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CHAPTER NOTES

Polynomials Class 10 Notes | CBSE Maths Chapter 2

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Ask me anything from this chapter. A concept, a numerical, or that one doubt you did not want to raise in class. Pick one to start:

Explain Polynomials simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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Polynomials Class 10 Notes | CBSE Maths

Chapter 2

Polynomials is Chapter 2 of CBSE Class 10 Maths. It builds on the Class 9 idea of a polynomial and its degree, then asks a sharper question: how are the zeroes of a polynomial connected to its coefficients? The chapter covers linear, quadratic and cubic polynomials, the value of a polynomial at a point, zeroes, what zeroes mean on a graph, the sum and product of the zeroes of a quadratic, and forming a quadratic when the sum and product of its zeroes are given.

For board exams this chapter sits in the Algebra unit and feeds straight into Quadratic Equations (Chapter 4). Its questions are short and exact: count the zeroes from a graph, find the zeroes of a quadratic and verify the relationship with its coefficients, build a quadratic from a given sum and product, or use $\alpha + \beta = -b/a$ and $\alpha\beta = c/a$ to find an unknown or evaluate an expression in α and β .

Quick Answer - Polynomials in 30

Polynomials of degree 1, 2 and 3 are linear, quadratic and cubic respectively. A zero of $p(x)$ if $p(k) = 0$. On a graph, the zero of $p(x)$ is where the graph meets the x-axis, so a polynomial $p(x) = ax^2 + bx + c$ has a zero-sum $S = -b/a$. For $ax^2 + bx + c$ with zeroes α and β , the zero-sum S and zero-product P is $k(x^2 + Sx + P)$.



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All Key Formulas at a Glance

Idea	Formula or rule	Use it when
General quadratic	$ax^2 + bx + c, a \neq 0$	Reading a, b, c from a quadratic
General cubic	$ax^3 + bx^2 + cx + d, a \neq 0$	Reading a, b, c, d from a cubic
Zero of a polynomial	k is a zero of p(x) if $p(k) = 0$	Checking whether a number is a zero
Zero of a linear polynomial	Zero of $ax + b = -b/a$	Any degree 1 polynomial
Graph and zeroes	Zeroes = x-coordinates of the graph of $y = p(x)$ meets the x-axis	
Maximum number of zeroes	Degree n $\Rightarrow$ at most n zeroes	
Sum of zeroes (quadratic)	$\alpha + \beta = -b/a$	
Product of zeroes (quadratic)	$\alpha\beta = c/a$	
Quadratic from its zeroes	$k[x^2 - (\alpha + \beta)x + \alpha\beta]$	
Cubic relations	$\alpha + \beta + \gamma = -b/a$ $\alpha\beta + \beta\gamma + \gamma\alpha = -c/a$ $\alpha\beta\gamma = -d/a$	



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Key Concepts

1. Polynomials, Degree and Types

A polynomial in one variable x is an expression made of terms like ax^n , where each coefficient is a real number and each power n is a whole number (0, 1, 2, 3, ...). If $p(x)$ is a polynomial in x , the **highest power of x in $p(x)$ is called the degree** of $p(x)$.

- $4x + 2$ is a polynomial in x of degree 1.
- $2y^2 - 3y + 4$ is a polynomial in y of degree 2.
- $5x^3 - 4x^2 + x + 7$ is a polynomial in x of degree 3.
- $7u^6 - 4u^2 + 8$ is a polynomial in u of degree 6.

Expressions such as $1/(x - 1)$, $\sqrt{x} + 2$ and $1/x + x$ are **not polynomials**. They have x in a denominator or a power of x that is not a whole number.

The chapter names polynomials by their degree.

Degree	Name	General form
1	Linear polynomial	$ax + b$
2	Quadratic polynomial	$ax^2 + bx + c$
3	Cubic polynomial	$ax^3 + bx^2 + cx + d$, $a \neq 0$

In every general form, a , b , c and d are real numbers. The condition $a \neq 0$ matters: if $a = 0$ in $ax^2 + bx + c$, it is no longer quadratic. The word "quadratic"

Reading coefficients correctly. Before using the standard form (descending powers) and read the coefficients correctly.



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Polynomial as given	Standard form	a	b	c
$6x^2 - 3 - 7x$	$6x^2 - 7x - 3$	6	-7	-3
$4u^2 + 8u$	$4u^2 + 8u + 0$	4	8	0
$t^2 - 15$	$t^2 + 0t - 15$	1	0	-15

2. Value of a Polynomial and Zero of a Polynomial

If $p(x)$ is a polynomial in x and k is any real number, the value obtained by replacing x by k in $p(x)$ is called the **value of $p(x)$ at $x = k$** . It is written $p(k)$.

Take $p(x) = x^2 - 3x - 4$.

- $p(2) = 2^2 - 3 \times 2 - 4 = 4 - 6 - 4 = -6$
- $p(0) = 0 - 0 - 4 = -4$
- $p(-1) = (-1)^2 - 3 \times (-1) - 4 = 1 + 3 - 4 = 0$
- $p(4) = 4^2 - 3 \times 4 - 4 = 16 - 12 - 4 = 0$

Since $p(-1) = 0$ and $p(4) = 0$, the numbers

Definition: a real number k is a zero of a polynomial $p(x)$ if $p(k) = 0$.

