



Pearson

# Mark Scheme (Results)

Summer 2017

Pearson Edexcel International A Level  
in Decision Mathematics D1 WDM01/01

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

# EDEXCEL GCE MATHEMATICS

## General Instructions for Marking

1. The total number of marks for the paper is 75.
2. The Edexcel Mathematics mark schemes use the following types of marks:
  - **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
  - **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
  - **B** marks are unconditional accuracy marks (independent of M marks)
  - Marks should not be subdivided.
3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
  - ft – follow through
  - the symbol  $\checkmark$  will be used for correct ft
  - cao – correct answer only
  - cso - correct solution only. There must be no errors in this part of the question to obtain this mark
  - isw – ignore subsequent working
  - awrt – answers which round to
  - SC: special case
  - oe – or equivalent (and appropriate)
  - dep – dependent
  - indep – independent
  - dp decimal places
  - sf significant figures
  - \* The answer is printed on the paper
  - $\square$  The second mark is dependent on gaining the first mark
4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.
  5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.
  6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.

- If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.
7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks																																																																		
1. (a)	$\frac{19.1}{5} = 3.82$ so lower bound is 4 bins	M1 A1 (2)																																																																		
(b)	Bin 1: <b>2.5 0.9 1.4</b> Bin 2: <b>3.1 1.5 0.3</b> Bin 3: <u>2.0</u> <u>1.9</u> 0.4 Bin 4: <u>1.2</u> Bin 5: 3.9	M1 <u>A1</u> A1 (3)																																																																		
(c)	e.g. middle right <div style="display: flex; justify-content: space-between;"> <div style="width: 80%;"> <table style="width: 100%; border-collapse: collapse;"> <tr> <td>2.5</td><td>0.9</td><td>3.1</td><td>1.4</td><td>1.5</td><td><u>2.0</u></td><td>1.9</td><td>1.2</td><td>0.3</td><td>0.4</td><td>3.9</td> </tr> <tr> <td>2.5</td><td><u>3.1</u></td><td>3.9</td><td><u>2.0</u></td><td>0.9</td><td>1.4</td><td>1.5</td><td><u>1.9</u></td><td>1.2</td><td>0.3</td><td>0.4</td> </tr> <tr> <td>3.9</td><td><u>3.1</u></td><td>2.5</td><td><u>2.0</u></td><td><u>1.9</u></td><td>0.9</td><td>1.4</td><td>1.5</td><td><u>1.2</u></td><td>0.3</td><td>0.4</td> </tr> <tr> <td>3.9</td><td><u>3.1</u></td><td>2.5</td><td><u>2.0</u></td><td><u>1.9</u></td><td>1.4</td><td><u>1.5</u></td><td><u>1.2</u></td><td>0.9</td><td><u>0.3</u></td><td>0.4</td> </tr> <tr> <td>3.9</td><td><u>3.1</u></td><td>2.5</td><td><u>2.0</u></td><td><u>1.9</u></td><td><u>1.5</u></td><td>1.4</td><td><u>1.2</u></td><td>0.9</td><td><u>0.4</u></td><td><u>0.3</u></td> </tr> <tr> <td>3.9</td><td>3.1</td><td>2.5</td><td>2.0</td><td>1.9</td><td>1.5</td><td>1.4</td><td>1.2</td><td>0.9</td><td>0.4</td><td>0.3</td> </tr> </table> </div> <div style="width: 15%; text-align: right;">           Pivot(s) 2.0 3.1 1.9 (3.9) (2.5) 1.2 1.5 0.3 (1.4) 0.4         </div> </div>	2.5	0.9	3.1	1.4	1.5	<u>2.0</u>	1.9	1.2	0.3	0.4	3.9	2.5	<u>3.1</u>	3.9	<u>2.0</u>	0.9	1.4	1.5	<u>1.9</u>	1.2	0.3	0.4	3.9	<u>3.1</u>	2.5	<u>2.0</u>	<u>1.9</u>	0.9	1.4	1.5	<u>1.2</u>	0.3	0.4	3.9	<u>3.1</u>	2.5	<u>2.0</u>	<u>1.9</u>	1.4	<u>1.5</u>	<u>1.2</u>	0.9	<u>0.3</u>	0.4	3.9	<u>3.1</u>	2.5	<u>2.0</u>	<u>1.9</u>	<u>1.5</u>	1.4	<u>1.2</u>	0.9	<u>0.4</u>	<u>0.3</u>	3.9	3.1	2.5	2.0	1.9	1.5	1.4	1.2	0.9	0.4	0.3	M1 A1 A1ft A1 (4)
2.5	0.9	3.1	1.4	1.5	<u>2.0</u>	1.9	1.2	0.3	0.4	3.9																																																										
2.5	<u>3.1</u>	3.9	<u>2.0</u>	0.9	1.4	1.5	<u>1.9</u>	1.2	0.3	0.4																																																										
3.9	<u>3.1</u>	2.5	<u>2.0</u>	<u>1.9</u>	0.9	1.4	1.5	<u>1.2</u>	0.3	0.4																																																										
3.9	<u>3.1</u>	2.5	<u>2.0</u>	<u>1.9</u>	1.4	<u>1.5</u>	<u>1.2</u>	0.9	<u>0.3</u>	0.4																																																										
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3.9	3.1	2.5	2.0	1.9	1.5	1.4	1.2	0.9	0.4	0.3																																																										
(d)	Bin 1: <b>3.9</b> 0.9 Bin 2: <b>3.1 1.9</b> Bin 3: <b>2.5 2.0</b> 0.4 Bin 4: <b>1.5</b> 1.4 1.2 0.3	M1 A1 (2)																																																																		
		<b>11 marks</b>																																																																		

