City & Guilds

9210-104
Level 6 Graduate Diploma in Engineering
Engineering surveying

Sample Paper

You should have the following for this examination
- answer booklets
- non-programmable calculator
- pens, pencils, drawing instruments

No additional data is attached

General instructions
- This examination paper is of **three hours** duration.
- This question paper consists of **nine** questions over four sections A, B, C and D.
- Answer **five** questions selecting at least one question from Section A, and one each from Section B, Section C and Section D.
- All questions carry equal marks. The maximum marks for each question within a question are given against that section.
- An electronic non-programmable calculator may be used but candidates **must** show clearly the steps prior to obtaining final numerical values.
- Drawings should be clear, in good proportion and in pencil. Do **not** use red ink.
- Use a separate answer book for each section.

Section A

1 a) Briefly describe the two main branches of Engineering Surveying. (4 marks)

b) List out three main sources of errors in Engineering survey measurements and give an example for each. (3 marks)

c) List out four types of errors that can happen when measuring a length by using a tape. (4 marks)

d) The three bays of a base line were measured by a steel tape in catenary as 29.284, 27.773 and 23.283 m, under respective pulls of 80, 80 and 60 kN, temperatures of 11 °C, 14 °C and 18 °C and differences of level of supports of 0.35, 0.72 and 0.65 m. If the tape was standardized on the flat at a temperature of 15°C under a pull of 55 kN, what are the lengths of the bays? 30 m of tape weighs exactly 1.5 kg with density of steel being 8300 kg/m^3, coefficient of expansion being 0.000 011 per °C and E = 210 × 103 N/mm^2. (9 marks)

2 a) Define the following, with respect to levelling:

i) Benchmark. (1 mark)

ii) Reduced level. (1 mark)

iii) Line of sight. (1 mark)

iv) Changing point. (1 mark)

b) Briefly describe the two peg test used to determine any collimation error in a tilting level. (3 marks)

c) Two survey stations A and B on opposite sides of a river are 1080 m apart, and reciprocal levels have been taken between them. The readings taken are as given in Table Q2(c),

Instrument at	Height of Instrument (m)	Staff at	Staff reading (m)
P	1.372	Q	1.735
Q	1.396	P	1.113

Table Q2(c)

Calculate

i) The ratio of refraction correction to curvature correction. (2 marks)

ii) The difference in level between P and Q. (3 marks)

d) The levelling readings given in Table Q2(d) were observed between two BMs, but the observer forgot to record the first back sight reading. It is also assumed that no errors were caused in measurements taken during the operation.

BS	IS	FS		R.L(m)	Remarks
?				49.62	BM1
	1.97				
3.41		1.10			
	1.37				
2.90		0.45			
	-1.09				
1.24		1.01			
	0.47				
1.86		0.36			
		0.91		57.97	BM2

Table Q2(d)

i) Reduce the levels using the rise and fall method applying necessary arithmetic checks. (6 marks)

ii) What is the BS reading at BM1? (2 marks)

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Section B

3 a) The Table Q3(a) shows a page of a survey field book with angular observations made by a theodolite set up at a point W.

Angles at **point W**				
Horizontal Readings				
Point	Face left	Face Right	Mean	Angle
X(RO)	00 03 50	180 04 30		
Y	17 22 10	197 23 10		
Z	83 58 50	264 00 00		
X(RO)	45 12 30	225 13 30		
Y	62 31 10	242 32 10		
Z	129 07 30	309 08 40		

Table Q3(a)

Calculate the angles XWY and XWZ. (6 marks)

b) The Table Q3(b) shows observations made during a closed theodolite traverse at a construction site.

Line	Reduced bearing	Length (m)
AB	S 6° 15' W	189.53
BC	S 29° 38' E	175.18
CD	N 81° 18' W	197.78
DE	N 12° 24' W	142.39
EA	N 42° 59' E	234.58

Table Q3(b)

i) If the coordinate of point A is (100.00E, 100.00N), calculate the coordinates of other points of the traverse. (11 marks)

ii) Compute the area of the traverse. (3 marks)

4 a) Briefly describe a method to obtain the multiplying constant (K) and the additive constant (C) of a tachometer fitted with an analectic lens. (4 marks)

b) List out four possible errors in measuring horizontal distances using a tachometer. (4 marks)

c) For calculating the radius of an existing circular curve of a road, three suitable points *P*, *Q* and *R* were selected on its centre-line. A theodolite was set at *Q* and the readings given in Table Q4(c) were taken on *P* and *R*, with the telescope horizontal and the staff vertical.