Zero of a linear polynomial. If k is a zero of a linear polynomial $ax + b$, then $ak + b = 0$. In general, if k is a zero of $ax + b$, then $ak + b = 0$.

zero of $ax + b = -b/a = -(\text{constant term}) / (\text{coefficient of } x)$

Note that zero itself can be a zero of a polynomial. This happens exactly when the constant term is zero.

3. Geometrical Meaning of the Zero of a Polynomial

Linear polynomial. The graph of $y = ax + b$ is a straight line. It passes through $(-2, -1)$ and $(2, 7)$. It crosses the x -axis at the point $(-3/2, 0)$. This x -coordinate is the zero of the polynomial. The line crosses the x -axis at exactly one point, $(-b/a, 0)$. So a linear polynomial has exactly one zero.



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Quadratic polynomial. Take $y = x^2 - 3x - 4$ and make a table of values (NCERT Table 2.1):

x	-2	-1	0	1	2	3	4	5
$y = x^2 - 3x - 4$	6	0	-4	-6	-6	-4	0	6

Plotting these points and joining them gives a U-shaped curve. The curve cuts the x-axis where $y = 0$, at $x = -1$ and $x = 4$, which are the zeroes of the polynomial. The graph of any quadratic $y = ax^2 + bx + c$ ($a \neq 0$) is a curve called a **parabola**. It **opens upwards when $a > 0$** and **opens downwards when $a < 0$** .

The zeroes of $ax^2 + bx + c$ are precisely the x-coordinates of the points where the parabola $y = ax^2 + bx + c$ meets the x-axis. Three cases can happen:

Case	What the parabola does	Number of zeroes
(i)	Cuts the x-axis at two distinct points (the two points are distinct)	2
(ii)	Touches the x-axis at exactly one point (the two points coincide)	1
(iii)	Lies completely above or completely below the x-axis	0

So a polynomial of degree 2 has **at most two** real zeroes. If $a > 0$, its graph stays above the x-axis only at $x = 2$, so its graph touches the x-axis only at $x = 2$.

Cubic polynomial. Take $y = x^3 - 4x$ (NCERT Table 2.2):

x	-2	0	2
$y = x^3 - 4x$	0	0	0

The zeroes are -2, 0 and 2, and these are the x-coordinates of the points where the parabola $y = x^3 - 4x$ meets the x-axis. You can confirm this by plotting the points and joining them. See the graph in the chapter:



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- $y = x^3$: the only zero is 0, and the graph meets the x-axis at the origin only.
- $y = x^3 - x^2 = x^2(x - 1)$: the only zeroes are 0 and 1, and the graph meets the x-axis at $x = 0$ and $x = 1$ only.

So a cubic polynomial has **at most three zeroes**.

General rule (Remark in NCERT): for a polynomial $p(x)$ of degree n , the graph of $y = p(x)$ meets the x-axis at most at n points. So a **polynomial of degree n has at most n zeroes**.

Counting zeroes from a graph. Count the number of distinct points where the curve meets the x-axis. A point where the curve only touches the axis and turns back still counts as a meeting point. Points where the curve meets the y-axis do not count. If the curve never meets the x-axis, the polynomial has no zero. The NCERT footnote says students are not meant to plot graphs of quadratic or cubic polynomials, and such plotting is not evaluated. Exercise 2.1 asks you to read given graphs and count zeroes.

4. Relationship between Zeroes and Coefficients

Start with $p(x) = 2x^2 - 8x + 6$. Split the middle term whose product is $6 \times 2x^2 = 12x^2$. These are

$$2x^2 - 8x + 6 = 2x^2 - 6x - 2x + 6 = 2x(x - 3) - 2(x - 3)$$

So the zeroes are 1 and 3. Now compare with

- Sum of zeroes = $1 + 3 = 4 = -(-8)/2 = 4$
- Product of zeroes = $1 \times 3 = 3 = 6/2 = 3$

A second check: $3x^2 + 5x - 2 = 3x^2 + 6x - x - 2$
zeroes are $1/3$ and -2 . Sum = $1/3 + (-2) = -5/3$

The general proof. Let α and β (alpha and beta) be the zeroes of $p(x)$. Then $(x - \alpha)$ and $(x - \beta)$ are factors of $p(x)$, so

$$\begin{aligned} ax^2 + bx + c &= k(x - \alpha)(x - \beta), \text{ where } k \text{ is a constant} \\ &= k[x^2 - (\alpha + \beta)x + \alpha\beta] \\ &= kx^2 - k(\alpha + \beta)x + k\alpha\beta \end{aligned}$$

Comparing the coefficients of x^2 , x and the constant term, we get
 $a = k$, $b = -k(\alpha + \beta)$ and $c = k\alpha\beta$. This gives



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$\alpha + \beta = -b/a = -(\text{coefficient of } x) / (\text{coefficient of } x^2)$

$\alpha\beta = c/a = (\text{constant term}) / (\text{coefficient of } x^2)$

5. Finding the Zeroes of a Quadratic and Verifying the Relationship

NCERT Exercise 2.2 asks you to find the zeroes and then verify the relationship. The routine has four steps.

