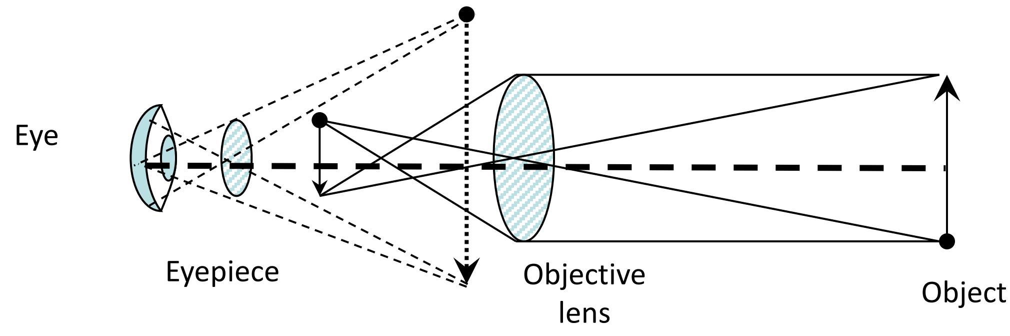
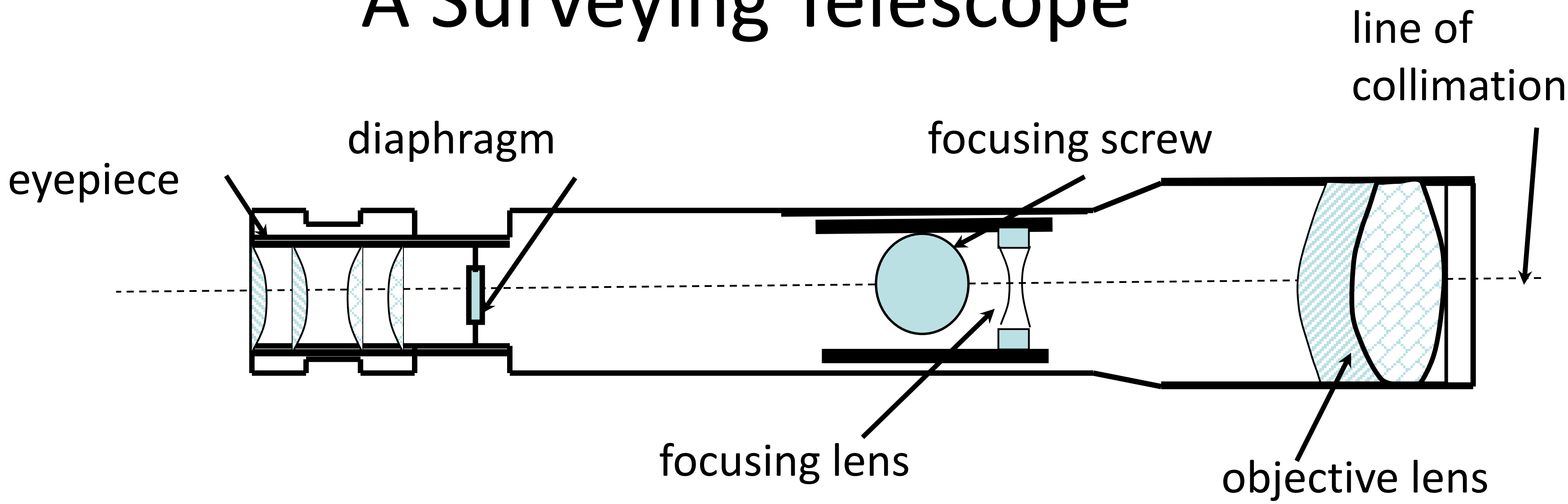
A Surveying Telescope

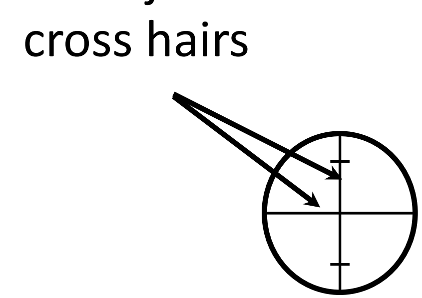


In its simplest form uses:

- Two convex lenses i.e. objective lens and eyepiece
- Rays from object (at distance more than focal length) throw objective lens constitutes real small inverted image
- Rays from inverted image (at distance less than focal length) throw eyepiece constitutes magnified and inverted virtual image

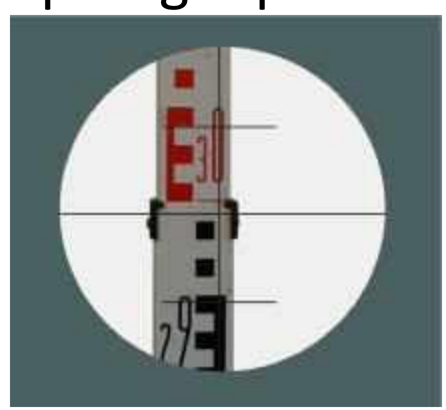
A Surveying Telescope

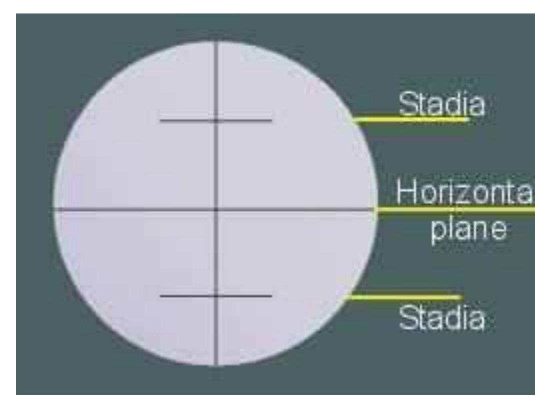




Eyepiece: Produces magnified image

Focusing lens: moves the image constituted by objective lens to be on the diaphragm plane





Focusing

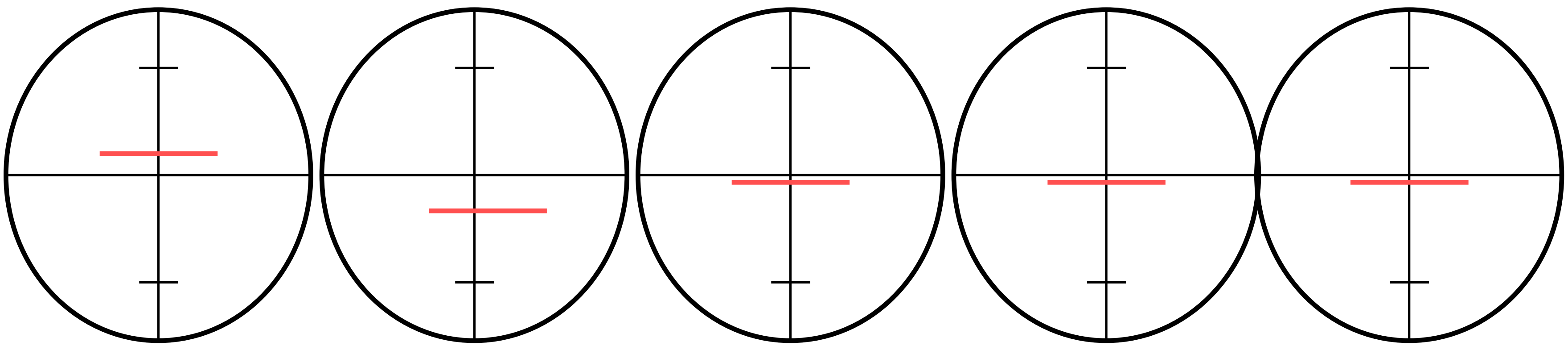
1. Rotate eyepiece to give a sharp, clear image of the cross hairs
2. Rotate focusing screw to give a sharp, clear image of the object being observed

