Mark Scheme (Results)

January 2023

Pearson Edexcel International Advanced Level
In Decision Mathematics (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.

PEARSON EDEXCEL IAL MATHEMATICS

General Instructions for Marking

1. The total number of marks for this paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

<u>'M' marks</u>
These are marks given for a correct method or an attempt at a correct method. In Mechanics they are usually awarded for the application of some mechanical principle to produce an equation.
e.g. resolving in a particular direction, taking moments about a point, applying a suvat equation, applying the conservation of momentum principle etc.
The following criteria are usually applied to the equation.

To earn the M mark, the equation
(i) should have the correct number of terms
(ii) be dimensionally correct i.e. all the terms need to be dimensionally correct
e.g. in a moments equation, every term must be a 'force x distance' term or 'mass x distance', if we allow them to cancel 'g' s.
For a resolution, all terms that need to be resolved (multiplied by sin or cos) must be resolved to earn the M mark.

M marks are sometimes dependent (DM) on previous M marks having been earned.
e.g. when two simultaneous equations have been set up by, for example, resolving in two directions and there is then an M mark for solving the equations to find a particular quantity – this M mark is often dependent on the two previous M marks having been earned.

'A' marks
These are dependent accuracy (or sometimes answer) marks and can only be awarded if the previous M mark has been earned. e.g. M0 A1 is impossible.

'B' marks
These are independent accuracy marks where there is no method (e.g. often given for a comment or for a graph).

A few of the A and B marks may be f.t. – follow through – marks.

3. General 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
- $\ast$ – 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 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)	A – B – D – F – C – E – G – A 43 + 45 + 49 + 55 + 50 + 48 + 55 = 345 (m) A – B – D – F – G – E – C – A 43 + 45 + 49 + 55 + 48 + 50 + 52 = 342 (m)	M1 A1 A1 **(3)**
(b)	RMST weight = 237 (m) **or** arcs in RMST are BD, BE, BG, DF, CE 237 + 43 + 47 = 327 (m)	B1 M1 A1 **(3)**
(c)	327 $\leqslant$ optimal distance $\leqslant$ 342	B1ft **(1)**
		(7 marks)

Notes for Question 1

a1M1: First four nodes correct for a nearest neighbour route starting at A – so must have at least A – B – D – F – … **or** in terms of arcs (AB, BD, DF,…) **or** in terms of weights (43, 45, 49,…)
a1A1: One correct route (in terms of arcs or nodes but not just weights), must return to A and corresponding correct length (units not required)
a2A1: Both routes correct (in terms of arcs or nodes but not just weights) and their corresponding correct lengths (units not required)

b1B1: cao for RMST weight (237) **or** correct arcs (BD(45), BE(46), BG(47), DF(49), CE(50) only) **or** 45 + 46 + 47 + 49 + 50 stated
b1M1: Adding the two correct least weighted arcs (AB(43) and AD(47)) to their attempt at RMST weight where their attempt at the RMST has a weight in the interval $224 \leqslant$ RMST weight $\leqslant 250$ (give bod if not clear where their attempt at RMST weight comes from but if working shown then must be from summing the weight of exactly five arcs). Allow unsimplified answers which imply the correct two arcs added to the weight of the RMST (e.g. 45 + 46 + 47 + 49 + 50 + 43 + 47 is equivalent to the two smallest arcs (43, 47) added to five arcs which sum to a value in the given interval).

If a candidate uses one of their NN routes from (a) and removes the arcs incident to A from this route and adds on the 43 and 47 (e.g. you may see 45 + 49 + 55 + 50 + 48 + 43 + 47) then this can still score M1 as they have added the weight of five arcs that form a spanning tree (not minimal but this is their attempt - with a total in the required interval) and they have then added on the two correct least weighted arcs

b1A1: CAO (327) – the correct answer of 327 with no working can score all three marks in this part

