GradeMax



Mark Scheme (Results)

January 2019

Pearson Edexcel International Advanced 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 IAL 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
- ⌐ The second mark is dependent on gaining the first mark ⌙

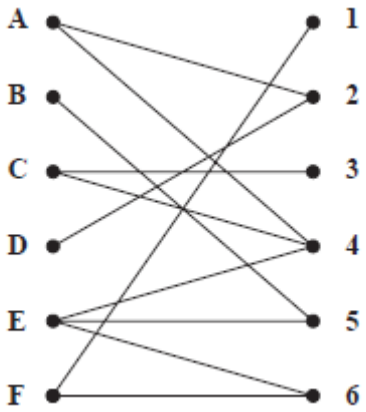
4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

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.

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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)	A bipartite graph consists of two sets of vertices X and Y The edges only join vertices in X to vertices in Y, not vertices within a set	B1 B1 **(2)**
(b)		B1 **(1)**
(c)	AP1: B – 5 = E – 6 = F – 1 AP2: B – 5 = E – 4 = C – 3 AP3: D – 2 = A – 4 = C – 3	M1
	Change status either stated **or** shown	A1
	IM1: A = 2, B = 5, C = 4, (D unmatched) E = 6, F = 1 IM2: A = 2, B = 5, C = 3, (D unmatched) E = 4, F = 6 IM3: A = 4, (B unmatched) C = 3, D = 2, E = 5, F = 6	A1
	AP1: D – 2 = A – 4 = C – 3 AP2: D – 2 = A – 4 = E – 6 = F – 1 AP3: B – 5 = E – 6 = F – 1	M1
	Change status either stated **or** shown	A1
	Complete matching: A = 4, B = 5, C = 3, D = 2, E = 6, F = 1	A1 **(6)**
		9 marks

Question Number	Scheme	Marks

Notes for Question 1

a1B1: Two sets of **vertices** – must contain the three words in bold – accept nodes for vertices but not points or any other non-technical language. These three words do not need to be in the same sentence (e.g. A bipartite graph consists of two sets. In set X the vertices… would be fine for B1) but candidates must imply the correct definition (e.g. a bipartite graph consists of sets of two vertices is B0)
a2B1: Edges/**arcs** must go from one (set) into the other – candidates must give an indication of going from one set to the other – however, they do not need to use the word 'set' for this mark. Candidates do not need to mention that edges should not join vertices within a set but if a candidate does imply that a bipartite graph can join vertices within a set then withold this mark (**no isw**). If a candidate **only** says that you cannot connect nodes from the same set then this is B0. As an absolute minimum accept a statement along the lines of: 'arcs must go from one to the other' – note that for this mark candidates must use the word 'edge(s)' or 'arc(s)' but other technical language may be absent or incorrect