The aim of focusing is to remove (eliminate) PARALLAX

When focussing any optical instrument it is vitally important that we eliminate Parallax.
Move the eye up and down (or from left to right) over the eyepiece of the telescope.

If the cross hairs move relative to the object being observed then Parallax exists and the focussing is not satisfactory.

Elimination of Parallax



Move eye up and down over the eyepiece

Images appear to move

Parallax has been removed
Therefore focussing is good

Parallax has been removed
Therefore focussing is good

Focus the crosshairs (using the Eyepiece)

Parallax exists and must be removed by better focussing

Focus the object (using the Focussing screw)

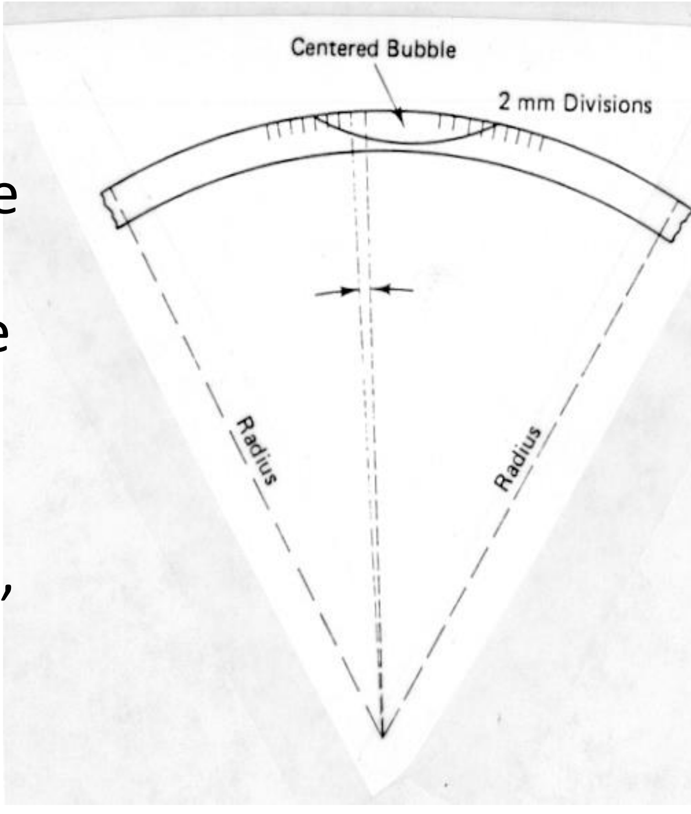
Parallax still exists and must be removed by better focussing

Level Bubble

- Accuracy of surveying equipment depends on the sensitivity of used circular and longitudinal bubbles
- Sensitivity is the angle corresponding to one division of bubble with length 2mm. It is related to the radius of bubble curvature
- Sensitivity= angle of tilt / one division of scale on glass

$$Sensitivity = \frac{\text{division(2mm)}}{\text{radius of curvature}}$$

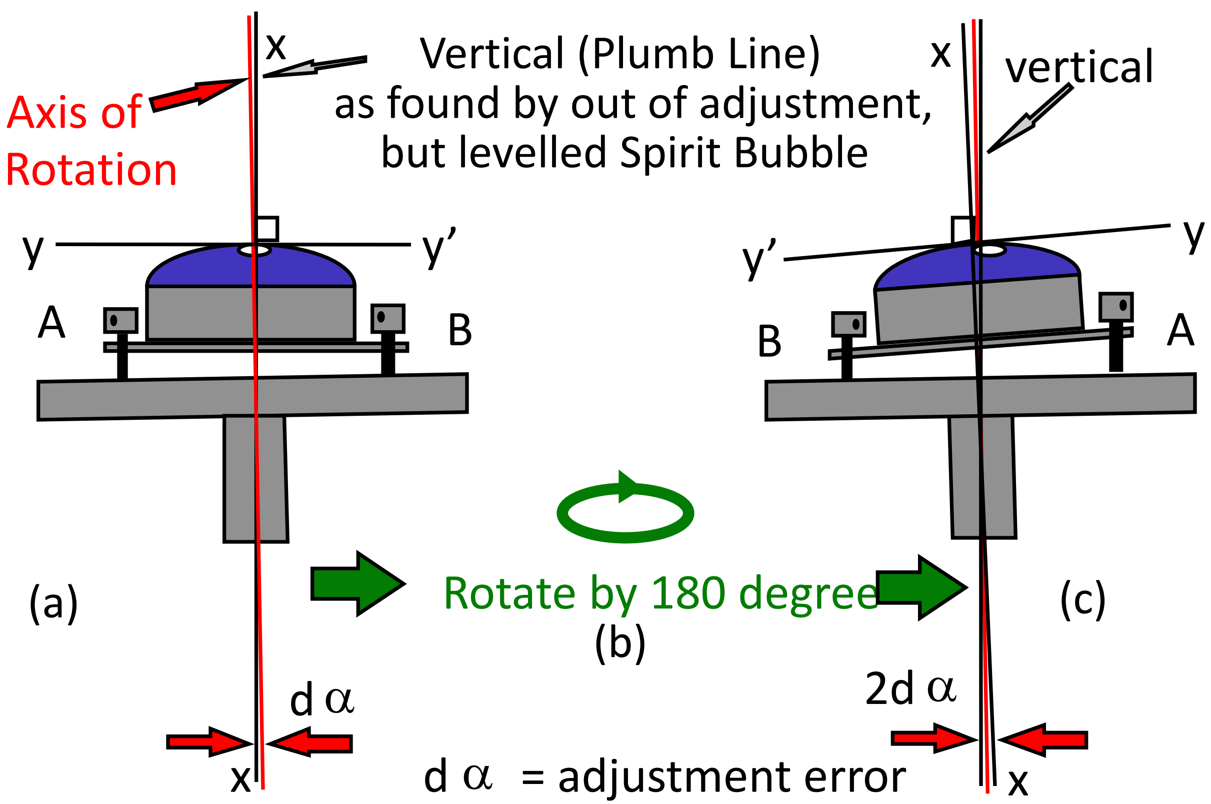
-



- Example: If it takes 20" of arc to move the bubble by 2 mm then the radius of curvature is 20 m.
- For first order leveling, the instruments have 2" bubbles (2" of arc to move the bubble 2 mm) with "206 m radius.
- Sensitivity of circular bubble around 15'
- Sensitivity of longitudinal bubble around 20"

