5. Quadratics and Polynomials

Section A - Revision Section

This section will help you revise previous learning which is required in this topic

R1 I have had experience of factorising. (common factor, difference of two squares and quadratic trinomials).

1. Factorise fully

(a) $98 - 8x^2$	**(b)** $5s^2 - 5t^2$	**(c)** $98 - 2x^2$
(d) $75x^2 - 243$	**(e)** $72 - 18x^2$	**(f)** $12x - 3x^3$
(g) $81 - x^4$	**(h)** $27w - 12w^3$	**(i)** $64a^4 - 4$

2. Factorise fully

(a) $2x^2 - 7x + 3$	**(b)** $2x^2 + 11x + 12$	**(c)** $3x^2 + 10x + 8$
(d) $x^2 + x - 6$	**(e)** $6x^2 + 7x + 2$	**(f)** $x^2 - 3x + 2$
(g) $5x^2 + 4x - 1$	**(h)** $7x^2 + 16x + 4$	**(i)** $2x^2 + 7x - 15$

3. Factorise fully

(a) $6 - x - x^2$	**(b)** $20 + 11x - 3x^2$	**(c)** $3 + x - 2x^2$
(d) $15 - 7x - 2x^2$	**(e)** $4 - 7x - 2x^2$	**(f)** $15 - 2x - x^2$

4. Factorise fully

(a) $3x^2 + 6x - 24$	**(b)** $15x^2y + 5x$	**(c)** $2x^2 - 32$
(d) $5x^3 - 45x$	**(e)** $18x^2 - 6x - 12$	**(f)** $12x^2y + 8xy^3$
(g) $10x^2 + 25x - 15$	**(h)** $6x^3 + 30x^2 + 36x$	**(i)** $7x^2 - 28$
(j) $2x^2 - 10x + 12$	**(k)** $3x^3 + 21x^2 + 30x$	**(l)** $6x^3 - 54x$

Quadratics and Polynomials

R2 I have revised solving Quadratic Equations

1. Solve each of these quadratic equations

(a) $x^2 + 7x + 12 = 0$ **(b)** $x^2 - 4 = 0$ **(c)** $n^2 + 3n + 2 = 0$

(d) $5x^2 + 15x = 0$ **(e)** $p^2 + 11p + 24 = 0$ **(f)** $12a - 3a^2 = 0$

(g) $s^2 + 6s + 8 = 0$ **(h)** $r^2 - 25 = 0$ **(i)** $n^2 + 5n + 6 = 0$

2. Solve each of these quadratic equations

(a) $x^2 - 11x + 24 = 0$ **(b)** $4x^2 - 9 = 0$ **(c)** $n^2 + 3n - 10 = 0$

(d) $5x^2 + 3x = 0$ **(e)** $p^2 - 10p + 24 = 0$ **(f)** $5a^2 - 20 = 0$

(g) $2n^2 + 7n + 3 = 0$ **(h)** $5r^2 + 7r + 2 = 0$ **(i)** $3n^2 - 4n + 1 = 0$

(j) $n^2 + 8n = -15$ **(k)** $5r^2 - 44r + 120 = -30 + 11r$

3. Solve these equations giving your answer to 2 significant figures.

(a) $x^2 - 3x - 1 = 0$ **(b)** $2x^2 + 5x + 1 = 0$ **(c)** $5x^2 - 7x - 2 = 0$

4. Solve these equations giving your answer to 3 significant figures.

(a) $3x^2 - 10x = -2$ **(b)** $2x^2 = 6x - 3$ **(c)** $4x^2 + x = 1$

R3 I have revised using the discriminant to find the nature of the roots of a quadratic.

Determine the nature of the roots of each quadratic equation using the discriminant.

(a) $x^2 + 8x + 16 = 0$ (b) $x^2 - 3x + 4 = 0$

(c) $2x^2 + 3x - 4 = 0$ (d) $3x^2 - 7x + 2 = 0$

(e) $x^2 - 5x + 3 = 0$ (f) $2x^2 - 4x + 2 = 0$

(g) $4 - 2x - x^2 = 0$ (h) $3 - 3x + 7x^2 = 0$

Quadratics and Polynomials

R4 **I have revised how to determine where quadratic graph cuts the axes, its turning point and its axis of symmetry.**

1. Sketch the graph of $y = (x+3)(x-1)$ showing clearly where the graph cuts the axes, the axis of symmetry and the coordinates of the turning point.

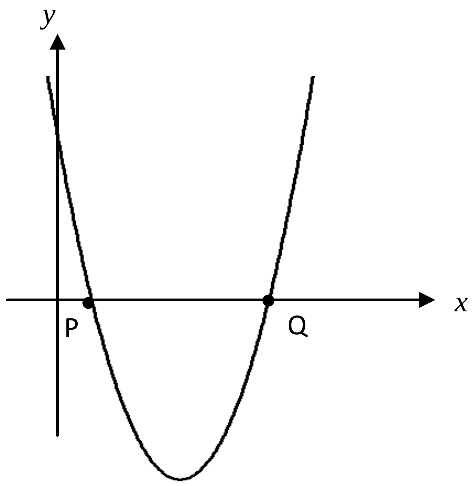
2. Sketch the graph of $y = (x+3)^2 + 6$ showing clearly the coordinates of the turning point and the axis of symmetry.

