levelling station, measure a back sight (BS) and a fore sight (FS) , except:

- at starting point A, where you have only a back sight measurement.
- at ending point B, where you have only a fore sight measurement.

Checking on levelling errors

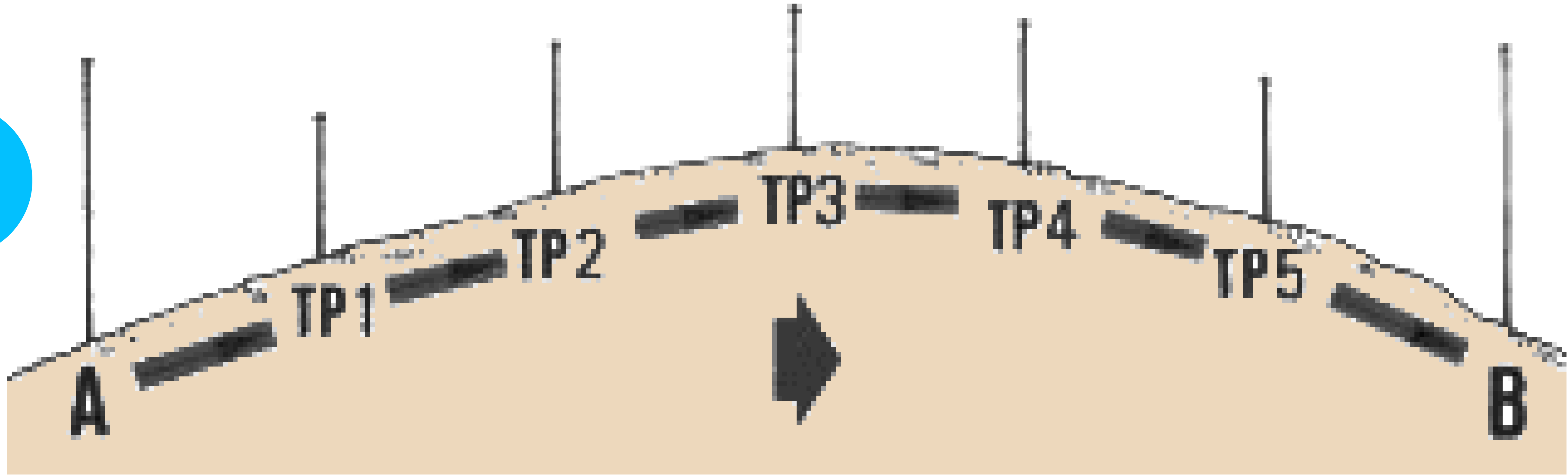
Checking on the arithmetic calculations does not tell you how accurate your survey has been. To fully check on your accuracy, level in the opposite direction , from the final point to the starting point, using the same procedure as before. You will probably find that the elevation of point A you obtain from this second levelling differs from the known elevation. This difference is the closing error .

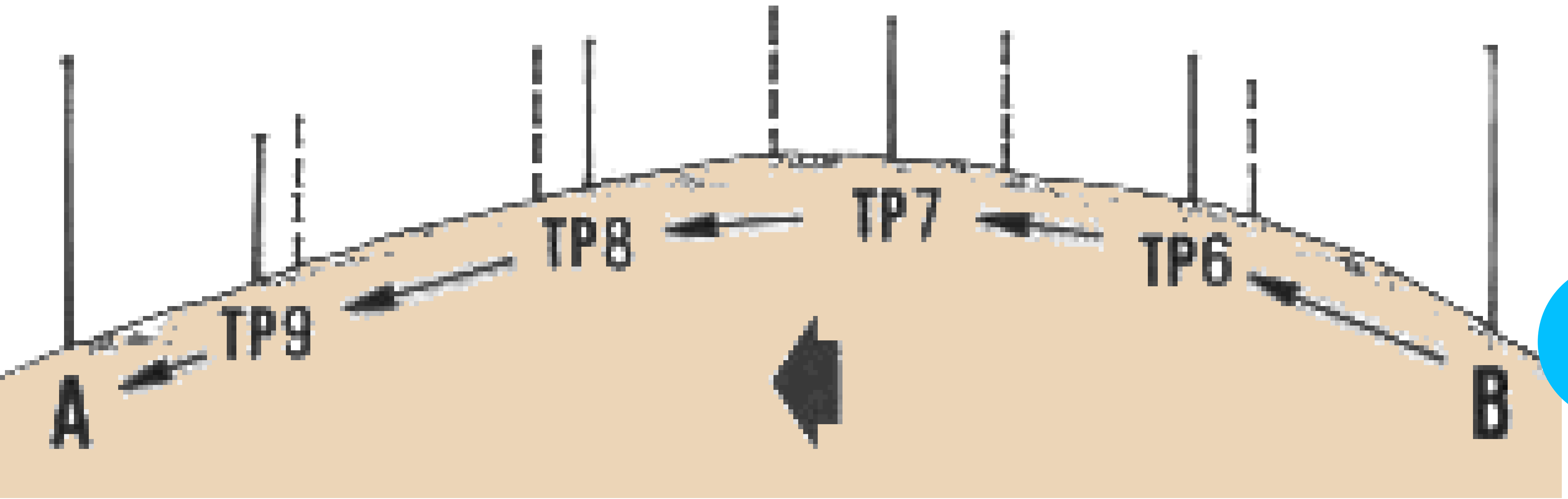




- From point A of a known elevation, survey by traversing through five turning points, TP1 ... TP5, and find the elevation of point B. To check on the levelling error, survey by traversing BA through four other turning points, TP6 ... TP9; then calculate the elevation of A. If the known elevation of starting point A is 153 m, and the calculated elevation of A at the end of the survey is 153.2 m, the closing error is 153.2 m- 153 m = 0.2 m.

- The closing error must be less than the permissible error, which is the limit of error you can have in a survey for it to be considered accurate. The size of the permissible error depends on the type of survey (reconnaissance, preliminary, detailed, etc.) and on the total distance travelled during the survey. To help you find out how accurate your survey has been, calculate the maximum permissible error (MPE) expressed in centimetres , as follows:





- Reconnaissance and preliminary surveys:
- MPE(cm) $= 10\sqrt{D}$
- Most engineering work:
- MPE(cm) $= 2.5\sqrt{D}$
- You have just finished a reconnaissance survey. Your closing error was 0.2 m or 20 cm, at the closure of a traverse 2.5 km + 1.8 km = 4.3 km long. In this case, the maximum permissible error (in centimetres) equals MPE(cm) $= 10\sqrt{3.4}$
- = 10 x 2.07 = 20.7 cm. Since your closing error is smaller than the MPE, your levelling measurements have been accurate enough for the purposes of a reconnaissance survey.
- where D is the distance surveyed, expressed in kilometres