IIT JEE Maths Formulas

Part 1

Circle Formula

The formula for circle are as stated below

Description	Formula
Area of a Circle	• In terms of radius: πr^2 • In terms of diameter: $\frac{\pi}{4} \times d^2$
Surface Area of a Circle	πr^2
General Equation of a Circle	The general equation of a circle with coordinates of a centre(h, k), and radius r is given as: $\sqrt{(x - h)^2 + (y - k)^2} = r$
Standard Equation of a Circle	The Standard equation of a circle with centre (a, b), and radius r is given as: $(x - a)^2 + (y - b)^2 = r^2$
Diameter of a Circle	$2 \times$ radius
Circumference of a Circle	$2\pi r$
Intercepts made by Circle	$x^2 + y^2 + 2gx + 2fy + c = 0$ i. On x −axis: $2\sqrt{g^2 - c}$ ii. On y −axis: $2\sqrt{f^2 - c}$
Parametric Equations of a Circle	$x = h + r\cos\theta\,;\, y = k + r\sin\theta$
Tangent	• **Slope form**: $y = mx \pm a\sqrt{1 + m^2}$ • **Point form:** $xx_1 + yy_1 = a^2$ or $T = 0$ • **Parametric form:** $x\cos\alpha + y\sin\alpha = a$
Pair of Tangents from a Point:	$SS_1 = T^2$
Length of a Tangent	$\sqrt{S_1}$
Director Circle	$x^2 + y^2 = 2a^2$ for $x^2 + y^2 = a^2$

Chord of Contact	$T = 0$ i. Length of chord of contact= $\frac{2LR}{\sqrt{R^2+L^2}}$ ii. Area of the triangle formed by the pair of the tangents and its chord of contact = $\frac{RL^3}{R^2+L^2}$ iii. Tangent of the angle between the pair of tangents from $(x_1, y_1) = \left(\frac{2RL}{L^2-R^2}\right)$ iv. Equation of the circle circumscribing the triangle PT_1, T_2 is: $(x - x_1)(x + g) + (y - y_1)(y + f) = 0$
Condition of orthogonality of Two Circles	$2g_1g_2 + 2f_1f_2 = c_1 + c_2$
Radical Axis	$S_1 - S_2 = 0$ i.e. $2(g_1 - g_2)x + 2(f_1 - f_2)y + (c_1 - c_2) = 0.$
Family of Circles	$S_1 + KS_2 = 0,\ S + KL = 0$

Quadratic Equation Formula

The formula for quadratic equation are as stated below

Description	Formula
General form of Quadratic Equation	$ax^2 + bx + c = 0$; where a, b, c are constants and $a \neq 0$.
Roots of equations	$\alpha = \frac{-b+\sqrt{b^2-4ac}}{2a},\ \beta = \frac{-b-\sqrt{b^2-4ac}}{2a}$
Sum and Product of Roots	If α and β are the roots of the quadratic equation $ax^2 + bx + c = 0$, then Sum of roots, $\alpha + \beta = -\frac{b}{a}$ Product of roots, $\alpha\beta = \frac{c}{a}$
Discriminant of Quadratic equation	The Discriminant of the quadratic equation $ax^2 + bx + c = 0$ is given by $D = b^2 - 4ac$.
Nature of Roots	• If $D = 0$, the roots are real and equal$\alpha = \beta = -\frac{b}{2a}$. • If $D \neq 0$, The roots are real and unequal. • If $D < 0$, the roots are imaginary and unequal. • If $D > 0$ and D is a perfect square, the roots are rational and unequal.

	• If $D > 0$ and D is not a perfect square, the roots are irrational and unequal.
Formation of Quadratic Equation with given roots	If α and β are the roots of the quadratic equation, then $(x - \alpha)(x - \beta) = 0;\ x^2 - (\alpha + \beta)x + \alpha\beta = 0;$ • $x^2 - (Sum\ of\ roots)x + product\ of\ roots = 0$
Common Roots	• If two quadratic equations $a_1x^2 + b_1x + c_1 = 0$ & $a_2x^2 + b_2x + c_2 = 0$ have both roots common, then $\frac{a_1}{a_2} = \frac{b_1}{b_2} = \frac{c_1}{c_2}$. • If only one root α is common, then $\alpha = \frac{c_1a_2 - c_2a_1}{a_1b_2 - a_2b_1} = \frac{b_1c_2 - b_2c_1}{c_1a_2 - c_2a_1}$
Range of Quadratic Expression $f(x) = ax^2 + bx + c$ **in restricted domain** $x \in [x_1, x_2]$	• If $-\frac{b}{2a}$ not belong to $[x_1, x_2]$ then, $f(x) \in \left[\left\{f\left(x_1\right), f\left(x_2\right)\right\},\ max\{f\left(x_1\right), f\left(x_2\right)\}\right]$ • If $-\frac{b}{2a} \in [x_1, x_2]$ then, $f(x) \in \left[\left\{f\left(x_1\right), f\left(x_2\right), -\frac{D}{4a}\right\},\ max\{f\left(x_1\right), f\left(x_2\right), -\frac{D}{4a}\}\right]$
Roots under special cases	Consider the quadratic equation $ax^2 + bx + c = 0$ • If $c = 0$, then one root is zero. Other root is $-\frac{b}{a}$. • If $b = 0$The roots are equal but in opposite signs. • If $b = c = 0$, then both roots are zero. • If $a = c$, then the roots are reciprocal to each other. • If $a + b + c = 0$, then one root is 1 and the second root is $\frac{c}{a}$. • If $a = b = c = 0$, then the equation will become an identity and will satisfy every value of x.
Graph of Quadratic equation	The graph of a quadratic equation $ax^2 + bx + c = 0$ is a parabola. • If $a > 0$, then the graph of a quadratic equation will be concave upwards. • If $a < 0$, then the graph of a quadratic equation will be concave downwards.
Maximum and Minimum value	Consider the quadratic expression $ax^2 + bx + c = 0$ • If $a < 0$, then the expression has the greatest value at $x = -\frac{b}{2a}$. The maximum value is $-\frac{D}{4a}$.

	• If $a > 0$, then the expression has the least value at $x = -\frac{b}{2a}$. The minimum value is $-\frac{D}{4a}$.
Quadratic Expression in Two Variables	The general form of a quadratic equation in two variables x and y is $ax^2 + 2hxy + by^2 + 2gx + 2fy + c$. To solve the expression into two linear rational factors, the condition is $\Delta = 0$ $\Delta = \begin{bmatrix} a & h & g \\ h & b & f \\ g & f & c \end{bmatrix} = 0$ $abc + 2fgh - af^2 - bg^2 - ch^2 = 0$ And $h^2 - ab > 0$. This is called the Discriminant of the given expression.