- 1. Write the polynomial in standard form $ax^2 + bx + c$ and note a, b, c with signs.
- 2. Factorise it. Choose the method that fits.
- 3. Set each factor equal to zero to get the two zeroes.
- 4. Compute the sum and product of the zeroes, then compute $-b/a$ and c/a separately, and show that they match.

Form of the polynomial	
$ax^2 + bx + c$, all non-zero	Split the middle product ac and
$ax^2 + bx$ ($c = 0$)	Take x (and any
$x^2 - k$ ($b = 0$, $k > 0$)	Use $a^2 - b^2 = ($
Perfect square	Use $(a - b)^2$ or

Worked illustration (NCERT Example 3).
Sum = $\sqrt{3} + (-\sqrt{3}) = 0 = -0/1 = -(\text{coefficient of } x)/(\text{coefficient of } x^2)$.
 $-3/1 = (\text{constant term})/(\text{coefficient of } x^2)$.

Presentation tip. Write both sides of each



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6. Forming a Quadratic from the Sum and Product of Its Zeroes

If the zeroes of a quadratic are α and β , then from the proof above the quadratic is $k(x - \alpha)(x - \beta) = k[x^2 - (\alpha + \beta)x + \alpha\beta]$. So if the sum of zeroes is S and the product is P ,

required quadratic = $k(x^2 - Sx + P)$, where k is any non-zero real number

NCERT Example 4. Find a quadratic polynomial, the sum and product of whose zeroes are -3 and 2 , respectively. Let the polynomial be $ax^2 + bx + c$ with zeroes α and β . Then $\alpha + \beta = -3 = -b/a$ and $\alpha\beta = 2 = c/a$. Taking $a = 1$ gives $b = 3$ and $c = 2$. One such polynomial is $x^2 + 3x + 2$. Every other quadratic that fits these conditions has the form $k(x^2 + 3x + 2)$, where k is real (and non-zero, so that it stays quadratic).

Why the answer is not unique. Multiplying a polynomial by a non-zero constant does not change where it equals zero. In the exam, one correct polynomial is enough.

Clearing fractions. When S or P is a fraction, clearing denominators first helps. For example, if $S = 1/4$ and $P = -1$, then multiplying by 4 gives $x^2 - (1/4)x - 1$. Taking $a = 4$ gives $b = -1$ and $c = -4$. So the polynomial is $4x^2 - x - 4$. Here $-b/a = 1/4$ and $c/a = -4/4 = -1$.

Sign trap. The middle coefficient is the negative of the sum of zeroes. For example, if $S = -5$ gives $+5x$. The product goes in with its sign.

7. Using the Relations: Unknown Coefficients

Many questions give a condition on the value of an expression in α and β . The relations help find S and P when the zeroes are irrational.

Standard identities. Rewrite the expression in terms of S and P .



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Expression	Rewrite as
$\alpha^2 + \beta^2$	$(\alpha + \beta)^2 - 2\alpha\beta$
$(\alpha - \beta)^2$	$(\alpha + \beta)^2 - 4\alpha\beta$
$1/\alpha + 1/\beta$	$(\alpha + \beta)/\alpha\beta$
$\alpha/\beta + \beta/\alpha$	$(\alpha^2 + \beta^2)/\alpha\beta$
$\alpha^2\beta + \alpha\beta^2$	$\alpha\beta(\alpha + \beta)$
$\alpha^3 + \beta^3$	$(\alpha + \beta)^3 - 3\alpha\beta(\alpha + \beta)$

Illustration. Let α, β be the zeroes of $x^2 - 5x + 3$. Then $\alpha + \beta = 5$ and $\alpha\beta = 3$.

- $\alpha^2 + \beta^2 = 25 - 6 = 19$
- $1/\alpha + 1/\beta = 5/3$
- $\alpha^3 + \beta^3 = 125 - 3 \times 3 \times 5 = 125 - 45 = 80$

Conditions that fix a coefficient.

- One zero is the reciprocal of the other:
- One zero is the negative of the other: $\alpha = -\beta$
- The sum of zeroes equals their product
- One zero is known: substitute it into $p(x)$ to get the other zero.

8. Zeroes and Coefficients of a Cubic

A similar relationship holds for a cubic. Take $p(x) = 2x^3 - 5x^2 - 14x + 8$. Then $p(4) = 0$, $p(-2) = 0$ and $p(1/2) = 0$. A cubic has three zeroes. Here $a = 2$, $b = -5$, $c = -14$, $d = 8$.

- Sum of zeroes = $4 + (-2) + 1/2 = 5/2 = -b/a$
- Sum of products of zeroes taken two at a time = $-14/2 = c/a$



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- Product of zeroes = $4 \times (-2) \times 1/2 = -4 = -8/2 = -d/a$

In general, if α , β , γ (gamma) are the zeroes of $ax^3 + bx^2 + cx + d$, $a \neq 0$, then

$$\alpha + \beta + \gamma = -b/a$$

$$\alpha\beta + \beta\gamma + \gamma\alpha = c/a$$

$$\alpha\beta\gamma = -d/a$$

Memory pattern. The signs alternate: minus, plus, minus. Divide the next coefficient after a by a each time: $-b/a$, then $+c/a$, then $-d/a$.

NCERT marks its cubic verification example (Example 5) with the note "Not from the examination point of view". The three relations do appear in the chapter summary, so know them, but keep the focus of your revision on the quadratic relations.