3. The graph below shows part of a parabola with equation of the form $y = (x+a)^2 + b$.

The equation of the axis of symmetry of the parabola is $x = 3$.

(a) State the value of a.

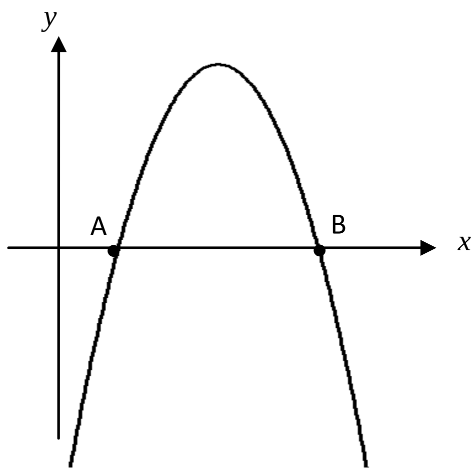
(b) P is the point (1, 0). State the coordinates of Q.



4. The graph below shows part of a parabola with equation of the form $y = -(x-6)(2-x)$.

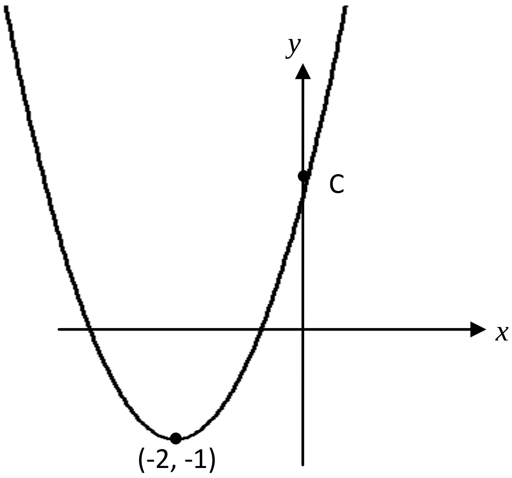
(a) State the coordinates of A and B.

(b) State the equation of the axis of symmetry.



Quadratics and Polynomials

5. The graph below shows part of a parabola with equation of the form $y = (x + a)^2 + b$.

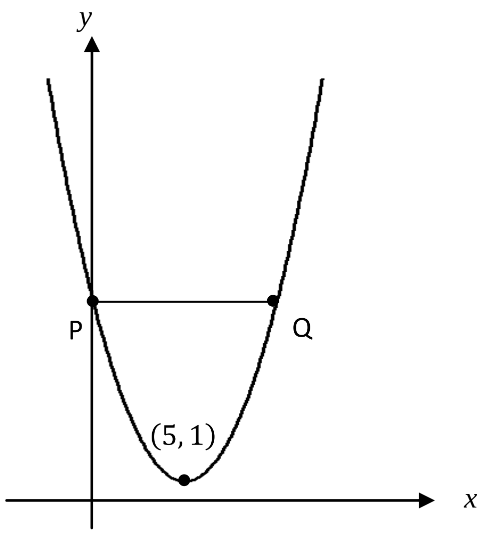


(a) Write down the equation of the axis of symmetry.

(b) Write down the equation of the parabola.

(c) Find the coordinates of C.

6. The graph below shows part of a parabola with equation of the form $y = (x + a)^2 + b$.



(a) State the values of a and b.

(b) State the equation of the axis of symmetry.

(c) The line PQ is parallel to the x-axis.

Find the coordinates of P and Q.

Quadratics and Polynomials

R5 I have revised points of intersection of straight lines.

Find the point of intersection between the following straight lines

(1) $5x + 2y = 9$

$2x + 3y = 8$

(2) $3x + 5y = 22$

$5x - 2y = 16$

(3) $5x - 3y = 12$

$7x - 2y = 19$

(4) $4x - 5y = -22$

$3x + 2y = -5$

(5) $7x + 8y = -5$

$9x + 10y = -7$

(6) $6x + 5y - 9 = 0$

$2y - 9x + 42 = 0$

(7) $y = 2x + 8$

$x - y = -5$

(8) $y = 3x - 14$

$x - 2y = 13$

Quadratics and Polynomials

Section B - Assessment Standard Section

This section will help you practise for your Assessment Standard Test for Quadratics and Polynomials (Relationships and Calculus 1.1)

1. **(a)** **(i)** Show that $(x-1)$ is a factor of $f(x) = x^3 - 6x^2 + 11x - 6$.

(ii) Hence factorise $f(x)$ fully.

(b) Solve $x^3 - 6x^2 + 11x - 6 = 0$.

2. **(a)** Show that $x = 1$ is a root of $x^3 + 8x^2 + 11x - 20 = 0$.

(b) Hence factorise $x^3 + 8x^2 + 11x - 20$ fully.

3. Solve the cubic equation $f(x) = 0$ given the following:

- When $f(x)$ is divided by $2x - 1$, the remainder is zero
- $(x + 3)$ is a factor of $f(x)$
- the graph of $y = f(x)$ passes through the point $(2, 0)$.

