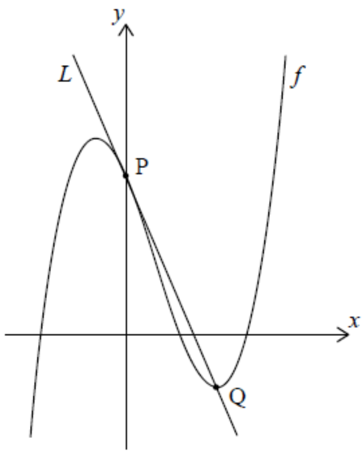
Ch2Review *[254 marks]*

Let $f(x) = x^3 - 2x^2 + ax + 6$. Part of the graph of f is shown in the following diagram.



The graph of f crosses the y-axis at the point P. The line L is tangent to the graph of f at P.

1a. Find the coordinates of P. *[2 marks]*

Markscheme

valid approach ***(M1)***

eg $f(0),\ 0^3 - 2(0)^2 + a(0) + 6,\ f(0) = 6,\ (0,\ y)$

(0, 6) (accept x = 0 **and** y = 6) ***A1 N2***

[2 marks]

1b. Find $f'(x)$. *[2 marks]*

Markscheme

$f' = 3x^2 - 4x + a$ ***A2 N2***

[2 marks]

1c. Hence, find the equation of L in terms of a. *[4 marks]*

Markscheme

valid approach ***(M1)***

eg $f'(0)$

correct working ***(A1)***

eg $3(0)^2 - 4(0) + a$, slope = a, $f'(0) = a$

attempt to substitute gradient and coordinates into linear equation ***(M1)***

eg $y - 6 = a(x - 0)$, $y - 0 = a(x - 6)$, $6 = a(0) + c$, $L = ax + 6$

correct equation ***A1 N3***

eg $y = ax + 6$, $y - 6 = ax$, $y - 6 = a(x - 0)$

[4 marks]

1d. The graph of f has a local minimum at the point Q. The line L passes through Q. *[8 marks]*

Find the value of a.

Markscheme

valid approach to find intersection ***(M1)***

eg $f(x) = L$

correct equation ***(A1)***

eg $x^3 - 2x^2 + ax + 6 = ax + 6$

correct working ***(A1)***

eg $x^3 - 2x^2 = 0$, $x^2(x - 2) = 0$

$x = 2$ at Q ***(A1)***

valid approach to find minimum ***(M1)***

eg $f'(x) = 0$

correct equation ***(A1)***

eg $3x^2 - 4x + a = 0$

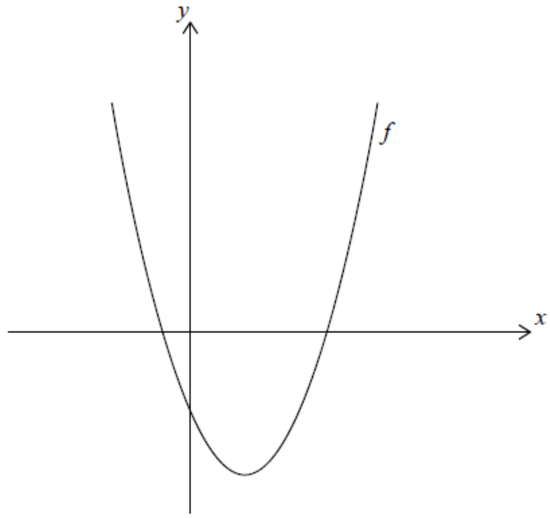
substitution of **their** value of x at Q into **their** $f'(x) = 0$ equation ***(M1)***

eg $3(2)^2 - 4(2) + a = 0$, $12 - 8 + a = 0$

$a = -4$ ***A1 N0***

[8 marks]

Let $f(x) = x^2 - 4x - 5$. The following diagram shows part of the graph of f.



2a. Find the x-intercepts of the graph of f. *[5 marks]*

Markscheme

valid approach *(M1)*

eg $f(x) = 0,\ \ x^2 - 4x - 5 = 0$

valid attempt to solve quadratic equation *(M1)*

eg factorizing, formula, completing the square

evidence of correct working *(A1)*

eg $(x-5)(x+1),\ \ x = \frac{4 \pm \sqrt{16 - 4(-5)}}{2}$

$x = -1,\ \ x = 5$ (accept (–1, 0), (5, 0)) ***A1A1 N3***

[5 marks]

2b. Find the equation of the axis of symmetry of the graph of f. *[2 marks]*

Markscheme

correct working *(A1)*

eg $\frac{-(-4)}{2(1)},\ \frac{-1+5}{2}$

$x = 2$ (must be an equation with $x =$) ***A1 N2***

[2 marks]

The function can be written in the form $f(x) = (x - h)^2 + k$.

2c. Write down the value of h. *[1 mark]*

Markscheme

$h = 2$ ***A1 N1***

[1 mark]

2d. Find the value of k. *[3 marks]*

Markscheme

METHOD 1

valid approach ***(M1)***

eg $f(2)$

correct substitution ***(A1)***

eg $(2)^2 - 4(2) - 5$

$k = -9$ ***A1 N2***

METHOD 2

valid attempt to complete the square ***(M1)***

eg $x^2 - 4x + 4$

correct working ***(A1)***

eg $(x^2 - 4x + 4) - 4 - 5$, $(x - 2)^2 - 9$

$k = -9$ ***A1 N2***

[3 marks]

2e. The graph of a second function, g, is obtained by a reflection of the graph of f in the y-axis, followed by a translation of $\begin{pmatrix} -3 \\ 6 \end{pmatrix}$. *[5 marks]*

Find the coordinates of the vertex of the graph of g.

Markscheme

METHOD 1 (working with vertex)

vertex of f is at (2, –9) ***(A1)***

correct horizontal reflection ***(A1)***

eg x = –2, (–2, –9)

valid approach for translation of **their** x **or** y value ***(M1)***

eg x – 3, y + 6, $\begin{pmatrix}-2\\-9\end{pmatrix}+\begin{pmatrix}-3\\6\end{pmatrix}$, one correct coordinate for vertex

vertex of g is (–5, –3) (accept x = –5, y = –3) ***A1A1 N1N1***

METHOD 2 (working with function)

correct approach for horizontal reflection ***(A1)***

eg $f(-x)$

correct horizontal reflection ***(A1)***

eg $(-x)^2-4(-x)-5$, x^2+4x-5, $(-x-2)^2-9$

valid approach for translation of **their** x **or** y value ***(M1)***

eg $(x+3)^2+4(x+3)-5+6$, $x^2+10x+22$, $(x+5)^2-3$, one correct coordinate for vertex

vertex of g is (–5, –3) (accept x = –5, y = –3) ***A1A1 N1N1***

[5 marks]

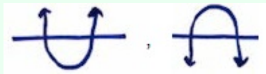
Let $f(x) = ax^2 - 4x - c$. A horizontal line, L, intersects the graph of f at $x = -1$ and $x = 3$.

3a. The equation of the axis of symmetry is $x = p$. Find p. *[2 marks]*

Markscheme

METHOD 1 (using symmetry to find *p*)

valid approach ***(M1)***

eg $\frac{-1+3}{2}$, 

p = 1 ***A1 N2***

Note: Award no marks if they work backwards by substituting *a* = 2 into $-\frac{b}{2a}$ to find *p*.

Do not accept $p = \frac{2}{a}$.

