GradeMax

Pearson Edexcel

Mark Scheme (Results)

October 2020

Pearson Edexcel International A Level In Decision Mathmatics D1 (WDM11/01)

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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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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

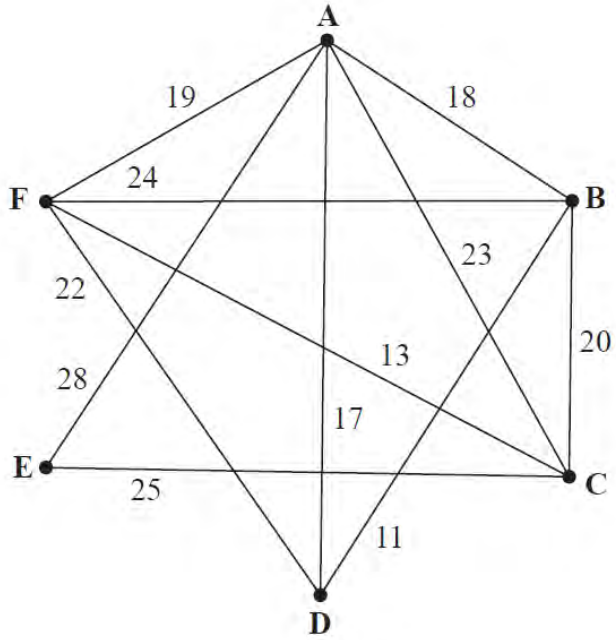
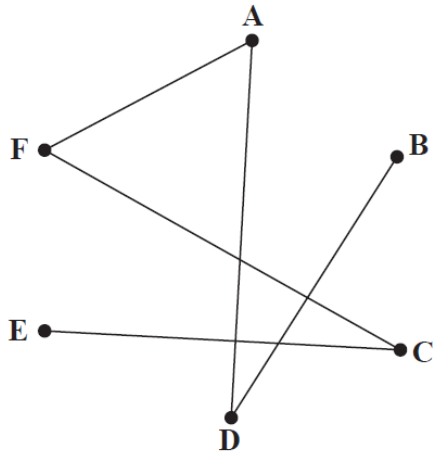
4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but manifestly absurd answers should never be awarded A marks.

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)		M1 A1 **(2)**
(b)	Kruskal: BD(11), CF(13), AD(17), reject AB(18), AF(19), reject BC(20), reject DF(22), reject AC(23), reject BF(24), CE(25) (not AE)	M1 A1 A1 **(3)**
(c)		B1
	Weight of MST = 85 (metres)	B1 **(2)**
		7 marks

Notes for Question 1

a1M1: At least 8 correct arcs with corresponding correct values **or** all 11 correct arcs
a1A1: CSO (11 arcs only + correct values) – give bod
b1M1: Kruskal's: first three arcs (BD, CF, AD) correctly chosen and at least one rejection seen at some point
b1A1: All arcs in tree selected correctly and in the correct order (BD, CF, AD, AF, CE) – no other arcs in MST
b2A1: CSO including all rejections correct and at the correct time – AE need not be considered but if AE is considered then it must be rejected after CE has been added to the MST
c1B1: CAO (tree)
c2B1: CAO (85)

<table>
<tr><th>Question Number</th><th>Scheme</th><th>Marks</th></tr>
<tr><td>2.(a)(i)</td><td>In the first pass of a bubble sort we compare the first value with the second and swap if the first is larger than the second.
We then compare the value that is second with the third value and swap if the second is larger than the third. Continue like this until the end of the list.</td><td>M1

A1</td></tr>
<tr><td>(a)(ii)</td><td>Bubble sort stops when we either have a list of length 1 to sort or we have a pass in which no swaps were made.</td><td>B1 B1 (4)</td></tr>
<tr><td>(b)</td><td>Maximum number of passes is 3 as only the three largest values are in the correct position.</td><td>B1
B1dep (2)</td></tr>
<tr><td>(c)</td><td>
<table>
<tr><td>0.9</td><td>1.2</td><td>1.5</td><td>0.5</td><td>1.4</td><td>1.1</td><td>0.7</td><td>1.7</td><td>2.2</td><td>3.2</td></tr>
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</table>
</td><td>M1