4. State the cubic equation $f(x)$ given the following:

- $x = 1$ is a root of $f(x)$
- the graph of $y = f(x)$ passes through the point $(-4, 0)$
- when $f(x)$ is divided by $x + 5$, the remainder is zero.

5. Find the value of k for which $2x^2 + 4x - k = 0$ has equal roots.

6. Find the values of k so that the graph of $y = kx^2 - 2x + 3$ does not cut or touch the x-axis.

Quadratics and Polynomials

Section C – Operational Skills Section

This section provides problems with the operational skills associated with Quadratics and polynomials.

O1	***Given the nature of the roots of a quadratic equation, I can use the discriminant to find an unknown.***

1. Find the value of k for which equation $2x^2 - 3k = 4x^2 + k^2 - 2k$ has equal roots. $k \neq 0$.

2. Find the smallest integer value of k for which

$f(x) = (x-2)(x^2 - 2x + k)$ has equal roots.

3. Find the values of k which ensures the following equation has equal roots

$$\frac{(x-3)^2}{x^2+3} = k.$$

4. Find two values of p for which the equation

$$p^2x^2 + 2(p+1)x + 4 = 0$$

has equal roots and solve the equation for x in each case.

5. If the roots of the equation $(x-1)(x+k) = -9$ are equal, find the values of k.

6. Find k, if the roots of the quadratic equation

$$2x^2 + (4k+2)x + 2k^2 = 0$$

are not real.

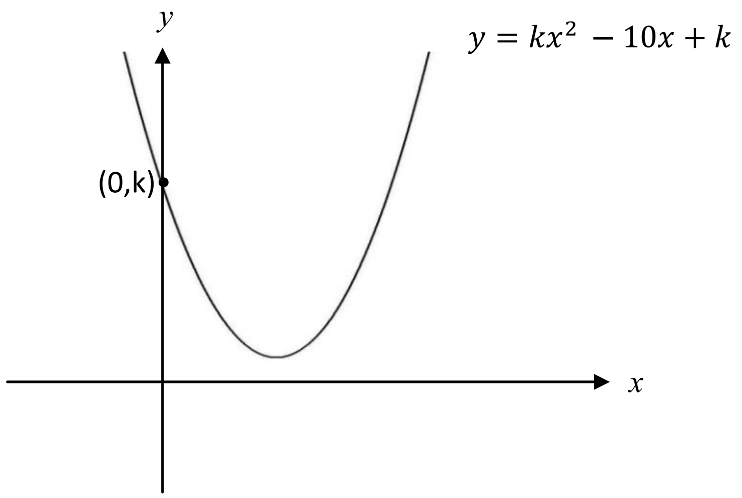
Quadratics and Polynomials

7. Find the range of values of k for which $(k + 1)x^2 + 4kx + 9 = 0$ has no real roots.

8. Find the range of values of m for which, $2x^2 + 5mx + m = 0$, has two real and distinct roots.

9. For what range of values of k does the equation $x^2 - 2kx + 2 = k$ have real roots.

10. Calculate the least positive integer value of k so that the graph of $y = kx^2 - 10x + k$ does not cut the $x -$ axis.



11. **(a)** Determine the nature of the roots of equation $2x^2 + 4x - k = 0$ when $k = 6$.

(b) Find the value of k for which $2x^2 + 4x - k = 0$ has equal roots.

12. Prove that for all values of k, that the equation $x^2 - 2x + k^2 + 2 = 0$

has no real roots

Quadratics and Polynomials

13. Find the nature of the roots of the equation $(p-1)^2 + 3p^2 = 6p - 11$.

14. (a) Prove that the roots of the equation,

$(9p^2 - 4qr)x^2 + 2(q+r)x - 1 = 0, where\ p, q, r \in Q$

are real for all values of p, q and r.

(b) Show also that if $q = r$ the roots are rational.

O2	***I can apply the condition for tangency.***

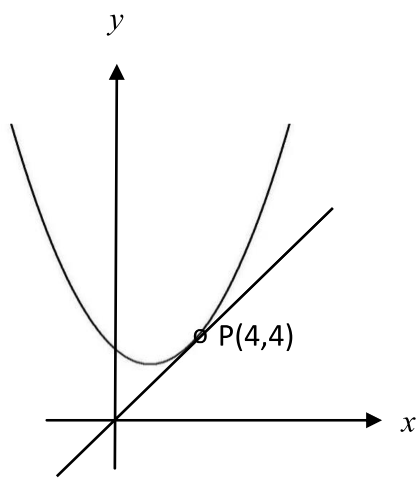
1. The point P(4,4) lies on the parabola $y = x^2 + mx + n$

(a) Find a relationship between m and n.

(b) The tangent to the parabola at point P is the line $y = x$.

Find the value of m.

(c) Using your values for m and n, find the value of the discriminant of $x^2 + mx + n = 0$. What feature of the above sketch is confirmed by this value?



2. Show that $y = 17 - 7x$ is a tangent to the parabola $y = -x^2 - x + 8$ and find the point of contact.

3. The line $y = -8x + k$ is a tangent to the parabola $y = 6x - x^2$.

Find the equation of the tangent.

