Loughborough University

Site Surveying and Measurement (CEM)
22CVA128

Semester 2 2023 | In-Person Exam Paper

This examination is to take place in-person at a central University venue under exam conditions. The standard length of time for this paper is **2 hours**.

You will not be able to leave the exam hall for the first 30 or final 15 minutes of your exam. Your invigilator will collect your exam paper when you have finished.

Help during the exam

Invigilators are not able to answer queries about the content of your exam paper. Instead, please make a note of your query in your answer script to be considered during the marking process.

If you feel unwell, please raise your hand so that an invigilator can assist you.

You may use a calculator for this exam. It must comply with the University's Calculator Policy for In-Person exams, in particular that it must not be able to transmit or receive information (e.g. mobile devices and smart watches are **not** allowed).

Candidates must write sufficient information to show the method used in deriving the answers.

Answer **THREE** questions in total.

Answer **QUESTION 1** from Section A.
Answer **TWO** questions from Section B.

You must use a separate answer book for each section. Print **SECTION A** or **SECTION B** on the front of the applicable answer books.

All questions carry equal marks.

A Formula Sheet is provided for Section B.

Continues/…

SECTION A
(You must answer this question)

1. a) Identify the location (or locations) of the following types of information in the contract documentation:

   i) locations and dimensions

   [3 marks]

   ii) descriptions and specifications

   [3 marks]

   iii) quantifications

   [2 marks]

   b) Describe the structure and content of the Bills of Quantities as used in the tender package and, later, the contract documents.

   [10 marks]

   c) Describe the purpose of billing paper, what it is used for, how it is organised, and the types of information contained in it.

   [15 marks]

Continues/…

SECTION B
(Answer **TWO** questions)

2. The following sequence of staff readings in metres were observed using an automatic level, in good weather conditions.

   BS: 1.624, ISs: 2.125 at Peg A, 2.010 at Peg B, 1.905 at Peg C, FS: 1.852
   BS: 0.624, ISs: 1.412 at Peg D, 0.325 at Peg E, FS: 0.595
   BS: 1.610, ISs: 1.458 at Ground Level Below Bridge, (3.351) at Bridge Soffit Level, FS: 0.487
   BS: 1.336, FS: 1.006

   Where the readings in brackets denote a location where the levelling staff was inverted.

   The first backsight was taken to a staff positioned on a Benchmark with a reduced level of 104.320m AOD. The final foresight was observed to a staff situated at a TBM at a reduced level of 105.570m AOD.

   a) Draft a levelling table and set out, reduce and check the level readings using either the Rise and Fall or the Height of Collimation method. Ensure that you show all appropriate checks and establish the misclosure of the levelling.

   [21 marks]

   b) Determine the allowable misclosure and comment on whether the levelling should be accepted or rejected.

   [2 marks]

   c) List the sources of error in levelling and explain how these errors can be reduced when carrying out levelling.

   [10 marks]

3. a) Describe the workflow for surveying three-dimensional detail using a total station.

   [21 marks]

   b) State which information should be normally included on the completed survey plan in addition to the actual surveyed area.

   [12 marks]

Continues/…

4. a) Outline the responsibilities of a setting out engineer, paying particular attention to the good working practises that should be adopted.

[17 marks]

Four sight rails are to be set out to control the excavation required for a drainage run. The horizontal length of the drainage run is 42.60m and has a design gradient of 1:35.
The drainage run starts at 0.00m chainage at an inspection chamber with an invert level of 24.279 mAOD.

The reduced levels of four pegs located at the base of the sight rails are:

Chainage (m) from inspection chamber at start of drainage run	**Reduced Level (m AOD) Pegs at base of sight rails**
0.00	25.281
14.20	24.931
28.40	25.129
42.60	25.015

b) Calculate the reduced levels of formation at each of the inspection chambers at the chainages 14.20m, 28.40m, 42.60m.

[5 marks]

c) Determine the length of the traveller to be used (as a multiple of 0.5m) if the top of each sight rail is to be set at a minimum of 0.5m above each of the pegs at the base of the sight rails.

[6 marks]

d) Calculate the vertical distances that the tops of the sight rails must be set relative to the reduced levels of the pegs at the following chainages:
0.00m, 14.20m, 28.40m, 42.60m.

[5 marks]

Continues/…

5. There are five systematic errors which may need to be corrected when using a steel band (steel tape).

   Describe and account for each systematic error listed below (a -e). All answers should include description of relevant functional models used for each correction and identification of all terms used.

   Indicate, where applicable, how simple surveying methods can simplify or even avoid the use of the correction.

   a) Standardisation

   [6 marks]

   b) Temperature

   [7 marks]

   c) Tension

   [7 marks]

   d) Sag (or Catenary)

   [7 marks]

   e) Slope

   [6 marks]

R N Stanley
D S Thomson

Formula Sheet on next page

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FORMULA SHEET

Levelling

Rise and Fall check formula:

$$\sum BS - \sum FS = \sum Rises - \sum Falls = LastRL - FirstRL$$

Height of Collimation check formula:

$$\sum BS - \sum FS = LastRL - FirstRL$$

$$\sum(\text{all } RL \text{ except 1st}) + \sum \text{IS} + \sum \text{FS} = \sum(\text{each } Hoc \times \text{no.IS and FS taken})$$

Allowable Misclosure formula:

$$\boldsymbol{allowable\ misclosure = m\sqrt{n}}$$ where m = 5mm, n = no. of instrument setups

Sight Rails

Gradient = Fall/ Distance

Formation Level at B = Formation Level at A - (gradient x length A to B)

minimum *Traveller Length* $_{\text{chainage}} = \text{RL}_{\text{peg}} - \text{RL}_{\text{Formation}}$

RL Sight Rail $_{\text{chainage}} = \text{RL}_{\text{Formation}} + Traveller\ Length$

Vertical Offset $_{chainage} = \text{RL}_{\text{Sight Rail}} - \text{RL}_{\text{peg}}$

Tape Corrections

$$C_{\text{Standard}} = \frac{D(L - L_s)}{L_s} \qquad C_{\text{Temperature}} = D\alpha(t - t_s)$$

$$C_{\text{Tension}} = \frac{D(T - T_s)}{EA} \qquad C_{\text{Catenary}} = -\frac{w^2 D^3(\cos^2\theta)}{24T^2}$$

$$C_{\text{Slope}} = -D(1 - \cos\theta) \qquad C_{\text{Slope}} = \sqrt{(D^2 - \Delta H^2)} - D \qquad C_{\text{Slope}} \approx -\frac{\Delta H^2}{2D}$$