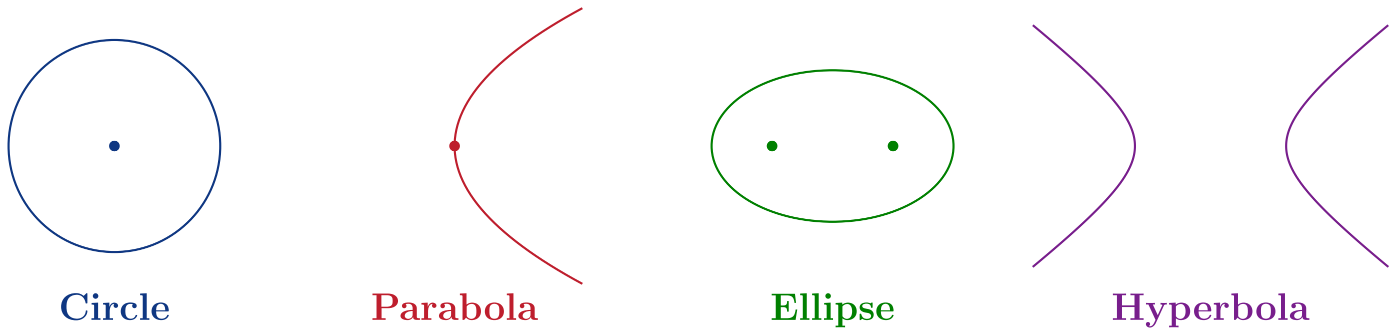

Conic Section Capsule

Comprehensive Formula Reference for IIT JEE Advanced

Modules: Circles • Parabola • Ellipse • Hyperbola • Pair of Straight Lines

Contents

MODULE 1: CIRCLES

0.1 Standard Equation, General Form & All Variants

WHEN IT CLICKS:

Need center/radius from equation, or write circle given geometric data.

Standard Form: $(x-h)^2 + (y-k)^2 = r^2$ Center: (h, k), Radius: r

General Form: $x^2 + y^2 + 2gx + 2fy + c = 0$

$$\text{Center} = (-g, -f), \qquad \text{Radius} = \sqrt{g^2 + f^2 - c}$$

Form	Equation	Notes
Diametric	$(x-x_1)(x-x_2) + (y-y_1)(y-y_2) = 0$	Endpoints $(x_1, y_1), (x_2, y_2)$
Parametric	$x = h + r\cos\theta,\ y = k + r\sin\theta$	$\theta \in [0, 2\pi)$
Through origin	$x^2 + y^2 + 2gx + 2fy = 0$	$c = 0$
Center on x-axis	$x^2 + y^2 + 2gx + c = 0$	$f = 0$
Center on y-axis	$x^2 + y^2 + 2fy + c = 0$	$g = 0$
Touches x-axis	$x^2 + y^2 + 2gx + 2fy + g^2 = 0$	$r = \lvert f\rvert$
Touches y-axis	$x^2 + y^2 + 2gx + 2fy + f^2 = 0$	$r = \lvert g\rvert$
Touches both axes	$x^2 + y^2 \pm 2ax \pm 2ay + a^2 = 0$	$r = \lvert a\rvert$

Condition for real circle: $g^2 + f^2 - c > 0$

Point circle: $g^2 + f^2 - c = 0$ **Imaginary:** $g^2 + f^2 - c < 0$

Intuition

Always convert to general form to extract center/radius. If coefficient of $x^2 \neq 1$, divide throughout first.

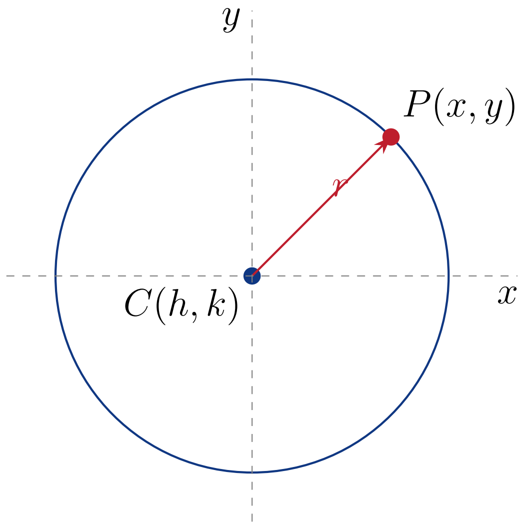

Figure 1: Standard circle with center $C(h, k)$ and radius r.

0.2 Intercepts on Axes

WHEN IT CLICKS:

Circle cuts coordinate axes; find length of intercepts.

$$\text{X-intercept} = 2\sqrt{g^2 - c}, \qquad \text{Y-intercept} = 2\sqrt{f^2 - c}$$

Touches x-axis: $g^2 = c$ **Touches y-axis:** $f^2 = c$ **Touches both:** $g^2 = f^2 = c$

0.3 Position of a Point & Power (S_1)

WHEN IT CLICKS:

Determine if point lies inside/outside/on circle; find tangent length.

