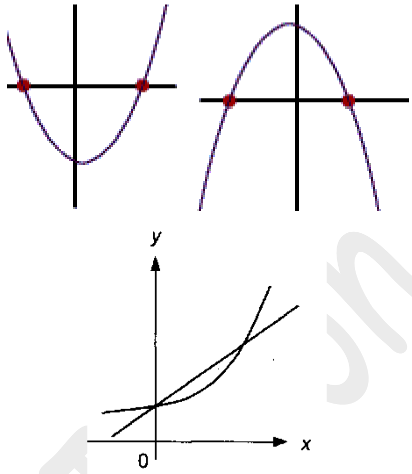
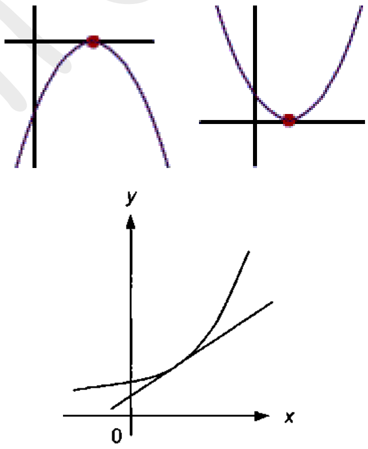
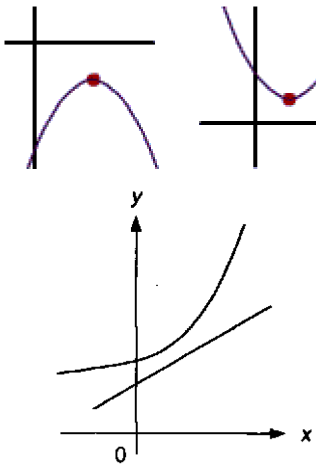
*Formulas highlighted in yellow are found in the formula list of the exam paper.

Quadratic Equation	
$b^2 - 4ac > 0$ Real and Distinct Roots / Unequal Roots	 Intersection at two different points
$b^2 - 4ac = 0$ Real and Equal Roots/Repeat Roots/ Coincident Roots.	 Tangency
$b^2 - 4ac < 0$ Imaginary roots Also known as Complex Roots.	 Non-intersection

Roots of Quadratic Equation	
The Quadratic Equation has solutions α and β	
Sum of Roots is $\alpha + \beta = -\frac{b}{a}$	Product of Roots is $\alpha\beta = \frac{c}{a}$
Equation: x^2 – (Sum of Roots) x + (Product of Roots) = 0	
$\alpha^2 + \beta^2 = (\alpha + \beta)^2 - 2\alpha\beta$	$\alpha - \beta = \pm\sqrt{(\alpha - \beta)^2 - 4\alpha\beta}$
$\alpha^4 + \beta^4 = (\alpha^2 + \beta^2)^2 - 2(\alpha\beta)^2$	

Indices		
Same Base Number	**Same Power**	
$x^a \times x^b = x^{a+b}$	$a^m \times b^m = (a \times b)^m$	Base number-Same → Power Add or Subtract
$\frac{x^a}{x^b} = x^{a-b}$	$\frac{a^m}{b^m} = \left(\frac{a}{b}\right)^m$	Power Same→ Base Number Multiply or Divide.
$\left(x^a\right)^b = x^{a \times b}$ **NOTE:** $\left(x^a\right)^b \neq x^a \times x^b$		
Other Laws of Indices		
$x^{-a} = \frac{1}{x^a}$	$x^{\frac{1}{b}} = \sqrt[b]{x^1}$	$x^0 = 1$

$x^a y^{-b} = \frac{x^a}{y^b}$	$x^{-\frac{1}{b}} = \frac{1}{x^{\frac{1}{b}}} = \frac{1}{\sqrt[b]{x^1}}$	
$\frac{1}{x^{-a}} = x^a$	$\left(\frac{x}{y}\right)^{-a} = \left(\frac{y}{x}\right)^a$	
$x^{\frac{a}{b}} = \sqrt[b]{x^a}$	$x^{-\frac{a}{b}} = \frac{1}{x^{\frac{a}{b}}} = \frac{1}{\sqrt[b]{x^a}}$	