Field Check of Level Instruments

(1) Check/Adjust Spirit Bubbles for 'vertical' axis to be plumb



Adjustment Procedure:

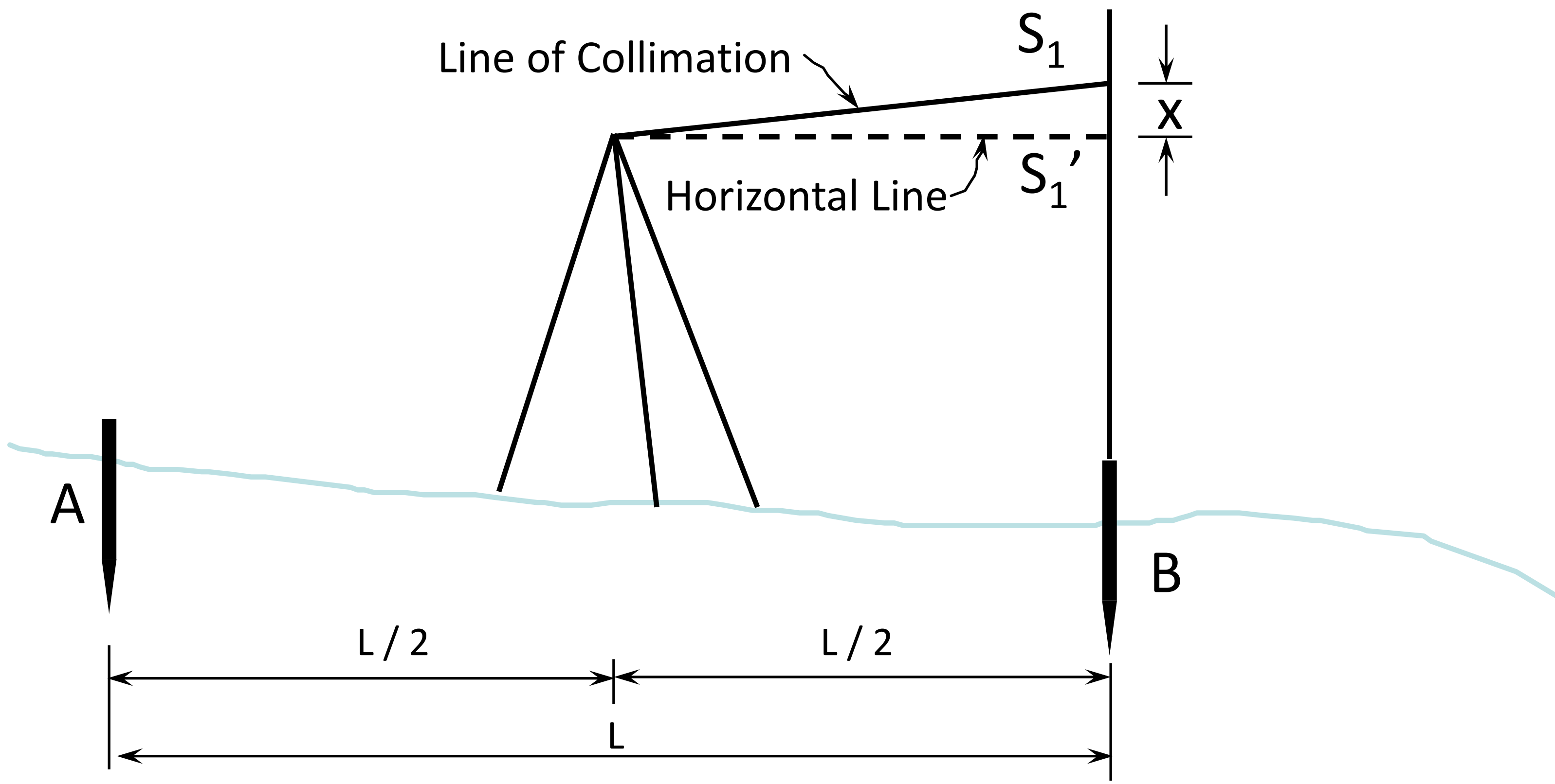
(a) Set up and level Instrument.

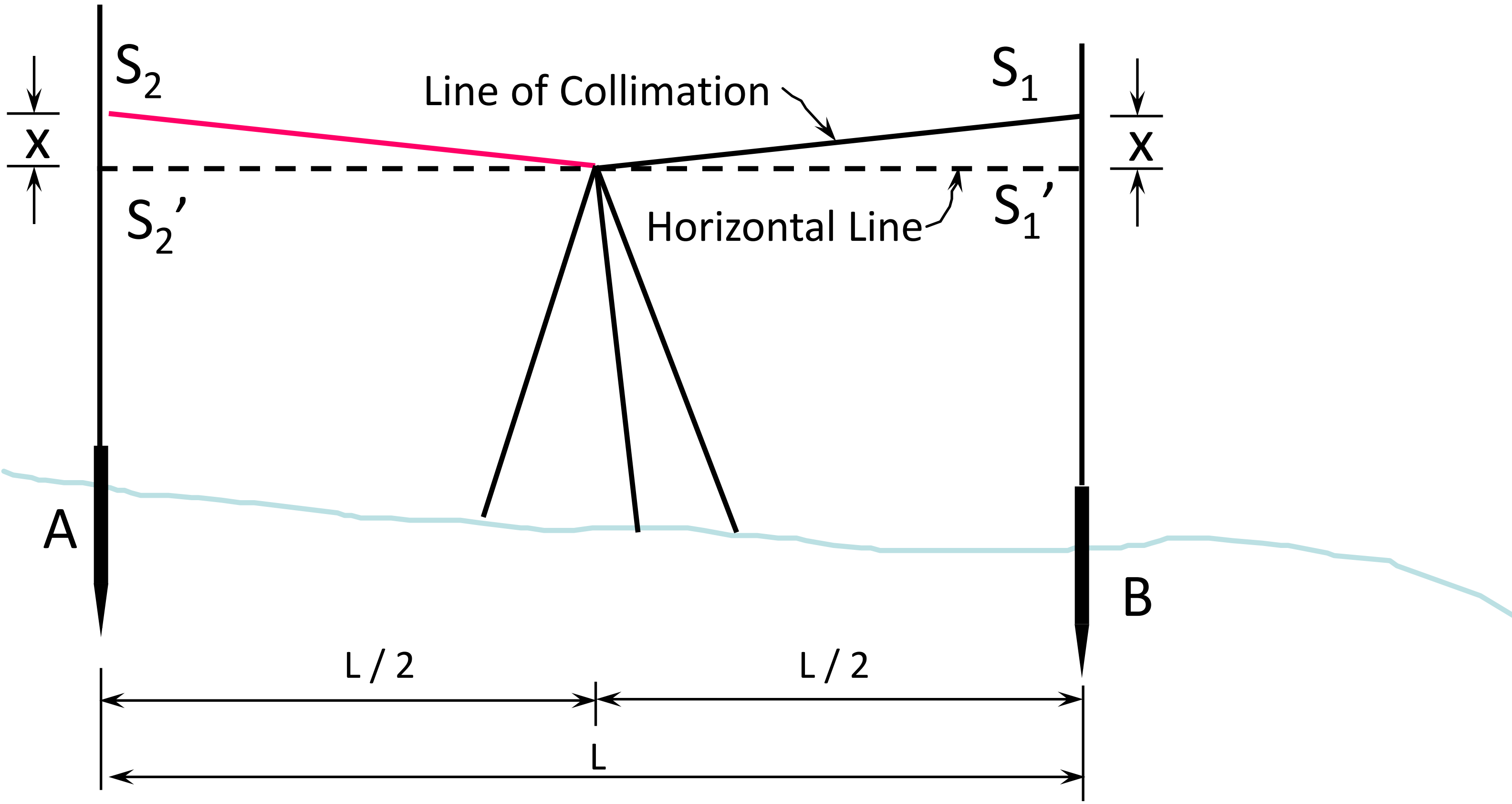
(b) Rotate Instrument by 180 degree.

