# Fd1Ch6 XMQs and MS

(Total: 70 marks)

1. FD1_2019 Q7 . 12 marks - FD1ch6 Linear programming
2. FD1_2020 Q4 . 10 marks - FD1ch6 Linear programming
3. FD1(AS)_2018 Q4 . 11 marks - FD1ch6 Linear programming
4. FD1(AS)_2019 Q5 . 10 marks - FD1ch6 Linear programming
5. FD1(AS)_2020 Q4 . 9 marks - FD1ch6 Linear programming
6. FD1(AS)_2021 Q3 . 9 marks - FD1ch6 Linear programming
7. FD1(AS)_2022 Q4 . 9 marks - FD1ch6 Linear programming

**7.** A shop sells two types of watch, analogue watches and digital watches.

The shop manager knows that, each month, she should order at least 60 watches in total. In addition, at most 80% of the watches she orders must be digital.

Let $x$ be the number of analogue watches ordered and let $y$ be the number of digital watches ordered.

(a) Write down inequalities, in terms of $x$ and $y$, to model these constraints.

**(2)**

Two further constraints are

$$y + 3x \geqslant 140$$

$$4y + x \geqslant 80$$

(b) Represent all these constraints on Diagram 1 in the answer book. Hence determine, and label, the feasible region, $R$.

**(4)**

The cost to the shop of ordering an analogue watch is five times the cost of ordering a digital watch. The shop manager wishes to minimise the total cost.

(c) Determine the number of each type of watch the shop manager should order. You must make your method clear.

**(3)**

Given that the minimum total cost of ordering the watches is £4455

(d) determine the cost of ordering one analogue watch and the cost of ordering one digital watch. You must make your method clear.

**(3)**

**(Total for Question 7 is 12 marks)**

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**TOTAL FOR PAPER IS 75 MARKS**