Quadratics and Polynomials

4. **(a)** Show that the line $y = x + 5$ is a tangent to the curve with equation $y = \frac{1}{4}x^2 + 3x + 9$.

(b) Find the point of contact of the tangent to the curve.

O3	**I can factorise a polynomial expression using the factor theorem.**

1. Show that $x = -4$ is a root of $x^3 + 8x^2 + 11x - 20 = 0$.

Hence factorise $x^3 + 8x^2 + 11x - 20$ fully.

2. (a) Show that $(x + 2)$ is a factor of $f(x) = 2x^3 + 3x^2 - 5x - 6$.

(b) Hence factorise $f(x)$ fully.

3. (a) Show that $(x + 1)$ is a factor of $f(x) = 2x^3 - 3x^2 - 3x + 2$.

(b) Hence factorise $f(x)$ fully.

4. Show that $(x - 2)$ is a factor of $f(x) = x^3 - 5x^2 + 2x + 8$.

(a) Factorise $x^3 - 5x^2 + 2x + 8$ fully

(b) Solve $x^3 + 2x = 5x^2 - 8$

5. Factorise fully

(a) $x^3 - 7x + 6$

(b) $2x^3 + 3x^2 - 2x - 3$

(c) $2x^3 - x^2 - 13x - 6$

(d) $3x^3 + 8x^2 - 5x - 6$

(e) $2x^4 + 6x^3 + 6x^2 + 2x$

(f) $x^5 + x^4 - x - 1$

Quadratics and Polynomials

O4	**I can evaluate an unknown coefficient of a polynomial by applying the remainder and/or the factor theorem.**

1. $f(x) = 2x^3 + ax^2 + bx + 4.$

Given that $(x - 2)$ is a factor of $f(x)$, and the remainder when $f(x)$ is divided by $(x - 5)$ is 54, find the values of *a* and *b*.

2. Find p if $(x - 4)$ is a factor of $x^3 - 9x^2 + px - 28.$

3. Given that $(x + 1)$ is a factor of $2x^3 + 3x^2 + px - 6$

(a) Find the value of p

(b) Hence or otherwise, solve $2x^3 + 3x^2 + px - 6 = 0$

4. Find the value of k if (x+5) is a factor of $3x^4 + 15x^3 - kx^2 - 9x + 5$

5. Given that $(x - 1)$ is a factor of $x^3 + x^2 - (t + 1)x - 4$, find the value of t.

6. Given that x = 3 is a root of the equation $x^4 - 3x^3 + px - 5$, find p.

7. When $x^4 - 3x^3 + px - 5$ is divided by $(x + 3)$ the remainder is 16.

Find the value of p.

Quadratics and Polynomials

O5 I can solve polynomial equations

1. Solve

(a) $x^3 + x^2 - 2x = 0$ **(b)** $x^3 - 7x - 6 = 0$

(c) $x^3 - 8x^2 + 9x + 18 = 0$ **(d)** $x^3 + x^2 - 9x - 9 = 0$

(e) $x^3 + 3x^2 - 18x - 40 = 0$ **(f)** $x^3 - 3x + 2 = 0$

2. The graph of $f(x) = x^2 + 6$ and the graph of $g(x) = x^3 + 3x^2 - 5x$ intersect at $(-1,\ 7)$.

Find all the points of intersection.

3. A curve with equation $y = x^3 - x^2 - 3x + 1$ and a straight line with equation $y = 2x - 4$ meet at the point $(1,\ -2)$.

Find the x −coordinates of the other points of contact.

Quadratics and Polynomials

O6	**I can solve a polynomial equation to determine where a curve cuts the x-axis.**

1. A function is defined on the set of real numbers by $f(x) = (x+3)(x^2+4)$.

Find where the graph of $y = f(x)$ cuts:

(a) the x -axis;

(b) the y -axis.

2. A function is defined by the formula $g(x) = 2x^3 - 7x^2 - 17x + 10$ where x is a real number.

(a) Show that $(x-5)$ is a factor of $g(x)$, and hence factorise $g(x)$ fully.

(b) Find the coordinates of the points where the curve with equation $y = g(x)$ crosses the x and y-axes.

3. A function is defined by the formula $f(x) = 5x - x^3$.

Find the coordinates of the points where the graph of $y = f(x)$ meets the x and y -axes.

4. $h(x) = x^3 - 5x^2 + 3x + 9$

(a) **(i)** Show that $(x+1)$ is a factor of $h(x)$.

(ii) Hence or otherwise factorise $h(x)$ fully.

(b) One of the turning points of the graph of $y = h(x)$ lies on the x-axis.