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Formula and Theorem Sheet

Result	Statement	Remember
Linear, quadratic, cubic	Degree 1, 2, 3	Leading coefficient $a \neq 0$
Zero of $p(x)$	k is a zero if $p(k) = 0$	A zero is a real number
Zero of $ax + b$	$-b/a$	Exactly one zero
Geometrical meaning	Zeros = x-coordinates where $y = p(x)$ meets the x-axis	Ignore y-axis crossings
Shape of $y = ax^2 + bx + c$	Parabola: opens upwards if $a > 0$, downwards if $a < 0$	
Maximum number of zeroes	Degree $n \Rightarrow n$ zeroes	
Sum of zeroes, quadratic	$\alpha + \beta = -b/a$	
Product of zeroes, quadratic	$\alpha\beta = c/a$	
Quadratic with given S and P	$k(x^2 - Sx + P)$	
Cubic: sum	$\alpha + \beta + \gamma = -b/a$	
Cubic: pair sum	$\alpha\beta + \beta\gamma + \gamma\alpha = c/a$	
Cubic: product	$\alpha\beta\gamma = -d/a$	



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Important Definitions

- **Degree of a polynomial:** the highest power of the variable in the polynomial.
- **Linear polynomial:** a polynomial of degree 1, of the form $ax + b$ with $a \neq 0$.
- **Quadratic polynomial:** a polynomial of degree 2. Any quadratic polynomial in x is of the form $ax^2 + bx + c$, where a, b, c are real numbers and $a \neq 0$.
- **Cubic polynomial:** a polynomial of degree 3. Its most general form is $ax^3 + bx^2 + cx + d$, where a, b, c, d are real numbers and $a \neq 0$.
- **Value of a polynomial at $x = k$:** the value obtained by replacing x by k in $p(x)$, written $p(k)$.
- **Zero of a polynomial:** a real number k is a zero of $p(x)$ if $p(k) = 0$.
- **Parabola:** the curve that is the graph of $y = ax^2 + bx + c$, $a \neq 0$. It opens upwards if $a > 0$ and downwards if $a < 0$.
- **Geometrical meaning of zeroes:** the zeroes of $p(x)$ are precisely the x -coordinates of the points where the graph of $y = p(x)$ intersects the x -axis.
- **α, β, γ :** Greek letters read as alpha, beta, gamma.



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Solved Examples (NCERT)

Example 1: Zeroes of $x^2 - 2x - 8$ (NCERT)

Question: Find the zeroes of the quadratic polynomial $x^2 - 2x - 8$ between the zeroes and the coefficients.

Solution: Two numbers with product -8 and sum 2 are 4 and -2 .

$$x^2 - 2x - 8 = x^2 - 4x + 2x - 8 = x(x - 4) + (x - 4)$$

So the zeroes are 4 and -2 . Here $a = 1$, $b = -2$, and $c = -8$.

Sum of zeroes $= 4 + (-2) = 2$, and $-b/a = 2$.

Product of zeroes $= 4 \times (-2) = -8$, and $c/a = -8$.

Example 2: Zeroes of $4s^2 - 4s + 1$ (NCERT)

Question: Find the zeroes of $4s^2 - 4s + 1$ between the zeroes and the coefficients.

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Solution: $4s^2 - 4s + 1 = (2s)^2 - 2(2s)(1) + 1^2 = (2s - 1)^2 = (2s - 1)(2s - 1)$.

So the zeroes are $1/2$ and $1/2$ (two equal zeroes). Here $a = 4$, $b = -4$, $c = 1$.

Sum = $1/2 + 1/2 = 1$, and $-b/a = 4/4 = 1$.

Product = $1/2 \times 1/2 = 1/4$, and $c/a = 1/4$. Hence verified.

The graph of $y = 4s^2 - 4s + 1$ would touch the axis at one point, $s = 1/2$. This is case (ii).

Example 3: Zeroes of $6x^2 - 3 - 7x$ (NCERT Exercise 2.2, Q1 (iii))

Question: Find the zeroes of $6x^2 - 3 - 7x$ and verify the relationship between the zeroes and the coefficients.

Solution: Standard form: $6x^2 - 7x - 3$, so $a = 6$, $b = -7$, $c = -3$. We need two numbers with product $6 \times (-3) = -18$ and sum -7 : these are -9 and 2 .

$$6x^2 - 9x + 2x - 3 = 3x(2x - 3) + 1(2x - 3)$$

So the zeroes are $-1/3$ and $3/2$.

Sum = $3/2 - 1/3 = 9/6 - 2/6 = 7/6$, and $-b/a = 7/6$.

Product = $(3/2)(-1/3) = -1/2$, and $c/a = -3/6 = -1/2$.

Example 4: Zeroes of $4u^2 + 8u$ (NCERT Exercise 2.2, Q2 (i))

Question: Find the zeroes of $4u^2 + 8u$ and verify the relationship between the zeroes and the coefficients.

Solution: $4u^2 + 8u = 4u(u + 2)$. The zeroes are 0 and -2 .

Sum = $0 + (-2) = -2$, and $-b/a = -8/4 = -2$.

Product = $0 \times (-2) = 0$, and $c/a = 0/4 = 0$.

