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CHAPTER NOTES

Conic Sections Class 11 Notes | CBSE Maths Chapter 10

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Conic Sections Class 11 Notes | CBSE Maths Chapter 10

Conic Sections is Chapter 10 of CBSE Class 11 Maths — the chapter where geometry and algebra finally shake hands. A single slice through a cone can give you a circle, a parabola, an ellipse, or a hyperbola, and each of these curves has a clean standard equation you can recognise on sight. Master this chapter and you unlock a whole family of questions in JEE, NEET-adjacent maths, and your board exam.

By the end of these notes you will be able to identify any conic from its equation, write the standard forms of the circle, parabola, ellipse and hyperbola, and pull out the focus, directrix, vertices, eccentricity, foci and latus rectum without hesitation. This is a high-weightage chapter carrying roughly 7–9 marks in boards, and the foundation for coordinate geometry, calculus, and most of analytic geometry that follows.

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Key Concepts

1. Sections of a Cone

A **conic section** is the curve obtained when a plane cuts a double right circular cone. Depending on the angle the cutting plane makes with the axis, you get four non-degenerate curves: the circle, ellipse, parabola and hyperbola.

[DIAGRAM: A double right circular cone with vertex V , axis, and a generator line making angle α with the axis. A cutting plane making angle β with the axis produces different conics.]

The Cutting-Angle Rule

Let the cone's generators make a semi-vertical angle α with the axis, and let the cutting plane make angle β with the axis.

- $\beta = 90^\circ$: the plane is perpendicular to the axis $\rightarrow$ **circle**.
- $\alpha < \beta < 90^\circ$: the plane cuts one nappe at a slant $\rightarrow$ **ellipse**.

- $\beta = \alpha$: the plane is parallel to a generator $\rightarrow$ **parabola**.
- $0 \leq \beta < \alpha$: the plane cuts both nappes $\rightarrow$ **hyperbola**.

Degenerate Conics

When the cutting plane passes through the vertex, you get a degenerate conic — a **point**, a **straight line**, or a **pair of intersecting lines**.

2. The Circle

A **circle** is the set of all points in a plane that are at a fixed distance (the **radius** r) from a fixed point (the **centre**).

Standard Equation

For centre (h, k) and radius r :

$$(x - h)^2 + (y - k)^2 = r^2$$

If the centre is the origin $(0, 0)$, this reduces to $x^2 + y^2 = r^2$.

General Equation

The general second-degree equation of a circle is:

$$x^2 + y^2 + 2gx + 2fy + c = 0$$

- **Centre:** $(-g, -f)$
- **Radius:** $r = \sqrt{g^2 + f^2 - c}$
- It represents a **real circle** only if $g^2 + f^2 - c > 0$; a point circle if it equals 0; and an imaginary circle if it is negative.

Note: A general second-degree equation $Ax^2 + By^2 + 2Hxy + 2Gx + 2Fy + C = 0$ represents a circle only when $A = B$ and $H = 0$ (no xy term, equal coefficients of x^2 and y^2).

3. The Parabola

A **parabola** is the set of all points in a plane that are equidistant from a fixed point (the **focus**) and a fixed line (the **directrix**).

The constant ratio of these two distances — the **eccentricity** e — equals exactly **1** for a parabola.

[DIAGRAM: A right-opening parabola $y^2 = 4ax$ with vertex at origin, focus at $(a, 0)$, directrix $x = -a$, axis along the x -axis, and the latus rectum as a vertical chord through the focus.]

Standard Forms

Equation	Opens	Focus	Directrix	Axis
$y^2 = 4ax$	Right	$(a, 0)$	$x = -a$	x-axis
$y^2 = -4ax$	Left	$(-a, 0)$	$x = a$	x-axis
$x^2 = 4ay$	Up	$(0, a)$	$y = -a$	y-axis
$x^2 = -4ay$	Down	$(0, -a)$	$y = a$	y-axis

Key Features (for $y^2 = 4ax$)

- **Vertex:** $(0, 0)$
- **Length of latus rectum:** $4a$
- **Latus rectum** is the chord through the focus, perpendicular to the axis.
- The parabola is symmetric about its axis.

4. The Ellipse

An **ellipse** is the set of all points in a plane the sum of whose distances from two fixed points (the **foci**) is constant. That constant equals the length of the major axis, $2a$.

Its eccentricity satisfies $0 < e < 1$.

[DIAGRAM: A horizontal ellipse centred at origin with major axis along x-axis, vertices $(\pm a, 0)$, foci $(\pm c, 0)$, minor axis along y-axis with endpoints $(0, \pm b)$.]