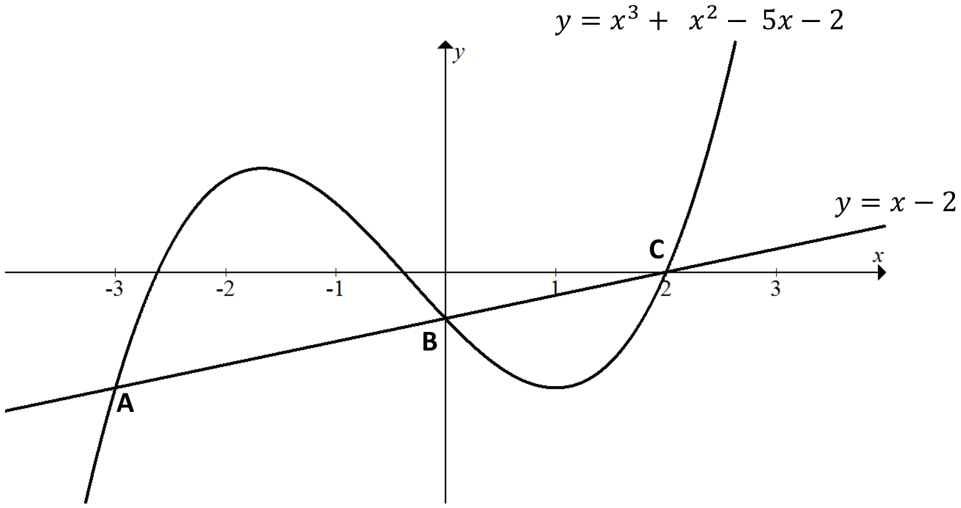
Write down the coordinates of this turning point.

5. Find where the graph of $y = x^4 + 6x^3 - 12x^2 - 88x - 96$ meets the x and y -axes.

Quadratics and Polynomials

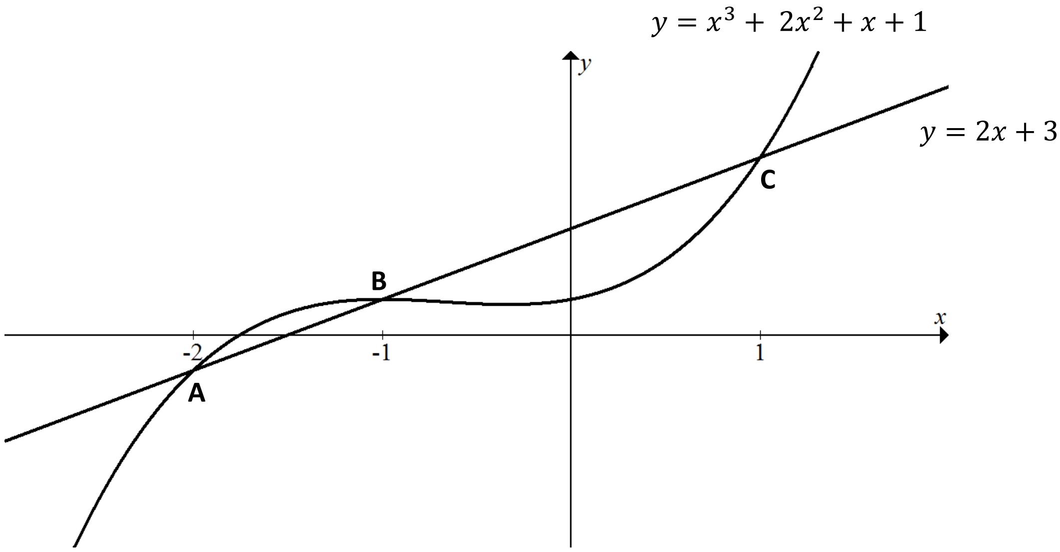
07 I can find points of intersection by solving polynomial equations.

1.



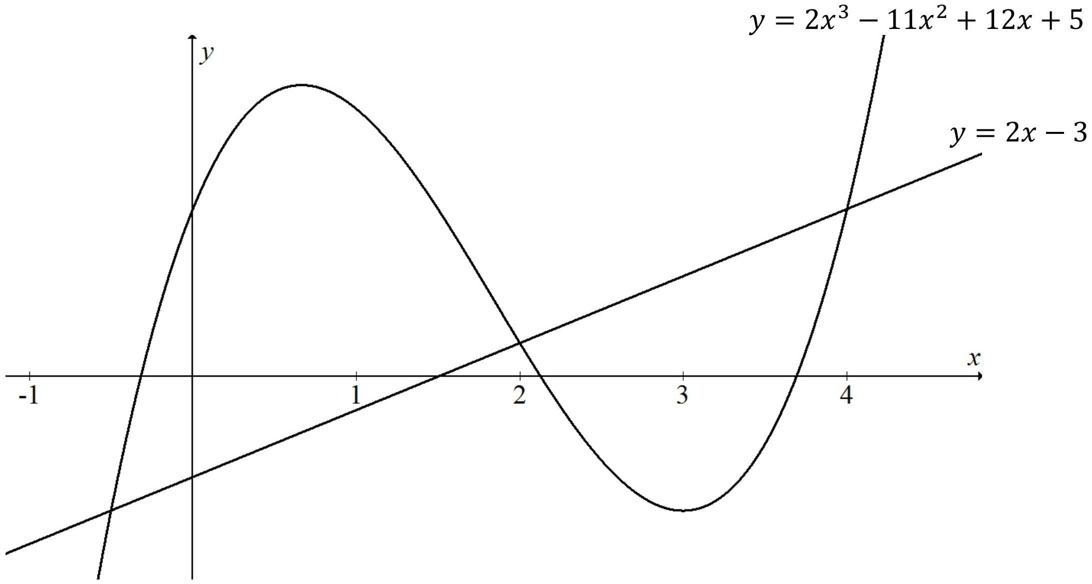
Find the coordinates of the points of intersection A, B and C where the line $y = x - 2$ meets the graph $y = x^3 + x^2 - 5x - 2$.