Example 5: Zeroes of $t^2 - 15$ (NCERT Exercise 2.2, Q3 (i))

Question: Find the zeroes of $t^2 - 15$ and verify the relationship between the zeroes and the coefficients.

Solution: $t^2 - 15 = t^2 - (\sqrt{15})^2 = (t - \sqrt{15})(t + \sqrt{15})$. The zeroes are $\sqrt{15}$ and $-\sqrt{15}$.



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Sum = $\sqrt{15} + (-\sqrt{15}) = 0$, and $-b/a = -0/1 = 0$.

Product = $(\sqrt{15})(-\sqrt{15}) = -15$, and $c/a = -15$. Hence verified.

Example 6: Zeroes of $3x^2 - x - 4$ (NCERT Exercise 2.2, Q1 (vi))

Question: Find the zeroes of $3x^2 - x - 4$ and verify the relationship between the zeroes and the coefficients.

Solution: Product $ac = 3 \times (-4) = -12$ and sum $b = -1$: the numbers are -4 and 3 .

$$3x^2 - 4x + 3x - 4 = x(3x - 4) + 1(3x - 4) = (x + 1)(3x - 4)$$

So the zeroes are -1 and $4/3$.

Sum = $-1 + 4/3 = 1/3$, and $-b/a = -(-1)/3 = 1/3$.

Product = $(-1)(4/3) = -4/3$, and $c/a = -4/3$. Hence verified.

Example 7: Quadratics from sum and product of zeroes (i) to (iii))

Question: Find a quadratic polynomial each having the following as its zeroes respectively: (i) $1/4, -1$ (ii) $\sqrt{2}, 1/\sqrt{2}$

Solution: Use $k(x^2 - Sx + P)$.

(i) $x^2 - (1/4)x - 1$. Taking $k = 4$: $4x^2 - x - 4$

(ii) $x^2 - \sqrt{2}x + 1/3$. Taking $k = 3$: $3x^2 - 3\sqrt{2}x + 1$

(iii) $x^2 - 0 \times x + \sqrt{5} = x^2 + \sqrt{5}$. Check: $-b/a = 0$

Example 8: Quadratics from sum and product of zeroes (iv) to (vi))

Question: Find a quadratic polynomial each having the following as its zeroes respectively: (iv) $1, 1$ (v) $-1/4, 1/4$

Solution:

(iv) $x^2 - x + 1$. Check: $-b/a = 1$, $c/a = 1$. ($x^2 - x + 1$ does not intersect the x-axis. The question only fixes $-b/a$ and c/a)



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(v) $x^2 - (-1/4)x + 1/4 = x^2 + (1/4)x + 1/4$. Taking $k = 4$: $4x^2 + x + 1$. Check: $-b/a = -1/4$, $c/a = 1/4$.

(vi) $x^2 - 4x + 1$. Check: $-b/a = 4$, $c/a = 1$.

Example 9: Finding k from a condition on the zeroes

Question: Find k if the sum of the zeroes of $x^2 - (k + 6)x + 2(2k - 1)$ is equal to half of their product.

Solution: Here $a = 1$, $b = -(k + 6)$, $c = 2(2k - 1)$.

Sum $= -b/a = k + 6$. Product $= c/a = 2(2k - 1) = 4k - 2$, so half of the product $= 2k - 1$.

$k + 6 = 2k - 1 \Rightarrow k = 7$.

Check: with $k = 7$, the polynomial is $x^2 - 13x + 26$. Sum $= 13$ and product $= 26$, and 13 is half of 26.

Example 10: Expressions in α and β

Question: If α and β are the zeroes of $2x^2 - 4x + 1$, find the value of $\frac{1}{\alpha} + \frac{1}{\beta}$.

Solution: $\alpha + \beta = -(-4)/2 = 2$ and $\alpha\beta = 1/2$

(i) $\alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta = 4 - 1 = 3$.

(ii) $1/\alpha + 1/\beta = (\alpha + \beta)/\alpha\beta = 2 \div (1/2) = 4$.

(iii) New sum $S = 1/\alpha + 1/\beta = 4$. New product $P = 1/\alpha\beta = 2$ (or any non-zero multiple).

No square roots were needed, even though the polynomial has irrational roots.

Example 11: Verifying the zeroes of a polynomial

Question: Verify that 3, -1, -1/3 are the zeroes of the polynomial $3x^3 - 7x^2 - 3x + 1$, and then verify the relationship between the zeroes and the coefficients.

Solution: Comparing with $ax^3 + bx^2 + cx + d$, we have $a = 3$, $b = -7$, $c = -3$, $d = 1$.



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$$p(3) = 3 \times 27 - 5 \times 9 - 11 \times 3 - 3 = 81 - 45 - 33 - 3 = 0$$

$$p(-1) = 3(-1) - 5(1) - 11(-1) - 3 = -3 - 5 + 11 - 3 = 0$$

$$p(-1/3) = 3(-1/27) - 5(1/9) - 11(-1/3) - 3 = -1/9 - 5/9 + 11/3 - 3 = -2/3 + 11/3 - 9/3 = 0$$

So $\alpha = 3, \beta = -1, \gamma = -1/3$.

$$\alpha + \beta + \gamma = 3 - 1 - 1/3 = 5/3 = -(-5)/3 = -b/a$$

$$\alpha\beta + \beta\gamma + \gamma\alpha = (3)(-1) + (-1)(-1/3) + (-1/3)(3) = -3 + 1/3 - 1 = -11/3 = c/a$$

$$\alpha\beta\gamma = 3 \times (-1) \times (-1/3) = 1 = -(-3)/3 = -d/a$$

All three relations hold. (NCERT marks this example "Not from the examination point of view".)

