Mark Scheme (Results)

Summer 2021

Pearson Edexcel International GCSE
In Mathematics B (4MB1)
Paper 02

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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.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

- **Types of mark**
  - M marks: method marks
  - A marks: accuracy marks
  - B marks: unconditional accuracy marks (independent of M marks)
- **Abbreviations**
  - cao – correct answer only
  - ft – follow through
  - isw – ignore subsequent working
  - SC - special case
  - oe – or equivalent (and appropriate)
  - dep – dependent
  - indep – independent
  - awrt – answer which rounds to
  - eeoo – each error or omission
- **No working**

  If no working is shown then correct answers normally score full marks
  If no working is shown then incorrect (even though nearly correct) answers score no marks.

- **With working**

  If the final answer is wrong always check the working in the body of the script (and on any diagrams), and award any marks appropriate from the mark scheme.

  If it is clear from the working that the “correct” answer has been obtained from incorrect working, award 0 marks.

  If a candidate misreads a number from the question. Eg. Uses 252 instead of 255; method marks may be awarded provided the question has not been simplified. Examiners should send any instance of a suspected misread to review.

  If there is a choice of methods shown, then award the lowest mark, unless the subsequent working makes clear the method that has been used.

  If there is no answer achieved then check the working for any marks appropriate from the mark scheme.

- **Ignoring subsequent work**

  It is appropriate to ignore subsequent work when the additional work does not change the answer in a way that is inappropriate for the question: eg. Incorrect cancelling of a fraction that would otherwise be correct.

  It is not appropriate to ignore subsequent work when the additional work essentially makes the answer incorrect eg algebra.

  Transcription errors occur when candidates present a correct answer in working, and write it incorrectly on the answer line; mark the correct answer.

- **Parts of questions**

  Unless allowed by the mark scheme, the marks allocated to one part of the question CANNOT be awarded to another.

Summary of changes from Provisional Mark Scheme

Question Number	Summary of change
10b	**Alternative methods using intersecting secants for 10(b) leading to awrt 29 (very common). Identical marking structure but slightly different at the end when working out the area of triangle *ABF*.** **<u>Method 1</u>** **M1 A1 – as per Method I for getting to either *BD* = 6.8 or *FB* = 9.8** $\frac{\sin(FAB)}{"9.8"} = \frac{\sin(18+"39")}{4.9+3.5} \Rightarrow FAB = 78.08334293...$ $AFB = 180 - FAB - (18+"39") = 44.91665707...$ **M1 for angle *AFB*.** $A = \frac{1}{2}("9.8")(3.5+4.9)\sin("44.9")$ **M1 (dependent on both previous M marks) for complete method for finding the required area of triangle *ABF*.** $= 29.062148...$ **A1 for 29 or better** **<u>Method 2</u>** **M1 A1 – as per Method I for getting to either *BD* = 6.8 or *FB* = 9.8** $\frac{\sin(FAB)}{"9.8"} = \frac{\sin(18+"39")}{4.9+3.5} \Rightarrow FAB = 78.08334293...$ $AFB = 180 - FAB - (18+"39") = 44.91665707...$ **M1 for angle *AFB*.** $\frac{AB}{\sin AFB} = \frac{4.9+3.5}{\sin(18+"39")} \Rightarrow AB = 7.071967199...$ $A = \frac{1}{2}(AB)(3.5+4.9)\sin(FAB)$ or $A = \frac{1}{2}(AB)("9.8")\sin(18+"39")$ **M1 (dependent on both previous M marks) for complete method for finding the required area of triangle *ABF*.** $= 29.062148...$ **A1 for 29 or better**

	Alternative method for finding *AB* Like Method II Case 2 (finding *AB*) $\dfrac{\sin FAD}{3} = \dfrac{\sin(180-51)}{3.5+4.9}$ **M1** for setting up an eqn for angle *FAD*. (*FAD* = 16.1141623…) $\dfrac{AB}{\sin(51-FAD)} = \dfrac{3.5+4.9}{\sin(18+"39")}$ **M1** (dep) for setting up an equation for *AB*. *AB* = 5.7284975… **A1** for *AB* = 5.7 or better. Area = $\frac{1}{2}(3.5+4.9)(AB)\sin((180-108)+FAD)$ **M1** (dep on both previous Ms) for a correct method for finding the area of triangle *ABF*. Area = 24.0466585… **A1** for 24 or better.

Question	Working	Answer	Mark	Notes
1(a)		56170	1	B1
(b)	$1.368\times10^9 - 2.144\times10^7$ or 1346560000			M1 for evidence of the correct subtraction (so M0 for $2.144\times10^7 - 1.368\times10^9$ unless recovered later) or for a correct answer (to at least 3 significant figures) in non-standard form (e.g., 1346560000, 13.4656×10^8, 1350000000, etc.). The correct answer implies this mark
		1.34656×10^9	2	A1 allow answers which round to (awrt) 1.35×10^9
(c)	$\frac{5.617\times10^4}{2.166\times10^6}$ or 0.02593…			M1 for evidence of division of the correct two values (condone for M1 $\frac{2.166\times10^6}{5.617\times10^4}$) or a correct answer (to at least 3 significant figures) in non-standard form (e.g., 0.0259, 0.259×10^{-1}, 0.0259326, etc.) or for 2.59×10^{-n} where *n* is a positive integer
		2.59×10^{-2}	2	A1 for awrt 2.59×10^{-2} (e.g., 2.593259464×10^{-2} scores both marks, but M1A0 for 2.6×10^{-2} if more accurate answer not seen)
				Total 5 marks

