Pearson Edexcel

Mark Scheme (Results)

January 2025

Pearson Edexcel International Advanced Level in Decision Mathematics D1(WDM11) Paper 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.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- 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 $\surd$ 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
- $\lfloor$ 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.

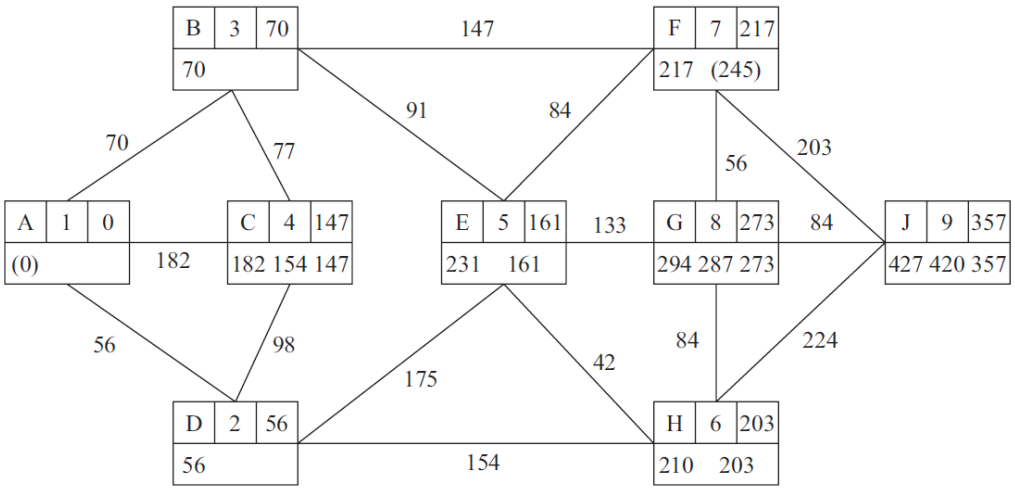
6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.
    - If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

7. Ignore wrong working or incorrect statements following a correct answer.

Question Number	Scheme	Marks
1.(a)	Bin 1: **26 19 10** Bin 2: **31 14** 3 5 Bin 3: 30 18 Bin 4: 33 Bin 5: 28	**M1** A1 A1**(3)**
(b)	middle right 26 19 31 10 14 **30** 33 18 3 28 5 Pivot 30 31 **33** 30 26 19 10 14 **18** 3 28 5 33, 18 33 31 30 26 **19** 28 18 10 14 **3** 5 (31) 19, 3 33 31 30 26 **28** 19 18 10 **14** 5 3 28, 14 33 31 30 28 26 19 18 14 10 **5** 3 (26) 5 33 31 30 28 26 19 18 14 10 5 3 (10)	M1 A1 A1ft A1 **(4)**
	middle left 26 19 31 10 14 **30** 33 18 3 28 5 Pivot 30 **31** 33 30 26 19 10 **14** 18 3 28 5 31, 14 33 31 30 26 **19** 18 28 14 10 **3** 5 (33), 19, 3 33 31 30 **26** 28 19 18 14 **10** 5 3 26, (18) 10 33 31 30 28 26 19 18 14 10 5 3 (28), (5)	
(c)	Bin 1: **33 19** 3 Bin 2: **31 18** 5 Bin 3: **30** 14 10 Bin 4: **28 26**	**M1** A1**(2)**
		9 marks
	Notes for Question 1	
a1M1	The **correct** first five items placed correctly (the bold values) and at least eight values placed in bins (allow repeated values). Condone cumulative totals or calculation of the remaining space for M1 only	
a1A1	First eight values placed correctly (the bold **and** underlined values) with all eleven correct values only placed in bins. This mark cannot be awarded if **any** repeated values or incorrect values are seen (even if the first eight values have been placed correctly)	
a2A1	CSO – no additional or repeated values (dependent on both previous marks)	