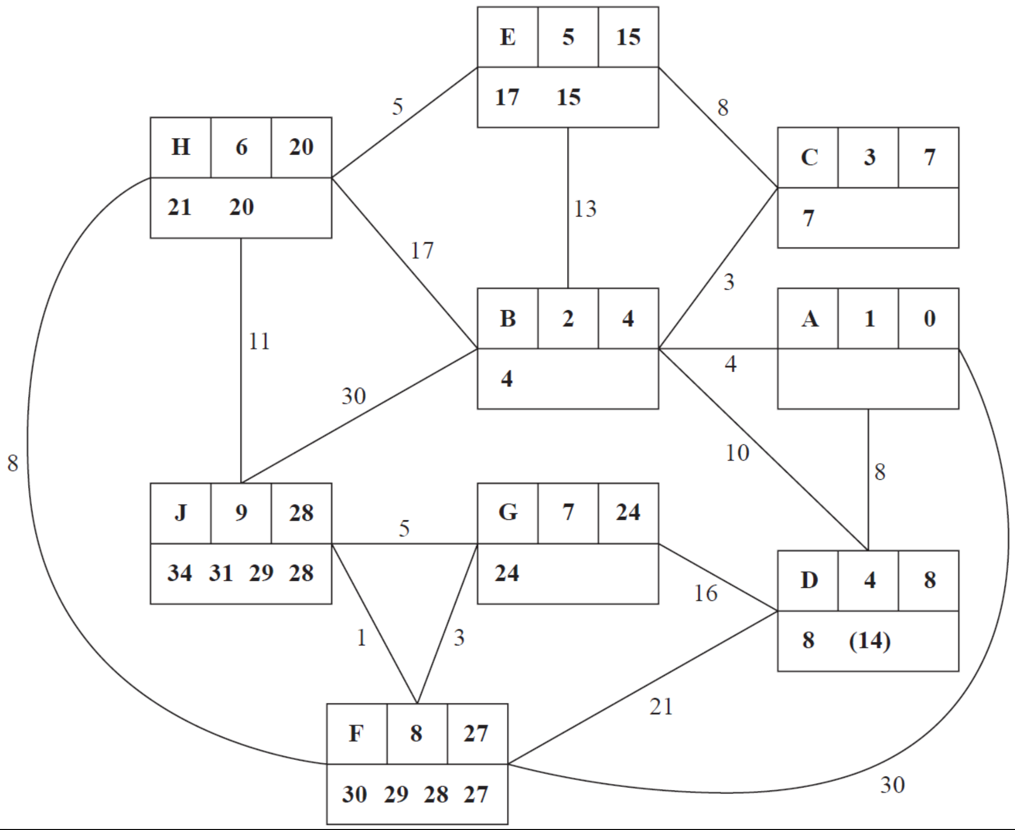
c1B1ft: Their numbers correctly used (their answer to (b) and their least value from (a)) with correct inequalities **(allow strict inequality for lower bound)** so an answer of 327 – 342 is B0. Lower bound must be less than upper bound. The LB must be $314 \leqslant$ LB $\leqslant 340$ and is dependent on scoring the M mark in (b). The UB is dependent on the M mark in (a) and there must be two different values in (a) stated (and they must have chosen the smaller of the two). Allow equivalent notation e.g. [314, 340] or (314, 340]

In (a) allow use of H for G or a combination of Gs and Hs. The following are all examples that would be acceptable for the correct route A – B – D – F – C – E – G – A in (a)

- A – B – D – F – C – E – H – A
- A – B – D – F – C – E – G/H – A
- A – B – D – F – C – E – H – G – A

- A – B – D – F – C – E – G – H – G – A
- A – B – D – F – C – E – H or G – G – A
- AB, BD, DF, FC, CE, EH/G, G/HA
- AB, BD, DF, FC, CE, EG (or EH), HA (or GA)
- AB, BD, DF, FC, CE, EH, HG, GA
- AB, BD, DF, FC, CE, EH, GA

In general accept a cycle of the form A – B – D – F – C – E – X – A where X is G or H or any combination of Gs and Hs (and similarly A – B – D – F – X – E – C – A for the second cycle or their equivalents in terms of arcs). **If any doubt regarding the route in (a) (or their answer to (b) and therefore its implication for (c)) then please contact your Team Leader and send the item to review**.

Question number	Scheme	Marks
2. (a)		M1 A1 (BCDE) A1 (HG) A1ft (FJ)
	Shortest path: A – D – G – F – J	A1
	Length: 28 (miles)	A1ft **(6)**
(b)	Shortest path: J – F – G – D – A – B – C – E – H	B1
	Length: 28 + 20 = 48 (miles)	B1ft **(2)**
(c)	A(BC)E + FG = 15 + 3 = 18* A(DG)F + E(HF)G = 27 + 16 = 43 A(D)G + E(H)F = 24 + 13 = 37	M1 A1 A1
	Repeat arcs: AB, BC, CE, FG	A1
	Length: 193 + 18 = 211 (miles)	A1ft **(5)**
(d)	EF (13) is the shortest link between two odd nodes excluding G Repeat EF (13) since this is the shortest path excluding G	M1
	We finish at A	A1
	Length of route = 193 + 13 = 206 (miles)	A1 **(3)**
		(16 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 H the working values must be 21 20 in that order (so 20 21 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