**Question 7 continued**

**Turn to page 24 for a spare copy of these axes if you need to correct your work.**

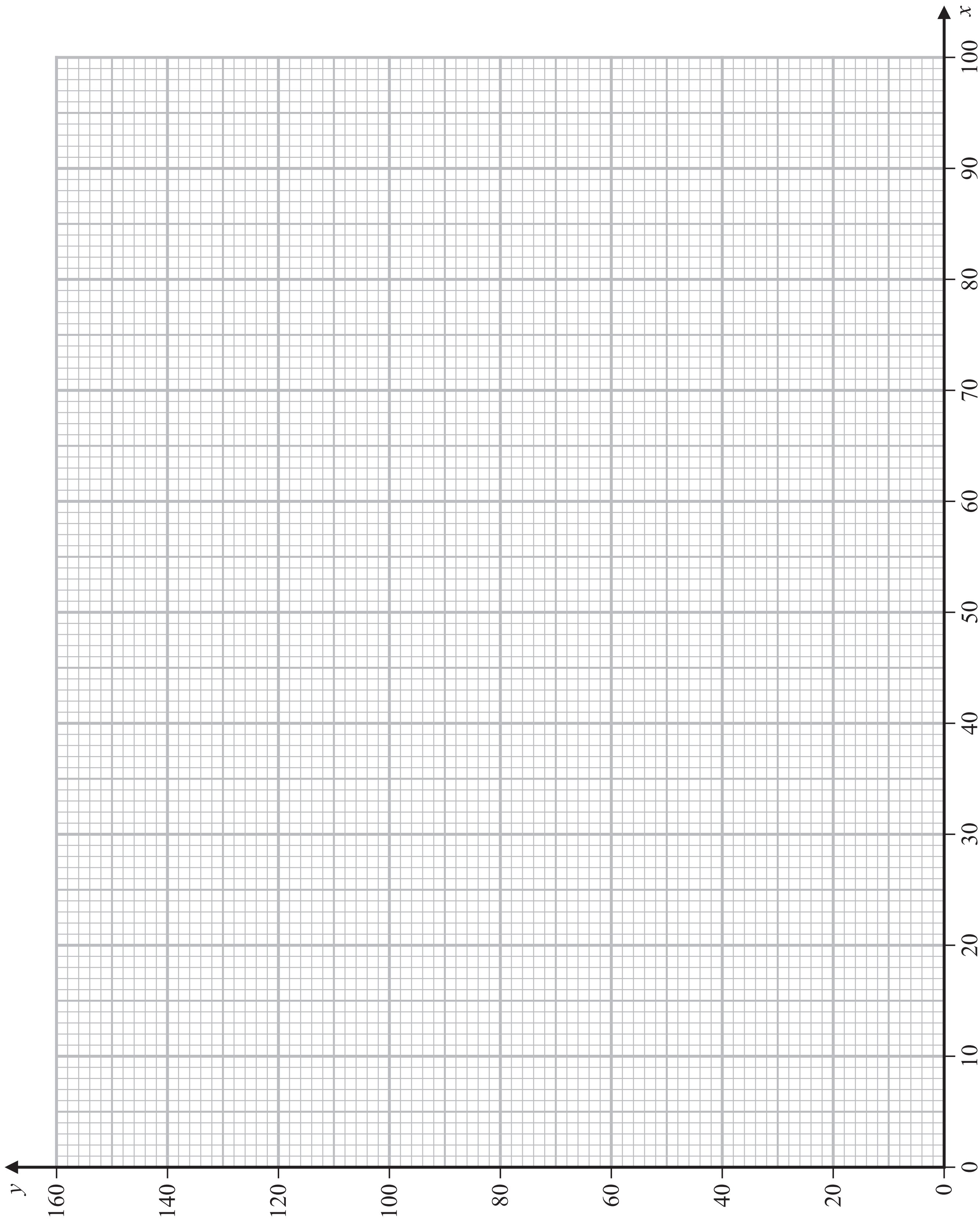


**Diagram 1**



P 6 1 1 8 2 A 0 2 1 2 4

*Turn over*

**Question 7 continued**

**Only use these axes if you need to correct your work.**

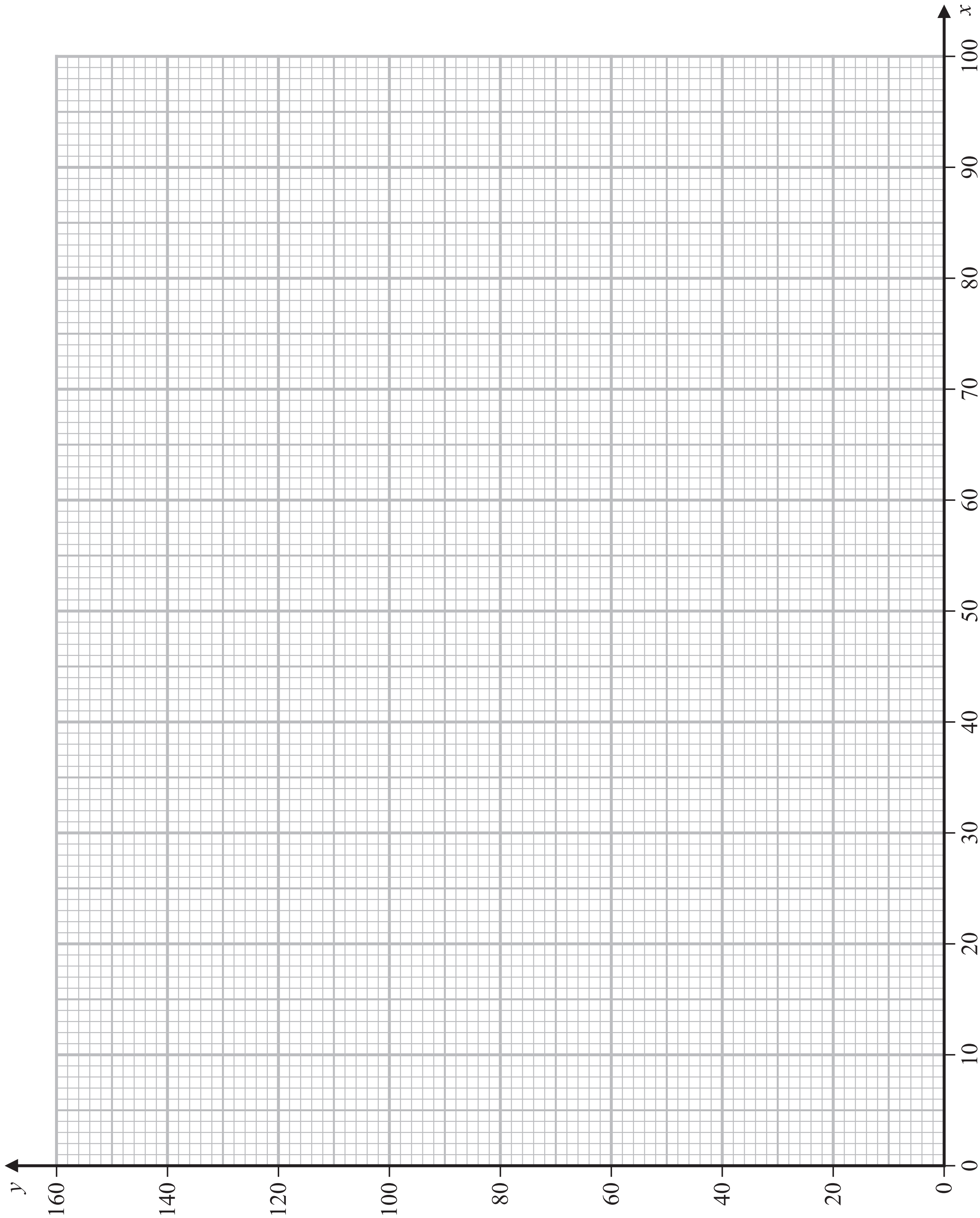


**Diagram 1**

**(Total for Question 7 is 12 marks)**

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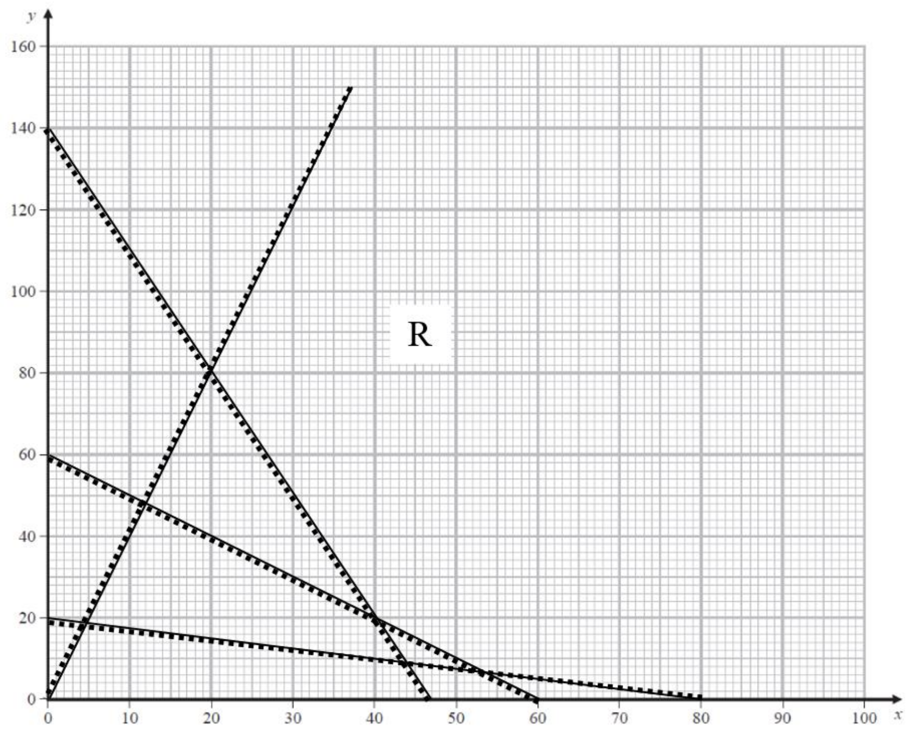
**TOTAL FOR PAPER IS 75 MARKS**

| Qu | Scheme | Marks | AOs |
|---|---|---|---|
| **7(a)** | $x+y \geq 60$ | B1 | 3.3 |
| | $y \leq \frac{4}{5}(x+y)$ | B1 | 3.3 |
| | | **(2)** | |
| **(b)** |  | B1<br>B1<br>B1<br>B1 | 1.1b<br>1.1b<br>1.1b<br>2.2a |
| | | **(4)** | |
| **(c)** | objective line drawn or point-testing | M1<br>A1 | 3.1a<br>1.1b |
| | (20, 80) so 20 analogue watches and 80 digital watches | A1 | 3.2a |
| | | **(3)** | |
| **(d)** | $20a + 80d = 4\,455$ | B1ft | 3.1b |
| | $a = 5d$ | B1 | 2.1 |
| | Leading to $a = 123.75$ and $d = 24.75$ so an analogue watch costs £123.75 and a digital watch costs £24.75 | dB1 | 2.2a |
| | | **(3)** | |

**(12 marks)**

| |
|---|
| **Notes for Question 7** |
| **(a) B1:** CAO – allow any equivalent form of $x+y\geq 60$ - do not condone strict inequality<br>**B1:** CAO – allow any equivalent form of $y\leq \frac{4}{5}(x+y)$ (but not $y\leq 80\%(x+y)$ only) and need not be simplified - do not condone strict inequality – isw if correct answer is incorrectly simplified<br><br>In **(b)**, lines must be long enough to define the correct feasible region and would pass if extended through one small square of the points stated:<br>$x+y=60$ must pass within one small square of its intersection with the axes – (0, 60) and (60, 0)<br>$y+3x=140$ must pass within one small square of its intersection with the axes – (0, 140) and $\left(\frac{140}{3},0\right)$ (so at 46.666…, 0)<br>$4y+x=80$ must pass within one small square of its intersection with the axes – (0, 20) and (80, 0)<br>$y=4x$ must pass within one small square of (0, 0) and (25, 100)<br>**In (b) condone for full marks lines which are drawn as dashed rather than solid**<br><br>**(b) B1**: 2 lines drawn correctly<br>**B1**: 3 lines drawn correctly<br>**B1**: 4 lines drawn correctly<br>**B1**: Region, *R*, correctly labelled – not just implied by shading – dependent on scoring the first three marks in this part<br><br>**(c) M1**: Drawing the correct objective line (with gradient – 5) or its reciprocal (with gradient $-\frac{1}{5}$) . Line must be correct to within one small square if extended from axis to axis. If lines shorter than (5, 0) to (0, 25) or (0, 5) to (25, 0) then M0. Or point testing at least two exact coordinates of their *R* using their objective function which must be of the form $k(5x+y)$ or $k(x+5y)$ for some positive real value *k*<br>**A1**: Correct objective line – condone lack of labelling of the objective line. Or point testing at least two of the correct exact coordinates which are (20, 80), (40, 20), (80, 0) and $\left(\frac{160}{3},\frac{20}{3}\right)$ using a correct objective function of the form $k(5x+y)$<br>**A1**: Correct number of watches – **must be in context** (and not just in terms of *x* and *y*) – dependent on a correct feasible region in **(b)** (so must have scored the first three marks in **(b)** but may not have labelled the FR as *R*)<br><br>**Condone use of *x* for *a* and *y* for *d* in part (d)**<br>**(d) B1ft**: A 'correct' equation (e.g. $20a+80d=4\,455$) involving their optimal point from **(c)** (accept any values even if non-integer) and 4455 –- note that for those who have done point testing in **(c)** the calculation 4455 / (their value for *P*) where *P* = $5x+y$ or $x+5y$ using their optimal point implies this mark<br>**B1**: CAO on the relationship between the costs of the two types of watches (*a* = 5*d*) – this mark may be implied e.g. 20(5*d*) + 80*d* = 4455 would score the first two marks in this part – note that for those who have done point testing in **(c)** the calculation 4455 / (their value for *P*) where *P* = $5x+y$ using their optimal point implies this mark e.g. just seeing 4455 / 180 is the first two marks in this part<br>**dB1**: CAO (dependent on first two B marks) – this mark is dependent on having the correct optimal point (20, 80) and is dependent on a correct feasible region in **(b)** (so must have scored at least the first three marks in **(b)**) – allow for $a=123.75$ and $d=24.75$ (so does not need to be in context or |

| |
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| units) – the correct answers with no working scores no marks in this part (however, note that 4455 / 180 is the minimum amount of working that is acceptable) |