$S_1 = x_1^2 + y_1^2 + 2gx_1 + 2fy_1 + c$

$$S_1 > 0 \Rightarrow \text{Outside}, \quad S_1 = 0 \Rightarrow \text{On}, \quad S_1 < 0 \Rightarrow \text{Inside}$$

Power of point: $S_1 = d^2 - r^2$ **Length of tangent:** $L = \sqrt{S_1}$

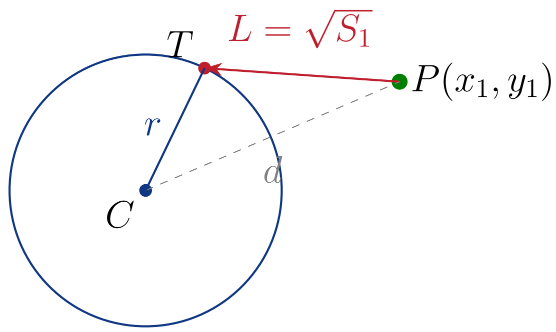

Figure 2: Length of tangent from external point.

0.4 Tangent — All Forms

WHEN IT CLICKS:

Find tangent at point on circle, or tangent with given slope.

Tangent at (x_1, y_1) **on** $S = 0$ **(T=0):**

$$xx_1 + yy_1 + g(x + x_1) + f(y + y_1) + c = 0$$

Tangent at (x_1, y_1) **on** $x^2 + y^2 = a^2$**:** $xx_1 + yy_1 = a^2$
Slope form to $x^2 + y^2 = a^2$**:** $y = mx \pm a\sqrt{1 + m^2}$

Condition for tangency: $\left|\frac{l(-g) + m(-f) + n}{\sqrt{l^2 + m^2}}\right| = r$

0.5 Normal to Circle

WHEN IT CLICKS:

Find normal at point on circle.

Normal at $P(x_1, y_1)$ (line through P and center $C(-g, -f)$):

$$\frac{x - x_1}{x_1 + g} = \frac{y - y_1}{y_1 + f}$$

For $x^2 + y^2 = a^2$: $y_1x - x_1y = 0$ (passes through origin).

Intuition

All normals pass through the center. Normal is perpendicular to tangent.

0.6 Chord of Contact, Chord with Midpoint & Pair of Tangents

WHEN IT CLICKS:

External point given, or midpoint of chord known.

Concept	**Formula**
Chord of contact from $P(x_1, y_1)$	$T = 0$
Chord bisected at $P(x_1, y_1)$	$T = S_1$
Pair of tangents from $P(x_1, y_1)$	$SS_1 = T^2$
Length of chord of contact	$\dfrac{2Lr}{\sqrt{S_1}}$ where $L = \sqrt{S_1}$
Area of triangle formed by tangents	$\dfrac{rL^3}{S_1}$

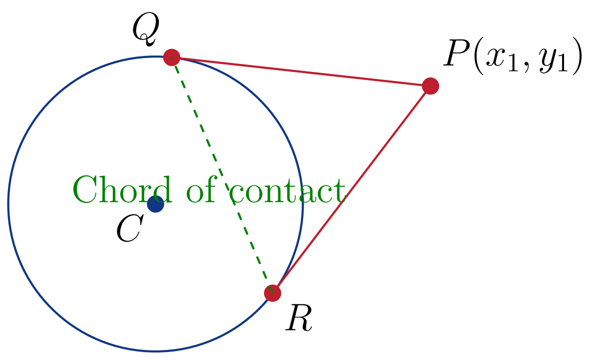

Figure 3: Chord of contact QR from external point P.

0.7 Director Circle & Orthogonality

WHEN IT CLICKS:

Locus of intersection of perpendicular tangents; two circles cutting at 90°.

Director Circle of $x^2 + y^2 = r^2$: $x^2 + y^2 = 2r^2$

Orthogonality Condition for S_1 and S_2:

$$2g_1g_2 + 2f_1f_2 = c_1 + c_2$$

Angle of intersection: $\cos\theta = \dfrac{r_1^2 + r_2^2 - d^2}{2r_1r_2}$

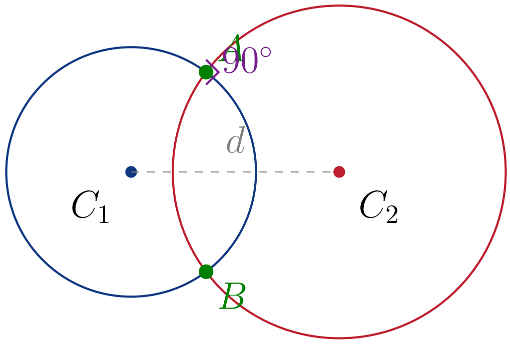

Figure 4: Orthogonal circles: tangents at intersection points are perpendicular.

0.8 Radical Axis & Family of Circles

WHEN IT CLICKS:

Finding locus of equal power, or circle through intersection of two circles.

Radical Axis: $S_1 - S_2 = 0$ (coefficients of x^2, y^2 must be equal)
Family through $S = 0$ **and** $L = 0$**:** $S + \lambda L = 0$
Family through $S_1 = 0$ **and** $S_2 = 0$**:** $S_1 + \lambda S_2 = 0$

0.9 Common Tangents (Two Circles)

WHEN IT CLICKS:

Given two circles, count or find common tangents.