A1

A1ft

A1cso (4)</td></tr>
<tr><td>(d)</td><td>Bin 1: 3.2 0.7
Bin 2: 2.2 1.7
Bin 3: 1.5 1.4 1.1
Bin 4: 1.2 0.9 0.5</td><td>M1 A1 A1(3)</td></tr>
<tr><td></td><td></td><td>13 marks</td></tr>
</table>

Notes for Question 2

ai1M1: Compare first value with second value (allow 'compare first and second') and swap if first is larger (oe) - allow 'wrong order' for M1 only – must be clear that the first value is being compared with the second value

ai1A1: Compare second with third (not just 'next two') and so on until the end of the list (oe e.g. 'all', 'last two', 'last') – must be clear that **all** the list of numbers has been considered

aii1B1: CAO – one of 'until only one item left' (oe e.g. 'stops after $n-1$ passes' but not just a statement along the lines of 'until all the required passes have been done') or 'until no swaps' (oe e.g. 'one pass gives the same result as the next pass') – no marks though if they only say 'when the list is in order' (oe)

aii2B1: CAO – both reasons stated correctly

b1B1: CAO (3)

b2B1dep: Correct reasoning – dependent on previous B mark – must mention that the three largest numbers are in the correct position (and not just that 1.7, 2.2 and 3.2 are in the correct position)

c1M1: Bubble sort. Consistent direction throughout sort, and first pass correct – do check these carefully as some candidates show the result of each comparison and swap in their first pass. No marks for quick sort or descending order

c1A1: Second and third passes correct – so end six numbers in place after third pass

c2A1ft: Their fourth and fifth passes correct following through from the candidate's third pass – so end eight numbers in place after fifth pass

c3A1: CSO (correct solution only) – with sixth pass showing no swaps (not just a statement that the list is in order after a fifth pass)

d1M1: First four items placed correctly (the boxed values). Condone cumulative totals for M1 only

d1A1: First eight items placed correctly (the boxed and underlined values) – any additional/repeated values scores M1 only

d2A1: CSO

Question Number	Scheme	Marks
3. (a)	e.g. add CD and remove AD, BA and BC gives 516 (km) e.g. add EF and remove EB, BA and AF gives 509 (km)	M1 A1 **(2)**
(b)	NNA: A – B – E – F – D – C – A	B1
	57 66 69 78 71 76 = 417 (km)	B1 **(2)**
(c)	Length of RMST = 248	B1
	248 + 66 + 69 = 383 (km)	M1 A1 **(3)**
		7 marks

Notes for Question 3

a1M1: Must clearly start with 2(length of given MST) and add and subtract at least one arc (to give a network of weight < 628) – graph must be connected and Eulerian

a1A1: CAO – shortcut(s) and length must be consistent (with length stated < 520). The shortcuts must be clearly stated (that is the arcs added and subtracted) and network must be connected and Eulerian

b1B1: CAO (must return to A) – must be stated in terms of either the nodes or arcs (e.g. AB, BE, EF,…) but not just the weights of the arcs

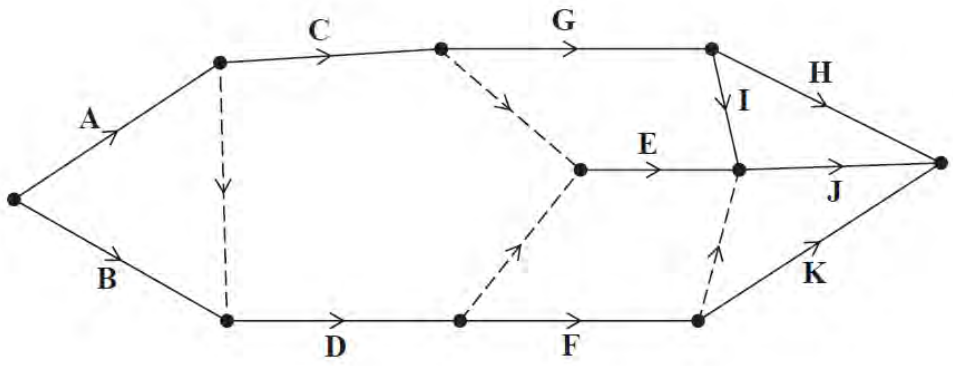
b2B1: CAO (417)

c1B1: Correct length of RMST (248) – maybe implied by later working

c1M1: Adding the two correct least weighted arcs (66 and 69) to their RMST length ($231 \leqslant$ length $\leqslant 265$)

