T Level Technical Qualification in

Construction: Design, Surveying and Planning

Core Knowledge and Understanding

Mark Scheme

Topic test 2: Construction mathematics and applied mathematics

T Level Construction: Design, Surveying and Planning

General Marking Guidance for all Topic Tests

- All learners must receive the same treatment. Marker must mark the first learner in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Learners must be rewarded for what they have shown they can do rather than penalised for omissions.
- You should mark according to the mark scheme not according to your perception of where the grade boundaries may lie.
- All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. You should always award full marks if deserved. You should also be prepared to award zero marks if the learner's response is not rewardable according to the mark scheme.
- Where judgement is required, a mark scheme will provide the principles by which marks will be awarded.
- Crossed out work should be marked **unless** the learner has replaced it with an alternative response.
- Accept incorrect/phonetic spelling (as long as the term is recognisable) unless instructed otherwise.

Points-Based Mark Scheme Guidance

Points-based mark schemes are made up of:

1) **Mark scheme rubric**
   A mark scheme rubric instructs a marker as to how each mark is awarded.

2) **Example Responses**
   These demonstrate the type of acceptable responses that a learner might provide and where each mark is awarded.

3) **Additional marking Guidance**
   This informs markers about any parameters which should be applied e.g. 'accept any other appropriate/alternative responses.'

Applying the points-based mark scheme guidance

Examiners should follow the mark scheme rubric and use the example responses as a guide for the relevance and expectation of the responses. Students must be credited for any appropriate response. Should candidates provide answers that meet the rubric but in an alternative order, credit should be given.

Levels-Based Mark Scheme Guidance

Levels-based mark schemes (LBMS) have been designed to assess students' work holistically. They consist of two parts:

1) **Indicative content**
   Indicative content reflects content-related points that a student might make but is not an exhaustive list. Nor is it a model answer. Students may make some or none of the points included in the indicative content as its purpose is as a guide for the relevance and expectation of the responses. Students must be credited for any appropriate response.

2) **Levels-based descriptors**
   Each level is made up of a number of traits which when combined together articulate the quality of response that a student needs to demonstrate. The traits progress across the levels to demonstrate the different expectations of each level. When using a levels-based mark scheme, the 'best fit' approach should be used.

Applying the levels-based descriptors

Examiners should take a 'best fit' approach to determining the mark.

- Examiners should first make a holistic judgement on which level most closely matches the student's response. Students will be placed in the level that best describes their answer. Answers can display characteristics from more than one level, and where this happens markers must use any additional guidance (e.g. weighting of traits) and their professional judgement to decide which level is most appropriate.

- The mark awarded within the level will be decided based on the quality of the answer and will be modified according to how securely all traits are displayed at that level:

  - Marks will be awarded at the top of that level if the student has evidenced each of the descriptor traits securely.

  - Where the response does not securely meet all traits, the marks should be awarded based on how closely the descriptor has been met.

Topic Test 2: Construction mathematics and applied mathematics – Mark Scheme

Notes to markers:

For maths questions there are two types of mark:

Method marks (**M**) – these are awarded for the correct process being followed.

Accuracy marks (**A**) – these are awarded for the correct answer as shown in the mark scheme

<u>Other conventions in the mark scheme</u>

(ft) – this means 'apply follow through' which means method marks can be awarded if a learner carries their incorrect answer forward and then uses the correct method in their subsequent working.

sf – significant figures. The final accuracy mark should only be awarded for answers given to the stated number of significant figures if required by a question.

dp – decimal places. The final accuracy mark should only be awarded for answers given to the stated number of decimal places if required by a question.

For other questions, do not penalise for truncating or rounding answers.

Question number	Working	Answer	Notes	Mark
1	Stress σ = Force/Area A = F/σ A = 300/420 A = 0.71 m^2 Area = $\pi d^2/4$ d = $\sqrt{(4A/\pi)}$ d = $\sqrt{(4x0.71/\pi)}$ d = 0.95 m **Alternative approach for area** Area = πr^2 r = $\sqrt{(A/\pi)}$ r = $(0.71/\pi)$ d = 2r d = 2x0.475 d = 0.95 m Accept any other appropriate method	d = 0.95 m	M1 for correct manipulation and population of formula for area, stress and force A1 for correct area M1 for correct population of formula for diameter of a circle A1 for correct value for diameter **Mark allocation for alternative method:** M1 for correct population of formula for radius of a circle A1 for correct value for diameter	

Question number	Working	Answer	Notes	Mark
2a	Mean = (484 + 540 + 785 + 1105 + 500)/5 Mean = 3414/5 Mean = 683 (£millions) to 3 s.f.	£ 683 million	A1 for correct answer	(1)

Question number: 2b(i)

Region	Estimated Cost (£ millions)	Estimated Cost - Mean Cost (£ millions)	(Estimated Cost - Mean Cost)^2
North East	484	- 199	39 601
North West	540	**-143**	**20 499**
Midlands	785	102	10 404
London and the South East	1105	**422**	**178 084**
South West	500	**-183**	**33 489**
		total	**282 077**

1 mark for 3 correct values of ‘cost - mean’

1 mark for 3 correct ‘squared values’

Allow ecf for an incorrect value for the mean from 2a.