Surds	
$\sqrt{a} \times \sqrt{b} = \sqrt{a \times b}$	$\sqrt{a} \div \sqrt{b} = \sqrt{\frac{a}{b}}$
$\sqrt{a} \times \sqrt{a} = \left(\sqrt{a}\right)^2 = a$	$m\sqrt{a} \times n\sqrt{b} = m \times n\sqrt{a \times b}$
$m\sqrt{a} + n\sqrt{a} = (m+n)\sqrt{a}$	$m\sqrt{a} - n\sqrt{a} = (m-n)\sqrt{a}$
Rationalizing Denominator	
$\frac{1}{n+\sqrt{a}} \times \frac{n-\sqrt{a}}{n-\sqrt{a}} = \frac{\left(n-\sqrt{a}\right)}{n^2-\left(\sqrt{a}\right)^2} = \frac{\left(n-\sqrt{a}\right)}{n^2-a}$	

$\frac{1}{n-\sqrt{a}}\times\frac{n+\sqrt{a}}{n+\sqrt{a}}=\frac{\left(n+\sqrt{a}\right)}{n^2-\left(\sqrt{a}\right)^2}=\frac{\left(n-\sqrt{a}\right)}{n^2-a}$
$\frac{1}{\sqrt{n}+\sqrt{a}}\times\frac{\sqrt{n}-\sqrt{a}}{\sqrt{n}-\sqrt{a}}=\frac{\left(n-\sqrt{a}\right)}{\left(\sqrt{n}\right)^2-\left(\sqrt{a}\right)^2}=\frac{\left(n-\sqrt{a}\right)}{n-a}$
$\frac{1}{\sqrt{n}-\sqrt{a}}\times\frac{\sqrt{n}+\sqrt{a}}{\sqrt{n}+\sqrt{a}}=\frac{\left(n+\sqrt{a}\right)}{\left(\sqrt{n}\right)^2-\left(\sqrt{a}\right)^2}=\frac{\left(n+\sqrt{a}\right)}{n-a}$

Polynomials & Partial Factions
$x^3+y^3=(x+y)\left(x^2-xy+y^2\right)$ $x^3-y^3=(x-y)\left(x^2+xy+y^2\right)$
Linear Factor $\frac{mx+n}{(ax+b)(cx-d)}=\frac{A}{(ax+b)}+\frac{B}{(cx+d)}$
Repeat Factors $\frac{mx+n}{(ax+b)(cx-d)^2}=\frac{A}{(ax+b)}+\frac{B}{(cx+d)}+\frac{C}{(cx+d)^2}$

Quadratic Factors
$$\frac{mx+n}{(ax+b)(cx^2-d)} = \frac{A}{(ax+b)} + \frac{Bx+C}{(cx^2+d)}$$
Note: If the highest coefficient of the NUMERATOR is the SAME or LARGER that the DENOMINATOR. Do LONG DIVISION before partial fractions.

Logarithm		
$\log_b 1 = 0$	$\ln 1 = 0$	$b^y = x$ $y = \log_b x$
$\log_b b = 1$	$\ln_e x = x$	Remember:
$\log_b b^x = x$	$e^{\ln a} = a$	1) $\ln x = \log_e x$
$\log_b m + \log_b n = \log_b (m \times n)$ Note: $\log_b m + \log_b n \neq \log_b m \times \log_b n$		2) $\log_e e = 1$ $\ln e = 1$
$\log_b m - \log_b n = \log_b (\frac{m}{n})$		
$\log_b m^a = a \times \log_b m$		

$\log_v u = \dfrac{\log_a u}{\log_a v}$ $\quad\quad \log_v u = \dfrac{\log_u u}{\log_u v} = \dfrac{1}{\log_u v}$	