b1M1	Quick sort using all 11 numbers (condone one item error or omission), pivot, p, chosen (must be choosing middle item – choosing first/last item as the 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. Bubble sort is M0.**	
b1A1	First and second passes correct but not choice of pivots for 3rd pass	
b2A1ft	Third and fourth passes correct following through from their second pass and choice of pivots for the third pass. The pivots for the third and fourth pass must be consistent with their second pass (MR or ML) If they choose one MR and one ML pivot for the second pass, they can score this mark if they then consistently choose either MR or ML pivots for the rest of their sort.	
b3A1	CSO (correct solution only – all previous marks in this part **must** have been awarded) including a fifth pass for middle right and choosing either 5 (MR) or 10 (ML) as pivots	
	Special Case for (b) If the candidate sorts into ascending order they can score M1 as per the main scheme (but with the values either side of the pivot reversed), A1 for a fully correct sort then A0 A0 even if the list is reversed at the end (so 2 marks max.). See below	
c1M1	**Their** seven largest items placed correctly and at least nine values placed in bins (if correct this will be the bold items but must check **their** packing if any of **their** seven largest values are incorrect – note that the maximum weight of a bin is 55). Condone cumulative totals or calculation of remaining space for M1 only. First-fit increasing scores no marks in this part. If no sort seen in (b) then mark (c) assuming the correct ordered list is being used	
c1A1	CAO	
	Ascending Sort Middle right 26 19 31 10 14 **30** 33 18 3 28 5 Pivot 30 26 19 10 14 **18** 3 28 5 30 31 **33** 18, 33 10 14 **3** 5 18 26 **19** 28 30 31 33 3, 19, (31) 3 10 **14** 5 18 19 26 **28** 30 31 33 14, 28 3 10 **5** 14 18 19 26 28 30 31 33 5 (26) 3 5 10 14 18 19 26 28 30 31 33 (10)	

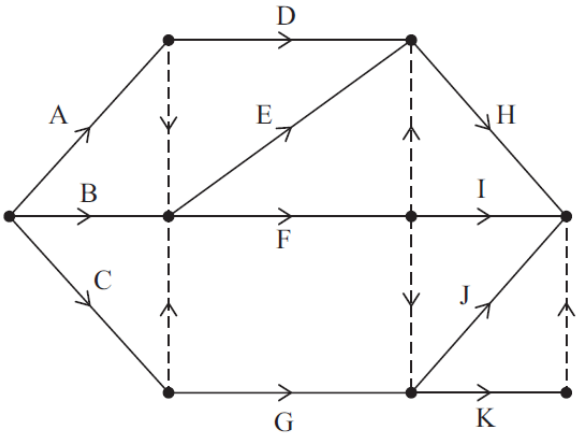
	Middle left 26 19 31 10 14 **30** 33 18 3 28 5 Pivot 30 26 19 10 **14** 18 3 28 5 30 **31** 33 14, 31 10 **3** 5 14 26 **19** 18 28 30 31 33 3, 19, (31) 3 **10** 5 14 18 19 **26** 28 30 31 33 10, (18) 26 3 5 10 14 18 19 26 28 30 31 33 (28), (5)	

Question Number	Scheme	Marks
2.(a) (i)		M1 A1 (ADBCE) A1 (HF) A1ft (GJ)
	Shortest path from A to J is ABFGJ	A1
(a) (ii)	Shortest length is 357 (metres)	A1ft **(6)**
(b)	Consider all pairings of A, C, E and J	M1
	AC + EJ 147 + 210 = 357 AE + CJ 161 + 364 = 525 AJ + CE 357 + 168 = 525	A1ft A1ft
	Length of route = 1 960 + 357 = 2 317 (metres)	A1 ft **(4)**
(c)(i)	Consider arcs between odd nodes not using A – shortest CE so repeat. Finish at J	M1 A1
(c)(ii)	Difference in length their "357" – 168 = 189 metres or their "2317" – 2128 = 189 (metres)	A1ft **(3)**
		13 Marks

