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edexcel

Mark Scheme (Results)

January 2015

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
   - ⌊ 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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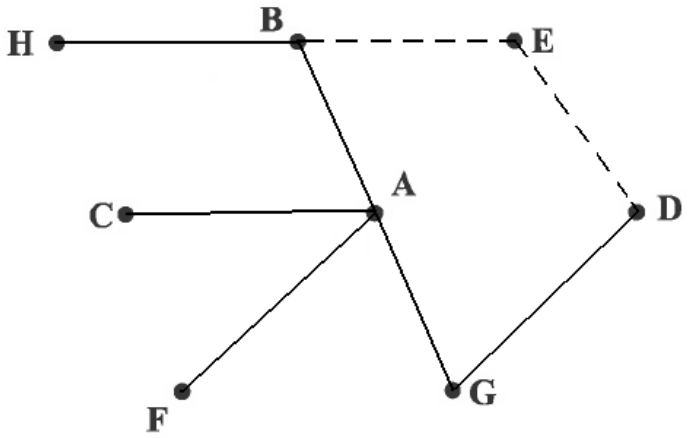
Question Number	Scheme	Marks
1. (a)	AC, AB, BH; AF AG; DG, DE or BE	M1 A1 A1 **(3)**
(b)		B1
	Weight of tree = 73 (mins)	B1 **(2)**
(c)	No – there are two different MST (with a weight of 73) either with DE or BE	B1 **(1)**
		6 marks

Notes for Question 1

a1M1: First three arcs correctly chosen in order {AC, AB, BH,…} **or** first four nodes correctly chosen in order{A, C, B, H,…}. **If any rejections seen at any point then M1 (max) only**. Order of nodes may be seen at the top of the matrix {1, 3, 2, -, -, -, -, 4} so please check the top of the matrix carefully.

a1A1: First five arcs correctly chosen in order {AC, AB, BH, AF, AG,…}**or** all eight nodes correctly chosen in order{A, C, B, H, F, G, D, E}. Order of nodes may be seen at the top of the matrix so for the first two marks accept {1, 3, 2, 7, 8, 5, 6, 4} (**do not** condone any missing numbers e.g. the number 8 must be above E).

a2A1: CSO – all **arcs** correct 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). Allow DE **or** BE for the final arc but not DE **and** BE.

Misread: 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).

b1B1: CAO (condone lack of weights on arcs) – condone, say, a dashed line between B and E if arc DE is in the tree (or vice-versa).

b2B1: CAO (73) (condone lack of units).

c1B1: CAO – mention of two different MST with either arc BE or DE.

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Question Number	Scheme	Marks
2. (a)	e.g. B can only do task 2 and F can only do task 6 therefore E will have no allocation as E can only do tasks 2 and 6 e.g. D has to do task 4 as task 4 can only be done by D therefore task 5 has to be done by A as task 5 can only be done by A and D which leaves task 3 with no worker as only A can do task 3	B1 **(1)**
(b)	C – 1 = A – 3 C – 1 = A – 5 = D – 4	B1 B1 **(2)**
(c)	A = 3, B = 2, C = 1, D = 5, E = 6 (F unmatched) A = 5, B = 2, C =1, D = 4, E = 6 (F unmatched)	B1 B1 **(2)**
(d)	Alternating path F – 6 = E – 2 = B – 5 = D – 4 **or** F – 6 = E – 2 = B – 5 = A – 3 Change status F = 6 – E = 2 – B = 5 – D = 4 **or** F = 6 – E = 2 – B = 5 – A = 3 Complete matching A = 3, B = 5, C = 1, D = 4, E = 2, F = 6	M1 A1 A1 **(3)** **8 marks**

