1. (a) $(1, -2)$ A1A1 N2 2

(b) $g(x) = 3(x-1)^2 - 2$ (accept $p = 1$, $q = -2$) A1A1 N2 2

(c) $(1, 2)$ A1A1 N2 2

[6]

2. (a) $f'(x) = x^2 - 2x - 3$ A1A1A1

evidence of solving $f'(x) = 0$ (M1)

e.g. $x^2 - 2x - 3 = 0$

evidence of correct working A1

e.g. $(x+1)(x-3)$, $\frac{2 \pm \sqrt{16}}{2}$

$x = -1$ (ignore $x = 3$) (A1)

evidence of substituting **their negative** x-value into $f(x)$ (M1)

e.g. $\frac{1}{3}(-1)^3 - (-1)^2 - 3(-1)$, $-\frac{1}{3} - 1 + 3$

$y = \frac{5}{3}$ A1

coordinates are $\left(-1, \frac{5}{3}\right)$ N3

(b) (i) $(-3, -9)$ A1 N1

(ii) $(1, -4)$ A1A1 N2

(iii) reflection gives $(3, 9)$ (A1)

stretch gives $\left(\frac{3}{2}, 9\right)$ A1A1 N3

[14]

3. (a) attempt to form composition (in any order) (M1)

$(f \circ g)(x) = (x-1)^2 + 4$ $(x^2 - 2x + 5)$ A1 N2

(b) **METHOD 1**

vertex of $f \circ g$ at (1, 4) (A1)

evidence of appropriate approach (M1)

e.g. adding $\begin{pmatrix} 3 \\ -1 \end{pmatrix}$ to the coordinates of the vertex of $f \circ g$

vertex of h at (4, 3) A1 N3

METHOD 2

attempt to find $h(x)$ (M1)

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

$h(x) = (x-4)^2 + 3$ (A1)

vertex of h at (4, 3) A1 N3

(c) evidence of appropriate approach (M1)

e.g. $(x-4)^2 + 3$, $(x-3)^2 - 2(x-3) + 5 - 1$

simplifying A1

e.g. $h(x) = x^2 - 8x + 16 + 3$, $x^2 - 6x + 9 - 2x + 6 + 4$

$h(x) = x^2 - 8x + 19$ AG N0

(d) **METHOD 1**

equating functions to find intersection point (M1)

e.g. $x^2 - 8x + 19 = 2x - 6$, $y = h(x)$

$x^2 - 10x + 25 = 0$ A1

evidence of appropriate approach to solve (M1)

e.g. factorizing, quadratic formula

appropriate working A1

e.g. $(x-5)^2 = 0$

$x = 5$ ($p = 5$) A1 N3

METHOD 2

attempt to find $h'(x)$ (M1)

$h'(x) = 2x - 8$ A1

recognizing that the gradient of the tangent is the derivative (M1)

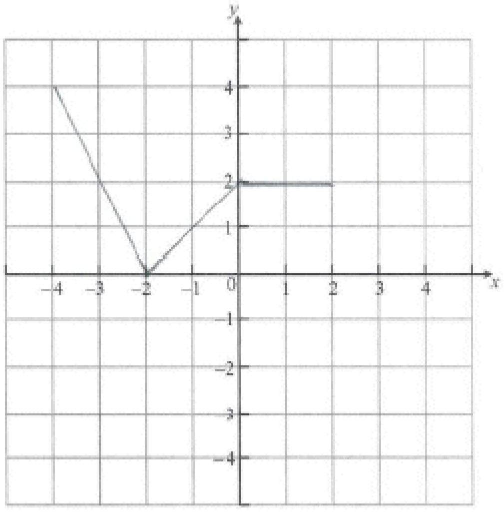
e.g. gradient at $p = 2$

$2x - 8 = 2$ ($2x = 10$) A1

$x = 5$ A1 N3

[12]

4. (a)



A2 N2

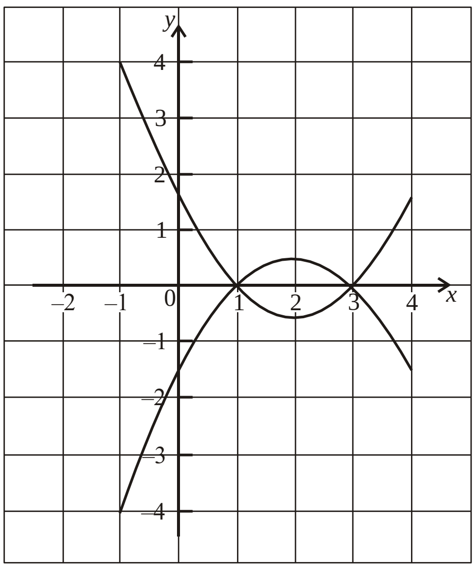
(b) evidence of appropriate approach (M1)

e.g. reference to any horizontal shift and/or stretch factor, $x = 3 + 1$, $y = \frac{1}{2} \times 2$

P is (4, 1) (accept $x = 4$, $y = 1$) A1A1 N3

[5]

5. (a)