Notes for Question 2	
	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 C the working values must be 182 154 147 in that order (so 182 147 154 is incorrect) **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**
ai1M1	A larger value replaced by a smaller value at least twice in the working values at either C, E, G, H, J
ai1A1	All values at A, D, B, C and E correct and the working values in the correct order
ai2A1	All values at H and F correct and the working values in the correct order
ai3A1ft	All values in G and J correct on the follow through and the working values in the correct order. To follow through G check that the working values at G follow from the candidate's final values for the nodes that are directly attached to G (which are E, F and H (and J)). For example, **if** correct then the order of labelling of nodes E, F and H are 5, 7 and 6 respectively so the working values at H should come from E, H and F in that order. The first working value at G should be their 161 (the Final value at E) + 133 (the weight of the arc EG), the second working value at G should be their 203 (the Final value at H) + 84 (the weight of the arc HG) and the third working value should be their 217 (the Final value at F) + 56 (the weight of the arc FG) . Repeat the process for J (which will have working values from F, G and H with the order of these nodes determined by the candidate's order of labelling at F, G and H)
ai4A1	CAO (accept route written in arcs)
aii1A1ft	Follow through their final value at J **only** – if answer is 357 but the final value at J is not 357 then A0
b1M1	The correct three pairings of the correct four nodes (A, C, E and J)
b1A1ft	Two rows correct including pairings **and** totals. Ft for AC, AE and AJ only using their values from (a) but allow recovery if correct totals seen here
b2A1ft	All three rows correct including pairings **and** totals. Ft for AC, AE and AJ only using their values from (a) but allow recovery if correct totals seen here
b3A1ft	1960 + their smallest from a choice of three totals
ci1M1	Considers arcs between odd nodes not including A (e.g. listing possible arcs to be repeated CE CJ and EJ) (A statement that CE is the shortest implies this mark)

ci1A1	Clear indication that CE is shortest (e.g. a statement or tick or starring of CE, not just using 168) (we do not need to see all values explicitly listed here) and therefore finish at J
cii1A1ft	**Dependent on M mark in (b)** 189 or their "357" – 168

<table>
<tr><td>Question Number</td><td colspan="8">Scheme</td><td>Marks</td></tr>
<tr><td rowspan="8">3.(a)</td><td colspan="8"><table>
<tr><td>a</td><td>b</td><td>c</td><td>d</td><td>e</td><td>f</td><td>g</td><td>h</td></tr>
<tr><td>1 980</td><td>462</td><td>914 760</td><td>30/7</td><td>4</td><td>1848</td><td>132</td><td></td></tr>
<tr><td>462</td><td>132</td><td>(914 760)</td><td>7/2</td><td>3</td><td>396</td><td>66</td><td></td></tr>
<tr><td>132</td><td>66</td><td>(914 760)</td><td>2</td><td>2</td><td>132</td><td>0</td><td>13 860</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</table></td><td>M1
A1
A1ft</td></tr>
<tr><td></td><td colspan="8">Output 13 860</td><td>A1 (4)</td></tr>
<tr><td>(b)</td><td colspan="8">Calculates the lowest common multiple of two numbers o.e. description</td><td>B1 (1)</td></tr>
<tr><td></td><td colspan="8"></td><td></td></tr>
<tr><td></td><td colspan="8"></td><td>5 marks</td></tr>
<tr><td></td><td colspan="8"></td><td></td></tr>
<tr><td colspan="10">Notes for Question 3</td></tr>
<tr><td></td><td colspan="8">Note values may be written on individual rows. Please award the marks for the complete rows shown above. The values in cell c do not need to be repeated in each row, but we will condone this.</td><td></td></tr>
<tr><td>a1M1</td><td colspan="8">First row cells a to g completed – something in each cell</td><td></td></tr>
<tr><td>a1A1</td><td colspan="8">First and second row correct. Accept decimal equivalent awrt 4.29 and 3.5 (h must have no numerical value in these rows)</td><td></td></tr>
<tr><td>a2A1ft</td><td colspan="8">Third row correct – ft their first and second rows</td><td></td></tr>
<tr><td>a3A1</td><td colspan="8">13 860 in Output row CSO</td><td></td></tr>
<tr><td>b1B1</td><td colspan="8">LCM CAO (accept e.g. smallest common multiple, minimum common multiple, minimum common product, smallest number which can be divided by both a and b o.e.) (do not accept times instead of multiple or product)</td><td></td></tr>
</table>