Condition	Number of Tangents
$d > r_1 + r_2$	4 (Separate)
$d = r_1 + r_2$	3 (External touch)
$\lvert r_1 - r_2\rvert < d < r_1 + r_2$	2 (Intersecting)
$d = \lvert r_1 - r_2\rvert$	1 (Internal touch)
$d < \lvert r_1 - r_2\rvert$	0 (One inside other)

Length of Direct Common Tangent: $\sqrt{d^2 - (r_1 - r_2)^2}$
Length of Transverse Common Tangent: $\sqrt{d^2 - (r_1 + r_2)^2}$

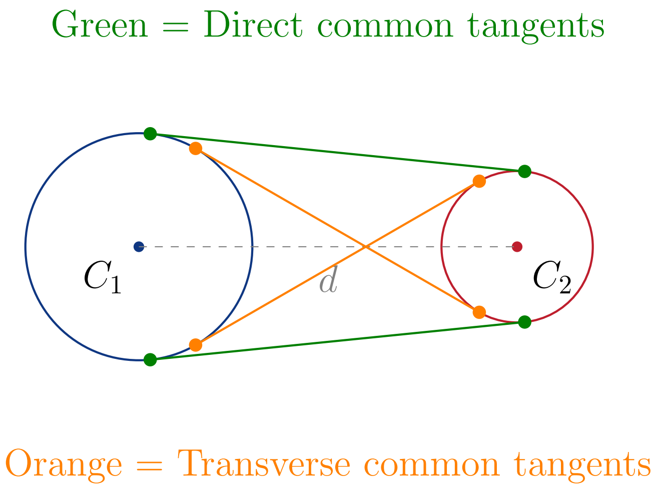

Figure 5: All four common tangents. Green touch same side (direct); orange cross between circles (transverse).

MODULE 2: PARABOLA

0.10 Standard Parabola & All Orientations

WHEN IT CLICKS:

Need focus, directrix, latus rectum, or axis.

Equation	Focus	Directrix	Axis	LR
$y^2 = 4ax$	$(a, 0)$	$x = -a$	$y = 0$	$4a$
$y^2 = -4ax$	$(-a, 0)$	$x = a$	$y = 0$	$4a$
$x^2 = 4ay$	$(0, a)$	$y = -a$	$x = 0$	$4a$
$x^2 = -4ay$	$(0, -a)$	$y = a$	$x = 0$	$4a$

Parametric ($y^2 = 4ax$): $(at^2, 2at)$ **Focal distance:** $PS = x_1 + a$

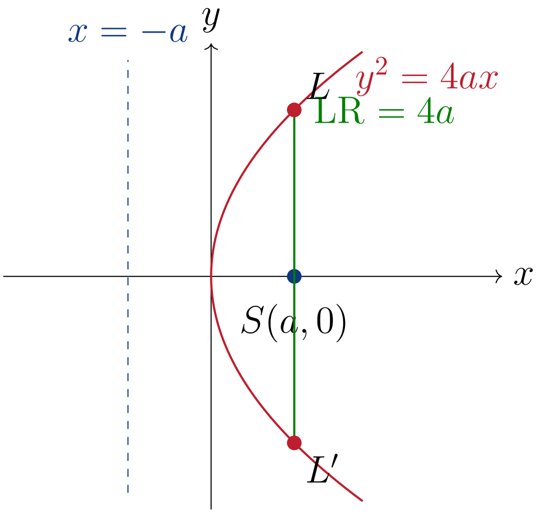

Figure 6: Standard parabola with focus $S(a, 0)$, directrix $x = -a$, and latus rectum LL'.

0.11 Tangent — All Forms

WHEN IT CLICKS:

Finding tangent at point, or tangent with given slope.

Type	$y^2 = 4ax$	$x^2 = 4ay$
Tangent at (x_1, y_1)	$yy_1 = 2a(x + x_1)$	$xx_1 = 2a(y + y_1)$
Tangent at t	$ty = x + at^2$	$tx = y + at^2$
Tangent with slope m	$y = mx + \frac{a}{m}$	$y = mx - am^2$
Condition for $y = mx + c$	$c = a/m$	$c = -am^2$
Point of contact	$\left(\frac{a}{m^2}, \frac{2a}{m}\right)$	$(-2am, am^2)$

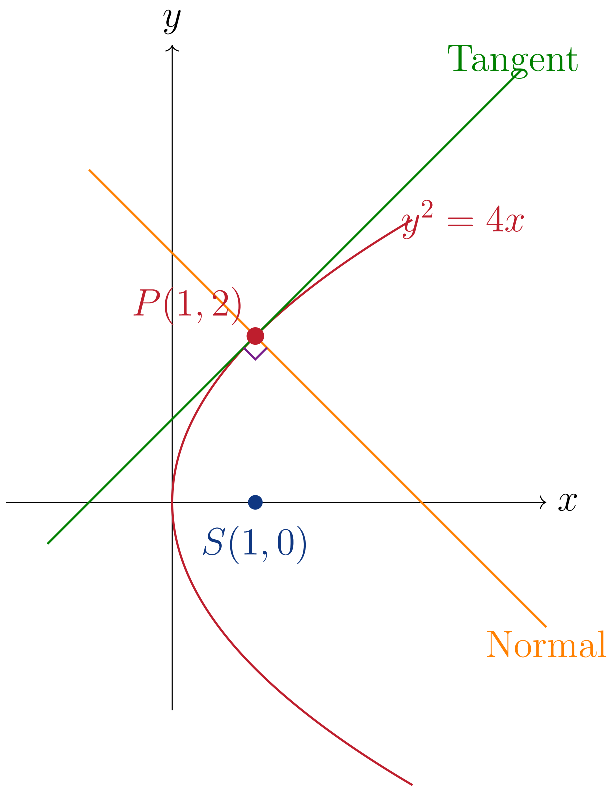

Figure 7: Tangent $y = x+1$ and normal $y = -x+3$ at $P(1, 2)$ on $y^2 = 4x$. They are perpendicular at P.

