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Mark Scheme (Results)

Summer 2014

Pearson Edexcel International A Level in Decision Mathematics 1 (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.

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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
   - oe – 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
   - $\lfloor$ or d… 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.

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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)	e.g. (middle right) Pivots M S Q C **E** P B F O E C **B** E M S Q **P** F O B,P B **C** E M **F** O P S **Q** (C),F,Q B C E F M **O** P Q **S** O,(S) B C E F **M** O P Q S (M) Sort complete	M1 A1 A1ft A1 **(4)**
(b)	Pivot 1 = $\left\lceil\frac{1+9}{2}\right\rceil = 5$ McCANN reject 1-5 Pivot 2 = $\left\lceil\frac{6+9}{2}\right\rceil = 8$ QUAGLIA reject 8-9 Pivot 3 = $\left\lceil\frac{6+7}{2}\right\rceil = 7$ PATEL P = PATEL, name found (so 3 iterations)	M1 A1 A1 **(3)**
(c)	e.g. $\log_2 641 = 9.324$, so 10 or maximum number of items in each pass: 641, 320, 160, 80, 40, 20, 10, 5, 2, 1 so 10 iterations	M1 A1 **(2)** **(9 marks)**

Notes for Question 1

a1M1: Quick sort – pivots, p, selected and first pass gives <p, p, >p. **If only choosing one pivot per iteration M1 only.**
a1A1: First pass correct, next two pivots chosen correctly for second pass.
a2A1ft: Second and third passes corrrect (follow through from their first pass and choice of pivots) – and next pivot(s) chosen consistently for fourth pass.
a3A1: CSO and 'sort complete' this could be shown **either** by a 'stop' statement **or** final list re-written **or** using each item as a pivot.
b1M1: Choosing middle right pivot (choosing middle left is M0) + discarding/retaining half the list. M1 **only** for an 'incorrect' list – allow 1 error (e.g. two letter interchanged) or 1 omission or 1 extra.
b1A1: First and second passes correct i.e. 5^{th} and 8^{th} items for a correct list **and** second half rejected (no sticky pivots).
b2A1: CSO Third pass correct i.e. 7^{th} item for a correct list + "found" (accept 'found', 'located', 'stop', etc. but not just the letter; must be convinced that P has been located). The number of iterations does **not** need to be stated explicitly.

Part (c): Candidates who consider maximum number of values at the start of each iteration:

- **M1** for at least 641, 320, 160, 80, … or embedded in a calculation e.g. [641+1] / 2 = 321, [320 + 1] / 2 = 161, [160 + 1] / 2 = 81, [80 + 1] / 2 = …
- **M1 A1** 641, 320, 160, 80, 40, 20, 10, 5, 2, 1 so 10 iterations

Candidates who consider maximum number of values at the end of each iteration:

- **M1** for at least 320, 160, 80, …
- **M1 A1** 320, 160, 80, 40, 20, 10, 5, 2, 1 so 10 iterations (so 9 iterations is A0).

Question Number	Scheme	Marks

Other numerical arguments

(The maximum number of iterations is the least integer value of n such that)

- **M1** $2^n > 641$ then **either** taking logs of both sides and attempt to solve for n (accept $2^n = 641$) **or** stating $n = 9.32$ ... (answer given correct to 1 dp).
- **M1 A1** the above with $n = 10$ (no errors if calculation seen) (allow recovery from equals).
- **M1** those candidates who state $2^n > 641$ and state $n = 10$ with no working unless 2^9 also considered.
- **M1** $\log_2 641 = \cdots$
- **M1 A1** ... $= 9.32$ ... (answer given correctly to 1 dp) and hence 10.
- $\frac{641}{2^n}$ considered with $n = 10$ is **M1** showing explicitly that $n = 10$ is the first value that gives value less that 1 gets **A1** (it is not sufficient to just say that $\frac{641}{2^{10}}$ is less than 1 either $\frac{641}{1024}$ or 0.625… (correct to 1 dp) must be seen).
- Candidates who say that halving 641 ten times gives a value less than 1 (or equal to 1) **M1 only**. Accept = 1 as when candidates talk about halving/dividing by 2 it is not always clear if they mean half the list or half the numbers in the list. However if the candidate explicitly shows that halving 641 ten times gives a value less than 1 which must be given either exactly or correct to 1 dp then **A1**.
- An answer of 10 with no working **M0**