– give bod but their RMST must only contain 4 arcs – this mark can be implied by the correct value for the lower bound

c1A1: CAO (383) – if correct answer with no working then award B0M1A1

Question Number	Scheme	Marks
4.(a)		M1 A1 A1 A1 A1 **(5)**
(b)	D and F are guaranteed to be critical	B1 **(1)**
(c)	Critical path: A – C – G – I – J	B1 **(1)**
		7 marks

Notes for Question 4

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 (use the table below to check this). **Activity on node is M0**

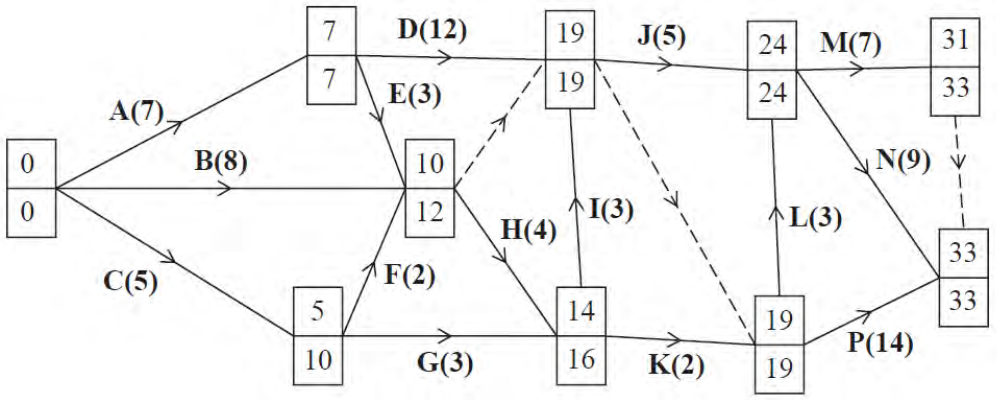
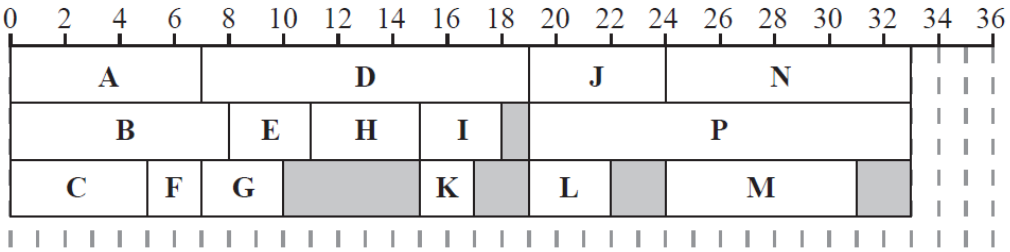
If an arc is not labelled, for example, if the arc for activity D is not labelled (but the arc is present) then this will lose the first A mark and the final (CSO) A mark – they can still earn the second A mark on the bod. If two or more arcs are not labelled then mark according to the scheme. Assume that a solid line is an activity which has not been labelled rather than a dummy (even if in the correct place for where a dummy should be)

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

a1M1: Eight activities (labelled on arc), one start and at least two dummies placed
a1A1: Activities A, B, C, 1st dummy (+ correct arrow on this dummy – this is the dummy at the end of A) and D dealt with correctly
a2A1: 2nd and 3rd dummies (+ correct arrows on these dummies – these dummies are the ones at the end of C and D) and E, F and G dealt with correctly
a3A1: 4th dummy (+ correct arrow on this dummy – this is the dummy at the end of F) and activities H, I , J and K dealt with correctly
a4A1: CSO – all arrows present and correctly placed with one finish
Please check all arcs carefully for arrows – if there are no arrows on any dummies then M1 only.
Note that additional (but unnecessary) 'correct' dummies that still maintain precedence for the network should only be penalised with the final A mark if earned

b1B1: CAO (D and F) and no other activities stated as critical (however, ignore K if stated too)
c1B1: CAO (A – C – G – I – J)

