edexcel

Mark Scheme (Results)

January 2014

Pearson Edexcel International Advanced Level

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.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

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

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

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $*$ The answer is printed on the paper
- ⌐ The second mark is dependent on gaining the first mark

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

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

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)	Either 11 10 14 8 13 6 4 15 7 17 Or 4 11 17 10 14 8 13 6 7 15	M1 A1 **(2)**
(b)	e.g. using middle right 11 17 10 14 8 [13] 6 4 15 7 pivot 13 17 [14] 15 13 11 10 8 [6] 4 7 pivots 14, 6 17 [15] 14 13 11 10 [8] 7 6 4 pivots 15, 8 (4) 17 15 14 13 11 [10] 8 7 6 4 pivots (17), 10, (7) 17 15 14 13 11 10 8 7 6 4 (sort complete)	M1 1A1 2A1ft 3A1 **(4)**
(c)	$\frac{105}{26} \approx 4.0385$ so 5 bins needed	M1 A1 **(2)**
		8 marks

Notes

a1M1: Bubble sort, end number in place correctly.
a1A1: CAO – isw after one complete pass

SC for (a): If list sorted into ascending order – must be fully correct so either
17 11 14 10 13 8 6 15 7 4 or 17 11 15 10 14 8 13 6 4 7 scores M1A0

b1M1: 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.**
b1A1: First pass correct, pivots chosen consistently for second pass.
b2A1ft: Second and third passes correct (ft from their first pass and choice of pivots) – need not be choosing the pivot for the fourth pass for this mark.
b3A1: CSO all correct including choice of pivots for the fourth pass and then **either** a 'stop' statement **or** final re-listing **or** using each item as a pivot.

Note: In part (b) if **either** ascending quick sort (which is not reversed at the end of the sort) **or** using the list after part (a) then mark as a misread (so remove the final two A marks earned in this part – so max of 2/4 in (b)). If list is reversed in part (b) after ascending quick sort then full marks can be awarded. If attempting quick sort on ordered list then M0.

c1M1: Attempt to find lower bound $(105 \pm 17) / 26$, **or** answer correct to 3 significant figures (either truncated or rounded) so accept 4.03 or 4.04). Must be a numerical argument.
c1A1: CSO including 5 (5 with no working scores M0).

Notes for Question 1 continued

Alternatives to 1(b)

Middle left ascending

11	17	10	14	[8]	13	6	3	15	7	pivot 8	M1
11	17	[10]	14	13	15	8	6	[4]	7	pivots 10, 4	1A1
11	17	[14]	13	15	10	8	[6]	7	4	pivots 14, 6	
[17]	15	14	[11]	13	10	8	7	6	4	pivots 17, 11, (7)	2A1ft
17	15	14	13	11	10	8	7	6	4	sort complete	3A1

Misreads for 1(b)

Middle right

11	17	10	14	8	[13]	6	4	15	7	pivot 13
11	10	8	[6]	4	7	13	17	[14]	15	pivots 6, 14
4	6	11	10	[8]	7	13	14	17	[15]	pivots 8, 15
4	6	7	8	11	[10]	13	14	15	17	pivot 10
4	6	7	8	10	11	13	14	15	17	sort complete

Middle left

11	17	10	14	[8]	13	6	4	15	7	pivot 8
6	[4]	7	8	11	17	[10]	14	13	15	pivots 4, 10
4	6	7	8	10	11	17	[14]	13	15	pivots 6, 14
4	6	7	8	10	[11]	13	14	[17]	15	pivots 11, 17
4	6	7	8	10	11	13	14	15	17	sort complete

:

Question Number	Scheme	Marks
2. (a)	AB, BC, CF, CE; FG, AD; EH, HI	M1; 1A1; 2A1 **(3)**
(b)	£191	B1 **(1)**
(c)(i)	CF, reject CE, AB, FG;{AD, reject AC}, reject DG, {reject BE, reject DF}, EH, reject FH, HI (Note BC and EF are already in the tree)	M1; 1A1 2A1
(ii)	e.g. Prim cannot be used since with Prim the tree 'grows' in a connected fashion e.g. Kruskal can build its tree from disconnected fragments	B2,1,0 **(5)**
(d)	£147	B1 **(1)**
		10 marks