Middle left for (a)

									Pivots
M	S	Q	C	**E**	P	B	F	O	E
C	B	E	M	S	**Q**	P	F	O	C,Q
B	C	E	M	**P**	F	O	Q	**S**	(B), P, (S)
B	C	E	M	**F**	O	P	Q	S	F
B	C	E	F	**M**	O	P	Q	S	M
B	C	E	F	**M**	O	P	Q	S	(O)

Sort complete

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Question Number	Scheme	Marks
2. (a)	(i) Complete matching: A matching where **every** member of **set** X is **paired** with a single member of set Y and vice-versa. (ii) Difference: A maximal matching is where the number of edges is as **large as possible** without necessarily pairing all vertices. A complete matching pairs **all** vertices.	B1 B1 B1 **(3)**
(b)	E.g. Alternating path: C – L = A – O Change status: C = L – A = O Improved matching: A = O, B = M, C = L, E = N, F = P	 M1 A1 A1 **(3)**
(c)	E.g. Alternating path: D – M = B – K Change status: D = M – B = K Complete matching: A = O, B = K, C = L, D = M, E = N, F = P	 M1 A1 A1 **(3)** **(9 marks)**

Notes for Question 2

a1B1**:** Complete: pairing or one to one.
a2B1: Complete: **all** elements from one **set** with all elements of the other ('all' and 'set' must be mentioned at least once).
a3B1: Difference: **all** compared to **at most**. Give bod but **must** mention 'all' compared to 'at most'.
b1M1: An alternating path from C to O or K (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 five arcs only).
c1M1: An alternating path from D to K or O, whichever one (of O or K) they didn't use in (b) (or vice versa).
c1A1: CAO – a correct path including change status either stated **or** shown. Chosen path clear.
c2A1: CAO 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).

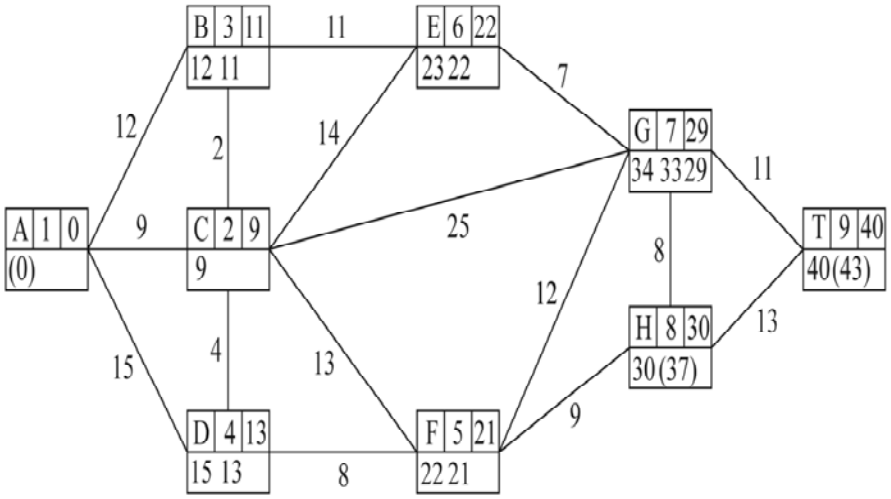
Improved matching:

Path 1	**A**	**B**	**C**	**D**	**E**	**F**
C-L-A-O	O	M	L		N	P
C-L-A-K	K	M	L		N	P

Complete matching:

Path 1	**Path 2**	**A**	**B**	**C**	**D**	**E**	**F**
C-L-A-O	D-M-B-K	O	K	L	M	N	P
C-L-A-O	D-N-E-K	O	M	L	N	K	P
C-L-A-K	D-M-B-K-A-O	O	K	L	M	N	P
C-L-A-K	D-N-E-K-A-O	O	M	L	N	K	P

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Question Number	Scheme	Marks
3. (a)	 Quickest route is ACBEGT Length of quickest route is 40 (minutes)	M1 A1 (ABCD) A1 (FEG) A1ft (HT) A1 B1ft **(6)**
(b)	Quickest journey A to F is ACDF So quickest journey A to T via F is ACDFHT = 43 (minutes)	M1 A1 **(2)**
(c)	e.g. Add 2 to each arc except GT and HT (or AB, AC and AD)	M1 A1 **(2)** **(10 marks)**