**4.**

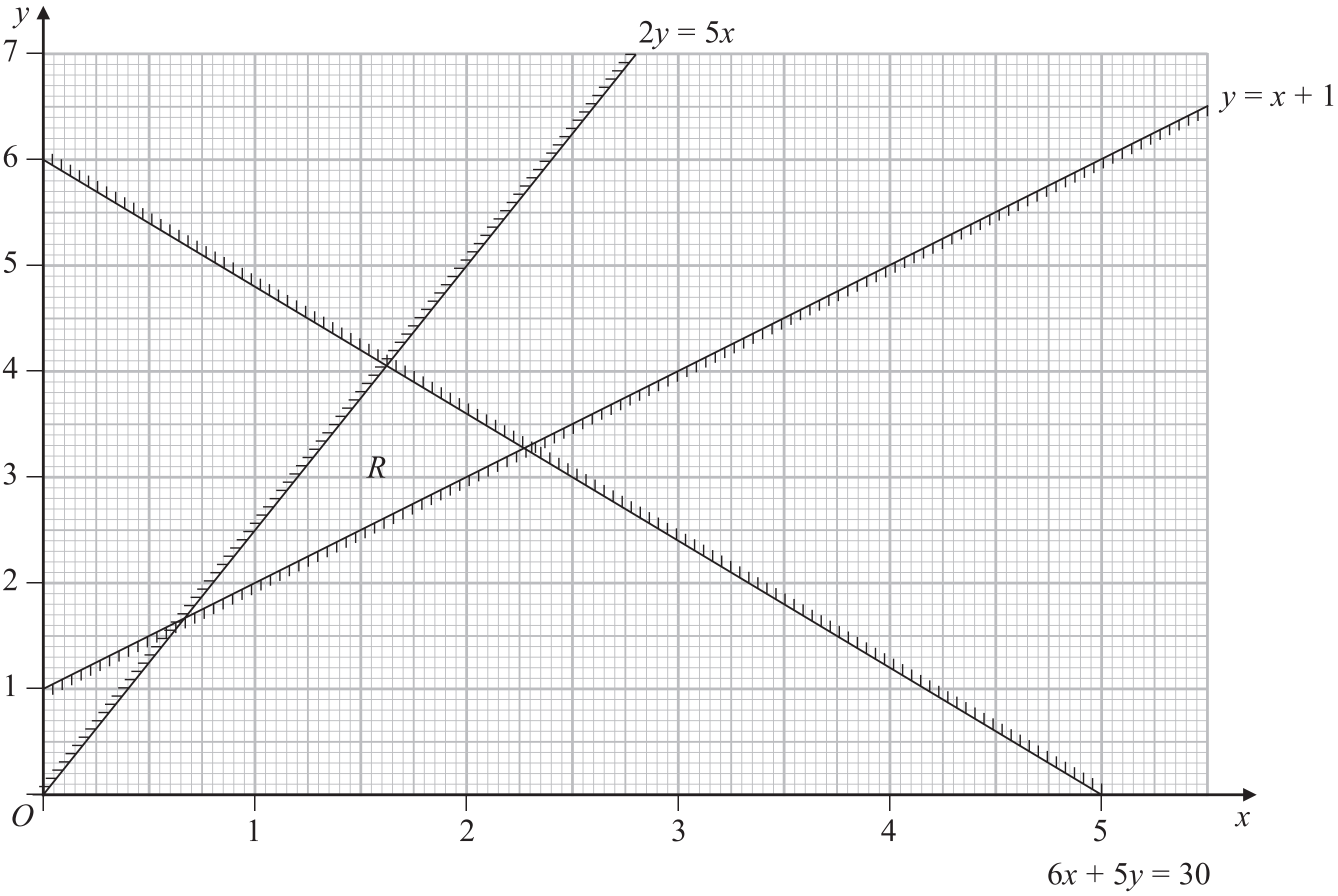


**Figure 3**

Figure 3 shows the constraints of a linear programming problem in $x$ and $y$, where $R$ is the feasible region.

(a) Write down the inequalities that define $R$.

**(2)**

The objective is to maximise $P$, where $P = 3x + y$

(b) Obtain the exact value of $P$ at each of the three vertices of $R$ and hence find the optimal vertex, $V$.

**(4)**

The objective is changed to maximise $Q$, where $Q = 3x + ay$. Given that $a$ is a constant and the optimal vertex is still $V$,

(c) find the range of possible values of $a$.

