1. The function f is defined by

$$f : x \mapsto |2x - 5|, \quad x \in \mathbb{R}$$

(a) Sketch the graph with equation $y = f(x)$, showing the coordinates of the points where the graph cuts or meets the axes.

(2)

(b) Solve $f = (x) = 15 + x$.

(3)

The function g is defined by

$$g : x \mapsto x^2 - 4x + 1, \ x \in \mathbb{R}, \quad 0 \le x \le 5$$

(c) Find fg(2).

(2)
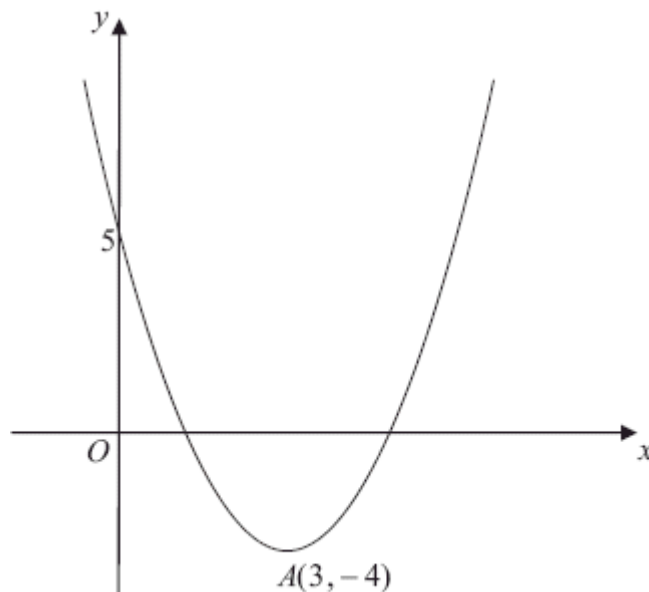
(d) Find the range of g.

(3)
(Total 10 marks)

2.

$A(3, -4)$

The diagram above shows a sketch of the curve with the equation $y = f(x)$, $x \in \mathbb{R}$.

The curve has a turning point at $A(3, -4)$ and also passes through the point $(0, 5)$.

(a) Write down the coordinates of the point to which *A* is transformed on the curve with equation

  (i) $y = |f(x)|$,

  (ii) $y = 2f\left(\frac{1}{2}x\right)$.

(4)

(b) Sketch the curve with equation

$$y = f(|x|)$$

(3)

On your sketch show the coordinates of all turning points and the coordinates of the point at which the curve cuts the *y*-axis.

The curve with equation $y = f(x)$ is a translation of the curve with equation $y = x^2$.

(c) Find f(*x*).

(2)

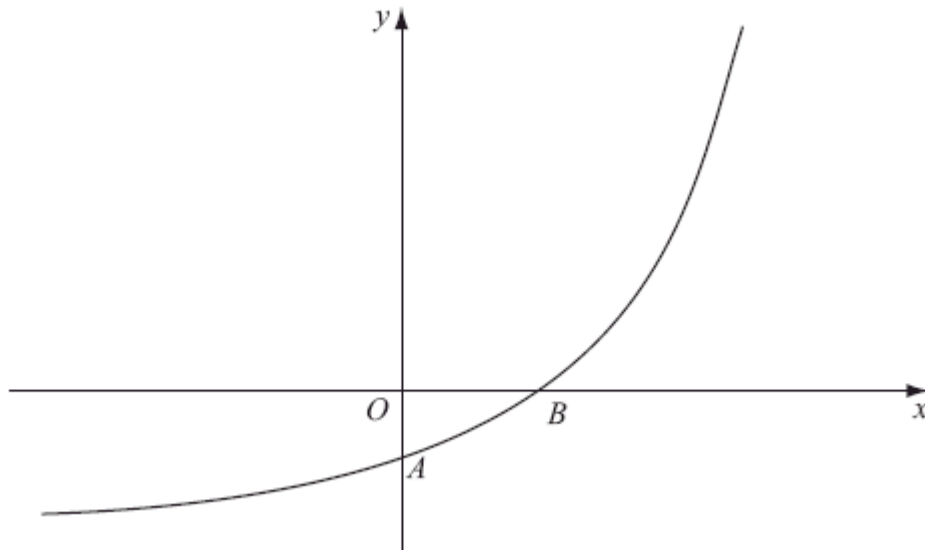(d) Explain why the function f does not have an inverse.

(1)
(Total 10 marks)

3. Sketch the graph of $y = \ln|x|$, stating the coordinates of any points of intersection with the axes.

(Total 3 marks)

4.

The figure above shows a sketch of part of the curve with equation $y = $ f(x), $x \in \mathbb{R}$

The curve meets the coordinate axes at the points $A(0, 1 - k)$ and 1 $B\left(\frac{1}{2}\ln k, 0\right)$, where k is a constant and $k > 1$, as shown in the diagram above.

On separate diagrams, sketch the curve with equation

(a) $y = \left| \text{f }(x) \right|$,

(3)

(b) $y = $ f$^{-1}(x)$

(2)

Show on each sketch the coordinates, in terms of k, of each point at which the curve meets or cuts the axes.
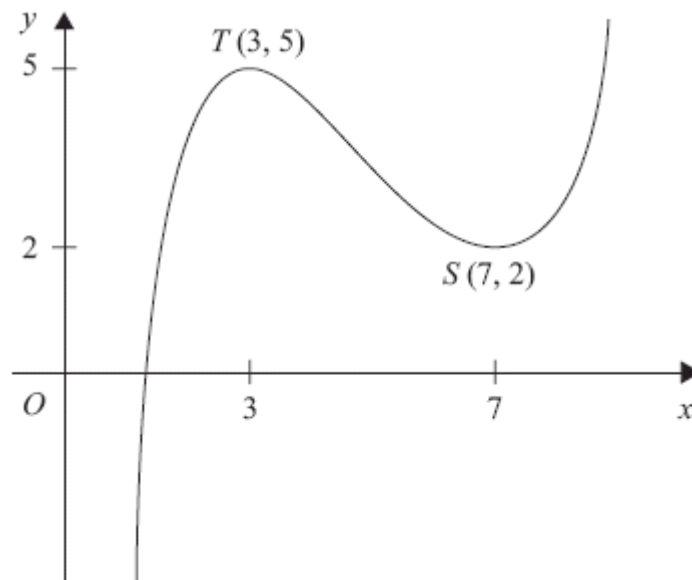
Given that f$(x) = $ e$^{2x} - k,$

(c)   state the range of f,

(1)

(d)   find f$^{-1}(x)$,

(3)

(e)   write down the domain of f^{-1}.

5.

The figure above shows the graph of $y = f(x)$, $1 < x < 9$.
The points $T(3, 5)$ and $S(7, 2)$ are turning points on the graph.

Sketch, on separate diagrams, the graphs of

(a) $y = 2f(x) - 4$,

(3)

(b) $y = |f(x)|$.

(3)

Indicate on each diagram the coordinates of any turning points on your sketch.

(Total 6 marks)

6.   For the constant k, where $k > 1$, the functions f and g are defined by

$$f: \ x \ \mapsto \ \ln(x + k), \qquad x > -k,$$

$$g: \ x \ \mapsto \ |2x - k|, \qquad x \in \mathbb{R}$$

(a)   On separate axes, sketch the graph of f and the graph of g.

On each sketch state, in terms of k, the coordinates of points where the graph meets the coordinate axes.

(5)

(b)   Write down the range of f.