0.12 Normal — All Forms

WHEN IT CLICKS:

Finding normal at point, or normal with given slope.

Type	$\boldsymbol{y^2 = 4ax}$
Normal at (x_1, y_1)	$y - y_1 = -\frac{y_1}{2a}(x - x_1)$
Normal at t	$y = tx - 2at - at^3$
Normal with slope m	$y = mx - 2am - am^3$
Condition for $y = mx + c$	$c = -2am - am^3$
Point of contact	$(am^2, -2am)$

0.13 Chord & Focal Chord

WHEN IT CLICKS:

Chord joining two points, or chord through focus.

Chord joining t_1, t_2: $y(t_1 + t_2) = 2x + 2at_1t_2$
Focal chord condition: $t_1t_2 = -1$
Length of focal chord: $a(t_1 - t_2)^2$ **at angle θ:** $4a \csc^2 \theta$

Intuition

Harmonic mean of focal chord segments $= 2a$. Product of segments $= 4a^2 \csc^2 \theta$.

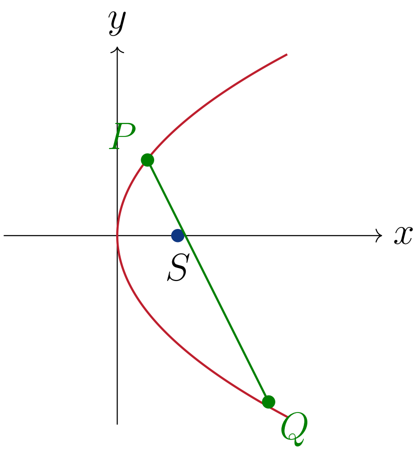

Figure 8: Focal chord PQ passing through focus S.

0.14 Director Circle & Reflection

Director circle of $y^2 = 4ax$: $x + a = 0$ (the directrix itself!)
Reflection property: Tangent at any point bisects the angle between focal radius and line parallel to axis.

MODULE 3: ELLIPSE

0.15 Standard Ellipse & Key Parameters

WHEN IT CLICKS:

Need foci, vertices, eccentricity, or latus rectum.

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \quad (a > b)$$

Parameter	Value
Foci	$(\pm ae, 0)$
Vertices	$(\pm a, 0)$
Eccentricity	$e = \sqrt{1 - b^2/a^2}$
Latus Rectum	$2b^2/a$
Directrices	$x = \pm a/e$
Sum of focal distances	$2a$
Parametric	$(a\cos\theta, b\sin\theta)$
Auxiliary circle	$x^2 + y^2 = a^2$
Director circle	$x^2 + y^2 = a^2 + b^2$

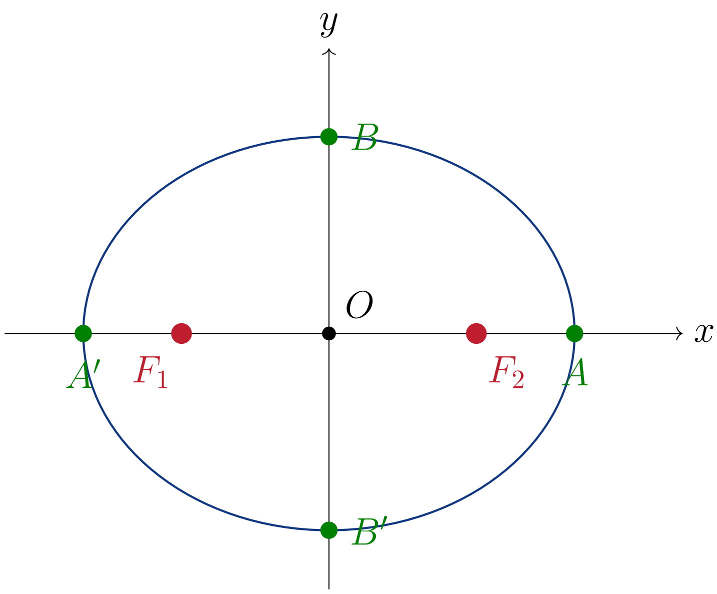

Figure 9: General ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ $(a > b)$ with eccentricity $e = \sqrt{1 - b^2/a^2}$. Foci $F_1(-ae, 0)$, $F_2(ae, 0)$; vertices $A(a, 0)$, $A'(-a, 0)$; minor-axis endpoints $B(0, b)$, $B'(0, -b)$.

0.16 Tangent — All Forms

WHEN IT CLICKS:

Finding tangent at point, or tangent with given slope.