Binomial Theorem

$$\binom{n}{r} = \frac{n!}{r!(n-r)!} \qquad \binom{n}{r} = {}^{n}C_r$$

Remember: $\binom{n}{0}=1,\ \binom{n}{1}=n,\ \binom{n}{2}=\dfrac{n(n-1)}{1\times 2},\ \binom{n}{3}=\dfrac{n(n-1)(n-2)}{1\times 2\times 3}$

Since:

$$(a+bx)^n = a^n + \binom{n}{1}a^{n-1}(bx)^1 + \binom{n}{2}a^{n-2}(bx)^2 + \binom{n}{3}a^{n-3}(bx)^3 \ldots\binom{n}{r}a^{n-r}(bx)^r + (bx)^n$$

Therefore:

$$(a+bx)^n = a^n + \frac{n}{1}a^{n-1}(bx)^1 + \frac{(n)(n-1)}{1\times 2}a^{n-2}(bx)^2 + \frac{(n)(n-1)(n-2)}{1\times 2\times 3}a^{n-3}(bx)^3 \ldots + (bx)^n$$

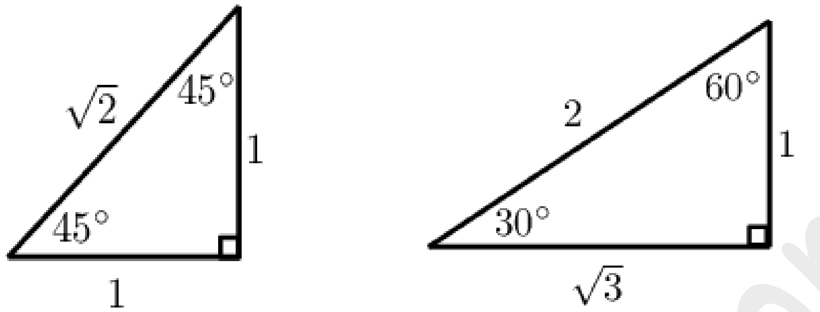
Alternate formula if a=1

$$(1+kx)^n = \binom{n}{0}1^n(kx)^0 + \binom{n}{1}1^{n-1}(kx)^1 + \binom{n}{2}1^{n-2}(kx)^2 + \ldots\binom{n}{n-1}1^{n-(n-1)}(kx)^{n-1} + \binom{n}{n}1^{n-n}(kx)^n$$

OR

$$(1+kx)^n = 1 + \binom{n}{1}(kx)^1 + \binom{n}{2}(kx)^2 + \ldots\binom{n}{n-1}(kx)^{n-1} + (kx)^n$$

Trigonometry



	30°	45°	60°
sin	$\frac{1}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2}$
cos	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2}$
tan	$\frac{1}{\sqrt{3}}$	1	$\sqrt{3}$

Principal Values of $\sin^{-1} x$, $\cos^{-1} x$, $\tan^{-1} x$,

$$-\frac{\pi}{2} \le \sin^{-1} x \le \frac{\pi}{2} \qquad 0 \le \cos^{-1} x \le \pi \qquad -\frac{\pi}{2} < \tan^{-1} x < \frac{\pi}{2}$$

$$\operatorname{cosec}\theta = \frac{1}{\sin\theta} \qquad \sec\theta = \frac{1}{\cos\theta} \qquad \cot\theta = \frac{1}{\tan\theta} = \frac{\cos\theta}{\sin\theta}$$

$$\sin^2\theta + \cos^2\theta = 1 \qquad 1 + \cot^2\theta = \operatorname{cosec}^2\theta \qquad 1 + \tan^2\theta = \sec^2\theta$$