(1)

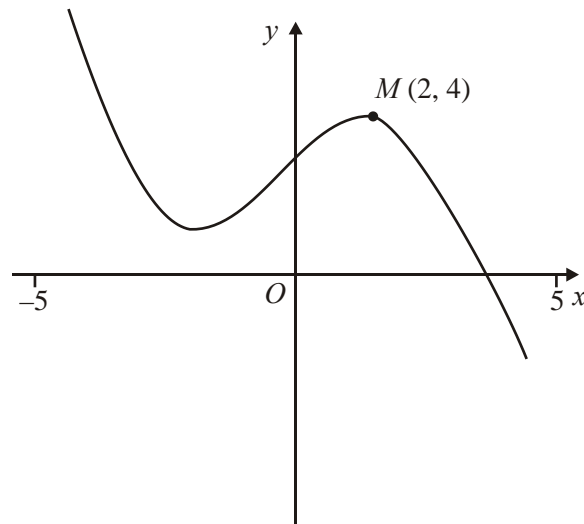(c)   Find $fg\left(\dfrac{k}{4}\right)$ in terms of k, giving your answer in its simplest form.

(2)

The curve C has equation $y = f(x)$. The tangent to C at the point with x-coordinate 3 is parallel to the line with equation $9y = 2x + 1$.

(d)   Find the value of k.

(4)
(Total 12 marks)

7.

The figure above shows the graph of $y = f(x)$, $-5 \le x \le 5$.
The point M (2, 4) is the maximum turning point of the graph.

Sketch, on separate diagrams, the graphs of

(a) $y = f(x) + 3$,

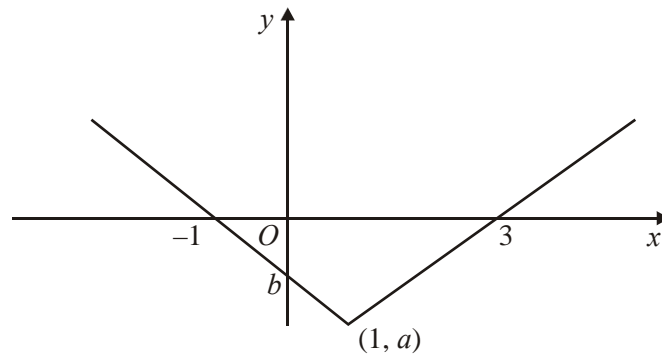**(2)**

(b) $y = |f(x)|$,

(2)

(c) $y = f(|x|)$.

(3)

Show on each graph the coordinates of any maximum turning points.

(Total 7 marks)

8.

This figure shows part of the graph of $y = f(x)$, $x \in \mathbb{R}$. The graph consists of two line segments that meet at the point $(1, a)$, $a < 0$. One line meets the x-axis at $(3, 0)$. The other line meets the x-axis at $(-1, 0)$ and the y-axis at $(0, b)$, $b < 0$.

In separate diagrams, sketch the graph with equation

(a) $y = f(x + 1)$,

(2)

(b) $y = f(|x|)$.

(3)

Indicate clearly on each sketch the coordinates of any points of intersection with the axes.

Given that $f(x) = |x - 1| - 2$, find
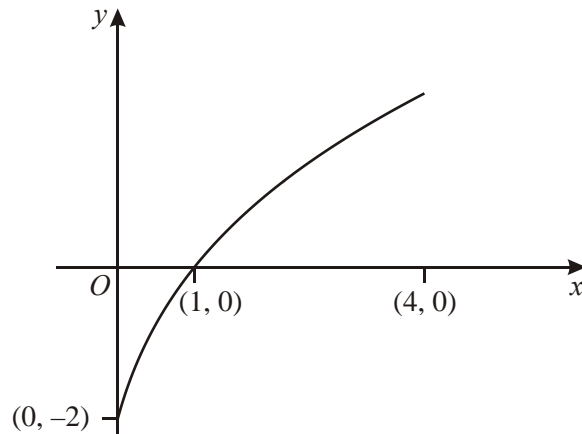
(c)   the value of a and the value of b,

(2)

(d)   the value of x for which $f(x) = 5x$.

(4)

(Total 11 marks)

9.

This diagram shows a sketch of the curve with equation $y = f(x)$, $0 \le x \le 4$. The curve passes through the point (1, 0) on the x-axis and meets the y-axis at the point (0, –2).

Sketch, on separate axes, the graph of

(a) $y = \left| f(x) \right|$,

(2)

(b) $y = f(2x)$,

(2)

(c) $y = f^{-1}(x)$,

(3)

in each case showing the coordinates of the points at which the graph meets the axes.

(Total 7 marks)

10.   The function f is defined by

$f: x \mapsto \left| 2x - 5 \right|$, $x \in \mathbb{R}$.

(a)   Sketch the graph of $y = f(x)$, showing the coordinates of points at which the graph meets or crosses the axes.

(3)

(b)   Find the values of x for which $f(x) = x$.

(4)

The function g is defined by

$$g: x \mapsto x(x-6), \quad x \in \mathbb{R}.$$

(c)   Find the range of g(x).

(3)

(d)   Find fg(1).

(2)
(Total 12 marks)

11.   The functions f and g are defined by

$$f: x \mapsto |x-a| + a, \quad x \in \mathbb{R},$$

$$g: x \mapsto 4x + a, \quad\quad x \in \mathbb{R}.$$

where a is a positive constant.

(a)   On the same diagram, sketch the graphs of f and g, showing clearly the coordinates of any points at which your graphs meet the axes.

(5)

(b)   Use algebra to find, in terms of a, the coordinates of the point at which the graphs of f and g intersect.

(3)

(c)   Find an expression for fg(x).

(2)

(d)   Solve, for x in terms of a, the equation
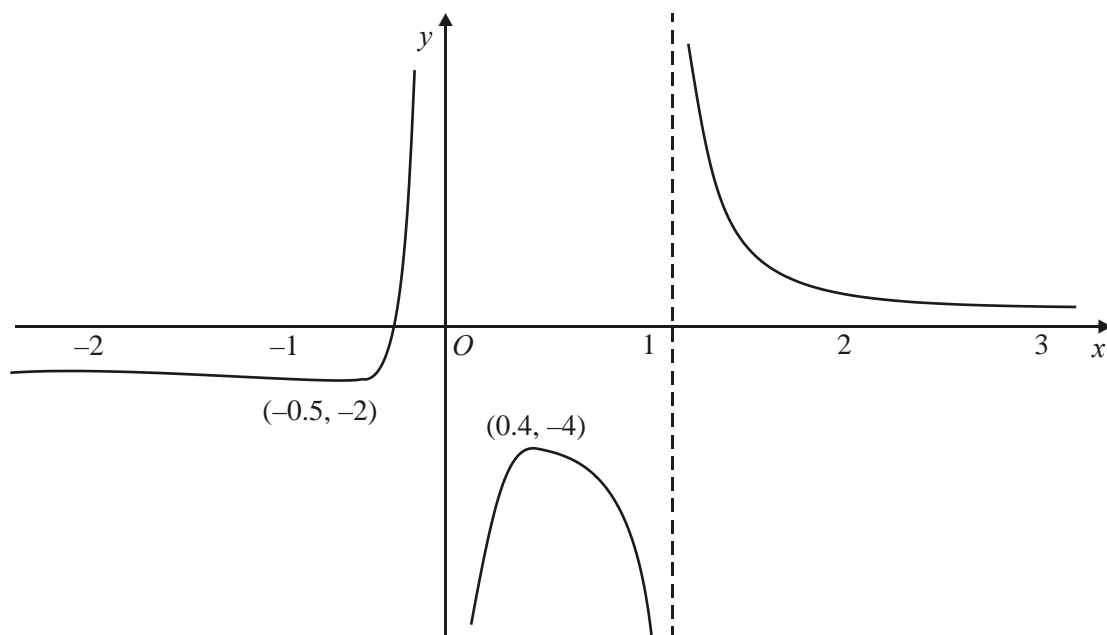
$$fg(x) = 3a.$$

(3)
(Total 13 marks)

12. (a) Sketch the graph of $y = |2x + a|$, $a > 0$, showing the coordinates of the points where the graph meets the coordinate axes.

