

Levelling Notes

Vertical Control

Site levels may be undertaken relative to a Local Datum or relative to Ordnance Datum Newlyn.

Vertical control is typically set out using an automatic level, whether optical, digital, or rotating laser level.

In the case of optical and digital levels, the level should be checked prior to use in case it is out of adjustment, this check is known as the two peg test. (see two peg test details)

Levels set using the GPS (GNSS) kit are typically not accurate enough for anything other than earthworks and even in that instance may not be considered accurate enough.

Total Stations can be used to set levels on site but the accuracy of the Total Station and distances being sighted over must be considered.

Using a 2 or 5 second Total Station may be considered accurate enough to use on site, a 20 second or even less accurate Total Station will not.

Levelling Datum's

The Level datum used, can include:

1. A Local Datum, for example, an arbitrary value on an existing floor level or manhole cover.
2. Ordnance Datum Newlyn, where levels are taken relative to an Ordnance Datum Bench mark and relate to mean sea level at Newlyn in Cornwall, the 0.000m mark for the datum.

Whichever Datum is used, the same methodologies are used to transfer the level to additional points.

The two levelling methods used when using a digital or optical level are:

1. The Rise and Fall method
2. Height of Collimation method

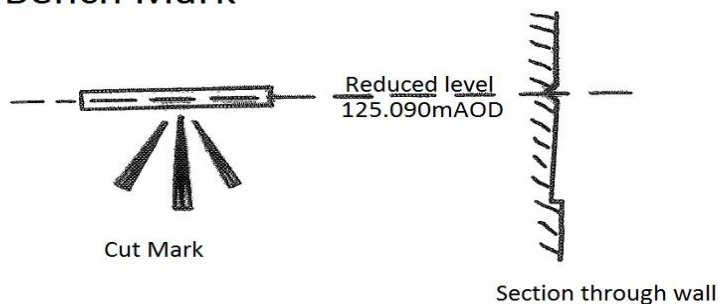
Ordnance Datum Newlyn



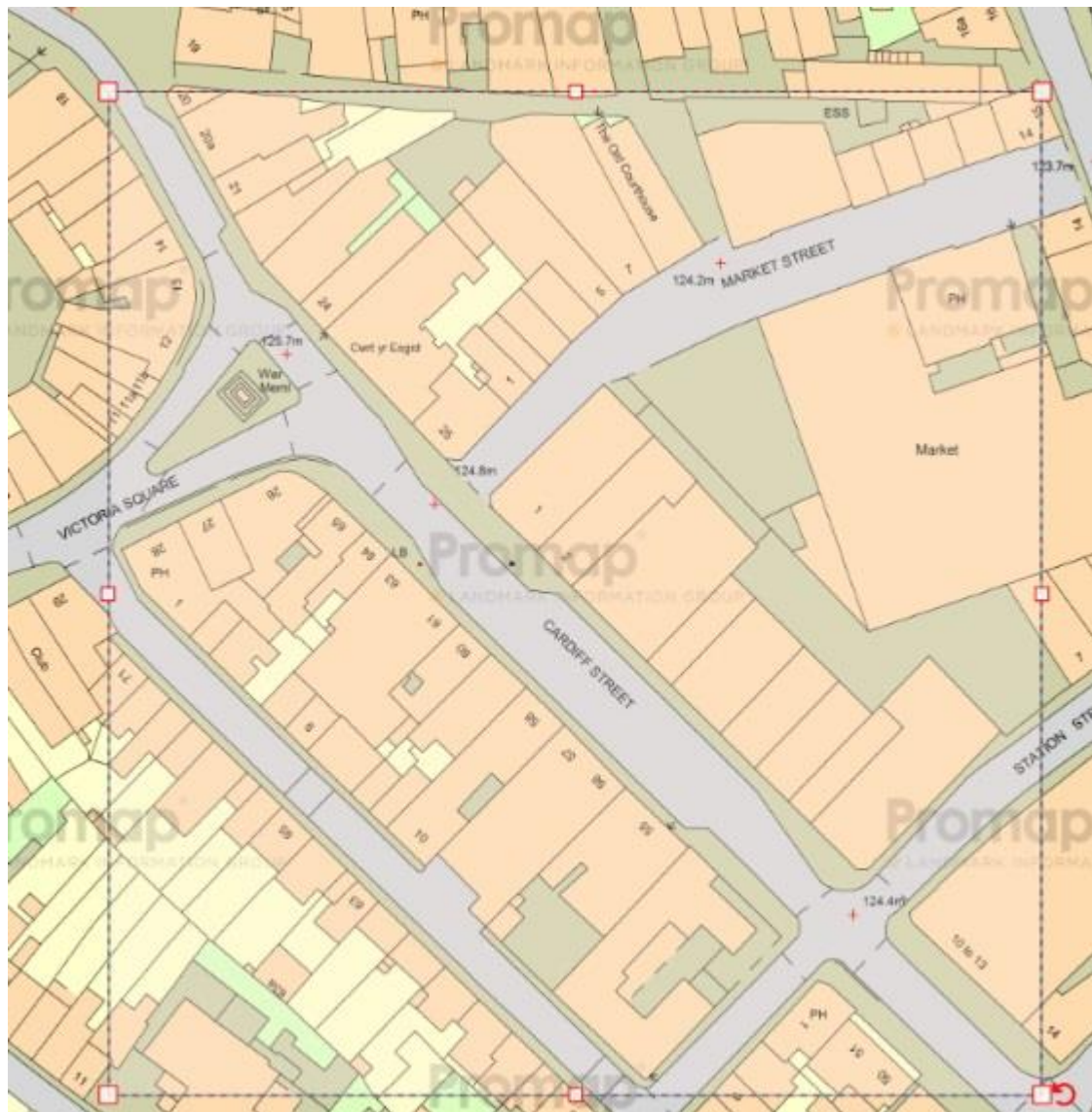
Ordnance Datum Bench Mark (OSBM) located on the boundary wall of the Court House, Aberdare.

