A. DERIVATIVES

I. DERIVATIVE BY FIRST PRINCIPLE OR DEFINITION

FORMULAE

1. $f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}$
2. Right Hand and Left Hand Derivatives

$Rf'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x)}{h}, h > 0$

$Lf'(x) = \lim_{h \to 0} \frac{f(x-h) - f(x)}{-h}, h > 0$

II. L HOSPITAL'S RULE

FORMULAE

If $\phi(x)$ and $\psi(x)$ and their derivatives $\phi'(x)$ and $\psi'(x)$ are continuous at $x = a$ and if $\phi(a) = \psi(a) = 0$, then

$$\underset{x \to a}{\text{Lt}} \frac{\phi(x)}{\psi(x)} = \underset{x \to a}{\text{Lt}} \frac{\phi'(x)}{\psi'(x)} = \frac{\phi'(a)}{\psi'(a)} \quad \text{provided } \psi'(a) \neq 0$$

III. ROLLE'S THEOREM AND MEAN VALUE THEOREM

FORMULAE

1. Rolle's Theorem

If f(x) be a function defined on [a, b] such that

i. f(x) is continuous in [a, b]

ii. f(x) is derivable in (a, b)

iii. f(a) = f(b),

then there exists at least one $c \in (a, b)$ such that $f'(c)=0$.

2. Lagrange's Mean Value Theorem

Let f(x) be a function defined in [a, b] such that

i. f(x) is continuous in [a, b]

ii. f(x) is derivable in (a, b)

then there exists at least one value $c \in (a, b)$ such that

$$f'(c) = \frac{f(b) - f(a)}{b - a}$$

A. CORRELATION

FORMULAE

1. Karl Pearson's Coefficient of Correlation

i. $r = \frac{\text{Cov}(X, Y)}{\sqrt{\text{Var}(X)}\sqrt{\text{Var}(Y)}}$

ii. $r = = \frac{n\Sigma XY - \Sigma X \Sigma Y}{\sqrt{n\Sigma X^2 - (\Sigma X)^2}\sqrt{n\Sigma Y^2 - (\Sigma Y)^2}}$

iii. $r = \frac{\Sigma xy}{n\sigma_x\sigma_y}$

iv. $r = \frac{n\Sigma XY - \Sigma X \Sigma Y}{\sqrt{n\Sigma X^2 - (\Sigma X)^2}\sqrt{n\Sigma Y^2 - (\Sigma Y)^2}}$

v. $r = \frac{n\Sigma uv - \Sigma u \Sigma v}{\sqrt{n\Sigma u^2 - (\Sigma u)^2}\sqrt{n\Sigma v^2 - (\Sigma v)^2}}$

2. The value of r lies between −1 and +1.

II. DERIVATIVE USING FORMULA

FORMULAE

1. i. $\frac{d(x^n)}{dx} = nx^{n-1}$ ii. $\frac{d}{dx}(e^x) = e^x$

iii. $\frac{d}{dx}(a^x) = a^x \ln a$ iv. $\frac{d}{dx}(\ln x) = \frac{1}{x}$

v. $\frac{d}{dx}(\sin x) = \cos x$ vi. $\frac{d}{dx}(\cos x) = -\sin x$

vii. $\frac{d}{dx}(\tan x) = \sec^2 x$ viii. $\frac{d}{dx}(\sec x) = \sec x \tan x$

ix. $\frac{d}{dx}(\cot x) = -\text{cosec}^2 x$

x. $\frac{d}{dx}(\text{cosec } x) = -\text{cosec } x \cdot \cot x$

2. i. $\frac{d}{dx}(\sin^{-1} x) = \frac{1}{\sqrt{1-x^2}}$ ii. $\frac{d}{dx}(\cos^{-1} x) = \frac{-1}{\sqrt{1-x^2}}$

iii. $\frac{d}{dx}(\tan^{-1} x) = \frac{1}{1+x^2}$ iv. $\frac{d}{dx}(\cot^{-1} x) = \frac{-1}{1+x^2}$

v. $\frac{d}{dx}(\sec^{-1} x) = \frac{1}{x\sqrt{x^2-1}}$ vi. $\frac{d}{dx}(\text{cosec}^{-1} x) = \frac{-1}{x\sqrt{x^2-1}}$

3. i. $\frac{d[uv]}{dx} = u\frac{dv}{dx} + v\frac{du}{dx}$ ii. $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$