Notes for Question 2

a1B1: CAO – must be a completely correct statement.
b1B1: CAO (C – 1 = A – 3).
b2B1: CAO (C – 1 = A – 5 = D – 4).
c1B1: CAO (A = 3, B = 2, C = 1, D = 5, E = 6).
c2B1: CAO (A = 5, B = 2, C =1 , D = 4, E = 6).
d1M1: An alternating path from F to either 3 or 4 (or vice-versa).
d1A1: CAO – a correct path including change status **either** stated (only accept 'change (of) status' or 'c.s.') **or** shown. Chosen path clear.
d2A1: 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
3. (a)	Bin 1: **1.1** **0.7** **0.9** 0.2 Bin 2: **1.9** 0.4 0.5 Bin 3: 2.1 Bin 4: 2.3 Bin 5: 1.7	**M1** A1 A1 **(3)**
(b) (i) **(ii)**	1.1 1.9 0.9 2.1 0.7 2.3 0.4 0.5 1.7 0.2 Comparisons: 9 Swaps: 7	M1 A1 B1 B1 **(4)**
(c)	e.g. using middle right 1.9 1.1 2.1 0.9 2.3 **0.7** 0.5 1.7 0.4 0.2 pivot 0.7 1.9 1.1 2.1 **0.9** 2.3 1.7 0.7 0.5 **0.4** 0.2 pivots 0.9 0.4 1.9 1.1 **2.1** 2.3 1.7 0.9 0.7 0.5 0.4 0.2 pivot(s) 2.1 (0.5) (0.2) 2.3 2.1 1.9 **1.1** 1.7 0.9 0.7 0.5 0.4 0.2 pivot(s) (2.3) 1.1 2.3 2.1 1.9 **1.7** 1.1 0.9 0.7 0.5 0.4 0.2 pivot 1.7 2.3 2.1 1.9 1.7 1.1 0.9 0.7 0.5 0.4 0.2 (sort complete)	M1 A1 A1ft A1 **(4)**
(d)	Bin 1: **2.3** 0.7 Bin 2: **2.1** 0.9 Bin 3: **1.9** **1.1** Bin 4: **1.7** 0.5 0.4 0.2	**M1** A1 A1 **(3)** **14 marks**

Notes for Question 3

a1M1: First four numbers placed correctly and at least six numbers put in bins. Condone cumulative totals here only.
a1A1: First seven numbers placed correctly.
a2A1: CSO – all correct.
bi1M1: Bubble sort, end number in place correctly.
SC **for M1 only**: 0.7 1.1 0.9 1.9 0.2 2.1 0.4 0.5 1.7 2.3 (ascending from left-hand end).
0.2 1.1 0.7 1.9 0.9 2.1 0.4 2.3 0.5 1.7 (ascending from right-hand end).
2.3 1.1 0.7 1.9 0.9 2.1 0.2 1.7 0.4 0.5 (descending from right-hand end).
bi1A1: CAO – isw after one complete pass.
bii1B1: Comparisons correct (9).
bii2B1: Swaps correct (7).
c1M1: Quick sort – pivots, p, selected and first pass gives >p, p, <p. **If only choosing 1 pivot per iteration M1 only. Using bubble sort in this part is M0.**
c1A1: First pass correct and next pivots chosen correctly/consistently for second pass.
c2A1ft: Second and third passes correct (follow through from their first pass and choice of pivots) – next pivot(s) chosen correctly/consistently for fourth pass.
c3A1: CSO – including choice of pivot for the fifth pass and then either a 'stop' statement or final re-listing or using each item as a pivot.
d1M1: **Must be using 'sorted' list** in decreasing order (independent of (c)). First five numbers placed correctly and at least six numbers put in bins. **First-fit increasing is M0**.
d1A1: First seven numbers placed correctly.
d2A1: CSO – all correct.

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Question Number	Scheme	Marks

SC for (d): If the 'sorted' list used in (d) has one 'error' from (c) (e.g. a missing number, an extra number or one number incorrectly placed) then **M1 only** can be awarded in (d) (for the first five numbers placed correctly). If there is more than one 'error' then M0. Allow full marks in (d) if a correct list is used in (d) even if the list is incorrect at the end of (c).