In this instance the OSBM is a cut mark, although in other instances, it could be a rivet on a bridge parapet or flush bracket attached to the side of a building.

OS Bench Mark



Ordnance Survey Bench Marks, were previously shown on the Ordnance Survey (OS) mapping, now their location and values can only be located on the Ordnance Survey website, using the Bench Mark locator provided.



OSBM's not shown on current OS mapping, only the arrows identifying their location, however spot levels are shown to one decimal place.
(Aberdare town centre, 2023)

E26		PIVOT WINDOW SILL MIDLAND BANK NO55 CARDIFF ST NE FACE									
	A	B	C	D	E	F	G	H	I	J	K
1	Square	Easting	Northing	Mark type	Description	Height	Order	Datum	Verified year	Levelling year	Metres above ground
2	SO	2	244	CUT MARK	CARADOG INFT SCH NW FACE N ANG	145.009	3 N	1964		0	0.9
3	SO	4	228	CUT MARK	HO NO15 JOHN ST N ANG NW FACE	149.596	3 N	1964		0	0.5
4	SO	5	216	CUT MARK	HO NO20 TREVOR ST S ANG SE FACE	161.139	3 N	1964		0	0.4
5	SO	5	238	CUT MARK	WALL NO55 MONK ST SE FACE S ANG	143.625	3 N	1964		0	0.8
6	SO	6	262	CUT MARK	TH ABERDARE SE FACE E ANG	129.092	3 N	1964		0	0.3
7	SO	11	228	CUT MARK	NO16 MARY ST NE FACE	146.292	3 N	1964		0	0.6
8	SO	11	235	CUT MARK	HO NO60 YNYS LWYD ST E ANG SE FACE	142.04	3 N	1964		0	0.6
9	SO	12	268	CUT MARK	WALL NO4 MAENDY PLACE NE ANG	128.741	3 N	1964		0	0.5
10	SO	14	223	CUT MARK	NO34 TAN Y BRYN ST SE FACE E ANG	147.218	3 N	1964		0	0.5
11	SO	14	264	CUT MARK	PALLADIUM CIN SW FACE 2.1M S ANG	128.623	3 N	1964		0	0.5
12	SO	15	275	CUT MARK	NO8 SEYMOUR ST SE FACE	127.257	3 N	1964		0	0.1
13	SO	18	249	CUT MARK	EMPLOYMENT EX MONK ST NW FACE W ANG	133.1	3 N	1964		0	0.5
14	SO	19	280	CUT MARK	NO55 PEMBROKE ST SE ANG SE FACE	126.199	3 N	1964		0	0.5
15	SO	22	232	CUT MARK	ST MARGARETS JUNIOR MIXED SCH W ANG NW FACE	137.358	3 N	1964		0	0.4
16	SO	23	259	CUT MARK	TWR ST ELVANS CH JUNC N FACE TWR W FACE PORCH NW FACE	133.405	3 N	1964		0	0.9
17	SO	23	271	CUT MARK	NO19 WHITCOMBE ST SW FACE	126.388	3 N	1964		0	0.3
18	SO	24	219	CUT MARK	HO NO17 STUART ST E ANG SE FACE	142.637	3 N	1964		0	0.3