2	$\frac{dy}{dx} = 3x^2 + 2ax + b$			M1 differentiating with at least 1 non-zero term correct.
	$3\times(2)^2 + 2a\times(2) + b = 9.8$ or $4a + b = -2.2$ **oe**			M1 dep on 1st M mark substitute in $x = 2$ into their $\frac{dy}{dx}$ and equating to 9.8 (allow any equivalent, e.g., $12 + 4a + b = 9.8$)
	$6 = 8 + 4a + 2b + 8$ or $2a + b = -5$ **oe**			M1 substitute in $x = 2$ and $y = 6$ into $y = x^3 + ax^2 + bx + 8$
	$2a = 5 - 2.2$ or $b = -10 + 2.2$			M1 dep on 2nd and 3rd M marks. Correct method (but allow one sign slip) for eliminating a or b from their simultaneous equations <u>Elimination method</u> (oe with coefficients of either a or b the same) e.g. $\begin{matrix} 2a + b = -5 \\ 4a + b = -2.2 \end{matrix} \Rightarrow (4a + b) - (2a + b) = -2.2 - (-5)$ (so for this set of equations the candidate must be subtracting the two equations) or e.g. $\begin{matrix} 4a + 2b = -10 \\ 4a + b = -2.2 \end{matrix} \Rightarrow (4a + 2b) - (4a + b) = -10 - (-2.2)$ <u>Substitution method</u> e.g. $b = -5 - 2a \Rightarrow 4a + (-5 - 2a) = -2.2$ or e.g. $a = \frac{1}{2}(-5 - b) \Rightarrow 4\left(\frac{-5 - b}{2}\right) + b = -2.2$ (or equivalent) This mark can be implied by either a correct value for a or for b. Allow by use of matrices.
		$a = 1.4$ $b = -7.8$	5	A1(oe e.g. $a = \frac{7}{5}, b = -\frac{39}{5}$) dependent on all four M marks **Correct answers with no working scores no marks**
				Total 5 marks

3 (a) (i)	$4x^2+18x+24=160$ oe			M1 adding **all** the subsets together and equating to 160. Need not be simplified (but if all 7 terms not shown explicitly then need to see at least $4x^2+18x+24=160$). Must see the 160 e.g. $4x^2+18x+24-160=0$ For reference (if fully un-simplified): $8x+\left(\frac{5}{2}x+7\right)+\left(x^2+9\right)+\left(4x-1\right)+\left(\frac{3}{2}x+8\right)+\left(2x^2+4\right)$ $+\left(x^2+2x-3\right)=160$
		$2x^2+9x-68=0$		A1 simplifying to the **given** 3 term quadratic (at least one intermediate line from initial line of working to given answer) – must include = 0 (allow $0=2x^2+9x-68$) so all terms on one side equal to zero
(ii)	$(2x+17)(x-4)[=0]$ oe			M1 correct method for solving the **given** 3 term quadratic – either by formula, completing the square or factorising. By factorising: brackets must expand to give 2 out of 3 correct terms By formula: correct substitution into fully correct formula (allow 1 sign error) By completing the square: must see $2\left(x+\frac{9}{4}\right)^2 \pm ...[=0]$ Either correct value of x $\left(x=-\frac{17}{2}\text{ or }x=4\right)$ can imply this mark **NB anything appearing in square brackets [..] is not required**
		$x=4$	4	A1 (A0 if $x=-\frac{17}{2}$ given as a final answer too)
(b)	$\dfrac{\frac{3\times"4"}{2}+8}{3\times"4"^2+7.5\times"4"+8}$ oe			M1 for either $\dfrac{\frac{3}{2}x+8}{\left(\frac{3}{2}x+8\right)+\left(4x-1\right)+\left(2x^2+4\right)+\left(x^2+2x-3\right)}$ oe or for an equivalent expression with their value of x (which must be a positive integer) – if value for x substituted then numerator must be less than 160
		$\frac{7}{43}$	2	A1 oe exact value (A0 if non-exact answer e.g., 0.163 given and exact answer not seen) – award M1A0 if 7/43 seen in working (but not given as final answer)
				Total 6 marks