4. Derivative of hyperbolic function

$\frac{d}{dx}(\sinh x) = \cosh x$

$\frac{d}{dx}(\cosh x) = \sinh x$

$\frac{d}{dx}(\tanh x) = \text{sech}^2 x$

$\frac{d}{dx}(\coth x) = -\text{cosech}^2 x$

$\frac{d}{dx}(\text{sech } x) = -\text{sech } x \tanh x$

$\frac{d}{dx}(\text{cosech } x) = -\text{cosech } x \coth x$

5. Derivative of inverse hyperbolic functions

$\frac{d(\sinh^{-1} x)}{dx} = \frac{1}{\sqrt{1+x^2}}$

$\frac{d}{dx}(\cosh^{-1} x) = \frac{1}{\sqrt{x^2-1}}$ $(x > 1)$

$\frac{d}{dx}(\tanh^{-1} x) = \frac{1}{1-x^2}$ $-1 < x < 1$

$\frac{d}{dx}(\coth^{-1} x) = \frac{-1}{x^2-1}$, $|x| > 1$

$\frac{d}{dx}(\text{sech}^{-1} x) = \frac{-1}{x\sqrt{1-x^2}}$, $|x| < 1$

$\frac{d}{dx}(\text{cosech}^{-1} x) = \frac{-1}{|x|\sqrt{1+x^2}}$, $x \in \mathbb{R} - \{0\}$

FORMULAE

1. Regression equation of Y on X

$Y - \bar{Y} = b_{YX}(X - \bar{X})$,

where, $b_{YX} = \frac{n\Sigma XY - \Sigma X \Sigma Y}{n\Sigma X^2 - (\Sigma X)^2}$

2. Regression equation of X on Y

$X - \bar{X} = b_{XY}(Y - \bar{Y})$

where, $b_{XY} = \frac{n\Sigma XY - \Sigma X \Sigma Y}{n\Sigma Y^2 - (\Sigma Y)^2}$

3. Relation between r and b

The correlation coefficient r is the geometric mean of two regression coefficients

$r = \sqrt{b_{YX} b_{XY}}$.

Also, the regression coefficients can be expressed in terms of r and σ as,

$b_{XY} = r\frac{\sigma_X}{\sigma_Y}$ and $b_{YX} = r\frac{\sigma_Y}{\sigma_X}$.

A. INVERSE CIRCULAR FUNCTIONS

FORMULAE

1. $2\sin A \cos B = \sin(A+B) + \sin(A-B)$
   $2\cos A \sin B = \sin(A+B) - \sin(A-B)$
   $2\cos A \cos B = \cos(A+B) + \cos(A-B)$
   $2\sin A \sin B = \cos(A-B) - \cos(A+B)$
2. $\sin C + \sin D = 2\sin\frac{C+D}{2}\cos\frac{C-D}{2}$
   $\sin C - \sin D = 2\cos\frac{C+D}{2}\sin\frac{C-D}{2}$
   $\cos C + \cos D = 2\cos\frac{C+D}{2}\cos\frac{C-D}{2}$
   $\cos C - \cos D = 2\sin\frac{C+D}{2}\sin\frac{D-C}{2}$
   $= -2\sin\frac{C+D}{2}\sin\frac{C-D}{2}$
3. Domain and range of inverse circular functions

Functions	Domain (x)	Range (y)
$y = \sin^{-1} x$	$-1 \le x \le 1$	$-\frac{\pi}{2} \le y \le \frac{\pi}{2}$
$y = \cos^{-1} x$	$-1 \le x \le 1$	$0 \le y \le \pi$
$y = \tan^{-1} x$	$(-\infty, \infty)$	$-\frac{\pi}{2} < y < \frac{\pi}{2}$
$y = \cot^{-1} x$	$(-\infty, \infty)$	$0 < y < \pi$
$y = \sec^{-1} x$	$x \ge 1$, or $x \le -1$	$0 \le y \le \pi, y \ne \frac{\pi}{2}$
$y = \text{cosec}^{-1} x$	$x \ge 1$, or $x \le -1$	$-\frac{\pi}{2} \le y \le \frac{\pi}{2}, y \ne 0$