METHOD 2 (calculating *a* first)
(i) & (ii) valid approach to calculate *a* ***M1***

eg $a + 4 - c = a(3^2) - 4(3) - c$, $f(-1) = f(3)$

correct working ***A1***

eg $8a = 16$

a = 2 ***AG N0***

valid approach to find *p* ***(M1)***

eg $-\frac{b}{2a}$, $\frac{4}{2(2)}$

p = 1 ***A1 N2***

[2 marks]

3b. Hence, show that *a* = 2. *[2 marks]*

Markscheme

METHOD 1

valid approach ***M1***

eg $-\frac{b}{2a}$, $\frac{4}{2a}$ (might be seen in (i)), $f'(1) = 0$

correct equation ***A1***

eg $\frac{4}{2a} = 1$, $2a(1) - 4 = 0$

$a = 2$ ***AG N0***

METHOD 2 (calculating *a* first)
(i) & (ii) valid approach to calculate *a* ***M1***

eg $a + 4 - c = a(3^2) - 4(3) - c$, $f(-1) = f(3)$

correct working ***A1***

eg $8a = 16$

$a = 2$ ***AG N0***

[2 marks]

3c. The equation of L is $y = 5$. Find the value of c. *[3 marks]*

Markscheme

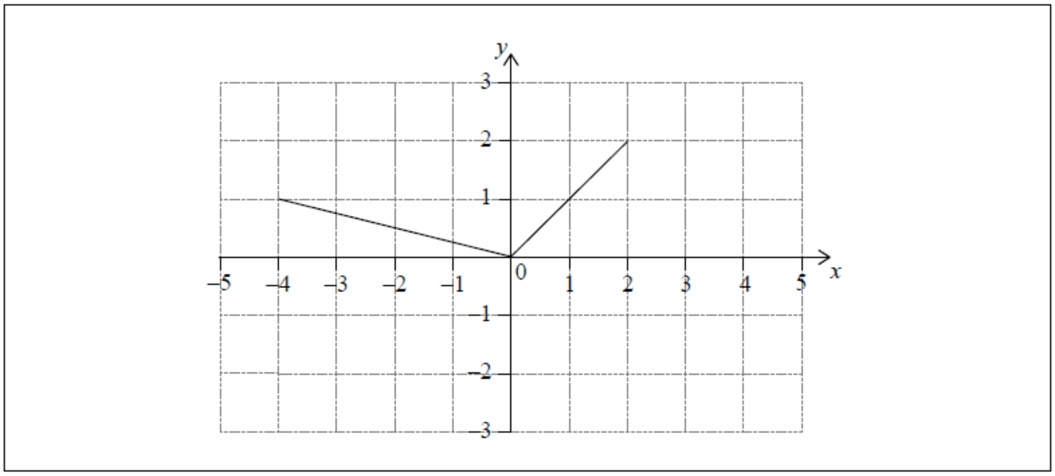
valid approach ***(M1)***
eg $f(-1) = 5$, $f(3) = 5$

correct working ***(A1)***
eg $2 + 4 - c = 5$, $18 - 12 - c = 5$

$c = 1$ ***A1 N2***

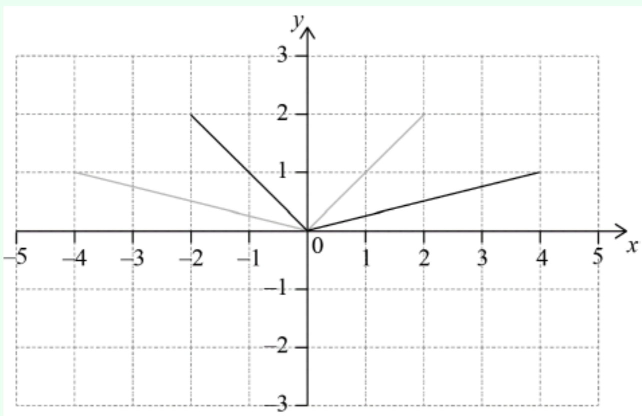
[3 marks]

The following diagram shows the graph of a function f, for $-4 \le x \le 2$.



4a. On the same axes, sketch the graph of $f(-x)$. *[2 marks]*

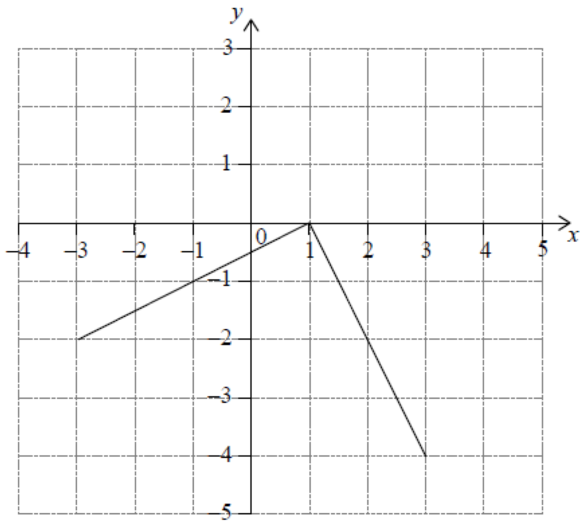
Markscheme



A2 N2

[2 marks]

4b. Another function, g, can be written in the form $g(x) = a \times f(x+b)$. The following diagram shows the graph of g. *[4 marks]*



Write down the value of *a* and of *b*.

Markscheme

recognizing horizontal shift/translation of 1 unit ***(M1)***

eg *b* = 1, moved 1 right

recognizing vertical stretch/dilation with scale factor 2 ***(M1)***

eg *a* = 2, *y* ×(−2)

a = −2, *b* = −1 ***A1A1 N2N2***

[4 marks]

---

5. Let $f(x) = px^2 + qx - 4p$, where *p* ≠ 0. Find Find the number of roots for the equation $f(x) = 0$. *[7 marks]*

Justify your answer.

Markscheme

METHOD 1

evidence of discriminant ***(M1)***
eg $b^2 - 4ac,\ \Delta$

correct substitution into discriminant ***(A1)***
eg $q^2 - 4p(-4p)$

correct discriminant ***A1***
eg $q^2 + 16p^2$

$16p^2 > 0 \ \left(\text{accept } p^2 > 0\right)$ ***A1***

$q^2 \geqslant 0 \ \left(\text{do not accept } q^2 > 0\right)$ ***A1***

$q^2 + 16p^2 > 0$ ***A1***

f has 2 roots ***A1 N0***

METHOD 2

y-intercept = −4*p* (seen anywhere) ***A1***

if *p* is positive, then the *y*-intercept will be negative ***A1***

an upward-opening parabola with a negative *y*-intercept ***R1***
eg sketch that must indicate *p* > 0.

if *p* is negative, then the y-intercept will be positive ***A1***

a downward-opening parabola with a positive y-intercept ***R1***
eg sketch that must indicate *p* > 0.

f has 2 roots ***A2 N0***

[7 marks]

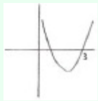
A quadratic function f can be written in the form $f(x) = a(x-p)(x-3)$. The graph of f has axis of symmetry $x = 2.5$ and y-intercept at $(0,\ -6)$

6a. Find the value of p. *[3 marks]*

Markscheme

METHOD 1 (using *x*-intercept)

determining that 3 is an x-intercept ***(M1)***

eg $x-3=0,$ 

valid approach ***(M1)***

eg $3-2.5,\ \frac{p+3}{2}=2.5$

$p=2$ ***A1 N2***

METHOD 2 (expanding *f* (*x*))

correct expansion (accept absence of a) ***(A1)***

eg $ax^2-a(3+p)x+3ap,\ x^2-(3+p)x+3p$

valid approach involving equation of axis of symmetry ***(M1)***

eg $\frac{-b}{2a}=2.5,\ \frac{a(3+p)}{2a}=\frac{5}{2},\ \frac{3+p}{2}=\frac{5}{2}$

$p=2$ ***A1 N2***

METHOD 3 (using derivative)

correct derivative (accept absence of a) ***(A1)***

eg $a(2x-3-p),\ 2x-3-p$

valid approach ***(M1)***

eg $f'(2.5)=0$

$p=2$ ***A1 N2***

[3 marks]