a1M1: A larger value replaced by a smaller value at least twice in the working values at either E, F, H or J
a1A1: All values at B, C, D and E correct and the working values in the correct order
a2A1: All values at H and G correct and the working values in the correct order
a3A1ft: All values in F and J correct on the follow through and the working values in the correct order. To follow through F check that the working values at F follow from the candidate's final values for the nodes that are directly attached to F (which are A, D, H, G (and J)). For example, **if** correct then the order of labelling of nodes A, D, H and G are 1, 4, 6 and 7 respectively so the working values at F should come from A, D, H and G in that order. The first working value at F should be 30 (from A), the second working value at F should be their 29 (the Final value at D) + 21 (the weight of the arc DF), the third working value at F should be their 20 (the Final value at H) + 8 (the weight of the arc HF) and the fourth working value at F should be their 24 (the Final value at G) + 3 (the weight of the arc FG). Repeat the process for J (which will have working values from B, H, G and F with the order of these nodes determined by the candidate's order of labelling at B, H, G and F)
a4A1: CAO (ADGFJ or AD, DG, GF, FJ but **not** JFGDA or equivalent from J to A)
a5A1ft: Follow through their final value at J **only** – if their answer is 28 but this is not the Final Value at J then A0

b1B1: CAO for the route (JFGDABCEH or JF, FG, GD, DA, AB, BC, CE, EH)
b2B1ft: 48 or follow through their final value at J + their final value at H

c1M1: Three distinct pairings of the nodes A, E, F and G
c1A1: Any two rows correct including pairings **and** totals
c2A1: All three rows correct including pairings **and** totals
c3A1: CAO - correct arcs clearly stated and not just in their working as AB, BC, CE and FG (allow BA, CB, etc.) – must be these arcs. Do not accept ABCE or AE via B and C
c4A1ft: Correct answer of 211 **or** follow through 193 + their least total from a choice of three

d1M1: Identifies the need to repeat one path of the three (AE, AF, EF) which does not include G (maybe implicit) or listing of only these possible repeats – **this mark is dependent on either scoring the M mark in (c) or stating all three possible paths**. If stating more than these three paths (AE, AF, EF) then it must be clear from later working that they are only considering these three. **As a minimum stating just one of these three paths (or any combination of these three paths with no others) can score this mark (so, for example, just stating AE and AF scores this mark) provided that they do not further imply that a path including G should be repeated (as this would indicate that mentioning one (or more) of these paths is for the purpose of not repeating it)**
d1A1: Identifies EF as the least **and** A as the finishing point. They have to explicitly state that **EF** is the **least** path that **does not include G**
d2A1: CAO (206)

<table>
<tr><th>Question number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>3.(a)</td><td>Bin 1: 1.8 1.4 1.6
Bin 2: 2.6 $\underline{0.9}$ $\underline{0.8}$ 0.6
Bin 3: $\underline{2.8}$ 1.2
Bin 4: $\underline{3.1}$
Bin 5: 2.4</td><td>M1 $\underline{\text{A1}}$ A1 (3)</td></tr>
<tr><td>(b)(i)</td><td>1.8 2.6 1.6 2.8 1.4 3.1 0.9 1.2 2.4 0.8 0.6</td><td>B1</td></tr>
<tr><td>(ii)</td><td>Comparisons: 10 Swaps: 6</td><td>B1 B1 (3)</td></tr>
<tr><td>(c)</td><td>e.g. using middle right

2.6 1.8 2.8 1.6 3.1 $\boxed{1.4}$ 1.2 2.4 0.9 0.8 0.6 pivot 1.4
2.6 1.8 2.8 $\boxed{1.6}$ 3.1 2.4 $\underline{1.4}$ 1.2 0.9 $\boxed{0.8}$ 0.6 pivots 1.6 0.8
2.6 1.8 $\boxed{2.8}$ 3.1 2.4 $\underline{1.6}$ $\underline{1.4}$ 1.2 $\boxed{0.9}$ $\underline{0.8}$ 0.6 pivots 2.8 0.9 (0.6)
3.1 $\underline{2.8}$ 2.6 $\boxed{1.8}$ 2.4 $\underline{1.6}$ $\underline{1.4}$ 1.2 $\underline{0.9}$ $\underline{0.8}$ 0.6 pivot(s) (3.1) 1.8 (1.2)
3.1 $\underline{2.8}$ 2.6 $\boxed{2.4}$ $\underline{1.8}$ $\underline{1.6}$ $\underline{1.4}$ 1.2 $\underline{0.9}$ $\underline{0.8}$ 0.6 pivot 2.4
3.1 $\underline{2.8}$ 2.6 $\underline{2.4}$ $\underline{1.8}$ $\underline{1.6}$ $\underline{1.4}$ 1.2 $\underline{0.9}$ $\underline{0.8}$ 0.6 (sort complete)