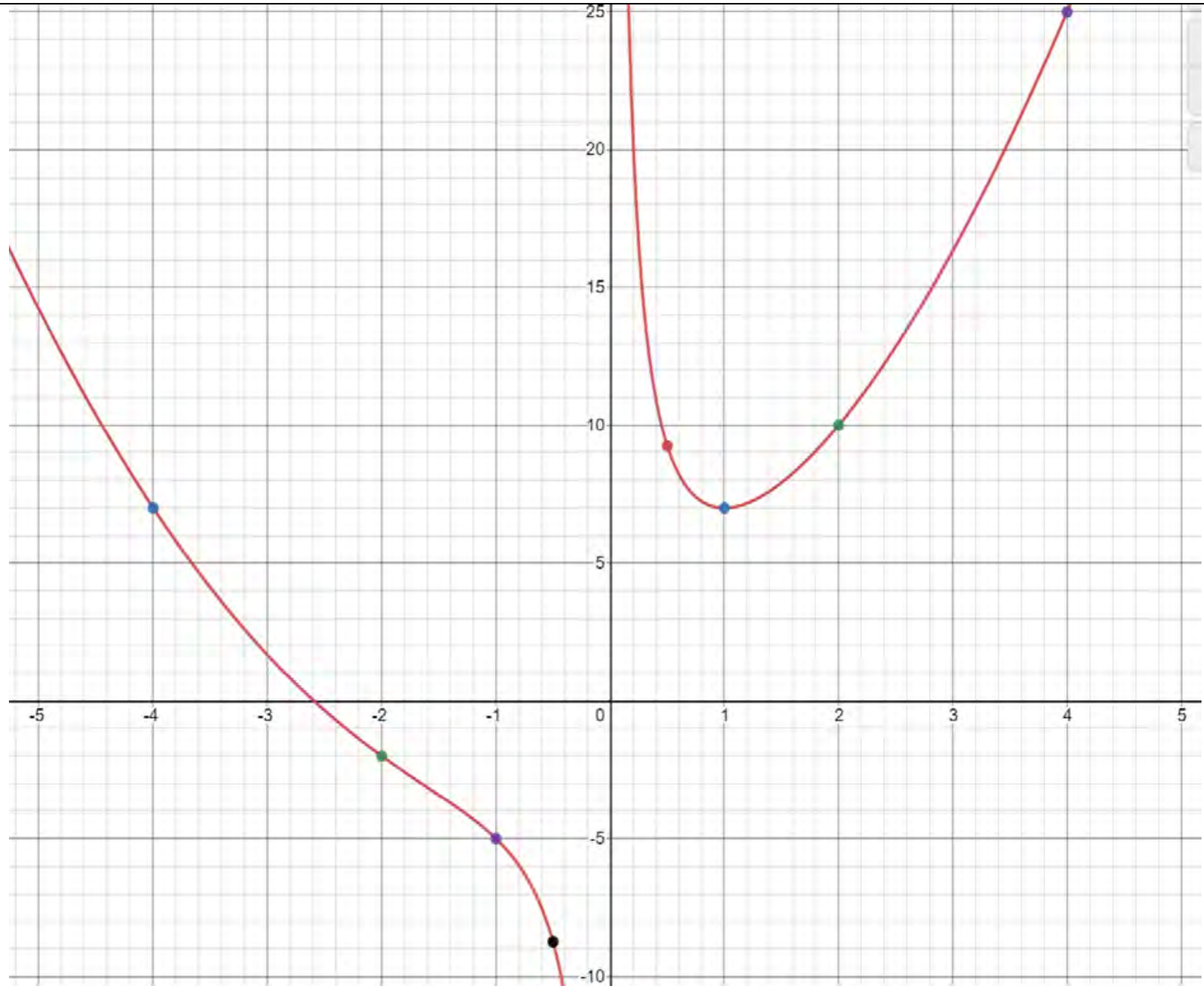
4(a)		$-2\mathbf{a}+5\mathbf{b}$	1	B1 oe (e.g., $5\mathbf{b}-2\mathbf{a}$) allow vectors not underlined throughout the question
(b) (i)	$\overrightarrow{OC}=5\mathbf{b}+6\mathbf{a}+5\mathbf{b}$ or $\overrightarrow{OC}=6\mathbf{a}+10\mathbf{b}$			M1 for finding either $\overrightarrow{OC}$, possibly seen as part of another vector e.g., $\overrightarrow{OP}$ where for reference: $\overrightarrow{OP}=\frac{1}{5}(5\mathbf{b}+6\mathbf{a}+5\mathbf{b})$ **or** for $\overrightarrow{AC}=-2\mathbf{a}+5\mathbf{b}+6\mathbf{a}+5\mathbf{b}\,(=4\mathbf{a}+10\mathbf{b})$
	$\overrightarrow{AP}=-2\mathbf{a}+\frac{1}{5}(\text{"}6\mathbf{a}+10\mathbf{b}\text{"})$ or $\overrightarrow{PB}=-\frac{1}{5}(\text{"}6\mathbf{a}+10\mathbf{b}\text{"})+5\mathbf{b}$ oe			M1 for finding either $\overrightarrow{AP}$ or $\overrightarrow{PB}$ (need not be simplified) oe (e.g., $\overrightarrow{PA}$ or $\overrightarrow{BP}$) e.g., $\overrightarrow{AP}=\overrightarrow{AC}+\overrightarrow{CP}=-2\mathbf{a}+5\mathbf{b}+6\mathbf{a}+5\mathbf{b}-4\left(\frac{6}{5}\mathbf{a}+2\mathbf{b}\right)\left[=-\frac{4}{5}\mathbf{a}+2\mathbf{b}\right]$ $\overrightarrow{PB}=\overrightarrow{PO}+\overrightarrow{OA}+\overrightarrow{AC}+\overrightarrow{CB}=-\left(\frac{6}{5}\mathbf{a}+2\mathbf{b}\right)+2\mathbf{a}+4\mathbf{a}+10\mathbf{b}-6\mathbf{a}-5\mathbf{b}$ $\left[=-\frac{6}{5}\mathbf{a}+3\mathbf{b}\right]$ **or** for $\overrightarrow{AP}=\left(\frac{1}{5}\overrightarrow{AC}+\frac{4}{5}\overrightarrow{AO}\right)=\frac{1}{5}(\text{"}4\mathbf{a}+10\mathbf{b}\text{"})+\frac{4}{5}(-2\mathbf{a})$
	$\overrightarrow{AP}=-\frac{4}{5}\mathbf{a}+2\mathbf{b}=\frac{2}{5}\overrightarrow{AB}$ or $\overrightarrow{PB}=-\frac{6}{5}\mathbf{a}+3\mathbf{b}=\frac{3}{5}\overrightarrow{AB}$ or $\overrightarrow{AP}=-\frac{4}{5}\mathbf{a}+2\mathbf{b}=\frac{2}{3}\overrightarrow{PB}$ oe			A1cso showing multiple using any two of *AP*, *BP*, *AB* (or *PA*, *PB*, *BA* or a mixture of the two e.g., *AP* with *BA*) oe, e.g., $\overrightarrow{AB}=\frac{5}{2}\overrightarrow{AP}$ or $\overrightarrow{AP}=\frac{2}{3}\overrightarrow{PB}$ or $\overrightarrow{AB}=\frac{5}{3}\overrightarrow{BP}$ or $\overrightarrow{AB}=-\frac{5}{3}\overrightarrow{PB}$ or $\overrightarrow{AP}=-\frac{2}{3}\overrightarrow{BP}$ or $\overrightarrow{AB}=-\frac{5}{2}\overrightarrow{PA}$ etc.
		AP and *AB* are parallel with the point *A* in common on each line $\therefore$ collinear		A1 for a comment that one is a multiple of the other (oe e.g. that they are parallel) and that there is a common point on each of the two lines (so if $\overrightarrow{AB},\overrightarrow{AP}$ used then must mention that *A* is the common point, if $\overrightarrow{PB},\overrightarrow{AB}$ used then must mention that *B* is the common point, etc.)
(b) (ii)		2 : 3	5	B1 oe Accept $m=2$ and $n=3$ oe (provided that *m* and *n* are in the ratio 2 : 3 e.g., 1 : 1.5 , 4 : 6 , or stating $m=1$ $n=1.5$, etc.)
				Total 6 marks

5	$2x^2=11-3(4x-5)^2$ **or** $2\left(\frac{5+y}{4}\right)^2=11-3y^2$			M1 for correct substitution of the linear equation $4x-y=5$ into the quadratic equation $2x^2=11-3y^2$ to form an (unsimplified) quadratic equation in either *x* or *y*. This mark can be implied by the second M mark.
	$2x^2=11-3(16x^2-40x+25)$ or $2\left(\frac{25+10y+y^2}{16}\right)=11-3y^2$			M1 for correct expansion of either their $(4x-5)^2$ or $\left(\frac{5+y}{4}\right)^2$ in correct equation (not dependent on previous M mark)
	$25x^2-60x+32[=0]$ or $25y^2+10y-63[=0]$			A1 for a correct 3 term quadratic in either *x* or *y* dep on both previous M marks (oe e.g., $50x^2-120x+64[=0]$, $50y^2+20y-126[=0]$, etc. look out for all signs reversed)
	$(5x-4)(5x-8)[=0]$ or $(5y-7)(5y-9)[=0]$			M1 correct method for solving their 3-term quadratic – either by formula, completing the square or factorising. By factorising: brackets must expand to give 2 out of 3 correct terms By formula: correct substitution into fully correct formula (allow 1 sign error). By completing the square: must see e.g., $25\left(x-\frac{6}{5}\right)^2\pm...[=0]$
	$4\times"0.8"-y=5$ or $4\times1.6-y=5$ or $4x-(-1.8)=5$ or $4x-1.4=5$ oe			M1indep substituting their two *x* values into either equation leading to values for *y* or vice versa (not dependent on any previous M marks) – this mark can be implied by correct values (if no working seen). This mark can be implied by both correct pairs of values.
		(0.8, –1.8) (1.6, 1.4)	6	A1 for both correct pairs of *x* and *y* values (oe e.g., $x=\frac{4}{5}, y=-\frac{9}{5}$ and $x=\frac{8}{5}, y=\frac{7}{5}$) This mark is dependent on all previous marks. **Correct answer(s) with no working scores no marks**
				Total 6 marks