(c) Air bubble now displaced by twice the amount of adjustment error.

(d) Remove 1/2 of displacement with foot screws, other 1/2 with bubble adjustment screws.

Two - Peg Test for a Level

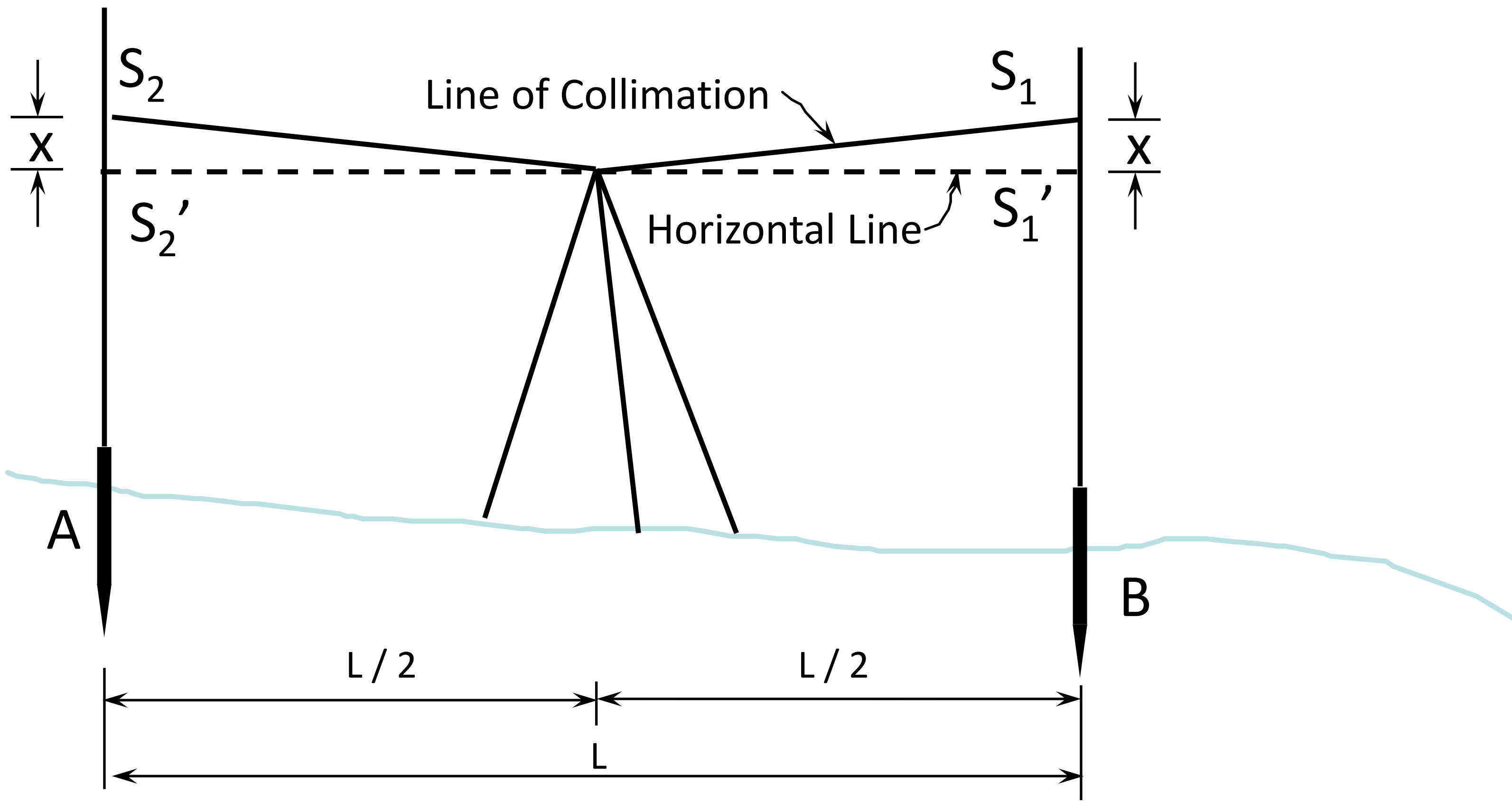




The TRUE height difference $\delta h_T = S_1' - S_2'$

The APPARENT height difference $\delta h_A = S_1 - S_2$

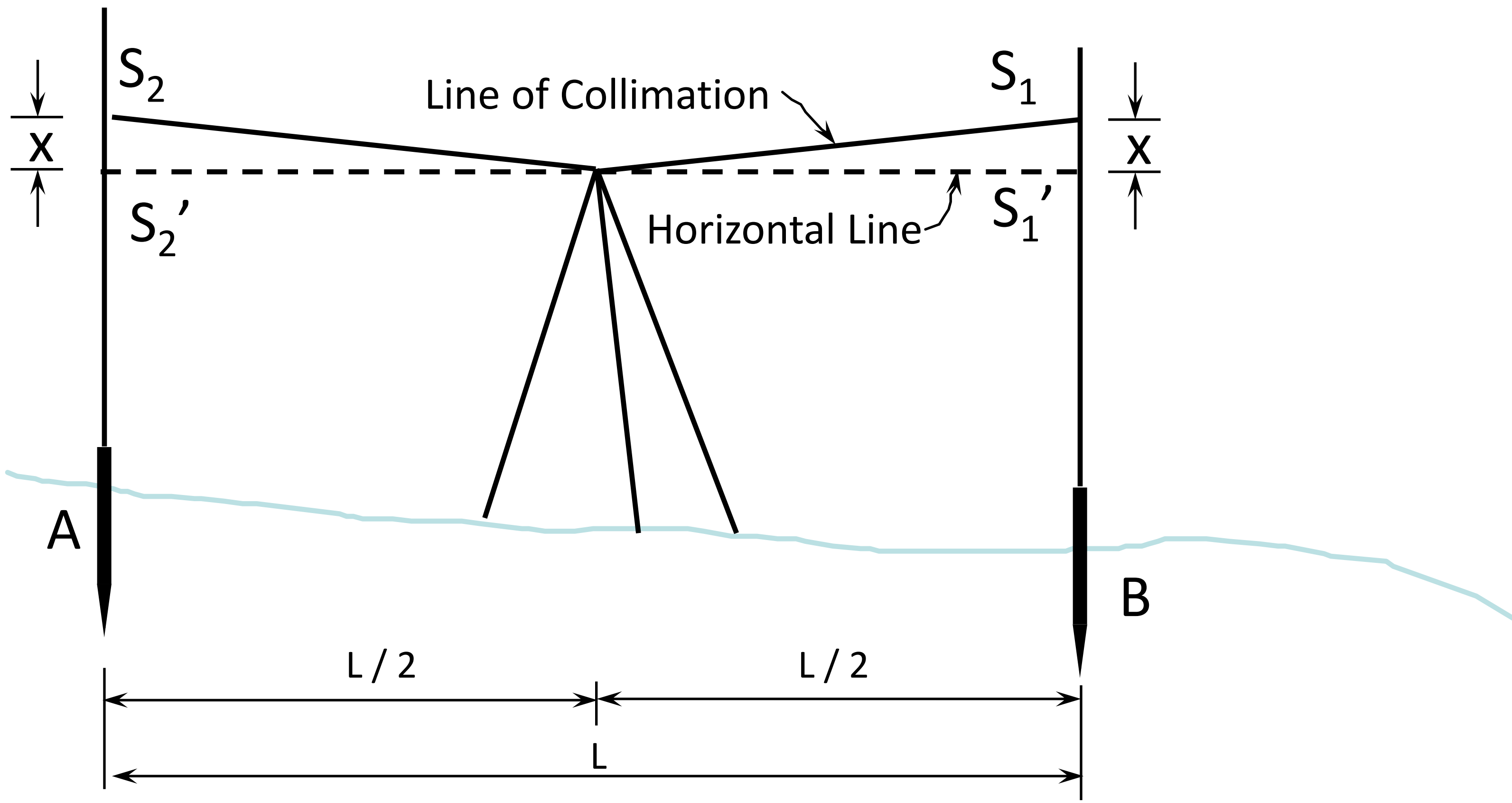
$S_1 = S_1' + x$ and $S_2 = S_2' + x$