e.g. using middle left

2.6 1.8 2.8 1.6 3.1 $\boxed{1.4}$ 1.2 2.4 0.9 0.8 0.6 pivot 1.4
2.6 1.8 $\boxed{2.8}$ 1.6 3.1 2.4 $\underline{1.4}$ 1.2 $\boxed{0.9}$ 0.8 0.6 pivots 2.8 0.9
3.1 $\underline{2.8}$ 2.6 $\boxed{1.8}$ 1.6 2.4 $\underline{1.4}$ 1.2 $\underline{0.9}$ $\boxed{0.8}$ 0.6 pivots (3.1) 1.8 (1.2) 0.8
3.1 $\underline{2.8}$ $\boxed{2.6}$ 2.4 $\underline{1.8}$ 1.6 $\underline{1.4}$ 1.2 $\underline{0.9}$ $\underline{0.8}$ 0.6 pivot(s) 2.6 (1.6) (0.6)
3.1 $\underline{2.8}$ $\underline{2.6}$ 2.4 $\underline{1.8}$ $\underline{1.6}$ $\underline{1.4}$ 1.2 $\underline{0.9}$ $\underline{0.8}$ 0.6 (sort complete)</td><td>M1

A1
A1ft

A1</td></tr>
<tr><td>(d)</td><td>Bin 1: 3.1 1.8
Bin 2: 2.8 $\underline{1.6}$ 0.6
Bin 3: 2.6 2.4
Bin 4: $\underline{1.4}$ $\underline{1.2}$ 0.9 0.8</td><td>M1 $\underline{\text{A1}}$ A1 (3)</td></tr>
<tr><td></td><td></td><td>(13 marks)</td></tr>
</table>

Notes for Question 3

PLEASE NOTE NO MISREADS IN THIS QUESTION – MARK ACCORDING TO THE SCHEME AND THE SPECIAL CASE IN PART (c) AND THE GUIDANCE FOR THE M MARK IN (d)

a1M1: The **correct** first four items placed correctly (the bold values) and at least eight values placed in bins (allow repeated values). Condone cumulative totals 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)

bi1B1: CAO – isw after one complete pass. Please check these carefully as some candidates show all the swaps and comparisons in the first pass and some show more than one complete pass. As a guide consider the placement of the 0.8 (when this is the second value from the right-hand side this will indicate the completion of the first pass)
bii1B1: Comparisons correct (10)
bii2B1: Swaps correct (6)

If the comparisons and swaps are not labelled then assume that the first number seen is the comparisons and the second number is the swaps (so seeing after the 1st pass of bubble sort the numbers 10, 6 then award both the second and third B marks in this part). If all they state is 6 then 10 then give **SC B1 B0** for the final two marks in this part

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 than the pivot). **If only choosing one pivot per iteration then M1 only**
c1A1: First pass correct and choosing consistent pivots for the second pass for this mark
c2A1ft: Second and third pass correct following through from their first pass and choice of pivots for the second pass these pivots for the second pass must be consistent (either both middle left or both middle right)
c3A1: CSO (correct solution only – all previous marks in this part **must** have been awarded) including a fifth pass shown (not just saying 'sort complete' after the fourth pass) for 'middle right' or a fourth pass shown for 'middle left'