Staff at	Horizontal bearing	Staff readings
P	0° 00'	1.825, 1.320, 0.815
R	200° 24'	2.435, 1.825, 1.215

Table Q4(c)

i) Calculate the radius of the horizontal circular curve of the road. (8 marks)

ii) If the instrument height at Q is 1.54 m, calculate the gradients of lines PQ and QR. (4 marks)

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Section C

5 a) Classify Electromagnetic Distance Measurement (EDM) according to the type of the electromagnetic energy generated. (3 marks)

b) Briefly describe the following measuring principles of EDMs.

i) Pulse method. (3 marks)

ii) Phase difference method. (3 marks)

c) Give two examples for each of the following sources of errors in EDMs.

i) Personal errors. (2 marks)

ii) Instrumental errors. (2 marks)

iii) Natural errors. (2 marks)

d) Discuss the advantages and disadvantages of EDM instruments over Optical Distance Measurement (ODM) instruments. (5 marks)

6 a) List out five advantages of Global Positioning System (GPS) in surveying measurements. (5 marks)

b) List out four factors influencing the final position of the survey stations measured with GPS. (4 marks)

c) Briefly describe the following.

i) Static positioning. (2 marks)

ii) Rapid static. (2 marks)

iii) Reoccupation. (2 marks)

d) Briefly describe the use of rotating laser instruments in construction setting out works. (5 marks)

Section D

7 a) Briefly describe the following of a simple circular curve with the use of a clear sketch.

i) Deflection angle. (1 mark)

ii) Apex angle. (1 mark)

iii) Apex distance. (1 mark)

iv) Main chord. (1 mark)

b) Explain how a circular curve can be set out with two theodolites. (4 marks)

c) Briefly explain how a circular curve can be set out when the intersection point is inaccessible. (4 marks)

d) A circular curve of 900 m radius has been set out connecting two straights with a deflection angle of 45°. It is decided, for construction reasons, that the mid-point of the curve must be moved 5 m towards the centre, i.e. away from the intersection point. The alignment of the straights is to remain unaltered.

Calculate,

i) The radius of the new curve. (2 marks)

ii) The distances from the intersection point to the new tangent points. (2 marks)

iii) The deflection angles required for setting out 25 m chords of the new curve. (2 marks)

iv) The length of the final sub-chord. (2 marks)

8 a) Discuss the use of Simpson's rule and the trapezoidal rule to find an area enclosed by a chain line, irregular boundary and first and last ordinates. (4 marks)

b) Table Q8(b) shows the offsets taken from a survey line to a curved boundary and the two end ordinates.

Chain age (m)	0	20	40	60	80	100	130	160	190
Offsets (m)	8.46	7.38	8.03	6.95	5.57	10.04	9.32	8.12	5.34

Table Q8(b)

Calculate the enclosed area by using Simpson's rule. (4 marks)

c) A cross section of cut and fill on a hillside section has the following dimensions.

Road width = 20 m
Centre height in cut = 0.75 m
Side slope in fill = 1 in 3
Existing ground slope = 1 in 6
Side slope in cut = 1 in 2

Calculate,

i) The side widths (6 marks)

ii) Areas of cut and fill. (6 marks)

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9 a) Explain how the verticality of a structure is checked with a theodolite. (4 marks)

b) Briefly describe the use of sight rails in Civil Engineering constructions. (4 marks)

c) Following data are available for excavation work of a trench between points P and Q.

Gradient of the trench = 1% (rising from P to Q)
Distance between P and Q = 100 m
Staff reading on a peg at P = 1.75 m
Staff reading on a peg at Q = 0.95 m
Height of collimation of a levelling instrument set up nearby = 43.85 m
Formation level of the trench at P = 40.00 m
Height of the sight rail above ground at P = 1.60 m

Calculate,

i) The height of the boning rod (3 marks)

ii) The height of the sight rail above ground at Q. (3 marks)

d) Describe the optical method that can be adopted to transfer the bearing of a surface line to the shaft bottom of a tunnel by a theodolite when the tunnel shaft is shallow and of relatively large diameter. (6 marks)