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Mark Scheme (Results)

January 2018

Pearson Edexcel
International Advanced Subsidiary Level
In Decision Mathematics D1 (WDM01)
Paper 01

edexcel

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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.

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PEARSON 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
   - o.e. – or equivalent (and appropriate)
   - d… or dep – dependent
   - indep – independent
   - dp decimal places
   - sf significant figures
   - * The answer is printed on the paper or ag- answer given
   - ⌐ or d… The second mark is dependent on gaining the first mark

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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.

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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)	Alternating path: D – 6 = E – 5 = F – 4 = B – 3 Change status: D = 6 – E = 5 – F = 4 – B = 3 Complete matching: A = 1, B = 3, C = 2, D = 6, E = 5, F = 4	M1 A1 A1 **(3)**
		5 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

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 but they must use either arc(s) **or** edge(s). 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: 'edges must go from one to the other'

b1M1: An alternating path from D to 3 (or vice – versa)

b1A1: CAO – a correct path including change status **either** stated **or** shown. Chosen path clear

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

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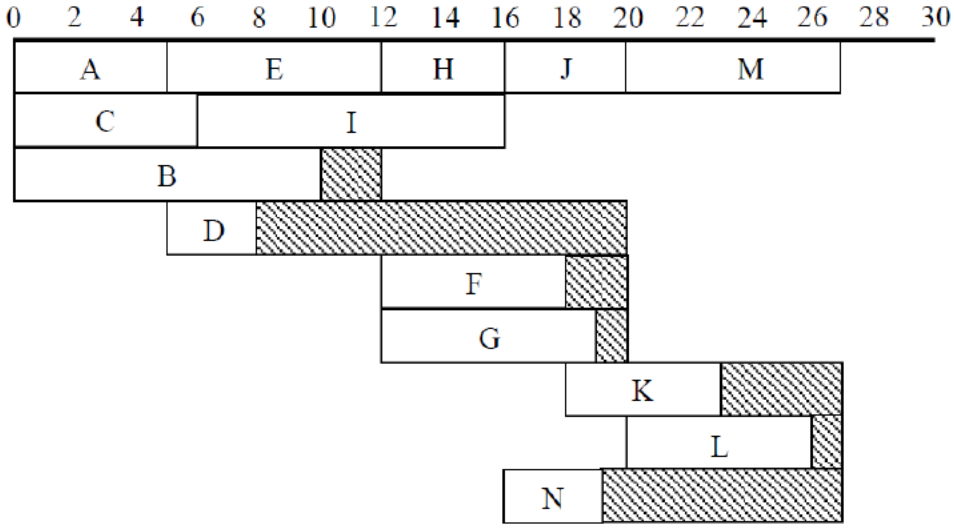
Question Number	Scheme	Marks
2.(a)	$w = 20, x = 6, y = 12, z = 10$	B4,3,2,1,0 **(4)**
(b)		M1 A1 M1 A1 **(4)**
(c)	Minimum workers is 4 activities H, I, F and G	M1
	together with 14 < time < 16	A1 **(2)**
		10 marks

Notes for Question 2

a1B1: Any one correct
a2B1: Any two correct
a3B1: Any three correct
a4B1: All four correct

b1M1: At least ten activities including at least four floats. A scheduling diagram scores M0
b1A1: The critical activities dealt with correctly and appearing just once (A, C, E, H, I, J and M) and 3 non-critical activities dealt with correctly
b2M1: Any five non-critical activities **correct**
b2A1: CSO – completely correct Gantt chart (exactly fourteen activities just once)

c1M1: Either a statement with the correct number of workers (4) and the correct activities (H, I, F and G) with any time stated **or** the correct number of workers (4) and a correct time
c1A1: A completely correct statement with details of both time and activities. Candidates only need to give a time within the correct interval of 14 < time < 16. Please note the strict inequalities for the time interval (e.g. implying a time of 14 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 15 – 16 is A0). Allow for example, 'on day 16' as equivalent to 15 < time < 16, and condone mention of 'day' if a correct time is given but 'at day 16' is A0