Activity	A	B	C	D	E	F	G	H	I	J	K
IPA	-	-	A	A, B	C, D	D	C	G	G	E, F, I	F

Question Number	Scheme	Marks
5.(a)		M1 A1 M1 A1 **(4)**
(b)	Lower bound is $\frac{87}{33} = 2.6363... = 3$	M1 A1 **(2)**
(c)	e.g. 	M1 A1 A1 A1 **(4)**
(d)	G is not a critical activity (it has a total float of 16 – 5 – 3 = 8 days) and so there is no benefit from reducing the duration of G by one day Activities D and P are both critical activities	M1
	However, D appears in both critical paths therefore reducing P would not reduce the minimum completion time (as there is still a critical path A – D – J – N of length 33) and so activity D should be shortened by one day	A1 **(2)**
		12 marks

Notes for Question 5

a1M1: All top boxes complete, values generally increasing in the direction of the arrows ('left to right'), condone one rogue
a1A1: CAO (top boxes)
a2M1: All bottom boxes complete, values generally decreasing in the opposite direction of the arrows ('right to left'), condone one rogue. Condone missing 0 and/or their 33 (at the end event) for the M mark only
a2A1: CAO (bottom boxes)
b1M1: Attempt to find lower bound: (a value in the interval [73 – 101] / their finish time) **or** (sum of the activities / their finish time) **or** (as a minimum) an awrt 2.6
b1A1: CSO – requires both a **correct** calculation **or** awrt 2.6 seen and 3. An answer of 3 with no working scores no marks
c1M1: Not a cascade chart. 4 workers used at most, at least 10 activities placed
c1A1: 3 workers. All 15 activities present (just once). Condone **two** errors. An activity can give rise to at most three errors; one on duration, one on time interval and only one on IPA
c2A1: 3 workers. All 15 activities present (just once). Condone **one** error. An activity can give rise to at most three errors; one on duration, one on time interval and only one on IPA

c3A1: CAO

Activity	Duration	Time interval	IPA
A	7	0 – 7	-
B	8	0 – 12	-
C	5	0 – 10	-
D	12	7 – 19	A
E	3	7 – 12	A
F	2	5 – 12	C
G	3	5 – 16	C
H	4	10 – 16	B, E, F
I	3	14 – 19	G, H
J	5	19 – 24	B, D, E, F, I
K	2	14 – 19	G, H
L	3	19 – 24	B, D, E, F, I, K
M	7	24 – 33	J, L
N	9	24 – 33	J, L
P	14	19 – 33	B, D, E, F, I, K

d1M1: D and P stated as being critical **or** activity G is not critical
d1A1: Correct answer of D with fully correct reason (G not critical, D and P are both critical but D appears in both/all critical paths or P appears in only one critical path)

Question Number	Scheme	Marks
6.(a)	$4y \le 7x+8$ $4y \ge x+8$ $3x+4y \le 24$	B1 B1 **(2)**
(b)	Min value of P is $8 \Rightarrow 2b=8 \ \therefore b=4$	B1
	Solve $4y=7x+8$ and $3x+4y=24$ simultaneously (to give $\mathrm{B}\left(\frac{8}{5},\frac{24}{5}\right)$)	M1
	$\mathrm{C}(4,3) \Rightarrow P=4a+12, \mathrm{B}\left(\frac{8}{5},\frac{24}{5}\right) \Rightarrow P=\frac{8}{5}a+\frac{96}{5}$	M1
	$4a+12>\frac{8}{5}a+\frac{96}{5} \Rightarrow a>...$	M1
	$a>3$	A1 **(5)**
		7 marks