Mark: (2)

Question number	Working	Answer	Notes	Mark
2b(ii)	Mean of squared values 282 077/5 = 56415 SD = sqrt of mean of squared values SD = 238 (£millions)	SD = 238 (£millions)	A1 for correct answer for S.D. **Note:** allow ecf for the incorrect value for the mean from 2a	(1)

Question number	Working	Answer	Notes	Mark
3	a) Voltage calculation V = IR V = 0.3 x 40 V = 12V b) Transformer equation $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ $\frac{230}{12} = \frac{575}{N_2}$ $N_2 = (12 \times 575)/230$ N_2 = 30 turns	12V 30 turns	M1 for correct manipulation and population of formula for voltage, current and resistance. A1 for correct voltage M1 for correct population of formula for the transformer (ft) **Note: allow follow through for the learner's value of V from part (a)** A1 for correct value for the number of turns **Note: allow follow through for the learner's value of V from part (a)**	**(2)** **(2)**

Question number	Working	Answer	Notes	Mark
4	Bricks 60 x (375/1000) x 1.05 = £23.63 Mortar 0.027 x 63.20 x 1.05 = £1.79 Labour (1.25x13.50 + 0.625x11) = 16.875 + 6.875 = £23.75 Total unit rate (m^2) = £49.17 Accept any other appropriate method	£ 49.17	M1 for cost of bricks M1 for cost of mortar M1 for cost of labour A1 for correct answer for unit rate	**(4)**

Question number	Working	Answer	Notes	Mar k
5a	Amount the length of each row reduces by = (0.4/tan33) + (0.4/tan50) = 0.62 + 0.34 = 0.96m Row 1 = 8m = 4 boards Row 2 = (8 - 0.96) = 7.04 = 4 boards Row 3 = (7.04 - 0.96) = 6.08 = 3 Row 4 = (6.08 - 0.96) = 5.12 = 3 boards Number of boards required for the shaded area: 4 + 4 + 3 + 3 = 12 boards	12	M1 fpr calculation of the change in length per row of boards M1 for recognition that rows 1, 2 and 3 must use whole boards M1 for a complete method to find the number of whole boards A1 Correct number of boards	**(4)**

Question number	Working	Answer	Notes	Mark
5b	Consider triangle ABD to find distance BD- Cosine rule to calculate side BD: $BD^2 = 83^2 + 67^2 - 2\times83\times67\times\cos 120$ $BD^2 = 16939$ $BD = \sqrt{16939} = 130.1$ m (1 d.p.) Pythagoras to find CD $CD = \sqrt{(130.1^2 - 101^2)}$ CD = 82.1 m Total length = 67+83+101+82.1 Total length = 333.1 m Number of panels 333.1/3.5 = 94.6 panels 95 panels Accept as an alternative approach 67/3.5= 19.1 (20) 83/3.5= 23.7 (24) 101/3.5= 28.8 (29) 82.1/3.5= 23.5 (24) 20+24+29+24 = 97 panels 97 panels	95 panels	M1 for correct value of length BD A1 for value of BD A1 for length of CD A1 for total number of panels	**(4)**

Question number	Working	Answer	Notes	Mark
6	Calculate the length of the sloping floor $L = \sqrt{(0.7^2+6^2)}$ L = 6.04m total length of the walls and floor 2 + 2 + 1.3 + 6.04 = 11.34m Area of ends and floor = 11.34 x 4 = 45.36m^2 Area of each side wall 8x2 - 0.5x(6x0.7) = 13.9 m^2 Total area 45.36 + 13.9 + 13.9 = 73.16m^2 = 73.2m^2	73.2m^2	M1 for calculating the length of the sloping floor A1 for length of sloping floor A1 for total length of the floor and wall A1 for area of walls and floor A1 for the area of each side wall A1 for correct value for total area	**(6)**