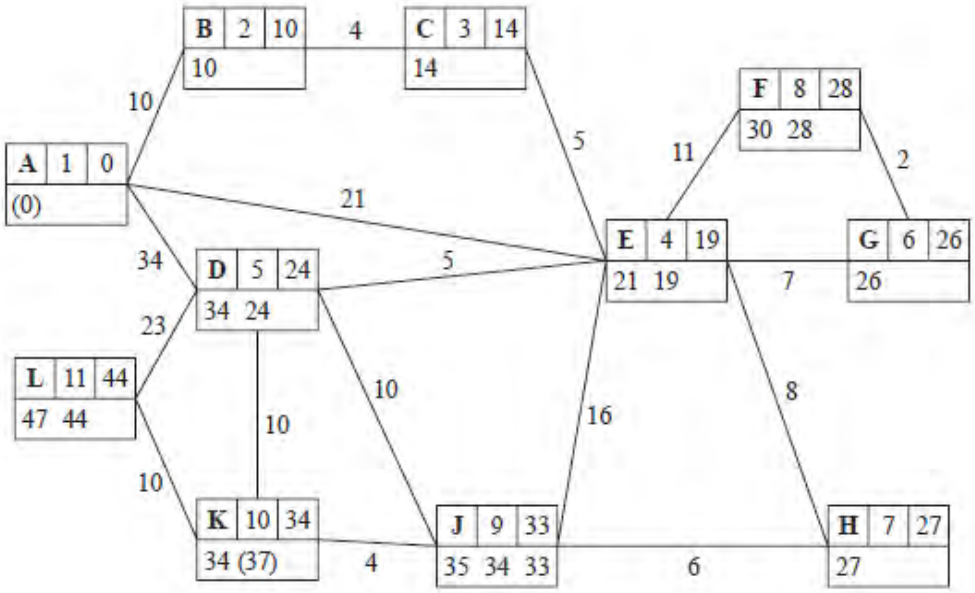
b1B1: CAO

c1M1: An alternating path (e.g. letter 1st set – number 2nd set – letter 1st set – …) from B to 1 (or vice-versa) or B to 3 (or vice-versa) or D to 3 (or vice-versa)
c1A1: 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
c2A1: CAO – improved matching - must follow from the correct stated path. Accept either stated **or** on a **clear** diagram (with five arcs **only**). **Please check the top of the second page as many candidates will draw either the improved or complete matching on the nodes provided there**
c2M1: An alternating path from D to 3 or D to 1 or B to 1 (or vice-versa in each case) (**must** be consistent with their first alternating path)
c3A1: CAO – a correct path including change status stated **or** shown. **Chosen path clear**
c4A1: CAO (complete matching) must follow from two correct stated paths (so **both** previous M marks must have been awarded). Accept on a clear diagram (with six arcs **only**)

A number of candidates are giving more than one alternating path in (c) - please award the marks for the alternating paths used that lead to their complete matching (so stating more than one solution can score full marks). If a candidate states two alternating paths and then only one improved matching and it is not explicitly clear by the candidate's working which of the two alternating paths gives the improved matching then award M1A0A1 (for the first A mark the chosen path must be clear and not simply implied by a correct improved matching if more than one AP given). They can, however, go on and score the final three marks using a consistent alternating path from their improved matching

SC for (c): some candidates are writing AP1 andAP3 from the first list next to each other with no improved matching and so it is not clear if they are applying the algorithm correctly e.g.
alternating path:
D – 2 = A – 4 = C – 3; B – 5 = E – 6 = F = 1
Change status:
D = 2 – A = 4 – C = 3; B = 5 – E = 6 – F = 1
Complete matching
A = 4, B = 5, C = 3, D = 2, E = 6, F = 1

This would scored M1 A0 A0 M1 A0 A1 (neither chosen path is clear – are they choosing two APs from the first list or does one follow the other (reading across the page) – either way it is not clear)

Question Number	Scheme	Marks
2.(a)	 Shortest route: A – B – C – E – D – K – L Length: 44 (km)	M1 A1 (ABCED) A1 (GHFJ) A1ft (KL) A1 A1ft **(6)**
(b)	Trace back from L including arc XY if (Y already lies on the path and) the difference between the final values of X and Y equals the weight of arc XY. **OR** e.g. 44 – 10 = 34 LK, 34 – 10 = 24 KD, 24 – 5 = 19 DE, 19 – 5 = 14 EC, 14 – 4 = 10 CB, 10 – 10 = 0 BA	B2, 1, 0 **(2)**
(c)	Shortest route: J – H – E – C – B – A – B – C – E – G – F Length: 33 + 28 = 61 (km)	B1 B1ft **(2)**
		10 marks

Question Number	Scheme	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 J the working values must be 35 34 33 in that order (so 35 33 34 is incorrect)
It is also important that the order of labelling is checked carefully – some candidates start with a label of 0 at A (rather than 1) – which is fine. Also 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

a1M1: A larger value replaced by a smaller value at least once in the working values at either D or E or F or J or L
a1A1: All values in A, B, C, E and D correct and the working values in the correct order at E and D (including order of labelling). Condone lack of 0 in A's working value
a2A1: All values G, H, F and J correct and the working values in the correct order. Penalise order of labelling only once per question (G, H, F and J must be labelled in that order and G must be labelled after A, B, C, E and D)
a3A1ft: All values in K and L correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question. To follow through K check that the working values at K follow from the candidate's final values from nodes D and J with the order of these values determined by the candidates order of labelling of D and J. Repeat this process for L (which will have working values from D and K with the order of these values determined by the candidates order of labelling of D and K). Note that an additional working value of 37 at K after the 34 is not an error so 34 37 is fine, however, any other number or 37 34 scores A0 in this part
a4A1: CAO - correct route (or from L to A)
a5A1ft: Follow through on their final value at L **only** (condone lack of units)