Competency-Based Questions (with answers)

1. Case-based: The fountain jet

In a garden, the path of a water jet is modelled by the equation $y = -x^2 + 6x - 8$, where x is the horizontal distance in metres and y is the height in metres. The jet leaves the water surface and falls into the water.

(a) Does the curve open upwards or downwards? The coefficient of x^2 is -1 , which is less than 0.

(b) At what horizontal distances does the jet hit the water? The zeroes of the polynomial are $x = 2$ and $x = 4$, that is $x^2 - 6x + 8 = 0$, $(x - 2)(x - 4) = 0$. These are the zeroes of the polynomial.

(c) Verify the sum and product of these zeroes. Sum of zeroes $= -6/(-1) = 6 = 2 + 4$. Product of zeroes $= -8/(-1) = 8 = 2 \times 4$.

2. Case-based: The rectangular plot

A rectangular plot has sides $(x + 3)$ m and $(x - 3)$ m.

(a) Write the area $A(x)$ as a polynomial. The area $A(x) = (x + 3)(x - 3) = x^2 - 9$. It is a quadratic polynomial.

(b) Find the zeroes of $A(x)$. From the factored form, the zeroes are $x = 3$ and $x = -3$.



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(c) Verify the relationship. Sum = $-3 + 1/2 = -5/2 = -b/a$. Product = $(-3)(1/2) = -3/2 = c/a$.

(d) For which values of x does the model describe a real plot? Both sides must be positive: $x + 3 > 0$ and $2x - 1 > 0$. So $x > 1/2$. At the zero $x = 1/2$ one side has length 0.

3. Source-based: Reading a table of values

A student makes this table for $y = x^3 - 4x$: at $x = -2, -1, 0, 1, 2$ the values of y are 0, 3, 0, -3, 0.

(a) Name the zeroes shown by the table. -2, 0 and 2, since $y = 0$ there.

(b) Can the polynomial have any other zero? Give a reason. No. It is a cubic, so it has at most three zeroes, and three have been found.

(c) Verify the cubic relations (practice only: NCERT marks cubic verification as not from the examination point of view). $a = 1, b = 0, c = -4, d = 0$. Sum = $-2 + 0 + 2 = 0 = -b/a$. Pair sum = $(-2)(0) + (0)(2) + (2)(-2) = -4 = c/a$. Product

4. Assertion-Reason

Assertion (A): The polynomial $x^2 + 1$ has no real zeroes.

Reason (R): The graph of $y = x^2 + 1$ lies completely above the x-axis.

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

Answer: (a). $x^2 \geq 0$, so $x^2 + 1 \geq 1$ for every x . Hence, $x^2 + 1$ is never zero. This is exactly why there is no zero.

5. Assertion-Reason

Assertion (A): The polynomial $x^3 - x$ has three real zeroes.

Reason (R): A polynomial of degree n has at most n real zeroes.

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.



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Answer: (d). $x^3 - x = x(x - 1)(x + 1)$ has exactly three zeroes: $-1, 0, 1$. A cubic cannot have four zeroes, so A is false. R is the correct general rule.

6. Assertion-Reason

Assertion (A): $x^2 - 5x + 6$ and $3x^2 - 15x + 18$ have the same zeroes.

Reason (R): Multiplying a polynomial by a non-zero constant does not change its zeroes.

- (a) Both A and R are true and R is the correct explanation of A.
- (b) Both A and R are true but R is not the correct explanation of A.
- (c) A is true but R is false.
- (d) A is false but R is true.

Answer: (a). $3x^2 - 15x + 18 = 3(x^2 - 5x + 6)$, and both have zeroes 2 and 3. R gives the reason: if $p(k) = 0$ then $3p(k) = 0$ too.

7. Error analysis: The wrong sign

Asked for a quadratic polynomial whose zeroes are -5 and 2 . The student wrote $x^2 + 3x - 10$. Find the error and correct it.

Answer: The middle coefficient must be the sum of the zeroes, $-b/a = -3$, so its zeroes (-5 and 2) add up to -3 . The correct polynomial is $x^2 - 3x - 10$, with zeroes 5 and -2 : sum 3 , product -10 .

8. Competency MCQ: Matching zeroes

Which polynomial has zeroes -2 and 5 ?

- (a) $x^2 - 3x - 10$ (b) $x^2 + 3x - 10$ (c) $x^2 - 7x + 10$

Answer: (a). Sum = 3 and product = -10 , so the polynomial is $x^2 - 3x - 10 = (x - 5)(x + 2)$.

Important Questions for

1-Mark Questions

Q1. If one zero of $5x^2 + 13x + k$ is the reciprocal of the other, find k .
Product of zeroes = 1 , so $k/5 = 1$ and $k = 5$.



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Q2. The graph of $y = p(x)$, where $p(x)$ is a quadratic, touches the x-axis at exactly one point. How many zeroes does $p(x)$ have?