Notes for Question 3

a1M1**:** A larger value replaced by smaller value at least once in the working values at either B or D or E or F or G.
a1A1**:** All values in boxes A, B, C and D correct and the working values in the correct order, including order of labelling.
a2A1**:** All values in boxes F, E and G correct and the working values in the correct order. Penalise order of labelling errors only once per question.
a3A1ft: All values in boxes H and T correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question.
a4A1**:** CAO for the route.
a1B1ft: Follow through on their final value at T – if their answer is not 40 follow through their final value at T.
b1M1: **Any** path from A to T via **their** shortest path from A to F.
b1A1: 43 and ACDFHT
c1M1: Valid general method – any mention of adding 2 to the weight of the arcs.
c1A1: CAO – so adding 2 to each arc except {GT, HT} or {AB, AC, AD}.

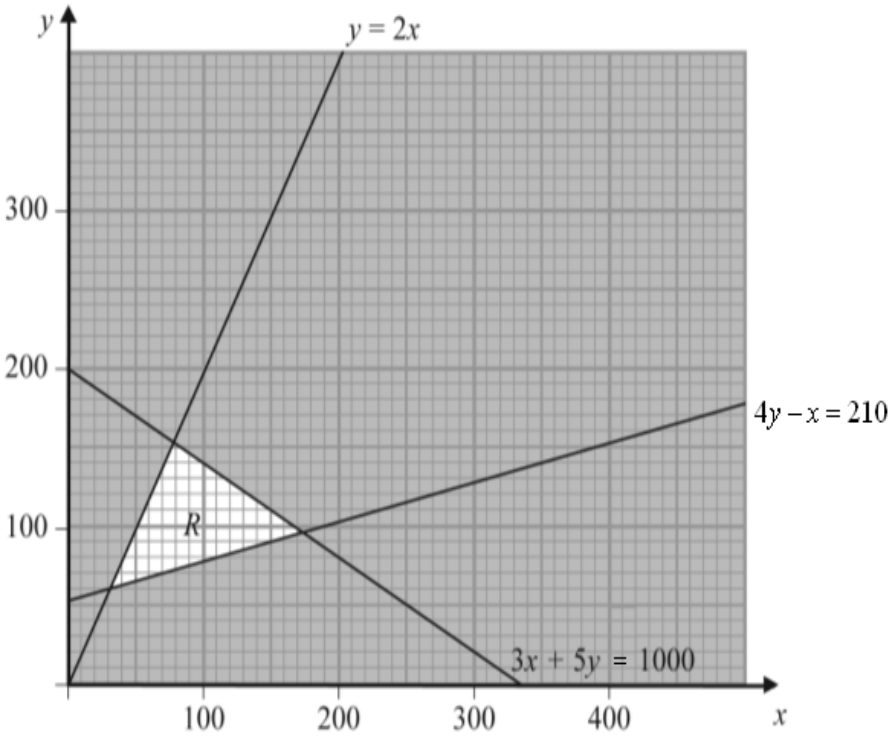
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Question Number	Scheme	Marks
4. (a)	E.g. (any three) • Kruskal starts with the shortest arc, Prim starts with any node. • It is necessary to check for cycles when using Kruskal (or it is not necessary to check for cycles when using Prim). • When using Prim the 'growing' tree is always connected. • When using Kruskal arcs are considered in ascending order of weight. • Prim can be used when the network is given in matrix form. • Prim add nodes to the growing tree, Kruskal adds arcs.	B1 B1 B1 **(3)**
(b)	DE, EB, BL, LF, BH; HG, GA, ES; SP, MP, AR	M1 A1 A1 **(3)**
(c)	ES + LG = 24 + 15 = 39 smallest EL + S(FL)G = 17 + 55 = 72 E(L)G + L(F)S = 32 + 40 = 72 Repeat ES and LG	M1 A1 (2 correct) A1 (3 correct) A1 **(4)**
(d)	The caretaker should repeat EL(17) as it is the minimum pair not including G (ES: 24, EL: 17, LS: 40) Therefore he should (start at G and) finish at S Length of route: 341 + 17 = 358 (metres)	M1 A1 A1 **(3)** **(13 marks)**