Binomial Theorem Formula

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Description	Formula
Binomial Theorem for positive Integral Index	$(x + a)^n = {}^nC_0 x^n a^0 + {}^nC_1 x^{n-1} a + {}^nC_2 x^{n-2} a^2 + \dots + {}^nC_r x^{n-r} a^r + \dots + {}^nC_n . x a^n$ General terms = $T_{r+1} = {}^nC_r x^{n-r} a^r$
Deductions of Binomial Theorem	• $(1 + x)^n = {}^nC_0 + {}^nC_1 x + {}^nC_2 x^2 + {}^nC_3 x^3 + \dots + {}^nC_r x^r + \dots + {}^nC_n x^n$ which is the standard form of binomial expansion. General Term= $(r + 1)^{th}$ term: $T_{r+1} = {}^nC_r$ $x^r = \frac{n(n-1)(n-2)......(n-r+1)}{r!} . x^r$ • $(1 - x)^n = {}^nC_0 - {}^nC_1 x + {}^nC_2 x^2 - {}^nC_3 x^3 + \dots + (-1)^r\, {}^nC_r x^r + \dots + (-1)^n\, {}^nC_n x^n$ General Term= $(r + 1)^{th}$ term: $T_{r+1} = (-1)^r . {}^nC_r$ $x^r = \frac{n(n-1)(n-2)......(n-r+1)}{r!} . x^r$
Middle Term in the expansion of $(x + a)^n$	• If n is even then middle term $= \left(\frac{n}{2} + 1\right)^{th}$ term. • If n is odd then middle terms are $\left(\frac{n+1}{2}\right)^{th}$ and $\left(\frac{n+3}{2}\right)^{th}$ term. • Binomial coefficients of middle term is the greatest Binomial coefficients

To determine a particular term in the expansion	In the expansion of $\left(x^{\alpha} \pm \frac{1}{x^{\beta}}\right)^{n}$, if x^{m} occurs in T_{r+1}, then r is given by $n\alpha - r(\alpha + \beta) = m => r = \frac{n\alpha - m}{\alpha + \beta}$ and the term which is independent of x then $n\alpha - r(\alpha + \beta) = 0 \ => r = \frac{n\alpha}{\alpha + \beta}$.
To find a term from the end in the expansion of $(x + a)^{n}$	$T_{r}(E) = T_{n-r+2}(B)$
Binomial Coefficients and their properties	In the expansion of $(1 + x)^{n} = C_{0} + C_{1}x + C_{2}x^{2} + ... + C_{r}x^{r} + ... + C_{n}x^{n}$ Where $C_{0} = 1,\ C_{1} = n,\ C_{2} = \frac{n(n-1)}{2!}$ i. $C_{0} + C_{1} + C_{2} + ... + C_{n} = 2^{n}$ ii. $C_{0} - C_{1} + C_{2} - C_{3} + ... = 0$ iii. $C_{0} + C_{2} + ... = C_{1} + C_{3} + ... = 2^{n-1}$ iv. $C_{0}^{2} + C_{1}^{2} + C_{2}^{2} + ... + C_{n}^{2} = \frac{2n!}{n!n!}$ v. $C_{0} + \frac{C_{1}}{2} + \frac{C_{2}}{3} + ... + \frac{C_{n}}{n+1} = \frac{2^{n+1}-1}{n+1}$ vi. $C_{0} - \frac{C_{1}}{2} + \frac{C_{2}}{3} - \frac{C_{3}}{4} + ... + \frac{(-1)^{n}.C_{n}}{n+1} = \frac{1}{n+1}$
Greatest term in the expansion of $(x + a)^{n}$:	• The term in the expansion of $(x + a)^{n}$ of greatest coefficients $= \{T_{\frac{(n+2)}{2}},\quad when\ n\ is\ even\ T_{\frac{(n+1)}{2}},\ T_{\frac{(n+3)}{2}}$ $when\ is\ is\ odd$ • The greatest term $= \{T_{p},\ T_{p+1},\ when\ \frac{(n+1)a}{x+a} = p\in Z\ T_{q+1},$ $When\ \frac{(n+1)a}{x+1}\ nnot\ belong\ to\ Z\ and\ q < \frac{(n+1)a}{x+a} < q + 1$
Multinomial Expansion	If $n\in N$ then the general terms of multinomial expansion $\left(x_{1} + x_{2} + x_{3} + ... + x_{k}\right)^{n}$ is $\sum_{r_{1}+r_{2}+...+r_{k}=n} \frac{n!}{r_{1}!r_{2}!...r_{k}!}x_{1}^{r1}.x_{2}^{r2} ... x_{k}^{r_{k}}$

Binomial Theorem for Negative Integer Or Fractional Indices	$(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \frac{n(n-1)(n-2)}{3!}x^3 + \ldots$ $+ \frac{n(n-1)(n-2)\ldots\ldots(n-r+1)}{r!}x^r + \ldots, \lvert x\rvert < 1$ $T_{r+1} = \frac{n(n-1)(n-2)\ldots\ldots(n-r+1)}{r!}x^r$

Part 2

Vectors Formula

The formula for vectors are as stated below

Description	Formula
Position Vector of a Point	If $\vec{a}$ and $\vec{b}$ are positive vectors of two points A and B, then $\vec{AB} = \vec{b} - \vec{a}$ • **Distance Formula:** Distance between the two points $A(\vec{a})$ and $B(\vec{b})$ is $AB = \lvert\vec{a} - \vec{b}\rvert$. • **Section Formula:** $\vec{r} = \frac{n\vec{a} + m\vec{b}}{m+n}$, Midpoint of $AB = \frac{\vec{a}+\vec{b}}{2}$
Scalar Product of Two vectors	$\vec{a}.\vec{b} = \lvert\vec{a}\rvert\lvert\vec{b}\rvert \cos\theta$, where $\lvert\vec{a}\rvert, \lvert\vec{b}\rvert$ are the magnitude of $\vec{a}$ and $\vec{b}$ respectively and θ is the angle between $\vec{a}$ and $\vec{b}$ • $i.i = j.j = k.k = 1;\ i.j = j.k = k.i = 0$, projection of $\vec{a}$ on $\vec{b} = \frac{\vec{a}.\vec{b}}{\lvert\vec{b}\rvert}$. • If $\vec{a} = a_1 i + a_2 j + a_3 k$ & $\vec{b} = b_1 i + b_2 j + b_3 k$ then $\vec{a}.\vec{b} = a_1 b_1 + a_2 b_2 + a_3 b_3$. • The angle $\emptyset$ between $\vec{a}$ & $\vec{b}$ is given by $\emptyset = \cos^{-1}\frac{\vec{a}.\vec{b}}{\lvert\vec{a}\rvert\lvert\vec{b}\rvert}$, $0 \le \emptyset \le \pi$. • $\vec{a}.\vec{b} = 0 \Leftrightarrow \vec{a}$ Perpendicular to $\vec{b}$ $(\vec{a} \ne 0, \vec{b} \ne 0)$.