Type	Equation
Tangent at (x_1, y_1)	$\frac{xx_1}{a^2} + \frac{yy_1}{b^2} = 1$
Tangent at θ	$\frac{x\cos\theta}{a} + \frac{y\sin\theta}{b} = 1$
Tangent with slope m	$y = mx \pm \sqrt{a^2m^2 + b^2}$
Condition for $y = mx + c$	$c^2 = a^2m^2 + b^2$

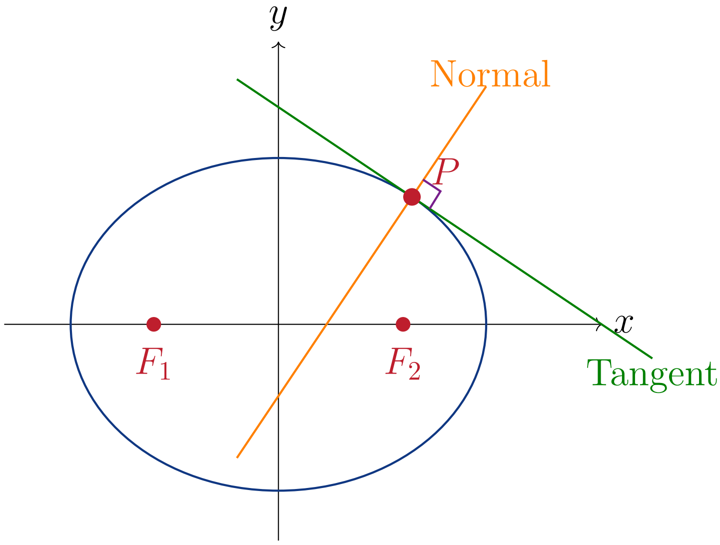

Figure 10: Tangent $\dfrac{xx_1}{a^2} + \dfrac{yy_1}{b^2} = 1$ and normal $\dfrac{a^2x}{x_1} - \dfrac{b^2y}{y_1} = a^2 - b^2$ at P on ellipse. They are perpendicular.

0.17 Normal — All Forms

Normal at (x_1, y_1): $\frac{a^2x}{x_1} - \frac{b^2y}{y_1} = a^2 - b^2$
Normal at θ: $ax\sec\theta - by\csc\theta = a^2 - b^2$
Normal with slope m: $y = mx \mp \frac{(a^2-b^2)m}{\sqrt{a^2+b^2m^2}}$

0.18 Focal Chord & Eccentric Angle

Focal chord condition: $\tan\frac{\theta_1}{2}\tan\frac{\theta_2}{2} = -\frac{1-e}{1+e}$
Focal chord length: $\frac{2a(1-e^2)}{1-e^2\cos^2\theta}$
Focal distances: $PS = a - ex_1$, $PS' = a + ex_1$, Sum $= 2a$

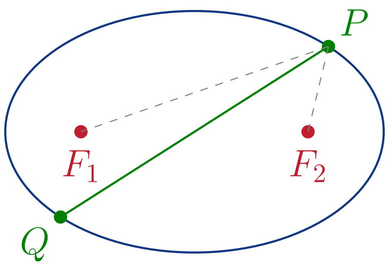

Figure 11: Focal chord PQ of an ellipse.

MODULE 4: HYPERBOLA

0.19 Standard Hyperbola & Key Parameters

WHEN IT CLICKS:

Need foci, vertices, eccentricity, or asymptotes.

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$$

Parameter	Value
Foci	$(\pm ae, 0)$
Vertices	$(\pm a, 0)$
Eccentricity	$e = \sqrt{1 + b^2/a^2}$
Latus Rectum	$2b^2/a$
Directrices	$x = \pm a/e$
Asymptotes	$y = \pm(b/a)x$
Parametric	$(a\sec\theta, b\tan\theta)$
Difference of focal distances	$2a$

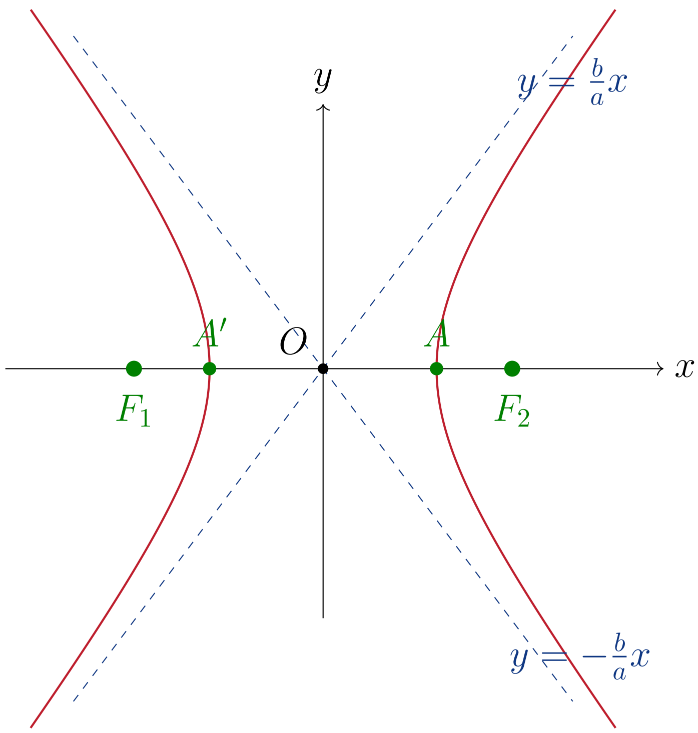

Figure 12: General hyperbola $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ with eccentricity $e = \sqrt{1 + b^2/a^2}$. Foci $F_1(-ae, 0)$, $F_2(ae, 0)$; vertices $A(a, 0)$, $A'(-a, 0)$; asymptotes $y = \pm(b/a)x$.