Notes for Question 6

a1B1: One correct inequality (allow strict inequality)
a2B1: All three inequalities correct (allow any equivalent forms)
b1B1: $b = 4$ (only)
b1M1: Solve correct pair of simultaneous equations to find B – this mark can be implied by correct coordinates of B stated
b2M1: Either linear expression in terms of a only (using their value of b) for either the correct C or their B (their B must be correct or a method for solving the correct simultaneous equations to find B must be seen)
b3M1: Their linear expression in a only for C compared to their linear expression in a only for B (allow any inequality or equals) and attempting to solve for a – this mark is dependent on one correct expression in a
b1A1: CAO ($a > 3$ only)

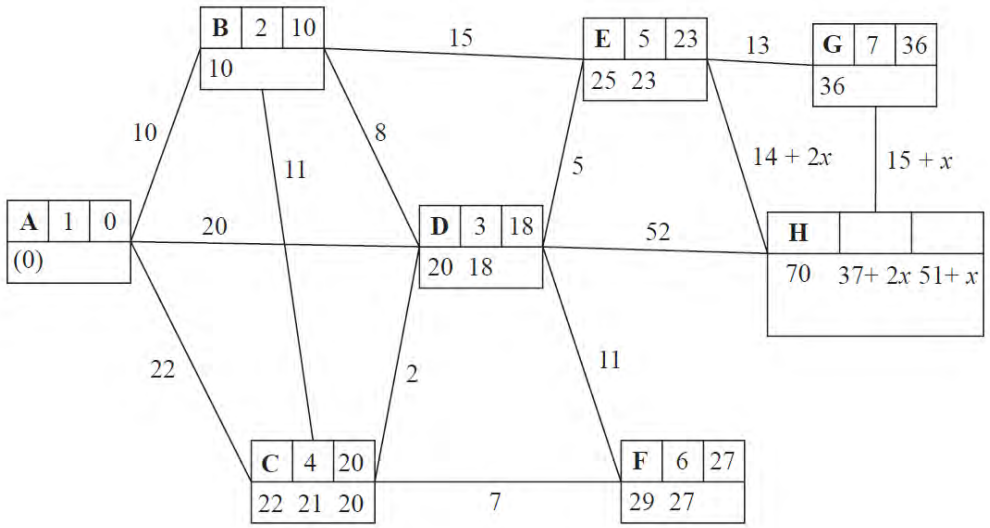
Alternative approach for (b)

b1B1: $b = 4$ (only)

b1M1: Finding the gradient of $3x + 4y = 24$ e.g. $y=-\frac{3}{4}x+6 \Rightarrow m=-\frac{3}{4}$ the gradient must either be stated explicitly or used later

b2M1: Gradient of the objective function stated as $-\frac{a}{b}$ (or used later) in terms of a only (so must have substituted their value of b)
b3M1: Their gradient of $3x + 4y = 24$ compared to their gradient of the objective function (in terms of a only) – allow any inequality or equals and attempting to solve for a – this mark is dependent on one correct gradient (if correct then should be $-\frac{a}{4}<-\frac{3}{4}$)
b1A1: CAO ($a > 3$ only)

Correct answer with no working please send to review

Question Number	Scheme	Marks
7.(a)		M1 A1 A1 A1ft
	Shortest path from A to H via DH: ABDH length: 70	A1
	Shortest path from A to H via EH: ABDEH length: $37 + 2x$	A1
	Shortest path from A to H via GH: ABDEGH length: $51 + x$	A1 **(7)**
(b)	A to H are the only two odd nodes in the network so repeat arcs in path ABDEH	M1
	$3x + 205 + 37 + 2x = 307$	M1
	$x = 13$	A1
	Time taken is 63 (minutes)	A1 **(4)**
		11 marks

Notes for Question 7

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 C the working values must be 22 21 20 in that order (22 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 in at least two of the working value boxes at any node except A, B, G or H (or once with at least two working values seen at H)
a1A1: All values in A, B, D and C correct and the working values in the correct order at D and C (including order of labelling)
a2A1: All values E and F correct and the working values in the correct order. Penalise order of labelling only once per question
a3A1ft: All values in G and H correct on the follow through and the working values in the correct order (the order at H must be correct but give bod). Penalise order of labelling only once per question. Ignore permanent label and final value at H only. Allow unsimplified expressions in x for the working values at H
a4A1: ABDH and 70
a5A1: ABDEH and $37 + 2x$
a6A1: ABDEGH and $51 + x$