Vector Product of Two vectors	• If $\vec{a}$ & $\vec{b}$ are two vectors and θ is the angle between them then • $\vec{a}\times\vec{b} = \lvert\vec{a}\rvert\lvert\vec{b}\rvert sin\,\theta\,\hat{n}$, where $\hat{n}$ is the unit vector perpendicular to both $\vec{a}$ & $\vec{b}$ such that $\vec{a}, \vec{b}$& $\hat{n}$ form a right handed screw system. • Geometrically $\lvert\vec{a}\times\vec{b}\rvert$ =area of the parallelogram whose two adjacents sides are represented by $\vec{a}$ & $\vec{b}$. • $\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = 0;\ \hat{i}\times\hat{j} = \hat{k},\ \hat{j}\times\hat{k} = \hat{i},\ \hat{k}\times\hat{i} = \hat{j}$ • If $\vec{a} = a_1\hat{i} + a_2\hat{j} + a_3\hat{k}$ & $\vec{b} = b_1\hat{i} + b_2\hat{j} + b_3\hat{k}$ then $\vec{a}\times\vec{b} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{vmatrix}$ • $\vec{a}\times\vec{b} = \vec{o} \leftrightarrow \vec{a}$ and $\vec{b}$ are parallel (collinear) ($\vec{a}\neq 0$, $\vec{b}\neq 0$) i.e. $\vec{a} = K\vec{b}$ where K is a scalar. • Unit vector perpendicular to the plane of $\vec{a}$ & $\vec{b}$ is $\hat{n} = \pm\frac{\vec{a}\times\vec{b}}{\lvert\vec{a}\times\vec{b}\rvert}$. • If $\vec{a}, \vec{b}$ & $\vec{c}$ are the position vectors of 3 points A, B & C then the vector area of triangle $ABC = \frac{1}{2}[\vec{a}\times\vec{b} + \vec{b}\times\vec{c} + \vec{c}\times\vec{a}]$. The points A, B & C are collinear if ▪ $\vec{a}\times\vec{b} + \vec{b}\times\vec{c} + \vec{c}\times\vec{a} = \vec{0}$ • Area of any quadrilateral whose diagonal vectors are $\vec{d}_1$ & $\vec{d}_2$ is given by $\frac{1}{2}\lvert\vec{d}_1\times\vec{d}_2\rvert$. • Lagrange’sIdentity: $(\vec{a}\times\vec{b})^2 = \lvert\vec{a}\rvert^2\lvert\vec{b}\rvert^2 - (\vec{a}.\vec{b})^2 = [(\vec{a}\times\vec{a})\,(\vec{a}\times\vec{b})\,(\vec{b}\times\vec{a})\,(\vec{b}\times\vec{b})]$
Scalar Triple Product	• The scalar triple product of three vectors $\vec{a}, \vec{b}$ & $\vec{c}$ is defined as: $\vec{a}\times\vec{b}.\vec{c} = \lvert\vec{a}\rvert\lvert\vec{b}\rvert\lvert\vec{c}\rvert\ \sin sin\,\theta\ \cos cos\,\emptyset$ • Volume of tetrahedron $V = [\vec{a}.\vec{b}.\vec{c}]$ • In a scalar triple product the position of dot and cross can be interchanged i.e.

	$\vec{a}.\left(\vec{b}\times\vec{c}\right)=\left(\vec{a}\times\vec{b}\right).\vec{c}$ Or $\left[\vec{a}\,\vec{b}\,\vec{c}\right]=\left[\vec{b}\,\vec{c}\,\vec{a}\right]=\left[\vec{c}\,\vec{a}\,\vec{b}\right]$ $\vec{a}.\left(\vec{b}\times\vec{c}\right)=-\vec{a}.(\vec{c}\times\vec{b})$ i.e. $\left[\vec{a}\,\vec{b}\,\vec{c}\right]=-\left[\vec{a}\,\vec{c}\,\vec{b}\right]$ • If $\vec{a}=a_1i+a_2j+a_3k$; $\vec{b}=b_1i+b_2j+b_3k$ & $\vec{c}=c_1i+c_2j+c_3k$ then $\left[\vec{a}.\vec{b}.\vec{c}\right]=\begin{bmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix}$ • If $\vec{a},\vec{b},\vec{c}$ are coplanar↔ $\left[\vec{a}\,\vec{b}\,\vec{c}\right]=0$. • Volume of tetrahedron OABC with O as origin & A($\vec{a}$), B($\vec{b}$) and C($\vec{c}$) be the vertices $=\left\lvert\frac{1}{6}\left[\vec{a}\,\vec{b}\,\vec{c}\right]\right\rvert$. • The position vector of the centroid of a tetrahedron if the pv's of its vertices are $\vec{a},\vec{b},\vec{c}$ & $\vec{d}$ are given by $\frac{1}{4}[\vec{a}+\vec{b}+\vec{c}+\vec{d}]$. •
Vector Triple Product	$\vec{a}\times\left(\vec{b}\times\vec{c}\right)=\left(\vec{a}.\vec{c}\right)\vec{b}-\left(\vec{a}.\vec{b}\right)\vec{c}$, $\left(\vec{a}\times\vec{b}\right)\times\vec{c}=\left(\vec{a}.\vec{c}\right)\vec{b}-(\vec{b}.\vec{c})\,\vec{a}$ **In general:** $\left(\vec{a}\times\vec{b}\right)\times\vec{c}\neq\vec{a}\times\left(\vec{b}\times\vec{c}\right)$

Parabola Formula

The formula for parabola are as stated below

Description	Formula
Equation of standard parabola:	The equation of parabola with focus at $(a, 0)$, $a > 0$ and directrix $x = -a$ is given as $y^2 = 4ax$ When vertex is (0, 0) then axis is given as $y = 0$ Length of latus rectum is equals to $4a$ Ends of the latus rectum are L(a, 2a) and L'(a, -2a).
Parametric representation	The point (x, y_1) lies outside, on or inside the parabola which is given as $y = 4ax$ Therefore, equation of parabola now becomes, $y_1^2 - 4ax \geq 0$ Or $y_1^2 - 4ax < 0$
Line and a parabola	Length of the chord intercepted by the parabola $y^2 = 4ax$ on the line $y = mx + c$ is given as