M1A1 N2

Note: *Award M1 for evidence of reflection in x-axis, A1 for correct vertex* ***and*** *all intercepts approximately correct.*

(b) (i) $g(-3) = f(0)$ (A1)

$f(0) = -1.5$ A1 N2

(ii) translation (accept shift, slide, *etc*.) of $\begin{pmatrix} -3 \\ 0 \end{pmatrix}$ A1A1 N2

[6]

6. (a) For a reasonable attempt to complete the square, (or expanding) (M1)

e.g. $3x^2 - 12x + 11 = 3(x^2 - 4x + 4) + 11 - 12$

$f(x) = 3(x - 2)^2 - 1$ (accept $h = 2$, $k = 1$) A1A1 N3

(b) **METHOD 1**

Vertex shifted to $(2 + 3, -1 + 5) = (5, 4)$ M1

so the new function is $3(x - 5)^2 + 4$ (accept $p = 5$, $q = 4$) A1A1 N2

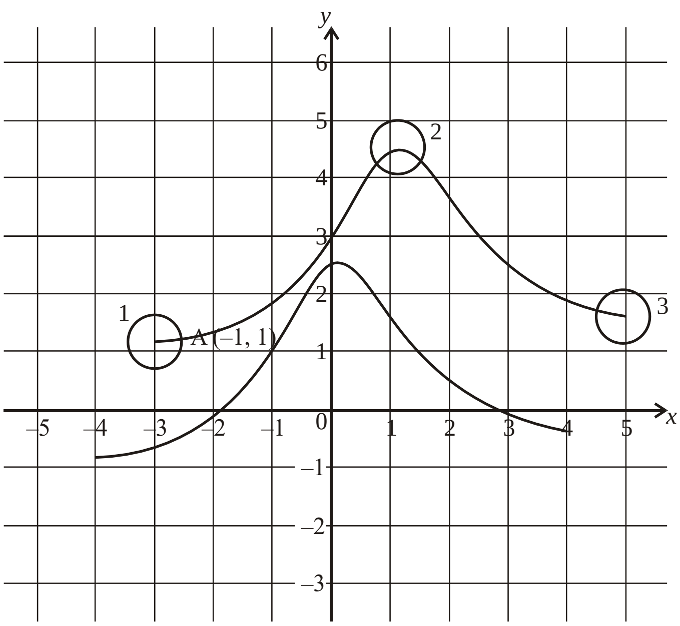
METHOD 2

$g(x) = 3((x - 3) - h)^2 + k + 5 = 3((x - 3) - 2)^2 - 1 + 5$ M1

$= 3(x - 5)^2 + 4$ (accept $p = 5$, $q = 4$) A1A1 N2

[6]

7. (a)



A1A1A1 N3

***Notes**: Award A1 for left end point in circle 1,*

A1 for maximum point in circle 2,

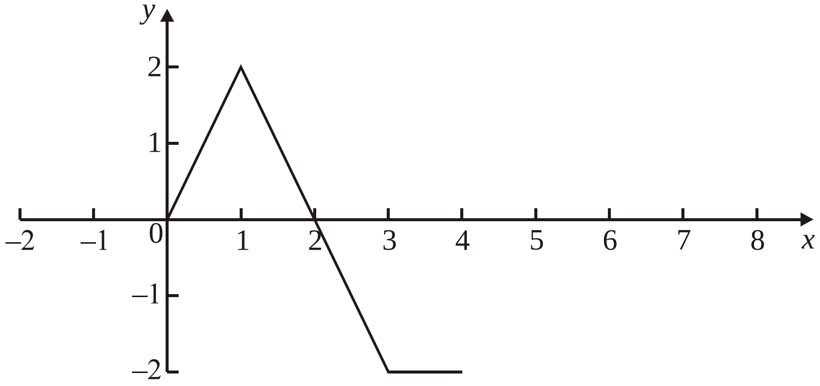
A1 for right end point in circle 3.

(b) $y = 1$ (must be an equation) A1 N1

(c) (0, 3) A1A1 N2

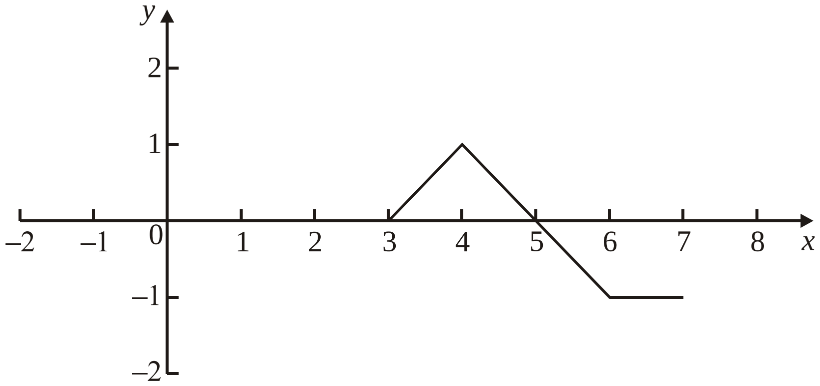
[6]

8. (a) (i)



(A2) (C2)

(ii)