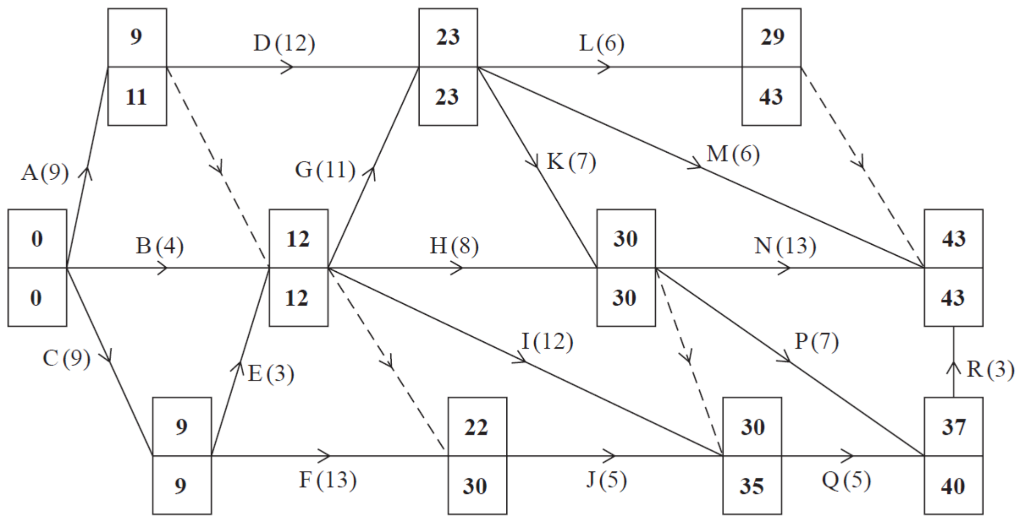
SC for (c): If using the original list or an incorrect list from the start of (c), or after the first pass, with only one error (an error is either one missing number, one extra number, two numbers transposed or one incorrect number) then they can score at most M1A0A1ftA0. If the candidate sorts into 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.).

d1M1: Their five largest items placed correctly and at least eight values placed in bins (if correct this will be the bold items but must check **their** packing if any of **their** five largest values are incorrect – note that the maximum weight of a bin is 5). Condone cumulative totals for M1 only. First-fit increasing scores no marks in this part. If no sort seen in (c) then mark (d) assuming the correct ordered list is being used
d1A1: 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)
d2A1: CSO – no additional or repeated values (dependent on both previous marks)

Question number	Scheme	Marks
4.(a)	see table	B2, 1, 0 **(2)**

Activity	Immediately preceded by	Activity	Immediately preceded by	Activity	Immediately preceded by
A	-	G	**A, B, E**	M	D, G
B	-	H	**A, B, E**	N	**H, K**
C	-	I	**A, B, E**	P	**H, K**
D	A	J	**A, B, E, F**	Q	**H, I, J, K**
E	C	K	D, G	R	**P, Q**
F	C	L	D, G		

(b)

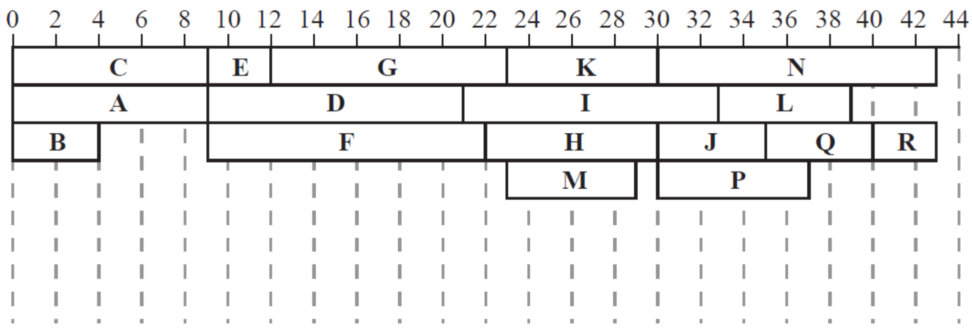


M1
A1
M1
A1 **(4)**

(c)	Critical activities: C, E, G, K and N	B1 **(1)**
(d)	Float on J = 35 – 22 – 5 = 8	B1ft **(1)**
(e)	Lower bound is $\frac{133}{43} = 3.0930... = 4$	B1 **(1)**

(f)

e.g.



M1
A1
A1
A1 **(4)**

(13 marks)

Notes for Question 4

a1B1: Any four (of the eight blank) rows correct
a2B1: All eight rows correct

b1M1: All top boxes complete, values generally increasing in the direction of the arrows (so generally going from 'left to right' across the network), condone one 'rogue' value (if values do not increase in the direction of the arrows then if one value is ignored and the remaining values do increase in the direction of

the arrows then this is considered to be a single rogue value). Note that all values in the top boxes could be incorrect but it can still score the M mark if the values are **increasing** in the way stated above
b1A1: CAO – **all** values correct in the top boxes
b2M1: All bottom boxes complete (but condone a blank box for the late event time at the end event node for the M mark only). Values generally decreasing in the opposite direction of the arrows (so generally going from 'right to left' across the network), condone one 'rogue' (as described above in **b1M1**)
b2A1: CAO – **all** values correct in the bottom boxes

c1B1: CAO (C, E, G, K and N only)