6b. Find the value of a. *[3 marks]*

Markscheme

attempt to substitute $(0,\ -6)$ ***(M1)***

eg $-6=a(0-2)(0-3),\ 0=a(-8)(-9),\ a(0)^2-5a(0)+6a=-6$

correct working ***(A1)***

eg $-6=6a$

$a=-1$ ***A1 N2***

[3 marks]

6c. The line $y=kx-5$ is a tangent to the curve of f. Find the values of k. *[8 marks]*

Markscheme

METHOD 1 (using discriminant)

recognizing tangent intersects curve once ***(M1)***

recognizing one solution when discriminant = 0 ***M1***

attempt to set up equation ***(M1)***

eg $g = f,\ kx - 5 = -x^2 + 5x - 6$

rearranging their equation to equal zero ***(M1)***

eg $x^2 - 5x + kx + 1 = 0$

correct discriminant (if seen explicitly, not just in quadratic formula) ***A1***

eg $(k-5)^2 - 4,\ 25 - 10k + k^2 - 4$

correct working ***(A1)***

eg $k - 5 = \pm 2,\ (k-3)(k-7) = 0,\ \frac{10 \pm \sqrt{100 - 4 \times 21}}{2}$

$k = 3,\ 7$ ***A1A1*** ***N0***

METHOD 2 (using derivatives)

attempt to set up equation ***(M1)***

eg $g = f,\ kx - 5 = -x^2 + 5x - 6$

recognizing derivative/slope are equal ***(M1)***

eg $f' = m_T,\ f' = k$

correct derivative of f ***(A1)***

eg $-2x + 5$

attempt to set up equation in terms of either x or k ***M1***

eg $(-2x+5)x - 5 = -x^2 + 5x - 6,\ k\left(\frac{5-k}{2}\right) - 5 = -\left(\frac{5-k}{2}\right)^2 + 5\left(\frac{5-k}{2}\right) - 6$

rearranging their equation to equal zero ***(M1)***

eg $x^2 - 1 = 0,\ k^2 - 10k + 21 = 0$

correct working ***(A1)***

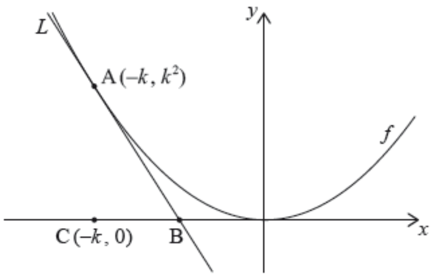
eg $x = \pm 1,\ (k-3)(k-7) = 0,\ \frac{10 \pm \sqrt{100 - 4 \times 21}}{2}$

$k = 3,\ 7$ ***A1A1*** ***N0***

[8 marks]

Let $f(x) = x^2$. The following diagram shows part of the graph of f.

diagram not to scale



The line L is the tangent to the graph of f at the point $\mathrm{A}(-k,\ k^2)$, and intersects the x-axis at point B. The point C is $(-k,\ 0)$.

7a. Write down $f'(x)$. *[1 mark]*

Markscheme

$f'(x) = 2x$ ***A1*** ***N1***

[1 mark]

7b. Find the gradient of L. *[2 marks]*

Markscheme

attempt to substitute $x = -k$ into their derivative ***(M1)***

gradient of L is $-2k$ ***A1*** ***N2***

[2 marks]

7c. Show that the x-coordinate of B is $-\frac{k}{2}$. *[5 marks]*

Markscheme

METHOD 1

attempt to substitute coordinates of A and their gradient into equation of a line ***(M1)***

eg $k^2 = -2k(-k) + b$

correct equation of L in any form ***(A1)***

eg $y - k^2 = -2k(x + k),\ y = -2kx - k^2$

valid approach ***(M1)***

eg $y = 0$

correct substitution into L equation ***A1***

eg $-k^2 = -2kx - 2k^2,\ 0 = -2kx - k^2$

correct working ***A1***

eg $2kx = -k^2$

$x = -\frac{k}{2}$ ***AG*** ***N0***

METHOD 2

valid approach ***(M1)***

eg $\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1},\ -2k = \frac{\text{rise}}{\text{run}}$

recognizing $y = 0$ at B ***(A1)***

attempt to substitute coordinates of A and B into slope formula ***(M1)***

eg $\frac{k^2 - 0}{-k - x},\ \frac{-k^2}{x + k}$

correct equation ***A1***

eg $\frac{k^2 - 0}{-k - x} = -2k,\ \frac{-k^2}{x + k} = -2k,\ -k^2 = -2k(x + k)$

correct working ***A1***

eg $2kx = -k^2$

$x = -\frac{k}{2}$ ***AG*** ***N0***

[5 marks]

7d. Find the area of triangle ABC, giving your answer in terms of k. *[2 marks]*

Markscheme

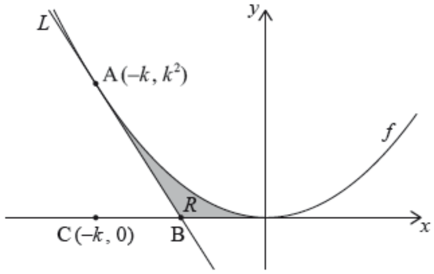
valid approach to find area of triangle ***(M1)***

eg $\frac{1}{2}(k^2)\left(\frac{k}{2}\right)$

area of $\text{ABC} = \frac{k^3}{4}$ ***A1*** ***N2***

[2 marks]

The region R is enclosed by L, the graph of f, and the x-axis. This is shown in the following diagram.



7e. Given that the area of triangle ABC is p times the area of R, find the value of p. *[7 marks]*

Markscheme

METHOD 1 ($\int f -$ triangle)

valid approach to find area from $-k$ to 0 ***(M1)***

eg $\int_{-k}^{0} x^2 \mathrm{d}x,\ \int_{0}^{-k} f$

correct integration (seen anywhere, even if ***M0*** awarded) ***A1***

eg $\frac{x^3}{3},\ \left[\frac{1}{3}x^3\right]_{-k}^{0}$

substituting **their** limits into **their** integrated function and subtracting ***(M1)***

eg $0 - \frac{(-k)^3}{3}$, area from $-k$ to 0 is $\frac{k^3}{3}$

Note: Award ***M0*** for substituting into original or differentiated function.

attempt to find area of R ***(M1)***

eg $\int_{-k}^{0} f(x)\mathrm{d}x -$ triangle

correct working for R ***(A1)***

eg $\frac{k^3}{3} - \frac{k^3}{4},\ R = \frac{k^3}{12}$

correct substitution into $\text{triangle} = pR$ ***(A1)***

eg $\frac{k^3}{4} = p\left(\frac{k^3}{3} - \frac{k^3}{4}\right),\ \frac{k^3}{4} = p\left(\frac{k^3}{12}\right)$

$p = 3$ ***A1 N2***

METHOD 2 ($\int (f - L)$)

valid approach to find area of R ***(M1)***

eg $\int_{-k}^{-\frac{k}{2}} x^2 - (-2kx - k^2)\mathrm{d}x + \int_{-\frac{k}{2}}^{0} x^2 \mathrm{d}x,\ \int_{-k}^{-\frac{k}{2}} (f - L) + \int_{-\frac{k}{2}}^{0} f$

correct integration (seen anywhere, even if ***M0*** awarded) ***A2***

eg $\frac{x^3}{3} + kx^2 + k^2x,\ \left[\frac{x^3}{3} + kx^2 + k^2x\right]_{-k}^{-\frac{k}{2}} + \left[\frac{x^3}{3}\right]_{-\frac{k}{2}}^{0}$

substituting **their** limits into **their** integrated function and subtracting ***(M1)***

eg

$$\left(\frac{\left(-\frac{k}{2}\right)^3}{3} + k\left(-\frac{k}{2}\right)^2 + k^2\left(-\frac{k}{2}\right)\right) - \left(\frac{(-k)^3}{3} + k(-k)^2 + k^2(-k)\right) + (0) - \left(\frac{\left(-\frac{k}{2}\right)^3}{3}\right)$$