Compound Angle Formula

$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$

$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$
$\tan(A \pm B) = \dfrac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$
Double Angle Formula
$\sin 2A = 2\sin A \cos A$ $\cos 2A = 2\cos^2 A - 1$ / $\cos 2A = \cos^2 A - \sin^2 A$ / $\cos 2A = 1 - 2\sin^2 A$ $\tan 2A = \dfrac{2\tan A}{1 - \tan^2 A}$
Half Angle Formula
$\sin\dfrac{A}{2} = \pm\sqrt{\dfrac{1-\cos A}{2}}$ $\cos\dfrac{A}{2} = \pm\sqrt{\dfrac{1+\cos A}{2}}$ $\tan\dfrac{A}{2} = \sqrt{\dfrac{1-\cos A}{1+\cos A}} = \dfrac{1-\cos A}{\sin A}$
R-Formula

$aCos\theta \pm bSin\theta = RCos(\theta \mp \alpha)$	Where $R = \sqrt{a^2 + b^2}$ $\tan\alpha = \dfrac{b}{a}$
$aSin\theta \pm bCos\theta = RSin(\theta \pm \alpha)$	

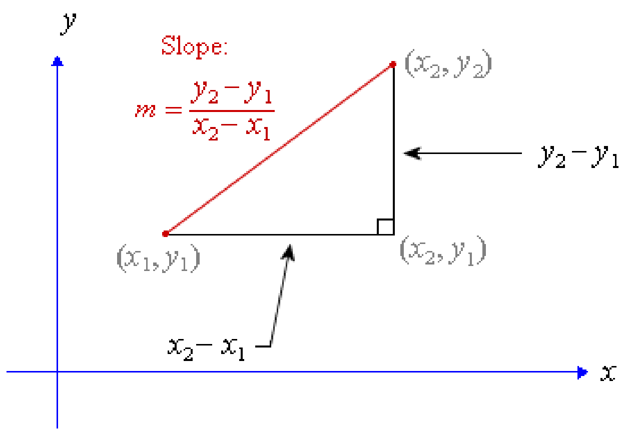
Coordinate Geometry

Gradient(m) = $\dfrac{y_2 - y_1}{x_2 - x_1}$

General Equation $Y - y_1 = m(X - x_1)$

where (x_1, y_1) is a point on the graph.

OR you may use y=mx+c

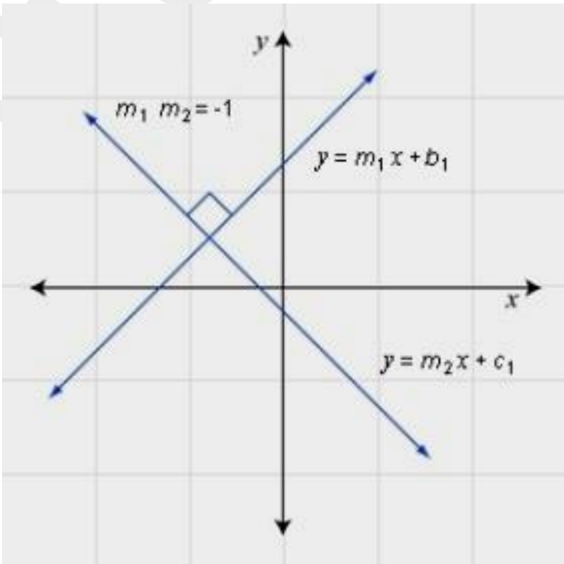


Mid-point of a line

$$\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$$

Distance between two points

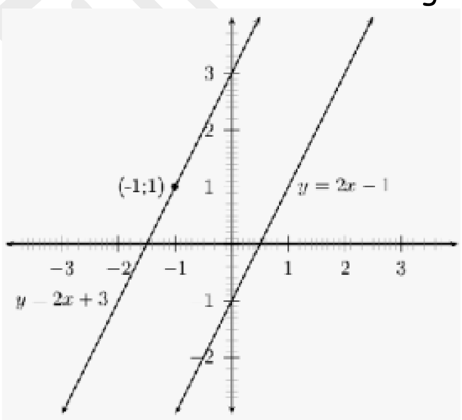
$$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$