2.



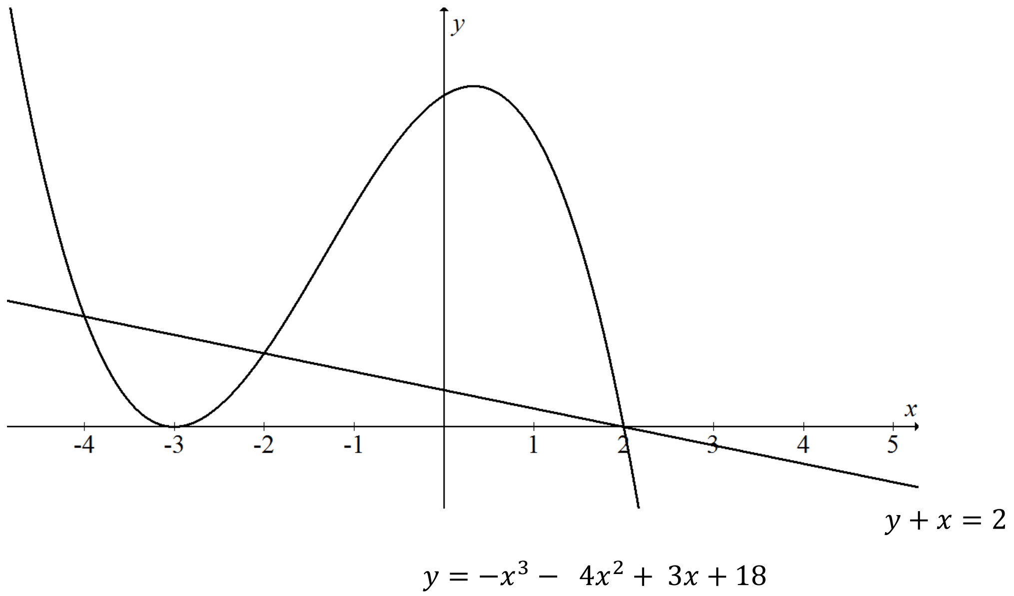
Find the coordinates of A, B and C the points of intersection between the line $y = 2x + 3$ and the curve $y = x^3 + 2x^2 + x + 1$.

3. **(a)** Fully factorise the polynomial $2x^3 - 11x^2 + 10x + 8$



(b) Hence or otherwise find the coordinates of the points of intersection of the line $y = 2x - 3$ and the graph $y = 2x^3 - 11x^2 + 12x + 5$

4. Find the points of intersection graph of the line $y + x = 2$ and the graph of $y = -x^3 - 4x^2 + 3x + 18$.



Quadratics and Polynomials

Section D - Cross Topic Exam Style Questions

Functions and Quadratics

1. Functions f and g are defined on the set of real numbers by

- $f(x) = x^2 + 3$
- $g(x) = x + 4$

(a) Find expressions for

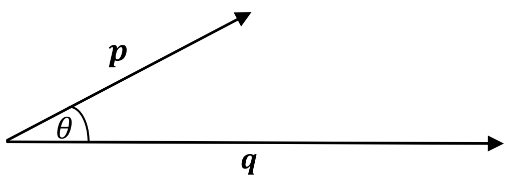
(i) $f(g(x))$

(ii) $g(f(x))$

(b) Show that $f(g(x)) + g(f(x)) = 0$ has no real roots.

Vectors and Polynomials

2. $\boldsymbol{p}$ and $\boldsymbol{q}$ are vectors given by $\boldsymbol{p} = \begin{pmatrix} k^2 \\ 3 \\ k+1 \end{pmatrix}$ and $\boldsymbol{q} = \begin{pmatrix} k \\ k^2 \\ -2 \end{pmatrix}$, where $k > 0$.



(a) If $\boldsymbol{p} \cdot \boldsymbol{q} = 1 - k$, show that $k^3 + 3k^2 - k - 3 = 0$.

(b) Show that $(k + 3)$ is a factor of $k^3 + 3k^2 - k - 3$ and hence factorise fully.

(c) Deduce the only possible value of k.

Quadratics and Polynomials

Vectors and Quadratics

3. P is the point $(1, -3, 0)$, Q$(1, -1, 2)$ and R$(k, -2, 0)$

(a) Express $\overrightarrow{QP}$ and $\overrightarrow{QR}$ in component form.

(b) Show that $\cos P\hat{Q}R = \frac{3}{\sqrt{2(k^2-2k+6)}}$

(c) If angle $PQR = 30°$, find the possible values of k.