Note: Award ***M0*** for substituting into original or differentiated function.

correct working for R ***(A1)***

eg $\frac{k^3}{24} + \frac{k^3}{24},\ -\frac{k^3}{24} + \frac{k^3}{4} - \frac{k^3}{2} + \frac{k^3}{3} - k^3 + k^3 + \frac{k^3}{24},\ R = \frac{k^3}{12}$

correct substitution into $\text{triangle} = pR$ ***(A1)***

eg $\frac{k^3}{4} = p\left(\frac{k^3}{24} + \frac{k^3}{24}\right),\ \frac{k^3}{4} = p\left(\frac{k^3}{12}\right)$

$p = 3$ ***A1*** ***N2***

[7 marks]

8. Let $f(x) = m - \frac{1}{x}$, for $x \neq 0$. The line $y = x - m$ intersects the graph of f in two distinct points. Find the possible values of m. *[7 marks]*

Markscheme

valid approach ***(M1)***

eg $f = y,\ m - \frac{1}{x} = x - m$

correct working to eliminate denominator ***(A1)***

eg $mx - 1 = x(x - m),\ mx - 1 = x^2 - mx$

correct quadratic equal to zero ***A1***

eg $x^2 - 2mx + 1 = 0$

correct reasoning ***R1***

eg for two solutions, $b^2 - 4ac > 0$

correct substitution into the discriminant formula ***(A1)***

eg $(-2m)^2 - 4$

correct working ***(A1)***

eg $4m^2 > 4,\ m^2 = 1$, sketch of positive parabola on the x-axis

correct interval ***A1*** ***N4***

eg $|m| > 1,\ m < -1$ or $m > 1$

[7 marks]

Consider $f(x) = x^2 + qx + r$. The graph of f has a minimum value when $x = -1.5$.

The distance between the two zeros of f is 9.

9a. Show that the two zeros are 3 and -6. *[2 marks]*

Markscheme

recognition that the x-coordinate of the vertex is -1.5 (seen anywhere) ***(M1)***

eg axis of symmetry is -1.5, sketch, $f'(-1.5) = 0$

correct working to find the zeroes ***A1***

eg -1.5 ± 4.5

$x = -6$ and $x = 3$ ***AG*** ***N0***

[2 marks]

9b. Find the value of q and of r. *[4 marks]*

Markscheme

METHOD 1 (using factors)

attempt to write factors ***(M1)***

eg $(x-6)(x+3)$

correct factors ***A1***

eg $(x-3)(x+6)$

$q = 3,\ r = -18$ ***A1A1*** ***N3***

METHOD 2 (using derivative or vertex)

valid approach to find q ***(M1)***

eg $f'(-1.5) = 0,\ -\frac{q}{2a} = -1.5$

$q = 3$ ***A1***

correct substitution ***A1***

eg $3^2 + 3(3) + r = 0,\ (-6)^2 + 3(-6) + r = 0$

$r = -18$ ***A1***

$q = 3,\ r = -18$ ***N3***

METHOD 3 (solving simultaneously)

valid approach setting up system of two equations ***(M1)***

eg $9 + 3q + r = 0,\ 36 - 6q + r = 0$

one correct value

eg $q = 3,\ r = -18$ ***A1***

correct substitution ***A1***

eg $3^2 + 3(3) + r = 0,\ (-6)^2 + 3(-6) + r = 0,\ 3^2 + 3q - 18 = 0,\ 36 - 6q - 18 = 0$

second correct value ***A1***

eg $q = 3,\ r = -18$

$q = 3,\ r = -18$ ***N3***

[4 marks]

10. Let $f(x) = 3\tan^4 x + 2k$ and $g(x) = -\tan^4 x + 8k\tan^2 x + k$, for $0 \leqslant x \leqslant 1$, where $0 < k < 1$. The graphs of f and g intersect at exactly one point. Find the value of k. *[8 marks]*

Markscheme

discriminant $= 0$ (seen anywhere) ***M1***

valid approach ***(M1)***

eg $f = g,\ 3\tan^4 x + 2k = -\tan^4 x + 8k\tan^2 x + k$

rearranging their equation (to equal zero) ***(M1)***

eg $4\tan^4 x - 8k\tan^2 x + k = 0,\ 4\tan^4 x - 8k\tan^2 x + k$

recognizing LHS is quadratic ***(M1)***

eg $4(\tan^2 x)^2 - 8k\tan^2 x + k = 0,\ 4m^2 - 8km + k$

correct substitution into discriminant ***A1***

eg $(-8k)^2 - 4(4)(k)$

correct working to find discriminant or solve discriminant $= 0$ ***(A1)***

eg $64k^2 - 16k,\ \frac{-(-16) \pm \sqrt{16^2}}{2 \times 64}$

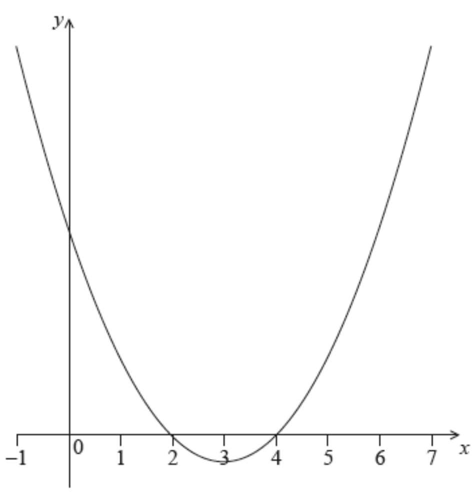
correct simplification ***(A1)***

*eg*x $16k(4k-1),\ \frac{32}{2 \times 64}$

$k = \frac{1}{4}$ ***A1*** ***N2***

[8 marks]

The following diagram shows part of the graph of a quadratic function f.



The vertex is at $(3,\ -1)$ and the x-intercepts at 2 and 4.

The function f can be written in the form $f(x) = (x-h)^2 + k$.

11a. Write down the value of h and of k. *[2 marks]*

Markscheme

$h = 3,\ k = -1$ ***A1A1*** ***N2***

[2 marks]

The function can also be written in the form $f(x) = (x - a)(x - b)$.

11b. Write down the value of a and of b. *[2 marks]*

Markscheme

$a = 2,\ b = 4\ (\text{or } a = 4,\ b = 2)$ ***A1A1*** ***N2***

[2 marks]

11c. Find the y-intercept. *[2 marks]*

Markscheme

attempt to substitute $x = 0$ into their f ***(M1)***

eg $(0 - 3)^2 - 1,\ (0 - 2)(0 - 4)$

$y = 8$ ***A1*** ***N2***

[2 marks]

Let $f(x) = px^2 + (10 - p)x + \frac{5}{4}p - 5$.

12a. Show that the discriminant of $f(x)$ is $100 - 4p^2$. *[3 marks]*

Markscheme

correct substitution into $b^2 - 4ac$ ***A1***

eg $(10 - p)^2 - 4(p)\left(\frac{5}{4}p - 5\right)$

correct expansion of each term ***A1A1***

eg $100 - 20p + p^2 - 5p^2 + 20p,\ 100 - 20p + p^2 - (5p^2 - 20p)$

$100 - 4p^2$ ***AG*** ***N0***

[3 marks]

12b. Find the values of p so that $f(x) = 0$ has two **equal** roots. *[3 marks]*

Markscheme

recognizing discriminant is zero for equal roots ***(R1)***

eg $D = 0,\ 4p^2 = 100$

correct working ***(A1)***

eg $p^2 = 25$, 1 correct value of p

both correct values $p = \pm 5$ ***A1 N2***

[3 marks]

Total [6 marks]

Let $f(x) = x^2 + x - 6$.