Sorting list into ascending order in (c)

- If the candidate sorts the list into ascending order and reverses the list in (c) then they 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 candidate says that the list needs reversing in (c) but doesn't actually show the reversed list in (c) then remove the final A mark earned in (c).

Middle left

1.9	1.1	2.1	0.9	[2.3]	0.7	0.5	1.7	0.4	0.2	Pivot 2.3	
2.3	1.9	1.1	2.1	0.9	[0.7]	0.5	1.7	0.4	0.2	Pivot 0.7	M1 A1
2.3	1.9	1.1	[2.1]	0.9	1.7	0.7	0.5	[0.4]	0.2	Pivot 2.1 0.4	
2.3	2.1	1.9	[1.1]	0.9	1.7	0.7	0.5	0.4	0.2	Pivot 1.1 (0.5) (0.2)	A1ft
2.3	2.1	[1.9]	1.7	1.1	0.9	0.7	0.5	0.4	0.2	Pivot 1.9 (0.9)	
2.3	2.1	1.9	1.7	1.1	0.9	0.7	0.5	0.4	0.2	(sort complete)	A1

Ascending order (middle right)

1.9	1.1	2.1	0.9	2.3	[0.7]	0.5	1.7	0.4	0.2	Pivot 0.7	
0.5	[0.4]	0.2	0.7	1.9	1.1	2.1	[0.9]	2.3	1.7	Pivot 0.4 0.9	M1 A1
0.2	0.4	0.5	0.7	0.9	1.9	1.1	[2.1]	2.3	1.7	Pivot (0.2) (0.5) 2.1	
0.2	0.4	0.5	0.7	0.9	1.9	[1.1]	1.7	2.1	2.3	Pivot 1.1 (2.3)	A1ft
0.2	0.4	0.5	0.7	0.9	1.1	1.9	[1.7]	2.1	2.3	Pivot 1.7	
0.2	0.4	0.5	0.7	0.9	1.1	1.7	1.9	2.1	2.3	sort complete	A1

Ascending order (middle left)

1.9	1.1	2.1	0.9	[2.3]	0.7	0.5	1.7	0.4	0.2	Pivot 2.3	
1.9	1.1	2.1	0.9	[0.7]	0.5	1.7	0.4	0.2	2.3	Pivot 0.7	M1 A1
0.5	[0.4]	0.2	0.7	1.9	1.1	[2.1]	0.9	1.7	2.3	Pivot 0.4 2.1	
0.2	0.4	0.5	0.7	1.9	[1.1]	0.9	1.7	2.1	2.3	Pivot (0.2) (0.5) 1.1	A1ft
0.2	0.4	0.5	0.7	0.9	1.1	[1.9]	1.7	2.1	2.3	Pivot (0.9) 1.9	
0.2	0.4	0.5	0.7	0.9	1.1	1.7	1.9	2.1	2.3	sort complete	A1