### Notes for Question 1

**a1M1:** Attempt to find the lower bound  $(19.1 \pm 3.9) / 5$  (a value of 3.82 seen with no working can imply this mark)

**a1A1:** CSO - correct calculation seen **or** 3.82 followed by 4 (bins) – accept 3.8 followed by 4 if correct calculation seen. An answer of 4 with no working scores M0A0

**b1M1:** First five items placed correctly and at least eight values placed in bins. Condone cumulative totals for M1 only (the values in bold)

**b1A1:** First nine items placed correctly (the underlined and bold values)

**b2A1:** CSO (correct solution only – so no additional/repeated values)

**c1M1:** Quick sort – pivot, p, chosen (must be choosing middle left or middle right – choosing first/last item as pivot is M0). After the first pass the list must read (values greater than the pivot), pivot, (values less than the pivot). **If only choosing one pivot per iteration then M1 only** – Bubble sort is not a MR and scores M1 only for 2.5 3.1 1.4 1.5 2.0 1.9 1.2 0.9 0.4 3.9 0.3 (for left to right) or 0.3 2.5 0.9 3.1 1.4 1.5 2.0 1.9 1.2 0.4 3.9 (right to left)

**c1A1:** First two passes correct **and** next pivots chosen correctly for third pass (but third pass does not need to be correct) – so they must be choosing (if middle right) pivot value of 1.2 or (if middle left) pivot value of 1.5

**c2A1ft:** Third and fourth passes correct (follow through from their second pass and choice of pivots). They do not need to be choosing a pivot for the fifth pass for this mark

**c3A1:** CSO (correct solution only – all previous marks in this part **must** have been awarded) - if middle right then a fifth pass in which the 0.4 is used as a pivot **must** be included **or** if middle left then a fifth pass in which the 0.3 is used as a pivot **and** a sixth pass in which the 0.9 is used as a pivot **must** be included

Question Number	Scheme	Marks
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**d1M1: Must be using sorted list** in descending order. First six items placed correctly and at least eight values placed in bins – condone cumulative totals for M1 only (the bold values)

**d1A1: CSO** (so no additional/repeated values)

No marks in (d) if the first six items have not been placed correctly

Misreads

- If the candidate has misread a number at the start of (a), so genuinely miscopy a number from the paper then mark the whole of (a), (b), (c) and (d) as a misread – removing the last two A marks earned. This gives a maximum of 9 marks in total for these four parts
- If they have used the correct numbers in say (a) and (b) and then use an incorrect number in (c) (say 5.2 instead of 2.5) or misread one of their own numbers during (c) then count it as one ‘error’ in either (c) (so they will lose at least the final A mark in (c) but should be able to gain at least the M mark and the follow through A mark) – then award the marks in (d) as per the main scheme. More than one ‘error’ in (c) loses all subsequent A marks in (c)

Sorting list into ascending order in (c)

- If the candidate sorts the list into ascending order and reverses the list in this part then this can score full marks in (c)
- If the list is not reversed in (c) then mark as a misread (so remove the last two A marks earned in (c)). If the list is reversed at the start of (d) but not in (c) then still treat this as a misread. If the list is in ascending order in (c) award no marks for first-fit increasing in (d). If the candidate says that the list needs reversing in (c) but does not actually show the reversed list in (c) then remove the final A mark earned