13a. Write down the y-intercept of the graph of f. *[1 mark]*

Markscheme

y-intercept is $-6,\ (0,\ -6),\ y = -6$ ***A1***

[1 mark]

13b. Solve $f(x) = 0$. *[3 marks]*

Markscheme

valid attempt to solve ***(M1)***

eg $(x-2)(x+3) = 0,\ x = \frac{-1\pm\sqrt{1+24}}{2}$, one correct answer

$x = 2,\ x = -3$ ***A1A1 N3***

[3 marks]

Let $f(x) = p + \frac{9}{x-q}$, for $x \neq q$. The line $x = 3$ is a vertical asymptote to the graph of f.

14a. Write down the value of q. *[1 mark]*

Markscheme

$q = 3$ ***A1 N1***

[1 mark]

14b. The graph of f has a y-intercept at $(0,\ 4)$. *[4 marks]*

Find the value of p.

Markscheme

correct expression for $f(0)$ ***(A1)***

eg $p + \frac{9}{0-3},\ 4 = p + \frac{9}{-q}$

recognizing that $f(0) = 4$ (may be seen in equation) ***(M1)***

correct working ***(A1)***

eg $4 = p - 3$

$p = 7$ ***A1 N3***

[3 marks]

14c. The graph of f has a y-intercept at $(0,\ 4)$. *[1 mark]*

Write down the equation of the horizontal asymptote of the graph of f.

Markscheme

$y = 7$ (must be an equation, do not accept $p = 7$ ***A1 N1***

[1 mark]

Total [6 marks]

Let $f(x) = a(x-h)^2 + k$. The vertex of the graph of f is at $(2, 3)$ and the graph passes through $(1, 7)$.

15a. Write down the value of h and of k. *[2 marks]*

Markscheme

$h = 2,\ k = 3$ ***A1A1 N2***

[2 marks]

15b. Find the value of a. *[3 marks]*

Markscheme

attempt to substitute
$(1, 7)$ in any order into **their**
$f(x)$ ***(M1)***

eg $7 = a(1-2)^2 + 3, 7 = a(1-3)^2 + 2, 1 = a(7-2)^2 + 3$

correct equation ***(A1)***

eg $7 = a + 3$

a = 4 ***A1 N2***

[3 marks]

Let
$f(x) = px^3 + px^2 + qx$.

16a. Find $f'(x)$. *[2 marks]*

Markscheme

$f'(x) = 3px^2 + 2px + q$ ***A2 N2***

Note: Award ***A1*** if only 1 error.

[2 marks]

16b. Given that $f'(x) \geqslant 0$, show that $p^2 \leqslant 3pq$. *[5 marks]*

Markscheme

evidence of discriminant (must be seen explicitly, not in quadratic formula) ***(M1)***

eg $b^2 - 4ac$

correct substitution into discriminant (may be seen in inequality) ***A1***

eg $(2p)^2 - 4 \times 3p \times q,\ 4p^2 - 12pq$

$f'(x) \geqslant 0$ then f' has two equal roots or no roots ***(R1)***

recognizing discriminant less or equal than zero ***R1***

eg $\Delta \leqslant 0,\ 4p^2 - 12pq \leqslant 0$

correct working that clearly leads to the required answer ***A1***

eg $p^2 - 3pq \leqslant 0,\ 4p^2 \leqslant 12pq$

$p^2 \leqslant 3pq$ ***AG*** ***N0***

[5 marks]

Let
$f(x) = 3x^2 - 6x + p$. The equation
$f(x) = 0$ has two equal roots.

17a. Write down the **value** of the discriminant. *[2 marks]*

Markscheme

correct value 0, or $36 - 12p$ ***A2*** ***N2***

[2 marks]

17b. Hence, show that $p = 3$. *[1 mark]*

Markscheme

correct equation which clearly leads to $p = 3$ ***A1***

eg $36 - 12p = 0,\ 36 = 12p$

$p = 3$ ***AG*** ***N0***

[1 mark]

17c. The graph of f has its vertex on the x-axis. *[4 marks]*

Find the coordinates of the vertex of the graph of f.

Markscheme

METHOD 1

valid approach ***(M1)***

eg $x = -\frac{b}{2a}$

correct working ***A1***

eg $-\frac{(-6)}{2(3)},\ x = \frac{6}{6}$

correct answers ***A1A1 N2***

eg $x = 1,\ y = 0;\ (1,\ 0)$

METHOD 2

valid approach ***(M1)***

eg $f(x) = 0$, factorisation, completing the square

correct working ***A1***

eg $x^2 - 2x + 1 = 0,\ (3x - 3)(x - 1),\ f(x) = 3(x - 1)^2$

correct answers ***A1A1 N2***

eg $x = 1,\ y = 0;\ (1,\ 0)$

METHOD 3

valid approach using derivative ***(M1)***

eg $f'(x) = 0,\ 6x - 6$

correct equation ***A1***

eg $6x - 6 = 0$

correct answers ***A1A1 N2***

eg $x = 1,\ y = 0;\ (1,\ 0)$

[4 marks]

17d. The graph of f has its vertex on the x-axis. *[1 mark]*

Write down the solution of $f(x) = 0$.

Markscheme

$x = 1$ ***A1 N1***

[1 mark]

17e. The graph of f has its vertex on the x-axis. *[1 mark]*

The function can be written in the form $f(x) = a(x - h)^2 + k$. Write down the value of a.

Markscheme

$a = 3$ ***A1*** ***N1***

[1 mark]

17f. The graph of f has its vertex on the x-axis. *[1 mark]*

The function can be written in the form $f(x) = a(x - h)^2 + k$. Write down the value of h.

Markscheme

$h = 1$ ***A1*** ***N1***

[1 mark]

17g. The graph of f has its vertex on the x-axis. *[1 mark]*

The function can be written in the form $f(x) = a(x - h)^2 + k$. Write down the value of k.

Markscheme

$k = 0$ ***A1*** ***N1***

[1 mark]

17h. The graph of f has its vertex on the x-axis. *[4 marks]*

The graph of a function g is obtained from the graph of f by a reflection of f in the x-axis, followed by a translation by the vector $\begin{pmatrix} 0 \\ 6 \end{pmatrix}$. Find g, giving your answer in the form $g(x) = Ax^2 + Bx + C$.

Markscheme

attempt to apply vertical reflection ***(M1)***

eg $-f(x),\ -3(x-1)^2$, sketch

attempt to apply vertical shift 6 units up ***(M1)***

eg $-f(x)+6$, vertex $(1,6)$

transformations performed correctly (in correct order) ***(A1)***

eg $-3(x-1)^2+6,\ -3x^2+6x-3+6$

$g(x)=-3x^2+6x+3$ ***A1*** ***N3***

[4 marks]

18. The equation $x^2+(k+2)x+2k=0$ has two distinct real roots. *[8 marks]*

Find the possible values of k.

Markscheme

evidence of discriminant ***(M1)***

eg $b^2-4ac,\ \Delta=0$

correct substitution into discriminant ***(A1)***

eg $(k+2)^2-4(2k),\ k^2+4k+4-8k$

correct discriminant ***A1***

eg $k^2-4k+4,\ (k-2)^2$

recognizing discriminant is positive ***R1***

eg $\Delta>0,\ (k+2)^2-4(2k)>0$

attempt to solve **their** quadratic in k ***(M1)***

eg factorizing, $k=\frac{4\pm\sqrt{16-16}}{2}$

correct working ***A1***

eg $(k-2)^2>0,\ k=2$, sketch of positive parabola on the *x*-axis

correct values ***A2*** ***N4***

eg $k\in\mathbb{R}$ and $k\neq 2,\ \mathbb{R}\backslash 2,\ ]-\infty,\ 2[\cup]2,\ \infty[$

[8 marks]

Let
$f(x) = 3x - 2$ and
$g(x) = \frac{5}{3x}$, for
$x \neq 0$.

