

CEE 3324a — AutoCAD Assignment A4 — Road Project (Group C5)

PART 1 — Vertical curve calculations

From F6: BC = 0+218.886, ELEV_{BC} = 150.550 m; EC = 0+251.915, ELEV_{EC} = 150.860 m; length of horizontal curve L = 251.915 – 218.886 = **33.029 m**. Back gradient at BC and forward gradient at EC = 0.00 %. Finished grade at BC and EC = existing ground.

$$g = \Delta \text{ELEV} / L = (150.860 - 150.550) / 33.029 = \mathbf{+0.009386} \text{ } (= +0.9386 \text{ \%})$$

Two vertical curves, LVC = L/2 = 16.5145 m each. Midpoint station = 218.886 + 16.5145 = **0+235.400**. Gradient at the end of VC1 = start of VC2 = 2g = **+0.018771**.

$$\text{ELEV} = \text{ELEV}_0 + g_1 \cdot x + (r/2) \cdot x^2, \quad r = (g_2 - g_1) / \text{LVC}$$

VC1 (BC → midpoint): $g_1 = +0.000000$, $g_2 = +0.018771$, $r = (+0.018771 - +0.000000) / 16.5145 = \mathbf{+0.0011367}$, ELEV₀ = 150.550 at 0+218.886

Station	x (m)	g1·x	(r/2)·x ²	ELEV (m)
0+218.886 (BC)	0.0000	+0.0000	+0.0000	150.550
0+220	1.1140	+0.0000	+0.0007	150.551
0+225	6.1140	+0.0000	+0.0212	150.571
0+230	11.1140	+0.0000	+0.0702	150.620
0+235	16.1140	+0.0000	+0.1476	150.698
0+235.400 (mid, PVI1)	16.5145	+0.0000	+0.1550	150.705

VC2 (midpoint → EC): $g_1 = +0.018771$, $g_2 = +0.000000$, $r = (+0.000000 - +0.018771) / 16.5145 = \mathbf{-0.0011367}$, ELEV₀ = 150.705 at 0+235.400

Station	x (m)	g1·x	(r/2)·x ²	ELEV (m)
0+235.400 (mid)	0.0000	+0.0000	-0.0000	150.705
0+240	4.5995	+0.0863	-0.0120	150.779
0+245	9.5995	+0.1802	-0.0524	150.833
0+250	14.5995	+0.2741	-0.1211	150.858
0+251.915 (EC)	16.5145	+0.3100	-0.1550	150.860

Check: ELEV at EC from VC2 = 150.860 = ELEV_{EC} 150.860 ✓. Midpoint elevation 150.705 = mean of BC and EC ✓. PVI1 = 0+227.143 (ELEV 150.550), PVI2 = 0+243.658 (ELEV 150.860) — tangent intersections of each curve.

Finished centreline grade, top of subgrade and existing ground at every station

Station	Proposed grade (FG)	Top of subgrade (FG–0.35)	Existing G.L. (CL)	G.L. topsoil removed (–0.15)
0+218.886 (BC)	150.550	150.200	150.550	150.400
0+220	150.551	150.201	150.514	150.364
0+225	150.571	150.221	150.519	150.369
0+230	150.620	150.270	150.488	150.338
0+235	150.698	150.348	150.447	150.297
0+240	150.779	150.429	150.281	150.131
0+245	150.833	150.483	150.278	150.128
0+250	150.858	150.508	150.726	150.576
0+251.915 (EC)	150.860	150.510	150.860	150.710

Cross-section computations (working for the drawings)

Template: 2 % crossfall CL → shoulder edge at 2.0 m; top of subgrade 0.35 m below finished grade everywhere. Hinge point = (2.0 m, $FG - 0.04 - 0.35$). Topsoil 0.15 m stripped over the full width, so slopes meet the *topsoil-removed* ground line. Ground between CL and the 5 m offset is a straight line through the two measured points; beyond 5 m it is taken level at the 5 m elevation (same convention as the sample calculation).