	$\frac{4}{m^2}(\sqrt{a\left(1+m^2\right)(a-mc)}$
Tangents to the parabola	Tangent of the parabola $y^2 = 4ax$ is given as T = 0 $y = mx + \frac{a}{m}$, $m\neq0$ is the tangent of parabola $y^2 = 4ax$ at $\left(\frac{a}{m^2}, \frac{2a}{m}\right)$
Normal to the parabola $y^2 = 4ax$	Normal to the parabola $y^2 = 4ax$ is given as $y - y_1 = \frac{-y_1}{2a}\left(x - x_1\right)$ at $\left(x_1, y_1\right)$
A chord with a given middle point	The equation of the chord of parabola $y^2 = 4ax$ with midpoint (x_1, y_1) is given as $T = S_1$. Here, $S_1 = y_1 - 4ax$

Definite Integration Formula

The formula for definite integration are as stated below

Description	Formula
Definite Integral as Limit Sum	$\int_a^b f(x)dx = \sum_{r=1}^{n} hf(a + rh)$ Here $h = \frac{b-a}{n}$ is the length of each subinterval
Definite Integral Formula Using the Fundamental theorem of calculus	$\int_a^b f(x)dx = F(b) - F(a)$, where $F'(x) = f(x)$
Properties of Definite Integral	• $\int_a^b f(x).dx = \int_a^b f(t).dt$ • $\int_a^b f(x).dx = -\int_b^a f(x).dx$ • $\int_a^b cf(x).dx = c\int_a^b f(x).dx$ • $\int_a^b f(x)\pm g(x).dx = \int_a^b f(x).dx \pm \int_a^b g(x).dx$ • $\int_a^b f(x).dx = \int_a^c f(x).dx + \int_c^b f(x).dx$ • $\int_a^b f(x).dx = \int_a^b f(a + b - x).dx$

	• $\int_{0}^{a} f(x).dx = \int_{0}^{a} f(a-x).dt$ This is a formula derived from the above formula. • $\int_{0}^{2a} f(x).dx = 2\int_{0}^{a} f(x).dx$ if $f(2a-x) = f(x)$ • $\int_{0}^{2a} f(x).dx = 0$ if $f(2a-x) =- f(x)$ • $\int_{-a}^{a} f(x).dx = 2\int_{0}^{a} f(x).dx$ if $f(x)$ is an even function (i.e., $f(-x) = f(x)$). • $\int_{-a}^{a} f(x).dx = 0$ if $f(x)$ is an odd function (i.e., $f(-x) =- f(x)$).
Definite Integrals involving Rational or irrational Expression	• $\int_{a}^{\infty} \frac{dx}{x^2+a^2} = \frac{\pi}{2a}$ • $\int_{a}^{\infty} \frac{x^m dx}{x^n+a^n} = \frac{\pi a^{m-n+1}}{n \frac{(m+1)\pi}{n})}$, $0 < m+1 < n$ • $\int_{a}^{\infty} \frac{x^{p-1} dx}{1+x} = \frac{\pi}{\sin\sin(p\pi)}$, $0 < p < 1$ • $\int_{a}^{\infty} \frac{dx}{\sqrt{a^2-x^2}} = \frac{\pi}{2}$ • $\int_{a}^{\infty} \sqrt{a^2 - x^2}dx = \frac{\pi a^2}{4}$ •
Definite Integrals involving Trigonometric Functions	• $\int_{0}^{\pi} mx)nx)dx = \{0\ if\ m \neq n\ \frac{\pi}{2}\ if\ m = n\quad m, n$ positive integers • $\int_{0}^{\pi} mx)nx)dx = \{\ 0\ if\ m \neq n\ \frac{\pi}{2}\ if\ m = n\quad m, n$ positive integers • $\int_{0}^{\pi} mx)nx)dx = \{\ 0\qquad if\ m+n\ even \frac{2m}{m^2-n^2}\ if\ m = n$ integers

	• $\int_0^{\frac{\pi}{2}} x\,dx = \int_0^{\frac{\pi}{2}} x\,dx = \frac{\pi}{4}$ • $\int_0^{\frac{\pi}{2}} x\,dx = \int_0^{\frac{\pi}{2}} dx = \frac{1.3.5.......2m-1}{2.4.6......2m}.\frac{\pi}{2}, m = 1, 2, ...$ • $\int_0^{\frac{\pi}{2}} x\,dx = \int_0^{\frac{\pi}{2}} dx = \frac{2.4.6....2m}{1.3.5...2m+1}, m = 1, 2, ...$ •
If $f(x)$ is a periodic function with period T	• $\int_0^{nT} f(x)dx = n\int_0^{T} f(x)dx,\ n\epsilon z,\ \int_a^{a+nT} f(x)dx = n\int_0^{T} f(x)dx,\ n\epsilon z$ • $\int_{mT}^{nT} f(x)dx = (n - m)\int_0^{T} f(x)dx,\ m, n\epsilon z,\ \int_{nT}^{a+nT} f(x)dx = \int_0^{a} f(x$ • $\int_{a+nT}^{b+nT} f(x)dx = \int_a^{a} f(x)dx,\ n\epsilon z,\quad a, b\epsilon R$ •
Leibniz Theorem	If $F(x) = \int_{g(x)}^{h(x)} f(t)dt$, then $\frac{dF(x)}{dx} = h^{'}(x)f(h(x)) - g^{'}(x)f(g(x))$

Ellipse Formula

The formula for ellipse are as stated below

Description	Formula
Standard Equation	$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, where $a >$ & $b^2 = a^2(1 - e^2)$ • Eccentricity: $e = \sqrt{1 - \frac{b^2}{a^2}}, (0 < e < 1)$, Directrices: $x = \pm\frac{a}{e}$ • Foci: $S = (\pm a\ e, 0)$. Length of major axes $=$ $2a$ and minor axes $= 2b$ • Vertices: $A^{'} = (-\ a, 0)$ & $A = (a, 0)$. • Latus Rectum: = $\frac{2b^2}{a} = 2a(1 - e^2)$

Auxiliary circle	$x^2 + y^2 = a^2$
Parametric Representation	$x = a\cos\theta$ & $y = b\sin\theta$
Position of a Point w.r.t. an Ellipse	The point $P(x_1, y_1)$ lies outside, inside or on the ellipse according as; $\frac{x_1^2}{a^2} + \frac{y_1^2}{b^2} - 1 >< or = 0.$
Line and an Ellipse	The line $y = mx + c$ meets the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ in two points real, coincident or imaginary according as c^2 is < =or > $a^2m^2 + b^2$.
Tangents	• Slope form: $y = mx \pm \sqrt{a^2m^2 + b^2}$, point form: $\frac{xx_1}{a^2} + \frac{yy_1}{b^2} = 1$ • Parametric form: $\frac{x\cos\theta}{a} + \frac{y\sin\theta}{b} = 1$
Normal	$\frac{a^2x}{x_1} - \frac{b^2y}{y_1} = a^2 - b^2$, $ax.\sec\theta - by.\operatorname{cosec}\theta = (a^2 - b^2)$, $y = mx - \frac{(a^2-b^2)m}{\sqrt{a^2+b^2m^2}}$
Director Circle	$x^2 + y^2 = a^2 + b^2$