Notes for Question 4

In (a) all technical language must be correct (so do not accept point for vertex/node etc.).

a1B1: Any one correct difference.
a2B1: Any two correct differences.
a3B1: Any three correct differences.
b1M1: First five arcs correctly chosen in order (do not accept weights) **or** first six nodes correctly chosen in order. {D,E,B,L,F,H}. **If any rejections seen at any point then M1 (max) only.**
b1A1: First eight arcs correctly chosen in order **or** all nodes correctly chosen in order. {D,E,B,L,F,H,G,A,S,P,M,R}.
b2A1: CSO – all arcs correctly stated.
Misread: Starting at a node other than D scores **M1 only** – must have the first five arcs (or six nodes) correct (and in the correct order).
c1M1: Three pairings of the **correct** four odd nodes.
c1A1: Two rows correct including pairing **and** total.
c2A1: Three rows correct including pairing **and** total.
c3A1: (Repeat) ES and LG.
d1M1: Identified the need to repeat one path of the three (ES, EL, LS) which does not include G (maybe implicit) or listing of possible repeats - if M0 in (c) must state all three possible paths. Stating any path (ES, EL, LS) is sufficient for this mark.
d1A1: Identifies EL **as the least of those paths not including G.** They have to explicitly state that EL is the least path that does not include G or they can list all three paths and then say EL is the least.
d2A1: CAO - finish at S **and** length of route 358.

Question Number	Scheme	Marks
5. (a)	$3x + 5y \leq 1000$	B1 **(1)**
(b)		B1 $3x + 5y = 1000$ B1 $y = 2x$ B1 $4y - x = 210$ B1 R **(4)**
(c)	Objective is to maximise (P =) $x + y$	B1 **(1)**
(d)	$(A =)(30, 60)$, $(B =)\left(76\frac{12}{13}, 153\frac{11}{13}\right)$, $(C =)\left(173\frac{9}{17}, 95\frac{15}{17}\right)$ At A, P = 90 At B, P = $230\frac{10}{13}$ At C, P = $269\frac{7}{17}$ So C is optimal point Testing integer solutions around C, x = 173 and y = 96 is optimal integer solution, so they should make 173 soft toys and 96 craft sets	M1 A1 A1 M1 A1 M1 A1 **(7)** **(13 marks)**

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Notes for Question 5

a1B1: CAO

b1B1: $3x + 5y = 1000$ passing through one small square of (0, 200), (200, 80), $(333\frac{1}{3}, 0)$.

b2B1: $y = 2x$ passing through one small square of (0, 0), (100, 200), (150, 300).

b3B1: $4y - x = 210$ passing through one small square of (0, 52.5), (200, 102.5), (400, 152.5).

b4B1: Region, R, correctly labelled – not just implied by shading – must have scored all three previous marks in this part.

cB1: CAO – correct expression.

d1M1: Attempt to solve two of the correct equations simultaneously, up to $x = \ldots$ or $y = \ldots$

d1A1: At least 1 correct R vertex found correct to at least 2dp (rounded or truncated) - (30, 60), (76.923…, 153.846…), (173.529…, 95.705…). If **any** vertex is stated correctly (with or without working) then this scores M1A1.

d2A1: All correct R vertices found **exactly. Must** be working for determining points B and C.

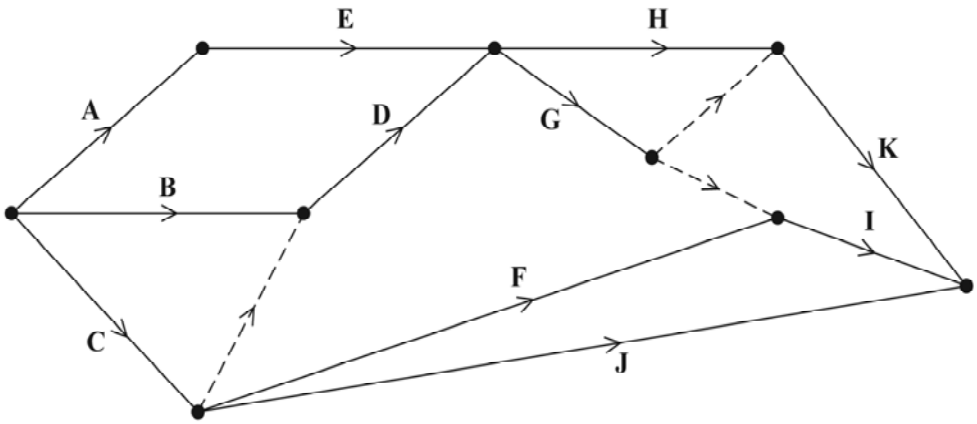
$B\left(\frac{1000}{13}, \frac{2000}{13}\right)$, $C\left(\frac{2950}{17}, \frac{1630}{17}\right)$.