(2)

(b) On the same axes, sketch the graph of $y = \dfrac{1}{x}$.

(1)

(c) Explain how your graphs show that there is only one solution of the equation

$$x|2x + a| - 1 = 0.$$

(1)

(d) Find, using algebra, the value of x for which $x|2x + 1| - 1 = 0$.

(3)
(Total 7 marks)

13.

The diagram above shows a sketch of part of the curve with equation $y = f(x)$, $x \in \mathbb{R}$.

The curve has a minimum point at $(-0.5, -2)$ and a maximum point at $(0.4, -4)$. The lines $x = 1$, the x-axis and the y-axis are asymptotes of the curve, as shown in the diagram above.

On a separate diagram sketch the graphs of

(a) $y = |f(x)|$,
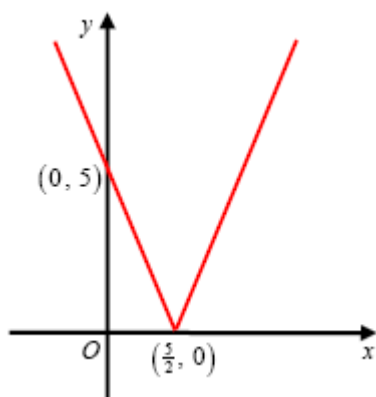
(4)

(b) $y = f(x - 3)$,

(4)

(c) $y = f(|x|)$.

(4)

In each case show clearly

(i)   the coordinates of any points at which the curve has a maximum or minimum point,

(ii)   how the curve approaches the asymptotes of the curve.

(Total 12 marks)

1.   (a)

A1   2

Note

   V or $\vee$ or $\vee$ graph with vertex on the x-axis.

A1: $\left(\frac{5}{2}, \{0\}\right)$ and $(\{0\}, 5)$ seen and the graph appears in both the first and second quadrants.

(b) $x = 20$ B1

   $2x - 5 = -(15 + x)$; $\Rightarrow x = -\frac{10}{3}$ A1 oe.   3

Note

   Either $2x - 5 = -(15 + x)$ or $-(2x - 5) = 15 + x$

(c) $\mathrm{fg}(2) = \mathrm{f}(-3) = \left|2(-3) - 5\right|; = \left|-11\right| = 11$ A1   2

Note

    Full method of inserting g(2) into $\mathrm{f}(x) = \left|2x - 5\right|$ or for inserting

$x = 2$ into $\left|2(x^2 - 4x + 1) - 5\right|$. There must be evidence of the modulus

being applied.

(d) $\mathrm{g}(x) = x^2 - 4x + 1 = (x - 2)^2 - 4 + 1 = (x - 2)^2 - 3$. Hence $\mathrm{g}_{\min} = -$

    Either $\mathrm{g}_{\min} = -3$ or $\mathrm{g}(x) \geq -3$ B1

    or $\mathrm{g}(5) = 25 - 20 + 1 = 6$

    $\underline{-3 \leq g(x) \leq 6}$ or $\underline{-3 \leq y \leq 6}$ A1   3

Note

    Full method to establish the minimum of g. Eg: $(x \pm \alpha)^2 + \beta$

leading to $\mathrm{g}_{\min} = \beta$. Or for candidate to differentiate the quadratic,

set the result equal to zero, find x and insert this value of x back into

$\mathrm{f}(x)$ in order to find the minimum.

B1: For either finding the correct minimum value of g

(can be implied by $\mathrm{g}(x) \geq -3$ or $\mathrm{g}(x) > -3$) or for stating that $\mathrm{g}(5) = 6$

A1: $\underline{-3 \leq g(x) \leq 6}$ or $\underline{-3 \leq y \leq 6}$ or $\underline{-3 \leq g \leq 6}$. **Note that**: $-3 \leq x \leq 6$ is A0.

Note that: $-3 \leq \mathrm{f}(x) \leq 6$ is A0. **Note that**: $-3 \geq \mathrm{g}(x) \geq 6$ is A0.

Note that: $\mathrm{g}(x) \geq -3$ or $\mathrm{g}(x) > -3$ or $x \geq -3$ or $x > -3$ with no

working gains M1B1A0.

Note that for the final Accuracy Mark:

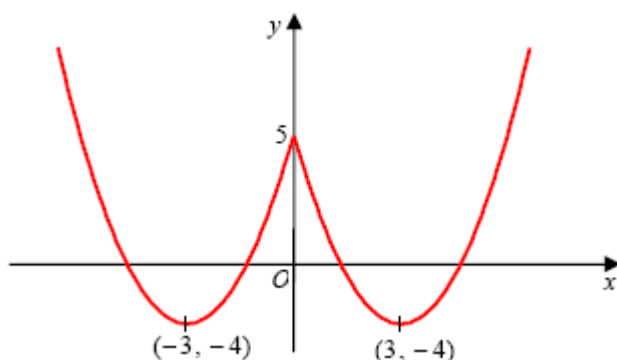If a candidate writes down $-3 < \mathrm{g}(x) < 6$ or $-3 < y < 6$, then award M1B1A0.

If, however, a candidate writes down $\mathrm{g}(x) \geq -3$, $\mathrm{g}(x) \leq 6$, then award A0.

If a candidate writes down $\mathrm{g}(x) \geq -3$ or $\mathrm{g}(x) \leq 6$, then award A0.

[10]

2.   (a)   (i) $(3, 4)$ B1 B1

        (ii) $(6, -8)$ B1 B1   4

(b)

B1 B1 B1   3

Note

B1: Correct shape for $x \geq 0$, with the curve meeting the positive y-axis
and the turning point is found below the x-axis. (providing candidate
does not copy the whole of the original curve and adds nothing else
to their sketch.).
B1: Curve is symmetrical about the y-axis or correct shape of curve for $x < 0$.
Note: The first two B1B1 can only be awarded if the curve has the correct
shape, with a cusp on the positive y-axis and with both turning points
located in the correct quadrants. Otherwise award B1B0.
B1: Correct turning points of $(-3, -4)$ and $(3, -4)$. Also, $(\{0\}, 5)$ is
marked where the graph cuts through the y-axis. Allow $(5, 0)$ rather
than $(0, 5)$ if marked in the "correct" place on the y-axis.