Quadratics and Polynomials

Answers

Section A

R1

1. (a) $2(7+2x)(7-2x)$ (b) $5(s+t)(s-t)$ (c) $2(7+x)(7-x)$

(d) $3(5x+9)(5x-9)$ (e) $18(2+x)(2-x)$ (f) $3x(2+x)(2-x)$

(g) $(9+x^2)(3+x)(3-x)$ (h) $3w(3+2w)(3-2w)$

(i) $4(4a^2+1)(2a+1)(2a-1)$

2. (a) $(2x-1)(x-3)$ (b) $(2x+3)(x+4)$ (c) $(3x+4)(x+2)$

(d) $(x+3)(x-2)$ (e) $(3x+2)(2x+1)$ (f) $(x-2)(x-1)$

(g) $(5x-1)(x+1)$ (h) $(7x+2)(x+2)$ (i) $(2x-3)(x+5)$

3. (a) $(3+x)(2-x)$ (b) $(4+3x)(5-x)$ (c) $(3-2x)(1+x)$

(d) $(3-2x)(5+x)$ (e) $(4+x)(1-2x)$ (f) $(3-x)(5+x)$

4. (a) $3(x+4)(x-2)$ (b) $5x(3xy+1)$ (c) $2(x+4)(x-4)$

(d) $5x(x+3)(x-3)$ (e) $6(3x+2)(x-1)$ (f) $4xy(3x+2y^2)$

(g) $5(2x-1)(x+3)$ (h) $6x(x+3)(x+2)$ (i) $7(x+2)(x-2)$

(j) $2(x-2)(x-3)$ (k) $3x(x+2)(x+5)$ (l) $6x(x+3)(x-3)$

R2

1. (a) $x=-3,-4$ (b) $x=-2,\ 2$ (c) $n=-2,-1$

(d) $x=-3,\ 0$ (e) $p=-3,-8$ (f) $a=0,\ 4$

(g) $s=-2,-4$ (h) $r=-5,\ 5$ (i) $n=-2,-3$

2. (a) $\mathrm{x}=3,\ 8$ (b) $\mathrm{x}=-\frac{3}{2},\ \frac{3}{2}$ (c) $\mathrm{n}=-5,\ 2$

(d) $x=-\frac{3}{5},0$ (e) $p=4,\ 6$ (f) $a=2,-2$

(g) $n=-3,-\frac{1}{2}$ (h) $r=-\frac{2}{5},-1$ (i) $n=\frac{1}{3},\ 1$

(j) $n=-5,-3$ (k) $r=5,6$

3. (a)$\mathrm{x}=3\cdot3,\ -0\cdot30$ (b) $\mathrm{x}=-0\cdot19,\ -2\cdot7$ (c) $\mathrm{x}=1\cdot6,\ -0\cdot24$

Quadratics and Polynomials

4. (a) $x = 3 \cdot 12,\ 0 \cdot 214$ (b) $x = 2 \cdot 37,\ 0 \cdot 634$

(c) $x = -0.390, 0 \cdot 640$

R3

(a) 0 therefore real and equal

(b) -7 therefore no real roots

(c) 41 therefore real and distinct

(d) 25 therefore real and distinct

(e) 13 therefore real and distinct

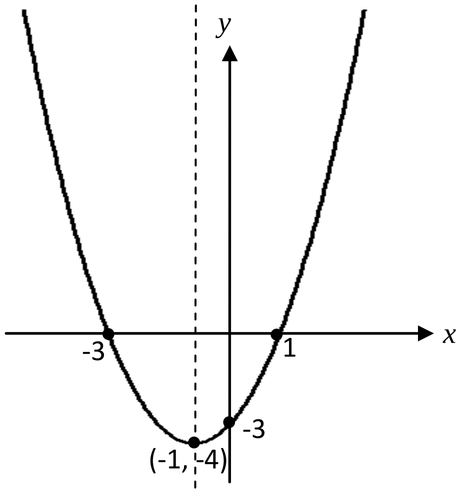
(f) 0 therefore real and equal

(g) **2**0 therefore real and distinct

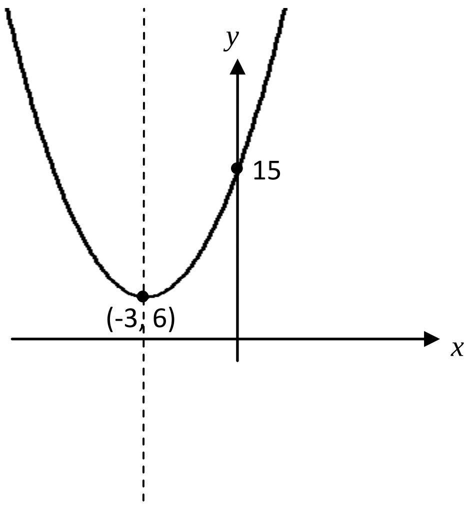
(h) $\mathbf{-75}$ therefore no real roots

R4

1.



2.