Middle left

											Pivot(s)
2.5	0.9	3.1	1.4	1.5	<u>2.0</u>	1.9	1.2	0.3	0.4	3.9	2.0
2.5	<u>3.1</u>	3.9	<u>2.0</u>	0.9	1.4	1.5	<u>1.9</u>	1.2	0.3	0.4	3.1 1.9
3.9	<u>3.1</u>	2.5	<u>2.0</u>	<u>1.9</u>	0.9	1.4	<u>1.5</u>	1.2	0.3	0.4	(3.9) (2.5) 1.5
3.9	<u>3.1</u>	2.5	<u>2.0</u>	<u>1.9</u>	<u>1.5</u>	0.9	1.4	<u>1.2</u>	0.3	0.4	1.2
3.9	<u>3.1</u>	2.5	<u>2.0</u>	<u>1.9</u>	<u>1.5</u>	1.4	<u>1.2</u>	0.9	<u>0.3</u>	0.4	(1.4) 0.3
3.9	<u>3.1</u>	2.5	<u>2.0</u>	<u>1.9</u>	<u>1.5</u>	1.4	<u>1.2</u>	<u>0.9</u>	0.4	<u>0.3</u>	(0.9)
3.9	<u>3.1</u>	2.5	<u>2.0</u>	<u>1.9</u>	<u>1.5</u>	1.4	<u>1.2</u>	<u>0.9</u>	0.4	<u>0.3</u>	

Ascending Middle right

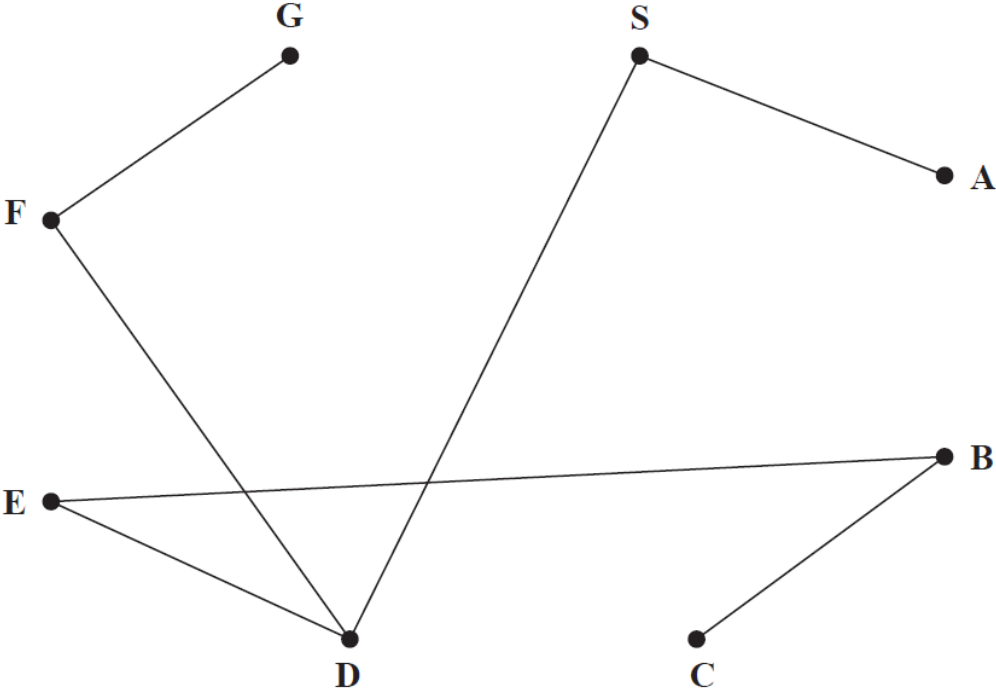
2.5	0.9	3.1	1.4	1.5	<u>2.0</u>	1.9	1.2	0.3	0.4	3.9
0.9	1.4	1.5	<u>1.9</u>	1.2	0.3	0.4	<u>2.0</u>	2.5	<u>3.1</u>	3.9
0.9	1.4	1.5	<u>1.2</u>	0.3	0.4	<u>1.9</u>	<u>2.0</u>	2.5	<u>3.1</u>	3.9
0.9	<u>0.3</u>	0.4	<u>1.2</u>	1.4	<u>1.5</u>	<u>1.9</u>	<u>2.0</u>	2.5	<u>3.1</u>	3.9
<u>0.3</u>	0.9	<u>0.4</u>	<u>1.2</u>	1.4	<u>1.5</u>	<u>1.9</u>	<u>2.0</u>	2.5	<u>3.1</u>	3.9
<u>0.3</u>	<u>0.4</u>	0.9	<u>1.2</u>	1.4	<u>1.5</u>	<u>1.9</u>	<u>2.0</u>	2.5	<u>3.1</u>	3.9