(c) $f(x) = (x - 3)^2 - 4$ or $f(x) = x^2 - 6x + 5$ A1   2

Note

    Either states f(x) in the form $(x \pm \alpha)^2 \pm \beta$; $\alpha, \beta \neq 0$
Or uses a complete method on $f(x) = x^2 + ax + b$, with $f(0) = 5$ and
$f(3) = -4$ to find both a and b.
A1: Either $(x - 3)^2 - 4$ or $x^2 - 6x + 5$

(d)   Either: The function f is a many-one {mapping}.   B1   1
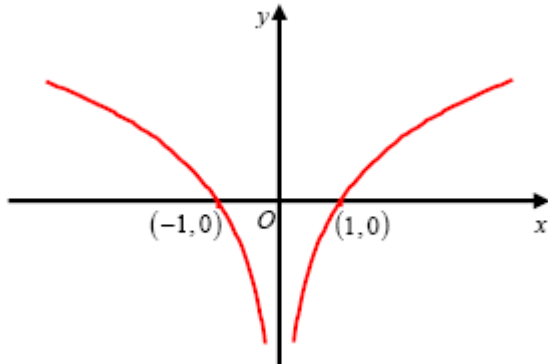   Or: The function f is not a one-one {mapping}.

Note

B1: Or: The inverse is a one-many {mapping and not a function}.
Or: Because f(0) = 5 and also f(6) = 5.
Or: One y-coordinate has 2 corresponding x-coordinates {and therefore
cannot have an inverse}.

[10]

3. $y= \ln|x|$

Right-hand branch in quadrants 4 and 1. Correct shape.	B1	
Left-hand branch in quadrants 2 and 3. Correct shape.	B1	
Completely correct sketch and both $(-1,\{0\})$ and $(1,\{0\})$	B1	3

[3]

4. (a)
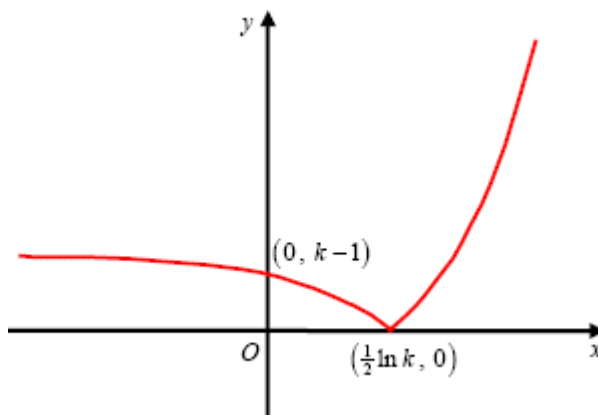
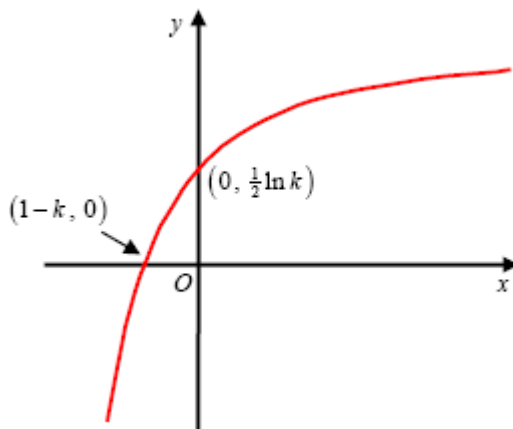|		
Curve retains shape when $x > \frac{1}{2}\ln k$	B1	
Curve reflects through the *x*-axis when $x > \frac{1}{2}\ln k$	B1	
$(0, k-1)$ and $(\frac{1}{2}\ln k, 0)$ marked in the correct positions.	B1	3

(b)

Correct shape of curve. The curve
should be contained in quadrants 1, 2 and 3   B1
(Ignore asymptote)

$(1 - k, 0)$ and $(0, \frac{1}{2}\ln k)$ B1   2

(c)   Range of f: $\underline{f(x) > -k}$ or $\underline{y > -k}$ or $\underline{(-k, \infty)}$ Either $\underline{f(x) > -k}$
                                                    or $\underline{y > -k}$ or
                                                    $\underline{(-k, \infty)}$ or $\underline{f > -k}$ or   B1   1
                                                    $\underline{\text{Range} > -k}$.

(d) $y = e^{2x} - k \implies y + k = e^{2x}$ Attempt to make x
        $\implies \ln(y + k) = 2x$ (or swapped y) the subject
        $\implies \frac{1}{2}\ln(y+k) = x$ Makes e^{2x} the subject and
                                                 takes ln of both sides

        Hence $f^{-1}(x) = \frac{1}{2}\ln(x+k)$ $\frac{1}{2}\ln(x+k)$ or $\ln\sqrt{(x+k)}$ <u>A1</u> cao   3

(e) $f^{-1}(x)$: Domain: $\underline{x > -k}$ or $\underline{(-k, \infty)}$ Either $\underline{x > -k}$ or $\underline{(-k, \infty)}$ or
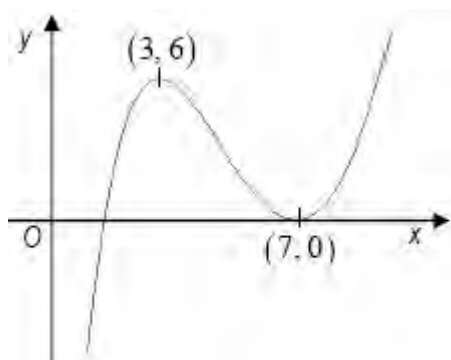   Domain $> -k$ or x "ft one sided   B1ft
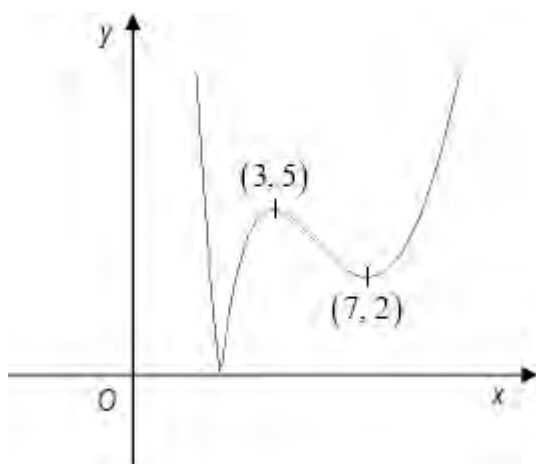   inequality" their part (c)
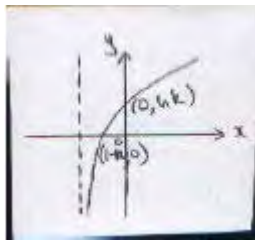   RANGE answer   1

[10]

5.   (a)

Shape   B1

(3, 6)   B1

(7, 0)   B1   3

(b)

Shape   B1

(3, 5)   B1

(7, 2)   B1   3
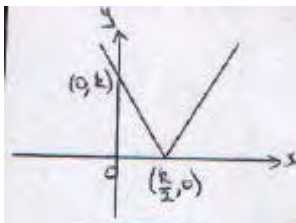
[6]

6. (a)

Log graph: Shape B1

Intersection with -ve x-axis dB1

$(0, \ln k)$, $(1 - k, 0)$ B1

Mod graph :V shape, vertex on +ve *x*-axis B1

$(0, k)$ and $\left(\dfrac{k}{2}, 0\right)$ B1 5

(b) f$(x) \in$ R , $-\infty <$ f$(x) < \infty$, $\infty < y < \infty$ B1 1

(c) $\text{fg}\left(\dfrac{k}{4}\right) = \ln\left\{k + \left|\dfrac{24}{4} - k\right|\right\}$ or $\text{f}\left(\left|-\dfrac{k}{2}\right|\right)$