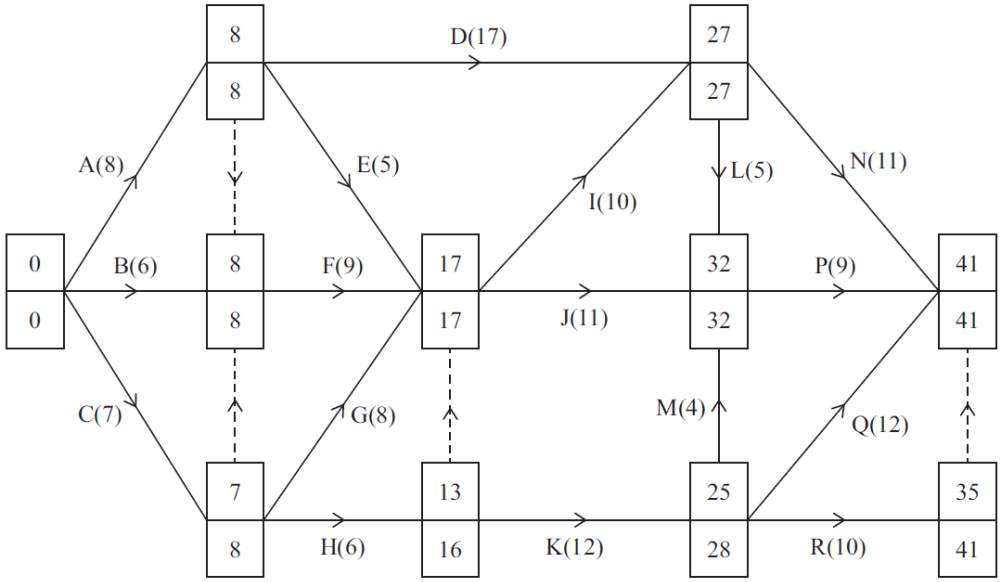
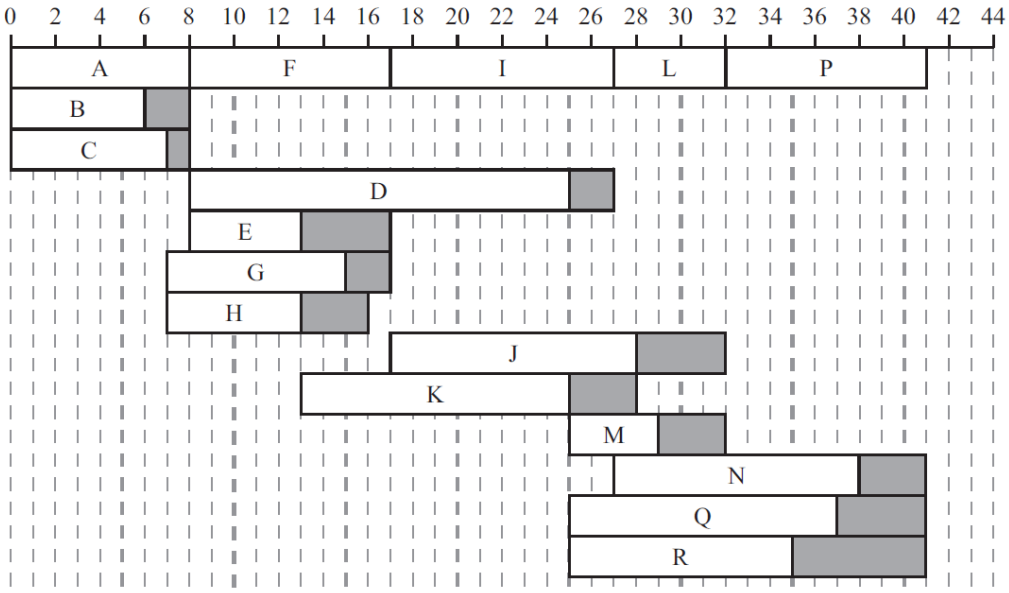
Question Number	Scheme	Marks
4.(a)	 e.g.	M1 A1 A1 A1 A1 **(5)**
(b)	Activities A, B, C, F and H are critical	B1 **(1)**
		6 marks
	Notes for Question 4	
	Condone lack of, or incorrect, numbered events throughout. 'Dealt with correctly' means that the activity starts from the correct event but need not necessarily finish at the correct event, e.g. 'H dealt with correctly' requires the correct precedences for this activity, i.e. D and E labelled correctly and leading into the same node, a dummy from the end of F into the node and H starting from that node but do not consider the end event. **Activity on node is M0**	
	If an arc is not labelled, for example, if the arc for activity E is not labelled (but the arc is present) then this will lose the first A mark and the final (CSO) A mark – they can still earn the second A mark on the bod. If two or more arcs are not labelled then mark according to the scheme. Assume that a solid line is an activity which has not been labelled rather than a dummy (even if in the correct place for where a dummy should be). **Ignore incorrect or lack of arrows on the activities for the first four marks only**	
a1M1	Nine activities (labelled on arc), one start and at least two dummies placed	
a1A1	Activities A, B, C, 1st two dummies (including correct arrow), D, E and F dealt with correctly	
a2A1	Activities G, H and I dealt with correctly and dummy from the end of F to end of D/E (including correct arrow)	
a3A1	Activities J and K dealt with correctly and dummy from the end of F to end of G (including correct arrow)	
a4A1	CSO – all arrows correctly placed for each activity with one finish and exactly five dummies (so uniqueness dummy for J/K required)	