Sort complete

Ascending Middle left

2.5	0.9	3.1	1.4	1.5	<u>2.0</u>	1.9	1.2	0.3	0.4	3.9
0.9	1.4	1.5	<u>1.9</u>	1.2	0.3	0.4	<u>2.0</u>	2.5	<u>3.1</u>	3.9
0.9	1.4	<u>1.5</u>	1.2	0.3	0.4	<u>1.9</u>	<u>2.0</u>	2.5	<u>3.1</u>	3.9
0.9	1.4	<u>1.2</u>	0.3	0.4	<u>1.5</u>	<u>1.9</u>	<u>2.0</u>	2.5	<u>3.1</u>	3.9
0.9	<u>0.3</u>	0.4	<u>1.2</u>	1.4	<u>1.5</u>	<u>1.9</u>	<u>2.0</u>	2.5	<u>3.1</u>	3.9
<u>0.3</u>	<u>0.9</u>	0.4	<u>1.2</u>	1.4	<u>1.5</u>	<u>1.9</u>	<u>2.0</u>	2.5	<u>3.1</u>	3.9

Sort complete

Question Number	Scheme	Marks
2. (a)	SD, DE, AS; BE, DF; BC, FG	M1; A1; A1 (3)
(b)	 <p data-bbox="231 1128 555 1160">Weight of tree = (£)1285</p>	B1  B1 (2)
(c)	<p data-bbox="231 1173 1244 1238">e.g. Prim's algorithm always selects arcs that bring a vertex not in the tree into the tree, so cycles cannot happen.</p> <p data-bbox="231 1245 1244 1310">e.g. Prim's algorithm always adds an additional vertex to the tree, so a cycle cannot happen.</p>	B1 (1)
		<b>6 marks</b>

**Notes for Question 2**

**a1M1:** First three arcs correctly chosen in order (SD, DE, AS, ...) **or** first four nodes correctly chosen in order (S, D, E, A, ...). **If any explicit rejections seen at any point then M1 (max) only.** No marks in (a) for list of weights only. Candidates may apply Prim's in matrix form so the order of the nodes may be seen at the top of the matrix – accept {1, 4, -, -, 2, 3, -, -} for the M mark. Allow DS for SD etc. throughout this part

**a1A1:** First five arcs correctly chosen in order (SD, DE, AS, BE, DF, ...) **or** all eight nodes correctly chosen in order (S, D, E, A, B, F, C, G). Candidates may apply Prim's in matrix form so the order of the nodes may be seen at the top of the matrix – accept {1, 4, 5, 7, 2, 3, 6, 8} – do not condone any missing numbers e.g. the number 8 must be above G

**a2A1:** CSO (correct solution only) – all arcs correctly stated and chosen in the correct order. Candidates must be considering arcs for this final mark (do not accept a list of nodes or numbers across the top of the matrix unless the correct list of arcs (in the correct order) is also seen)

**b1B1:** CAO (condone lack of weights on arcs)

**b2B1:** CAO (condone lack of or incorrect units)

**c1B1:** CAO – as a minimum accept mention that Prim's **adds** vertices/nodes (when adding arcs to the tree)



Question Number	Scheme	Marks
<b>3.(a)</b>	Bipartite (graph)	B1 (1)
<b>(b)</b>	Alternating path $B - 5 = C - 4 = E - 1 = D - 3 = A - 2$ or $B - 5 = C - 6 = F - 4 = E - 1 = D - 3 = A - 2$	M1
	Change status $B = 5 - C = 4 - E = 1 - D = 3 - A = 2$ or $B = 5 - C = 6 - F = 4 - E = 1 - D = 3 - A = 2$	A1
	Complete matching $A = 2, B = 5, C = 4, D = 3, E = 1, F = 6$ or $A = 2, B = 5, C = 6, D = 3, E = 1, F = 4$	A1 (3)
<b>(c)</b>	Either $A = 2, B = 5, C = 4, D = 3, E = 1, F = 6$ or $A = 2, B = 5, C = 6, D = 3, E = 1, F = 4$	B1 (1)
<b>(d)</b>	Worker A must do task 2 so D must do task 3. Hence E must do task 1 and therefore B must do task 5. Workers C and F can both be allocated to either tasks 4 or 6. Therefore there are two, and only two, possible complete matchings.	B1 B1 (2)
		<b>7 marks</b>

### Notes for Question 3

**a1B1:** CAO – but be charitable on spelling, award if phonetically close

**b1M1:** An alternating path (e.g. letter 1<sup>st</sup> set – number 2<sup>nd</sup> set – letter 1<sup>st</sup> set – ...) from B to 2 (or vice-versa)

**b1A1:** CAO – a correct path including change status **either** stated (only accept ‘change (of) status’ or ‘c.s’ but not, e.g. ‘change state’) or shown (all symbols e.g. (... – ... = ... – ...) interchanged (... = .... – ... = ...)) Chosen path clear

**b2A1:** CAO (complete matching) must follow from the correct stated path. Accept on a clear diagram (with six arcs only)