19a. Find $f^{-1}(x)$. *[2 marks]*

Markscheme

interchanging x and y ***(M1)***

eg $x = 3y - 2$

$f^{-1}(x) = \frac{x+2}{3}$ $\left(\text{accept } y = \frac{x+2}{3}, \frac{x+2}{3}\right)$ ***A1 N2***

[2 marks]

19b. Show that $\left(g \circ f^{-1}\right)(x) = \frac{5}{x+2}$. *[2 marks]*

Markscheme

attempt to form composite (in any order) ***(M1)***

eg $g\left(\frac{x+2}{3}\right)$, $\frac{\frac{5}{3x}+2}{3}$

correct substitution ***A1***

eg $\frac{5}{3\left(\frac{x+2}{3}\right)}$

$\left(g \circ f^{-1}\right)(x) = \frac{5}{x+2}$ ***AG N0***

[2 marks]

Let
$h(x) = \frac{5}{x+2}$, for
$x \geqslant 0$. The graph of *h* has a horizontal asymptote at
$y = 0$.

19c. Find the y-intercept of the graph of h. *[2 marks]*

Markscheme

valid approach ***(M1)***

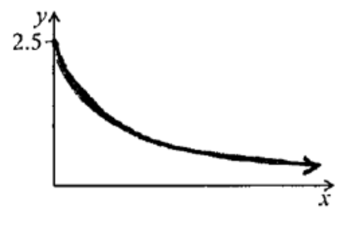
eg $h(0)$, $\frac{5}{0+2}$

$y = \frac{5}{2}$ $(\text{accept } (0, 2.5))$ ***A1 N2***

[2 marks]

19d. Hence, sketch the graph of h. *[3 marks]*

Markscheme



A1A2 ***N3***

Notes: Award ***A1*** for approximately correct shape (reciprocal, decreasing, concave up).

Only if this ***A1*** is awarded, award ***A2*** for all the following approximately correct features: *y*-intercept at $(0, 2.5)$, asymptotic to *x*-axis, correct domain $x \geqslant 0$.

If only two of these features are correct, award ***A1***.

[3 marks]

19e. For the graph of h^{-1}, write down the x-intercept; *[1 mark]*

Markscheme

$x = \frac{5}{2}$ $(\text{accept } (2.5, 0))$ ***A1*** ***N1***

[1 mark]

19f. For the graph of h^{-1}, write down the equation of the vertical asymptote. *[1 mark]*

Markscheme

$x = 0$ (must be an equation) ***A1*** ***N1***

[1 mark]

19g. Given that $h^{-1}(a) = 3$, find the value of a. *[3 marks]*

Markscheme

METHOD 1

attempt to substitute 3 into h (seen anywhere) ***(M1)***

eg $h(3),\ \frac{5}{3+2}$

correct equation ***(A1)***

eg $a = \frac{5}{3+2},\ h(3) = a$

$a = 1$ ***A1 N2***

[3 marks]

METHOD 2

attempt to find inverse (may be seen in (d)) ***(M1)***

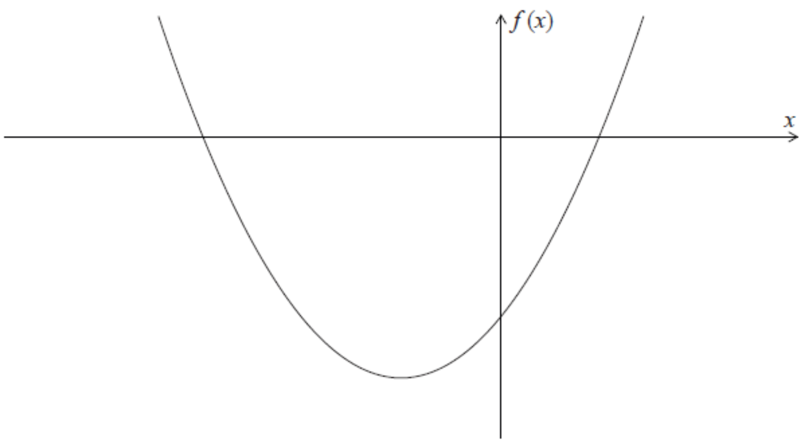
eg $x = \frac{5}{y+2},\ h^{-1} = \frac{5}{x} - 2,\ \frac{5}{x} + 2$

correct equation, $\frac{5}{x} - 2 = 3$ ***(A1)***

$a = 1$ ***A1 N2***

[3 marks]

The diagram below shows part of the graph of
$f(x) = (x-1)(x+3)$.



20a. (a) Write down the x-intercepts of the graph of f . *[6 marks]*

(b) Find the coordinates of the vertex of the graph of f .

Markscheme

(a) $x = 1$, $x = -3$ (accept $(1, 0)$, $(-3, 0)$) ***A1A1*** ***N2***

[2 marks]

(b) **METHOD 1**

attempt to find x-coordinate ***(M1)***

eg $\frac{1+-3}{2}$, $x = \frac{-b}{2a}$, $f'(x) = 0$

correct value, $x = -1$ (may be seen as a coordinate in the answer) ***A1***

attempt to find **their** y-coordinate ***(M1)***

eg $f(-1)$, -2×2 , $y = \frac{-D}{4a}$

$y = -4$ ***A1***

vertex $(-1, -4)$ ***N3***

METHOD 2

attempt to complete the square ***(M1)***

eg $x^2 + 2x + 1 - 1 - 3$

attempt to put into vertex form ***(M1)***

eg $(x + 1)^2 - 4$, $(x - 1)^2 + 4$

vertex $(-1, -4)$ ***A1A1*** ***N3***

[4 marks]

20b. Write down the x-intercepts of the graph of f . *[2 marks]*

Markscheme

$x = 1$, $x = -3$ (accept $(1, 0)$, $(-3, 0)$) ***A1A1*** ***N2***

[2 marks]

20c. Find the coordinates of the vertex of the graph of f . *[4 marks]*

Markscheme

METHOD 1

attempt to find x-coordinate ***(M1)***

eg $\frac{1+-3}{2}$, $x = \frac{-b}{2a}$, $f'(x) = 0$

correct value, $x = -1$ (may be seen as a coordinate in the answer) ***A1***

attempt to find **their** y-coordinate ***(M1)***

eg $f(-1)$, -2×2 , $y = \frac{-D}{4a}$

$y = -4$ ***A1***

vertex $(-1, -4)$ ***N3***

METHOD 2

attempt to complete the square ***(M1)***

eg $x^2 + 2x + 1 - 1 - 3$

attempt to put into vertex form ***(M1)***

eg $(x+1)^2 - 4$, $(x-1)^2 + 4$

vertex $(-1, -4)$ ***A1A1*** ***N3***

[4 marks]

21a. Find the value of $\log_2 40 - \log_2 5$. *[3 marks]*

Markscheme

evidence of correct formula ***(M1)***

eg $\log a - \log b = \log \frac{a}{b}$, $\log\left(\frac{40}{5}\right)$, $\log 8 + \log 5 - \log 5$

Note: Ignore missing or incorrect base.

correct working ***(A1)***

eg $\log_2 8$, $2^3 = 8$

$\log_2 40 - \log_2 5 = 3$ ***A1*** ***N2***

[3 marks]

21b. Find the value of $8^{\log_2 5}$. *[4 marks]*

Markscheme

attempt to write 8 as a power of 2 (seen anywhere)   ***(M1)***

eg $(2^3)^{\log_2 5}$, $2^3 = 8$, 2^a

multiplying powers   ***(M1)***

eg $2^{3\log_2 5}$, $a\log_2 5$

correct working   ***(A1)***

eg $2^{\log_2 125}$, $\log_2 5^3$, $\left(2^{\log_2 5}\right)^3$

$8^{\log_2 5} = 125$ ***A1***   ***N3***

[4 marks]

Let
$f(x) = \sin x + \frac{1}{2}x^2 - 2x$, for
$0 \le x \le \pi$.