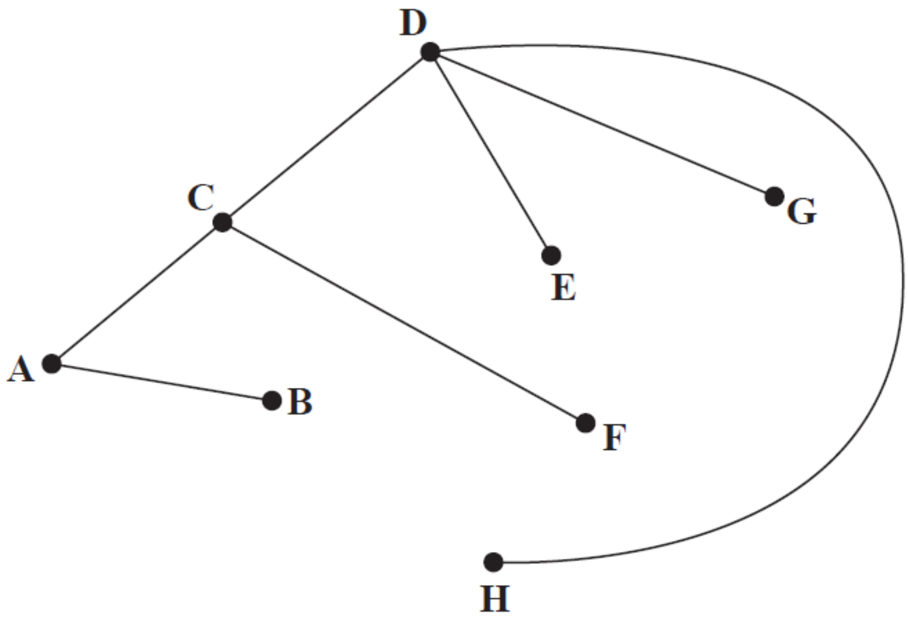
d1B1ft: correct calculation seen for their J (provided total float is non-negative). Correct answer or the correct answer following through the event times for J with no working seen scores B0 – must see all three numbers in their calculation

e1B1: CSO – 4 together with **either** a **correct** calculation seen **or** an awrt 3.1. An answer of 4 with no working scores B0. If working seen then it must be correct

f1M1: Not a cascade (Gantt) chart. 5 'workers' used at most and at least 8 new (11 in total) activities placed
f1A1: 4 workers. All 14 new (17 in total) activities present (just once). Condone at most **three** errors. An activity can give rise to at most three errors; one on duration, one on time interval and only one on IPA
f2A1: 4 workers. All 14 new (17 in total) activities present (just once). Condone **one** error **either** precedence **or** time interval **or** activity length; An activity can give rise to at most three errors; one on duration, one on time interval and only one on IPA
f3A1: 4 workers. All 14 new (17 in total) activities present (just once). No errors**.**

The table below is helpful in checking an activities duration, time interval and IPA

Activity	Duration	Time interval	IPA
D	12	9 – 23	A
E	3	9 – 12	C
F	13	9 – 30	C
G	11	12 – 23	A, B, E
H	8	12 – 30	A, B, E
I	12	12 – 35	A, B, E
J	5	22 – 35	A, B, E, F
K	7	23 – 30	D, G
L	6	23 – 43	D, G
M	6	23 – 43	D, G
N	13	30 – 43	H, K
P	7	30 – 40	H, K
Q	5	30 – 40	H, I, J, K
R	3	37 – 43	P, Q

Question number	Scheme	Marks
5.(a)	E.g. You cannot have a graph with an odd number of odd vertices E.g. $\frac{1+2+2+3+3+4+4+6}{2}=12.5$ which is not an integer and so therefore not possible to have a graph with the given vertex orders	B1 **(1)**
(b)	As vertex C appears more than once A – C – D – E – C – B – F is not an example of a path on T	B2, 1, 0 **(2)**
(c)	AC, AB, CD; DH, DG; CF, DE	M1; A1; A1 **(3)**
(d)		B1 **(1)**
(e)	$21 < x < 25$	B2, 1, 0 **(2)**
		(9 marks)

Notes for Question 5

a1B1: CAO – common examples that score B1:

- Cannot have (a graph with an) odd number of odd vertices
- Cannot have a graph with three odd vertices
- The sum of the degrees/order (of the vertices) is 25 which is not even therefore not possible (but not just for obtaining 25 and saying 'impossible'). The 25 must be linked either in words to the 'sum of the degrees/order' **or** explicitly showing 1+ 2 + 2 + 3 + 3 + 4 + 4 + 6 = 25 so just '25 is not even' scores B0
- The sum of the degrees/order (of the vertices) is 25 which is odd therefore not possible (with equivalent justification of the 25 as in the previous bullet-point)
- $\frac{1+2+2+3+3+4+4+6}{2}=12.5$ which is not an integer so therefore impossible. They do not have to explain that they are using the result that $\sum$ vertex degrees = 2(no of arcs) but they must explain why a value of 12.5 leads to the required graph not being possible. A value of 12.5 with no working (or explanation) scores B0

In (a) do not condone clearly incorrect technical language e.g. using ‘arc’ when it should be ‘vertex’

b1B1: No + attempt at a reason which includes **either** the mention of a cycle/circle/loop etc. **or** the repeating of a vertex/node/point etc. is sufficient for this mark (condone incorrect technical language) – give bod (but ‘no because there is a repeated arc’ **only** scores B0 unless we also see mention of a repeated vertex (oe) as well)
b2DB1: No + correct reason (dependent on first B mark in (b)) – no bod – must refer to C appearing twice (**not** just that a vertex is repeated) or that it contains the cycle C – D – E – C (**not** just that it contains a cycle). **All technical language must be correct if used for this mark and do not isw any incorrect reasoning**

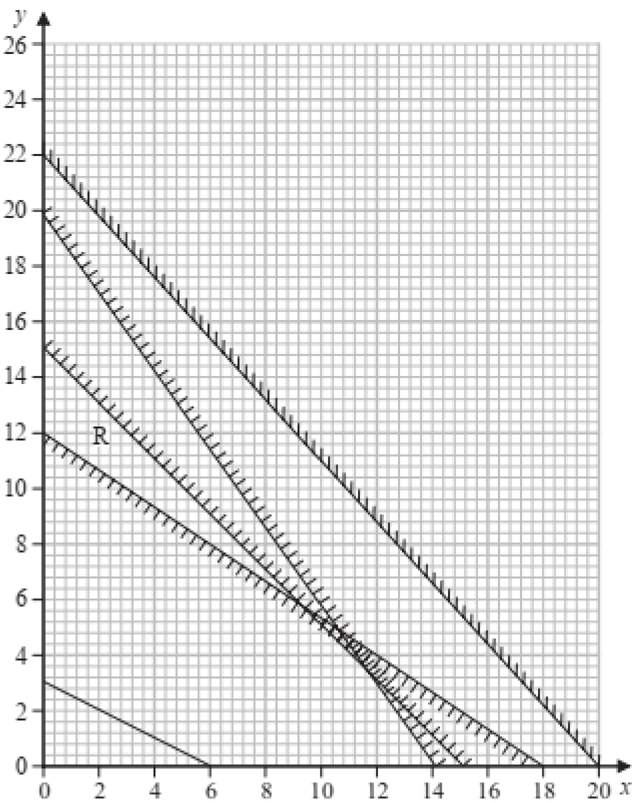
The minimum acceptable answer for both marks in this part is, ‘it is not a path as C appears twice’

c1M1: Prim’s – first three arcs correctly chosen in order (AC, AB, CD) **or** first four nodes (A, C, B, D) 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, 3, 2, 4, -, -, -, -}. However, do not accept a list of weights only (as the weights in the network are not unique)
c1A1: First five arcs correctly chosen in order (AC, AB, CD, DH, DG) **or**
all eight nodes {A, C, B, D, H, G, F, E} correctly chosen in order. Order of nodes may be seen at the top of a matrix so for the first two marks accept {1, 3, 2, 4, 8, 7, 6, 5} (**no** missing numbers). However, do not accept a list of weights only (as the weights in the network are not unique)
c2A1: CSO – all **arcs** correctly **stated** and chosen in the correct order (with no additional incorrect arcs). They must be considering arcs for this final mark (do not accept a list of the weights of each arc, nodes or numbers across the top of the matrix unless the correct list of arcs (in the correct order) is also seen)

Misread in (c): Starting at a node other than A scores **M1 only** – **must** have the first three arcs (or four nodes) correct (and in the correct order) – condone any rejections seen for this mark

d1B1: CAO (ignore weights on arcs even if incorrect)

e1B1: $x < 25$ or $x \leqslant 25$ or $x < 24$ or $x \leqslant 24$ or equivalent notation e.g. (… , 25)
e2B1: CAO ($21 < x < 25$) or equvialent notation (e.g. (21, 25))