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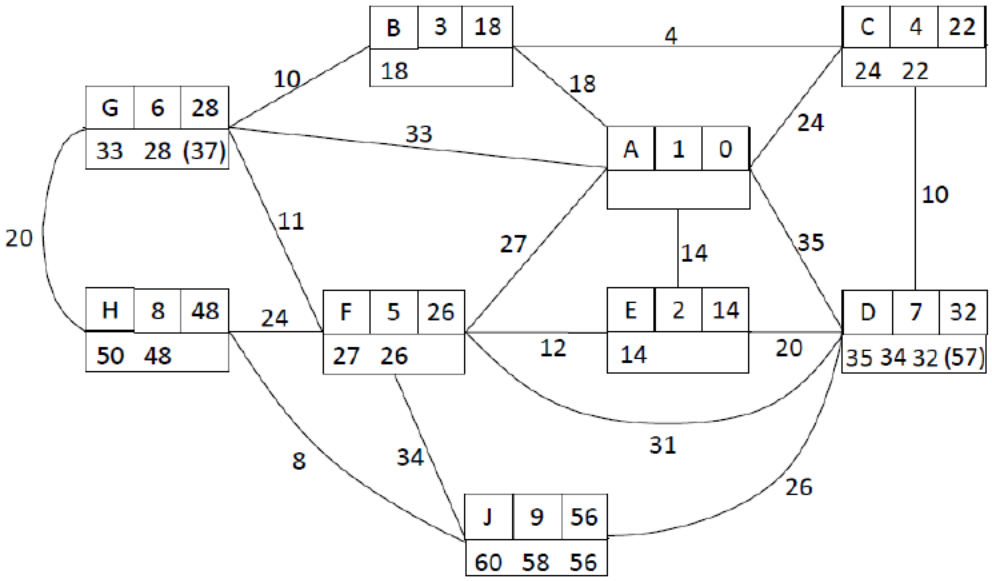
Question Number	Scheme	Marks
3. (a)		M1 A1 (EBC) A1 (FGD) A1ft (HJ)
	Shortest path: ABGHJ	A1
	Length: 56 (km)	A1ft **(6)**
(b)	Route from D to H via A: DCBABGH	B1
	Length: 80 (km)	B1ft **(2)**
(c)	EF, FG, BG, CB; CD, AE; GH, HJ	M1; A1; A1 **(3)**
(d)	Length of MST: 89 (km)	B1 **(1)**
		12 marks

Notes for Question 3

a1M1: A larger value replaced by a smaller value at least once in the working values at either C or D or F or G or H or J

a1A1: All values in E, B and C correct and the working values in the correct order at C (including order of labelling)

a2A1: All values F, G and D correct and the working values in the correct order. Penalise order of labelling only once per question (F, G and D must be labelled in that order and after A, E, B and C)

a3A1ft: All values in H and J correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question (H and J must be labelled in that order and H labelled after all other nodes (excluding J)). To follow through H check that the working values at H follows from the candidate's final values from F and G and that the final value, and order of labelling, follows through correctly. Repeat this process for J (which will have working values from F, D and H)

a4A1: CAO - correct path (ABGHJ)

a5A1ft: Follow through on their final value at J

b1B1: CAO – correct route (DCBABGH)

b2B1ft: Follow through their final value at D + their final value at H

c1M1: First four arcs (or five nodes - EFGBC) correctly chosen in order. **If any rejections seen at any point then M1 (max) only**. Starting at any other node scores M1 only – from A this would be AE, EF, FG, BG,… (or AEFGB…)

c1A1: First six arcs (or all nodes – EFGBCDAHJ) correctly chosen in order

c2A1: CSO – all arcs correctly stated and chosen in the correct order (with no extras)

d1B1: CAO (condone lack of or incorrect units)

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Question Number	Scheme	Marks
4. (a)	$y \le 3x$ oe $3y \ge x$ oe $5x+3y \le 15$ oe	B3,2,1,0 **(3)**
(b)	$(0,0)$, $\left(\frac{15}{14},\frac{45}{14}\right)$, $\left(\frac{5}{2},\frac{5}{6}\right)$	B1 M1 A1 **(3)**
(c)	At $(0,0), P=0$ $\left(\frac{15}{14},\frac{45}{14}\right), P=\frac{165}{14}$ therefore $\left(\frac{15}{14},\frac{45}{14}\right)$ is the optimal vertex $\left(\frac{5}{2},\frac{5}{6}\right), P=\frac{15}{2}$	M1 A1 A1 **(3)**
(d)	$2\left(\frac{15}{14}\right)+k\left(\frac{45}{14}\right) \ge 2\left(\frac{5}{2}\right)+k\left(\frac{5}{6}\right)$	M1
	$k \ge \frac{6}{5}$	A1 **(2)**
		11 marks