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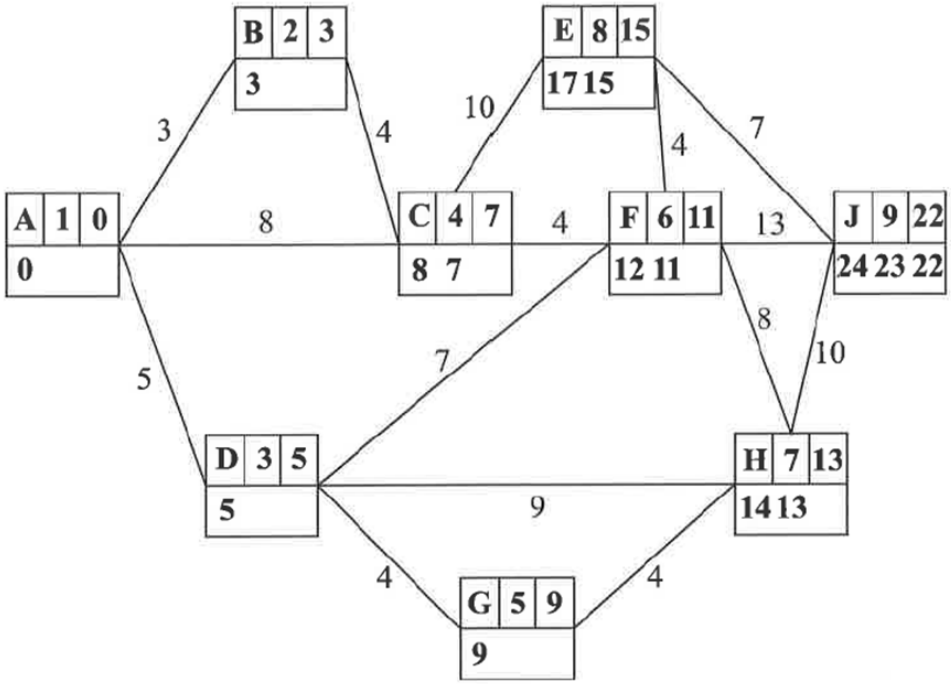
Question Number	Scheme	Marks
4. (a)	 Shortest route: ABCFEJ Length: 22 (metres)	M1 A1 (ABDC) A1(GFH) A1ft (EJ) A1 A1ft **(6)**
(b)	AE + FJ = 15 + 11 = 26 AF + EJ = 11 + 7 = 18* AJ + EF = 22 + 4 = 26 Arcs AB, BC, CF, EJ will be traversed twice	M1 A1ft A1ft A1ft A1 **(5)**
(c)	Route: e.g. ABADGHDFHJEJFECFCBCA Length: 100 + 18 = 118	B1 B1ft **(2)**
(d)	Start at E, finish at J (or vice versa) **or** start at C, finish at J (or vice-versa) Length: 100 – 3 – 4 + 4 = 97 (metres)	M1 A1 B1 **(3)** **16 marks**

Notes for Question 4

a1M1: A larger value replaced by a smaller value at least once in the working values at either C or E or F or H or J.
a1A1: All values in A, B, C and D correct and the working values in the correct order, including order of labelling. Condone lack of 0 in A's working value.
a2A1: All values in F, G and H correct and the working values in the correct order. Penalise order of labelling only once per question. Condone an additional working value at H of 19 after the 13.
a3A1ft: All values in E and J correct on the follow through and the working values in the correct order. Penalise order of labelling only once per question.
a4A1: CAO (ABCFEJ) for the route.
a5A1ft: Follow through on their final value at J – if their answer is not 22 follow through their final value at J (condone lack of units).
b1M1: Three pairings of the **correct** four odd nodes.
b1A1ft: One row correct including pairing **and** total (the ft on the first three A marks in (b) is for using their final values at E, F and J from (a) for the lengths of AE, AF and AJ only).
b2A1ft: Two rows correct including pairings **and** totals.
b3A1ft: All three rows correct including pairings **and** totals.
b4A1: The smallest repeat **arcs** AB, BC, CF and EJ clearly stated. Accept ABCF, EJ but **not** AF.

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Question Number	Scheme	Marks
	c1B1: Any correct route (checks: 20 nodes, starting and finishing at A, pairings AB, BC, CF, EJ appear twice in the route and that A, C and F appear three times, B, D, E, H and J appear twice and G appears once). c2B1ft: Correct answer of 118 **or** 100 + their least out of a choice of at least **two** totals given in (b). d1M1: Any consideration/mention of all the odd nodes (C, E, F and J) **or** consideration/mention of all the odd pairings (CE, CF, CJ, EF, EJ, FJ) **or** consideration/mention of arcs EF **and** CF (and no others) having least weight **or** EF **and** CF (and no others) having a weight of 4 **or** listing one correct starting and finishing point (must be clear). d1A1: Both combinations of starting and finishing points correct (E and J + C and J) and no others. d1B1: CAO (97)	