If two lines have perpendicular gradient i.e. 90° to each other.

$$m_1 = -\frac{1}{m_2} \quad \text{or} \quad m_1 \times m_2 = -1$$

When two lines have the same gradient

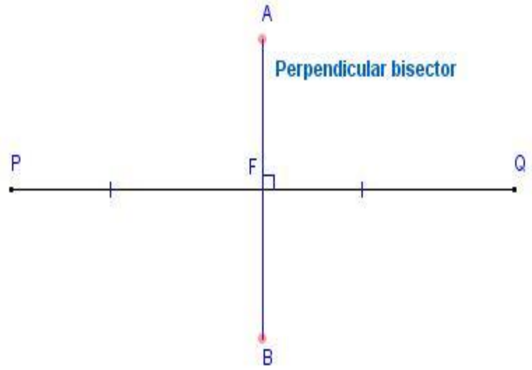


$$m_1 = m_2$$

Perpendicular Bisector

1. The two lines AB and PQ must intersect at 90°

$m_1(AB) = -\frac{1}{m_2(PQ)}$



2. One Line (AB) will cut the mid-point of the other line (PQ)

Mid-point PQ = $\left(\frac{x_2+x_1}{2}, \frac{y_2+y_1}{2}\right)$

Area of Plane Figure (Polygon Figure)

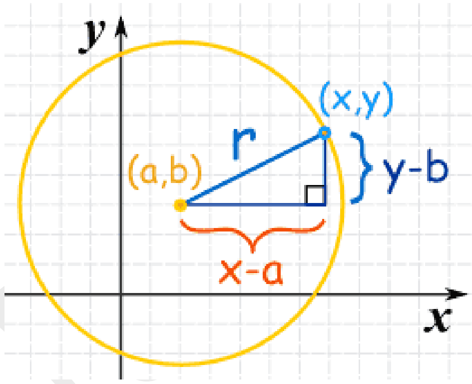
Vertices A(x_1,y_1), B(x_2,y_2),C (x_3,y_3)

$$\frac{1}{2}\begin{vmatrix} x_1 & x_2 & x_3 & x_4 & x_1 \\ y_1 & y_2 & y_3 & y_4 & y_1 \end{vmatrix}$$

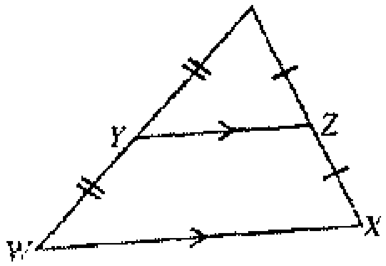
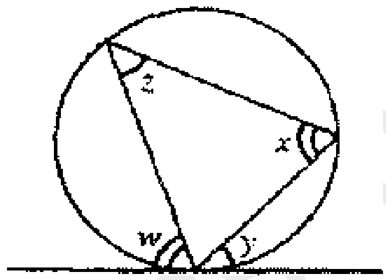
$$\frac{1}{2}\left|(x_1y_2 + x_2y_3 + x_3y_4 + x_4y_1) - (x_2y_1 + x_3\,y_2 + x_4y_3 + x_1y_4)\right|$$

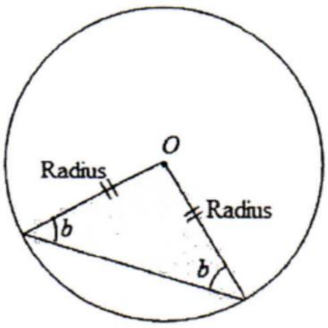
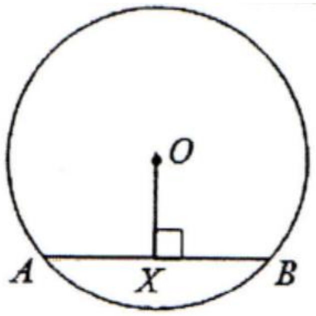
*It does NOT matter if you calculate in a clockwise or anti-clockwise direction.