Notes for Question 4

Mark all parts of this question together and check the graph carefully for inequalities/equations

a1B1: Either two equations correct or one correct inequality (condone strict inequality)

a2B1: Two correct inequalities (condone strict inequalities)

a3B1: CAO (all three inequalities correct)

b1B1: (0, 0)

b1M1: Using simultaneous equations to get the other **two** vertices – must get to $x = ...$ and $y = ...$ or correctly stating the coordinates of one vertex (with or without working) but must be exact

b1A1: CAO of $\left(\frac{15}{14},\frac{45}{14}\right)$ and $\left(\frac{5}{2},\frac{5}{6}\right)$ (oe) - condone if stated with no working

c1M1: Point testing at least two of their vertices using the correct objective function $P = 2x + 3y$ (objective line method is M0)

c1A1: Point testing two of the correct vertices correctly – condone testing (1.07, 3.21) and/or (2.5, 0.833) (oe correct to 3 sf)

c2A1: All three correct exact vertices tested correctly and correct conclusion that $\left(\frac{15}{14},\frac{45}{14}\right)$ is the optimal vertex **and** $P=\frac{165}{14}$ or $11\frac{11}{14}$ (must be clear), **do not** isw if integer vertices are then considered/stated

d1M1: Setting up a linear inequality (with any inequality sign) or an equation involving the new objective function ($Q = 2x + ky$) and the candidate's two non-zero vertices from (b) (accept at least 3 sf but not integer coordinates) – ignore any consideration of (0,0). Or consideration of the gradient of the objective line **and** the gradient of $5x + 3y = 15$ together e.g. $-\frac{2}{k} \le -\frac{5}{3}$ (accept any inequality or equals sign – condone lack of negative signs provided they are absent from **both** gradients)

d1A1: CAO (allow strict inequality) – if more than one inequality given then A0 unless $k \ge \frac{6}{5}$ explicitly selected as their only answer. Correct answer with no working scores M1A0 – all working must be correct for this mark

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Question Number	Scheme	Marks
5. (a)	Start and finish at G and K (or vice-versa)	B1 **(1)**
(b)	B(J)G + D(EH)K = 49 + 67 = 116	M1
	B(JHE)D + G(H)K = 91 + 48 = 139	A1
	B(A)K + G(C)D = 40 + 56 = 96*	A1
	Arcs AB, AK, CG and CD will be traversed twice	A1 **(4)**
(c)	Route: e.g. BABJKAKHJGBCGCDCFGHFDHED	B1
	Length = 601 + 96 = 697 (m)	B1ft **(2)**
		7 marks

Notes for Question 5

a1B1: CAO (G and K only)

b1M1: Three distinct pairings of the correct four nodes (BGDK)
b1A1: Any two rows correct including pairing and total
b2A1: All three rows correct including pairing and total
b3A1: CAO correct **arcs** clearly stated (must be AB, AK, CG, CD **only**)

c1B1: CAO checks: starts at B finish at D, 24 vertices, AB, AK, CG and CD appear twice and A appearing twice, B(3), C(3), D(3), E(1), F(2), G(3), H(3), J(2), K(2)
c2B1ft: 601 + their smallest repeat out of a choice of at least two distinct pairings of the correct four nodes from (b) (condone lack of or incorrect units)

Mark parts (b) and (c) together

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Question Number	Scheme	Marks
6. (a)	Bin 1: 30 11 21 16 4 Bin 2: 53 39 Bin 3: 50 43 Bin 4: 60	M1 A1 A1 **(3)**
(b)(i)	11 21 16 4 30 39 43 50 53 60	B1
(ii)	Comparisons: 6 Swaps: 2	B1 B1 **(3)**
(c)	e.g. middle right 30 11 21 53 50 **39** 16 4 60 43 53 50 **60** 43 39 30 11 **21** 16 4 60 53 **50** 43 39 30 21 11 **16** 4 60 53 50 43 39 30 21 16 11 **4** 60 53 50 43 39 30 21 16 11 4	M1 A1 A1ft A1 **(4)**
(d)	Bin 1: 60 39 Bin 2: 53 43 4 Bin 3: 50 30 16 Bin 4: 21 11	M1 A1 A1 **(3)**
		13 marks