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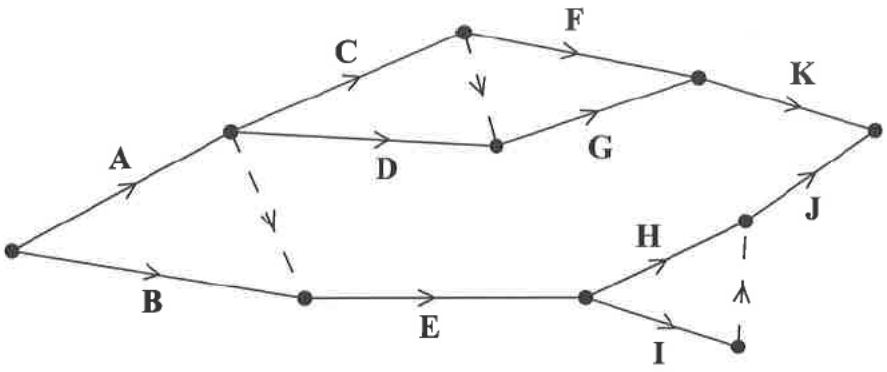
Question Number	Scheme	Marks
5. (a)		M1 A1 A1 A1 A1 **(5)**
(b)	Dummies are needed to show either – dependency where subsequent activities **do not all** depend on the **same** preceding activities – that an activity can be **uniquely** represented in terms of its end events	B1 B1 **(2)** **7 marks**

Notes for Question 5

In (a) condone lack of, or incorrect, numbered events throughout – also 'dealt with correctly' means that the activity starts from the correct event but may not finish at the correct event. **Activity on node is M0**.

Do not penalise the same error twice with the first three A marks, for example, if activity C is not labelled (but the arc is present) then this will lose the first A mark and the final (CSO) A mark – they can still earn the second A mark on the bod.

a1M1: Eight activities (labelled on arc), one start and at least one dummy placed.
a1A1: Activities A, B, 1st dummy (+ arrow) and C, D and E dealt with correctly.
a2A1: 2nd dummy (+ arrow) and F, G and K dealt with correctly.
a3A1: Activities H, I, 3rd dummy (+ arrow) and J dealt with correctly.
a4A1: CSO – **all** arrows present **and** correctly placed with one finish.

Penalise lack of, or incorrect, arrows on the dummies only once with the first three A marks (on the first occurrence).

b1B1: Dependency + some explanation of what this means, bod – allow a correct example using any nodes/letters.
b2B1: Uniqueness – please note that, for example, 'so that activities can be defined uniquely' is not sufficient to earn this mark. There must be some mention of describing activities either in terms of the event **at each end** or in terms of an activities **events**. However, give bod on statements that imply that an activity begins and ends at the same event.