22a. Find $f'(x)$.   *[3 marks]*

Markscheme

$f'(x) = \cos x + x - 2$ ***A1A1A1***   ***N3***

Note: Award ***A1*** for each term.

[3 marks]

Let
g be a quadratic function such that
$g(0) = 5$. The line
$x = 2$ is the axis of symmetry of the graph of
g .

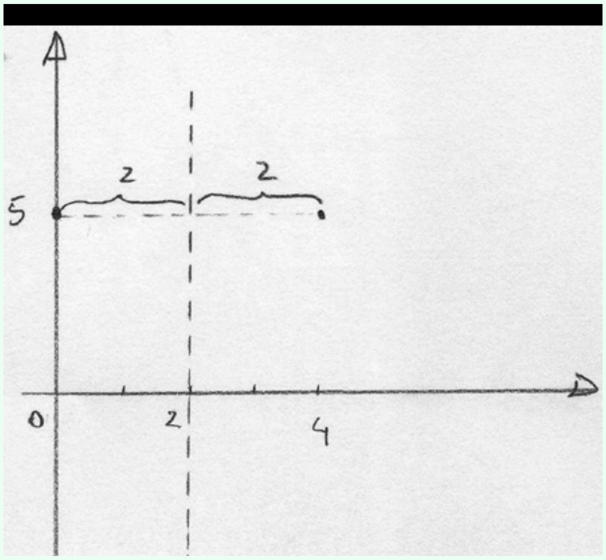
22b. Find $g(4)$.   *[3 marks]*

Markscheme

recognizing $g(0) = 5$ gives the point $(0, 5)$ ***(R1)***

recognize symmetry ***(M1)***

eg vertex, sketch



$g(4) = 5$ ***A1*** ***N3***

[3 marks]

The function
g can be expressed in the form
$g(x) = a(x - h)^2 + 3$.

22c. (i) Write down the value of h . *[4 marks]*

(ii) Find the value of a .

Markscheme

(i) $h = 2$ ***A1 N1***

(ii) substituting into $g(x) = a(x - 2)^2 + 3$ (not the vertex) ***(M1)***

eg $5 = a(0 - 2)^2 + 3$, $5 = a(4 - 2)^2 + 3$

working towards solution ***(A1)***

eg $5 = 4a + 3$, $4a = 2$

$a = \frac{1}{2}$ ***A1*** ***N2***

[4 marks]

22d. Find the value of x for which the tangent to the graph of f is parallel to the tangent to the graph of g. *[6 marks]*

Markscheme

$g(x) = \frac{1}{2}(x-2)^2 + 3 = \frac{1}{2}x^2 - 2x + 5$

correct derivative of g ***A1A1***

eg $2 \times \frac{1}{2}(x-2)$, $x-2$

evidence of equating both derivatives ***(M1)***

eg $f' = g'$

correct equation ***(A1)***

eg $\cos x + x - 2 = x - 2$

working towards a solution ***(A1)***

eg $\cos x = 0$, combining like terms

$x = \frac{\pi}{2}$ ***A1*** ***N0***

Note: Do not award final ***A1*** if additional values are given.

[6 marks]

---

23. The equation $x^2 - 3x + k^2 = 4$ has two distinct real roots. Find the possible values of k. *[6 marks]*

Markscheme

evidence of rearranged quadratic equation (may be seen in working) ***A1***

e.g. $x^2 - 3x + k^2 - 4 = 0$, $k^2 - 4$

evidence of discriminant (must be seen explicitly, not in quadratic formula) ***(M1)***

e.g. $b^2 - 4ac$, $\Delta = (-3)^2 - 4(1)(k^2 - 4)$

recognizing that discriminant is greater than zero (seen anywhere, including answer) ***R1***

e.g. $b^2 - 4ac > 0$, $9 + 16 - 4k^2 > 0$

correct working (accept equality) ***A1***

e.g. $25 - 4k^2 > 0$, $4k^2 < 25$, $k^2 = \frac{25}{4}$

both correct values (even if inequality never seen) ***(A1)***

e.g. $\pm\sqrt{\frac{25}{4}}$, ± 2.5

correct interval ***A1*** ***N3***

e.g. $-\frac{5}{2} < k < \frac{5}{2}$, $-2.5 < k < 2.5$

Note: Do not award the final mark for unfinished values, or for incorrect or reversed inequalities, including $\leq$, $k > -2.5$, $k < 2.5$.

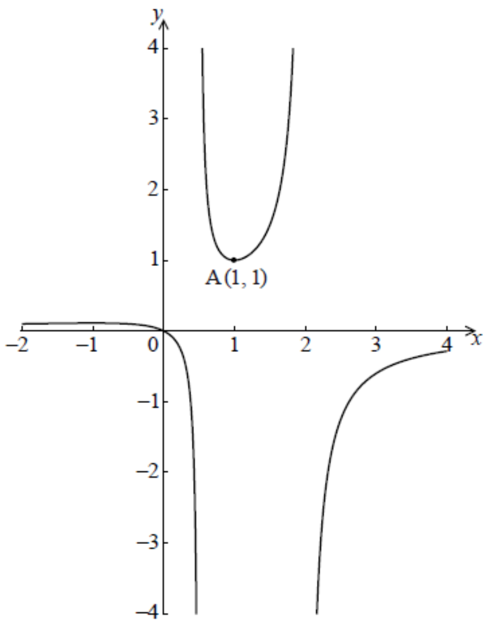
Special cases:

If working shown, and candidates attempt to rearrange the quadratic equation to equal zero, but find an incorrect value of *c*, award ***A1M1R1A0A0A0***.

If working shown, and candidates do not rearrange the quadratic equation to equal zero, but find $c = k^2$ or $c = \pm 4$, award ***A0M1R1A0A0A0***.

[6 marks]

Let
$f(x) = \frac{x}{-2x^2+5x-2}$ for
$-2 \le x \le 4$,
$x \ne \frac{1}{2}$,
$x \ne 2$. The graph of
f is given below.



The graph of
f has a local minimum at A(
1,
1) and a local maximum at B.