3. **(a)** -3 **(b)** (5, 0)

4. **(a)** $x = 2, 6$ **(b)** $x = 4$

5. **(a)** $x = -2$ **(b)** $7 = (x + 2)^2 - 1$ **(c)** (0, 3)

6. **(a)** $a = -5,\ b = 1$ **(b)** $x = 5$ **(c)** P(0, 26), Q(10, 26)

R5

1. $x = 1,\ y = 2$ **2.** $x = 4,\ y = 2$ **3.** $x = 3,\ y = 1$

4. $x = -3,\ y = 2$ **5.** $x = -3,\ y = 2$ **6.** $x = 4,\ y = -3$

7. $x = -3,\ y = 2$ **8.** $x = 3,\ y = -5$

Quadratics and Polynomials

Section B

1. (a) (i) Proof (ii) $f(x) = (x-1)(x-2)(x-3)$

(b) $x = 1, x = 2 \ and \ x = 3$

2. (a) Proof (b) $(x-1)(x+4)(x+5)$

3. $x = -3, x = \frac{1}{2} \ and \ x = 2$

4. $f(x) = (x-1)(x+4)(x+5)$ OR $f(x) = x^3 + 8x^2 + 11x - 20$

5. $k = -2$ **6.** $k > \frac{1}{3}$

Section C

O1

1. $k = -1$

2. If $k = 1$ then there are 2 equal roots (of 1).
But $k = 0$ also produces 2 equal roots (of 2).
Therefore $k = 0$ is the smaller value.

3. $k = 0, k = 4$

4. $p = -\frac{1}{3}$, 1 $x = -6$ repeated, $x = -2$ repeated

5. $k = -7, k = 5$ **6.** $k < -\frac{1}{4}$ **7.** $-\frac{3}{4} < k < 3$

8. $\mathrm{m} < 0, m > \frac{8}{25}$ **9.** $\mathrm{k} \leq -2, \mathrm{k} \geq 1$ **10.** $k = 6$

11. **(a)** **Since** $b^2 - 4\mathrm{ac} > 0$ (64) the roots are real and distinct. (b) $k = -2$

12. $-4k^2 < 0$ which is true for all values of x.

13. **Since** $b^2 - 4\mathrm{ac} < 0$ (-8) there are no real roots.

14. **Since** $b^2 - 4\mathrm{ac} \geq 0$ for all p, q and r, the roots are always real.

O2

1. **(a)** $n = -12 - 4m$ **(b)** $m = -7$

(c) Since $b^2 - 4\mathrm{ac} < 0 \ (-15)$, there are no real roots, curve does not cut x-axis.

2. $\mathrm{b}^2 - 4\mathrm{ac} = 0$, one point of contact ∴ line is tangent to parabola. (3,-4)

Quadratics and Polynomials

3. $k = 49$. $y = -8x + 49$

4. **(a)** $b^2 - 4ac = 0 \Rightarrow equal\ roots \Rightarrow only\ one\ point\ of\ contact \Rightarrow tangency$

(b) (-4, 1)

O3

1. $(x+4)(x+5)(x-1)$ **2.** $(x+2)(2x-3)(x+1)$

3. $(x+1)(2x-1)(x-2)$

4. **(a)** $(x-2)(x-4)(x+1)$ **(b)** $x = 2, x = 4, x = -1$

5. **(a)** $(x+3)(x-1)(x-2)$ **(b)** $(2x+3)(x+1)(x-1)$

(c) $(x+2)(x-3)(2x+1)$ **(d)** $(3x+2)(x-1)(x+3)$

(e) $2x(x+1)^3$ **(f)** $(x+1)^2(x^2+1)(x-1)$

O4

1. $a = -10,\ b = 10$ **2.** $p = 27$

3. **(a)** $p = -5$ **(b)** $x = -1,\ 1\cdot5,\ -2$

4. $k = 2$ **5.** $t = -3$ **6.** $p = \frac{5}{3}$

7. $p = 47$

O5

1. (a) $x = -2, 0, 1$ **(b)** $x = -1, -2, 3$ **(c)** $x = -1, 3, 6$

(d) $x = -3, -1, 3$ **(e)** $x = -5, -2, 4$ **(f)** $x = -2, 1$

2. (-3, 15), (2, 10) **3.** $x = \pm\sqrt{5}$

O6

1. **(a)** (-3, 0) **(b)** (0, 12)

2. **(a)** proof, $(x-5)(2x-1)(x+2)$ **(b)** (-2, 0), ($\frac{1}{2}$, 0), (5, 0); (0, 10)

3. $(0,0)(-\sqrt{5},0)(\sqrt{5},0)$

4. (a) (i) proof (ii) $(x+1)(x-3)^2$ (b) (3, 0)

5. (-6, 0), (-2, 0) repeated, (4, 0)

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O7

1. A(-3,-5), B(0,-2), C(2,0)

2. A(-2,-1), B(-1,1), C(1,5)

3. **(a)** $(x-2)(2x+1)(x-4)$ **(b)** $(-\frac{1}{2},-4)$ (2,1) (4,5)

4. (-4,6), (-2,4), (2,0)

Section D

1. **(a)** **(i)** $(x+4)^2+3$ (ii) x^2+7

(b) Since $b^2-4ac<0$ (-142) No real roots.

2. **(a)** Proof **(b)** $(k+3)(k+1)(k-1)$ **(c)** $k=1$

3. **(a)** $\overrightarrow{QP}=\begin{pmatrix}0\\-2\\-2\end{pmatrix}, \overrightarrow{QR}=\begin{pmatrix}k-1\\-1\\-2\end{pmatrix}$

(b) Proof

(c) $k=0$ and $k=2$