4. Self adjust property
   $\sin \sin^{-1} x = x = \sin^{-1} \sin x$
   $\cos \cos^{-1} x = x = \cos^{-1} \cos x$
   $\tan \tan^{-1} x = x = \tan^{-1} \tan x$
5. Reciprocal property
   $\sin^{-1} x = \text{cosec}^{-1}\frac{1}{x}$ $\quad$ $\cos^{-1} x = \sec^{-1}\frac{1}{x}$
   $\tan^{-1} x = \cot^{-1}\frac{1}{x}$
6. Conversion property
   $\sin^{-1} x = \cos^{-1}\sqrt{1-x^2}$ $\quad$ $\sin^{-1} x = \tan^{-1}\frac{x}{\sqrt{1-x^2}}$
   $\sin^{-1} x = \sec^{-1}\frac{1}{\sqrt{1-x^2}}$ $\quad$ $\sin^{-1} x = \cot^{-1}\frac{\sqrt{1-x^2}}{x}$
7. For any numerical value of x,
   i. $\sin^{-1} x + \cos^{-1} x = \frac{\pi}{2}$ $\quad$ ii. $\tan^{-1} x + \cot^{-1} x = \frac{\pi}{2}$
   iii. $\text{cosec}^{-1} x + \sec^{-1} x = \frac{\pi}{2}$
8. For given numerical value of x.
   a. $\sin^{-1}(-x) = -\sin^{-1} x$ $\quad$ b. $\cos^{-1}(-x) = \pi - \cos^{-1} x$
   c. $\tan^{-1}(-x) = -\tan^{-1} x$ $\quad$ d. $\cot^{-1}(-x) = \pi - \cot^{-1} x$
9. $\tan^{-1} x + \tan^{-1} y = \tan^{-1}\left(\frac{x+y}{1-xy}\right)$, $xy < 1$
10. $\sin^{-1} x + \sin^{-1} y = \sin^{-1}\{x\sqrt{1-y^2} + y\sqrt{1-x^2}\}$
11. $\cos^{-1} x + \cos^{-1} y = \cos^{-1}\left(xy - \sqrt{1-x^2}\sqrt{1-y^2}\right)$

FORMULAE AND IMPORTANT POINTS

1. Complex Number
   An ordered pair (a, b) of two real numbers a and b is said to be a complex number.
2. $i^2 = -1$
   In general:
   $i^{4n} = 1, i^{4n+1} = i, i^{4n+2} = -1, i^{4n+3} = -i$, where $n \in \mathbb{Z}$.
3. If $Z = a + ib$, then $\overline{Z} = a - ib$
4. If $Z = a + ib$, then $|Z| = \sqrt{a^2 + b^2}$
5. Cube Roots of Unity
   $1, \frac{-1+i\sqrt{3}}{2}, \frac{-1-i\sqrt{3}}{2}$ are three cube roots of unity
6. Properties of cube roots of unity
   i. Each imaginary cube root of unity is the square of the other.
   ii. The sum of the three cube roots of unity is zero.
   iii. Each complex cube root of unity is the reciprocal of the other.
   iv. The product of two imaginary cube roots of unity is 1.
7. $\omega^3 = 1$
   In general $\omega^{3n} = 1$ for $n \in \mathbb{Z}$.
8. If $z_1 = r_1(\cos\theta_1 + i\sin\theta_1)$ and $z_2 = r_2(\cos\theta_2 + i\sin\theta_2)$
   then, $z_1 z_2 = r_1 r_2\{\cos(\theta_1+\theta_2) + i\sin(\theta_1+\theta_2)\}$.
   and $\frac{z_1}{z_2} = \frac{r_1}{r_2}[\cos(\theta_1-\theta_2) + i\sin(\theta_1-\theta_2)]$.
9. $\text{amp}(z_1 z_2) = \text{amp}(z_1) + \text{amp}(z_2)$.
   $\text{amp}\left(\frac{z_1}{z_2}\right) = \text{amp}(z_1) - \text{amp}(z_2)$.
10. De-Moivre's Theorem
    For any positive integer n
    $[r(\cos\theta + i\sin\theta)]^n = r^n(\cos n\theta + i\sin n\theta]$.