**(4)**

**(Total for Question 4 is 10 marks)**



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**4.**

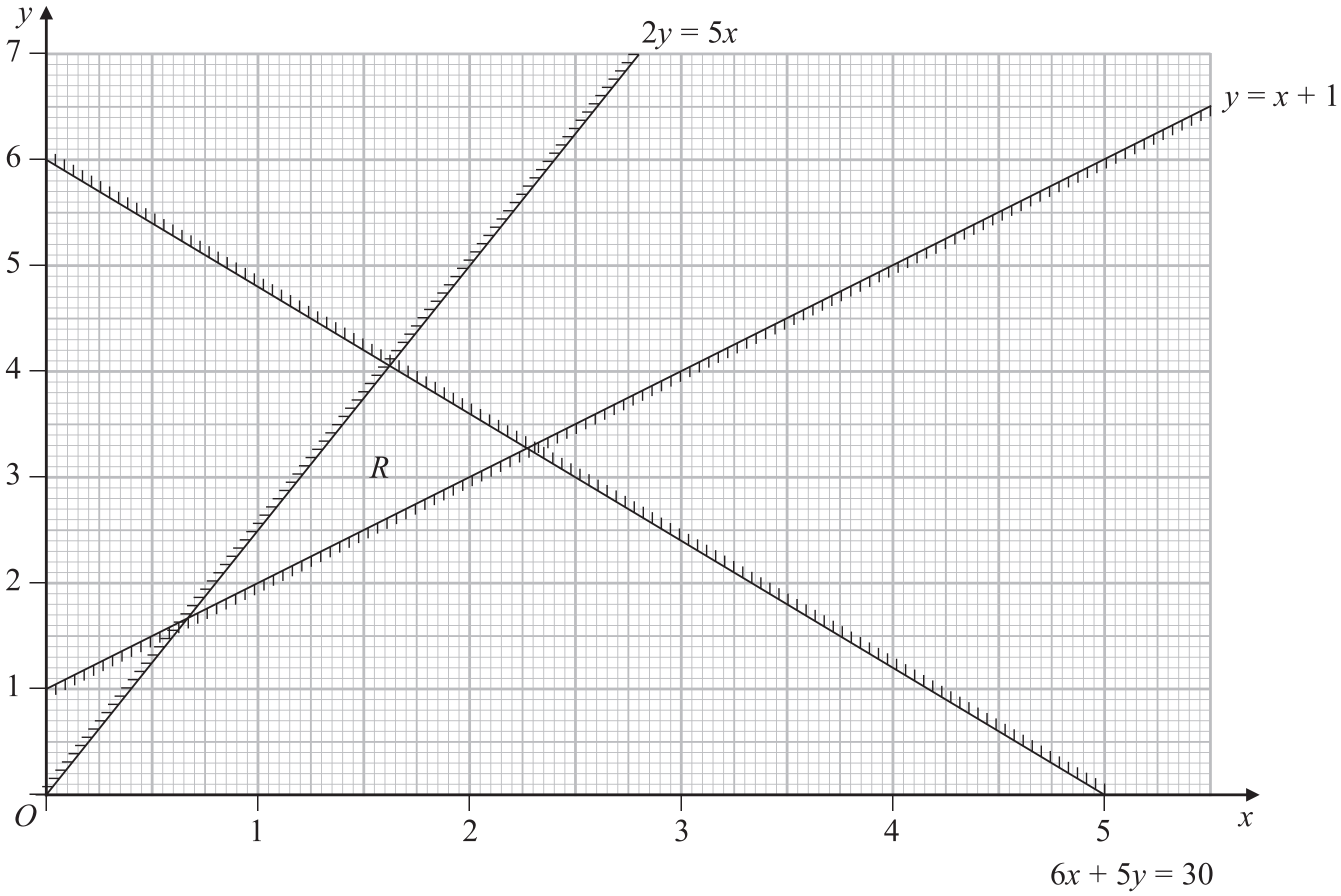


**Figure 3**

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **4(a)** | $2y \le 5x,\ y \ge x+1,\ 6x+5y \le 30$ | B2,1,0 | 1.1b<br>2.5 |
| | | **(2)** | |
| **(b)** | $\left(\frac{2}{3},\frac{5}{3}\right),\left(\frac{60}{37},\frac{150}{37}\right),\left(\frac{25}{11},\frac{36}{11}\right)$<br><br>$\left(\frac{2}{3},\frac{5}{3}\right) \to P = \frac{11}{3}$<br>$\left(\frac{60}{37},\frac{150}{37}\right) \to P = \frac{330}{37}$<br>$\left(\frac{25}{11},\frac{36}{11}\right) \to P = \frac{111}{11}$ so optimal vertex is $\left(\frac{25}{11},\frac{36}{11}\right)$ | B1<br>B1<br><br>M1<br>A1 | 1.1b<br>1.1b<br><br>2.1<br>2.2a |
| | | **(4)** | |
| **(c)** | $Q = 3x + ay$<br>$3\left(\frac{25}{11}\right)+\frac{36a}{11} > 3\left(\frac{60}{37}\right)+\frac{150a}{37}$<br>$\Rightarrow a < \frac{5}{2}$<br>$3\left(\frac{25}{11}\right)+\frac{36a}{11} > 3\left(\frac{2}{3}\right)+\frac{5a}{3}$<br>$\Rightarrow a > -3$ | <br>M1<br>A1<br>M1<br>A1 | <br>3.1a<br>2.2a<br>1.1b<br>2.2a |
| | | **(4)** | |
| | | | **(10 marks)** |

**Notes for Question 4**

**(a)**
**B1:** Any two correct (accept strict inequalities) – accept equivalent inequalities
**B1:** CAO (accept equivalent inequalities but inequalities must not be strict)
**(b)**
**B1:** One correct vertex (must be exact)
**B1:** All three correct vertices (must be exact)
**M1:** Testing all three of their vertices in the correct objective function
**A1:** Correct three values of $P$ and correct optimal vertex either stated or clearly indicated on the graph

**(c)**

**M1:** Their optimal point from (b) evaluated in $Q$ compared to their $\left(\frac{60}{37}, \frac{150}{37}\right)$ evaluated in $Q$ (with correct inequality)

**A1:** $a < \frac{5}{2}$

**M1:** Their optimal point from (b) evaluated in $Q$ compared to their $\left(\frac{2}{3}, \frac{5}{3}\right)$ evaluated in $Q$ (with correct inequality)

**A1:** $a > -3$

**4.** The manager of a factory is planning the production schedule for the next three weeks for a range of cabinets. The following constraints apply to the production schedule.

- The total number of cabinets produced in week 3 cannot be fewer than the total number produced in weeks 1 and 2
- At most twice as many cabinets must be produced in week 3 as in week 2
- The number of cabinets produced in weeks 2 and 3 must, in total, be at most 125

The production cost for each cabinet produced in weeks 1, 2 and 3 is £250, £275 and £200 respectively.

The factory manager decides to formulate a linear programming problem to find a production schedule that minimises the total cost of production.

The objective is to minimise $250x + 275y + 200z$

(a) Explain what the variables $x$, $y$ and $z$ represent.

**(1)**

(b) Write down the constraints of the linear programming problem in terms of $x$, $y$ and $z$.

**(2)**

Due to demand, exactly 150 cabinets must be produced during these three weeks. This reduces the constraints to

$$x + y \leqslant 75$$
$$x + 3y \geqslant 150$$
$$x \geqslant 25$$
$$y \geqslant 0$$

which are shown in Diagram 1 in the answer book.

Given that the manager does not want any cabinets left unfinished at the end of a week,

(c) (i) use a graphical approach to solve the linear programming problem and hence determine the production schedule which minimises the cost of production. You should make your method and working clear.

(ii) Find the minimum total cost of the production schedule.

**(8)**

**(Total for Question 4 is 11 marks)**

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**TOTAL FOR DECISION MATHEMATICS 1 IS 40 MARKS**

**END**

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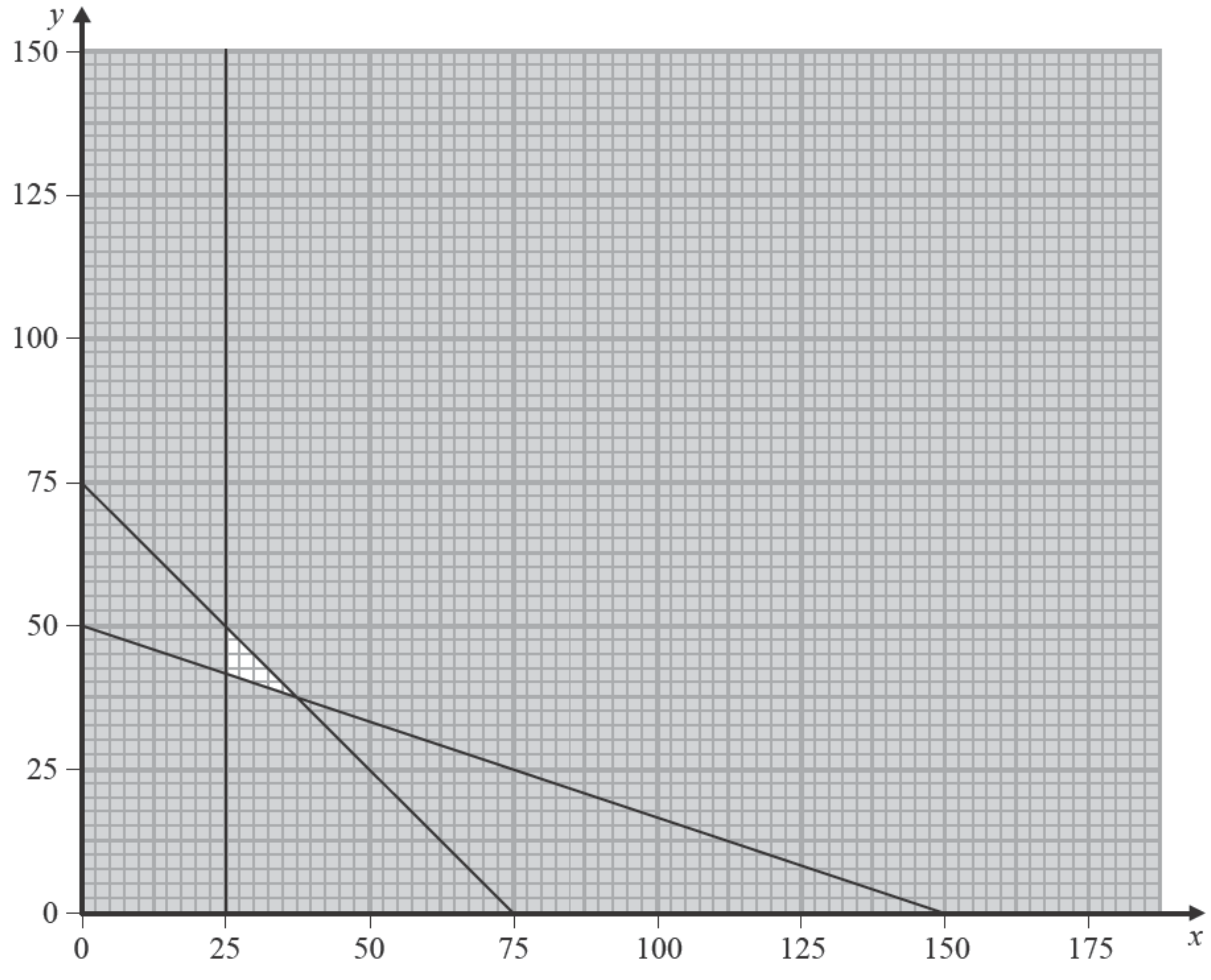