Question 6

For reference: $y = x^2 + 2x + \dfrac{4}{x}$ and

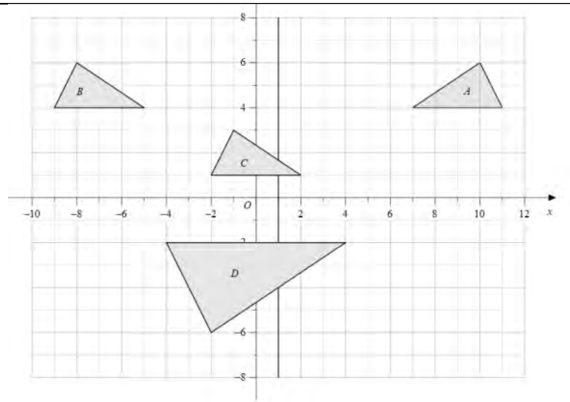
x	-4	-2	-1	-0.5	0.5	1	2	4
y	**7**	**−2**	**−5**	-8.75	**9.25**	7	10	25



6(a)		7, −2, −5, 9.25	2	B2 −1 each error or omission (to a maximum of 2 marks)
(b)		Points plotted	1	B1ft follow through their 4 values from (a) (allow +/− one small square accuracy in plotting on the given axes in the answer book)
(c)	Points joined with smooth curve except for $x = -0.5$ and 0.5 with minimum at (1,7)		1	B1 for joining their eight points (4 points on the positive side of the x-axis joined and the other 4 points on the negative side of the x-axis joined) with a smooth curve (B0 if line segments between points) B0 if points at 0.5 and −0.5 connected Condone no curve between −0.5 and 0.5 – if curve drawn in this interval, then as $x \to 0^+, y \to +\infty$ and $x \to 0^-, y \to -\infty$
(d)		−2.6	1	B1 ft where their graph crosses the x-axis, but their value of x must be to at least one decimal place and, in the interval, $-4 \le x \le -2$ (For reference: $x = -2.594313...$ - if value of x clearly comes from solving on a calculator then B0). If curve crosses the x-axis more than once, then B0
(e)	Line drawn through (0, 1.5) with positive gradient			M1 for straight line passing through (0, 1.5) with positive gradient – line need not intersect their curve (and allow this mark if curve not attempted)
		−1.2, 1.1 and 3.1	3	A2, −1 for each error/omission (up to a maximum of 2 marks). Must have a drawn a line and curve. The values given to at least one decimal place and must lie in the intervals $-1.4 \le x \le -1$, $1 \le x \le 1.4$ and $2.8 \le x \le 3.2$ **and must follow from their graph**. (For reference: $x = -1.174833...$, $1.111418...$, $3.063415...$ - if values of x clearly come from solving on calculator, then A0)
				Total 8 marks

7(a)	$0.2P + 0.8P\times\ldots$ or $\frac{25}{80}\times 80\%[=25\%]$			M1 P may be any value e.g., $20[\%] + 80[\%]\times\ldots$
	$\left(0.2P + 0.8P\times\frac{55000}{80000}\right)\times 100 = 75\%$ or $100-\frac{25}{80}\times 80\% = 75\%$		2	A1cso allow $\left(20[\%] + 80[\%]\times\frac{55000}{80000}\right) = 75[\%]$ oe e.g., $\left(0.2+0.8\times\frac{55000}{80000}\right) = 0.75$ which is equivalent to 75% (if working in decimals/fractions then must relate to equivalent percentage). Allow equivalent fractions e.g., $\frac{11}{16}$ for $\frac{55000}{80000}$.
(b)	$0.048\times 2000[\times 0.75]$			M1 no need for the 0.75 For M1 allow 1.048×2000
		\$72	2	A1 (\$ sign not required)
(c)	$0.25\times 2000[=500]$			M1 for calculating Graham's share in dollars (implied by use of 500 in an equation to find *x*)
	$"500"\times 0.76[=380]$			M1 for converting Graham's share in dollars into pounds or for 2000×0.76 (converting the \$2000 into pounds)
	$\frac{"500"}{1.2}x\left[=\frac{1250}{3}x\right]$			M1 for converting Graham's share in dollars into euros or for converting the \$2000 into euros $\frac{2000}{1.2}y\left[=\frac{5000}{3}y\right]$ for some value *y*
	$x = ("380"+20)\times\frac{1.2}{"500"}$			M1 for a complete, correct method for calculating *x* (in any equivalent form, e.g., $\frac{"500"}{1.2}x = "380"+20$) – the correct answer can imply this mark
		0.96	5	A1
				Total 9 marks

8(a)		$155 < h \leqslant 160$	1	B1 (allow intention of this interval e.g. give benefit of doubt if interval is given as $155 < h < 160$)
(b)	$(145\times5)+(152.5\times8)+$ $(157.5\times11)+(162.5\times6)+$ $(167.5\times12)+(180\times3)$			M2 for at least 5 (of the 6) correct products added together **or** M1 for the use of **any** value in interval (including end points) for at least 4 (of the 6) products added together
	$\frac{\text{"7202.5"}}{45}$			M1dep on at least 1 of the previous M marks for dividing by 45
		160.1	4	A1 awrt 160.1 (for reference: 160.055555…) allow exact e.g., $\frac{2881}{18}$
(c)		$\frac{2}{3},\frac{5}{9},\frac{2}{5}$	1	B1 all 3 correct (must be using fractions but allow exact equivalents, e.g., $\frac{4}{6}$ for $\frac{2}{3}$ on first branch)
(d)	$\frac{21}{45}\times\frac{1}{3}\times\frac{4}{9}$ or $\frac{21}{45}\times\text{"}\frac{2}{3}\text{"}\times\frac{3}{5}$			M1 for calculating the probability that a person has a height of more than 160 cm and fair hair with either eye colour
	$\left(\frac{21}{45}\times\frac{1}{3}\times\frac{4}{9}\right)+\left(\frac{21}{45}\times\text{"}\frac{2}{3}\text{"}\times\frac{3}{5}\right)$			M1 for completely correct method (with their probability (between 0 and 1) for not blue eye colour from part (c)) or M2 for using the complement e.g. $\frac{21}{45}\times\left(1-\left(\frac{1}{3}\times\text{"}\frac{5}{9}\text{"}\right)-\left(\frac{2}{3}\times\text{"}\frac{2}{5}\text{"}\right)\right)$
		0.2558….	3	A1 0.26 or better (0.255802...) or exact (e.g., $\frac{518}{2025}$) SC for 1 mark only for $\left(\frac{1}{3}\times\frac{4}{9}\right)+\left(\frac{2}{3}\times\frac{3}{5}\right)=\frac{74}{135}$ or for $1-\left(\frac{1}{3}\times\frac{5}{9}\right)-\left(\frac{2}{3}\times\frac{2}{5}\right)=\frac{74}{135}$ or 0.55 or better (0.548148…) for not including the height of more than 160 cm – also allow this SC mark for $k\left(\frac{74}{135}\right)$ where $0 < k \leq 1$
				Total 9 marks