Notes

a1M1: First four arcs (AB, BC, CF, CE) correctly chosen, or first five nodes (ABCFE) correctly chosen in order. **If any rejections seen at any point then M1 (max) only.**

a1A1: First six arcs correctly chosen (AB, BC, CF, CE, FG, AD), or all nodes in order (ABCFEGDHI).
a2A1: CSO (must be arcs).
b1B1: CAO
ci1M1: Kruskal's - first three arcs (CF, AB, FG) correctly chosen and **at least one rejection seen at some point.**
ci1A1: All arcs in tree selected correctly at correct time (CF, AB, FG, AD, EH, HI). Ignore any reference to BC and EF.
ci2A1: CSO including all rejections correct and at the correct time. Ignore any reference to BC and EF.
cii1B1: Partially correct answer – e.g. an indication that the arcs (BC and EF) are not connected **or** any mention of the tree being (initially) disconnected - so in both of these examples a pertinent correct statement is made but no explicit mention is made to either of the two minimum connector algorithms (i.e. no mention is made of Prim requiring arcs to be connected or that Kruksal can grow in a disconnected fashion). Give bod but for this mark there must be some mention of the 'unconnected' nature of the two initial arcs or problem. Note: describing how Kruskal can be adapted to find the MST scores no marks.
cii2B1: Fully correct answer (so either Kruskal allows a tree to be formed from initially unconnected arcs or Prim requires the arcs/tree to be connected at all times - so linking the correct algorithm with the issues of this particular problem) – do not condone incorrect technical language for this mark (e.g. vertex for arc, point for vertex etc.)
d1B1: CAO

Question Number	Scheme	Marks

Notes for Question 2 continued

Misread: Starting at a node other than A scores **M1 only –** must have the first four arcs (or five nodes) correct.

Starting at	Minimum arcs required for M1 only	Nodes
A	AB, BC, CF, CE	ABCFE
B	AB, BC, CF, CE	BACFE
C	CF, CE, FG, BC	CFEGB
D	AD, AB, BC, CE	DABCE
E	CE, CF, FG, BC	ECFGB
F	CF, CE, FG, BC	FCEGB
G	FG, CF, CE, BC	GFCEB
H	EH, CE, CF, FG	HECFG
I	HI, EH, CE, CF	IHECF

Question Number	Scheme	Marks
3. (a)	A matching is a **pairing** of some or all of the elements of **one set** X, **with** elements of **another** set Y	1B1 2B1 **(2)**
(b)	B – 5 = S – 4 = T – 6 Change status to give B = 5 – S = 4 – T = 6 Improved matching: B = 5, C = 1, (H unmatched), K = 2, S = 4, T = 6	M1 1A1 2A1 **(3)**
(c)	Either H – 6 = T – 4 = S – 2 = K – 1 = C – 3 Changing status to give: H = 6 – T = 4 – S = 2 – K = 1 – C = 3 Complete matching: B = 5, C = 3, H = 6, K = 1, S = 2, T = 4 Alternative H – 6 = T – 4 = S – 5 = B – 2 = K – 1 = C – 3 Changing status to give: H = 6 – T = 4 – S = 5 – B = 2 – K = 1 – C = 3 Complete matching: B = 2, C = 3, H = 6, K = 1, S = 5, T = 4	M1 1A1 2A1 **(3)** **8 marks**