**Diagram 1**

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P 6 0 2 0 8 A 0 1 0 1 2

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **4(a)** | $x$ is the number of cabinets produced in week 1, $y$ is the number of cabinets produced in week 2 and $z$ is the number of cabinets produced in week 3 | B1 | 2.5 |
| | | **(1)** | |
| **(b)** | $x+y\le z$<br>$z\le 2y$<br>$y+z\le 125$<br>$(x, y, z\ge 0)$ | B1<br>B1 | 3.3<br>3.3 |
| | | **(2)** | |
| **(c)(i)** | Objective is $P=250x+275y+200(150-x-y)$ | M1 | 3.1a |
| | $P$ = 50$x$ + 75$y$ (+ 30000) | A1 | 1.1b |
| | Objective line drawn or at least two vertices tested | M1 | 3.1a |
| | Optimal point $\left(25, \dfrac{125}{3}\right)$ | A1 | 1.1b |
| | Consideration of integer coordinates around the optimal vertex | M1 | 1.1b |
| | Correct integer coordinate (25, 42) | A1 | 1.1b |
| | The production schedule is 25 cabinets in week 1, 42 cabinets in week 2 and 83 cabinets in week 3 | B1 | 3.2a |
| **(c)(ii)** | Total cost of production is £34 400 | B1 | 1.1b |
| | | **(8)** | |
| | | **(11 marks)** | |

| Notes |
|---|
| **(a)**<br>**B1:** Cao - must contain 'number of…' (oe e.g. 'amount of', 'quantity of',…) at least once |
| **(b)**<br>**B1:** Any one correct (accept strict inequalities)<br>**B1:** All three correct |
| **Note that the vertices of the FR are** $\left(25, \frac{125}{3}\right), (25, 50), \left(\frac{75}{2}, \frac{75}{2}\right)$<br>**(c)(i)**<br>**M1:** Attempt to derive new objective function in terms of *x* and *y* only by using $x + y + z = 150$ **or** attempt to calculate all three values of *z* using $x + y + z = 150$<br>**A1:** Cao for objective in terms of *x* and *y* only **or** all three correct *z* values $\left(\frac{250}{3}, 75, 75\right)$<br>**M1:** Objective line drawn consistent with their objective function (or its reciprocal) **or** testing two of the correct vertices (to at least 1 decimal place where applicable) in their objective function involving *x* and *y* only **or** testing two of the correct vertices (to at least 1 decimal place where applicable) in $250x + 275y + 200z$<br>**A1:** Correct optimal point $\left(25, \frac{125}{3}\right)$ **or** $\left(25, \frac{125}{3}, \frac{250}{3}\right)$ **-** accept 41.6 or 41.7 **(**or better) – so at least 1 decimal place (truncated or rounded) if not given exact<br>**M1:** Consideration of integer point(s) (e.g. (25, 41) etc.) around the optimal vertex – must have attempted point testing of the vertices of the feasible region or objective line<br>**A1:** Correct integer coordinate (25, 42) stated <u>and</u> either clear rejection of (26, 41) - by checking in $x + 3y \geq 150$ <u>or</u> testing of (27, 41) in a correct objective function<br>**B1:** Cao (in context – so not in terms of *x*, *y* and *z*)<br><br>**(c)(ii)**<br>**B1:** Cao (£34,400) – condone lack of units |

**5.** Ben is a wedding planner. He needs to order flowers for the weddings that are taking place next month. The three types of flower he needs to order are roses, hydrangeas and peonies.

Based on his experience, Ben forms the following constraints on the number of each type of flower he will need to order.

- At least three-fifths of all the flowers must be roses.
- For every 2 hydrangeas there must be at most 3 peonies.
- The total number of flowers must be exactly 1000

The cost of each rose is £1, the cost of each hydrangea is £5 and the cost of each peony is £4

Ben wants to minimise the cost of the flowers.

Let $x$ represent the number of roses, let $y$ represent the number of hydrangeas and let $z$ represent the number of peonies that he will order.

(a) Formulate this as a linear programming problem in $x$ and $y$ only, stating the objective function and listing the constraints as simplified inequalities with integer coefficients.

**(7)**

Ben decides to order the minimum number of roses that satisfy his constraints.

(b) (i) Calculate the number of each type of flower that he will order to minimise the cost of the flowers.

(ii) Calculate the corresponding total cost of this order.

**(3)**

**(Total for Question 5 is 10 marks)**

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**TOTAL FOR DECISION MATHEMATICS 1 IS 40 MARKS**

**END**

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **5(a)** | Minimise $(P=)\,x+5y+4z$ | B1 | 3.3 |
| | Subject to $x \geq \frac{3}{5}(x+y+z)(\Rightarrow 2x \geq 3y+3z)$ | B1 | 3.3 |
| | $3y \geq 2z$ | B1 | 3.3 |
| | $x+y+z=1000$ | B1 | 3.3 |
| | $z=1000-x-y$ substituted into objective and constraints gives | M1 | 3.1a |
| | Minimise $(P=)\,y-3x(+\ 4000)$ subject to<br>$x \geq 600$ and $2x+5y \geq 2000$ | A1<br>A1 | 1.1b<br>1.1b |
| | | **(7)** | |
| **(b)** | **(i)** Using least value of $x$ to find $y$ and $z$<br>600 roses, 160 hydrangeas and 240 peonies<br>**(ii)** £2360 | M1<br>A1<br>A1 | 3.4<br>3.2a<br>1.1b |
| | | **(3)** | |
| | | | **(10 marks)** |

**Notes**

**(a)**

**B1:** CAO (for objective) – must contain 'minimise' or 'min' only (so not 'minimum') either when stated in terms of $x$, $y$ and $z$ or $x$ and $y$ only

**B1:** $x \geq \frac{3}{5}(x+y+z)$ oe – need not be simplified for this mark, accept $x \geq \frac{3}{5}(1000)$

**B1:** $3y \geq 2z$ or any equivalent form (need not be simplified nor integer coefficients for this mark)

**B1:** $x+y+z=1000$ (could be implied by earlier/later working)

**M1:** Eliminating $z$ from either the objective **or** both constraints using the constraint $x+y+z=1000$

**A1:** Correct objective in terms of $x$ and $y$ only – condone lack of 'minimise'

**A1:** Both constraints correct ( $x \geq 600$ and $2x+5y \geq 2000$ - must be integer coefficients for this mark)

**(b)(i)**

**M1:** Using their least value of $x$ to find both $y$ and $z$ (with both $y$ and $z$ being positive integers) – note that all values must satisfy the constraint $x+y+z=1000$ (and must all be integers)

**A1:** All three types of flowers correct (in context – so not just in terms of $x$, $y$ and $z$) – must come from correct constraints in (a)

**(ii)**

**A1:** CAO for cost (condone lack of units but not 2360p) – must come from correct constraints in (a)

**SC for (b)** – for those candidates with the constraint $2y \geq 3z$ in (a) leading to 600 roses, 240 hydrangeas and 160 peonies (so not just in terms of $x$, $y$ and $z$) together with (£)2440 award **SC M1A1A0** in (b)