9				
(a)		$x = 1$ drawn		M1 this mark can be implied by correct triangle *B* or for a completely correct reflection in the line $y = 1$, or for two of the three vertices correct
		Triangle *B*	2	A1 (vertices at $(-9,4),(-5,4),(-8,6)$)
(b)	$(-2,1),(-1,3),(2,1)$			B1ft moving their triangle *B* 7 units to the right.
		Triangle *C*	2	B1ft moving their triangle *B* 3 units down (if correct vertices of triangle *C* are at $(-2,1),(2,1),(-1,3)$)
(c)	$\begin{pmatrix}2 & 0\\ 0 & -2\end{pmatrix}$"$\begin{pmatrix}-2 & 2 & -1\\ 1 & 1 & 3\end{pmatrix}$"			M1 coordinates in second matrix may be in any order. Follow through the coordinates of their triangle *C*
	$\begin{pmatrix}-4 & 4 & -2\\ -2 & -2 & -6\end{pmatrix}$			A1 ft for correct working out product of their $\begin{pmatrix}2 & 0\\ 0 & -2\end{pmatrix}$"$\begin{pmatrix}-2 & 2 & -1\\ 1 & 1 & 3\end{pmatrix}$"
		Triangle *D*	3	A1 cao (vertices at $(-4,-2),(-2,-6),(4,-2)$) – award full marks if drawn correctly
(d)	Enlargement SF – 2 Centre (6, 2)		3	M1 (following marks cannot be awarded without ‘enlargement’) condone ‘enlarge/enlarged’ – if not a **single** transformation then M0 A1 (must see either ‘SF’, ‘scale factor’ or ‘factor’) A1 (word ‘centre’ not required e.g. ‘about (6, 2)’ is sufficient)
				Total 10 marks

10(a)	$\angle DAB = 180 - 108 = 72°$ Opposite angles of a cyclic quadrilateral are supplementary (or sum to 180°)			**Angles throughout part (a) may be shown on Figure 2.** **Reasoning only counts towards the final B mark (so therefore are independent of the first four marks in this part)** M1 for calculating angle *DAB*
	$\angle AOB = 102°$ angle at the centre is twice (oe) the angle at the circumference			M1 for calculating angle *AOB*
	$\angle OBA$ (or $\angle OAB$) $= \dfrac{180 - "102"}{2} \left[= 39°\right]$ Angle sum of a triangle is 180° **and** base angles of an isosceles triangle are equal (*OA* = *OB*)			M1 dep for correct method for calculating either angle *OBA* or *OAB* – dependent on previous M mark
	$\angle OBD = 180 - 51 - 72 - 39 = 18°$ Angle sum of a triangle is 180° **or** $\angle OBD = 360 - 51 - 33 - 258 = 18°$ Angle sum of a quadrilateral **and** angles at a point are 360°	shown		A1 (degree symbol not required) – dependent on all previous M marks (note that answer is given so sufficient working must be shown)
			5	B1 for 3 (of the 5 or possibly 6) correct reasons – must include underlined (or the exact mathematical equivalent) words. Allow angles for angle, etc. and allow equivalent symbols, e.g., ∡ for angle, Δ for triangle, etc.

Alternative 1 for 10(a)				**Angles throughout part (a) may be shown on Figure 2. Reasons only count towards the final B mark (so are independent of the first four marks in this part)**
	$\angle DAB = 180 - 108 = 72°$ Opposite angles of a cyclic quadrilateral are supplementary (or sum to 180°)			M1 for calculating angle *DAB*
	$\angle DOB = "72" \times 2 \left[= 144° \right]$ angle at the centre is twice (oe) the angle at the circumference			M1 dep for correct method for finding $\angle DOB$ - dependent on previous M mark
	$\angle OBD = \dfrac{180 - "144"}{2}$ Angle sum of a triangle is 180° **and** base angles of an isosceles triangle are equal (*OB* = *OD*)			M1 for correct method for finding $\angle OBD$ - dependent on both previous M marks
	Or $\angle OBD = \dfrac{180 - 144}{2} = 18°$	shown		A1 (degree symbol not required) – dependent on all previous M marks (note that answer is given so sufficient working must be shown)
				B1 for 3 (of the 4) correct reasons – must include underlined (or the exact mathematical equivalent) words. Allow angles for angle, etc. and allow equivalent symbols, e.g., $\measuredangle$ for angle, Δ for triangle, etc.

Alternative 2 for 10(a)				**Angles throughout part (a) may be shown on Figure 2. Reasons only count towards the final B mark (so are independent of the first four marks in this part)**
	$\angle AOB = 102°$ angle at the centre is twice (oe) the angle at the circumference			M1 for calculating angle *AOB*
	$\angle OBA$ (or $\angle OAB$) $= \dfrac{180 - "102"}{2} [= 39°]$ Angle sum of a triangle is 180° **and** base angles of an isosceles triangle are equal ($OA = OB$)			M1 dep for correct method for calculating either angle *OBA* or *OAB* – dependent on previous M mark
	$\angle ACB = 51$ (angles in the same segment are equal) $\Rightarrow \angle ACD = 57$ and therefore $\angle DBA = 57$ (angles in the same segment are equal)			M1 for calculating angle *DBA*
	$\angle OBD = 57 - \left(\dfrac{180-102}{2}\right) = 57 - 39 = 18°$	shown		A1 (degree symbol not required) – dependent on all previous M marks (note that answer is given so sufficient working must be shown)
				B1 for 3 (of the 5) correct reasons – must include underlined (or the exact mathematical equivalent) words. Allow angles for angle, etc. and allow equivalent symbols, e.g., $\measuredangle$ for angle, Δ for triangle, etc.