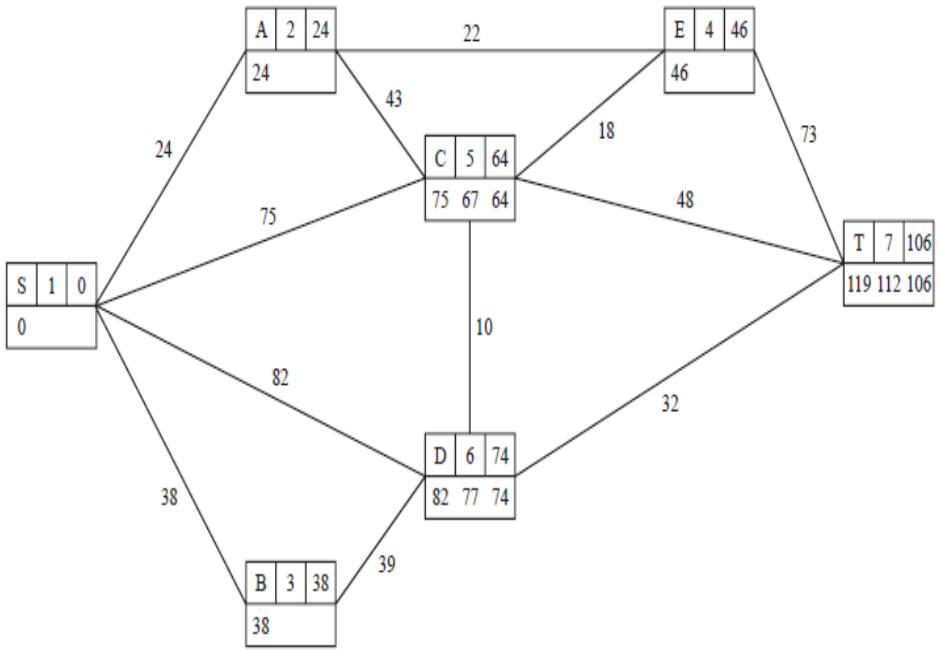
Notes

a1B1: pairing or one to one
a2B1: element(s) from one set with element(s) of the other.
b1M1: Alternating path from B to 6 - or vice versa
b1A1: CAO including change status (stated or shown), chosen path clear.
b2A1: CAO. Must follow from correct stated path, diagram okay (must be a clear diagram with only five arcs)
c1M1: Alternating path from H to 3 (or vice versa)
c1A1: CAO including change status (stated or shown), chosen path clear.
c2A1: CAO. Must follow from two correct stated paths, diagram okay (must be a clear diagram with only six arcs). Must have scored both M marks in part (b) and (c).

Question Number	Scheme	Marks
4. (a)	AE + IJ = 56 + 38 = 94 AI + EJ = 54 + 39 = 93* AJ + EI = 47 + 48 = 95 Repeat arcs AB, BD, DH, HI, EG and GJ.	M1 1A1 2A1 3A1 4A1 **(5)**
(b)	Length: 367 + 93 = 460 metres	B1ft **(1)**
(c)	Only AE needs to be repeated so new length is 367 + 35 + 56 = 458 metres So the distance travelled by the robot is decreased	M1 A1ft **(2)**
		8 marks