CUT (topsoil-removed ground at 2.0 m $\geq$ hinge): 3:2 sideslope down 1.00 m to the ditch bottom at 3.50 m, then 2:1 backslope up to ground: $h_{\text{back}} = G'_{5\text{m}} - (FG - 1.39)$, horizontal = $2 \cdot h_{\text{back}}$, catch = $3.50 + 2 \cdot h_{\text{back}}$. FILL (ground below hinge): 3:2 sideslope from the hinge down to ground.

Station	Side	FG CL	Hinge (2.0 m)	Ditch bot. (3.5 m)	G' at 5 m	Type	h to catch	Catch offset	Catch elev
0+218.886	L	150.550	150.160	149.160	150.358	CUT	1.198	5.90	150.358
0+218.886	R	150.550	150.160	149.160	150.200	CUT	1.040	5.58	150.200
0+220	L	150.551	150.161	149.161	150.364	CUT	1.203	5.91	150.364
0+220	R	150.551	150.161	149.161	150.191	CUT	1.030	5.56	150.191
0+225	L	150.571	150.181	149.181	150.405	CUT	1.224	5.95	150.405
0+225	R	150.571	150.181	149.181	150.241	CUT	1.060	5.62	150.241
0+230	L	150.620	150.230	149.230	150.448	CUT	1.218	5.94	150.448
0+230	R	150.620	150.230	149.230	150.191	CUT	0.961	5.42	150.191
0+235	L	150.698	150.308	149.308	150.491	CUT	1.183	5.87	150.491
0+235	R	150.698	150.308	—	150.120	FILL	0.086	2.13	150.222
0+240	L	150.779	150.389	—	150.163	FILL	0.243	2.36	150.146
0+240	R	150.779	150.389	—	150.122	FILL	0.262	2.39	150.127
0+245	L	150.833	150.443	—	150.164	FILL	0.297	2.45	150.146
0+245	R	150.833	150.443	—	150.107	FILL	0.325	2.49	150.118
0+250	L	150.858	150.468	149.468	150.667	CUT	1.199	5.90	150.667
0+250	R	150.858	150.468	149.468	150.538	CUT	1.070	5.64	150.538
0+251.915	L	150.860	150.470	149.470	150.862	CUT	1.392	6.28	150.862
0+251.915	R	150.860	150.470	149.470	150.346	CUT	0.876	5.25	150.346

Offsets are measured from the centreline; L = left / R = right looking up-station (BC → EC).

PART 3 (bonus) — Area and volume calculation

Section chosen for the manual calculation: STA 0+225 (cut section). Datum line = 149.000 m. Heights are above the datum; distances are offsets from the centreline (left −, right +).

(a) Datum-line method

Area under the ground line (topsoil removed) minus area under the template (top of subgrade + slopes), both taken from the datum, between the two catch points. Sub-areas are trapezoids: $(h_1 + h_2)/2 \times \text{width}$.

Offset from	Offset to	Width	h1 ground	h2 ground	Ground sub-area	h1 template	h2 template	Template sub-area
-5.95	-5.00	0.95	1.405	1.405	1.332	1.405	0.931	1.107
-5.00	-3.50	1.50	1.405	1.394	2.099	0.931	0.181	0.834
-3.50	-2.00	1.50	1.394	1.383	2.083	0.181	1.181	1.022
-2.00	+0.00	2.00	1.383	1.369	2.752	1.181	1.221	2.402
+0.00	+2.00	2.00	1.369	1.318	2.687	1.221	1.181	2.402
+2.00	+3.50	1.50	1.318	1.279	1.948	1.181	0.181	1.022
+3.50	+5.00	1.50	1.279	1.241	1.890	0.181	0.931	0.834
+5.00	+5.62	0.62	1.241	1.241	0.769	0.931	1.241	0.673
Σ		11.57			15.561			10.296

CUT AREA = 15.561 − 10.296 = **5.27 m²**

(b) Check by coordinate method

Axes: datum line (N = height above datum) and the centreline (E = offset). Traverse: template left → right, then ground right → left. $2A = \sum(N_i \cdot E_{i+1}) - \sum(N_i \cdot E_{i-1})$.