Method I: Using intersecting secants to find *FB* or *BD*				**Note that lengths given in the question are not exact and so therefore there are a number of valid areas for triangle *ABF*** **There are many ways of finding the required area – in essence for Method I the first two marks are for calculating the length of either *FB* or *BD*, the third mark is for setting up a correct equation for either *AB* or *AD* and the final two marks are for a complete, correct method for calculating the area of triangle *ABF*** **NB an answer which rounds to 23 or 24 with no obvious incorrect working scores full marks. Note that using $\frac{1}{2}\times 8.4\times AB$ (therefore assuming angle *FAB* is 90°) which for reference gives 23.3375… can score M1A1M1M0A0 maximum**
Case 1: Finding length *AB*				
(b)	$FE\times FA = FD\times FB$ oe or $3.5\times 8.4 = 3.0\times FB$ oe			M1 correct method for finding *FB* or *BD* e.g. $3.5\times 8.4 = 3.0\times(3+BD)$
	$FB = 9.8$			A1 or for $BD = 6.8$
	$\frac{AB}{\sin 51} = \frac{"9.8"-3}{\sin 72}$ (or AB = awrt 5.56)			M1 setting up correct sine rule formula to find length *AB* (For reference: *AB* = 5.556549424…)
	Area $= \frac{1}{2}\times "5.56"\times "9.8"\times \sin(18+"39")$			M1 dep (on both previous M marks) for the correct method for finding area of triangle *ABF*
		23	5	A1 (allow 23 or better from correct working) – For reference: 22.83456086… Note for last the two marks if using Heron's formula then M1 for Area = $\sqrt{s(s-8.4)(s-9.8)(s-AB)}$ where $s=\frac{1}{2}(8.4+9.8+AB)$ then A1 for the Area = awrt 23. For reference: 23.29849718…

Case 2: Finding length *AD* using a quadratic in *AD*				First two marks as in **Case 1**
	$AD^2-(6\cos129)AD-61.56=0$			M1 setting up a quadratic equation in *AD* from the cosine rule (For reference: *AD* = 6.182007686…)
	Area = Area of ΔABD + Area of ΔADF $=\frac{1}{2}\times AD\times"6.8"\times\sin(51)+\frac{1}{2}\times AD\times3\times\sin(180-51)$			M1 dep (on both M marks) for the correct method for finding the area of triangle *ABF*
		23 or 24		A1 (allow 23 or 24 or better) – For reference for the method above the area is 23.5411793… Note for the last two marks that there are a number of ways of calculating the area of triangle *ABD* e.g. Area *ABD* $=\frac{1}{2}\times AD\times AB\times\sin72$ with *AB* from either (i) $\frac{AB}{\sin51}=\frac{AD}{\sin57}$ or (ii) $\frac{AB}{\sin51}=\frac{BD}{\sin72}$ or (iii) $AB^2=AD^2+BD^2-2(AD)(BD)\cos51$ With Areas for reference (i) 24.046658… (ii) 23.541179… (iii) 23.7178995… **or** Area $ABD=\frac{1}{2}\times AB\times BD\times\sin(57)$ with *AB* as above giving for reference (i) 23.5411793… (ii) 23.0508726… (iii) 23.2222883…

Case 3: Finding length *AD* using sine rule				First two marks as in **Case 2**
	$\frac{AD}{\sin 57} = \frac{6.8}{\sin 72}$			M1 setting up an equation in AD from the sine rule (For reference: $AD = 5.996446861\ldots$)
	Area = Area of $\Delta ABD +$ Area of ΔADF $= \frac{1}{2}\times AD \times "6.8" \times \sin(51) + \frac{1}{2}\times AD \times 3 \times \sin(180-51)$			M1 dep (on both M marks) for the correct method for finding area of triangle *ABF*
		23		A1 (allow 23 or better) – For reference: 22.8345608… Note for the last two marks that there are a number of ways of calculating the area of triangle *ABD* e.g. Area *ABD* $= \frac{1}{2}\times AD \times AB \times \sin 72$ with *AB* from either (i) $\frac{AB}{\sin 51} = \frac{AD}{\sin 57}$ or (ii) $\frac{AB}{\sin 51} = \frac{BD}{\sin 72}$ or (iii) $AB^2 = AD^2 + BD^2 - 2(AD)(BD)\cos 51$ With all three areas being 22.8345608… **or** Area $ABD = \frac{1}{2}\times AB \times BD \times \sin(57)$ with *AB* as above giving with all areas again being 22.8345608…

Method II: Finding *BD* or *AB* using trigonometry				**In essence for Method II the first mark is for setting up a quadratic equation in *AD*, the second and third marks are for finding either the length *BD* or *AB* and the final two marks are for a complete, correct method for calculating the area of triangle *ABF***
Case 1: Finding *BD*				
	$8.4^2 = 3^2 + AD^2 - 2(3)(AD)\cos(180-51)$ $\Rightarrow AD^2 - (6\cos 129)AD - 61.56 = 0$			M1 for setting up a quadratic equation in *AD* (For reference: *AD* = 6.182007686…)
	$\dfrac{BD}{\sin 72} = \dfrac{AD}{\sin 57}$			M1 dep (on previous M mark) for setting up an equation for *BD* using sine rule
	$BD = 7.01$			A1 (7.01 or better) For reference: 7.010426881…
	$\text{Area} = \text{Area of } \Delta ABD + \text{Area of } \Delta ADF$ $= \frac{1}{2} \times AD \times \text{"}7.01\text{"} \times \sin(51) + \frac{1}{2} \times AD \times 3 \times \sin(129)$			M1 dep (on both previous M marks) for the correct method for finding the area of triangle *ABF*
		24		A1 (allow 24 or better from correct working) – For reference: 24.0466585…
Case 2: Finding *AB*				
	$8.4^2 = 3^2 + AD^2 - 2(3)(AD)\cos(180-51)$ $\Rightarrow AD^2 - (6\cos 129)AD - 61.56 = 0$			M1 for setting up a quadratic equation in *AD* (For reference: *AD* = 6.182007686…)
	$\dfrac{AB}{\sin 51} = \dfrac{AD}{\sin 57}$			M1 dep (on previous M mark) for setting up an equation for *AB* using sine rule
	$AB = 5.73$			A1 (5.73 or better) For reference: 5.728497566…
	$\text{Area} = \text{Area of } \Delta ABD + \text{Area of } \Delta ADF$ $= \frac{1}{2} \times AD \times \text{"}5.73\text{"} \times \sin(72) + \frac{1}{2} \times AD \times 3 \times \sin(129)$			M1 dep (on both previous M marks) for the correct method for finding the area of triangle *ABF*
		24		A1 (allow 24 or better from correct working) – For reference: 24.0466585…