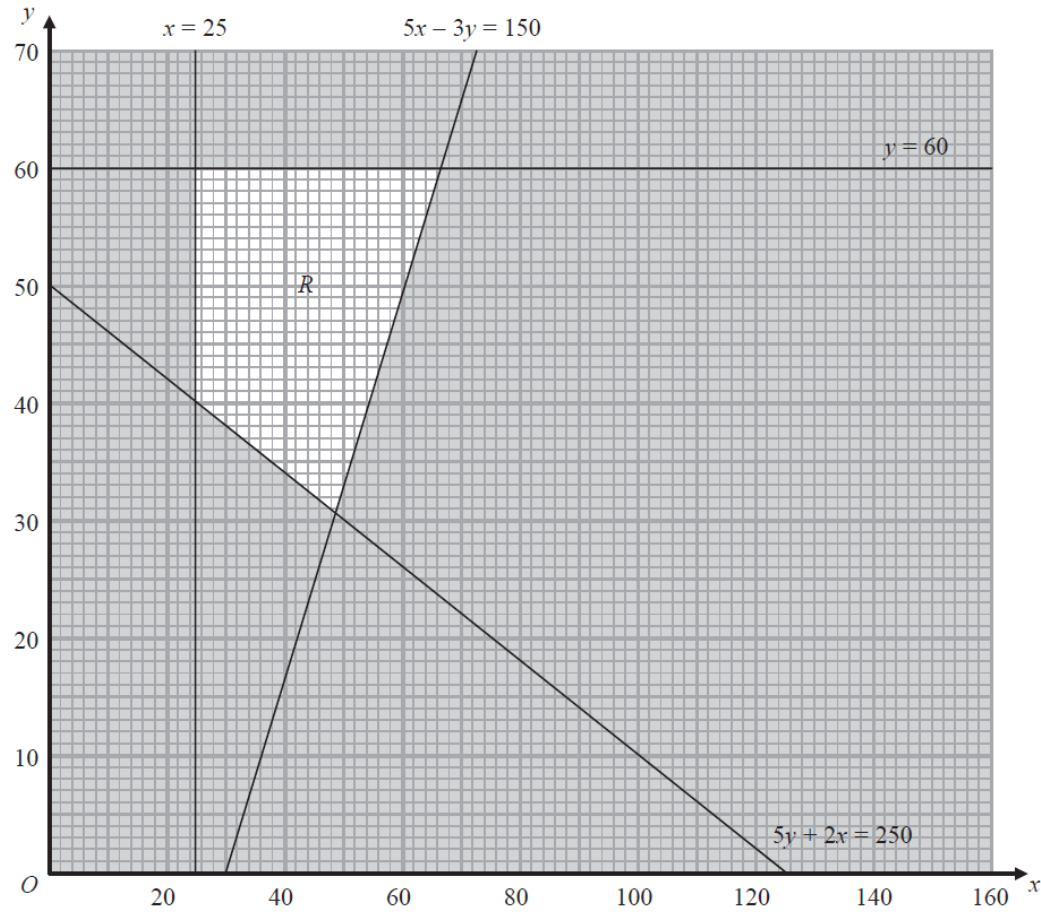
**c1b1:** CAO – different from the one given in (b) – if an incorrect matching is given in (b) then award this mark for either correct matching

**d1B1:** CAO – explicitly stating that workers A, B, D and E can only do activities 2, 5, 3 and 1 respectively

**d2B1:** CAO – explicitly stating that workers C and F can both be allocated to the two tasks of 4 and 6

Question Number	Scheme	Marks
4.(a)	<pre> graph LR     Start((0)) -- B(10) --&gt; B10[10]     Start -- C(9) --&gt; C9[10]     Start -- A(7) --&gt; A7[16]     B10 -- E(12) --&gt; E12[27]     B10 -- F(15) --&gt; F15[26]     C9 -- G(16) --&gt; G16[26]     A7 -- D(11) --&gt; D11[25]     E12 -- I(10) --&gt; I10[37]     F15 -- J(7) --&gt; J7[37]     G16 -- K(5) --&gt; K5[37]     D11 -- M(4) --&gt; M4[43]     I10 -- N(6) --&gt; N6[43]     J7 -- P(5) --&gt; P5[43]     K5 -- P(5) --&gt; P5[43]     M4 --&gt; End((43))     N6 --&gt; End     P5 --&gt; End </pre>	M1 A1 M1 A1 <b>(4)</b>
(b)	Critical activities: B, G, L and N	B1
	Length of the critical path: 43 (days)	DB1ft <b>(2)</b>
(c)	Total float on D = 27 – 10 – 11 = 6 (days)	M1 A1 <b>(2)</b>
(d)		M1 A1 A1 A1 <b>(4)</b>
(e)	Lower bound is 5 workers e.g. activities G, D, E, F and H together with 17 < time < 19	M1 A1 <b>(2)</b>
		<b>14 marks</b>