	Please check all arcs carefully for arrows – if there are no arrows on any dummies then M1 only. **Note that additional (but unnecessary) 'correct' dummies that still maintain precedence for the network should only be penalised with the final A mark if earned. Note that this answer is not unique (e.g. J and K are interchangeable, the arrow on the dummy between K and J can go in either direction or this dummy could be at the start of J and K)**	
b1B1	CAO (A, B, C, F and H and no others, but condone mention of D and/or I)	

Question Number	Scheme	Marks
5. (a)	Maximise $(P) = 1.50x + 2.00y + 1.80z$	B1 B1
		(2)
(b)	$\frac{x}{400} + \frac{y}{240} + \frac{z}{300} \leqslant 1 \quad \Rightarrow 3x + 5y + 4z \leqslant 1200$ * (result given in question)	M1 A1
		(2)
(c)	$x \geqslant \frac{40}{100}(x + y + z) \quad \Rightarrow 3x \geqslant 2y + 2z$ $y \leqslant \frac{25}{100}(x + y + z) \quad \Rightarrow 3y \leqslant x + z$ $3y \leqslant 2z$ $(x,\ y,\ z \geqslant 0)$	M1 A1 A1
		(3)
		7 marks
	Notes for Question 5	
a1B1	Maximise stated (accept max but not maximum)	
a2B1	Objective function correct (we do not need to see $P =$) accept $1.5x + 2y + 1.8z$ or if they work in pence so 150x + 200y + 180z accept the use of correct fractions **Do not ISW if they multiply by 10 and $P = 15x + 20y + 18z$ is seen – this is B0**	
bM1	Attempts inequality for total quantity of ice cream: Sum of the correct 3 fractions $\leqslant 1$	
bA1	CSO * (result given in question)	
cM1	Attempts at least two non-trivial constraints (any inequality symbol or equals) (must be using fractions or decimals but not just e.g. 40%) Each inequality must have the correct ingredients (e.g. x, 40/100, and $x + y + z$) correct simplified inequalities can imply this. Accept $2y \leqslant 3z$ for this mark	
c1A1	Two non-trivial constraints correct – simplified with integer coefficients (so accept multiples)	
c2A1	All non-trivial constraints correct – simplified with integer coefficients (so accept multiples) (note we do not need to see $x,\ y,\ z \geqslant 0$)	