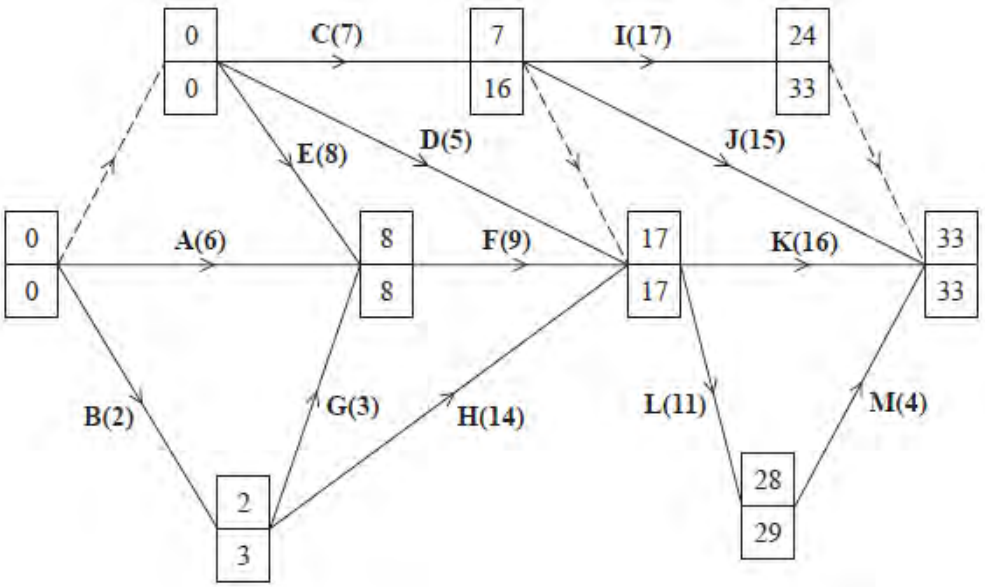
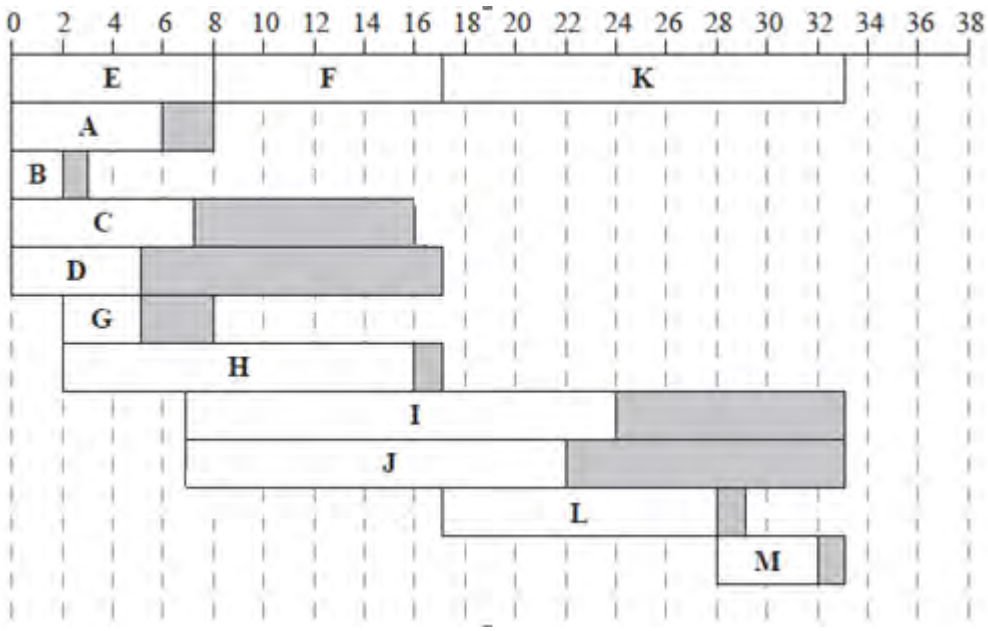
b1B1: General Explanation: Any indication of 'working backwards' or 'tracing back' through the network – it must be clear from the candidate's explanation that they are considering working backwards through the network but give bod for seeing just the phrase 'working backwards' (oe)
Calculation: Must see two consecutive correct calculations working backwards from L for **their** network – we do not need to see the corresponding nodes for this mark. Allow 44 – 10 – 10 – 5 – 5 – 4 – 10 = 0 for B1 only
b2B1: General explanation: For the second B mark we must see