Part 3

Inverse Trigonometric Functions formula

The formula for inverse trigonometric functions are as stated below

Description	Formula
Arcsine Function	Arcsine function is an inverse of sine function which is denoted by sin^{-1} The formula for arcsin is given as $sin^{-1}(-x) = -sin^{-1}(x),\ x\in[-1, 1]$

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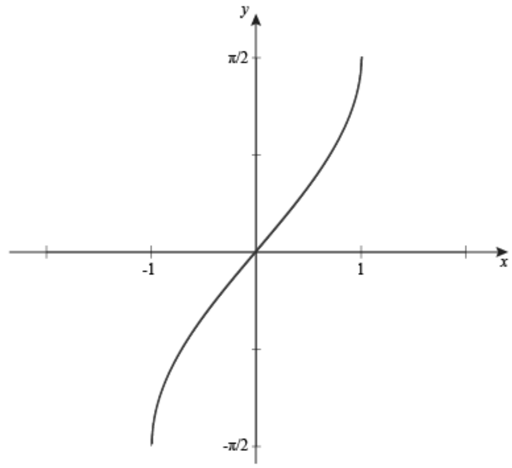
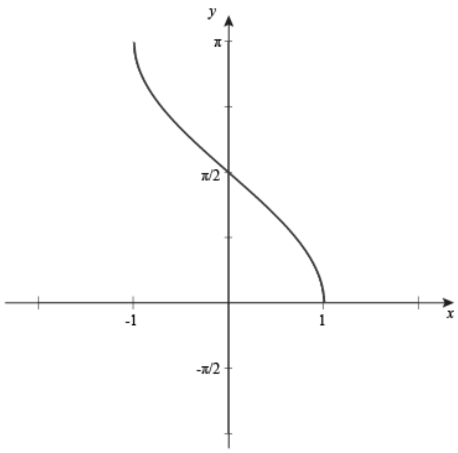
Domain of arcsin is $-1 \le x \le 1$
Range of arcsin is $-\frac{\pi}{2} \le y \le \frac{\pi}{2}$


Differentiation of $sin^{-1}(x)$ is $\frac{1}{\sqrt{1-x^2}}$
</td>
</tr>
<tr>
<td>Arccosine Function</td>
<td>
Arccosine function is an inverse of cosine function which is denoted by cos^{-1}
$$cos^{-1}(-x) = \pi - cos^{-1}(x),\ x \in [-1,\ 1]$$
Domain of arccos is $-1 \le x \le 1$
Range of arccos is $0 \le y \le \pi$


Differentiation of $cos^{-1}(x)$ is $-\frac{1}{\sqrt{1-x^2}}$
</td>
</tr>
<tr>
<td>Arctangent Function</td>
<td>
Arctangent function is an inverse of tangent function which is denoted by tan^{-1}
$$tan^{-1}(-x) = -tan^{-1}(x),\ x \in R$$
Domain of Arctangent is $-\infty \le x \le \infty$
Range of Arctangent is $-\frac{\pi}{2} \le y \le \frac{\pi}{2}$
</td>
</tr>
</table>

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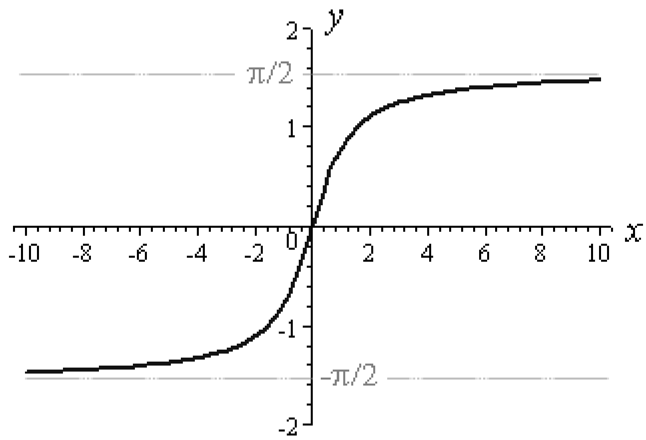
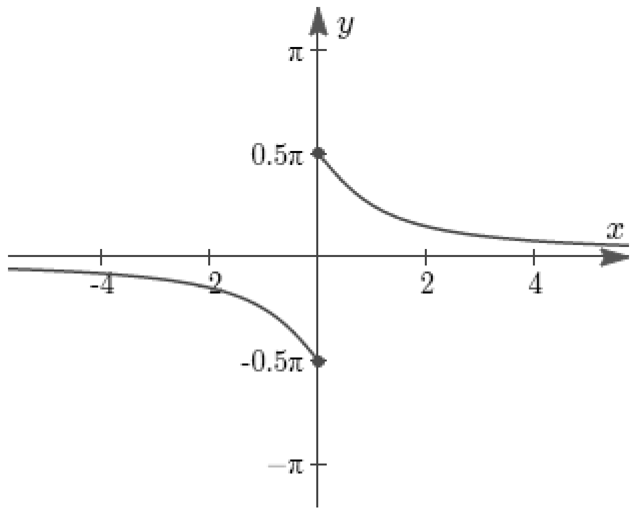
<tr>
<td></td>
<td>

Differentiation of $tan^{-1}(x)$ is $\frac{1}{1+x^2}$</td>
</tr>
<tr>
<td>Arc cotangent (Arc cot) Function</td>
<td>Arc cotangent function is an inverse of cotangent function which is denoted by cot^{-1}