0.20 Tangent & Normal

Tangent at (x_1, y_1): $\frac{xx_1}{a^2} - \frac{yy_1}{b^2} = 1$
Tangent at θ: $\frac{x\sec\theta}{a} - \frac{y\tan\theta}{b} = 1$
Tangent with slope m: $y = mx \pm \sqrt{a^2m^2 - b^2}$
Condition: $c^2 = a^2m^2 - b^2$
Normal at (x_1, y_1): $\frac{a^2x}{x_1} + \frac{b^2y}{y_1} = a^2 + b^2$

0.21 Conjugate Hyperbola & Rectangular Hyperbola

Conjugate of $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$: $\frac{y^2}{b^2} - \frac{x^2}{a^2} = 1$
Relation: $\frac{1}{e^2} + \frac{1}{e'^2} = 1$
Rectangular hyperbola: $x^2 - y^2 = a^2$, $e = \sqrt{2}$
Parametric of $xy = c^2$: $(ct, c/t)$, Tangent at t: $\frac{x}{t} + yt = 2c$

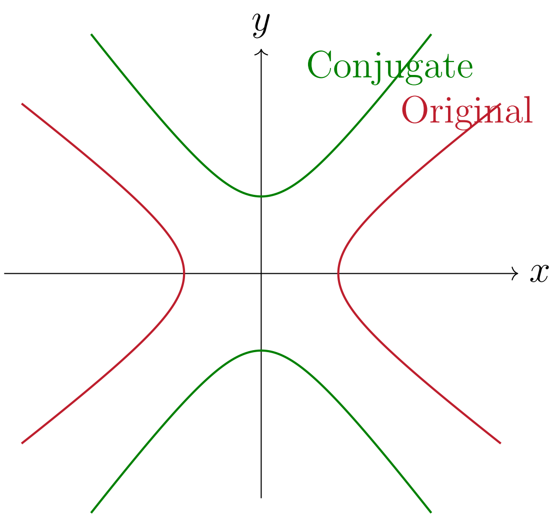

Figure 13: Hyperbola and its conjugate share the same asymptotes.

MODULE 5: PAIR OF STRAIGHT LINES

0.22 Homogeneous Equation & Angle

WHEN IT CLICKS:

Given $ax^2 + 2hxy + by^2 = 0$, find angle or bisectors.

Angle between lines: $\tan\theta = \left|\dfrac{2\sqrt{h^2 - ab}}{a+b}\right|$

Perpendicular condition: $a + b = 0$ **Coincident:** $h^2 = ab$

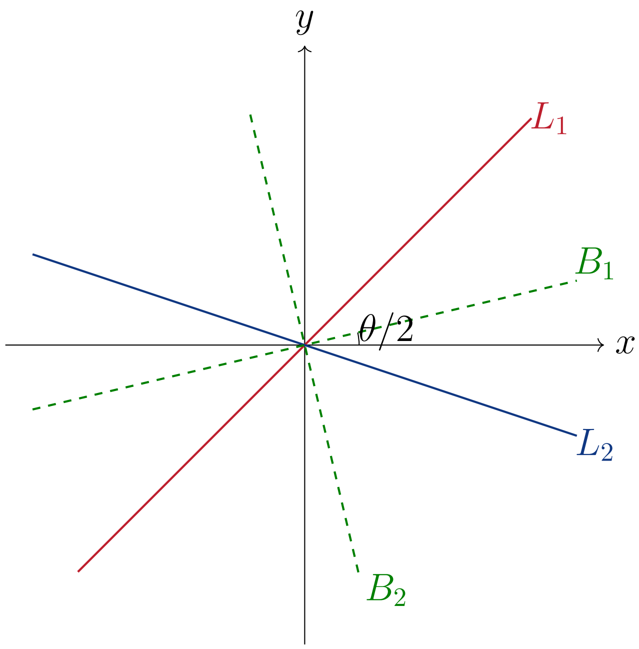

Figure 14: Pair of lines L_1, L_2 and their two angle bisectors B_1, B_2 (dashed).

0.23 General Second-Degree Equation

$ax^2 + 2hxy + by^2 + 2gx + 2fy + c = 0$ represents pair of lines iff

$$abc + 2fgh - af^2 - bg^2 - ch^2 = 0$$

Angle: $\tan\theta = \left|\dfrac{2\sqrt{h^2 - ab}}{a+b}\right|$ **Perpendicular:** $a + b = 0$

0.24 Angle Bisectors

For $ax^2 + 2hxy + by^2 = 0$:

$$\frac{x^2 - y^2}{a - b} = \frac{xy}{h}$$

0.25 Homogenization

WHEN IT CLICKS:

Find lines joining origin to intersection of curve and line.

Replace $1 = -\frac{lx+my}{n}$ in the curve equation to get homogeneous equation.