d2M1: Evaluating the correct objective function at at least two of their points for their feasible region – allow this mark if vertices have been read off their graph. Condone for this M mark those candidates who state their coordinates and then test the 'nearest' integer values. E.g. if they state (76.9, 153.8) then allow for the M mark those that test either one of (76, 153), (77, 153), (76, 154) or (77, 154) **only** – maybe implied by their value for P.

d3A1: All three correct P values either given exactly $\left\{90, \frac{3000}{13}, \frac{4580}{17}\right\}$ **or** to at least 1 dp (rounded or truncated) $\{90, 230.769\ldots, 269.411\ldots\}$. They must be testing the exact coordinates for this mark.

d3M1: Testing the correct inequalities for at least two of (173, 95), (173, 96), (174, 95), (174, 96).

d4A1: CSO (all previous marks in (d) must have been awarded) accept $x = 173$ and $y = 96$ or as coordinates.

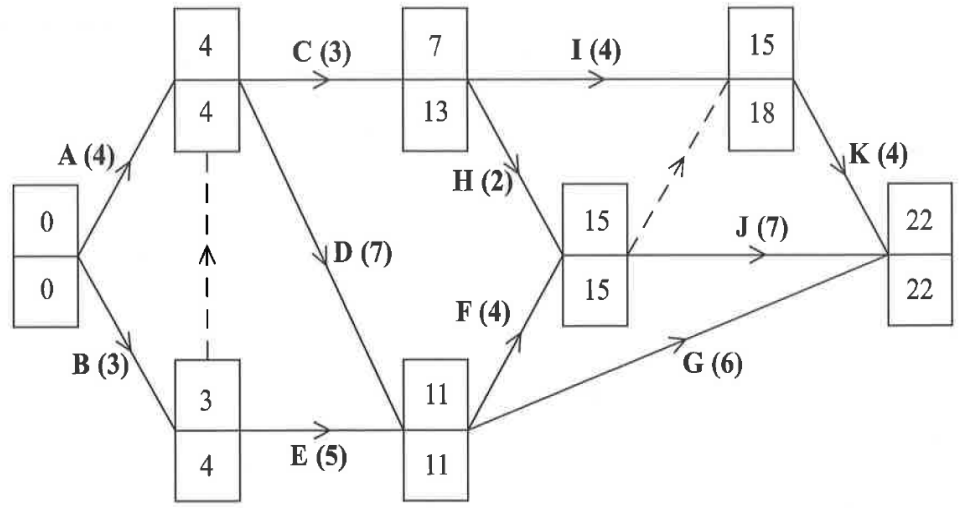
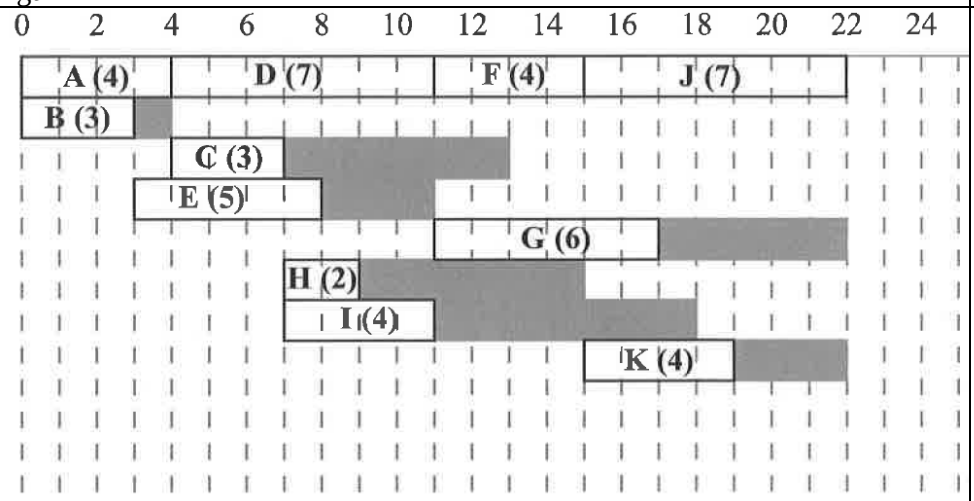
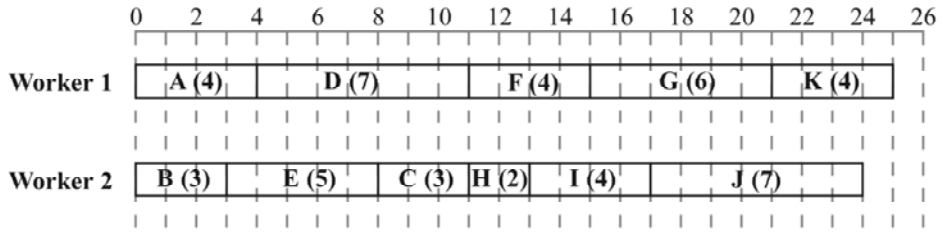
Question Number	Scheme	Marks
6. (a)		M1 A1 A1 A1 A1 **(5)**
(b)	Dummies are either needed: to show dependency (where subsequent activities **do not all** depend on the same preceding activities), **or** so that an activity can be uniquely represented in terms of its events.	B1 B1 **(2)** **(7 marks)**