$$cot^{-1}(-x) = \pi - cot^{-1}(x),\ x \in R$$

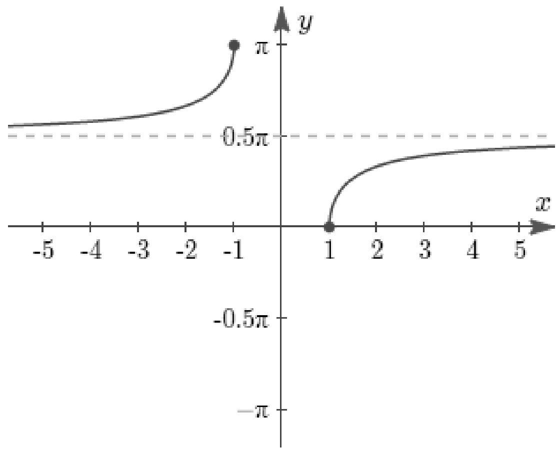
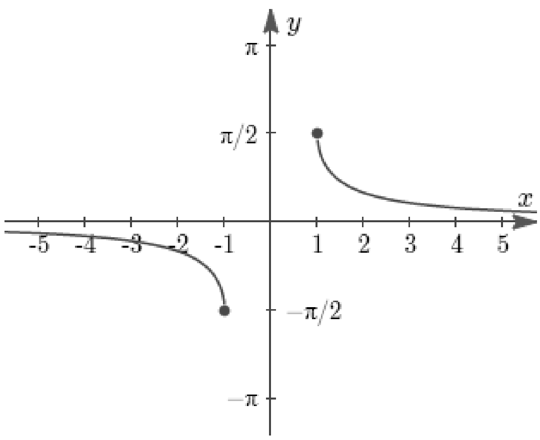
Domain of Arc cotangent is $-\infty \leq x \leq \infty$
Range of Arc cotangent is $0 \leq y \leq \pi$



Differentiation of $cot^{-1}(x)$ is $\frac{-1}{1+x^2}$</td>
</tr>
<tr>
<td>Arc secant Function</td>
<td>Arc secant function is an inverse of cosine function which is denoted by cot^{-1}

$$sec^{-1}(-x) = \pi - sec^{-1}(x),\ |x| \geq 1$$

Domain of Arc secant is $-\infty \leq x \leq -1$ or $1 - \infty \leq x \leq -\infty$
Range of Arc secant is $0 \leq y \leq \pi,\ y \neq \frac{\pi}{2}$</td>
</tr>
</table>

	 Differentiation of $sec^{-1}(x)$ is $\frac{-1}{\|x\|\sqrt{x^2-1}}$
Arc cosecant Function	Arc cosecant function is an inverse of sine function which is denoted by $cosec^{-1}$ $cosec^{-1}(-x) = -cosec^{-1}(x),\ x \geq 1$ Domain of Arc cosecant is $-\infty \leq x \leq -1\ or\ 1\ -\infty \leq x \leq -\infty$ Range of Arc cosecant is $-\frac{\pi}{2} \leq y \leq \frac{\pi}{2},\ y \neq 0$  Differentiation of $cosec^{-1}(x)$ is $\frac{1}{\|x\|\sqrt{x^2-1}}$

Straight Line Formula

The formula for straight line are as stated below

Description	Formulas
Distance Formula	$d = \sqrt{(x_1 - x_2)^2 - (y_1 - y_2)^2}$
Section Formula	$x = \frac{mx_2 \pm nx_1}{m \pm n};\ y = \frac{my_2 \pm ny_1}{m \pm n}$
Centroid, Incentre and Excenter	Centroid $G\left(\frac{x_1+x_2+x_3}{3}, \frac{y_1+y_2+y_3}{3}\right)$

	In center $I(\frac{ax_1+bx_2+cx_3}{a+b+c}, \frac{ay_1+by_2+cy_3}{a+b+c})$ Excentre $I_1\left(\frac{-a_x+bx_2+cx_3}{-a+b+c}, \frac{-ay_1+by_2+cy_3}{-a+b+c}\right)$
Area of Triangle	$\Delta\, ABC = \frac{1}{2}\left\|x_1\, y_1\, 1\, x_2\, y_2\, 1\, x_3\, y_3\, 1\right\|$
Slope formula	Line Joining two points $(x_1 y_1)\&(x_2 y_2)$ $m = \frac{y_1-y_2}{x_1-x_2}$
Condition of collinearity of three points	$\left\|x_1\, y_1\, 1\, x_2\, y_2\, 1\, x_3\, y_3\, 1\right\| = 0$
Angle between two straight lines	$tan\theta = \left\|\frac{m_1-m_2}{1+m_1m_2}\right\|$
Bisector of the angles between two lines	$\frac{ax+by+c}{\sqrt{a^2+b^2}} = \pm\frac{(a^{\|}x+b^{\|}y+c^{\|})}{\sqrt{a^{'2}+b^{'2}}}$
Condition of Concurrency	For three lines $a_1x + a_2y + c_1 = 0, i = 123$ is $\left\|a_1\, b_1\, c_1\, a_2\, b_2\, c_2\, a_3\, b_3\, c_3\right\| = 0$
A pair of straight lines through origin	$ax^2 + 2hxy + by^2 = 0$ If θ is the acute angle between the pair of straight lines, then $tan\theta$ $= \left\|\frac{2\sqrt{(h^2-ab)}}{a+b}\right\|$
Two Lines:	$ax + bx + c = 0\ and\ a^{'}x + b^{'}y + c^{'} = 0$ Two lines a. Parallel if $\frac{a}{a^{'}} = \frac{b}{b'} \neq \frac{c}{c'}$ b. Distance between two parallel lines= $\left\|\frac{C_1-C_2}{\sqrt{a^2+b^2}}\right\|$ c. Perpendicular: $if\ aa^{'} + bb^{'} = 0$
A point and line	a. Distance between point and line= $\left\|\frac{ax_1+by_1+c}{\sqrt{a^2+b^2}}\right\|$ b. Reflection of a point about a line: $\frac{x-x_1}{a} = \frac{y-y_1}{b} =- 2\frac{ax_1+by_1+c}{a^2+b^2}$ c. Foot of the perpendicular from a point on the line is $\frac{x-x_1}{a} = \frac{y-y_1}{b} =- \frac{ax_1+by_1+c}{a^2+b^2}$

Indefinite Integration formula

The formula for indefinite integration are as stated below

If f & g are functions of x such that $g'(x) = f(x)$ then,	$\int f(x)dx = g(x) + c \Leftrightarrow \frac{d}{dx}\{g(x) + c\} = f(x)$ Here, c is called the constant of integration
Standard Formula:	• $\int (ax + b)^{n}\, dx = \frac{(ax+b)^{n+1}}{a(n+1)} + c,\ \ n \neq -1$ • $\int \frac{dx}{ax+b} = \frac{1}{a}\ln ln\,(ax + b) + c$ • $\int e^{ax+b} dx = \frac{1}{a} e^{ax+b} + c$ • $\int a^{px+q} dx = \frac{1}{P}\frac{a^{px+q}}{\ln ln\, a} + c$, Here $a > 0$ • $\int sin\,(ax + b)dx = -\frac{1}{a}\cos cos\,(ax + b) + c$ • $\int cos\,(ax + b)dx = \frac{1}{a}\sin sin\,(ax + b) + c$ • $\int tan\,(ax + b)dx = \frac{1}{a}\ln ln\ \sec sec\,(ax + b) + c$ • $\int cot\,(ax + b)dx = \frac{1}{a}\ln ln\ \sin sin\,(ax + b) + c$ • $\int (ax + b)dx = \frac{1}{a} tan\,(ax + b) + c$ • $\int (ax + b)dx = -\frac{1}{a} cot\,(ax + b) + c$ • $\int dx = ln\,(sec\,x + tan\,x) + c$ or $\int dx = ln\, tan\left(\frac{\pi}{4} + \frac{x}{2}\right) + c$