A. NEWTON'S LAW OF MOTION

FORMULAE

1. Momentum = mv
   Change in momentum = mv – mu
   Average rate of change of momentum = $\frac{m(v-u)}{t}$
2. Upward force: R = m(a + g)
   Downward force: R = m(g – a)
3. Impulsive force: $F = \frac{d(mv)}{dt}$, as m is constant
4. Principle of conservation of linear momentum
   mv – MV = 0
   $m_1 v_1 + m_2 v_2 = (m_1 + m_2) v$

B. PROJECTILES

FORMULAE

1. Equations of Motion of a Projectile
   For the vertical motion,
   $v\sin\theta = u\sin\alpha - gt$
   and for the horizontal motion,
   $v\cos\theta = u\cos\alpha$
2. Time to reach the greatest height
   $t = \frac{u\sin\alpha}{g}$
3. Time of Flight and Range
   $T = \frac{2u\sin\alpha}{g}$ $\quad$ $R = \frac{u^2\sin 2\alpha}{g}$
4. Maximum horizontal range $= \frac{u^2}{g}$
5. Greatest height: $H = \frac{u^2\sin^2\alpha}{2g}$

A. ELLIPSE

FORMULAE

Tables for Different Types of Ellipse

Ellipse	Center	Vertex	Focus	Major axis	Minor axis	Eccentricity (e)	Length of Latus ratum	Directrix
$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$, $a>b>0$	(0, 0)	(±a, 0)	(±ae, 0)	2a	2b	$\sqrt{1-\frac{b^2}{a^2}}$	$\frac{2b^2}{a}$	$x=\pm\frac{a}{e}$
$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$, $b>a>0$	(0, 0)	(0, ±b)	(0, ±be)	2b	2a	$\sqrt{1-\frac{a^2}{b^2}}$	$\frac{2a^2}{b}$	$y=\pm\frac{b}{e}$
$\frac{(x-h)^2}{a^2}+\frac{(y-k)^2}{b^2}=1$, $a>b>0$	(h, k)	(h±a, k)	(h±ae, k)	2a	2b	$\sqrt{1-\frac{b^2}{a^2}}$	$\frac{2b^2}{a}$	$x=h\pm\frac{a}{e}$
$\frac{(x-h)^2}{a^2}+\frac{(y-k)^2}{b^2}=1$, $b>a>0$	(h, k)	(h, k±b)	(h, k±be)	2b	2a	$\sqrt{1-\frac{a^2}{b^2}}$	$\frac{2a^2}{b}$	$y=k\pm\frac{b}{e}$

B. HYPERBOLA

FORMULAE

Tables for Different Types of Hyperbola

Equation of hyperbola	$\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$	$\frac{y^2}{b^2}-\frac{x^2}{a^2}=1$	$\frac{(x-h)^2}{a^2}-\frac{(y-k)^2}{b^2}=1$	$\frac{(x-h)^2}{a^2}-\frac{(y-k)^2}{b^2}=1$
Center	(0, 0)	(0, 0)	(h, k)	(h, k)
Vertices	(± a, 0)	(0, ± b)	(h ± a, k)	(h, k ± b)
Foci	(± ae, 0)	(0, ± be)	(h ± a, k)	(h, k ± be)
Equation of transverse axis	y = 0	x = 0	x = h	y = k
Equation of conjugate axis	x = 0	y = 0	y = k	x = h
Length of transverse axis	2a	2b	2a	2b
Length of conjugate axis	2b	2a	2b	2a
Equation of directrices	$x=\pm\frac{a}{e}$	$y=\pm\frac{b}{e}$	$x=h\pm\frac{a}{e}$	$x=k\pm\frac{b}{e}$
Eccentricity (e)	$\sqrt{1+\frac{b^2}{a^2}}$	$\sqrt{1+\frac{a^2}{b^2}}$	$\sqrt{1+\frac{b^2}{a^2}}$	$\sqrt{1+\frac{a^2}{b^2}}$
Latus rectum	$\frac{2b^2}{a}$	$\frac{2a^2}{b}$	$\frac{2b^2}{a}$	$\frac{2a^2}{b}$

FORMULAE

1. Scalar Product

   If $\vec{a}=(a_1, a_2)$ and $\vec{b}=(b_1, b_2)$ then

   $\vec{a}\cdot\vec{b}=a_1b_1+a_2b_2$

   If $\vec{a}=(a_1, a_2, a_3)$, $\vec{b}=(b_1, b_2, b_3)$ then

   $\vec{a}\cdot\vec{b}=a_1b_1+a_2b_2+a_3b_3$

2. The angle between two vectors $\vec{a}$ and $\vec{b}$ is given by $\cos^{-1}\left(\frac{\vec{a}\cdot\vec{b}}{|\vec{a}||\vec{b}|}\right)$.