Notes for Question 6

In (a) condone lack of, or incorrect, numbered events throughout – also 'dealt with correctly' means that the activity starts from the correct event but not necessarily finishes at the correct event. **Activity on node is M0.** Ignore incorrect or lack of arrows for the first four marks in (a) only.

a1M1: 7 activities (labelled on arc) and one dummy placed.
a1A1: One start + activities A, B, C and E dealt with correctly.
a2A1: Activities D, F, G, H and J and the 1st dummy dealt with correctly.
a3A1: Activities I, K and the 2nd and 3rd dummies dealt with correctly.
a4A1: CSO - **all** arrows present and correctly placed with one finish.
b1B1: dependency + some explanation of what this means, generous – allow a correct example based on the correct network diagram in the MS (**not** based on their diagram).
b2B1: uniqueness – please note that e.g. 'so that activities can be defined uniquely' is **not** sufficient to earn this mark. There must be some mention of describing activities in terms of the event at each end. However, give bod on statements that imply that an activity begins and ends at the same event.

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Question Number	Scheme	Marks
7.(a)		M1 A1 A1 **(3)**
(b)	ADFJ Length 22	B1 B1 **(2)**
(c)		M1 A1 M1 A1 **(4)**
(d)	i) D & E ii) J & G	B1 B1 **(2)**
(e)	e.g. 	M1 A1 A1 **(3)** **(14 marks)**

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Notes for Question 7

a1M1: All top boxes and all bottom boxes completed. Values generally increasing from left to right (for top boxes), and values generally decreasing from right to left (for bottom boxes). Condone missing 0 **or** 22 for M only (for bottom boxes). Condone one rogue value in top boxes **and** one rogue value in bottom boxes.
a1A1: CAO for top boxes.
a2A1: CAO for bottom boxes.
b1B1: CAO path.
b2B1: CAO length.
c1M1: At least 8 different activities including at least 4 floats.
c1A1: Critical activities dealt with correctly.
c2M1: The correct 11 activities (only once) including at least 7 floats.
c2A1: Non-critical activities dealt with correctly.
d1B1: CAO
d2B1: CAO
e1M1: 2 lines for 2 workers or 3 lines for 3 workers, all 11 activities present (just once) with time ≤ 25.
e1A1: 2 workers. Condone one error either precedence or activity length. Time must be 25.
e2A1: 2 workers. No errors.

Activity	Duration	IPA
A	4	-
B	3	-
C	3	A, B
D	7	A, B
E	5	B
F	4	D, E
G	6	D, E
H	2	C
I	4	C
J	7	F, H
K	4	F, H, I

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