Question number	Working	Answer	Notes	Mark
7	**Simpson's Rule** $Area = \frac{w}{3} \times [(y_1 + y_n) + 4(y_2 + y_4 + y_6 + ...) + 2(y_3 + y_5 + ...)]$ $Area = \frac{3}{3} \times [(2 + 2.3) + 4(1.9 + 2.4 + 2.1) + 2(2.2 + 2.3)]$ Area = 1 x (4.3 + 4x6.4 + 2x4.5) Area = 4.3 + 25.6 + 9 Area = 38.9m^2 Volume = Area x 2.5 Volume = 38.9 x 2.5 Volume = 97.25 m^3 Volume = 97.3 m^3 (to 3sf)	Accept answers rounding to 97.3m^3 (to 3 sf)	M1 for correct substitution of value of 'w'(3) into the formula M1 for correct substitution of values for y M1 for simplification of terms A1 for correct answer for area M1 for correct process for calculating volume (ft) A1 for correct answer for volume to 3sf **Note**: A1 can only be awarded for an answer to 3sf.	**(6)**

Question number	Method	Answer	Notes	Mark
8	Contractor A would remove 1495/12 = 124.58 m^3 per hour (Work rate plant A × T) + (work rate plant B × T) = 1, where T is the time for job completion. Work by plant A = work rate x time, 1 = work rate x 12, Work rate plant A = 1 ÷ 12 Work by plant b = work rate x time, 1 = work rate x 7, work rate plant B = 1 ÷ 7 (1/7 x T) + (1/12 x T) = 1 T/ 7 + T / 12 = 1 19T / 84 = 1 Time = 84 ÷ 19, T = 4.42 hours Volume removed by contractor A: 4.42 x 124.58 m^3 Volume = 550.6 m^3 Volume = 551 m^3	551m^3	M1 for process of calculating how much material contractor A can remove per hour M1 for process of calculating work rate of plant A and plant B M1 for identifying relationship between work rates and total time M1 for correct rearranging of formula A1 for correct answer in hours A1 for correct answer (to 3sf) for the volume of material removed by contractor A	**(6)**

Question number	Working	Answer	Notes	Mark
9	$\int_{38}^{40} 3x^2 + 8x + 2$ $y = \left[x^3 + 4x^2 + 2x\right]_{38}^{40}$ y = $[40^3 + 4\text{x}40^2 + 2\text{x}40] - [38^3 + 4\text{x}38^2 + 2\text{x}38]$ y = [64000 + 6400 + 80] - [54872 + 5776 + 76] y = 70480 - 60724 y = 9756 mJ	y = 9756	M1 for setting up definite integral A1 for correct integration of definite integral M1 for substituting values for lower limit M1 for substituting values for upper limit M1 for process of calculating definite integral A1 for correct value for y	**(6)**

Question number	Working	Answer	Notes	Mark
10	$V = 200 = \pi r^2 h$ therefore $h = (200/\pi r^2)$ $A = 2\pi r^2 + 2\pi r h$ $A = 2\pi r^2 + 2\pi r \times 200/\pi r^2$ $A = 2\pi r^2 + 400/r$ $\frac{dA}{dr} = 4\pi r - \frac{400}{r^2}$ For the minimum radius, $dA/dr=0$ $4\pi r - \frac{400}{r^2} = 0$ $4\pi r = \frac{400}{r^2}$ $4\pi r^3 = 400$ $r^3 = 400/4\pi$ $r = \sqrt[3]{\frac{400}{4\pi}}$ r = 5.6 m	r = 5.6 m	M1 rearranging formula for volume in terms of h M1 process to derive an expression for A in terms of r A1 for correct differentiation M1 for recognition that for a minimum value dA/dr = 0 **Note:** this might be implied in the working M1 for rearranging in terms of r A1 Correct answer for r	**(6)**

Question number	Working	Answer	Notes	Mark
11	Volume of concrete required: CSA = 900mm x 450mm CSA = 0.9 x 0.45 = 0.405m^2 Volume = CSA x length Volume = 0.405 x 16.5 Volume = 6.6825 m^3 Amount of cement required 500x(6.6825 / 1.56) = 2141.8 kg Ratio of cement to coarse aggregates is 1:4 Therefore Coarse aggregates = 2141.8 x 4 Amount of coarse aggregates = 8567.3 kg	8567.3 kg Accept answers rounding to 8567 kg	A1 for correct CSA of the trench A1 for correct volume of concrete required M1 for method of calculating the amount of cement required A1 for correct amount of cement M1 for applying ratio for cement:coarse aggregates A1 for correct answer correct amount of coarse aggregates	**(6)**