The TRUE height difference $\delta h_T = S_1' - S_2'$

The APPARENT height difference $\delta h_A = S_1 - S_2$

$S_1 = S_1' + x$ and $S_2 = S_2' + x$ $\delta h_A = (S_1' + x) - (S_2' + x)$



The TRUE height difference $\delta h_T = S_1' - S_2'$

The APPARENT height difference $\delta h_A = S_1 - S_2$

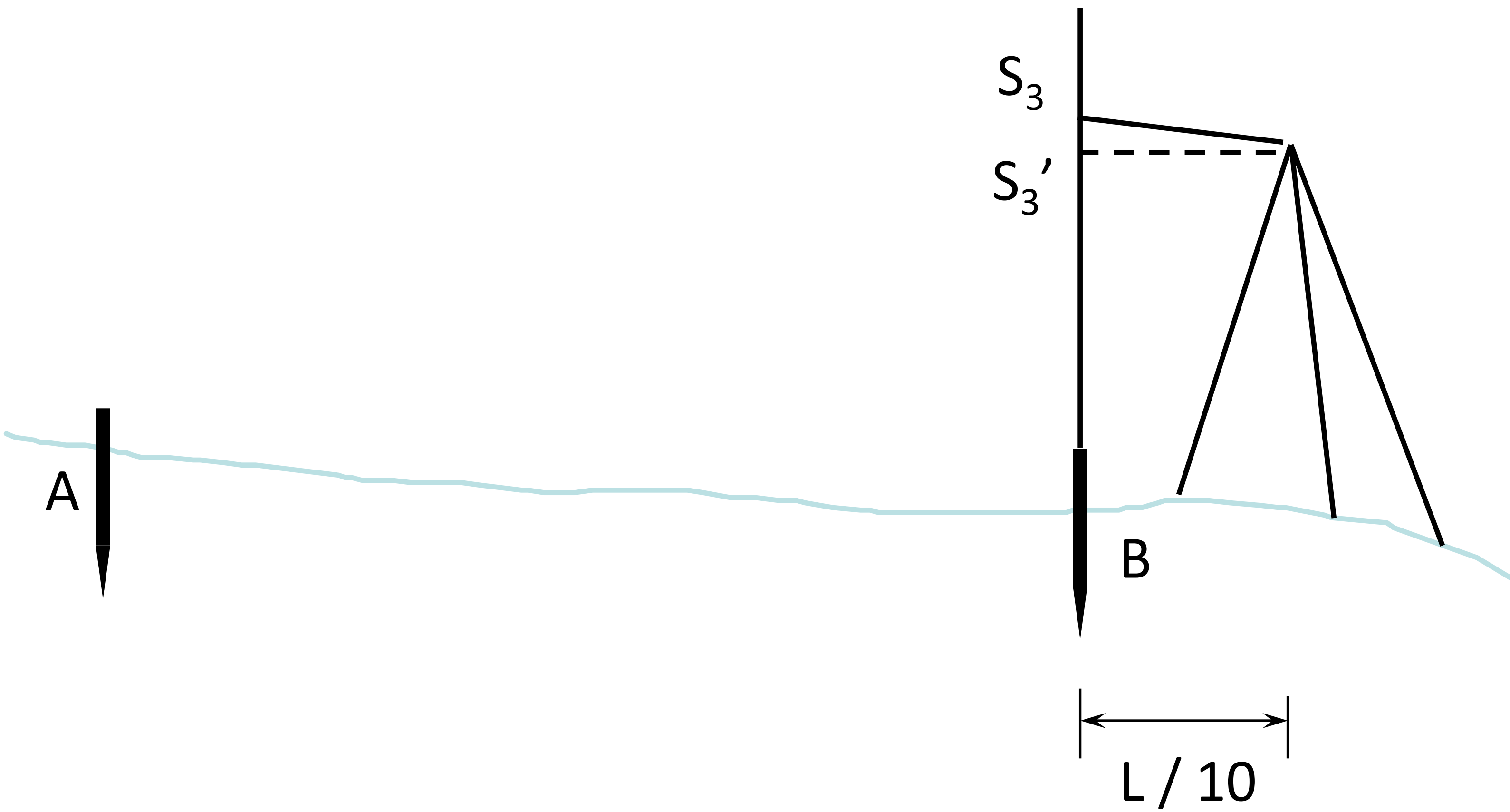
$S_1 = S_1' + x$ and $S_2 = S_2' + x$ $\delta h_A = S_1' - S_2' = \delta h_T$