19	SO	28	222	CUT MARK	HO NO15 GLAN NANT ST E ANG SE FACE	137.407	3 N	1964		0	0.5
20	SO	28	263	CUT MARK	STO P ENT CH SW SIDE VICTORIA SQ JUNC WALLS NE FACE	126.757	3 N	1964		0	0.8
21	SO	29	279	CUT MARK	NBM DAIRY OPP NO29 SW SIDE GLOUCESTER ST 1.5M E ANG NE FACE	124.813	3 N	1964		0	0.5
22	SO	33	258	CUT MARK	BOOT HOTEL ABERDARE SW FACE W ANG	125.77	3 N	1964		0	0.4
23	SO	37	262	CUT MARK	WALL COURT HO N FACE 0.6M W OF N ANG	125.09	3 N	1964		0	0.4
24	SO	38	227	CUT MARK	NOS UPPER REGENT ST NW FACE	138.471	3 N	1964		0	0.7
25	SO	38	247	CUT MARK	SCH CROSS ST SE FACE 1.2M S ANG	127.669	3 N	1964		0	0.5
26	SO	38	250	PIVOT	PIVOT WINDOW SILL MIDLAND BANK NO55 CARDIFF ST NE FACE	125.971	3 N	1964		0	1.2
27	SO	41	223	CUT MARK	HO NO6 BOND ST 1.5M N ANG NW FACE	138.014	3 N	1964		0	0.4
28	SO	43	269	CUT MARK	BLDG 23A COMMERCIAL ST SW FACE 6.1M SE W ANG	124.432	3 N	1964		0	0.4
29	SO	44	231	CUT MARK	HO NO13 ALBERT ST SW FACE	136.438	3 N	1964		0	0.5
30	SO	44	260	CUT MARK	COWBRIDGE ARMS PH NW FACE N ANG	124.27	3 N	1964		0	0.5
31	SO	45	239	CUT MARK	HO NO42 BUTE ST 4.2M N ANG NE FACE	132.627	3 N	1964		0	0.6
32	SO	47	223	CUT MARK	CAPEL SOAR E ANG SE FACE	134.764	3 N	1964		0	0.4
33	SO	47	253	CUT MARK	PORCH TABERNACLE CH DUKE ST NE FACE N ANG	124.038	3 N	1964		0	0.8
34	SO	47	269	CUT MARK	IRON BRIDGE R CYNON NW PARA JUNC WALL SE FACE	125.37	3 N	1964		0	0.5
35	SO	48	200	CUT MARK	NBM GARAGE NW SIDE RD SE FACE E ANG	133.1	3 N	1965		0	0.5
36	SO	49	281	CUT MARK	WALL W SIDE LANE 3.0M N ANG BLDG E FACE	126.218	3 N	1964		0	0.5
37	SO	52	227	CUT MARK	GTP SE SIDE BETHUEL ST ENT UPPER MARDY LO NW FACE	133.268	3 N	1964		0	0.6
38	SO	53	275	CUT MARK	NO66 ABERNANT RD SW FACE 3.0M S ANG	124.871	3 N	1964		0	0.7
39	SO	54	232	CUT MARK	WALL ENT CLUB JUNC RDS NE FACE	124.45	3 N	1964		0	0.4
40	SO	62	224	CUT MARK	WALL SW SIDE CARDIFF RD 6M NW NO438 NE FACE	123.036	3 N	1964		0	0.8
41	SO	71	298	CUT MARK	WALL NO41 ABERNANT RD NW FACE N ANG	135.471	3 N	1964		0	0.3
42	SO	81	273	CUT MARK	NBM GIRLS GRAMMAR SCH ABERDARE SE FACE 1.8M E ANG	125.465	3 N	1965		0	0.9