Question Number	Scheme	Marks
6.(a)	**Classical** problem must visit **every vertex exactly once** and **returns to start** but **practical** problem must visit **every vertex at least once** and **returns to start**	B1 B1
		(2)
(b)	Either AB, BC, CK, HK, JK, CD, GJ, FG, EG or AB, BC, CK, HK, JK, GJ, FG, EG, CD	M1 A1 A1
		(3)
(c)	$89 \times 2 = 178$ (miles)	B1
		(1)
(d)	ABCKHJGFEDA 140 (miles)	M1 A1 A1
		(3)
(e)	Route from A as it is the smaller value or 140 because $140 < 145$	B1ft
		(1)
(f)	Lower Bound = 89 – 16 + (16 + 19) = 108 (miles)	M1 A1
		(2)
(g)	$108 \leqslant L \leqslant 140$	B1ft
		(1)
		13 marks

Notes for Question 6		
a1B1	General idea that Classical visits vertices once but practical is at least once. Any mention of travelling along every arc is B0	
a2B1	Need to see all the words in bold (accept equivalent technical language e.g. node instead of vertex) – must include return to start	
b1M1	Prim's – first three arcs correctly chosen in order (AB, BC, CK, …) **or** first four nodes {A, B, C, K, … } correctly chosen in order. If any explicit rejections seen at some point then M1 (max) only. Order of nodes may be seen at the top of a matrix/table {1, 2, 3, - , - , -, -, -, -, 4 }. Starting at any other node can score M1 only for first three arcs chosen correctly	
b1A1	First six arcs correctly chosen in order {AB, BC, CK, HK, JK, CD, …} or {AB, BC, CK, HK, JK, GJ, …}**or** all 10 nodes {A, B, C, K, H, J, D, G, F, E} or {A, B, C, K, H, J, G, F, E, D}correctly chosen in order. Order of nodes may be seen at the top of a matrix so for the first two marks accept {1, 2, 3, 7, 10, 9, 8, 5, 6, 4} or {1, 2, 3, 10, 9, 8, 7, 5, 6, 4} (**no** missing numbers).	
b2A1	CSO – all **arcs** correctly **stated** and chosen in the correct order (with no additional arcs). They 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)	
c1B1	CAO	
d1M1	NN route attempted – first seven nodes correct ABCKHJG (accept arcs for this mark AB, BC, CK, KH, HJ, JG or complete numbering on table {1, 2, 3, 10, 9, 8, 7, 5, 6, 4} which is clearly a separate calculation from part (b))	
d1A1	CAO – route correct including return to A (accept arcs AB, BC, CK, KH, HJ, JG, GF, FE, ED, DA) (condone if arcs stated alphabetically instead of in route order)	
d2A1	CAO – distance 140	
e1B1ft	States A or 140 **and** reason correct (smaller value) but ft their answer to (d) dependent on M1 in (d)	
f1M1	Their "89" – 16 + two shortest from A (a new calculation to find the RMST may be seen e.g. new table with A deleted and a new MST calculation, with the correct 8 arcs circled BC CD CK EG FG GJ JK KH plus two shortest from A)	
f1A1	CAO – an answer of 108 implies both of these marks	
g1B1ft	FT their answers to (e) and (f) but dep on B1 in (e) and M1 in (f) and their (f) < their (e) (accept $108 < L \leqslant 140$ or interval notation [108, 140] or (108, 140])	

Question Number	Scheme	Marks
7.(a)	Dummy is required to uniquely define Activity Q and Activity R	B1 **(1)**
(b)		M1 A1 M1 A1 **(4)**
(c)	A F I L P	B1 **(1)**
(d)	28 – 13 – 12 = 3 (days)	M1 A1 **(2)**
(e)		M1 A1 A1 A1 **(4)**
(f)	At time $12 < t < 13$ activities D, E, F, G and H must be happening. Therefore five workers required	M1 A1 **(2)**
		14 marks