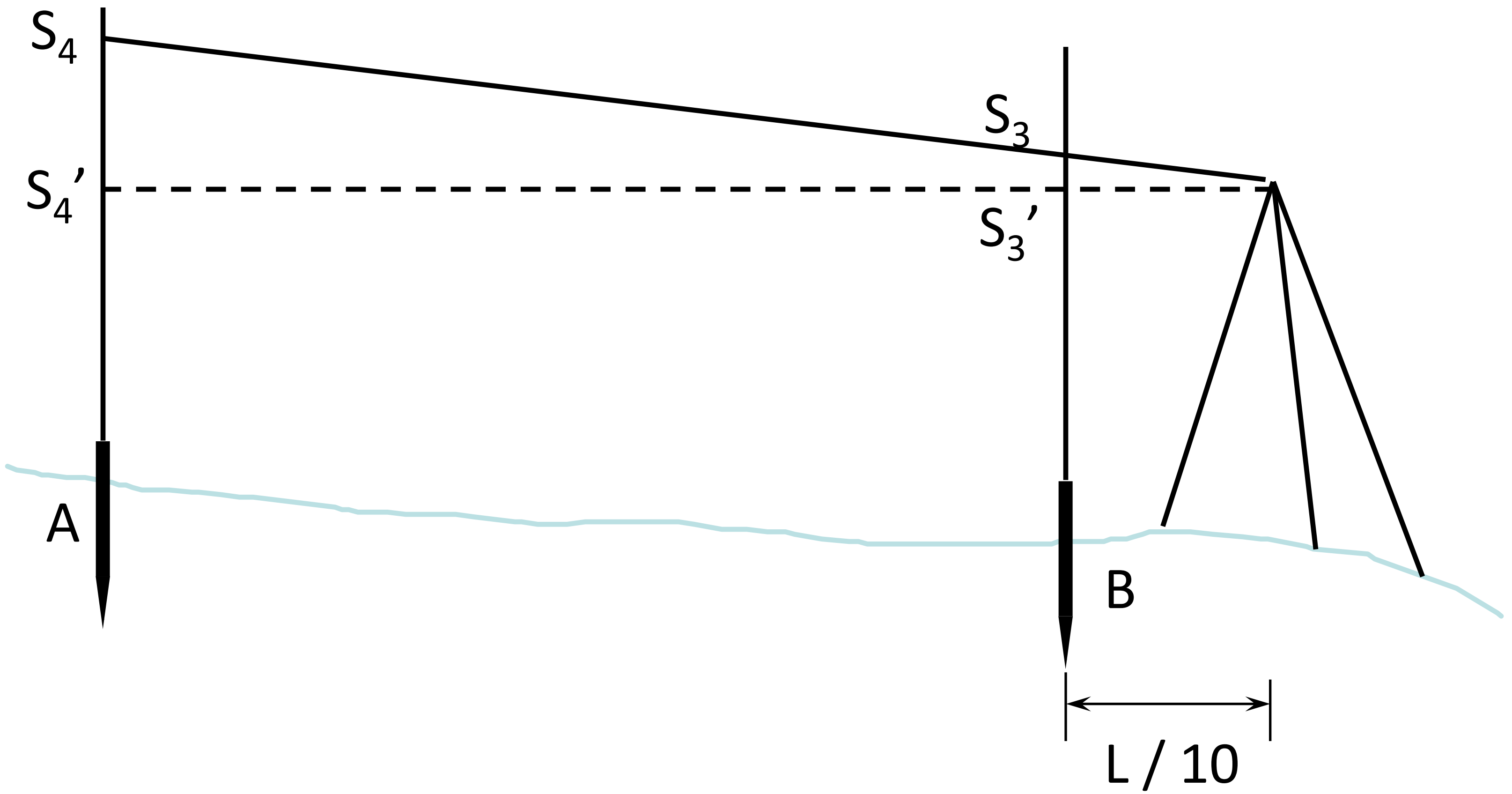
Therefore :

$$\delta h_A = \delta h_T$$

This is true since the instrument is the same distance from both staff positions and the errors x are equal and cancel out.

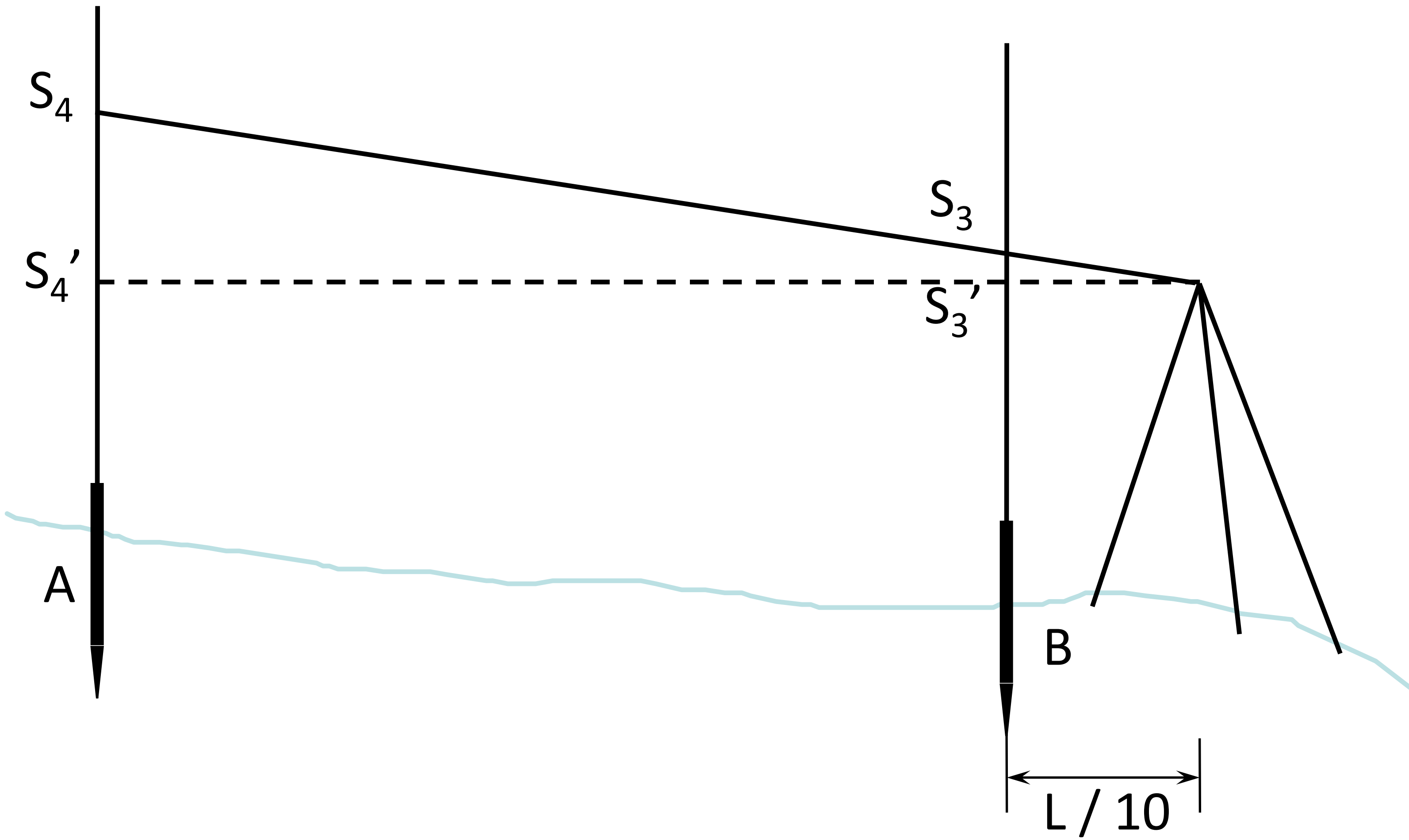
Now move the instrument outside the “odd numbered” peg