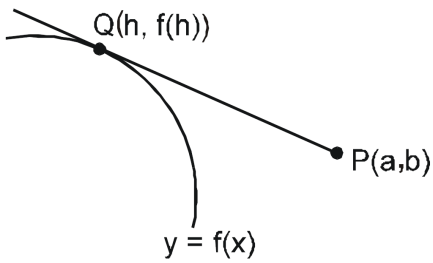
	• $\int dx = ln\,(x + cot\,x) + c$ or $\int dx = ln\,tan\,\frac{x}{2} + c$ or $\int dx = ln\,(cosec\,x + cot\,x) + c$ • $\int \frac{dx}{\sqrt{a^2-x^2}} = \frac{x}{a} + c$ • $\int \frac{dx}{a^2+x^2} =- \frac{1}{a}\frac{x}{a} + c$ • $\int \frac{dx}{\lvert x\rvert\sqrt{x^2+a^2}} =- \frac{1}{a}\frac{x}{a} + c$ • $\int \frac{dx}{\sqrt{x^2+a^2}} = ln\left[x + \sqrt{x^2 + a^2}\right] + c$ • $\int \frac{dx}{\sqrt{x^2-a^2}} = ln\left[x + \sqrt{x^2 - a^2}\right] + c$ • $\int \frac{dx}{a^2-x^2} = \frac{1}{2a}ln\left\lvert\frac{a+x}{a-x}\right\rvert + c$ • $\int \frac{dx}{x^2-a^2} = \frac{1}{2a}ln\left\lvert\frac{x-a}{x+a}\right\rvert + c$ • $\int \sqrt{a^2 - x^2}dx = \frac{x}{2}\sqrt{x^2 + a^2} + \frac{a^2}{2}\frac{x}{a} + c$ • $\int \sqrt{x^2 + a^2}dx = \frac{x}{2}\sqrt{x^2 + a^2} + \frac{a^2}{2}ln\left(\frac{x+\sqrt{x^2+a^2}}{a}\right) + c$ • $\int \sqrt{x^2 - a^2}dx = \frac{x}{2}\sqrt{x^2 - a^2} - \frac{a^2}{2}ln\left(\frac{x+\sqrt{x^2-a^2}}{a}\right) + c$
Integration by substitutions	If we substitute $f(x) = t$, then $f^{'}(x)dx = dt$
Integration by part	$\int(f(x)g(x))dx = f(x)\int(g(x))dx - \int\left(\frac{d}{dx}(f(x))\int(g(x))dx\right)dx$

Integration of type	$\int \frac{dx}{ax^2+bx+c}, \int \frac{dx}{\sqrt{ax^2+bx+c}}, \int \sqrt{ax^2 + bx + c}dx$ Make the substitute $x + \frac{b}{2a} = t$
Integration of trigonometric functions	$\int \frac{dx}{a+bx}\ or \int \frac{dx}{a+bx}\ \ or\ \int \frac{dx}{ax + bsinsin\, x\ coscos\, x + cx}$ Here we put tan $tan\, x\ = t$ $\int \frac{dx}{a+bsinsin\, x}\ or \int dx/(a + b\cos cos\, x\,)\ or \int \frac{dx}{a+bsinsin\, x + ccoscos\, x}$ Here we put tan $tan\, \frac{x}{2}\ = t$
Integration of type	$$\int \frac{x^2+1}{x^4+Kx^2+1}dx$$ Here k is any constant So, we divide numerator and denominator by x^2 and put $x \mp \frac{1}{x} = t$

Application of Derivatives Formula

The formula for application of derivatives are as stated below

Description	Formula
Equation of tangent and normal	• Tangent at (x_1, y_1) is given by $\left(y - y_1\right) = f'\left(x_1\right)\left(x - x_1\right)$, here the $f'(x_1)$ should be real • And normal at (x_1, y_1) is given by $\left(y - y_1\right) = -\frac{1}{f'\left(x_1\right)}(x - x_1)$, here the $f'\left(x_1\right)$ should be non-zero and real.
Tangent from an external point	Given a point $P(a,\ b)$ which does not lie on the curve $y\ =\ f(x)$, then the equation of possible tangents to the curve $y\ =\ f(x)$, passing through $(a,\ b)$ can be found by solving for the point of contact Q. $$f'(h) = \frac{f(h)-b}{h-a}$$

	 And equation of the tangent is $$y - b = \frac{f(h)-b}{h-a}(x - a)$$
Length of tangent, normal, subtangent, subnormal	• $PT = \lvert k\rvert\sqrt{1 + \frac{1}{m^2}}$ is the length of the tangent • $PN = \lvert k\rvert\sqrt{1 + m^2}$ is the length of normal • $TM = \left\lvert\frac{k}{m}\right\rvert$ is the length of the subtangent • $MN = \lvert km\rvert$ is the length of subnormal
Angle between the curves	Angle between two intersecting curves is defined as the acute angle between their tangents (or normal) at the point of intersection of two curves. So, $$\tan tan\,\theta = \left\lvert\frac{m_1-m_2}{1+m_1m_2}\right\rvert$$
Rolle's Theorem:	If a function f defined on [a, b] is • continuous on [a, b] • derivable on (a, b) and • f(a) = f(b), • then there exists at least one real number c between a and b (a < c < b) such that f'(c) = 0
Lagrange's Mean Value Theorem (LMVT):	If a function f defined on [a, b] is (i) Continuous on [a, b] and (ii) derivable on (a, b) then there exists at least one real numbers between a and b (a < c < b) such that $$\frac{f(b)-f(a)}{b-a} = f'(c)$$
Formulae of Mensuration	• Volume of a cuboid $= lbh$ • Surface area of cuboid $= 2(lb + bh + hl)$ • Volume of cube $= a^3$ • Surface area of cube $= 6a^2$ • Volume of a cone $= \frac{1}{3}\pi r^2 h$