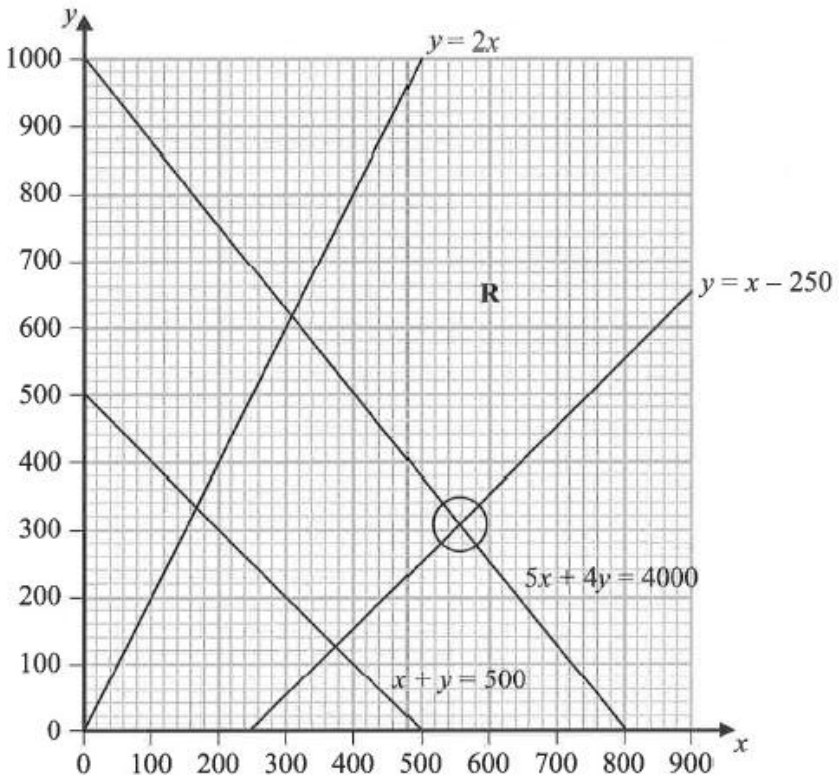
Notes

a1M1: Three distinct pairings of **their** four odd nodes
a1A1: One row correct including pairing **and** total
a2A1: Two rows correct including pairing **and** total
a3A1: Three rows correct including pairing **and** total
a4A1: CAO correct **arcs** identified AB, BD, DH, HI, EG, GJ (accept ABDHI and EGJ).
b1B1ft: **Must have a choice of at least two pairs seen in part (a)**. 379 + their least from (a).
c1M1: Aim to include their AE (56) [ft from (a)] and add IJ (35) **or** 35 + '56' **or** 367 + 35 + '56'. Must see a numerical argument. Or if AE + IJ was the smallest pairing from (a) then comparing/mention of 35 with 38.
c1A1ft: Correct calculation and conclusion from their working.

Question Number	Scheme	Marks
5. (a)		M1 1A1 (SABE) 2A1 (CD) 3A1ft (T)
	Shortest path S to T: SAECDT Length of shortest path S to T: 106 km	4A1 5A1ft **(6)**
(b)	Shortest paths S to T excluding CE: SACDT and SBDT Length is 109 km	DM1 1A1 2A1 **(3)**
		9 marks

Notes

a1M1: Big replaced by smaller at least once in the working values at either C or D or T.
a1A1: S, A, B and E boxes all correct, including order of labelling.
a2A1: C and D boxes all correct (including working values in the correct order). Penalise order of labelling only once per question (so C and D labelled in that order with C labelled after S, A, B and E).
a3A1ft: T correct ft (including working values in the correct order). Penalise order of labelling only once per question (so T labelled after all other nodes).
a4A1: Route (SAECDT) CAO
a5A1ft: ft on their final value (if their answer is not 106 ft their final value at T) – ignore incorrect/lack of units.
b1DM1: Must have scored the M mark in (a). Finding at least one correct path from S to T excluding arc CE.
b1A1: Both paths correct (SACDT and SBDT)
b2A1: Length (109) CAO (ignore incorrect/lack of units)

Question Number	Scheme	Marks
6. (a)		B3, 2, 1, 0 4B1 R labelled **(4)**
(b)	Use SE to find exact intersection of $5x + 4y = 4000$ with $y = x - 250$ Use SE to find exact intersection of $5x + 4y = 4000$ with $y = 2x$ $\mathrm{P}\left(555\frac{5}{9}, 305\frac{5}{9}\right)$, and $\left(307\frac{9}{13}, 615\frac{5}{13}\right)$ Attempting to evaluate C at **both** points **and** selecting optimal point $C_p = 2\times555\frac{5}{9}+5\times305\frac{5}{9}=2638\frac{8}{9}$ $\left[\text{other is } 3692\frac{4}{13}\right]$	1M1 2M1 1A1, 2A1 3M1 3A1 **(6)**
(c)	Maximum value of $k = 861\frac{1}{9}$	M1 A1 **(2)**
		12 marks

Notes

(a) Lines must pass though one small square of points stated.

a1B1: for two lines drawn correctly
a2B1: for three lines drawn correctly
a3B1: for all four lines drawn correctly