The |modulus| in the formula will convert any negative values to positive.

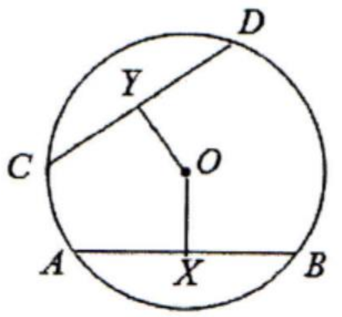
Circles	
Radius of a circle $r=\sqrt{(x-a)^2+(y-b)^2}$ Equation of a Circle $(x-a)^2+(y-b)^2=r^2$ (Standard Form) or $x^2+y^2+2gx+2fy+c=0$ (General Form) where $a=-g,\ b=-f$ and $r=\sqrt{g^2+f^2-c}$	

Proofs in Plane Geometry

Midpoint Theorem

 	
If X and Y are midpoints,
then YZ // WX
YZ = $\frac{1}{2}$ WX
	Tangent –Chord Theorem
	(Alternate Segment Theorem)
	
	
	Angle W = Angle X
	Angle Y = Angle Z

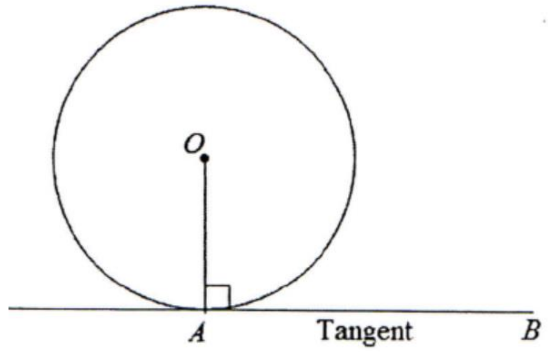
Isosceles Triangle  	Perpendicular from Centre Bisects Chord $\angle OXA = \angle OXB = 90^0$ 

Equal Chord, Equal Distance from Centre



Tangent Perpendicular Radius

$\angle OAB = 90^0$

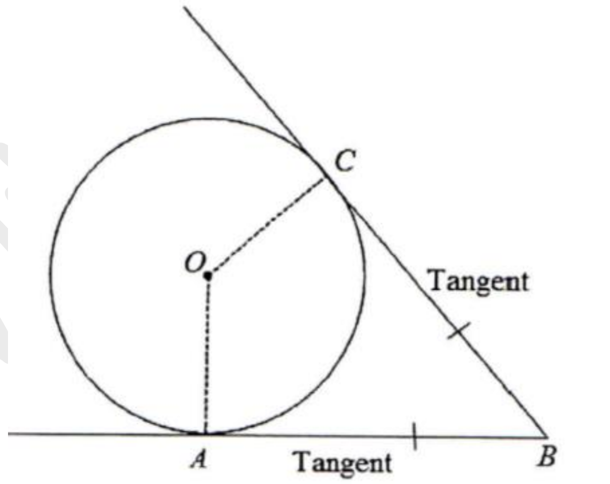


Tangents from External Point

BC=BA

$\angle OCB = \angle OAB = 90^o$

OA = OC (radius)



Differentiation		
$\frac{dy}{dx}(ax^n) = anx^{n-1}$ Where' a' and 'n' are constants. .	$\frac{dy}{dx}(a) = 0$	Sum/Difference of Function $\frac{d}{dx}(u \pm v) = \frac{du}{dx} \pm \frac{dv}{dx}$

Chain Rule	Quotient Rule
$\frac{dy}{dx}=\frac{dy}{du}\times\frac{du}{dx}$	$\frac{d}{dx}\left(\frac{u}{v}\right)=\frac{v\frac{du}{dx}-u\frac{dv}{dx}}{v^2}$