- Working backwards **from L** (not just 'end', 'or final node', etc.)
- Including an **arc** (XY) if the **difference** between the **final values** (of X and Y) is equal to the **weight** (of the arc XY)

Must include all the words in bold (or their equivalent, for example, distance for weight, edge for arc,…) – technical language must be correct

Calculation: for the second B mark we must see all the correct calculations (so no follow through) from L to A for the correct diagram **and** the linking of **all** arcs/nodes to these calculations, for example, L: 44 – 10 = 34 K, K: 34 – 10 = 24 D, etc. is acceptable. **All** values (including the 44 and 0) **and** nodes (including L and A) must be present. These marks in (b) are independent of the route stated in (a)

c1B1: CAO (or from F to J)
c2B1ft: 61 **or** their final value at J + their final value at F (condone lack of units)

Question Number	Scheme	Marks
3.(a)		M1 A1 M1 A1 **(4)**
(b)	Critical activities: E, F and K	B1 **(1)**
(c)		M1 A1 A1 A1 **(4)**
(d)	Minimum workers is 4 activities K, I, J and L	M1
	together with 18 < time < 22	A1 **(2)**
		11 marks

Question Number	Scheme	Marks

Notes for Question 3

a1M1: 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)
a1A1: CAO for the top boxes
a2M1: 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 33 for the M only
a2A1: CAO for the bottom boxes

b1B1: CAO (E, F and K **only**)

c1M1: At least ten activities including at least six floats. A scheduling diagram scores M0
c1A1: The correct critical activities dealt with correctly and appearing just once (E, F and K) and three non-critical activities dealt with correctly
c2A1: Any seven non-critical activities correct (this mark is not dependent on the previous A mark)
c3A1: CSO – completely correct Gantt chart (exactly thirteen activities appearing just once)

d1M1: Either a statement with the correct number of workers (4) and the correct activities (K, I, J and L) with any numerical time stated **or** the correct number of workers (4) and a correct time in the interval $18 < t < 22$ (note strict inequalities) **or** the correct activities and a correct time in the interval $18 < t < 22$
d1A1: A completely correct statement with details of both time and activities. Candidates only need to give a time within the correct interval of $18 < t < 22$. Please note the strict inequalities for the time interval (e.g. implying a time of 18 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 18 – 19 is A0). Allow for example, 'on day 19' as equivalent to $18 < t < 19$

Alternative solution for (d): **M1** for 4 workers, correct activities of E, A, G and H, and a mention of a time in the interval $4 < t < 6$. **A1** for the above + explicit reference to G having to take place in either the time interval $4 < t < 5$ or the time interval $5 < t < 6$ (so must infer that if G doesn't happen in one time interval then it must happen in the other – mentioning just one of these intervals is A0)

Question Number	Scheme	Marks
4.(a)	$\frac{1785}{475} = 3.75...$ so lower bound is 4	M1 A1 **(2)**
(b)	Van 1: 180 80 115 100 Van 2: 250 150 Van 3: 230 95 105 Van 4: 90 Van 5: 390 **The van is therefore required 5 times**	M1 A1 A1 **(3)**
(c)	e.g. using middle right 180 80 250 115 100 230 150 95 105 90 390 Pivot 230 250 390 230 180 80 115 100 150 95 105 90 Pivots 390, 150 390 250 230 180 150 80 115 100 95 105 90 Pivots (250, 180) 95 390 250 230 180 150 115 100 105 95 80 90 Pivots 100, 90 390 250 230 180 150 115 105 100 95 90 80 Pivot(s) 105 (80) 390 250 230 180 150 115 105 100 95 90 80 (Sort complete)	M1 A1 A1ft A1 **(4)**
(d)	Van 1: 390 80 Van 2: 250 180 Van 3: 230 150 95 Van 4: 115 105 100 90 **The van is therefore required 4 times**	M1 A1 A1 **(3)**
(e)	e.g. (note that these lists are not exhaustive – see guidance in notes) Van 1: 390 80 / Van 2: 250 115 105 / Van 3: 230 150 95 / Van 4: 180 100 90 Van 1: 390 80 / Van 2: 250 115 105 / Van 3: 230 150 90 / Van 4: 180 100 95 Van 1: 390 80 / Van 2: 250 100 95 / Van 3: 230 150 90 / Van 4: 180 115 105	M1 A1 **(2)**
		14 marks