Question number	Scheme	Marks
6. (a)	Minimise (P =) 300x + 400y + 400z	B1
	Subject to:	
	$275x+200y+100z \leqslant 5500$ $(\Rightarrow 11x+8y+4z \leqslant 220)$	B1
	$5x+2y+3z \leqslant 70$	B1
	$\frac{x}{15}+\frac{y}{20}+\frac{z}{30} \leqslant 1 \Rightarrow 4x+3y+2z \leqslant 60$	M1 A1
	$x+y+z \geqslant 18$ $(x, y, z \geqslant 0)$	B1 **(6)**
(b)	e.g Martin makes apple cakes and chocolate cakes in the ratio of 2:1 e.g. for every one chocolate cake that Martin makes he has to make 2 apple cakes (assuming that he makes chocolate/apple cakes) e.g. Martin should make twice as many apple cakes as chocolate cakes e.g. The number of apple cakes that Martin makes should be double the number of chocolate cakes he makes	B1 **(1)**
(c)		B1 B1 B1 B1 **(4)**
(d)	Drawing an objective line accept reciprocal gradient	M1
	Correct objective line	A1
	Martin should make 9 carrot cakes, 6 apple cakes and 3 chocolate cakes	A1
	Minimum amount of sugar is 6300 grams (or 6.3 kg)	A1 **(4)**
(e)	Martin has 1525 grams of flour remaining	B1
	Martin also has 4 eggs remaining	B1 **(2)**
		(17 marks)

Notes on Question 6

a1B1: CAO – expression correct (300*x* + 400*y* + 400*z* or 0.3*x* +0.4*y* + 0.4*z* **only**) and 'minimise' or 'min' but not 'minimum'. ISW if either of these two expressions are seen and then 'simplified'

a2B1: CAO ($275x+200y+100z \leqslant 5500$) oe but must be four terms only with integer coefficients e.g. $11x+8y \leqslant 220-4z$

a3B1: CAO ($5x+2y+3z \leqslant 70$) oe but must be four terms only with integer coefficents

a1M1: Correct method $\frac{x}{15}+\frac{y}{20}+\frac{z}{30} \bullet 1$ where $\bullet$ is any inequality symbol or =

a1A1: CAO ($4x+3y+2z \leqslant 60$) oe must be four terms only with integer coefficients

a4B1: CAO ($x+y+z \geqslant 18$) oe must be four terms only with integer coefficients

b1B1: CAO but give bod if intention is correct. Some correct examples include:

- (Martin makes) apple (cakes) and chocolate (cakes) in the ratio of 2:1
- For every one chocolate (cake that Martin makes he has to) make 2 apple (cakes)
- (Martin should make) twice as many apple (cakes) as chocolate (cakes)
- The number of apple cakes (that Martin makes should be) double the number of chocolate cakes (he makes)

Please check these carefully for those candidates that imply incorrectly that Martin should make two chocolate cakes for every one apple cake. Furthermore, do not condone an answer that implies an inequality (e.g. use of words such as, 'at least', 'at most', etc.)

The lines in **(c)** must define the correct FR **and if extended** would pass within a small square of their point of intersection with the axes

c1B1: Any two lines correctly drawn
c2B1: Any three lines correctly drawn
c3B1: All four lines correctly drawn
c4B1: Correct *R* labelled – not just implied by shading – dependent on scoring the first three marks in this part **and all four lines being drawn from axis to axis (within one small square)**

d1M1: Drawing the correct objective line (gradient –0.5) or its reciprocal (gradient –2) on the graph. Line must be correct to within one small square if extended from axis to axis. If line is shorter than (0, 1) to (2, 0) (or for the reciprocal (0, 2) to (1, 0)) then M0
d1A1: Correct objective line – same condition that the line must be correct to within one small square if extended from axis to axis and be no shorter than the line from (0, 1) to (2, 0)

The final 4 marks are all dependent on the first three B marks in (c), the first two marks in part (d) and they must not have implied an incorrect *R* in (c) (but give bod if region not labelled in (c) or if the lines did not go axis to axis in (c) as this was penalised with the final mark in (c))

d2A1: CAO (in context) – as a minimuim accept 9 carrot, 6 apple and 3 chocolate
d3A1: CAO (6300 or 6.3) – no units required but if stated then must be correct – so 6300 kg is A0

e1B1: CAO (1525 (grams) or 1.525 (kg) of flour) – no units required but if stated then must be correct – so 1525 kg is A0
e2B1: CAO 4 (eggs)

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