3. Projection of $\vec{a}$ on $\vec{b}=\frac{\vec{a}\cdot\vec{b}}{|\vec{b}|}$

   Projection of $\vec{b}$ on $\vec{a}=\frac{\vec{a}\cdot\vec{b}}{|\vec{a}|}$

4. Perpendicular or orthogonal vectors: Two vectors $\vec{a}$ and $\vec{b}$ are orthogonal if and only if $\vec{a}\cdot\vec{b}=0$

5. $\vec{i}\cdot\vec{j}=\vec{j}\cdot\vec{k}=\vec{k}\cdot\vec{i}=0$

   $\vec{i}\cdot\vec{i}=\vec{j}\cdot\vec{j}=\vec{k}\cdot\vec{k}=1$

6. If $\vec{a}=(a_1, a_2, a_3)$, $\vec{b}=(b_1, b_2, b_3)$, then

   $\vec{a}\times\vec{b}=(a_2b_3-a_3b_2)\vec{i}-(a_1b_3-a_3b_1)\vec{j}+(a_1b_2-a_2b_1)\vec{k}$

   $$=\begin{vmatrix}\vec{i} & \vec{j} & \vec{k}\\ a_1 & a_2 & a_3\\ b_1 & b_2 & b_3\end{vmatrix}$$

7. $\vec{a}\times\vec{b}=(|\vec{a}||\vec{b}|\sin\theta)\hat{n}=ab\sin\theta\,\hat{n}$

8. Angle between Two Vectors

   $$\theta=\sin^{-1}\frac{|\vec{a}\times\vec{b}|}{|\vec{a}||\vec{b}|}$$

9. Vector perpendicular to $\vec{a}$ and $\vec{b}=\vec{a}\times\vec{b}$.

   Unit vector perpendicular to $\vec{a}$ and $\vec{b}=\frac{\vec{a}\times\vec{b}}{|\vec{a}\times\vec{b}|}$.

10. Vector Products of $\vec{i}, \vec{j}, \vec{k}$

    a. $\vec{i}\times\vec{j}=\vec{k}$, $\vec{j}\times\vec{k}=\vec{i}$, $\vec{k}\times\vec{i}=\vec{j}$

    b. $\vec{j}\times\vec{i}=-\vec{k}$, $\vec{k}\times\vec{j}=-\vec{i}$, $\vec{i}\times\vec{k}=-\vec{j}$

    c. $\vec{i}\times\vec{i}=\vec{j}\times\vec{j}=\vec{k}\times\vec{k}=0$

11. $\vec{a}\times\vec{b}\neq\vec{b}\times\vec{a}$ but $\vec{a}\times\vec{b}=-\vec{b}\times\vec{a}$

12. Area of the parallelogram $=|\vec{a}\times\vec{b}|=ab\sin\theta$

    Area of the triangle $=\frac{1}{2}|\vec{a}\times\vec{b}|=\frac{1}{2}ab\sin\theta$

13. Two vectors $\vec{a}$ and $\vec{b}$ are parallel if $\vec{a}\times\vec{b}=0$.

A. SEQUENCE AND SERIES

FORMULAE AND IMPORTANT POINTS

1. Sequence
   A sequence of numbers is a set of numbers arranged in a definite order.
   An infinite sequence is a function $f : \mathbb{N} \to \mathbb{R}$ defined by $f(n) = a_n$, $n \in \mathbb{N}$ (the set of natural numbers)

2. Arithmetic progression:
   i. $t_n = a + (n-1)d$
   ii. $S_n = \frac{n}{2}(a + l)$
   iii. $S_n = \frac{n}{2}[2a + (n-1)d]$
   iv. A.M. between a and b $= \frac{a+b}{2}$
   v. To insert n A.M's between a and b, $d = \frac{b-a}{n+1}$

3. Geometric Progression
   i. $t_n = ar^{n-1}$
   ii. $S_n = \frac{a(r^n - 1)}{r-1}$ if $r > 1$ and $S_n = \frac{a(1-r^n)}{1-r}$ if $r < 1$
   iii. $S_n = \frac{lr - a}{r-1}$, $r \neq 1$
   iv. $S_\infty = \frac{a}{1-r}$, $|r| < 1$
   v. If a and b are two positive numbers, G.M $= \sqrt{ab}$
   vi. To insert n G.M's between a and b, $(r) = \left(\frac{b}{a}\right)^{1/n+1}$