Question Number	Scheme	Marks

Notes for Question 4

PLEASE NOTE NO MISREADS IN THIS QUESTION – MARK ACCORDING TO THE SCHEME AND THE SPECIAL CASES IN PARTS (c) AND (d)

a1M1: Attempt to find the lower bound $(1785 \pm 390)/475$ (a value of 3.75 or 3.76 seen with no working can imply this mark)
a1A1: CSO - correct calculation seen **or** 3.75 **or** 3.76 followed by 4 – accept 3.8 if correct calculation seen. An answer of 4 with no working scores M0A0
b1M1: First four items placed correctly and at least eight values placed in bins - condone cumulative totals for M1 only (the boxed values)
b1A1: First eight items placed correctly (the boxed **and** underlined values)
b2A1: CSO (so no additional/repeated values) + explicitly stating 5 or 5 vans or 5 loads but **not** 5 bins
c1M1: Quick sort, pivot, p, chosen (must be choosing middle left or right – 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 that the pivot). **If only choosing one pivot per iteration then M1 only** – Bubble sort is not a MR and scores M1 only for 180 250 115 100 230 150 95 105 90 390 80 (for left to right) **or** 390 180 80 250 115 100 230 150 95 105 90 (for right to left)
c1A1: First two passes correct. They do not need to be choosing a pivot for the third pass
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) including if middle right a fifth pass in which the 105 is used as a pivot **or** if middle left a 'sort complete' - this could be shown by the final list being re-written or 'sorted' statement or each item being used as a pivot (which would therefore mean that the final list would have been written twice)
SC for (c): If using an incorrect list from the start of (c) with only one error (an error is either one missing number, one extra number, two numbers transposed or one incorrect number) then the most they can score is M1A0A1ftA0

Middle left for (c)

180 80 250 115 100 <u>230</u> 150 95 105 90 390	Pivot 230
<u>250</u> 390 [230] 180 80 115 <u>100</u> 150 95 105 90	Pivots 250, 100
390 [250] [230] 180 <u>115</u> 150 105 [100] 80 <u>95</u> 90	Pivots (390), 115, 95
390 [250] [230] <u>180</u> 150 [115] 105 [100] [95] <u>80</u> 90	Pivots 180, (105), 80
390 [250] [230] [180] 150 [115] 105 [100] [95] 90 [80]	Sort complete

Question Number	Scheme	Marks

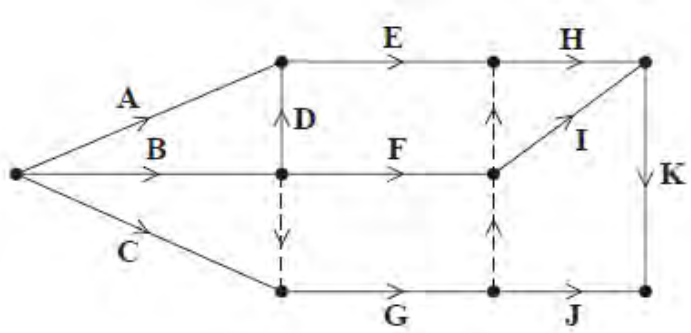
Sorting list into ascending order in (c)

- 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 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 remove the last two A marks earned in (c). 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 last A mark earned

d1M1: Must be using the correct sorted list in descending order. First four items placed correctly and at least eight values placed in bins – condone cumulative totals for M1 only (the boxed values)
d1A1: First eight items placed correctly (the boxed **and** underlined values)
d2A1: CSO (so no additional/repeated values) + explicitly stating 4 or 4 vans or 4 loads but **not** 4 bins. **However, only penalise the lack of (or incorrectly) stating the number of van loads once on the first occurance** (so if a candidate fails to state the number of van loads in both parts they could score at most two marks in (b) but all three marks in (d))
SC for (d) – if 'sorted' list is incorrect from part (c) and M0 would be awarded in (d) then award M1 only in (d) for their first eight items correctly placed – by 'incorrect' they can have only one 'error'- an 'error' is one missing number, one extra number, one incorrect number or one number incorrectly placed. Allow full marks in (d) if a correct list is used in (d) even if the list is incorrect at the end of (c). Please note that if 'sorted' list is incorrect in (c) and it is clear that this has been used from their working in (d) then please award at most M1 in (d)

e1M1: A solution containing **all correct** eleven values (so no ft from misreads or incorrect values in this part) in which each van has no more than 3 values and does not contain more than 475 in total – allow at most five vans used
e1A1: CAO (4 vans only, no van containing more than 3 values and no van containing more than 475)
Note for (e): possibilities are