Standard Forms

Equation	Major axis	Vertices	Foci
$x^2/a^2 + y^2/b^2 = 1 \quad (a > b)$	x-axis (length $2a$)	$(\pm a, 0)$	$(\pm c, 0)$
$x^2/b^2 + y^2/a^2 = 1 \quad (a > b)$	y-axis (length $2a$)	$(0, \pm a)$	$(0, \pm c)$

Key Relations

- **Relation between a, b, c:** $c^2 = a^2 - b^2$
- **Eccentricity:** $e = c/a = \sqrt{1 - b^2/a^2}$, with $0 < e < 1$
- **Length of major axis:** $2a$; **minor axis:** $2b$
- **Length of latus rectum:** $2b^2/a$
- Sum of focal distances of any point = $2a$

5. The Hyperbola

A **hyperbola** is the set of all points in a plane the *difference* of whose distances from two fixed points (the **foci**) is constant (equal to $2a$, the length of the transverse axis).

Its eccentricity satisfies $e > 1$.

[DIAGRAM: A horizontal hyperbola centred at origin with two branches opening left and right, vertices $(\pm a, 0)$, foci $(\pm c, 0)$, and the two asymptotes $y = \pm(b/a)x$ crossing at the centre.]

Standard Forms

Equation	Transverse axis	Vertices	Foci	Asymptotes
$x^2/a^2 - y^2/b^2 = 1$	x-axis	$(\pm a, 0)$	$(\pm c, 0)$	$y = \pm(b/a)x$
$y^2/a^2 - x^2/b^2 = 1$	y-axis	$(0, \pm a)$	$(0, \pm c)$	$y = \pm(a/b)x$

Key Relations

- **Relation between a, b, c:** $c^2 = a^2 + b^2$
- **Eccentricity:** $e = c/a = \sqrt{1 + b^2/a^2}$, with $e > 1$
- **Length of transverse axis:** $2a$; **conjugate axis:** $2b$
- **Length of latus rectum:** $2b^2/a$
- A **rectangular (equilateral) hyperbola** has $a = b$, so $e = \sqrt{2}$ and asymptotes $y = \pm x$.

6. Eccentricity — The Unifying Idea

Every conic can be defined by a single ratio $e = (\text{distance from focus})/(\text{distance from directrix})$. This **eccentricity** tells you instantly which conic you are looking at.

Conic	Eccentricity (e)	c-relation
Circle	$e = 0$	foci coincide at centre
Ellipse	$0 < e < 1$	$c^2 = a^2 - b^2$
Parabola	$e = 1$	—
Hyperbola	$e > 1$	$c^2 = a^2 + b^2$

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	7–9 marks	Circle equations, parabola focus/latus rectum, ellipse & hyperbola standard forms
JEE Main / Advanced	2–4 questions	Eccentricity, foci, tangents, latus rectum, locus problems
Competitive (CUET etc.)	2–3 questions	Identifying conics, finding centre/radius, standard-form conversions

[TABLE: Question-type split — VSA (1 mark): identify the conic, state eccentricity; SA (2–3 marks): find focus/directrix/latus rectum, centre & radius of a circle; LA (5 marks): derive the equation of an ellipse/hyperbola from given foci and vertices.]

Important Definitions

Term	Definition
Conic section	Curve formed by the intersection of a plane and a double right circular cone
Circle	Locus of points at a fixed distance r from a fixed centre: $(x - h)^2 + (y - k)^2 = r^2$
Parabola	Locus of points equidistant from a focus and a directrix; $e = 1$
Ellipse	Locus of points whose distances from two foci sum to a constant $2a$; $0 < e < 1$
Hyperbola	Locus of points whose distances from two foci differ by a constant $2a$; $e > 1$
Focus	Fixed point used to define a conic
Directrix	Fixed line used (with the focus) to define a conic
Eccentricity (e)	Ratio of distance from focus to distance from directrix; fixes the conic type
Latus rectum	Focal chord perpendicular to the major/transverse axis; $4a$ (parabola) or $2b^2/a$ (ellipse, hyperbola)
Asymptote	Line a hyperbola approaches but never meets: $y = \pm(b/a)x$

Solved Examples

Example 1

Find the centre and radius of the circle $x^2 + y^2 - 6x + 4y - 12 = 0$.

Answer: Here $2g = -6$, $2f = 4$, $c = -12$, so $g = -3$, $f = 2$. Centre = $(-g, -f) = (3, -2)$. Radius = $\sqrt{(g^2 + f^2 - c)} = \sqrt{(9 + 4 + 12)} = \sqrt{25} = 5$.