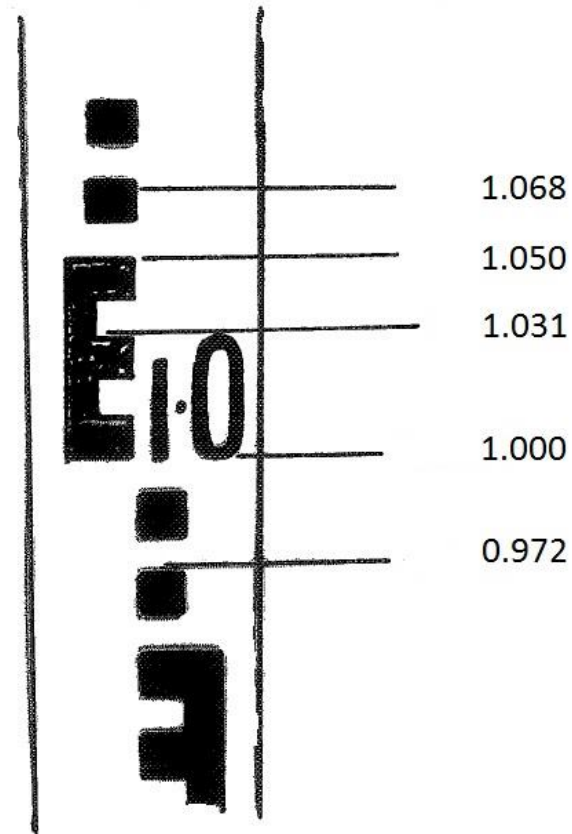
The location and values of OSBM's located in Aberdare, as provided by the OS



Typical Optical Level

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Levelling Staff



Staff readings are taken where the main horizontal cross hair, cuts across the staff, (see examples above).

It must be ensured that the staff is vertical before taking any readings, this can be achieved with the use of a staff bubble, or by rocking the staff towards and away from the optical level and taking the lowest reading on the staff.

When levelling between points, the level should whenever possible be set up midway between them, so as to cancel out any errors where the line of sight is not horizontal, for instance the line of site may be diverging from the horizontal and sighting above or below the horizontal line of collimation.

Where the level is out of adjustment and the line of site diverges from the horizontal, the apparent difference in level between points will differ from the actual level difference, if the level is not exactly midway between the points.
(see the two peg test)

Height of Collimation method

A reading is taken on the staff located at the back sight (BS.) A and added to the reduced level of A, the calculated value equates to the level of the horizontal line of sight (collimation level), subtracting the staff reading at intermediate points or fore sight (FS.) gives you the reduced level (RL.) of the ground at the base of staff at these locations.

Setting vertical level using Height of Collimation method

Where you establish the height of collimation (HC.) of the instrument you can subtract the proposed ground level from the height of collimation, to calculate the staff reading required to set out the proposed ground level at that point.

Note:

Height of Collimation = Reduced level at back sight + staff reading at back sight

RL. (at intermediate or FS. position) = HC. - staff reading at intermediate / FS.

The use of the Rise and fall method is more commonly used to transfer level control between control stations on site or to determine the level of individual points on site.

The Height of Collimation method is more commonly used to survey kerb heights rail track levels where readings have to be taken at set intervals ie where you have lots of intermediate readings.

The Height of Collimation method is the method typically used to set levels on site. Once you have determined the Height of collimation of the laser on the rotating laser level, the staff reading can be calculated to set the proposed ground level, bracket level etc. by subtracting the proposed level from the instruments height of collimation.