	• Curved surface area of cone $= \pi rl \ (l = slant\ height)$ • Curved surface area of a cylinder $= 2\pi rh$ • Total surface area of a cylinder $= 2\pi rh + 2\pi r^2$ • Volume of a sphere $= \frac{4}{3}\pi r^3$ • Surface area of a sphere $= 4\pi r^2$ • Area of a circular sector $= \frac{1}{2}r^2\theta$, here θ is in radian • Volume of a prism $= (area\ of\ the\ base)\times(height)$ • Lateral surface area of a prism $= (perimeter\ of\ the\ base) \times (height)$ • Total surface area of a prism $= (lateral\ surface\ area)\times 2(area\ of\ the\ base)$ • Volume of a pyramid $= \frac{1}{3}(area\ of\ the\ base)\times(height)$ • Curved surface area of a pyramid $= \frac{1}{2}(perimeter\ of\ the\ base)\times(slant\ height)$

Part 4

Sequence & Series

The formula for sequence and series are as stated below

Description	Formula
An arithmetic progression (A. P)	$a,\ a + d,\ a + 2d,\ ...,\ a + (n - 1)d$ is an A. P. Let a be the first term and d be the common difference of an A. P., then n^{th} term $= t_n = a + (n - 1)d$

The sum of first n terms of A. P.	$S_n = \frac{n}{2}[2a + (n - 1)d] = \frac{n}{2}[a + l]$ r^{th} term of an A. P. when sum of first r terms is given is $t_r = S_r - S_r - 1$
Properties of A. P.	• If a, b, c are in A. P. ⇒$2b = a + c$ & if a, b, c, d are in A. P. ⇒$a + d = b + c$ • Sum of the terms of an A.P. equidistant from the beginning & end = sum of first & last term.
Arithmetic Mean	If three terms are in A.P. then the middle term is called the A.M. between the other two, so if a, b, c are in A.P., b is A.M. of a & c. n – Arithmetic Means between two number If a, b are any two given numbers & $a,\ A_1,\ A_2, ...,\ A_n, b$ are in A.P. then $A_1,\ A_2, ...\ A_n$ are the n A.M.'s between a & b. $A_1 = a + \frac{b-a}{n+1}$ $A_2 = a + \frac{2(b-a)}{n+1}, ..., A_n = a + \frac{n(b-a)}{n+1}$ $\sum_{r=1}^{n} A_r = nA$ where A is the single A.M. between a & b.
Geometric Progression	$a, ar, ar^2, ar^3, ar^4,\ ...,$ is a G.P. with a as the first term & r as a common ratio. • n^{th} term $= ar^{n-1}$ • Sum of the first n terms i.e., $S_n = \{\frac{a(r^n-1)}{r-1},\quad r\neq1\ na,\qquad r = 1$
Harmonic Mean	• If a, b, c are in H.P., b is the H.M. between a & c, then $b = \frac{2ac}{a+c}$ • H.M. of $a_1,\ a_2\ ...\ a_n$ is given by $\frac{1}{H} = \frac{1}{n}\left[\frac{1}{a_1} + \frac{1}{a_2} + ... + \frac{1}{a_n}\right]$
Relation between means:	$G^2 = AH,\ \ A.M.\geq G.M.\geq H.M.$ • $A.M. = G.M. = H.M.$ if $a_1 = a_2 = a_3 = ... = a_n$
Important Results	• $\sum_{r-1}^{n}(a_r \pm b_r) = \sum_{r-1}^{n} a_r \pm \sum_{r-1}^{n} b_r$

	• $\sum_{r-1}^{n} k\, a_r = k \sum_{r-1}^{n} a_r$ • $\sum_{r-1}^{n} k = nk$ where k is constant • $\sum_{r-1}^{n} r = 1 + 2 + 3 + \ldots + n = \frac{n(n+1)}{2}$ • $\sum_{r-1}^{n} r^2 = 1^2 + 2^2 + 3^2 + \ldots + n^2 = \frac{n(n+1)(2n+1)}{6}$ • $\sum_{r-1}^{n} r^3 = 1^3 + 2^3 + 3^3 + \ldots + n^3 = \frac{n^2(n+1)^2}{4}$

Hyperbola Formula

The formula for hyperbola are as stated below

Description	Formula
Standard Equation	$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ where $b^2 = a^2\left(e^2 - 1\right)$ Foci: $S \equiv (\pm ae, 0)$ Directrices: $x = \pm \frac{a}{e}$ Vertices: $A \equiv (\pm a, 0)$ Latus Rectum $l = \frac{2b^2}{a} = 2a\left(e^2 - 1\right)$
Conjugate Hyperbola	$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ Are conjugate hyperbolas of each
Auxiliary Circle	$x^2 + y^2 = a^2$
Parametric Representation	$x = a \sec sec\, \theta$ and $y = b \tan tan\, \theta$
Position of A point w.r.t hyperbola	$s_1 \equiv \frac{x_1^2}{a^2} - \frac{y_1^2}{b^2} - 1 \geq or < 0$ According to the point $\left(x_1, y_1\right)$ lies inside on or outside the curve
Tangents	Slope form: $y = mx \pm \sqrt{a^2 m^2 - b^2}$ Point Form: at the point $\left(x_1, y_1\right)$ is $\frac{xx_1}{a^2} - \frac{yy_1}{b^2} = 1$ Parametric form: $\frac{x secsec\, \theta}{a} - \frac{y tantan\, \theta}{b} = 1$

Normal:	• At the point $P\left(x_1, y_1\right)$ is $\frac{a^2x}{x_1} + \frac{b^2y}{y_1} = a^2 + b^2 = a^2e^2$ • At the point $P(a\sec sec\,\theta,\ b\tan tan\,\theta)$ is $\frac{ax}{\sec sec\,\theta} + \frac{by}{\tan tan\,\theta} = a^2 + b^2 = a^2e^2$ • Equation of normal in term of its slope m is $y = mx \pm \frac{\left(a^2+b^2\right)m}{\sqrt{a^2-b^2m^2}}$
Asymptotes	$\frac{x}{a} + \frac{y}{b} = 0$ and $\frac{x}{a} - \frac{y}{b} = 0$ Pair of asymptotes: $\frac{x^2}{a^2} - \frac{y^2}{b^2} = 0$ •
Rectangular Or Equilateral Hyperbola	• $xy = c^2$ eccentricity is $\sqrt{2}$ • Vertices: $(\pm c \pm c)$ • Foci: $\pm\sqrt{2}c, \pm\sqrt{2}c$ • Directrices: $x + y = \pm\sqrt{2}c$ • Latus Rectum $l = 2\sqrt{2}c = T.A. = C.A.$ • Parametric equation $x = ct, y = \frac{c}{t}, t\epsilon R - \{0\}$ • Equation of the tangent at $P\left(x_1, y_1\right) = \frac{x}{x_1} + \frac{y}{y_1} = 2$ • Equation of the tangent at $P(t) = \frac{x}{t} + ty = 2c$ • Equation of the normal at $P(t) = xt^3 - yt = c\left(t^4 - 1\right)$ • Chord with a given middle point as $(h, k) = kx + hy = 2hk$