One zero (the two zeroes are equal). The x-coordinate of the touching point is that zero.

Q3. If α and β are the zeroes of $x^2 - x - 6$, find $\alpha^2\beta + \alpha\beta^2$.

$\alpha + \beta = 1$, $\alpha\beta = -6$. $\alpha^2\beta + \alpha\beta^2 = \alpha\beta(\alpha + \beta) = -6 \times 1 = -6$.

Q4. What is the maximum number of zeroes a cubic polynomial can have?

Three, because a polynomial of degree n has at most n zeroes.

Q5. Write a quadratic polynomial whose zeroes are -3 and 4 .

$S = 1$, $P = -12$, so $x^2 - x - 12$.

2-Mark Questions

Q6. Find the zeroes of $x^2 + 2\sqrt{2}x - 6$ and verify the relationship between the zeroes and the coefficients.

Split: product -6 , sum $2\sqrt{2}$: the terms are:
 $x^2 + 3\sqrt{2}x - \sqrt{2}x - 6 = x(x + 3\sqrt{2}) - \sqrt{2}(x + 3\sqrt{2})$
Zeroes: $\sqrt{2}$ and $-3\sqrt{2}$. Sum $= -2\sqrt{2} = -b/a$

Q7. Find a quadratic polynomial whose zeroes are 1 and $-1/3$.

$x^2 - 2x - 1/3$. Multiply by 3: $3x^2 - 6x - 1$. Coefficients: $3, -6, -1$.

Q8. If 2 is a zero of $x^2 + 3x + k$, find k and the other zero.

$p(2) = 4 + 6 + k = 0$, so $k = -10$. Product $= -10$.
 $(-5) = -3 = -b/a$.

Q9. α and β are the zeroes of $x^2 - 6x + k$, find k if $3\alpha + 2\beta = 1$.

$\alpha + \beta = 6$. Then $3\alpha + 2\beta = 2(\alpha + \beta) + \alpha = 12 + \alpha = 1$.
So $\alpha = -11$. Then $\beta = 17$.
Product $= -11 \times 17 = -187 = k$.

3-Mark Questions

Q10. Find the zeroes of $4\sqrt{3}x^2 + 5x - 2\sqrt{3}$ and verify the relationship between the zeroes and the coefficients.

$ac = 4\sqrt{3} \times (-2\sqrt{3}) = -24$ and $b = 5$, so split $5x$ as $8x - 3x$.
 $4\sqrt{3}x^2 + 8x - 3x - 2\sqrt{3} = 4x(\sqrt{3}x + 2) - \sqrt{3}(\sqrt{3}x + 2)$
Zeroes: $\sqrt{3}/4$ and $-2/\sqrt{3} = -2\sqrt{3}/3$.

Sum $= \sqrt{3}/4 - 2\sqrt{3}/3 = (3\sqrt{3} - 8\sqrt{3})/12 = -5\sqrt{3}/12 = -b/a$

Product $= (\sqrt{3}/4)(-2/\sqrt{3}) = -1/2$, and $c/a = (-2\sqrt{3})/(4\sqrt{3}) = -1/2$.



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Q11. If α and β are the zeroes of $x^2 - 3x + 1$, find a quadratic polynomial whose zeroes are α^2 and β^2 .

$$\alpha + \beta = 3, \alpha\beta = 1.$$

$$\text{New sum} = \alpha^2 + \beta^2 = 9 - 2 = 7. \text{ New product} = \alpha^2\beta^2 = (\alpha\beta)^2 = 1.$$

Required polynomial: $x^2 - 7x + 1$.

Q12. The difference of the zeroes of $x^2 - 7x + k$ is 3. Find k and the zeroes.

Let the zeroes be α and β with $\alpha > \beta$. $\alpha + \beta = 7$ and $\alpha - \beta = 3$. Adding: $2\alpha = 10$, so $\alpha = 5$ and $\beta = 2$. $k = \alpha\beta = 10$. The zeroes are 5 and 2.

5-Mark Questions

Q13. If α and β are the zeroes of $p(x) = 3x^2 - 5x - 2$, (i) find the zeroes and verify the relationship between the zeroes and the coefficients, (ii) find $\alpha/\beta + \beta/\alpha$, (iii) find a quadratic polynomial whose zeroes are 2α and 2β .

(i) $a = 3, b = -5, c = -2$. Two numbers with product $3 \times (-2) = -6$ and sum -5 are -6 and 1 .

$$3x^2 - 6x + x - 2 = 3x(x - 2) + 1(x - 2) = (3x + 1)(x - 2)$$

$$\text{Sum} = 2 - 1/3 = 5/3, \text{ and } -b/a = -(-5)/3 = 5/3$$

$$\text{Product} = 2 \times (-1/3) = -2/3, \text{ and } c/a = -2/3$$

$$(ii) \alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta = 25/9 + 4/3 = 37/9$$

$$\alpha/\beta + \beta/\alpha = (\alpha^2 + \beta^2)/\alpha\beta = (37/9) \div (-2/3) = -37/6$$

$$\text{Check with the zeroes: } 2 \div (-1/3) + (-1/3) = -6 + (-1/3) = -19/3$$

$$(iii) \text{ New sum} = 2(\alpha + \beta) = 10/3. \text{ New product} = 4\alpha\beta = -8/3$$

$$x^2 - (10/3)x - 8/3. \text{ Multiply by 3: } 3x^2 - 10x - 8$$

$$\text{zeroes } 4 = 2 \times 2 \text{ and } -2/3 = 2 \times (-1/3).$$

Q14. If α and β are the zeroes of $2x^2 - 5x + 3$, find the zeroes of $2x^2 - 5x + 3\alpha + 2\beta$.