MODULE 6: ADVANCED UNIFIED CONCEPTS

0.26 Pole & Polar (Unified)

Conic	Polar of (x_1, y_1)	Pole of $lx + my + n = 0$
Circle	$xx_1 + yy_1 = a^2$	$\left(-\frac{al}{n}, -\frac{am}{n}\right)$
Parabola	$yy_1 = 2a(x + x_1)$	$\left(\frac{n}{l}, -\frac{2am}{l}\right)$
Ellipse	$\frac{xx_1}{a^2} + \frac{yy_1}{b^2} = 1$	$\left(-\frac{a^2l}{n}, -\frac{b^2m}{n}\right)$
Hyperbola	$\frac{xx_1}{a^2} - \frac{yy_1}{b^2} = 1$	$\left(-\frac{a^2l}{n}, \frac{b^2m}{n}\right)$

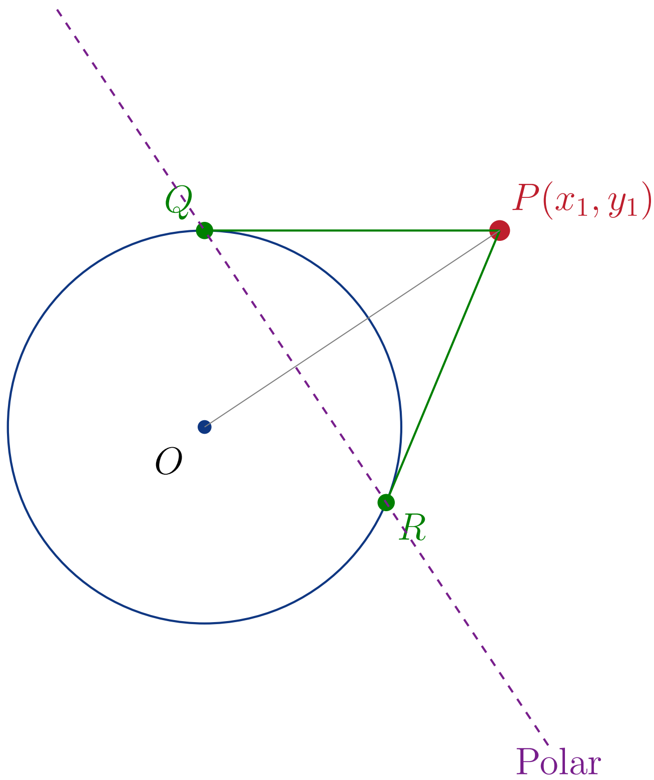

Figure 15: Pole and polar: P is pole, chord of contact QR (line $xx_1 + yy_1 = a^2$) is polar.

0.27 Confocal Conics & Eccentricity

Confocal: $\frac{x^2}{a^2+\lambda} + \frac{y^2}{b^2+\lambda} = 1$
For confocal ellipse & hyperbola: $e_1^2 + e_2^2 = 2$

0.28 Director Circle (Unified)

Conic	Director Circle
Circle $x^2 + y^2 = a^2$	$x^2 + y^2 = 2a^2$
Parabola $y^2 = 4ax$	$x + a = 0$ (directrix)
Ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$	$x^2 + y^2 = a^2 + b^2$
Hyperbola $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$	$x^2 + y^2 = a^2 - b^2$ (if $a > b$)

0.29 Quick Reference: Tangent Conditions

Conic	Tangent with slope m	Condition
Circle	$y = mx \pm a\sqrt{1 + m^2}$	$c^2 = a^2(1 + m^2)$
Parabola	$y = mx + \frac{a}{m}$	$c = a/m$
Ellipse	$y = mx \pm \sqrt{a^2m^2 + b^2}$	$c^2 = a^2m^2 + b^2$
Hyperbola	$y = mx \pm \sqrt{a^2m^2 - b^2}$	$c^2 = a^2m^2 - b^2$

0.30 Quick Reference: Focal Distances

Conic	Focal Distance
Parabola $y^2 = 4ax$	$PS = x_1 + a$
Ellipse	$PS = a - ex_1$, $PS' = a + ex_1$, Sum $= 2a$
Hyperbola	$PS = ex_1 - a$, $PS' = ex_1 + a$, Diff $= 2a$

0.31 Quick Reference: Eccentricity & Latus Rectum

Conic	Eccentricity	Latus Rectum
Circle	$e = 0$	$2a$ (diameter)
Parabola	$e = 1$	$4a$
Ellipse	$e = \sqrt{1 - b^2/a^2}$	$2b^2/a$
Hyperbola	$e = \sqrt{1 + b^2/a^2}$	$2b^2/a$
Rectangular Hyperbola	$e = \sqrt{2}$	$2a$

JEE Advanced Tips & Tricks for Conic Sections

Intuition

How to use this page: Before solving any conic problem, run through the **4-step filter** below. Then match the pattern to one of the **8 problem archetypes**. This saves 3–5 minutes per question.

Step 1 — The 4-Step Recognition Filter

Ask yourself	Action
1. Is the curve symmetric?	Check even/odd in x and y. If yes, halve the interval and double (parity kill).
2. Is the point on the curve or outside?	Compute S_1. Inside/outside decides polar vs. chord of contact.
3. Are the coordinates parametric?	Convert to $(at^2, 2at)$, $(a\cos\theta, b\sin\theta)$, or $(a\sec\theta, b\tan\theta)$. Trig simplifies almost everything.
4. Is there a line + curve?	Apply condition of tangency $c^2 = a^2m^2 \pm b^2$ (sign depends on conic). If a chord, use homogenisation or $T = S_1$.