Question Number	Scheme	Marks

Notes for Question 6 continued

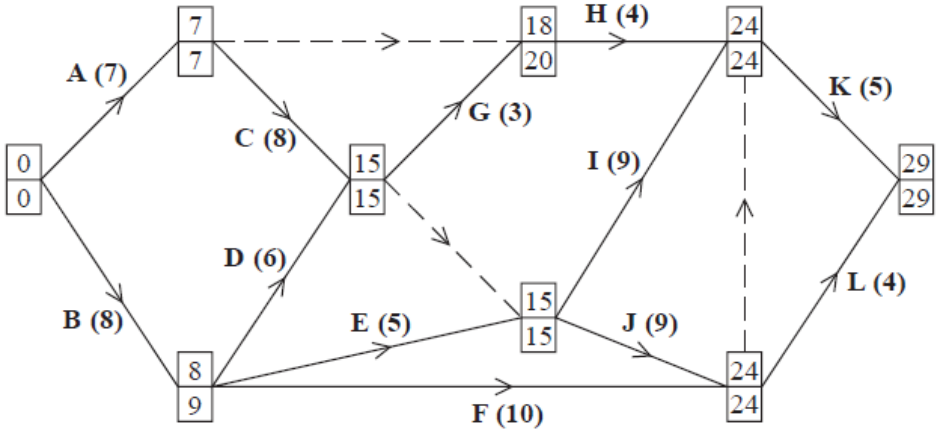
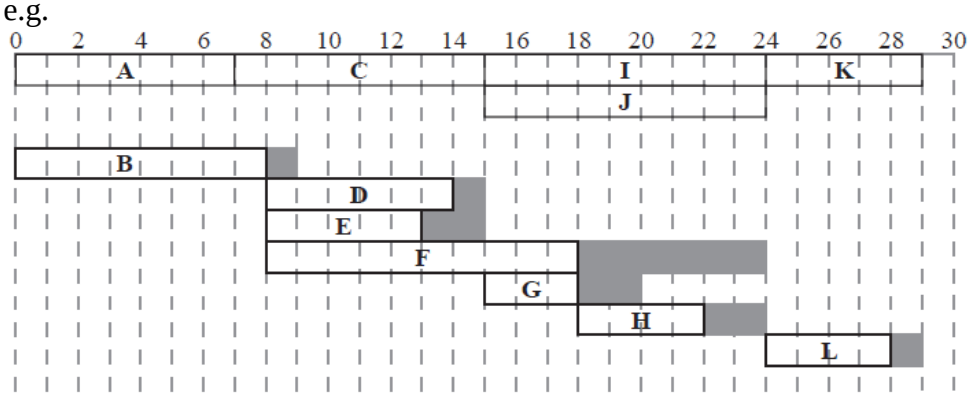
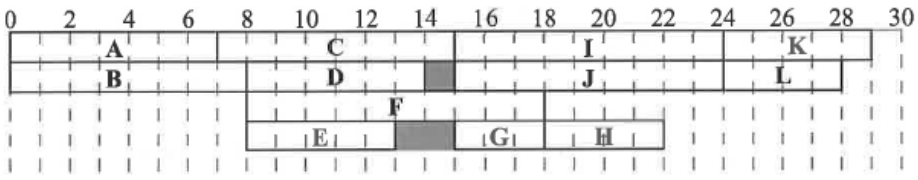
$x + y = 500$ passes through (0, 500), (250,250), (500, 0)
$5x + 4y = 4000$ passes through (0, 1000), (400,500), (800, 0)
$y = 2x$ passes through (0, 0), (200,400), (400, 800)
$y = x - 250$ passes through (250, 0), (500,250), (700, 450)

a4B1: Region, R, labelled correctly - not just implied by shading - must have scored all three previous marks in this part.

b1M1: Must see simultaneous equations ($y = x - 250$ and $5x + 4y = 4000$) being used to find 'exact' point (or correct to 2 dp) – must get to $x = \cdots$ or $y = \cdots$.
b2M1: Must see simultaneous equations ($y = 2x$ and $5x + 4y = 4000$) being used to find 'exact' point (or correct to 2 dp) – must get to $x = \cdots$ or $y = \cdots$.
b1A1: accept awrt (555.56, 305.56) exact answers are $\left(\frac{5000}{9}, \frac{2750}{9}\right)$ or $\left(555\frac{5}{9}, 305\frac{5}{9}\right)$
b2A1: accept awrt (307.69, 615.38) exact answers are $\left(\frac{4000}{13}, \frac{8000}{13}\right)$ or $\left(307\frac{9}{13}, 615\frac{5}{13}\right)$