See booking sheet below:

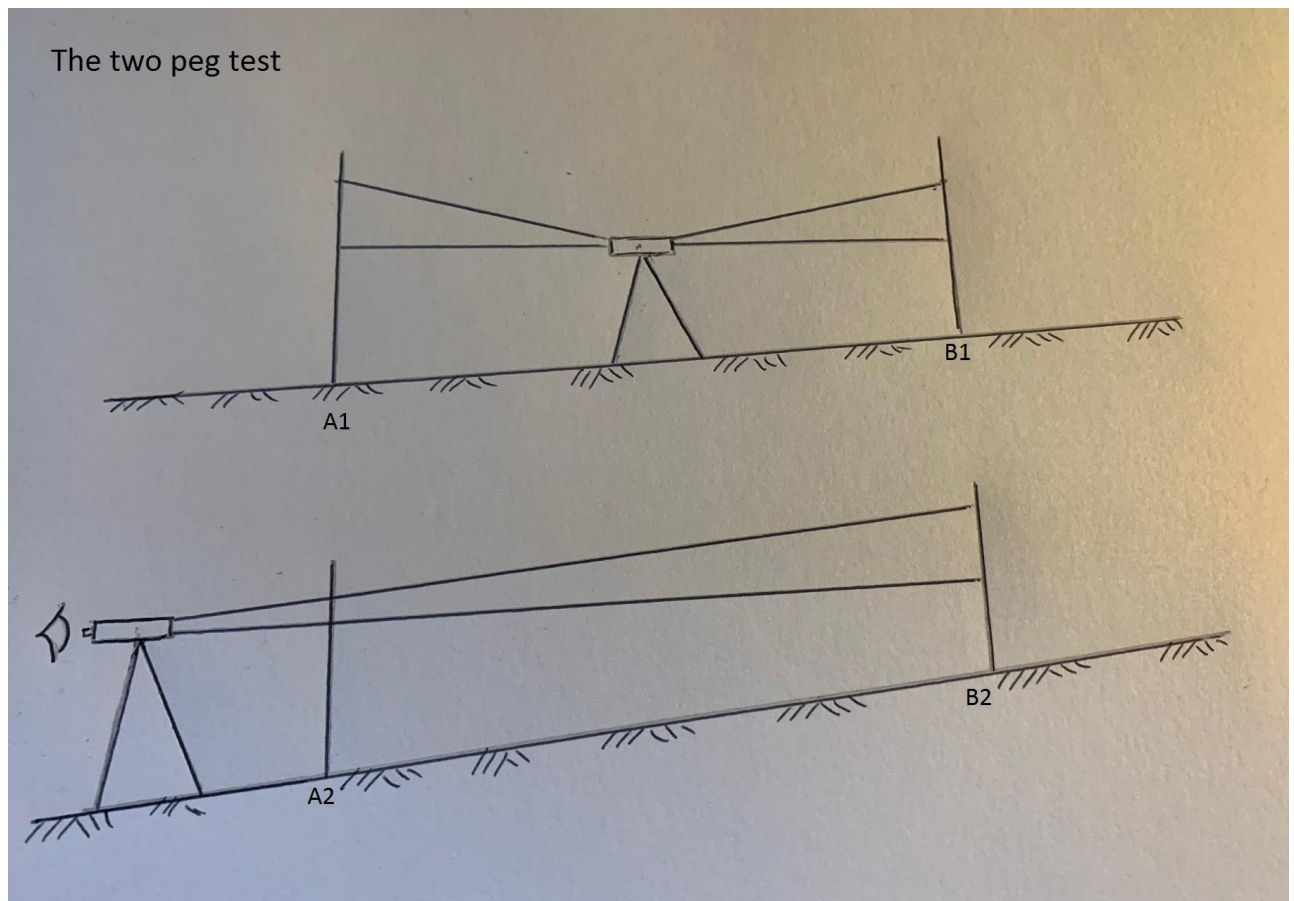
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The two peg test

To check, if the horizontal line of collimation is diverging from the horizontal.