- A bin with 390 and 80
- A bin with 250 and any two of the remaining values below 150
- A bin with 230 and either 150 and 90 **or** 150 and 95 **or** any two remaining values < 150
- A bin with 180 and the remaining values

Question Number	Scheme	Marks
5.(a)		M1 A1 A1 A1 A1 **(5)**
(b)	Activities B, (D), E, H and K must be critical	B1 **(1)**
		6 marks

Notes for Question 5

In (a) condone lack of, or incorrect, numbered events throughout. 'Dealt with correctly' means that the activity starts from the correct event but need not necessarily finishes at the correct event, e.g. 'G dealt with correctly' requires the correct precedences for this activity, i.e. B and C labelled correctly and leading into the same node and G starting from that node but do not consider the end node for G. **Activity on node is M0**

If an arc is not labelled, for example, if the arc for activity G is not labelled (but the arc is present) then this will lose the second A mark and the final (CSO) A mark – they can still earn the third 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 corrct place for where a dummy should be)

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

a1M1: At least eight activities (labelled on arc), one start, at least two dummies placed and A, B, and C dealt with correctly
a1A1: Activities D, E and 1st dummy (including correct arrow on this dummy – the one after B) dealt with correctly
a2A1: Activities F, G and 2nd and 3rd dummies (including correct arrows on these dummies) dealt with correctly
a3A1: Activities H, I, J and K dealt with correctly
a4A1: 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 additional (but unecessary) 'correct' dummies that still maintain precedence for the network should only be penalised with the final A mark if earned

b1B1: CAO (with no additional activities – so accept B, E, H, K **or** B, D, E, H, K **only**)

Question Number	Scheme	Marks
6.(a)	e.g. (each arc contributes 1 to the orders of two nodes, and so) the sum of the orders of all the nodes is equal to twice the number of arcs Which implies that the sum of the orders of all the nodes is even and therefore there must be an even (or zero) number of vertices of odd order hence there cannot be an odd number of vertices of odd order	B2, 1, 0 **(2)**
(b)(i)	Prim: AB, AD, BC, DE; EF, FG; GJ, HJ	M1; A1; A1
(b)(ii)	Weight = 92 (mins)	B1 **(4)**
(c)	$20x + 17$ + repeat arcs = 162	
	B and E are the only two odd nodes so must be paired	B1
	$4x + 3$ (BE) is clearly greater in value than $x + (2x + 3) + (x – 1) = 4x + 2$ (AB, AD, DE) so repeated arcs are either AB, AD, DE ($4x + 2$) or BC, CE ($7x – 17$)	B1
	$4x + 2 = 7x – 17 \Rightarrow x = 19/3$	B1
	$x < 19/3 \Rightarrow 20x + 7x – 17 = 145 \therefore x = 6$	M1 A1
	$x > 19/3 \Rightarrow 20x + 4x + 2 = 145 \therefore x = 143/24 < 19/3$ so $x \neq 143/24$	A1 **(6)**
		12 marks

Notes for Question 6

a1B1: For one of the following points:

- 'Sum of the order/valencies of the nodes/vertices = 2(number of arcs/edges)'
- 'Each arc/edge contributes 1 to the order/valency of two nodes/vertices'
- 'Sum of the order/valencies of the nodes/vertices is even'

But condone for B1 only

- 'sum of the valencies = 2(number of arcs/edges)' **or** 'sum of the nodes/vertices = 2(number of arcs/edges)' **or** 'sum of the orders = 2(number of arcs/edges)
- 'sum of the valencies is even' **or** 'sum of the nodes/edges is even'

a2B1: stating that 'the sum of the order (or valencies) of the nodes/vertices = 2(number of arcs/edges) therefore the sum of the order (of the nodes/vertices) is even which implies that there must be an even number of nodes/vertices of odd order (or there cannot be an odd number of nodes/vertices of odd order) **OR** each arc/edge contributes 1 to the order of two nodes/vertices therefore the sum of the order (of the nodes/vertices) is even which implies that there must be an even number of nodes/vertices of odd order (or there cannot be an odd number of nodes/vertices of odd order)

So in summary the first B mark should be awarded for a broadly correct statement (but allow bod as shown in the last two bullet-points above) but for both B marks a fully correct explanation must be given without any bod (please note therefore it is not possible to score B0B1). Do not accept non-technical language for nodes/arcs for either B1B0 or B1B1