Pt	N (h)	E (offset)	N·E(next)	N·E(prev)
1	1.405	-5.95	-7.025	-8.357
2	0.931	-5.00	-3.259	-5.538
3	0.181	-3.50	-0.362	-0.905
4	1.181	-2.00	+0.000	-4.134
5	1.221	+0.00	+2.442	-2.442
6	1.181	+2.00	+4.134	+0.000
7	0.181	+3.50	+0.905	+0.362
8	0.931	+5.00	+5.232	+3.259
9	1.241	+5.62	+6.205	+6.205
10	1.241	+5.00	+4.343	+6.974
11	1.279	+3.50	+2.559	+6.397
12	1.318	+2.00	+0.000	+4.612
13	1.369	+0.00	-2.738	+2.738
14	1.383	-2.00	-4.842	+0.000
15	1.394	-3.50	-6.971	-2.788
16	1.405	-5.00	-8.357	-4.918
17	1.405	-5.95	-8.357	-7.025
Σ			-16.090	-5.559

$2A = -16.090 - (-5.559) = 10.532 \rightarrow A = 5.27 \text{ m}^2$ ✓ agrees with datum-line method (and with the AutoCAD AREA command on the drawing).

CHECK SHEET FOR AREAS AND VOLUME CALCULATION

Sign convention as in the sample: – = CUT, + = FILL. Areas from the cross-section drawings (AutoCAD AREA on the closed template/ground polygon; STA 0+225 confirmed by hand above).

Chainage	0+218.886	0+220	0+225	0+230	0+235	0+240	0+245	0+250	0+251.915
Cut area (m²)	5.37	5.18	5.27	4.55	2.29	0.00	0.00	4.81	5.59
Fill area (m²)	0.00	0.00	0.00	0.00	0.16	1.20	1.48	0.00	0.00
NET AREA (m²)	-5.37	-5.18	-5.27	-4.55	-2.13	+1.20	+1.48	-4.81	-5.59

Transition chainages (net area changes sign) — distance to the zero-area point is in proportion to the end areas:

between 0+235 and 0+240: $d = 2.13 / (2.13 + 1.20) \times 5.000 = 3.198 \text{ m} \rightarrow$ transition at **0+238.198**

between 0+245 and 0+250: $d = 1.48 / (1.48 + 4.81) \times 5.000 = 1.176 \text{ m} \rightarrow$ transition at **0+246.176**

Volumes by the end-area method ($V = (A1 + A2)/2 \times \text{distance}$; triangular prisms at the transitions):

From	To	A1 (m²)	A2 (m²)	Length (m)	Volume (m³)	Cut / Fill
0+218.886	0+220	-5.37	-5.18	1.114	5.88	CUT
0+220	0+225	-5.18	-5.27	5.000	26.10	CUT
0+225	0+230	-5.27	-4.55	5.000	24.53	CUT
0+230	0+235	-4.55	-2.13	5.000	16.68	CUT
0+235	0+238.198	-2.13	0.00	3.198	3.40	CUT
0+238.198	0+240	0.00	+1.20	1.802	1.08	FILL
0+240	0+245	+1.20	+1.48	5.000	6.70	FILL
0+245	0+246.176	+1.48	0.00	1.176	0.87	FILL
0+246.176	0+250	0.00	-4.81	3.824	9.20	CUT
0+250	0+251.915	-4.81	-5.59	1.915	9.96	CUT

TOTAL FILL VOLUME REQUIRED = 8.6 m³

Total cut volume = 95.8 m³. All cut can be used as fill, so the fill is supplied from the cut and about 87.1 m³ of surplus excavated material is hauled away. (Topsoil stripping and the 0.35 m imported granular + asphalt are separate quantities.)