4. Harmonic Progression
   i. $t_n = \frac{1}{a + (n-1)d}$
   ii. If a and b are two positive numbers, $H = \frac{2ab}{a+b}$

5. Relations between A.M., G.M. and H.M.
   a. $A \times H = G^2$
   b. $A > G > H$

6. i. $1 + 2 + 3 + \cdots + n = \sum n = \frac{n(n+1)}{2}$.
   ii. Sum of first n even natural numbers $= n(n+1)$.
   iii. Sum of first n odd natural numbers $= n^2$.
   iv. $1^2 + 2^2 + 3^2 + \cdots + n^2 = \sum n^2 = \frac{n(n+1)(2n+1)}{6}$
   v. $1^3 + 2^3 + 3^3 + \ldots + n^3 = \sum n^3 = \left\{\frac{n(n+1)}{2}\right\}^2$

7. Sum of n Terms of an Arithmetico-Geometric Series
   $$S_n = \frac{a}{1-r} + dr\frac{(1-r^{n-1})}{(1-r)^2} - \frac{\{a + (n-1)d\}r^n}{1-r}$$
   Sum to infinity:
   $$S_\infty = \frac{a}{1-r} + \frac{dr}{(1-r)^2}, |r| < 1$$

B. MATHEMATICAL INDUCTION

FORMULAE AND IMPORTANT POINTS

1. Principle of Mathematical induction
   A statement $P(n)$ is true for all $n \in \mathbb{N}$, where $\mathbb{N}$ is the set of natural numbers, provided
   a. $P(1)$ is true and
   b. $P(k+1)$ is true whenever $P(k)$, $k \in \mathbb{N}$ is true.

FORMULAE AND IMPORTANT POINTS

1. A function $f(x)$ defined by
   $f(x) = a_0x^n + a_1x^{n-1} + a_2x^{n-2} + a_3x^{n-3} + \cdots + a_{n-1}x + a_n$, $(a_0 \neq 0)$
   is said to be a polynomial of degree n in x, where $a_0, a_1, a_2, \cdots, a_n \in \mathbb{R}$ are all constants, n is a non-negative integer.

2. The roots of the quadratic equation $ax^2 + bx + c = 0$ are
   $$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

3. Nature of the Roots of Quadratic Equations
   a. i. If $b^2 - 4ac > 0$, then $\sqrt{b^2 - 4ac}$ is real, hence the roots are real and distinct, for $a, b, c \in \mathbb{R}$.
      ii. If $b^2 - 4ac > 0$ and a perfect square, then the roots are rational and distinct for a, b, c rational.
      iii. If $b^2 - 4ac > 0$ and not a perfect square, then the roots are irrational and distinct.
   b. If $b^2 - 4ac = 0$, then $\sqrt{b^2 - 4ac} = 0$, the roots are real and equal for $a, b, c \in \mathbb{R}$.
   c. If $b^2 - 4ac < 0$, then $\sqrt{b^2 - 4ac}$ is an imaginary number. So the roots are imaginary and distinct.

4. i. If a quadratic equation has an irrational root, then other root will be its conjugate. That is, if $p + \sqrt{q}$ be one root, the other root will be the conjugate irrational quantity $p - \sqrt{q}$ and conversely.
   ii. Imaginary roots always occur in conjugate pair. That is, if $p + iq$ be one root, the other root will be the conjugate imaginary quantity $p - iq$ and conversely.

5. Relation between Roots and Coefficients of quadratic equation $ax^2 + bx + c = 0$
   Sum of the roots $= -\frac{b}{a} = -\frac{\text{coefficient of } x}{\text{coefficient of } x^2}$
   Product of the roots $= \frac{c}{a} = \frac{\text{constant term}}{\text{coefficient of } x^2}$.

6. Formulation of Quadratic Equation
   $x^2 - (\text{sum of roots})\,x + (\text{product of roots}) = 0$

7. Condition for one root common
   $(bc_1 - b_1c)(ab_1 - a_1b) = (ca_1 - c_1a)^2$
   The common root is
   $\frac{bc_1 - b_1c}{ca_1 - c_1a}$ or, $\frac{ca_1 - c_1a}{ab_1 - a_1b}$

8. Condition for two roots common
   $\frac{a}{a_1} = \frac{b}{b_1} = \frac{c}{c_1}$