SC: If no working shown and coordinates are given exactly or correct to 2dp then award M0M0A1A1 (if one coordinate correct then M0M0A1A0 or M0M0A0A1 – award in order as given in b1A1 and b2A1)

b3M1: Evaluating C at **both** of their points and **clearly selecting** their optimal point
b3A1: CAO, accept answer correct to 4 s.f. (either truncated or rounded) – so accept either the correct exact answer or an awrt to either 2638 or 2639 - must be clearly **selected** as optimal value
$\left(\text{exact values are } \mathbf{\frac{23750}{9}} \textbf{ or } \mathbf{2638\frac{8}{9}} \text{ the other value is } \frac{48000}{13} \text{ or } 3692\frac{4}{13}\right)$
c1M1: Seeking to find $x + y$ at their optimal point.
c1A1: CAO, accept awrt 861.11 $\left(\text{exact value is } \frac{7750}{9} \text{ or } 861\frac{1}{9}\right)$

Question Number	Scheme	Marks
7. (a)		1M1 1A1 2M1 2A1 **(4)**
(b)	e.g. 	1M1 1A1 2M1 2A1 **(4)**
(c)	Four workers e.g. between 17 < time < 18, four activities I, J, F and G need to be happening	1B1 2B1 **(2)**
(d)	e.g. 	M1 1A1 2A1 3A1 **(4)** **14 marks**

Notes

a1M1: All top boxes complete, values generally increasing left to right, condone one rogue value.
a1A1: CAO

Question Number	Scheme	Marks

Notes for Question 7 continued

a2M1: All bottom boxes complete, values generally decreasing right to left, condone one rogue value. Condone missing 0 or 29 for the M only.
a2A1: CAO
b1M1: Not a scheduling diagram. At least 9 activities including at least 4 floats.
b1A1: Critical activities dealt with correctly.
b2M1: All 12 activities including at least 7 floats.
b2A1: Non-critical activities dealt with correctly.
c1B1: A correct answer of 4, with the correct activities (IJFG) and some mention of time.
c2B1: A correct statement with details of time and activities. Note strict inequality on time – note that **on** day 18 is equivalent to 17 < time < 18.
d1M1: Not a cascade chart. 4 'workers' used at most. At least 7 activities.
d1A1: ABCIJK correct. A – 7; B – 8: C – 8; I – 9; J – 9; K – 5. B completed by its late finish time (9).
d2A1: 4 workers. All 12 activities present (just once). Condone one error either precedence, or activity length, on activities D, E, F, G, H, L.
d3A1: 4 workers. All 12 activities present (just once). No errors on activities D, E, F, G, H, L

Activity	Duration	I.P.A.		Activity	Duration	I.P.A.
A	7	-		**G**	**3**	**C D**
B	8	-		**H**	**4**	**A G**
C	8	A		I	9	C D E
D	**6**	**B**		J	9	C D E
E	**5**	**B**		K	5	F H I J
F	**10**	**B**		**L**	**4**	**F J**

Question Number	Scheme	Marks
8.	Minimise $(C) = 660x + 600y$ Subject to: $20x + 50y \geq 15000 \Rightarrow 2x + 5y \geq 1500$ $\frac{2}{5}(x+y) \leq x \leq \frac{3}{5}(x+y)$ Which simplifies to $2y \leq 3x$ **and** $2x \leq 3y$ or equivalent. $(x, y \geq 0)$	B1 1M1 1A1 2M1 2A1, 3A1 **6 marks**

Notes

1B1: CAO Expression correct and 'minimise'. Accept working in £'s (C) = 6.6x + 6y
1M1: Condone incorrect inequality (but not equals) sign seen here.
1A1: CAO Must have 2x, 5y and 1500.
2M1: Correct method, dealing with both 40% and 60% of total items – need to see both $\frac{2}{5}(x + y)$ **and** $\frac{3}{5}(\mathrm{x} + \mathrm{y})$ as part of an inequality (not an equation).
2A1: CAO for the 40% inequality – accept strict inequality
3A1: CAO for the 60% inequality – accept strict inequality - may be combined into one inequality

SC: if 2A0 and 3A0 then award SCA1A0 for either $k(2y) \leq k(3x)$ or $k(2x) \leq k(3y)$ for any positive integer k.

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