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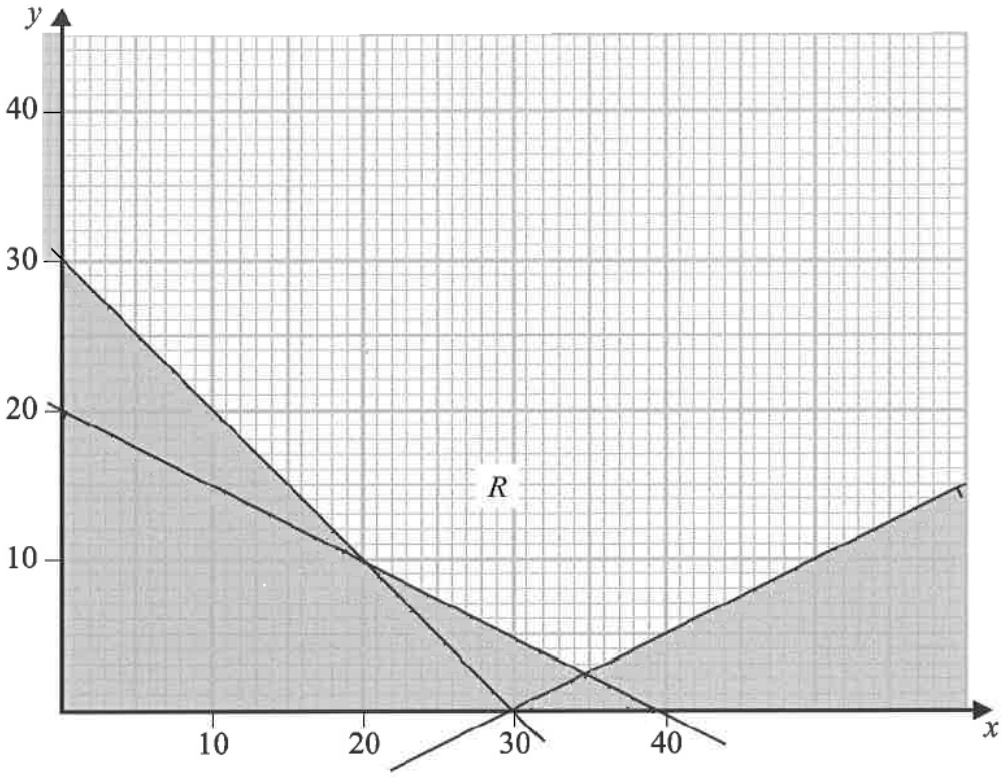
Question Number	Scheme	Marks
6. (a)	$x + y \geq 30$	B1 **(1)**
(b)	$x \geq 0,\ y \geq 0$	B1 **(1)**
(c)		B1 B1 B1 B1 **(4)**
(d)	Objective line drawn (34,3) so 34 red hats and 3 green hats	M1 A1 A1 **(3)**
(e)	$34r + 3g = 107.5$ $g = 3r$ Leading to $r = 2.50$ and $g = 7.50$ So a red hat costs £2.50 and a green hat costs £7.50	B1ft B1 DB1 **(3)** **12 marks**

Notes for Question 6

a1B1: CAO ($x + y \geq 30$).

b1B1: CAO (accept $x, y \geq 0$ **or** x and y are non-negative) – do not accept strict inequalities.

In (c) lines must pass through one small square of the points stated:

$x + y = 30$ passes through (0, 30), (15, 15), (30, 0)

$2y + x = 40$ passes through (0, 20), (20, 10), (40, 0)

$2y - x = -30$ passes through (30, 0), (50, 10), (60, 15)

c1B1: $x + y = 30$ drawn correctly.

c2B1: $2y + x = 40$ drawn correctly.

c3B1: $2y - x = -30$ drawn correctly.

c4B1: Region, R, correctly labelled – not just implied by shading - must have scored all three previous marks in this part. Condone lack of shading for $x \geq 0$.

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Question Number	Scheme	Marks

d1M1: Drawing the correct objective line or its reciprocal $\left(m = -3 \text{ or } -\frac{1}{3}\right)$. Line must be correct to within one small square if extended from axis to axis.

d1A1: Correct objective line $\left(m = -\frac{1}{3}\right)$ – condone lack of labelling of the objective line.

d2A1: Correct point identified – accept as a coordinate (34, 3).

e1B1ft: A 'correct' equation involving **their** optimal point from (d) (accept any values even if non-integer) and 107.50.

e2B1: CAO on the relationship between the costs of green hats and red hats ($g = 3r$) – this mark may be implied e.g. $34r + 3(3r) = 107.5$ would score the first two marks in this part.

e3DB1: CAO – this mark is dependent on having the correct optimal point (34, 3) in (d).