$= \ln\left(\dfrac{3k}{2}\right)$ A1 2

(d) $\dfrac{\mathrm{d}y}{\mathrm{d}x} = \dfrac{1}{x + k}$ B1

Equating (with $x = 3$) to grad. of line; $\dfrac{1}{3 + k} = \dfrac{2}{9}$ A1

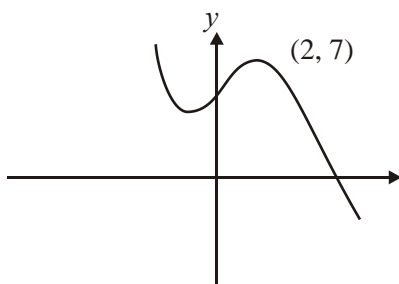$k = 1½$ A1ft 4

[12]
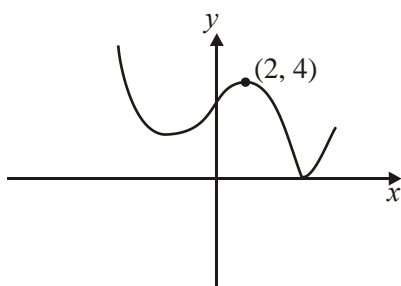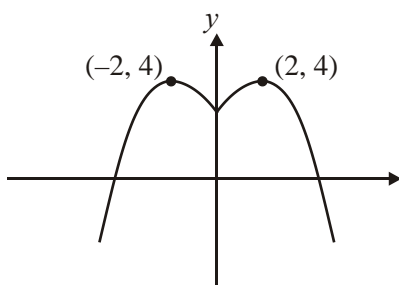
7.   (a)

B1 Shape
B1 Point   2

   (b)

B1 Shape
B1 Point   2

   (c)

B1 Shape > 0
B1 Point $x < 0$
B1 Point
(–2, 4)   3

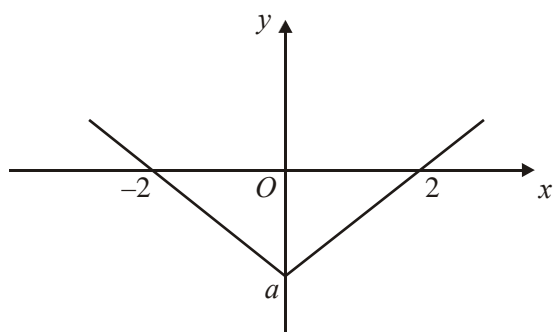**[7]**

8. (a)

Translation ← by 1
Intercepts correct   A1   2

(b)
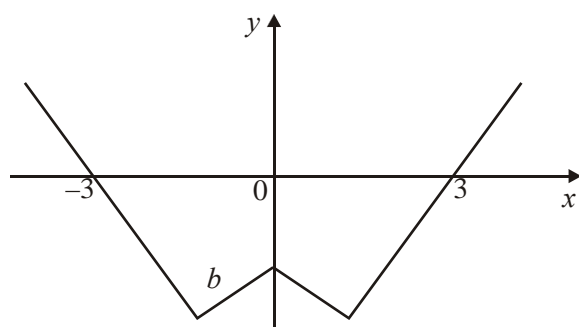
$x \geq 0$, correct "shape"   B1
[provided not just original]
Reflection in y-axis   B1ft
Intercepts correct   B1   3

(c) $a = -2, b = -1$ B1B1   2

(d)   Intersection of $y = 5x$ with $y = -x - 1$ M1A1

      Solving to give $x = -\dfrac{1}{6}$ M1A1   4

                                                                      [11]

9. (a)

Reflected in x-axis 0 < x < 1
Cusp + coords   A1   2
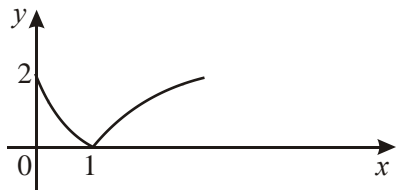*Clear curve going correct way*
Ignore curve x < 0
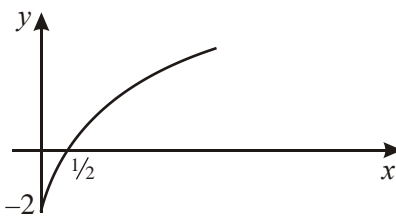
General shaped and -2   B1
(1/2, 0)   B1   2
Ignore curve x< 0
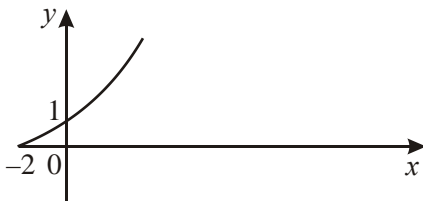
Rough reflection in y = x   B1
(0,1) or 1 on y-axis   B1
(-2, 0) or -2 on x-axis and no curve x < -2   B1   3

[7]

10. (a)

Correct shape, vertex on *x*-axis	B1	
(0, 5)or 5 on *y*-axis	B1	
(2 ½, 0)or 2½ on *x*-axis	B1	3

(b) $2x – 5 = x \Rightarrow x = 5$ A1

          accept stated

     $2x – 5 = –x$ or equivalent

     $x = 1^2/_3$ accept exact equivalents   A1   4

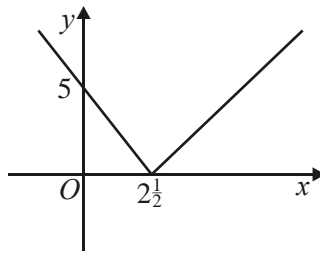(c)   Method for finding either coordinate of the lowest point
(differentiating and equating to zero, completing the square,
using symmetry).

     $x = 3$ or $g(x) = –9$ A1

     $g(x) \geq –9$ A1   3

(d) $fg(1) = f(–5)$

     $= 15$ A1   2

                                              [12]

11. (a)
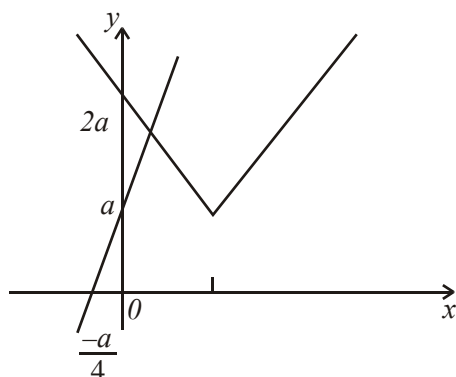
V shape right way up	B1	
vertex in first quadrant	B1	
g	B1	
–1 eeoo; $2a$, a, $-\dfrac{a}{4}$	B2 (1, 0)	5

(b) $4x + a = (a - x) + a$

$5x = a,$ $x = \dfrac{a}{5}$

$y = \dfrac{9a}{5}$ A1   3

   both correct

(c) $\mathrm{fg}(x) = |4x + a - a| + a = |4x| + a$ A1   2

(d) $|4x| + a = 3a \Rightarrow |4x| = 2a$

$x = \dfrac{a}{2}, -\dfrac{a}{2}$ A1, A1   3

                                                                        [13]

12.   (a)
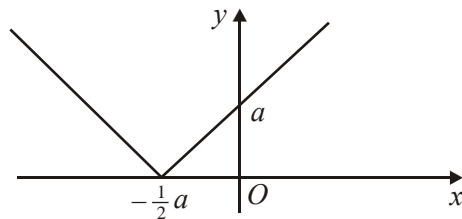
   V graph with 'vertex' on *x*-axis