The APPARENT height difference $\delta h_A = S_3 - S_4$

But the TRUE height difference δh_T We already know is



The APPARENT height difference $\delta h_A = S_3 - S_4$

But the TRUE height difference $\delta h_T = S_1 - S_2$

Therefore if $\delta h_A = \delta h_T$ then the instrument is OK

If NOT then the error is e = $(S_1 - S_2) - (S_3 - S_4) \; / \; L$ mm / m

<u>Summary : Two - Peg Test</u>

Place two pegs about L = 30m (to 40m) apart.

Set up level midway between the two pegs.

Read staff on each peg, and calculate <u>true</u> height difference.

Move level about L / 10 = 3m (or 4m) beyond one of the pegs.

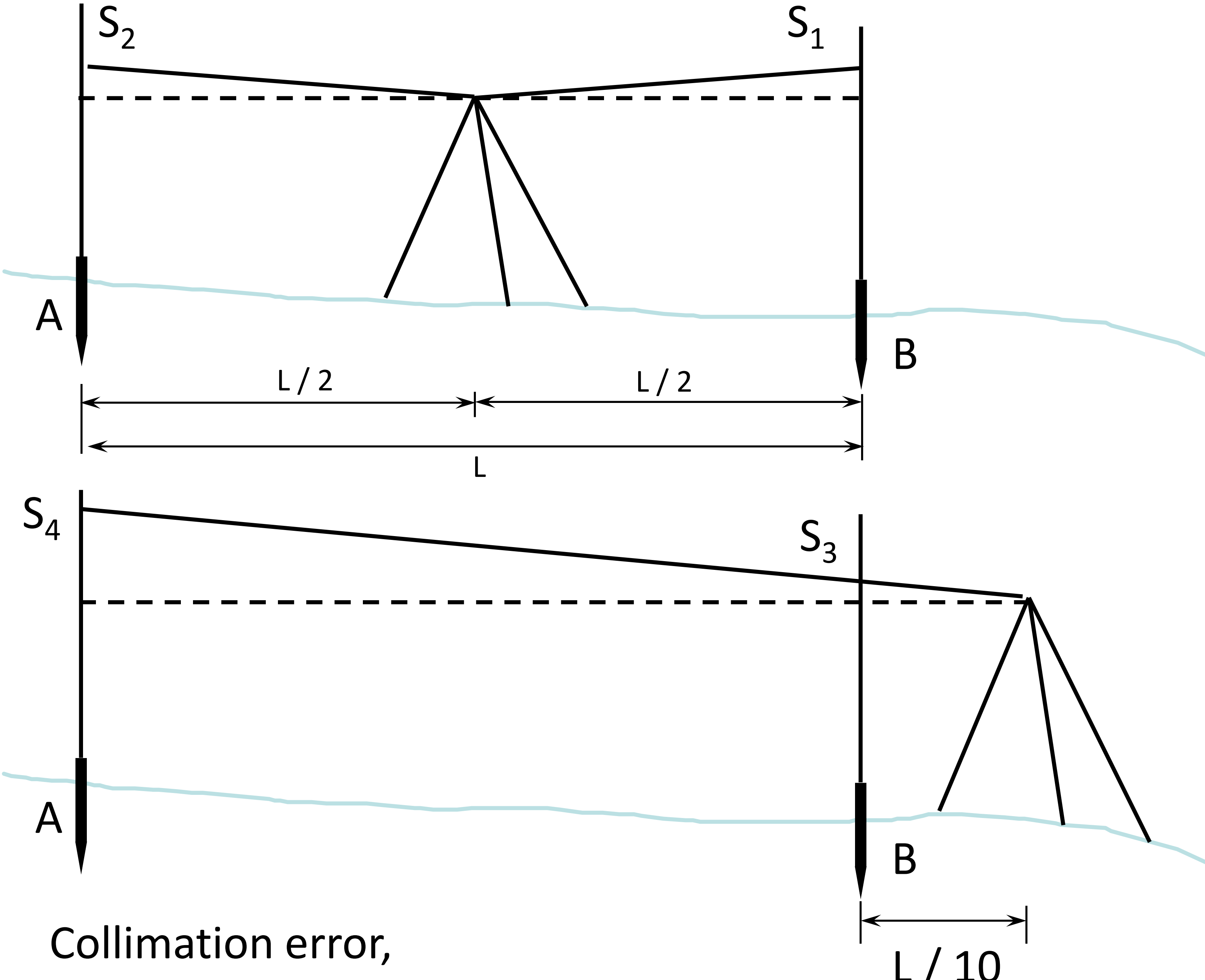
Read staff on each peg again, and calculate height difference.

> Collimation Error e = difference in the differences
> and is expressed as a number of mm per L m

<u>Acceptable errors</u>

Uren and Price 1mm per 20m

Test should be carried out regularly say once per week or two.