**4.**

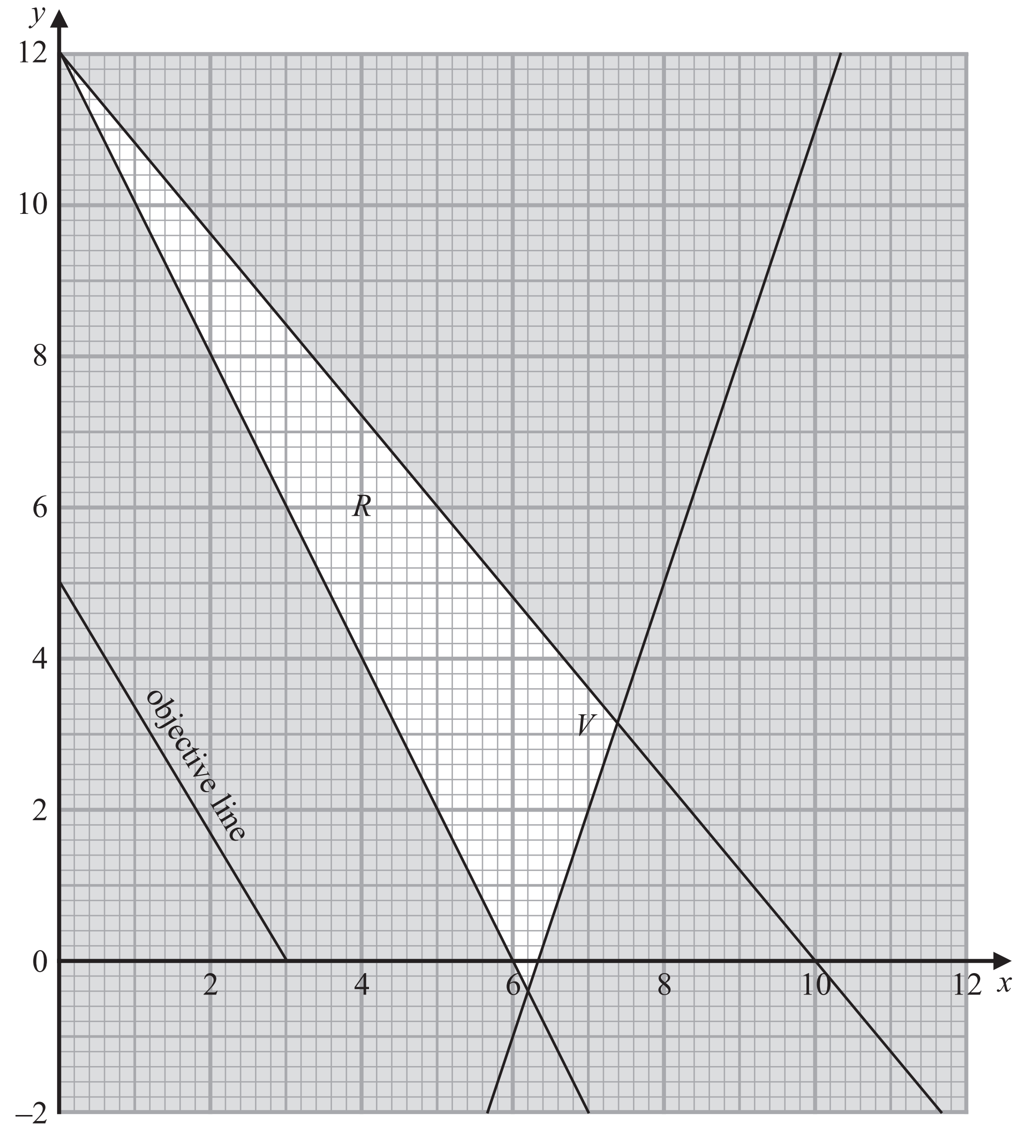


**Figure 3**

Figure 3 shows the constraints of a linear programming problem in $x$ and $y$, where $R$ is the feasible region. Figure 3 also shows an objective line for the problem and the optimal vertex, which is labelled as $V$.

The value of the objective at $V$ is 556

Express the linear programming problem in algebraic form. List the constraints as simplified inequalities with integer coefficients and determine the objective.

**(9)**

**(Total for Question 4 is 9 marks)**

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**TOTAL FOR DECISION MATHEMATICS 1 IS 40 MARKS**

**END**

**4.**

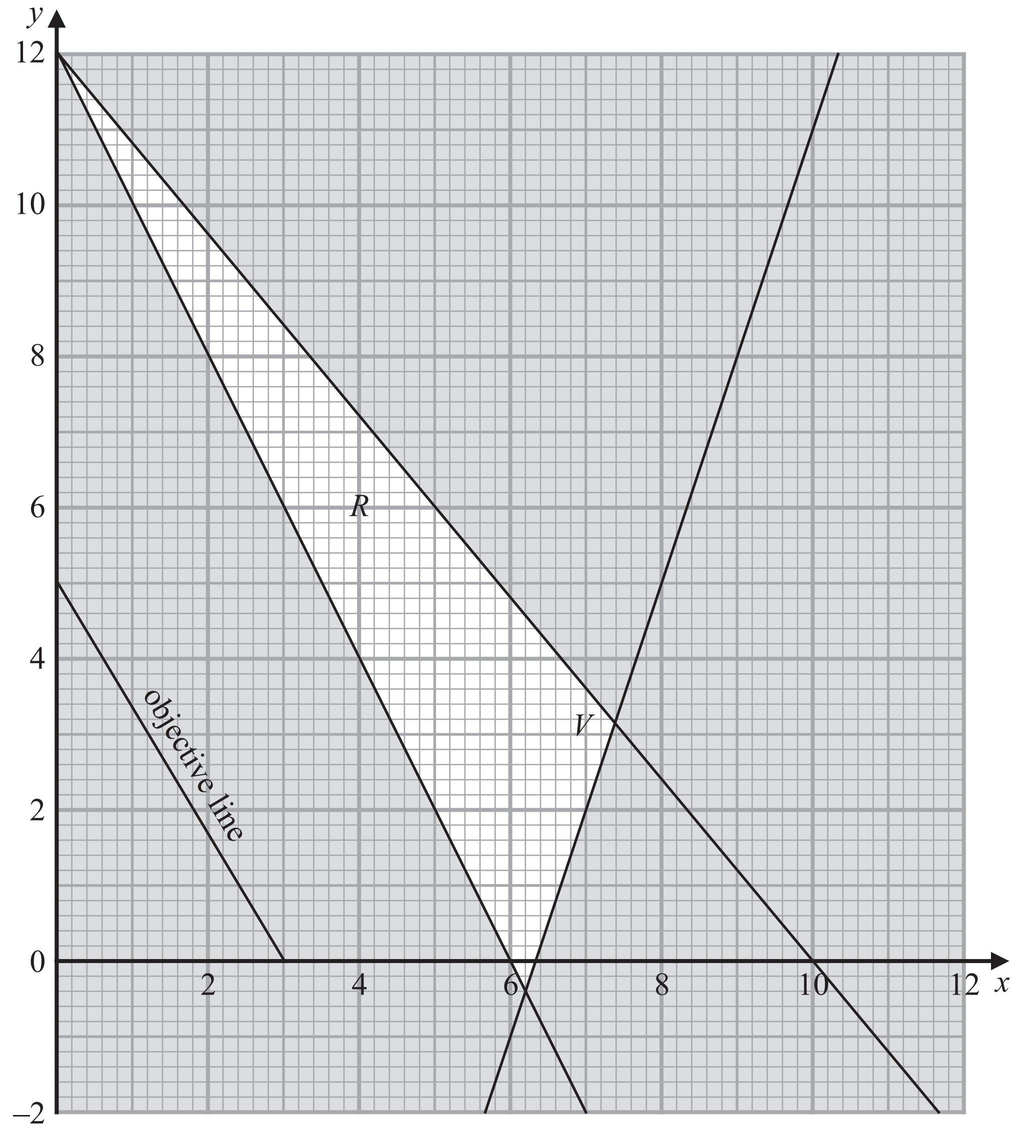


**Figure 3**

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **4** | Line through (0, 12) and (6, 0) is $2x + y = 12$<br>Line through (0, 12) and (10, 0) is $6x + 5y = 60$<br>Line through (7, 2) and (9, 8) is $3x - y = 19$ | M1 | 1.1b |
| | $2x + y \geq 12$ | A1 | 3.4 |
| | $6x + 5y \leq 60$ | A1 | 1.1b |
| | $3x - y \leq 19$ | A1 | 1.1b |
| | Solving correct two equations to find $V$ | M1 | 1.1b |
| | $V\left(\frac{155}{21}, \frac{22}{7}\right)$ | A1 | 2.2a |
| | $P = k(5x + 3y)$ and substituting $P = 556$ and their $V$ | M1dep | 3.4 |
| | Maximise<br>$P = 60x + 36y$ | B1<br>A1 | 2.5<br>2.2a |
| | | **(9)** | |
| | | | **(9 marks)** |