   $\{-\frac{1}{2}a , (0)\}$ and $\{(0), a\}$ seen   A1   2
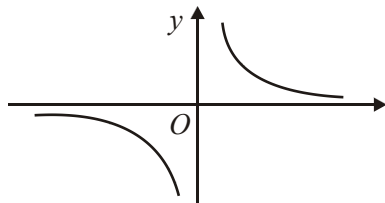
   Correct graph (could be separate)   B1   1

(c)   Meet where $\dfrac{1}{x} = |2x + a| \Rightarrow x|2x + a| - 1 = 0$; only one meet   B1   1

(d) $2x^2 + x - 1$ B1

   Attempt to solve; $x = \frac{1}{2}$ (no other value)   A1   3

                                                                        [7]

13.   (a)

$x < 0$

   B1 shape

$0 < x < 1$

   B1 shape

$x > 1$ 4

   B1 shape
   B1 points

(b)

M1 *any translation*
    correct direction, translation
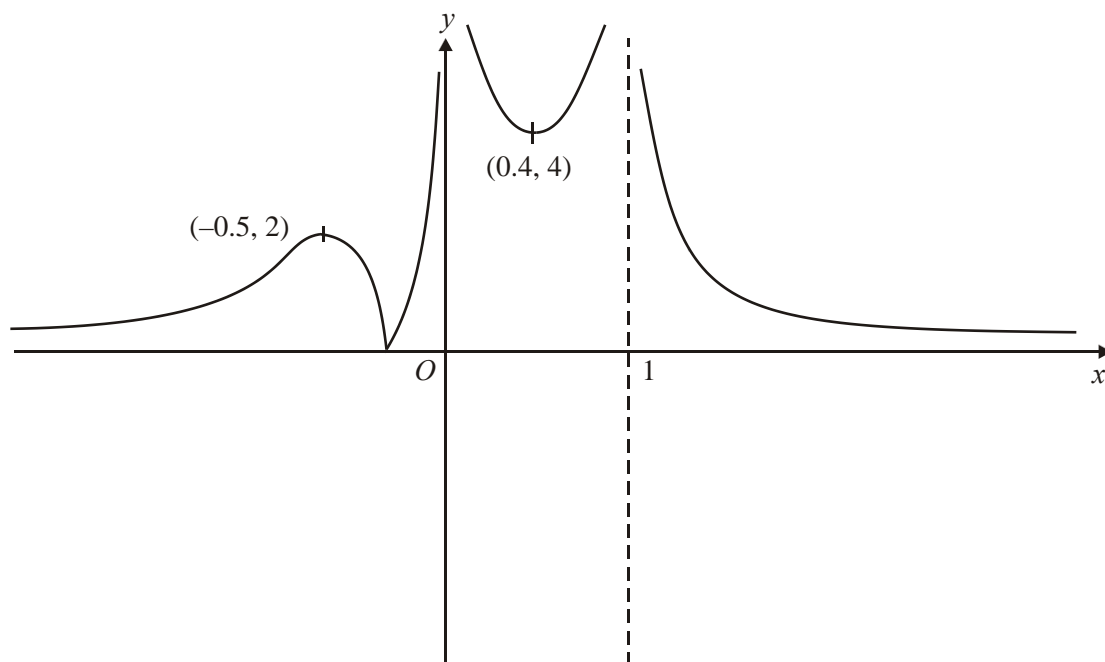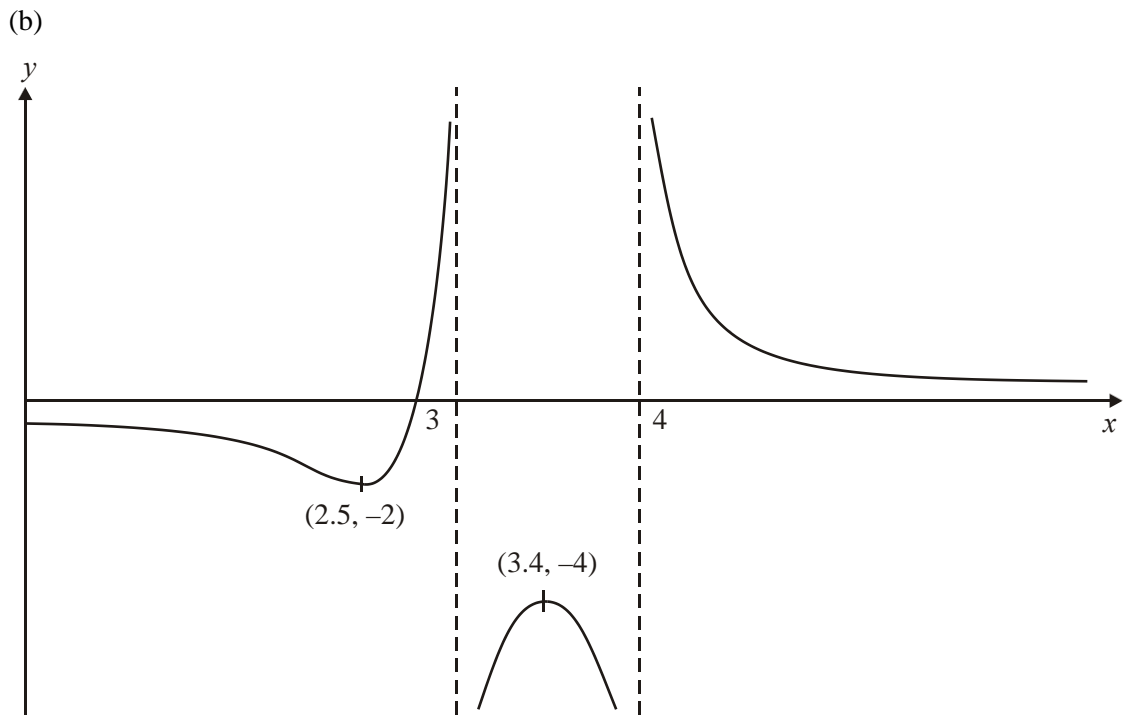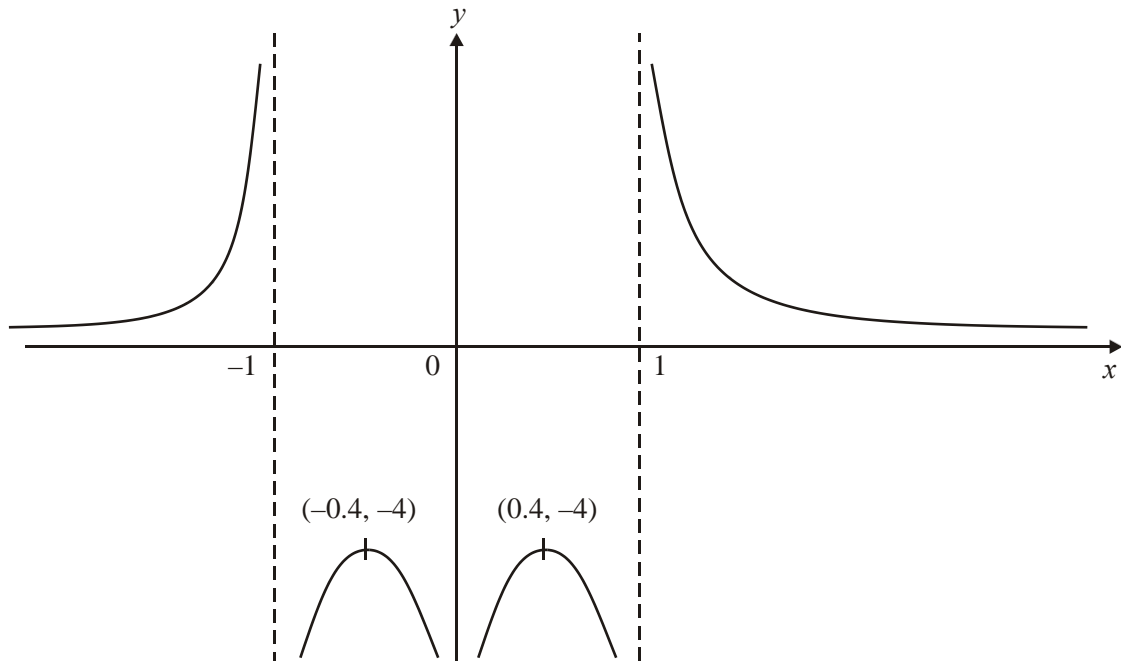*B1 points*
B1 asymptotes   4