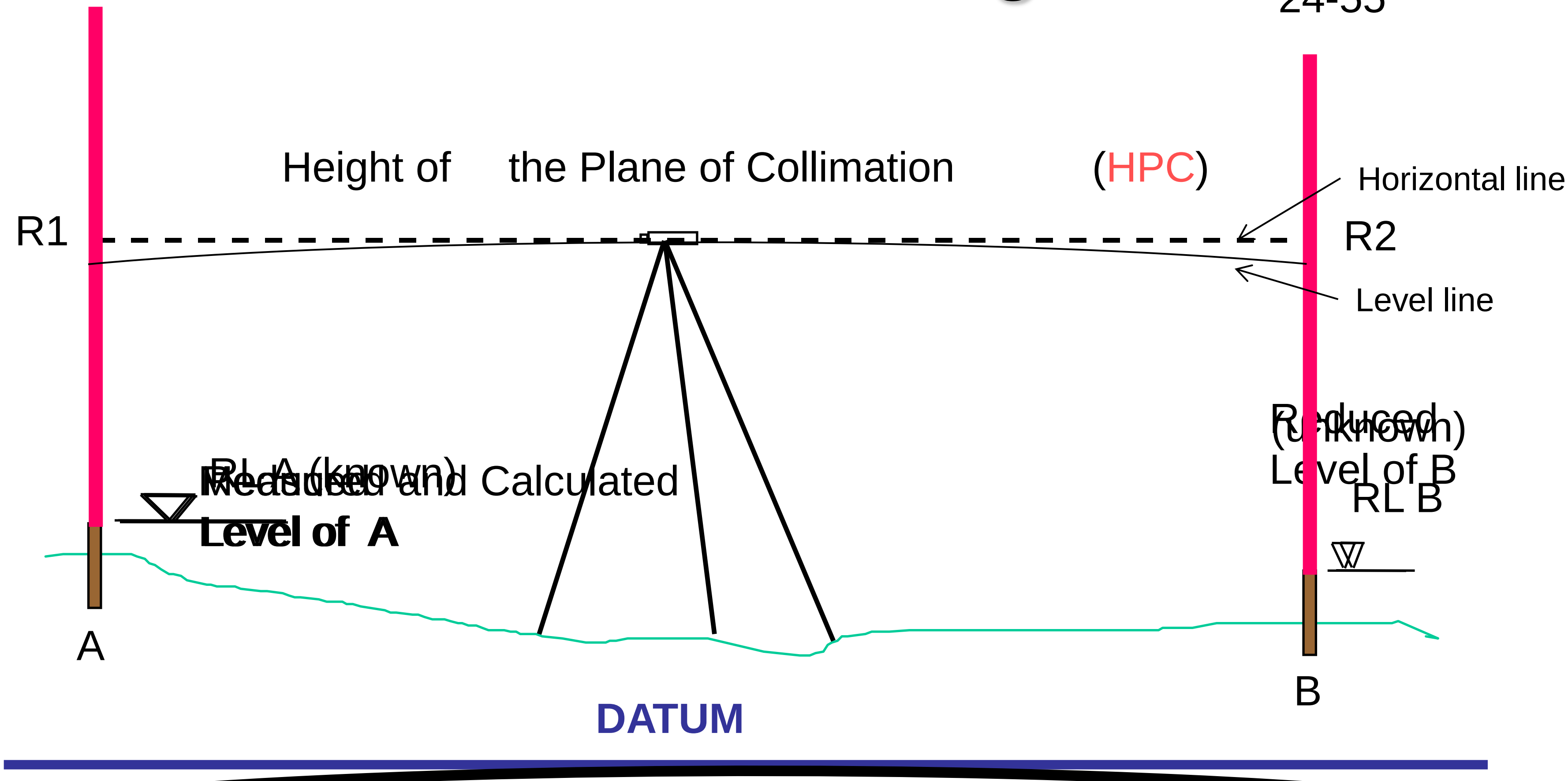
Collimation error,

$e = (S_1 - S_2) - (S_3 - S_4)$ mm / Lm

Levelling

Levelling Staff

Chapter 2
24-55



HPC = RL A + R1

RL B = HPC - R2

Effect of Earth Curvature

$$(R + c)^2 = R^2 + L^2$$

i.e.

$$R^2 + c^2 + 2Rc = R^2 + L^2$$

Therefore

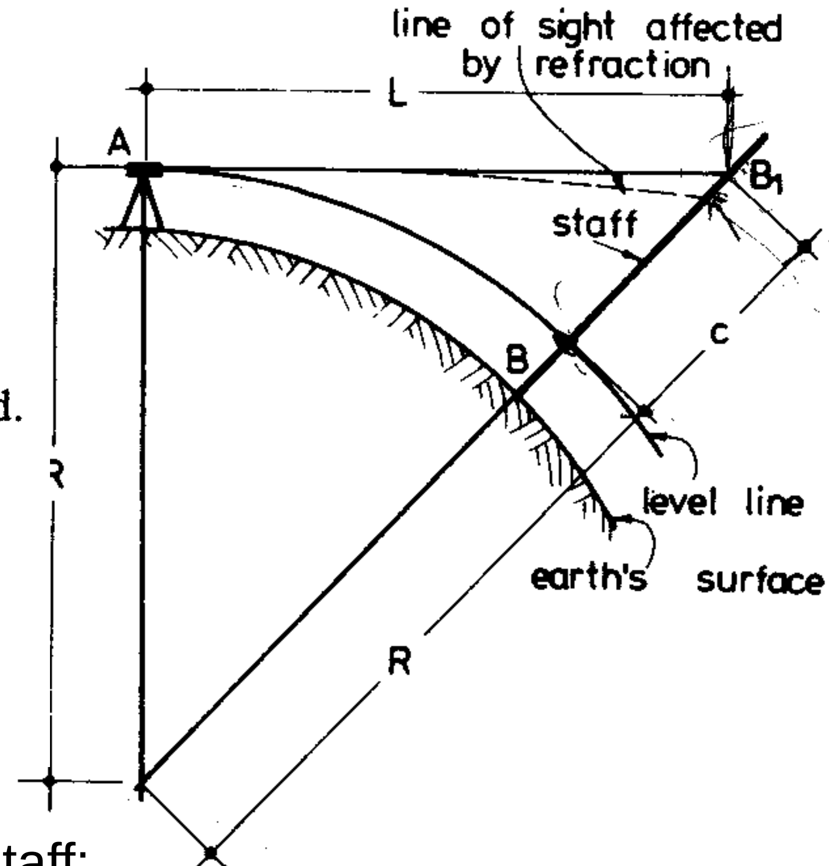
$$c(c + 2R) = L^2$$
$$c = L^2/(c + 2R)$$

Since c is so small compared with R, it can be ignored. Therefore,

$$c = (L^2/2R) \text{ kilometres}$$

i.e.

$$c = \left(\frac{L^2}{12\,740}\right) \text{ km}$$



Where L is distance between level and staff;
R is radius of Earth 6370km.

L (m)	20	40	50	60	80	100
Curvature Error (mm)	0	.12	.2	.28	.5	.78

1. The levelling specifications recommend the maximum distance between level and staff to be 50m due to:

- Reduce curvature error.
- Increase the ability to see the divisions of staff.

2. The levelling specifications recommend the level to be midway between first and last readings to:

- Reduce or eliminate curvature error.

- Reduce or eliminate line of sight error.