24a. Use the quotient rule to show that $f'(x) = \frac{2x^2-2}{(-2x^2+5x-2)^2}$. *[6 marks]*

Markscheme

correct derivatives **applied** in quotient rule ***(A1)A1A1***

$1, -4x+5$

Note: Award ***(A1)*** for 1, ***A1*** for $-4x$ and ***A1*** for 5, **only** if it is clear candidates are using the quotient rule.

correct substitution into quotient rule ***A1***

e.g. $\frac{1\times(-2x^2+5x-2)-x(-4x+5)}{(-2x^2+5x-2)^2}$, $\frac{-2x^2+5x-2-x(-4x+5)}{(-2x^2+5x-2)^2}$

correct working ***(A1)***

e.g. $\frac{-2x^2+5x-2-(-4x^2+5x)}{(-2x^2+5x-2)^2}$

expression clearly leading to the answer ***A1***

e.g. $\frac{-2x^2+5x-2+4x^2-5x}{(-2x^2+5x-2)^2}$

$f'(x)=\frac{2x^2-2}{(-2x^2+5x-2)^2}$ ***AG N0***

[6 marks]

24b. Hence find the coordinates of B. *[7 marks]*

Markscheme

evidence of attempting to solve $f'(x)=0$ ***(M1)***

e.g. $2x^2-2=0$

evidence of correct working ***A1***

e.g. $x^2=1, \frac{\pm\sqrt{16}}{4}, 2(x-1)(x+1)$

correct solution to quadratic ***(A1)***

e.g. $x=\pm1$

correct *x*-coordinate $x=-1$ (may be seen in coordinate form $\left(-1,\frac{1}{9}\right)$) ***A1 N2***

attempt to substitute -1 into *f* (do not accept any other value) ***(M1)***

e.g. $f(-1)=\frac{-1}{-2\times(-1)^2+5\times(-1)-2}$

correct working

e.g. $\frac{-1}{-2-5-2}$ ***A1***

correct *y*-coordinate $y=\frac{1}{9}$ (may be seen in coordinate form $\left(-1,\frac{1}{9}\right)$) ***A1 N2***

[7 marks]

24c. Given that the line $y=k$ does not meet the graph of *f*, find the possible values of *k*. *[3 marks]*

Markscheme

recognizing values between max and min ***(R1)***

$\frac{1}{9} < k < 1$ ***A2*** ***N3***

[3 marks]

25. Consider the equation $x^2 + (k-1)x + 1 = 0$, where k is a real number. *[7 marks]*

Find the values of k for which the equation has two **equal** real solutions.

Markscheme

METHOD 1

evidence of valid approach ***(M1)***

e.g. $b^2 - 4ac$, quadratic formula

correct substitution into $b^2 - 4ac$ (may be seen in formula) ***(A1)***

e.g. $(k-1)^2 - 4 \times 1 \times 1$, $(k-1)^2 - 4$, $k^2 - 2k - 3$

setting **their** discriminant equal to zero ***M1***

e.g. $\Delta = 0, (k-1)^2 - 4 = 0$

attempt to solve the quadratic ***(M1)***

e.g. $(k-1)^2 = 4$, factorizing

correct working ***A1***

e.g. $(k-1) = \pm 2$, $(k-3)(k+1)$

$k = -1$, $k = 3$ (do not accept inequalities) ***A1A1*** ***N2***

[7 marks]

METHOD 2

recognizing perfect square ***(M1)***

e.g. $(x+1)^2 = 0$, $(x-1)^2$

correct expansion ***(A1)(A1)***

e.g. $x^2 + 2x + 1 = 0$, $x^2 - 2x + 1$

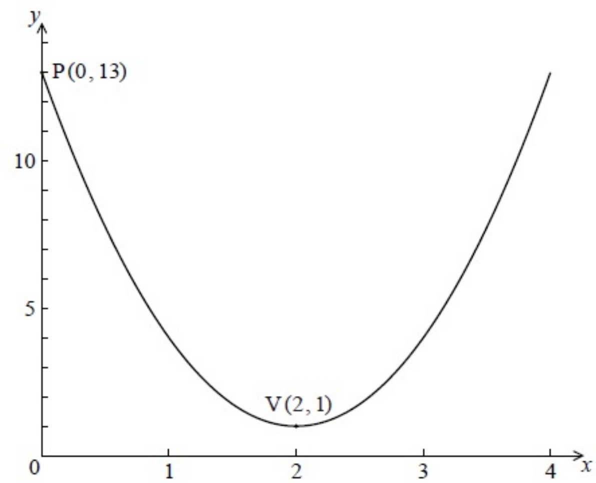
equating coefficients of x ***A1A1***

e.g. $k - 1 = -2$, $k - 1 = 2$

$k = -1$, $k = 3$ ***A1A1*** ***N2***

[7 marks]

The following diagram shows the graph of a quadratic function *f* , for
$0 \leq x \leq 4$.



The graph passes through the point P(0, 13) , and its vertex is the point V(2, 1) .

26a. The function can be written in the form $f(x) = a(x - h)^2 + k$. *[4 marks]*

(i) Write down the value of *h* and of *k* .

(ii) Show that $a = 3$.

Markscheme

(i) $h = 2$, $k = 1$ ***A1A1 N2***

(ii) attempt to substitute coordinates of any point (except the vertex) on the graph into *f* ***M1***

e.g. $13 = a(0 - 2)^2 + 1$

working towards solution ***A1***

e.g. $13 = 4a + 1$

$a = 3$ ***AG N0***

[4 marks]

26b. Find $f(x)$, giving your answer in the form $Ax^2 + Bx + C$. *[3 marks]*

Markscheme

attempting to expand **their** binomial ***(M1)***

e.g. $f(x) = 3(x^2 - 2 \times 2x + 4) + 1$, $(x-2)^2 = x^2 - 4x + 4$

correct working ***(A1)***

e.g. $f(x) = 3x^2 - 12x + 12 + 1$

$f(x) = 3x^2 - 12x + 13$ (accept $A = 3$, $B = -12$, $C = 13$) ***A1*** ***N2***

[3 marks]

26c. Calculate the area enclosed by the graph of f, the x-axis, and the lines $x = 2$ and $x = 4$. *[8 marks]*

Markscheme

METHOD 1

integral expression ***(A1)***

e.g. $\int_2^4 (3x^2 - 12x + 13)$, $\int f \mathrm{d}x$

$\text{Area} = [x^3 - 6x^2 + 13x]_2^4$ ***A1A1A1***

Note: Award ***A1*** for x^3 , ***A1*** for $-6x^2$, ***A1*** for $13x$.

correct substitution of **correct** limits into **their** expression ***A1A1***

e.g. $(4^3 - 6 \times 4^2 + 13 \times 4) - (2^3 - 6 \times 2^2 + 13 \times 2)$, $64 - 96 + 52 - (8 - 24 + 26)$

Note: Award ***A1*** for substituting 4, ***A1*** for substituting 2.

correct working ***(A1)***

e.g. $64 - 96 + 52 - 8 + 24 - 26, 20 - 10$

$\text{Area} = 10$ ***A1*** ***N3***

[8 marks]

METHOD 2

integral expression ***(A1)***

e.g. $\int_2^4 (3(x-2)^2 + 1)$, $\int f \mathrm{d}x$

$\text{Area} = [(x-2)^3 + x]_2^4$ ***A2A1***

Note: Award ***A2*** for $(x-2)^3$, ***A1*** for x .

correct substitution of **correct** limits into **their** expression ***A1A1***

e.g. $(4-2)^3 + 4 - [(2-2)^3 + 2]$, $2^3 + 4 - (0^3 + 2)$, $2^3 + 4 - 2$

Note: Award ***A1*** for substituting 4, ***A1*** for substituting 2.

correct working ***(A1)***

e.g. $8+4-2$

$\text{Area}=10$ ***A1*** ***N3***

[8 marks]

METHOD 3

recognizing area from 0 to 2 is same as area from 2 to 4 ***(R1)***

e.g. sketch, $\int_2^4 f=\int_0^2 f$

integral expression ***(A1)***

e.g. $\int_0^2 (3x^2-12x+13)$, $\int f\mathrm{d}x$

$\text{Area}=[x^3-6x^2+13x]_0^2$ ***A1A1A1***

Note: Award ***A1*** for x^3 , ***A1*** for $-6x^2$, ***A1*** for $13x$.

correct substitution of **correct** limits into **their** expression ***A1(A1)***

e.g. $(2^3-6\times 2^2+13\times 2)-(0^3-6\times 0^2+13\times 0)$, $8-24+26$

Note: Award ***A1*** for substituting 2, ***(A1)*** for substituting 0.

$\text{Area}=10$ ***A1*** ***N3***

[8 marks]