(c)

B1 shape > 0
B1 shape < 0
B1 points
B1 asymptotes   4

[12]

1. This question discriminated well across all abilities with about 60% of candidates scoring at least 6 of the 10 marks available, but only about 10% of candidates scoring full marks. A significant proportion of candidates were able to offer fully correct solutions to parts (a), (b) and (c) but sometimes struggled to correctly state the range of g in part (d).

    Part (a) was well answered and common errors included candidates incorrectly stating that the graph met the *x*-axis at $\frac{2}{5}$; or omitting the coordinates where the graph meets or cuts the coordinate axes; or drawing the graph of $y = |2x| - 5$ Candidates should refrain from using dotted lines and/or superimposing the graph of $y = |2x - 5|$ on top of the graph of $y = 2x - 5$. A separate labelled graph makes it easier for examiners to mark.

    It was common for some candidates to find only one solution to part (b). The solution found from $2x - 5 = 15 + x$ was more often seen, but it was also very common to see just the solution from either $2x - 5 = -(15 + x)$ or $-2x + 5 = 15 + x$ Errors were seen in some scripts due to a lack of bracketing resulting in the equation $-2x - 5 = 15 + x$ being solved. A few candidates successfully achieved both answers by squaring the initial equation.

    Part (c) was answered poorly by a significant number of candidates who found that fg(2) was –11, with no evidence of the modulus having been applied. Also, a few other candidates who correctly achieved $|-11|$, believed that it was equal to ±11. The expected error that candidates might find gf(2) instead of fg(2) was happily very rare.

    In part (d), many candidates assumed that the boundaries for the domain would lead to the boundaries for the range and worked out g(0) and g(5) to give their range as $1 \le g(x) \le 6$. Fortunately for them this led to one of the marks being allocated for g(5) = 6. On the other hand, other candidates were able to work out the minimum of g(*x*) by either using methods such as completing the square, differentiation or trial and error, resulting in $g(x) \ge -3$, but failed to spot the restricted domain so missing the maximum value of g(5) = 6. It is refreshing to see that more candidates are using the correct notation for the range, but examiners suggest that teachers need to continually remind candidates that the range should be expressed in terms of 'g(*x*)'or '*y*' and not in terms of '*x*'. A significant minority of candidates, however, understood the restricted nature of g(*x*)and were able to correctly state that $-3 \le g(x) \le 6$.

2. This question discriminated well across all abilities with about 73% of candidates scoring at least 7 of the 10 marks available, but only about 13% of candidates scoring full marks. The majority of candidates were able to offer fully correct solutions to parts (a) and (b) but sometimes struggled to correctly answer parts (c) and (d).

    In part (a), the majority of candidates gained at least 3 out of the 4 marks available. The most common errors were coordinates of (–3, –4) stated in part (i) or (1.5, –8) stated in part (ii).

    The majority of candidates gave the correct sketch in part (b), although a few candidates incorrectly gave the coordinates of the turning points or omitted the value where $y = f(|x|)$ meets the *y*-axis. The four most popular incorrect sketches are shown below.
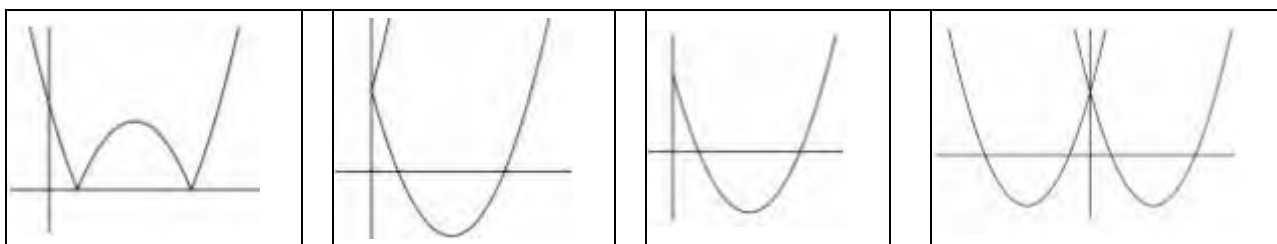
Only a minority of candidates were able to correctly answer part (c). The most popular correct approach was for candidates to write down an equation for f(x) in the form $(x + p)^2$ by looking at the sketch given in the question. Some candidates incorrectly wrote f(x) as $(x^2 – 3) – 4$, whilst others wrote $y = f(x – 3) – 4$ but could not proceed to the correct answer. The method of writing f(0) = 5 and f(3) = –4, together with f(x) = $x^2 + ax + b$ in order to find both a and b was successfully executed by only a few candidates.

In part (d), only a minority of candidates were able to explain why the function f did not have an inverse by making reference to the point that f(x) was not one-one or indeed that f(x) was many-one. In some explanations it was unclear to examiners about whether the candidates were referring to the function f or its inverse f^{-1}. The most common examples of incorrect reasons given were 'you cannot square root a negative number'; 'the inverse of f is the same as the original function'; 'it cannot be reflected in the line $y = x$'; 'f is a one-many function'; or 'a quadratic does not have an inverse'.

If a candidate made reference to a quadratic function they needed to elaborate further by referring to the domain by saying for example, 'In f, one y-coordinate has 2 corresponding x-coordinates'.

3.   Whilst most candidates knew how to draw $y = \ln x$, the graph of $y = \ln|x|$ was often misinterpreted as y = $|\ln x|$ or y = $|\ln|x||$ or $y = \ln(–x)$ and many other different combinations.

Some candidates seemed to realise that the required sketch would be symmetrical about the y-axis even if they did not know the actual shape of the curve. A generous method mark in this question meant that few candidates scored 0 marks. Examiners also report that some candidates need to improve the presentation of their sketches.

4.   In part (a), almost all candidates realised that the transformed curve was the same as the original curve for $x > \frac{1}{2} \ln k$, and only a few failed to reflect the other part of the curve correctly through the x-axis. A significant number of candidates in this part struggled to write down the correct coordinates for the y-intercept in terms of k. The most common incorrect answers were (0, k + 1)and (0, 1 – k). A few candidates did not state the coordinates of the y-intercept in the simplest form. An answer of $(0, |1 – k|)$ was accepted on the y-axis in this part.