Notes for Question 6

a1M1: First five items placed correctly and at least seven values placed in bins (the underlined values) - condone cumulative totals for M1 only
a1A1: First eight items placed correctly (the underlined and boxed values)
a2A1: CSO (so no additional/repeated values)
bi1B1: CAO for fourth pass (11 21 16 4 30 39 43 50 53 60) – must be clear
bii2B1: CAO for comparisons (6)
bii3B1: CAO for swaps (2) – if two values stated with no labelling then assume that the first value is for comparisons and the second is for swaps – if only one value stated with no labelling then B0B0 in (b)(ii)
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**. No marks in (c) if bubble sort used
c1A1: First pass correct, next two pivots chosen correctly for second pass
c2A1ft: Second and third passes correct (follow through from their first pass and choice of pivots)
c3A1: CSO
d1M1: Must be using 'sorted' list in descending order. First four items placed correctly and at least seven values placed in bins (the underlined values) - condone cumulative totals for M1 only
d1A1: First eight items placed correctly (the underlined and boxed values)
d2A1: CSO (so no additional/repeated values)

SC for part (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 six items correctly placed – by 'incorrect' they can have only one 'error'- an 'error' is one missing number, one extra 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)

Misreads

- If the candidate has misread a number at the start of (a), so genuinely miscopy a number then mark the whole of (a), (c) and (d) as a misread (not (b)) – removing the last two A marks earned. This gives a maximum of 8 marks in total for these three parts

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Question Number	Scheme	Marks

- If they have used the correct numbers at any point in (a) and then use an incorrect number in (c) (say 35 instead of 53) from the beginning of the sort or misread one of their own numbers during (c) then count it as one 'error' in (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 mark (d) according to the SC above. 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

SC for (c) – candidates who use either **11 21 30 16 4 39 43 50 53 60** (bubble sort after three passes) or **11 21 16 4 30 39 43 50 53 60** (bubble sort after four passes) in (c) can score M1A1 only for correctly completing the quick sort (note that M1 only **cannot** be awarded for this **SC**)

Middle left for (c)

30 11 21 53 **50** 39 16 4 60 43
53 60 50 30 11 21 **39** 16 4 43
60 53 50 43 39 30 11 **21** 16 4
60 53 50 43 39 30 21 11 **16** 4
60 53 50 43 39 30 21 16 **11** 4
60 53 50 43 39 30 21 16 11 4

Ascending middle right

30 11 21 53 50 **39** 16 4 60 43
30 11 **21** 16 4 39 53 50 **60** 43
11 **16** 4 21 30 39 53 **50** 43 60
11 **4** 16 21 30 39 43 50 53 60
4 11 16 21 30 39 43 50 53 60 sort complete

Ascending middle left

30 11 21 53 **50** 39 16 4 60 43
30 11 21 **39** 16 4 43 50 **53** 60
30 11 **21** 16 4 39 43 50 53 60
11 **16** 4 21 30 39 43 50 53 60
11 4 16 21 30 39 43 50 53 60
4 11 16 21 30 39 43 50 53 60 sort complete

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Question Number	Scheme	Marks
7. (a)	Maximise $0.75x+1.2y+1.45z$	B1
	Subject to $x+z<200$	B1
	$5y \geq 2x$	M1 A1
	$\frac{3}{4}(x+y+z) \geq y \Rightarrow 3x+3z \geq y$ $(x,y,z \geq 0)$	M1 A1 **(6)**
(b)	$x=100, z=25$ leading to $40 \leq y \leq 375$ Minimum profit (£)159.25, Maximum profit (£)561.25	M1 A1 A1 **(3)**
		9 marks