Case 3: Finding *BD* and *AB*				
	$8.4^2 = 3^2 + AD^2 - 2(3)(AD)\cos(180-51)$ $\Rightarrow AD^2 - (6\cos 129)AD - 61.56 = 0$			M1 for setting up a quadratic equation in *AD* (For reference: *AD* = 6.182007686…)
	$\dfrac{BD}{\sin 72} = \dfrac{AD}{\sin 57}$ **or** $\dfrac{AB}{\sin 51} = \dfrac{AD}{\sin 57}$			M1 dep (on previous M mark) for setting up an equation for either *AB* or *BD* using sine rule
	BD = 7.01 **or** *AB* = 5.73			A1 (*AB* = 5.73 or better or *BD* = 7.01 or better) For reference: *AB* = 5.728497566… or *BD* = 7.010426881…
	Area = $\dfrac{1}{2}(AB)(3+BD)\sin(\text{"39"}+18)$			M1 for correct, complete method for finding the area of triangle *ABF* (or as two separate triangles, e.g., $\dfrac{1}{2}(3)(AD)\sin(180-51)+\dfrac{1}{2}(BD)(AB)\sin(\text{"39"}+18)$)
		24		A1 (allow 24 or better from correct working) – For reference: 24.0466585…
				Total 10 marks

11(a)	$AC = (AB =)\dfrac{4}{\cos 35}$			M1 for calculating AC or AB - note that use of cosine rule $AB^2 = AC^2 + 8^2 - 2(8)(AC)\cos 35$ with $AB = AC$ must simplify to $AC\cos 35 = 4$ or $AB\cos 35 = 4$ before awarding this mark – for reference: AC (or AB) = 4.883098355…
	$\perp$ height $h = 4\tan 35$			M1 implied by 3rd method mark. For reference: perpendicular height of triangle ABC is 2.800830153…
	Area Cross Section ABC $\frac{1}{2}(BC)h = \frac{1}{2}(8)(4\tan 35)$ **Or** $\frac{1}{2}(AC)(BC)\sin 35 = \frac{1}{2}\left(\frac{4}{\cos 35}\right)(8)\sin 35$ **Or** $\frac{1}{2}(AB)(BC)\sin 35 = \frac{1}{2}\left(\frac{4}{\cos 35}\right)(8)\sin 35$			M1 for correct method for finding the area of cross section ABC – may find AB or AC from the sine rule e.g., $\frac{AB(\text{or } AC)}{\sin 35} = \frac{8}{\sin 110}$ and then Area = $\frac{1}{2}(AC)(BC)\sin 35 = \frac{1}{2}(AB)(BC)\sin 35 = \frac{1}{2}\left(\frac{8\sin 35}{\sin 110}\right)(8)\sin 35$ or Area = $\frac{1}{2}(AB)(AC)\sin 110 = \frac{1}{2}\left(\frac{8\sin 35}{\sin 110}\right)\left(\frac{8\sin 35}{\sin 110}\right)\sin 110$ For reference: Area ABC = 11.203322061… Allow use of Heron's formula with $AC = AB = \frac{4}{\cos 35}$ and $BC = 8$ giving $s = \frac{1}{2}\left(8 + 2\left(\frac{4}{\cos 35}\right)\right) = 8.883098...$ **and** Area $ABC = \sqrt{s(s-8)\left(s - \frac{4}{\cos 35}\right)\left(s - \frac{4}{\cos 35}\right)}$
	Surface area = $8(24) + 2(\text{Area } ABC) + 2(\text{Area } AEDC)$ $= 8(24) + 2(16\tan 35) + 2(24)\left(\frac{4}{\cos 35}\right)$			M1 dep on all previous M marks – complete, correct method for finding the surface area of the prism e.g., $8(24) + 2(11.20...) + 2(24)(4.88...)$
		449	5	A1 (449 or better) For reference: 448.7953623…

11(b)	$2\pi\left(3\sqrt{3}+2\right)^2+2\pi\left(3\sqrt{3}+2\right)h=\left(224+60\sqrt{3}\right)\pi$ oe			M1 setting up a correct equation. Allow with no π or $2\pi\left(r\right)^2+2\pi\left(r\right)h=\left(224+60\sqrt{3}\right)\pi$ oe
	$2\left(9\times3+12\sqrt{3}+4\right)+2\left(3\sqrt{3}+2\right)h=\left(224+60\sqrt{3}\right)$ oe			M1dep multiplying out brackets correctly with $\sqrt{3}\times\sqrt{3}$ being replaced by 3 (allow with π in each term) Or $2\left(9\times3+12\sqrt{3}+4\right)+2\left(r\right)h=\left(224+60\sqrt{3}\right)$ oe Allow $62+24\sqrt{3}+\left(6\sqrt{3}+4\right)h=224+60\sqrt{3}$ oe for this mark
	$h=\dfrac{81+18\sqrt{3}}{3\sqrt{3}+2}$			A1 rearranging to get a correct expression for h e.g., $h=\dfrac{9\left(9+2\sqrt{3}\right)}{3\sqrt{3}+2}$, $h=\dfrac{\left(81+18\sqrt{3}\right)\pi}{\left(3\sqrt{3}+2\right)\pi}$, $h=\dfrac{\left(162+36\sqrt{3}\right)\pi}{\left(6\sqrt{3}+4\right)\pi}$, etc.
	$h=\dfrac{\left(81+18\sqrt{3}\right)}{\left(3\sqrt{3}+2\right)}\times\dfrac{\left(3\sqrt{3}-2\right)}{\left(3\sqrt{3}-2\right)}$ oe **or** $h=\dfrac{9\sqrt{3}(3\sqrt{3}+2)}{3\sqrt{3}+2}$			M1 dep (on both previous M marks) multiplying by $\dfrac{k\left(3\sqrt{3}-2\right)}{k\left(3\sqrt{3}-2\right)}$ with any real value of k e.g. $\dfrac{\left(-3\sqrt{3}+2\right)}{\left(-3\sqrt{3}+2\right)}$, $\dfrac{\left(4-6\sqrt{3}\right)}{\left(4-6\sqrt{3}\right)}$, etc. **or** $9\sqrt{3}(a+b)$ with at least one of a or b correct
	$=\dfrac{243\sqrt{3}+162-162-36\sqrt{3}}{27-4}$ **or** $h=\dfrac{9\sqrt{3}(3\sqrt{3}+2)}{3\sqrt{3}+2}$ or $9\sqrt{3}$			M1 dep on all previous M marks - multiplying out brackets (with at most one slip) e.g., $\dfrac{9\left(18-23\sqrt{3}-18\right)}{4-27}$, $\dfrac{648-828\sqrt{3}-648}{16-108}$, etc.
		$3\sqrt{27}$	6	A1 – if first three marks earned and then followed by $9\sqrt{3}$ or $3\sqrt{27}$ with no working seen then award 3 out of 6
				Total 11 marks