In part (b), many candidates realised that they needed to reflect the given curve through the line $y = x$. Although the majority of these candidates managed to draw the correct shape of the transformed curve, a few seemed unable to visualise the correct position after reflection and incorrectly positioned their curve going through the fourth quadrant. Those candidates who correctly reflected the original curve through the line $y = x$ were often unable to see that the effect of reflecting points A and B in the line $y = x$ was a reversal of x- and y-coordinates. The most common incorrect coordinates for the x and y intercepts in this part were $\left(-\frac{1}{2}\ln k, 0\right)$ and $(0, -1 + k)$ respectively.

In parts (a) and (b), examiners were fairly tolerant with curvature. Those candidates, however, who drew curves going back on themselves to give an upside-down U in the second quadrant in part (a) or a C-shape in the third quadrant in part (b) were not awarded the relevant mark for the shape of their curve.

The majority of candidates struggled with part (c). Some candidates sketched the curve of $y = e^{2x}$ and proceeded to translate this curve down k units in the y-direction and in most cases these candidates were able to write down the correct range. A significant number of candidates wrote their range using x rather than using either y or f (x). Common incorrect answers for the range were $y \in \mathbb{R}$, $y > 0$, $y > k$ or $y \geq k$

Part (d) was well answered and a majority of candidates were able to score some marks with a large number scoring full marks. The general procedure of changing the subject and switching x and y was well known. There was the occasional difficulty with taking logarithms of both sides. A common error was an incorrect answer of $\frac{1}{2}$ $\ln(x - k)$. As x only appears once in the original function, a few candidates instead chose to use a flowchart method to find the inverse. Nearly all those who did this arrived at the correct answer.

Again, as with part (c), many candidates struggled to give the correct domain for the inverse function in part (e). Those candidates who correctly stated that the domain of the inverse function is the same as the range of the original function failed in many cases to obtain the follow-through mark. This was because they did not change y or f (x) in their range inequality to x in their domain inequality.

5.   The principles of transforming graphs were well understood. Part (a) was generally well done and almost all candidates recognised that the transformation left the shape and the x-coordinates of the stationary points unchanged. The y-coordinates, however, were often given incorrectly. Part (b) was very well done and the majority reflected the correct part of the curve in the x-axis and it was pleasing to note that almost all candidates knew they had to draw a cusp and not round off the curve. A few drew the graph of $y = f\big(|x|\big)$ instead of $y = f\big(|x|\big)$.

6.   Most candidates scored the first mark in part (a) for a correctly shaped curve. However, many candidates appeared to ignore the information given that $k > 1$ and so it was common to see graph of f incorrectly crossing the positive x-axis and negative y-axis. Candidates were more successful with their sketches of g. Part (b) was not well done with many giving a range which contradicted their sketches. Incorrect answers implied a lack of understanding of the difference between the domain and range of a function. In part (c), most candidates showed good understanding of the required order of operations. However, the modulus sign was often omitted completely or treated as a bracket leading to a frequent incorrect answer of $\ln\left(\dfrac{k}{2}\right)$. Part (d) was sometimes misinterpreted and it was not uncommon to see candidates using $y - y_1 = m(x - x_1)$ and attempting to find the equation of a tangent. Those candidates who found f′(3) and equated it to the gradient of the line were usually successful in finding the correct value of k, although the gradient of the line was sometimes given as 2 and sometimes as $\dfrac{1}{9}$

7.   This question was similar in style to several that candidates will have seen in the past papers. Many well-rehearsed and totally correct solutions were seen. Where errors did occur, the problem was usually with $f(|x|)$. Some candidates clearly knew that they were looking for a reflection in the y axis, but they then produced a sketch with a large α shape in the first quadrant, having left the original section in place and reflected the section from the second quadrant in the y axis.

There are some candidates who seem to think that when drawing the modulus function you draw just the positive sections and ignore anything that lies below the x axis.

A small minority of candidates appeared to be drawing sketches more like $y = x + 3$, $y = |x + 3|$ or $y = |x| + 3$, and a third sketch that was a repeat of their second. This often involved creating an associated table of values. Their answer completely ignored the original function sketched for them.

8.   Pure Mathematics P2

Most candidates tackled this with confidence (sometimes unwarranted).

(a)   Many understood that the question required a translation by one unit, but this was frequently to the right rather than to the left.

(b)   This was usually incorrect. The majority of candidates drew $y = |f(x)|$ It is difficult to say whether this was through lack of attention in reading the question or through a lack of understanding, but this is not the first time that the function $y = f(|x|)$ has been set.

(c)   This was generally well done, although some candidates made heavy weather of substituting the x values into the modulus function, some clearly seeing the modulus bracket as a substitute notation for +/-.

(d)   Some candidates drew themselves a new sketch and identified the required solution with apparent ease. However, many candidates appeared to have no idea how to solve an equation involving a modulus sign. A lot simply ignored the modulus sign; while others knew the solution involved positives and negatives, but appeared to scatter plus and minus signs randomly throughout their working.

Core Mathematics

(a) and (b)   f(x+1) was usually correct, with the graph translated one unit to the left, but f(|x|) was more difficult for many candidates. The most common errors were use of |f(x)| and only plotted for x » 0. Candidates were generally well trained in labelling coordinates but the 'b' was sometimes missing in b).

(c)   Candidates found this part straight forward.

(d)   A squaring approach was used by some candidates but most solved linear equations. A number obtained two solutions x = -3/4 and x = -1/6 but then failed to eliminate x = -3/4. Candidates who drew y = 5x on their sketch usually isolated x = -1/6 as the single solution.

9.   Usually well done, though reflecting the part of the curve below the *x*-axis in part (a) defeated most. In part (b) many candidates drew y = f(*x*/2). In part (c) the majority of candidates knew it was a reflection in the line *y* = *x*, with some losing marks for *x*< -2. The common error was the coordinates of the intercepts being interchanged.

10.   The sketch was generally well done. In part (b), the solution $x = 5$ was usually found but the modulus confused many and they gave the other answer as $x = -5$. Some did not recognise that there was a second solution and that they needed to solve $-(2x-5) = x$. The finding of the range in part (c) proved very demanding and many produced no working or just stated $y \in \square$ or *y* … 0. Those who were successful usually used differentiation to show a minimum but a number of neat solutions involving completing the square were seen. In part (d), although a few calculated gf(1) or f(1)´ g(1), the majority knew the correct order of operations but the modulus sign caused confusion and the answer -15 was common.

11.   Although the majority of candidates could gain some marks in part (a), full marks were very uncommon. The vertex of the graph of $y = f(x)$ was more commonly found on either of the two axes than at the correct (a, a). This diagram was intended in assist with part (b) but, as the diagram was often wrong, recognising that the only solution of the equation came from $-(x - a) + a = 4x + a$ proved difficult. Part (c) proved easier although a minority dropped the modulus sign. A few candidates stated that fg(x) meant 'g first and then f' and then actually did the exact opposite. To gain marks it is not enough to know a principle, it must actually be applied to the question. In part (d), the majority of candidates could find the positive solution of the equation but the second solution was often omitted.

12.   Candidates familiar with the modulus function produced excellent solutions. However, it was common in part (a) to see the vertex of the mod graph at (0, a), or on the positive side of the x-axis, and in part (b) to see the negative branch of the hyperbola omitted. Those candidates who answered the earlier parts well often gained the mark in part (c). Part (d) was generally well answered with the majority of candidates forming the quadratic equation and solving correctly to give $x = \dfrac{1}{2}$ and $x = -1$; most then went on to reject $x = -1$. The question did say, "Prove, using algebra, …", and so candidates who gave $x = \dfrac{1}{2}$ by inspection of the given modulus equation only gained one of the three marks.

13.   No Report available for this question.