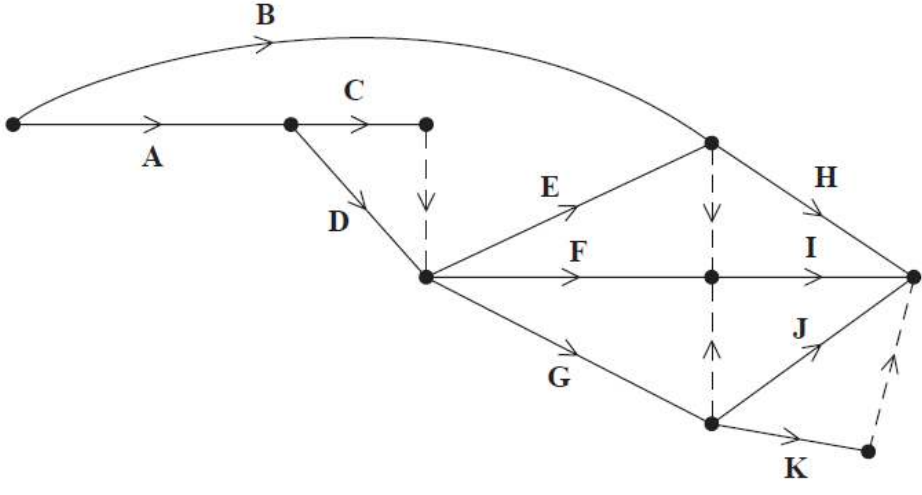
Question Number	Scheme	Marks
<b>Notes for Question 4</b>		
<p><b>a1M1:</b> All top boxes complete, values in the top boxes generally increasing in the direction of the arrows ('left to right'), condone one 'rogue' value (if values do not increase in the direction of the arrows then if one value is ignored and then the values do increase in the direction of the arrows then this is considered to be only one rogue value)</p> <p><b>a1A1:</b> CAO for the top boxes</p> <p><b>a2M1:</b> All bottom boxes complete, values generally decreasing in the opposite direction of the arrows ('right to left'), condone one rogue. Condone missing 0 and/or 43 for the M only</p> <p><b>a2A1:</b> CAO for the bottom boxes</p> <p><b>b1B1:</b> CAO – critical activities (B, G, L and N)</p> <p><b>Db2B1ft:</b> follow through from their (a) – dependent on scoring the first M mark in (a)</p> <p><b>c1M1:</b> Correct calculation for their activity D seen – correct for their three numbers. Final value must be non-negative</p> <p><b>c1A1:</b> CAO (no ft on this mark). Answer of 6 with no working scores no marks in this part</p> <p><b>Note that it is acceptable for the critical activities to appear on separate lines or for several activities to appear on the same line as long as their length and floats are clear and do not overlap</b></p> <p><b>d1M1:</b> At least 10 activities including at least 5 floats. A scheduling diagram scores M0</p> <p><b>d1A1:</b> The critical activities dealt with correctly and appearing just once (B, G, L and N) and three non-critical activities dealt with correctly</p> <p><b>d2A1:</b> Any 6 non-critical activities correct (this mark is not dependent on the previous A mark)</p> <p><b>d3A1:</b> CSO – completely correct Gantt chart (exactly 15 activities appearing just once)</p> <p><b>e1M1:</b> A statement with the correct number of workers (5) <b>and</b> the correct activities (G, D, E, F and H) and any time stated</p> <p><b>e1A1:</b> A completely correct statement with details of both time <b>and</b> activities. Candidates only need to give a time within the correct interval. Please note the strict inequalities for the time interval. Allow for example, 'on day 18' as equivalent to interval <math>17 &lt; \text{time} &lt; 18</math> – but for this mark it must absolutely clear that they are considering a time in the required interval (and not at time 17 and/or 19)</p>		