**Notes**

**M1:** Correct method for finding the equation of one of the three lines
**A1:** CAO (with correct inequality sign from shading) $2x + y \geq 12$ (allow a positive multiple but must have integer coefficients)
**A1:** CAO $6x + 5y \leq 60$ (allow a positive multiple but must have integer coefficients)
**A1:** CAO $3x - y \leq 19$ (allow a positive multiple but must have integer coefficients)

If A0A0A0 then award A1A0A0 only for one 'correct' strict inequality and/or non-integer coefficients e.g. $x + 0.5y > 6$

**M1:** Attempt to find $V$ by solving the correct pair of simultaneous equations – for this mark either the correct method for solving the simultaneous equations must be seen or if no method seen then this mark can be implied by correctly stating the exact coordinates of $V$ (or correct to at least 3 sf)
**A1:** Correct deduction of the exact coordinates for $V$
**M1dep:** Uses the model to write down a suitable objective and substitutes $P = 556$ and their $V$ into $P = k(5x + 3y)$. Dependent on previous M mark.

Or this mark can be awarded for forming both equations $\frac{155}{21}x + \frac{22}{7}y = 556$ and $3x - 5y = 0$

**B1:** Maximise (oe) e.g. allow 'max' – this mark is independent of all other marks
**A1:** Correct objective function (this mark cannot be awarded for $5x + 3y$)
**Note that the complete LP formulation is**
Maximise $P = 60x + 36y$
Subject to $2x + y \geq 12$
$6x + 5y \leq 60$
$3x - y \leq 19$

**3.** Donald plans to bake and sell cakes. The three types of cake that he can bake are brownies, flapjacks and muffins.

Donald decides to bake 48 brownies and muffins in total.

Donald decides to bake at least 5 brownies for every 3 flapjacks.

At most 40% of the cakes will be muffins.

Donald has enough ingredients to bake 60 brownies or 45 flapjacks or 35 muffins.

Donald plans to sell each brownie for £1.50, each flapjack for £1 and each muffin for £1.25
He wants to maximise the total income from selling the cakes.

Let $x$ represent the number of brownies, let $y$ represent the number of flapjacks and let $z$ represent the number of muffins that Donald will bake.

Formulate this as a linear programming problem in $x$ and $y$ only, stating the objective function and listing the constraints as simplified inequalities with integer coefficients.

You should **not** attempt to solve the problem.

**(Total for Question 3 is 9 marks)**

| Question | Scheme | Marks | AOs |
|---|---|---|---|
| **3** | Maximise $P = 1.5x + y + 1.25z$ | B1 | 3.3 |
| | Subject to $x + z = 48$ | B1 | 3.3 |
| | $3x \geq 5y$ | M1 | 3.3 |
| | $\frac{2}{5}(x + y + z) \geq z \quad (\Rightarrow 2x + 2y \geq 3z)$ | M1 | 3.3 |
| | $\frac{x}{60} + \frac{y}{45} + \frac{z}{35} \leq 1 \quad (\Rightarrow 21x + 28y + 36z \leq 1260)$ | M1 | 3.3 |
| | Two of $3x \geq 5y$, $\frac{2}{5}(x + y + z) \geq z$ and $\frac{x}{60} + \frac{y}{45} + \frac{z}{35} \leq 1$ | A1 | 1.1b |
| | $z = 48 - x$ substituted into objective and constraints gives | M1 | 3.1a |
| | Maximise $P = 0.25x + y + 60$ subject to | A1 | 1.1b |
| | $3x \geq 5y, \quad 5x + 2y \geq 144, \quad 15x \geq 28y + 468$ | A1 | 2.5 |
| | | **(9)** | |
| | | | **(9 marks)** |

**Notes:**

**B1:** cao (for objective) – must contain 'maximise'

**B1:** cao ( $x + z = 48$ )

**M1:** $3x \square 5y$ – where $\square$ is any inequality or equals (allow $5x \geq 3y$ for this mark)

**M1:** $\frac{2}{5}(x + y + z) \square z$ oe – where $\square$ is any inequality or equals

**M1:** $\frac{x}{60} + \frac{y}{45} + \frac{z}{35} \square 1$ oe – where $\square$ is any inequality or equals

**A1:** Any two of the three inequalities in *x*, *y* and *z* (or *x* and *y* only) stated correctly

**M1:** Eliminating *z* from the objective and at least one constraint using $x + z = 48$

**A1:** Any two of the four correct (objective and three constraints) in *x* and *y* only

**A1:** cao (all four parts but do not penalise lack of 'maximise' for a second time)

**4.**

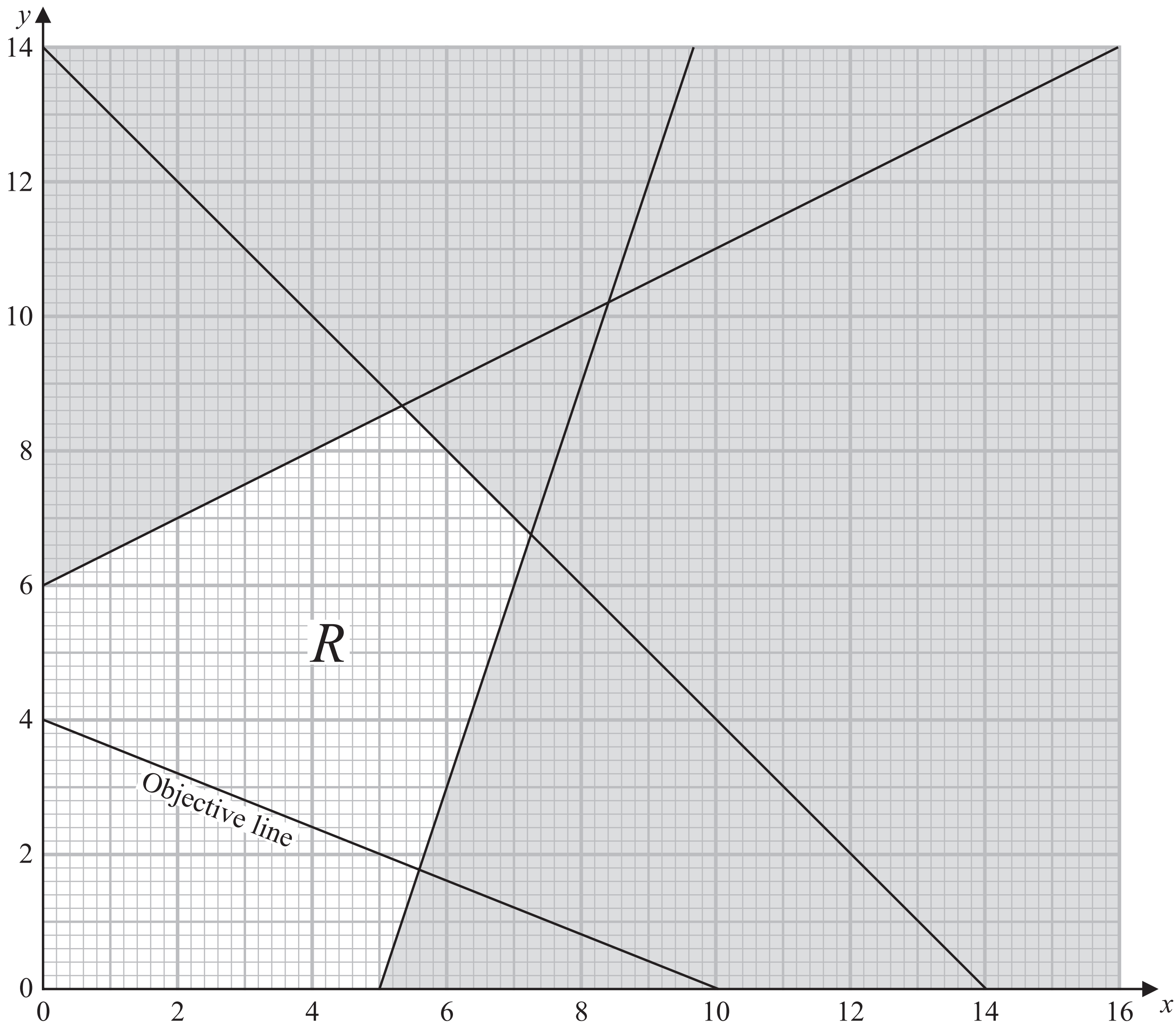


**Figure 3**

Figure 3 shows the constraints of a maximisation linear programming problem in $x$ and $y$, where $x \geqslant 0$ and $y \geqslant 0$. The unshaded area, including its boundaries, forms the feasible region, $R$. An objective line has been drawn and labelled on the graph.