Notes for Question 7		
a1B1	CAO – accept equivalent explanations (e.g. to allow two activities to start at the same event and end at the same event – see examples)	
b1M1	**All** top boxes complete, values generally increasing in the direction of the arrows ('left to right'), condone one rogue value which is a number in a top box greater than the subsequent value	
b1A1	CAO (top boxes)	
b2M1	**All** bottom boxes complete, values generally decreasing in the opposite direction of the arrows ('right to left'), condone one rogue value which is a number in a bottom box greater than the previous value. Condone missing 0 and/or their 41 (at the end event) for the M mark only	
b2A1	CAO (bottom boxes)	
c1B1	CAO	
d1M1	Their "Late End Time K" – "Early Start Time K" – 12 or a correct equivalent calculation e.g. 41 – 7 – 6 – 12 – 4 – 9 (= 3)	
d1A1	CAO	
e1M1	Cascade Chart not a schedule. At least 11 activities including at least 6 floats	
e1A1	Critical activities (AFILP) correct and at least 3 non-critical activities correct	
e2A1	At least 9 non-critical activities correct	
e3A1	CAO All 17 activities present (just once). No errors**.**	
f1M1	Either a statement with the correct number of workers (5) and stating the correct activities (D, E, F, G and H) with any numerical time stated **or** the correct number of workers (5) and a time in the interval $12 \leqslant t \leqslant 13$ – mark the numerical value only not their use of the words 'day/time' (or equivalent)	
f1A1	A completely correct statement with details of both time **and** activities. Candidates must give a time within the correct interval of $12 < t < 13$, e.g. 12.5 (or 'on/during day 13') or $t \in (12, 13)$ and state the correct activities (D, E, F, G and H). (If using set notation there must be a statement linking time to (12, 13)) Please note inequalities for the time interval implying a time of 12 is incorrect. Answers given as an interval of time are acceptable provided the time interval stated is correct for all its possible values (e.g. time 12 – 13 or 'between 12 and 13' is A0). A completely correct statement with an additional incorrect statement scores A0 (so do not ignore subsequent working)	

Question Number	Scheme	Marks
8. (a)	$y \leqslant 3x + 4$ $x + 2y \geqslant 24$ $2x + 5y \leqslant 100$ $4x + y \leqslant 64$	B1 B1 **(2)**
(b)	$4x + y = 64$ $\quad$ $x + 2y = 24$ $2x + 5y = 100 \Rightarrow \left(\frac{110}{9}, \frac{136}{9}\right)$ $\quad$ $y = 3x + 4 \Rightarrow \left(\frac{16}{7}, \frac{76}{7}\right)$	M1 A1 A1
	$P = ax + by$ $\frac{110}{9}a + \frac{136}{9}b = \frac{628}{9} \Rightarrow 55a + 68b = 314$ $\frac{16}{7}a + \frac{76}{7}b = \frac{260}{7} \Rightarrow 4a + 19b = 65$ $a = 2 \quad b = 3$ $(P =)\ 2x + 3y$	dM1 A1
		(5)
(c)	(3, 11)	B1
		(1)
		8 marks

Notes for Question 8		
a1B1	Any two inequalities correct – condone strict inequalities here (accept equivalent forms)	
a2B1	All four inequalities correct (accept equivalent forms)	
b1M1	Attempts to solve either pair of simultaneous equations to find min and max points (they may attempt to find all 4 vertices) **Note they may use calculators to solve these equations, with no working shown. The correct two pairs of coordinates implies M1 A1 A1 (These values may be seen on the diagram)** **If the correct coordinates are not seen and no working is shown, this is M0**	
b1A1	One pair correctly solved (accept decimal equivalents awrt (12.22, 15.11) and (2.29, 10.86)	
b2A1	Both pairs correctly solved (accept decimal equivalents)	
b2dM1 (cM1 on ePen)	Forms a pair of simultaneous equations using $P = ax + by$ and their minimum and maximum values and solves to obtain a and b **(dependent on the previous M mark) Condone use of alternative letters instead of a and b (but not x and y)**	
b3A1 (cA1 on ePen)	CAO – ($P =$) $2x + 3y$ (must follow from correct working) Note we do not need $P =$, but if they write e.g. $2x + 3y = 0$ this is A0	
c1B1 (dB1 on ePen)	CAO (note the correct coordinates may be embedded in a calculation of the minimum profit e.g. 2(3) + 3(11) = 39 (we will accept a value of 39 with no obvious wrong working as evidence of the correct point) Accept 3, 11 here	

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