12(a)		–3	1	B1 allow $x=-3$ or $x\neq-3$
(b)		$\frac{1}{2}$	1	B1 oe (e.g. 0.5)
(c)	$\text{g}(x) = 2(x+1)^2 \pm\ldots$			M1 attempting to complete the square. Allow $\text{g}(x)=\left(\sqrt{2}x+\sqrt{2}\right)^2 \pm\cdots$
	$y="2"(x+"1")^2-"3"$			M1 getting an equation in completed square form. Or for $\text{g}(x)=\left(\sqrt{2}x+\sqrt{2}\right)^2-3$
	$\frac{y+"3"}{"2"}=(x+"1")^2$			M1dep on at least one method mark being awarded. Allow use of their completed square form. Rearranging to get $(x+"1")^2$ on its own. Or for $\left(\sqrt{2}x+\sqrt{2}\right)^2=y+3$
	$\left[\text{g}^{-1}(x)=\right]\sqrt{\frac{x+3}{2}}-1$ oe			A1 need RHS – allow any letter for *x* and ignore LHS but must take the positive square root (but may recover later).
	$4-\frac{7}{\left(\sqrt{\frac{x+"3"}{"2"}}-"1"+3\right)}=1.2$ oe			M1dep on previous M being awarded for substituting their $\text{g}^{-1}(x)$ into f(x) or for $\text{f}^{-1}(1.2)=-1+\sqrt{\frac{x+3}{2}}\Rightarrow -1+\sqrt{\frac{x+3}{2}}=\frac{7}{4-1.2}-3$ (so for putting $\text{g}^{-1}(x)=\text{f}^{-1}(1.2)$ with an attempt at the inverse of f)
	$\frac{7}{2.8}-2=\sqrt{\frac{x+"3"}{"2"}}$			
	$"2"\left(\frac{7}{2.8}-2\right)^2-"3"=x$			M1 dep on previous M being awarded for rearranging and squaring to get *x*. Or for $\sqrt{\frac{x+3}{2}}=\left(\frac{7}{4-1.2}-3\right)+1\Rightarrow x=2\left(-\frac{1}{2}+1\right)^2-3$
		– 2.5	7	A1 (dependent on all previous M marks) – correct answer with no working scores full marks

Alternative				
(c)	$x = \mathrm{gf}^{-1}(1.2)$			M1 for correctly re-arranging to make *x* the subject in terms of g and f^{-1}
	$y = 4 - \dfrac{7}{x+3}$ $xy + 3y = 4x + 12 - 7$			M1 putting *y* = (or any other letter) and attempt to remove fraction by multiplying all terms by (*x* + 3)
	$x(6y-4) = 5-3y$			M1 for re-arranging to get all *x*'s on one side and factorising *x* out (condone sign errors) or $y = 4 - \dfrac{7}{x+3} \Rightarrow \dfrac{7}{x+3} = 4 - y \Rightarrow x + 3 = \dfrac{7}{4-y}$ implies this and the previous M mark
	$\left[\mathrm{f}^{-1}(x) = \right]\dfrac{5-3x}{x-4}$			A1 need RHS only – can be equal to any letter (or just the expression) and can use any letter for *x* oe e.g., $\dfrac{7}{4-x} - 3$, $\dfrac{3x-5}{4-x}$, $-3 - \dfrac{7}{x-4}$, etc.
	$\left[\mathrm{f}^{-1}(1.2)\right] = \dfrac{5 - 3\times1.2}{1.2-4}$ $[= -0.5]$			M1 dep (dependent on 2nd and 3rd M marks) substitute 1.2 into f^{-1}
	$\left[\mathrm{g}(\text{"}-0.5\text{"})\right]$ $= 2\times(-0.5)^2 + 4\times(-0.5) - 1$			M1 dep on previous M mark - substitute their $\mathrm{f}^{-1}(1.2)$ into g(*x*)
		–2.5	7	A1

(d)	$\text{gh}(x) = 2\ \ x+2\ ^{2} + 4\ \ x+2\ \ -1$			M1 substitute $x + 2$ for x into $2x^2 + 4x - 1$ or for working with h(x) and g(x) with g(x) in the form $2(x+\alpha)^2 \pm \beta$ or $\left(\sqrt{2}x+\alpha\right)^2 \pm \beta$ where α and β are positive real numbers
	$\text{m}(x) = 2\left(x^2+4x+4\right)+4x+8-1+3$ oe			M1 dep multiplying out brackets correctly or for substituting h into g(x) where g(x) is in completed square form e.g., $\text{m}(x) = 2(x+2+1)^2 - 3 + 3$ or $\left(\sqrt{2}(x+2)+\sqrt{2}\right)^2 - 3 + 3$
	$2(x \pm n)^2$ or $n(x+3)^2$			M1 dep (on previous M mark) simplify to perfect square form where n is an integer.
		$2(x+3)^2$	4	A1 (dependent on all previous M marks) – allow those that state $a = 2$ and $b = 3$. The correct answer with no working (or with no obvious incorrect working) scores full marks.
(e)	domain of m^{-1} = range of m			M1 allow 0 or any inequality with any letter with 0 (e.g., m < 0) for this mark. Or for correctly re-arranging to $\left[\text{m}^{-1}(x) =\right] -b \pm \sqrt{\frac{x}{a}}$ (accept either + or –).
		$x \geqslant 0$	2	A1 – must be x **and** correct inequality sign
				Total 15 marks

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