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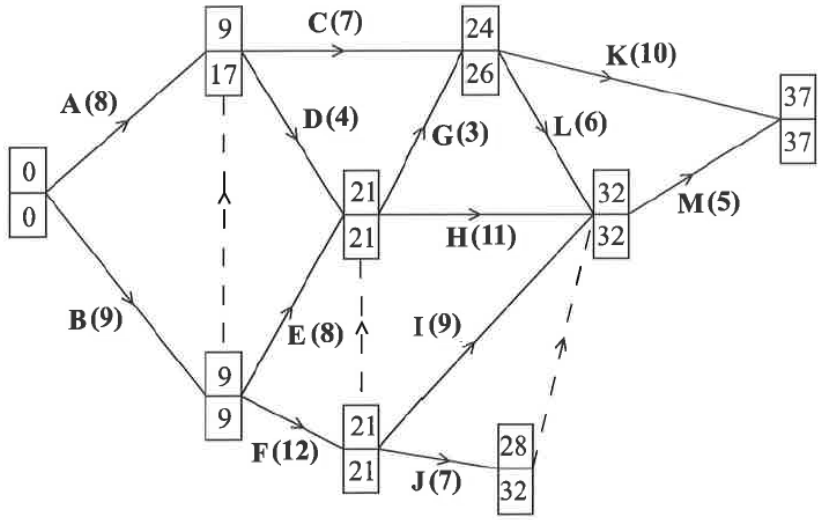
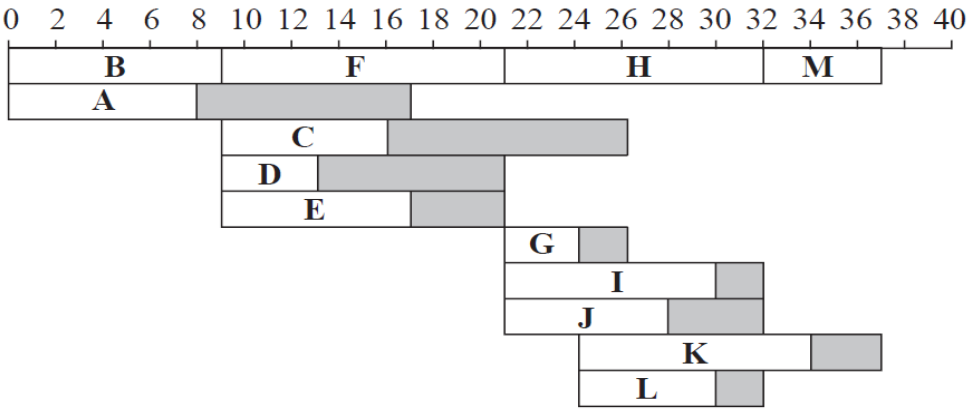
Question Number	Scheme	Marks
7. (a)	$x = 12$ $y = 3$	B1 B1 **(2)**
(b)		M1 A1 A1 **(3)**
(c)	Lower bound = $\frac{99}{37} = 2.675\ldots$ so 3 workers	B1 **(1)**
(d)		M1 A1 A1 A1 **(4)**
(e)	Lower bound is 5 workers – e.g. activities H, I, J, K and L together with 27 < time < 28	M1 A1 **(2)** **12 marks**

Notes for Question 7

a1B1: Correct value (12) for x.
a2B1: Correct value (3) for y.

b1M1: All (but one) boxes complete and any three values correct.
b1A1: Any five values correct.
b2A1: CAO (all seven values correct).

c1B1: CSO – no incorrect working – if 3 workers with no working then give on the bod.

d1M1: At least nine activities including at least five floats. **Scheduling diagram scores M0**.
d1A1: The correct critical activities (B, F, H and M) dealt with correctly.
d2A1: All correct non-critical activities present with floats with five non-critical activities correct.
d3A1: All nine non-critical activities correct.

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Question Number	Scheme	Marks
e1M1: A statement with the correct number of workers (5) **and** the correct activities (H, I, J, K and L) with some mention of time. e1A1: A completely correct statement with details of both time **and** activities. Candidates only need to give a time within the correct interval. Please note the strict inequalities for the time interval. Allow for example, 'on day 28' as equivalent to $27 < \text{time} < 28$.		

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