Example 2

Find the equation of a circle with centre $(2, -3)$ and radius 4.

Answer: $(x - 2)^2 + (y + 3)^2 = 4^2 \rightarrow (x - 2)^2 + (y + 3)^2 = 16$, i.e. $x^2 + y^2 - 4x + 6y - 3 = 0$.

Example 3

For the parabola $y^2 = 12x$, find the focus, directrix and length of the latus rectum.

Answer: Compare with $y^2 = 4ax \rightarrow 4a = 12 \rightarrow a = 3$. Focus = $(3, 0)$; directrix $x = -3$; length of latus rectum = $4a = 12$.

Example 4

Find the coordinates of the foci and the eccentricity of the ellipse $x^2/25 + y^2/9 = 1$.

Answer: $a^2 = 25$, $b^2 = 9$, so $a = 5$, $b = 3$. $c^2 = a^2 - b^2 = 25 - 9 = 16 \rightarrow c = 4$. Foci = $(\pm 4, 0)$; eccentricity $e = c/a = 4/5 = 0.8$.

Example 5

Find the eccentricity, foci and length of the latus rectum of the hyperbola $x^2/16 - y^2/9 = 1$.

Answer: $a^2 = 16$, $b^2 = 9$, so $a = 4$, $b = 3$. $c^2 = a^2 + b^2 = 25 \rightarrow c = 5$. Eccentricity $e = c/a = 5/4 = 1.25$; foci = $(\pm 5, 0)$; latus rectum = $2b^2/a = 2(9)/4 = 4.5$.

Example 6

Find the equation of the ellipse whose vertices are $(\pm 6, 0)$ and foci are $(\pm 4, 0)$.

Answer: $a = 6$, $c = 4 \rightarrow b^2 = a^2 - c^2 = 36 - 16 = 20$. Equation: $x^2/36 + y^2/20 = 1$.

Important Questions for Board Exams

1-Mark Questions (VSA)

1. What is the eccentricity of a parabola?

2. Write the standard equation of a circle with centre at the origin and radius r .
3. For the ellipse $x^2/a^2 + y^2/b^2 = 1$ ($a > b$), what is the length of the latus rectum?
4. What are the asymptotes of the hyperbola $x^2/a^2 - y^2/b^2 = 1$?
5. Name the conic obtained when a plane cuts a cone perpendicular to its axis.

2–3-Mark Questions (SA)

1. Find the centre and radius of the circle $2x^2 + 2y^2 - 8x + 12y - 6 = 0$.
2. Find the focus, directrix and latus rectum of the parabola $x^2 = -16y$.
3. Find the foci, vertices and eccentricity of the ellipse $9x^2 + 4y^2 = 36$.
4. Find the eccentricity and the length of the latus rectum of the hyperbola $9x^2 - 16y^2 = 144$.

5-Mark Questions (LA)

1. Define a parabola and derive its standard equation $y^2 = 4ax$ taking the focus at $(a, 0)$ and directrix $x = -a$.
 2. Find the equation of the ellipse whose foci are $(\pm 5, 0)$ and the length of the major axis is 18. State its eccentricity.
 3. Find the equation of the hyperbola with vertices $(\pm 7, 0)$ and one focus at $(10, 0)$. Find its eccentricity and latus rectum.
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Quick Revision Points

- Conics come from slicing a cone — circle, ellipse, parabola, hyperbola, set by the cutting angle
 - Circle: $(x - h)^2 + (y - k)^2 = r^2$; general $x^2 + y^2 + 2gx + 2fy + c = 0$, centre $(-g, -f)$, $r = \sqrt{g^2 + f^2 - c}$
 - Parabola: $y^2 = 4ax \rightarrow$ focus $(a, 0)$, directrix $x = -a$, latus rectum $4a$; $e = 1$
 - Ellipse: $x^2/a^2 + y^2/b^2 = 1$, $c^2 = a^2 - b^2$, $e = c/a$ ($0 < e < 1$), latus rectum $2b^2/a$
 - Hyperbola: $x^2/a^2 - y^2/b^2 = 1$, $c^2 = a^2 + b^2$, $e = c/a$ ($e > 1$), asymptotes $y = \pm(b/a)x$, latus rectum $2b^2/a$
 - Eccentricity ladder: circle 0, ellipse 0–1, parabola 1, hyperbola >1
 - Latus rectum is the focal chord perpendicular to the axis
 - Rectangular hyperbola: $a = b$, $e = \sqrt{2}$, asymptotes $y = \pm x$
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Next Chapter: Chapter 11 — Introduction to Three Dimensional Geometry



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