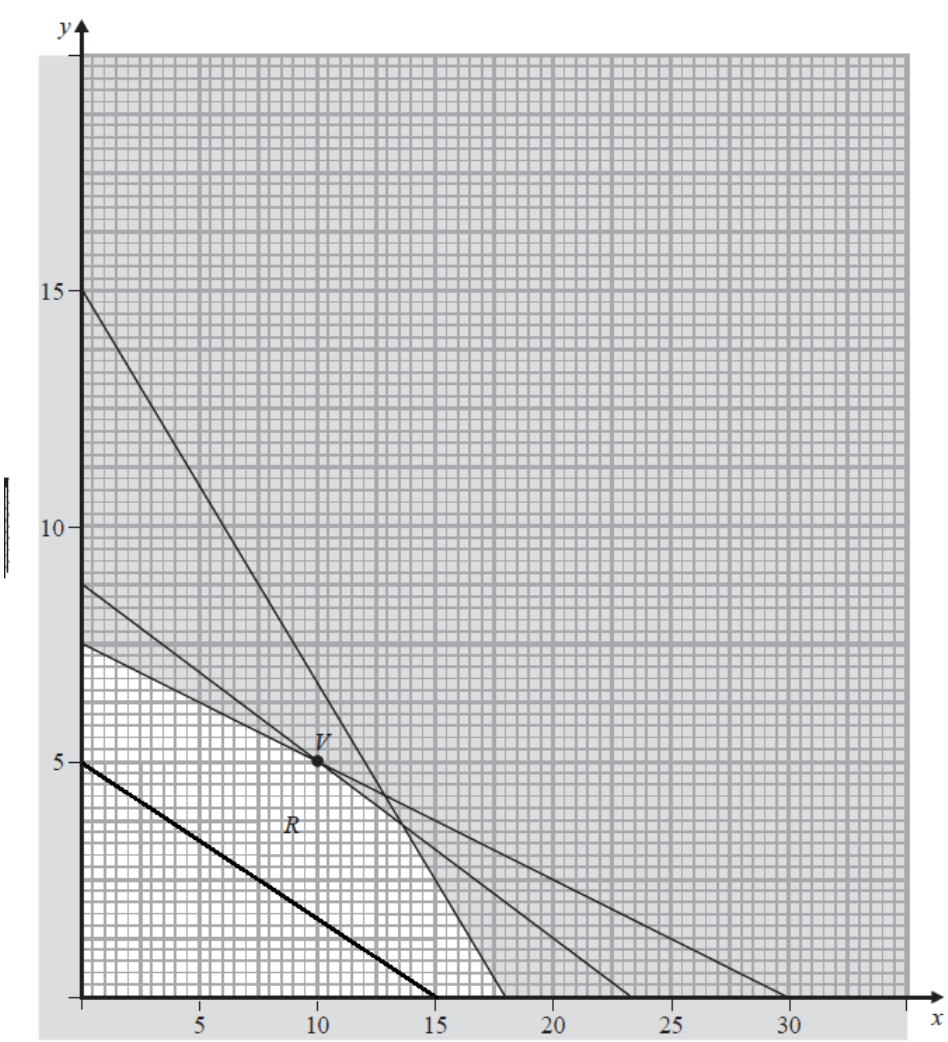
Question Number	Scheme	Marks

bi1M1: Prim – First four arcs (AB, AD, BC, DE) correctly chosen, or first five nodes (A, B, D, C, E) correctly chosen in order. **If any explicit rejections seen at any point then M1 (max) only**. A list of weights only scores M0. Candidates may apply Prim's in matrix form so the order of the nodes may be seen at the top of a matrix – accept {1,2,4,3,5,-,-,-,-} for the M mark. Allow CB for BC etc. throughout (b)
bi1A1: First six arcs correctly chosen in order (AB, AD, BC, DE, EF, FG), **or** all nodes correctly chosen in order (A, B, D, C, E, F, G, J, H). Candidates may apply Prim's in matrix form so the order of the nodes may be seen at the top of a matrix – accept {1,2,4,3,5,6,7,9,8} – do not condone any missing numbers e.g. the number 9 must be above H
bi2A1: 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)