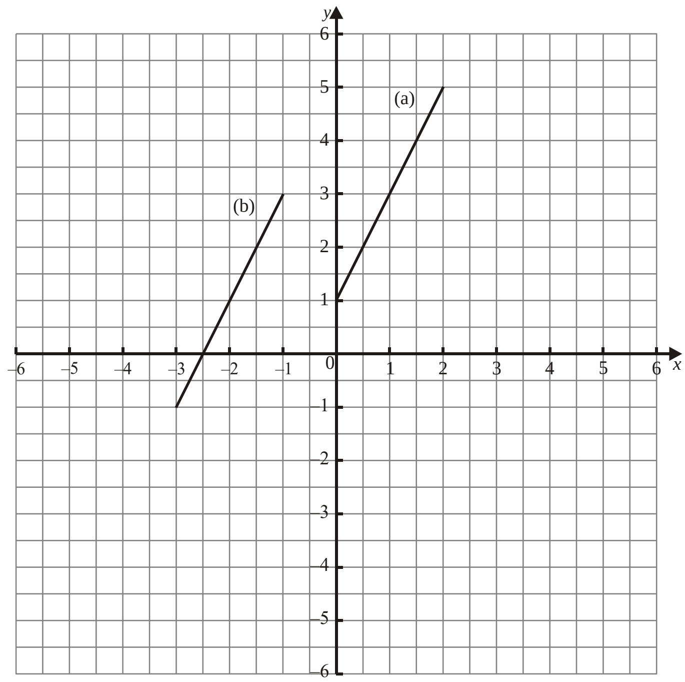


(A2) (C2)

(b) A′ (3, 2) (Accept $x = 3$, $y = 2$) (A1)(A1) (C2)

[6]

9.



(a) (A1)(A1) (C2)

(b) (A1)(A3) (C4)

(a) ***Note:*** *Award (A1) for the correct line, (A1) for using the given domain.*

(b) Correct domain (A1)

EITHER

The correct line drawn (A3)

OR

$g(x) = f(x + 3) - 2$

$= (2(x + 3) + 1) - 2$ (M1)

$= 2x + 5$ (A1)

Candidate's line drawn (A1)

OR

$g(-3) = -1 \quad g(-1) = 3$ (A1)(A1)

Line joining $g(-3)$ and $g(-1)$ drawn (A1)

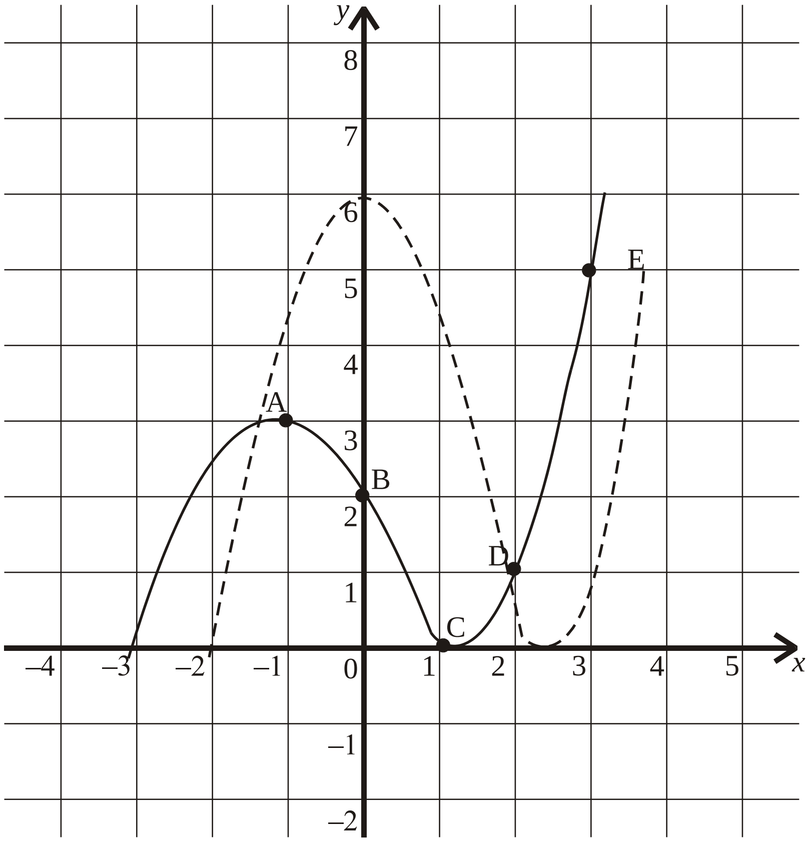
[6]

10. (a) $g(x) = 2f(x - 1)$

x	0	1	2	3
$x - 1$	–1	0	1	2
$f(x - 1)$	3	2	0	1

$g(0) = 2f(-1) = 6$ (A1) (C1)
$g(1) = 2f(0) = 4$ (A1) (C1)
$g(2) = 2f(1) = 0$ (A1) (C1)
$g(3) = 2f(2) = 2$ (A1) (C1)

(b) Graph passing through (0, 6), (1, 4), (2, 0), (3, 2) (A1)
Correct shape. (A1)



(C2)

[6]