Question Number	Scheme	Marks
5.(a)	$x \geq 25, y \leq 60$	B1 B1 (2)
(b)	 <p>The graph shows a coordinate system with x and y axes. The x-axis is labeled from 0 to 160 in increments of 20. The y-axis is labeled from 0 to 70 in increments of 10. A shaded feasible region R is bounded by the following lines: a vertical line at <math>x = 25</math>, a horizontal line at <math>y = 60</math>, a line with equation <math>5x - 3y = 150</math>, and a line with equation <math>5y + 2x = 250</math>. The origin is labeled O.</p>	B1 B1 B1 B1 (4)
(c)	$(C =) x + 3y$	B1 (1)
(d)	<p><math>A = (25, 40), B = (25, 60), C = (66, 60)</math>  <math>D = \left(\frac{1500}{31}, \frac{950}{31}\right)</math> or <math>\left(48\frac{12}{31}, 30\frac{20}{31}\right)</math>  At A, <math>C = 145</math>  At B, <math>C = 205</math>  At C, <math>C = 246</math>  At D, <math>C = \frac{4350}{31}</math> or <math>140\frac{10}{31} (= 140.322\dots)</math>  So D is the optimal point  Testing integer solutions around D, <math>x = 48</math> and <math>y = 31</math> is optimal integer solution, so they should have 48 junior prizes and 31 senior prizes</p>	B1 B1 M1 A1 M1 A1 M1 A1 (8)
		15 marks

Question Number	Scheme	Marks
<b>Notes for Question 5</b>		
<b>a1B1:</b> CAO ( $x \geq 25$ )		
<b>a2B1:</b> CAO ( $y \leq 60$ )		
<p>In (b) lines must be long enough to define the correct feasible region and pass through one small ‘square’ of the points stated in either the horizontal or vertical direction e.g. for (25, 60) the line must pass through a point in the interval [23,27] for <math>x</math> <b>or</b> [59,61] for <math>y</math>:</p>		
<ul style="list-style-type: none"> <li>• <math>x = 25</math> from (25, 10) to (25, 62)</li> <li>• <math>y = 60</math> from (0, 60) to (100, 60)</li> <li>• <math>5x - 3y = 150</math> from (36, 10) to (69, 65)</li> <li>• <math>5y + 2x = 250</math> from (0, 50) to (125, 0)</li> </ul>		
<b>b1B1:</b> Any two lines correctly drawn		
<b>b2B1:</b> Any three lines correctly drawn		
<b>b3B1:</b> All four lines correctly drawn		
<b>b4B1:</b> Region, R, correctly labelled – <b>not</b> just implied by shading – dependent on scoring the first three marks in this part		
<b>c1B1:</b> CAO – correct expression in the form $k(x+3y)$ for any positive real number $k$ (but not $k$ )		
<b>d1B1:</b> Any two of (25, 40), (25, 60), (66,60) stated correctly – accept $x = 25$ , $y = 40$ , etc. throughout (d)		
<b>d2B1:</b> All three integer coordinates stated correctly		
<b>d1M1:</b> Using simultaneous equations to find the non-integer vertex – must get to $x = \dots$ <b>and</b> $y = \dots$ . Must be a correct method to solve simultaneous equations but allow slips/errors. If no working present then this mark can be awarded for an awrt (48.4, 30.6)		
<b>d1A1:</b> CAO $\left(\frac{1500}{31}, \frac{950}{31}\right)$ or $\left(48\frac{12}{31}, 30\frac{20}{31}\right)$ – must be exact (condone correct recurring decimal notation).		
<p>If correct answer seen with no working then award M1 A1 in this part. ISW if correct exact answer seen which is then given in non-exact form</p>		
<b>d2M1:</b> Evaluating their objective function at at least three of their vertices for their feasible region.		
<b>d2A1:</b> All four correct $C$ values (from a correct objective function) either given exactly or correct to at least 1 dp		
<b>d3M1:</b> Testing any two of (48, 30) or (48, 31) or (49, 30) or (49, 31) in a correct objective function or the correct pair of inequalities. Note candidates may reject a point after testing in only one correct inequality which is acceptable – this mark is not dependent on any previous mark		
<b>d3A1:</b> CSO (all previous marks must have been awarded in this <b>question</b> ) – must have tested (48, 31) in the correct objective function or correct pair of inequalities – accept $x = 48$ and $y = 31$ or stated as a pair of coordinates		

Question Number	Scheme	Marks
6. (a)	<p>The diagram shows a network with 8 nodes (A-H) and weighted edges. Each node contains a 3x3 grid of numbers representing its state. Edges are labeled with weights: A-B (31), A-C (27), A-F (23), B-E (6), B-H (6), C-D (17), C-F (5), D-E (25), D-G (5), D-H (21), E-F (4), E-H (13), F-G (6), G-H (13).</p>	M1 A1 (ADGF) A1 (HC) A1ft (EB)
	Shortest Path: ADGFHEB	A1
	Length: 36 (km)	A1ft (6)
(b)	Route: ADGFCFHEB	B1
	Length: 25 + 21 = 46 (km)	B1ft (2)
(c)	$G(F)H + EB = 10 + 6 = 16^*$	M1
	$G(FH)E + H(E)B = 16 + 12 = 28$	A1
	$G(FHE)B + HE = 22 + 6 = 28$	A1
	Repeat BE, FG & FH	A1 (4)
(d)	Route: e.g. ADFGDHGFHEDBEBHFA	B1
	Length: $223 + 16 - 27 - 17 - 5 = 190$ (km)	M1 A1 (3)
(e)	Finishing point: G	B1
	Difference is $16 - 6 = 10$ (km)	B1 (2)
		17 marks
<b>Notes for Question 6</b>		
<p><b>In (a) it is important that all values at each node are checked very carefully – the order of the working values must be correct for the corresponding A mark to be awarded e.g. at H the working values must be 30 27 24 in that order (30 24 27 is incorrect) and with no additional working values. It is also important that the order of labelling is checked carefully. The order of labelling must be a strictly increasing sequence – so 1, 2, 3, 3, 4, ... will be penalised once (see notes below) but 1, 2, 3, 5, 6, ... is fine. Errors in the final values and working values are penalised before errors in the order of labelling</b></p>		