Misread: Starting at a node other than A scores M1 only in (b)(i) – must have the first four arcs (or five nodes) correct (and in the correct order)

bii1B1: CAO (92) – condone lack of units

c1B1: Consideration of B and E (as odd nodes) – this mark can be implied by considering the pairing of B with E at any point (need not see explicit reference to B and E e.g. one correct equation in x would imply this mark)
c2B1: Explicit consideration of why BE cannot be the least pairing of B with E – candidates must clearly reject with a reason why the arc BE is not the shortest path between B and E. As a minimum accept both expressions stated correctly in the form $ax + b$ and then BE > BADE or $4x + 3 > 4x + 2$ but B0 if just stating both expressions and selecting $4x + 2$ without any reason given – do not award this mark if any of the expressions for BE or BADE are stated incorrectly
c3B1: Consideration for what values of x either of the two other paths would be least – so for this mark we must see the value of 19/3 or 6.333… (to at least 3 s.f. or equivalent) as either the solution to the linear equation $4x + 2 = 7x – 17$ or as a solution to an inequality involving these two linear expressions
c1M1: Correct equation in x for any of the three possible pairings of B with E – so for this mark only accept $20x + 17 + 4x + 3 = 162$ **or** $20x + 17 + x – 1 + x + 2x + 3 = 162$ **or** $20x + 17 + 2x – 4 + 5x – 13 = 162$ (or equivalent) - any of these three equations would imply the first B mark (consideration of B and E as odd nodes)
c1A1: CAO (for $x = 6$) – this must come from the correct equation $20x + 17 + 7x – 17 = 162$ and not from rounding 5.9583… or 5.9166… - allow this mark even if 143/24 (or equivalent e.g. 5.9583…) **or** 71/12 (or equivalent e.g. 5.91666…) is given as a possible solution too
c2A1: Correctly shows that the pairings of AB, AD and DE does not give a consistent value for x – as a minimum for this mark the candidate must explicitly state that 143/24 or 5.9583… (to at least 3 s.f.) is less than 19/3 or 6.333… (to at least 3 s.f.) **and** so therefore x cannot take the value of 143/24 or 5.9583… (either mathematically or in words)

Question Number	Scheme	Marks
7.(a)	Maximise $50x+150y$ Subject to: $x+4y\le 30$ $3x+8y\le 70$ $5x+6y\le 90$ $(x\ge 0, y\ge 0)$	B1 M1 A1 **(3)**
(b)		B1 B1 B1 B1 **(4)**
(c)	Correct objective line drawn V labelled correctly	B1 B1 **(2)**
(d)	10 *Manhattan* and 5 *Brooklyn* bookcases Profit: £1250	B1 B1 **(2)**
(e)	Packaging 5 hours	B1 B1 **(2)**
		13 marks

Question Number	Scheme	Marks

Notes for Question 7

a1B1: Expression correct <u>together</u> with 'maximise' or 'max' but not 'maximum' – isw if coefficients are subsequently simpified but $50x + 150y$ must be seen at some point for this mark to be awarded. The 'max' must appear beside the correct expression
a1M1: One correct simplified constraint with integer coefficients
a1A1: All three correct simplified constraints with integer coefficients and no others

In (b)

$x + 4y = 30$ must pass within one small square of its intersection with the axes – (0, 7.5) and (30, 0)
$3x + 8y = 70$ must pass within one small square of its intersection with the axes – (0, 8.75) and (23.33…, 0)
$5x + 6y = 90$ must pass within one small square of its intersection with the axes – (0, 15) and (18, 0)

b1B1: Any one line correctly drawn
b2B1: Any two lines correctly drawn
b3B1: All three lines correctly drawn
b4B1: Region, *R*, correctly labelled – not just implied by shading – dependent on scoring the first three marks in this part. Do not award this mark if any additional constaints are shown on the graph

c1B1: Correct objective line drawn - if their line <u>on</u> the graph is shorter than the length equivalent to that of the line from (0, 1) to (3, 0) then B0. Line must be correct to within one small square if extended from axis to axis
c2B1: The correct *V* labelled or clearly identified on their graph – dependent on a correct objective line, scoring the first three B marks in (b) and a correct feasible region implied by shading if not labelled

d1B1: CAO in context – so not in terms of *x* and *y* only – dependent on first three B marks in (b) and the first mark in (c)
d2B1: CAO (condone lack of units) - dependent on first three B marks in (b) and the first mark in (c)

e1B1: CAO (packaging only) – not dependent on any previous marks
e2B1: CAO (condone lack of units but do not accept 5 minutes) – not dependent on any previous marks

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