Step 2 — The 8 JEE Advanced Archetypes

Archetype	**Recognise by**	**Weapon**
A. Tangent at a point	Point given on conic	$T = 0$ (universal)
B. Tangent with slope	"Line $y = mx + c$ touches"	Discriminant $= 0$ or $c^2 =$ condition
C. Chord of contact	External point $P(x_1, y_1)$	$T = 0$ (same as tangent form!)
D. Chord with midpoint	Midpoint (x_1, y_1) of chord given	$T = S_1$ (universal)
E. Focal chord	Chord passes through focus	Parameter relations: $t_1 t_2 = -1$ (parabola), $\tan\frac{\theta_1}{2}\tan\frac{\theta_2}{2} = -\frac{1-e}{1+e}$ (ellipse)
F. Pole/polar	"Polar of point" or "pole of line"	$T = 0$ and inverse formula
G. Director circle	Locus of perpendicular tangents	$x^2 + y^2 = a^2 + b^2$ (ellipse), directrix (parabola)
H. Reflection / optical	"Tangent bisects angle", "reflect from focus"	Use reflection property (parabola: parallel to axis)

Step 3 — Speed Shortcuts (JEE Adv. specific)

1. For any conic, if asked for a tangent at parametric point, use the **parametric tangent** directly — never expand to Cartesian.

2. For an ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, if the tangent has slope m, the point of contact is $\left(\pm\dfrac{a^2 m}{\sqrt{a^2m^2+b^2}}, \mp\dfrac{b^2}{\sqrt{a^2m^2+b^2}}\right)$. Memorise this once, use everywhere.

3. Focal distance trick (ellipse): $PS = a - ex_1$, $PS' = a + ex_1$. Sum $= 2a$ instantly, without computing e or a.

4. Focal distance trick (hyperbola): $PS = ex_1 - a$ (near focus), $PS' = ex_1 + a$ (far focus). Difference $= 2a$.

5. For **parabola** $y^2 = 4ax$, focal chord at parameter t has length $a(t + 1/t)^2$; the harmonic mean of segments $= 2a$, independent of t.

6. Director circle: if tangents from a point are perpendicular, the point lies on $x^2 + y^2 = a^2 + b^2$ (ellipse) or $x = -a$ (parabola). Use **without finding the point**.

7. Orthogonality: two circles cut orthogonally iff $2g_1g_2 + 2f_1f_2 = c_1 + c_2$.

8. Pole–polar reciprocity: if P lies on polar of Q, then Q lies on polar of P. This is symmetric — cuts work in half.

9. Homogenisation converts a curve + line problem into a pair of straight lines through origin — then use angle/bisector formulas.

Step 4 — Common Traps to Avoid

Intuition

Trap 1: Sign of a^2 vs. b^2 in ellipse. If $a < b$, the major axis is along y-axis and the eccentricity formula becomes $e = \sqrt{1 - a^2/b^2}$. Always check which is larger.

Trap 2: Parabola $y^2 = 4ax$ vs. $x^2 = 4ay$. In the first, "focus is $(a, 0)$", tangent slope formula $y = mx + a/m$. In the second, focus is $(0, a)$, tangent slope formula $y = mx - am^2$. Do not interchange.

Trap 3: Focal chord parameter relation. For parabola, $t_1t_2 = -1$; for ellipse, $\tan\frac{\theta_1}{2}\tan\frac{\theta_2}{2} = -\frac{1-e}{1+e}$. Students often use the parabola formula for ellipse.

Trap 4: Hyperbola tangent condition has a minus sign. $c^2 = a^2m^2 - b^2$ (not +). If $|am| < |b|$, no real tangent exists with that slope.

Trap 5: Normal slope for parabola: $c = -2am - am^3$, but for ellipse it is $c = \mp\frac{(a^2-b^2)m}{\sqrt{a^2+b^2m^2}}$. Do not mix.

Trap 6: Chord of contact vs. chord bisected at a point. Chord of contact: external point, uses $T = 0$. Chord bisected: midpoint is *inside* the conic, uses $T = S_1$.

Trap 7: Rectangular hyperbola $xy = c^2$ is rotated. Its asymptotes are coordinate axes; parameterisation is $(ct, c/t)$, not $(a\sec\theta, b\tan\theta)$.

Trap 8: Pair of lines through origin vs. general. If the equation is homogeneous (all terms degree 2), the lines pass through origin; otherwise shift to intersection point first.

Step 5 — The 30-Second Checklist Before Submitting

- ☐ Did I check whether the conic is **horizontal or vertical** before applying formulas?
- ☐ Did I use **parametric form** where possible instead of Cartesian?
- ☐ For focal chord problems, did I use the correct **parameter relation** ($t_1t_2 = -1$ for parabola, tangent half-angle for ellipse)?
- ☐ For a tangent-slope problem, did I correctly use the **condition** ($c^2 = a^2m^2 + b^2$ for ellipse, $c^2 = a^2m^2 - b^2$ for hyperbola)?
- ☐ For an external point, did I use $T = 0$ (chord of contact), not $T = S_1$ (chord bisected)?
- ☐ For pole/polar, did I remember P lies on polar of $Q \Leftrightarrow Q$ lies on polar of P?
- ☐ Did I verify the equation of the conic has **coefficient of x^2 equal to coefficient of y^2** before calling it a circle?
- ☐ For a pair of lines, did I check the **determinant condition** $abc + 2fgh - af^2 - bg^2 - ch^2 = 0$?