If A0A0A0 for the final three marks in **(a)** then award A1A0A0 for all 3 routes stated correctly or all 3 correct values stated explicitly (so not just left in the working values at H)

b1M1: Indication of repeating arcs in a path from A to H. As a minimum: stating A and H as the odd nodes for the network (not just stating A and H) **or** stating a route from A to H with 5 nodes only **or** stating the need to repeat a path/route from A to H - this mark is for making their method clear
b2M1: $3x + 205 +$ (one of their paths involving x) $= 307$ – this mark is for making their working clear
b1A1: CAO ($x = 13$) – this mark is dependent on the second M mark only
b2A1: CAO (63) – this mark is dependent on the second M mark only

SC If M0M0 then **both** correct answers of $x = 13$ and 63 score M0M0A0A1 only (so treating the final mark as a B mark)

Question Number	Scheme	Marks
8.(a)	Minimise $P = 8x + 10y + 14z$	B1
	Subject to $x + y + z \geq 200$	B1
	$3y \leq x$	B1
	$\frac{7}{10}(x + y + z) \geq x$ or $\frac{1}{5}(x + y + z) \leq y$	M1
	$x + z \leq 4y$ $3x \leq 7y + 7z$ $(x, y, z \geq 0)$	A1 A1 **(6)**
(b)(i)	$z = 200 - x - y$ substituted into constraints gives	M1
	$x \leq 140, y \geq 40$	A1
	Using their least value of y and greatest value of x to find z	dM1
	140 ring doughnuts, 40 jam doughnuts and 20 custard doughnuts	A1
(b)(ii)	£18 or 1800	A1 **(5)**
		11 marks

Notes for Question 8

a1B1: Expression correct <u>together</u> with 'minimise' or 'min' but not 'minimum' – isw if coefficients are subsequently simpified but $8x + 10y + 14z$ must be seen at some point for this mark to be awarded. The 'min' must appear beside (or near to) the correct expression

a2B1: CAO ($x + y + z \geq 200$) oe

a3B1: CAO **(** $3y \leq x$) oe

a1M1: $\frac{7}{10}(x + y + z) \square x$ oe or $\frac{1}{5}(x + y + z) \square y$ oe where $\square$ is any inequality or equals – allow 0.7 and 0.2 but not 70% or 20% unless recovered to a fraction or decimal later

a1A1: Either $x + z \leq 4y$ or $3x \leq 7y + 7z$ **or** both correct but not simplified or with integer coefficients (so $\frac{7}{10}(x + y + z) \geq x$ and $\frac{1}{5}(x + y + z) \leq y$ can score this mark)

a2A1: Both correct – must be simplified (e.g. only one term in each variable) and integer coefficients but allow positive integer multiplies (e.g. $2x + 2z - 8y \leq 0$)

bi1M1: Using $x + y + z = 200$ to obtain either an inequality (or value) for either x or y

bi1A1: Any one of $x \leq 140$ or $y \geq 40$ correct (this mark can be implied for either $x = 140$ or $y = 40$ seen provided not from incorrect working)

bi2dM1: Using their least value of y and greatest value of x to find z (so not from the inequality $3y \leq x$) - the total of x, y and z must be 200 (and dependent on first M mark)

bi2A1: All three types of doughnuts correct (in context) - so not just in terms of x, y and z

bii1A1: CAO for cost – if 1800 given then this is fine (without pence) but if 18 then must be £

SC in (b): If correct answers from either no working or from explicitly solving three correct equations e.g. $x - 4y + z = 0$ $3x - 7y - 7z = 0$ with no algebraic working then award M0A0 M1 (for correct values of x, y and z) A1 (for $x + y + z = 200$ answers in context) and A1 for 1800. If solving these three equations with algebraic working then full marks can be awarded. If no marks awarded according to the notes above and solving any other (e.g. incorrect) sets of equations then no marks in **(b)**.

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