(a) List the constraints as simplified inequalities with integer coefficients.

**(3)**

The optimal value of the objective function is 216

(b) (i) Calculate the exact coordinates of the optimal vertex.

(ii) Hence derive the objective function.

**(5)**

Given that $x$ represents the number of small flower pots and $y$ represents the number of large flower pots supplied to a customer,

(c) deduce the optimal solution to the problem.

**(1)**

**(Total for Question 4 is 9 marks)**

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**TOTAL FOR DECISION MATHEMATICS 1 IS 40 MARKS**

**END**

**4.**

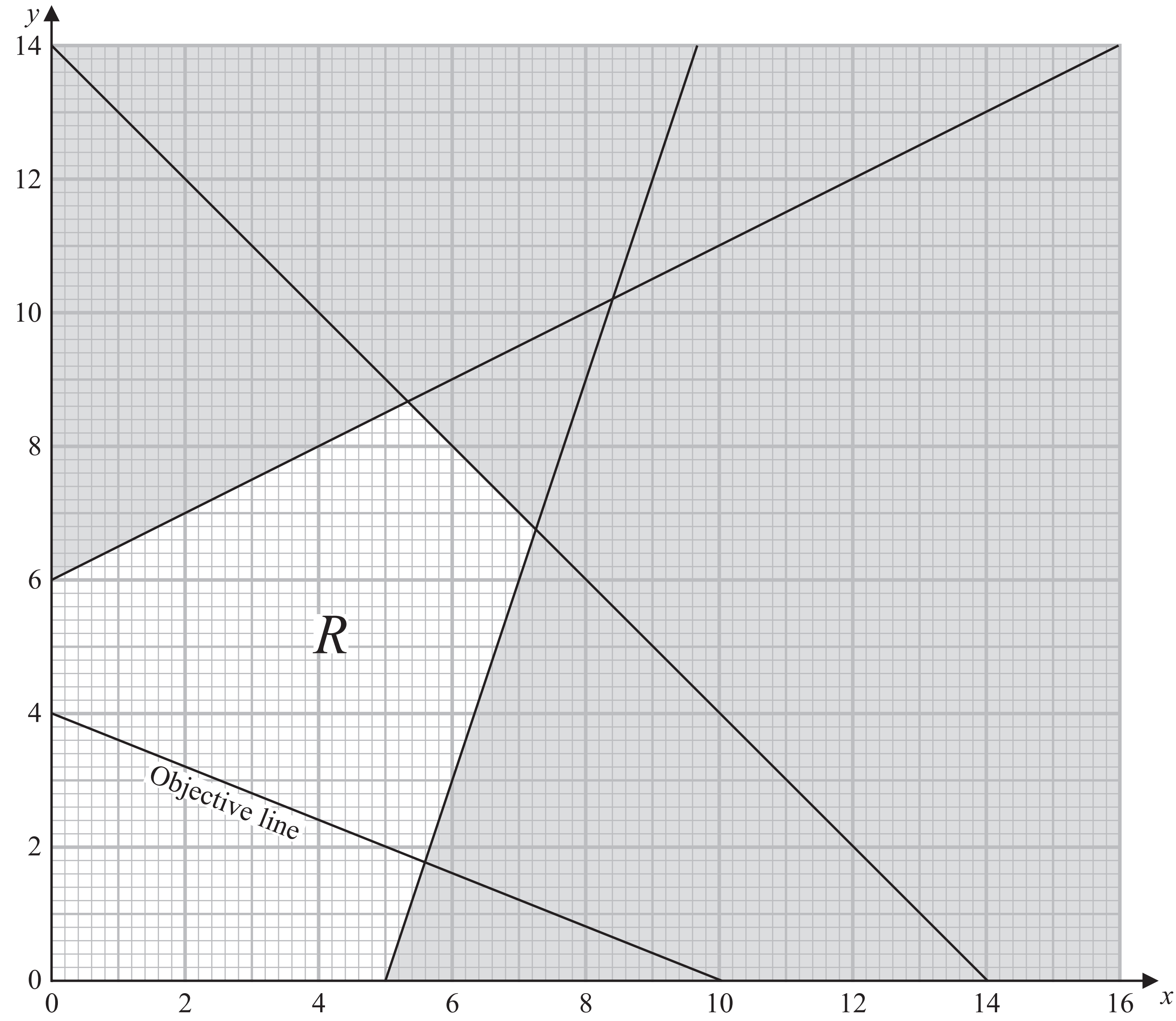


**Figure 3**

| Qu | Scheme | Marks | AOs |
|---|---|---|---|
| **4(a)** | $x+y\leqslant 14$<br>$2y-x\leqslant 12$<br>$3x-y\leqslant 15$<br>$(x\geqslant 0, y\geqslant 0)$ | M1<br><br>A1<br>A1 | 3.3<br><br>1.1b<br>2.5 |
| | | **(3)** | |
| **(b)(i)**<br><br><br>**(ii)** | Attempts to solve two equations to find optimal vertex<br>$\left(\frac{16}{3},\frac{26}{3}\right)$<br><br>$P=k(4x+10y)$<br><br>$216=k\left(4\times\frac{16}{3}+10\times\frac{26}{3}\right)$<br><br>$(P=)8x+20y$ | M1<br><br>A1<br><br>M1<br><br>ddM1<br><br>A1 | 3.4<br><br>1.1b<br><br>3.1a<br><br>3.4<br><br>2.2a |
| | | **(5)** | |
| **(c)** | 6 small (flower pots) and 8 large (flower pots) | B1 | 3.2a |
| | | **(1)** | |
| | | | **(9 marks)** |

**Notes for Question 4**

**a1M1:** One correct non-trivial inequality in any form e.g. $x-2y+12\geqslant 0.$ Condone strict inequality. Must be simplified to three terms only but coefficients do not need to be integers
**a1A1:** Two correct non-trivial inequalities in any form e.g. $x-2y+12\geqslant 0.$ Condone strict inequalities. Must be simplified to three terms only but coefficients do not need to be integers
**a2A1:** All three non-trivial inequalities correct with three terms and integer coefficients

**bi1M1:** Attempt to solve their $x+y=14$ and $2y-x=12$ (so their line with negative gradient and their line that passes through (0, 6)) simultaneously with at least one equation correct – the correct answer with no working implies this mark
**bi1A1:** cao $\left(\frac{16}{3},\frac{26}{3}\right)$ or $\left(5\frac{1}{3},8\frac{2}{3}\right)$ - must be exact (allow $x = \ldots, y = \ldots$) and clearly stated as the optimal vertex if more than one vertex of the FR found
**bii1M1:** Expression comprising of a constant (unknown) multiple/factor of $2x+5y$
e.g. $k(4x+10y)$ - M0 if assuming the objective is $4x + 10y$ or if no $k$ (or equivalent letter)
**bii2ddM1:** Dependent on both previous M marks. Forming an equation with the expression $k(4x+10y)$ (or any multiple/factor of this), the 216 and their optimal vertex
**bii1A1:** cao – accept $8x + 20y$ or this expression equal to any letter but not for e.g. $8x + 20y = 0$ or 216

**c1B1:** 6 small and 8 large – not for (6, 8) or $x = 6$, $y = 8$ – must be in context