The automatic level is set up midway between 2 pins, about 30 metres apart, let's call them A and B. A will be the back sight and B the fore sight, using the rise and fall levelling method the difference in level between the two pins is measured. We then set the automatic level directly adjacent to the back sight pin A and retake our readings between pin A and pin B and recalculate the difference in level between the two pins, if it is the same as the initial difference in level, all is good, however if the vertical interval has changed the automatic level is not sighting a horizontal line, it may be sighting high or low dependent on the figures shown. In the event of the instrument failing this check it should be sent for a service and recalibration.



If $A1 - B1$ equals $A2 - B2$ then the instrument is in adjustment.

Where the level has not been checked using the two peg test, back sight and foresight lengths should be kept equidistant, so that errors caused by the horizontal line of collimation diverging from the horizontal cancel themselves out.

Errors and Mistakes while levelling

Common errors include.

1. Setting the level up on ground that is not stable.
2. Using unstable change points.
3. Not opening the staff properly and checking that the appropriate poppers are engaged.
4. Allowing dirt or other material to stick to the bottom of the staff, which can subsequently fall off, resulting in readings which are not relative to each other.
5. Not holding the staff vertically, with the use of a staff bubble, or allowing the surveyor to take the lowest staff reading by rocking the staff back and forth.
6. Omitting a zero when taking a staff reading, for example booking 3.030 instead of 3.003.
7. Transposing the figures when taking a staff reading, for example booking 7.420 instead of 7.240
8. Booking a reading in the wrong column or row.
9. Sighting too near the ground where the reading can be affected by heat shimmer

Good practice while levelling

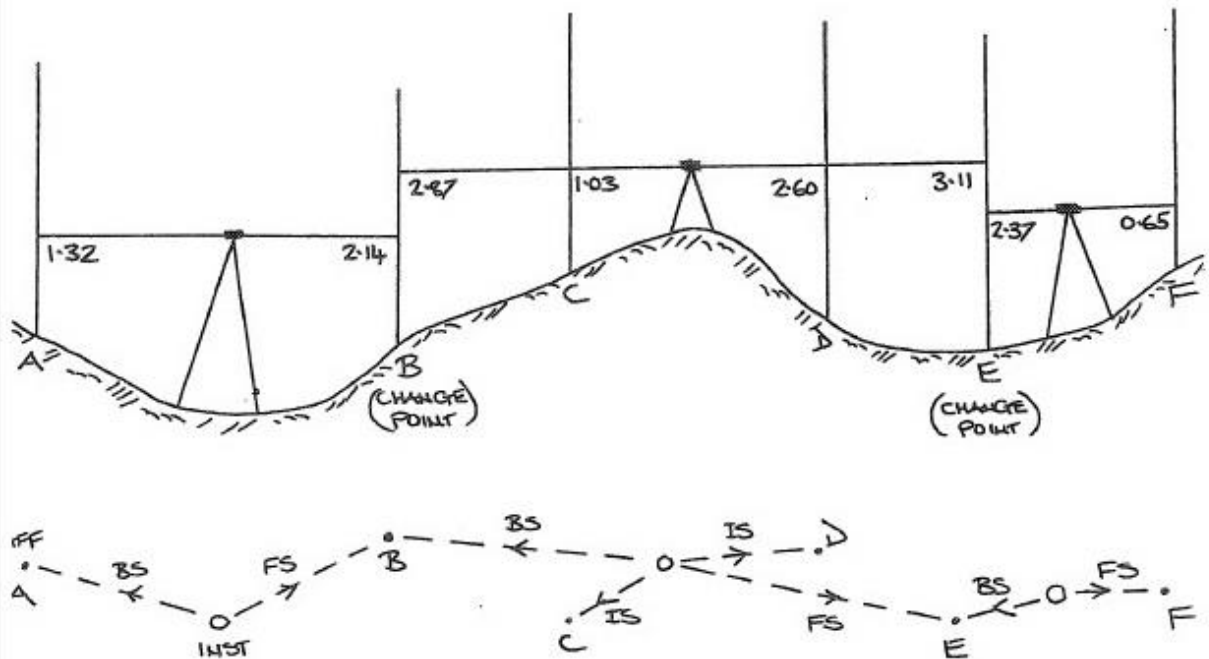
These include:

1. Wherever possible, keep fore sight and back sight points equidistant, so has to cancel out errors due to diverging horizontal line of sight.
2. Closing the levelling loop by levelling back to the start point and checking your closing error.
3. Carrying out all checks when you close the loop.
The sum of the back sights, equal the sum of the fore sights.
The sum of the rises, equal the sum of the falls.