Notes for Question 7

a1B1: Expression correct (or $75x+120y+145z$) **together with** 'maximise' or 'max' but not 'maximum' – isw if coefficients are subsequently simpified but either $0.75x+1.2y+1.45z$ or $75x+120y+145z$ **together with** 'maximise' or 'max' must be seen at some point for this mark to be awarded

a2B1: CAO ($x+z<200$)

a1M1: Correct method: $5y \square 2x$ (oe e.g. $2.5y \square x$) where $\square$ is any inequality or equals. An exact equivalent answer (with or without integer coefficients) can score M1 **or** for $2y \geq 5x$ (oe)

a1A1: CAO ($5y \geq 2x$ oe) - answer must have integer coefficients with like terms collected i.e. $k(5y \geq 2x)$ for any positive integer k - the correct answer with no working can score M1 A1

a2M1: $\frac{3}{4}(x+y+z) \square y$ (oe) where $\square$ is any inequality or equals. The bracket must be present or implied by later working. An exact equivalent answer (with or without integer coefficients) with no working can score M1. Accept equivalent fractions or decimals for 3/4 but not 75% (unless later converted to a correct fraction/decimal)

a2A1: CAO $(3x+3z \geq y)$(oe) - answer must have integer coefficients with like terms collected i.e. $k(3x+3z \geq y)$ for any positive integer k - the correct answer with no working can score M1 A1

b1M1: Substituting $x=100$ **and** $z=25$ into their inequalities and obtaining **either** two values of y **or** two inequalities for y **or** for either correct answer of 159.25 **or** 561.25 seen

b1A1: CAO - $40 \leq y \leq 375$ (oe) **or** $y=40$ **and** $y=375$ (must come from correct working/inequalities)

b2A1: CAO on minimum and maximum profit (must come from correct working) – condone lack of or incorrect units. Furthermore, candidates do not need to explicitly state which is the minimum and which is the maximum profit for this mark

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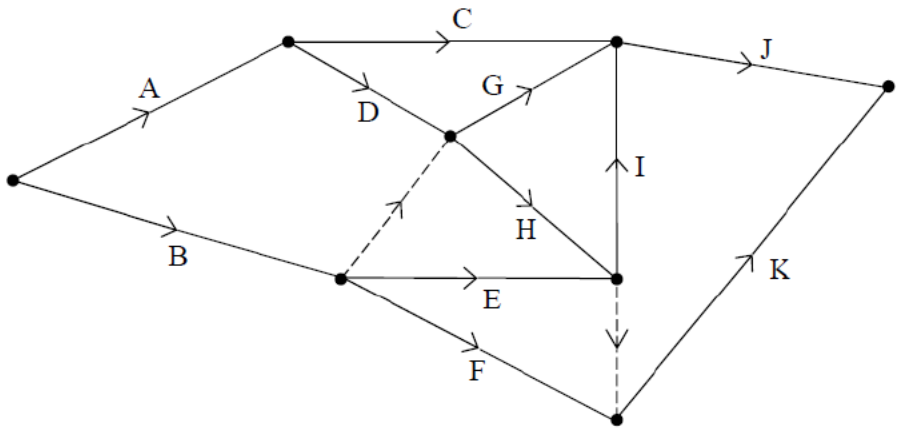
Question Number	Scheme	Marks
8. (a)		M1 A1 A1 A1 A1 **(5)**
(b)	25 – 12 – 10 = 3	B1 **(1)**
(c)	The path is not critical as activity H is not critical because this activity has a total float of 3	M1 A1 **(2)**
		8 marks

Notes for Question 8

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

Do not penalise the same labelling omission twice with the first three A marks, for example, if 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 and third A marks on the bod

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

a1M1: At least nine activities (labelled on arc), one start, at least two dummies placed and A, B, C and D dealt with correctly
a1A1: E, F and 1st dummy + correct arrow (the dummy after B) dealt with correctly
a2A1: G, H and I dealt with correctly
a3A1: J, K and 2nd dummy + correct arrow (the dummy after E) dealt with correctly
a4A1: CSO – all arrows present and correctly placed with one finish and no additional dummies. **Please check all arcs carefully for arrows**
b1B1: CAO (accept 3 with no working)
c1M1: No + attempt at a reason – if no attempt at (b) then M0A0 in (c)
c1A1: CAO - No + valid reason – dependent on (b) correct - must mention that the (total) float of H is 3 **or** that the (total) float of H is positive **or** the (total) float of H is not zero (in all cases (b) must be correct, H must be mentioned and their answer must contain some numerical argument). Note that e.g. 'No because H is not critical' or 'No because H has a (total) float' scores M1A0

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