# Math Formulas: Conic Sections

## The Parabola Formulas

The standard formula of a parabola

1. $$y^2 = 2\,p\,x$$

Parametric equations of the parabola:

2. $$x = 2\,p\,t^2$$
$$y = 2\,p\,t$$

Tangent line in a point $D(x_0, y_0)$ of a parabola $y^2 = 2px$ is :

3. $$y_0\,y = p\,(x + x_0)$$

Tangent line with a given slope $m$:

4. $$y = m\,x + \frac{p}{2m}$$

**Tangent lines from a given point**

Take a fixed point $P(x_0, y_0)$. The equations of the tangent lines are:

5. $$\begin{aligned} y - y_0 &= m_1(x - x_0) \\ y - y_0 &= m_2(x - x_0) \\ m_1 &= \frac{y_0 + \sqrt{y_0^2 - 2px_0}}{2x_0} \\ m_2 &= \frac{y_0 - \sqrt{y_0^2 - 2px_0}}{2x_0} \end{aligned}$$

## The Ellipse Formulas

The set of all points in the plane, the sum of whose distances from two fixed points, called the foci, is a constant.

**The standard formula of a ellipse:**

6. $$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

**Parametric equations of the ellipse:**

7. $$x = a\,\cos t$$
$$y = b\,\sin t$$

**Tangent line in a point $D(x_0, y_0)$ of a ellipse:**

8. $$\frac{x_0\,x}{a^2} + \frac{y_0\,y}{b^2} = 1$$

**Eccentricity of the ellipse:**

9. $$e = \frac{\sqrt{a^2 - b^2}}{a}$$

**Foci of the ellipse:**

10.
$$\begin{aligned} &\text{if } a \ge b \Longrightarrow F_1\left(-\sqrt{a^2-b^2},0\right) \quad F_2\left(\sqrt{a^2-b^2},0\right) \\ &\text{if } a < b \Longrightarrow F_1\left(0,-\sqrt{b^2-a^2}\right) \quad F_2\left(0,\sqrt{b^2-a^2}\right) \end{aligned}$$

**Area of the ellipse:**

11.
$$A = \pi \cdot a \cdot b$$

## The Hyperbola Formulas

The set of all points in the plane, the difference of whose distances from two fixed points, called the foci, remains constant.

**The standard formula of a hyperbola:**

12.
$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$$

**Parametric equations of the Hyperbola:**

13.
$$\begin{aligned} x &= \frac{a}{\sin t} \\ y &= \frac{b\ \sin t}{\cos t} \end{aligned}$$

**Tangent line in a point $D(x_0, y_0)$ of a Hyperbola:**

14.
$$\frac{x_0 x}{a^2} - \frac{y_0 y}{b^2} = 1$$

**Foci:**

15.
$$\begin{aligned} &\text{if } a \ge b \Longrightarrow F_1\left(-\sqrt{a^2+b^2},0\right) \quad F_2\left(\sqrt{a^2+b^2},0\right) \\ &\text{if } a < b \Longrightarrow F_1\left(0,-\sqrt{a^2+b^2}\right) \quad F_2\left(0,\sqrt{a^2+b^2}\right) \end{aligned}$$

**Asymptotes:**

16.
$$\begin{aligned} &\text{if } a \ge b \Longrightarrow y = \frac{b}{a}x \text{ and } y = -\frac{b}{a}x \\ &\text{if } a < b \Longrightarrow y = \frac{a}{b}x \text{ and } y = -\frac{a}{b}x \end{aligned}$$