Since you will really have a perfect result the difference is known as the closing error or misclosure and should normally be expected to be a few mm.

Should it be anything greater, the difference in level should be adjusted in proportion to the individual lengths of the loop (see handout Sources of error in levelling).

LEVELLING – HEIGHT OF COLLIMATION (HPC) BOOKINGS



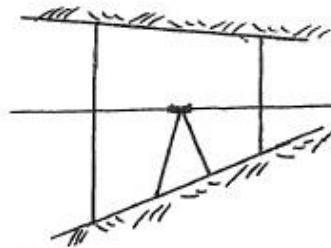
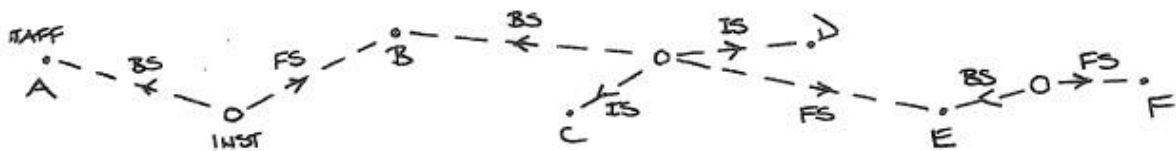
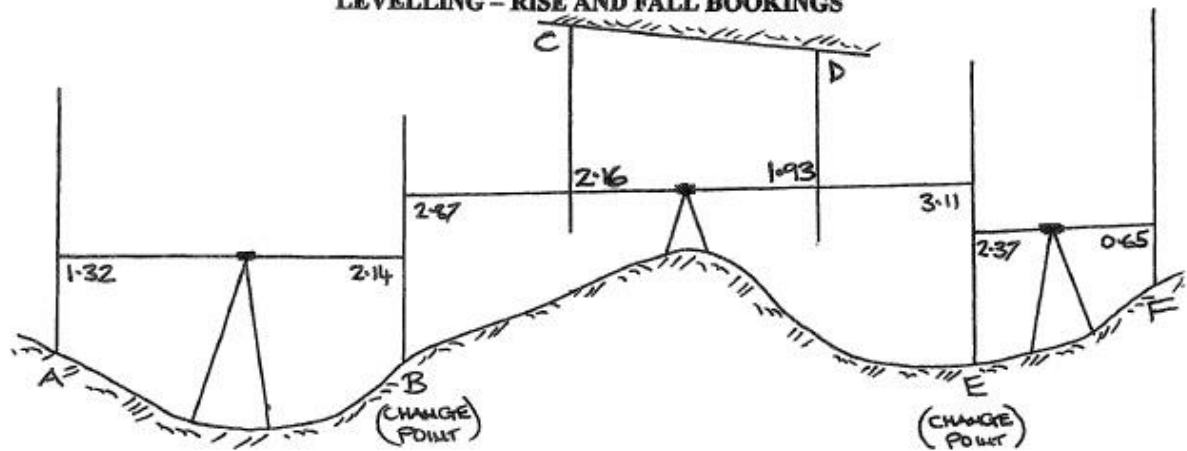
BS	IS	FS	HPC	RL	REMARKS

Check: Sum of (Each collimation height x number of reduced levels from it) _____

Check: Sum of all intermediate sights =
Sum of all foresights =
Sum of all RL's except first =

Check OK

LEVELLING – RISE AND FALL BOOKINGS



BS	IS	FS	RISE	FALL	RL	REMARKS

CHECK:

$$1) \quad \Sigma BS - \Sigma FS = \Sigma RISES - \Sigma FALLS = \text{LAST R.L.} - \text{FIRST R.L.}$$

Note: Consider an inverted staff readings as a minus figure (remembering that a minus, minus equals a plus)