$$\alpha + \beta = 5/2, \alpha\beta = 3/2.$$

$$\text{New sum} = (2\alpha + 3\beta) + (3\alpha + 2\beta) = 5(\alpha + \beta) = 25/2$$

$$\text{New product} = (2\alpha + 3\beta)(3\alpha + 2\beta) = 6\alpha^2 + 13\alpha\beta + 6\beta^2$$

$$\text{Now } 6(\alpha^2 + \beta^2) = 6[(\alpha + \beta)^2 - 2\alpha\beta] = 6(25/4 - 3) = 75/2 - 18 = 21/2$$

$$21/2 + 13 \times 3/2 = 75/2 + 39/2 = 114/2 = 57$$

$$\text{Polynomial: } x^2 - (25/2)x + 57. \text{ Multiply by 2: } 2x^2 - 25x + 114$$



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Common Mistakes and Examples

1. Reading coefficients from the unsorted polynomial
 Example: Find the sum of the zeroes of $6x^2 - 7x - 3$.
 Solution: Rewrite as $6x^2 - 7x - 3$ first, so $b = -7$ and $c = -3$.

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2. **Dropping the minus in the sum.** Writing $\alpha + \beta = b/a$. Fix: the sum is $-b/a$. For $x^2 - 2x - 8$ the sum is $+2$.
3. **Adding a minus to the product.** Writing $\alpha\beta = -c/a$ for a quadratic. Fix: the product is c/a . The minus sign on the product belongs to the cubic, $\alpha\beta\gamma = -d/a$.
4. **Wrong sign in the formed quadratic.** Writing $x^2 + Sx + P$. Fix: use $x^2 - Sx + P$ and check the answer with $-b/a$.
5. **Verifying only one side.** Writing "sum = 4" and stopping. Fix: compute the sum from the zeroes and $-b/a$ from the coefficients separately, show both, then write "Hence verified".
6. **Losing the zero 0.** For $4u^2 + 8u$, dividing by u gives only $u = -2$. Fix: factorise as $4u(u + 2)$, which gives both zeroes 0 and -2 .
7. **Giving only the positive root.** For $t^2 - 15$, writing only $\sqrt{15}$. Fix: $t^2 - 15 = (t - \sqrt{15})(t + \sqrt{15})$, so $-\sqrt{15}$ is also a zero.
8. **Counting y-axis crossings as zeroes.** Fix: zeroes are only where the graph meets the x-axis. A point where the curve touches the x-axis and turns back still counts once.
9. **Claiming more zeroes than the degree** cubic at most three. If your count from
10. **Finding irrational zeroes when you do** quadratic and square surds. Fix: use $(\alpha$
11. **Sign slips when substituting negatives** always put negative numbers and fracti



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Quick Revision Points

- The degree of a polynomial is the highest
- Degrees 1, 2 and 3 give linear, quadratic
- General quadratic: $ax^2 + bx + c$, with a ,
- General cubic: $ax^3 + bx^2 + cx + d$, with
- k is a zero of $p(x)$ if $p(k) = 0$.
- The zero of $ax + b$ is $-b/a$.
- Zeroes are the x-coordinates of the poi
- The graph of a quadratic is a parabola:
- A quadratic has two distinct zeroes, two

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- A polynomial of degree n has at most n zeroes.
- $x^3 - 4x$ has zeroes $-2, 0, 2$; x^3 has only 0 ; $x^3 - x^2$ has 0 and 1 .
- For $ax^2 + bx + c$: $\alpha + \beta = -b/a$ and $\alpha\beta = c/a$.
- Quadratic with zero-sum S and zero-product P : $k(x^2 - Sx + P)$, $k \neq 0$.
- Multiplying by a non-zero constant does not change the zeroes.
- For $ax^3 + bx^2 + cx + d$: $\alpha + \beta + \gamma = -b/a$, $\alpha\beta + \beta\gamma + \gamma\alpha = c/a$, $\alpha\beta\gamma = -d/a$.
- $\alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta$ and $1/\alpha + 1/\beta = (\alpha + \beta)/\alpha\beta$.
- Reciprocal zeroes: $c = a$. Zeroes that are negatives of each other: $b = 0$. One zero equal to 0 : $c = 0$.
- Plotting graphs of quadratic or cubic polynomials is not evaluated; Exercise 2.1 practises reading given graphs.

Weightage in Board Exams

Polynomials belongs to the **Algebra** unit of Class 10. It is covered in Two Variables, Quadratic Equations and Functions. Here is the course structure for the marks given to the topics in this way.

Question type	
MCQ and Assertion-Reason	Number of zeroes of zeroes; the polynomial given-zero condition
Short answers	Find the zeroes of polynomial (with surd coefficients);
Longer answers	Expressions in α and β ; finding unknown zeroes
Case-based	A curved path or a graph of zeroes, shape and



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Practise every NCERT exercise question in



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