Question Number	Scheme	Marks
	<p><b>a1M1:</b> A larger value replaced by a smaller value at least once in the working values at either B or C or E or F or H</p> <p><b>a1A1:</b> All values at A, D, G, F correct and the working values in the correct order at F. Condone lack of 0 in A's working value – please check carefully for a 9 in the working values at D</p> <p><b>a2A1:</b> All values at H and C correct and the working values in the correct order. Penalise order of labelling only once per question (H and C must be labelled in that order and H labelled after A, D, G and F)</p> <p><b>a3A1ft:</b> All values in E and B correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question (E and B must be labelled in that order and E labelled after all other nodes (excluding B)). To follow through E check that all working values at E follow from the candidate's final values from nodes D and H (in the order that the candidate has labelled these two nodes) and that the final value, and order of labelling, follows through correctly. Repeat this process for B (which will have working values from D, E and H)</p> <p><b>a4A1:</b> CAO - ADGFHEB</p> <p><b>a5A1ft:</b> If their final value is not 36 follow through their final value at B (condone incorrect or no units)</p> <p><b>b1B1:</b> CAO - ADGFCFHEB</p> <p><b>b2B1ft:</b> Ft their final value at C + 21</p> <p><b>c1M1:</b> Three distinct pairings of B, E, G and H</p> <p><b>c1A1:</b> Any two rows correct including pairings <b>and</b> totals</p> <p><b>c2A1:</b> All three rows correct including pairings <b>and</b> totals</p> <p><b>c3A1:</b> CAO correct <b>arcs</b> clearly (not just in their working) stated: BE, FG and FH. Do not accept GH, GFH or GH via F</p> <p><b>d1B1:</b> Any correct route (the route may be given in terms of either vertices (ADF...) or arcs (AD, DF, FG,...)) – checks: start and finish at A, 17 vertices (repeats BE, FG, FH and nodes A(2), B(2), D(3), E(2) F(3), G(2), H(3))</p> <p><b>d1M1:</b> complete method: <math>223 +</math> (their smallest repeat out of a choice of at least two totals seen) – (at least two arcs incident to C) <b>or</b> the correct answer of 190</p> <p><b>d1A1:</b> CAO with full working – accept as a minimum <math>223 + 16 - 49</math> but not just 190 or <math>223 - 33</math></p> <p><b>e1B1:</b> CAO (G)</p> <p><b>e2B1:</b> CAO (10)</p>	

Question Number	Scheme	Marks
7.	<p>e.g.</p> 	<p>M1 A1 A1 A1 A1 <b>5 marks</b></p>

**Notes for Question 7**

Condone lack of, or incorrect, numbered events throughout and arcs which cross one another. ‘Dealt with correctly’ means that the activity starts from the correct event but need not necessarily finish at the correct event, e.g. ‘H dealt with correctly’ requires the correct immediate precedences for this activity, i.e. B and E labelled correctly and leading into the same node and H starting from that node but not necessarily H leading into the end node. **Activity on node is M0**

**Ignore incorrect or lack of arrows on the activities for the first four marks only**

**M1:** 7 activities (labelled on arc), one start, at least one dummy placed **and** activities A, B, C and D dealt with correctly

**1A1:** First dummy correct (+ arrow) and activities E, F and G dealt with correctly

**2A1:** Second and third dummies correct (+ arrows) and activities H and I dealt with correctly

**3A1:** Fourth dummy correct (+ arrow) and activities J and K dealt with correctly

**4A1:** CSO (all four previous marks must have been awarded) - all arrows present and correctly placed with one finish and no additional dummies. Please check all arcs carefully for arrows

Note that there are a number of additional valid solutions in which the candidate may deal with the dummies with regards to activities C,D and J,K so it is vital that the diagram is checked carefully for any other equally acceptable/valid solution



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