Product Rule

$$\frac{d}{dx}(uv)=u\frac{dv}{dx}+v\frac{du}{dx}$$

$\frac{d}{dx}(\sin x)=\cos x$ $\frac{d}{dx}(\tan x)=\sec^2 x$ $\frac{d}{dx}(\cos x)=-\sin x$

Use Chain Rule to differentiate the functions below.

$$\frac{d}{dx}\left[a\sin\left(bx+c\right)\right]=a\times\cos(bx+c)\times b$$

$$\frac{d}{dx}\left[a\cos\left(bx+c\right)\right]=a\times-\sin(bx+c)\times b$$

$$\frac{d}{dx}\left[a\tan\left(bx+c\right)\right]=a\times\sec^2(bx+c)\times b$$

$\frac{d}{dx}\left[a\sin^n(bx+c)\right] = a \times n \times \sin^{n-1}(bx+c) \times \cos(bx+c) \times b$ $\frac{d}{dx}\left[a\cos^n(bx+c)\right] = a \times n \times \cos^{n-1}(bx+c) \times -\sin(bx+c) \times b$ $\frac{d}{dx}\left[a\tan^n(bx+c)\right] = a \times n \times \tan^{n-1}(bx+c) \times \sec^2(bx+c) \times b$
Exponential/Natural Logarithm Function

$\frac{d}{dx}(e^{ax+b}) = ae^{ax+b}$ 'a' is a constant	$\frac{d}{dx}(e^x) = e^x$
$\frac{d}{dx}(\ln x) = \frac{1}{x}$ (where x>0)	$\frac{d}{dx}[\ln(ax+b)] = \frac{a}{ax+b}$ (where ax +b>0)

Integration		
$\int ax^n \, dx = \frac{ax^{n+1}}{n+1} + c$ where n≠-1	$\int a \, dx = ax + c$	$\int (ax+b)^n \, dx = \frac{(ax+b)^{n+1}}{(n+1)(a)} + c$ n≠1,a≠0; a & b are constants
Product of constant and a function $\int af(x)dx = a\int f(x)dx$		Sum and Difference of function $\int[\alpha f(x) \pm \beta g(x)]dx = \alpha\int f(x)dx \pm \beta\int g(x)dx$

$$\int a\cos bx\,dx = \frac{a\sin bx}{b} + c$$

$$\int a\sin bx\,dx = -\frac{a\cos bx}{b} + c$$

$$\int a\sec^2 bx\,dx = \frac{a\tan bx}{b} + c$$

$\int \frac{1}{x}\,dx = \ln x + c$ where x>0

$$\int \frac{1}{ax+b}\,dx = \frac{\ln(ax+b)}{a} + C$$

$$\int \frac{1}{ax^n+b}\,dx = \frac{\ln(ax^n+b)}{a\times n\times x^{n-1}} + C$$

$$\int e^x\,dx = e^x + c$$

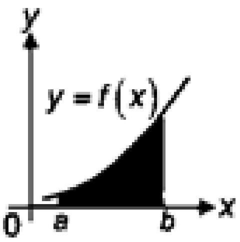
$$\int e^{ax+b}\,dx = \frac{e^{ax+b}}{a} + C$$

$$\int e^{ax^n+b}\,dx = \frac{e^{ax^n+b}}{a\times n\times x^{n-1}} + C$$

Integration of Area

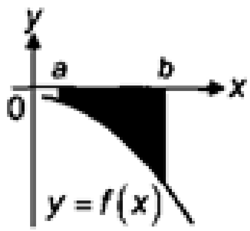
Area between Curve and X-axis

$$\int_a^b f(x)dx$$



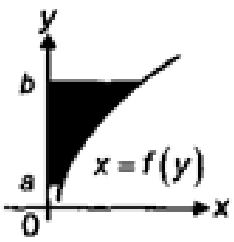
Area between Curve and X-axis

$$-\int_a^b f(x)dx$$



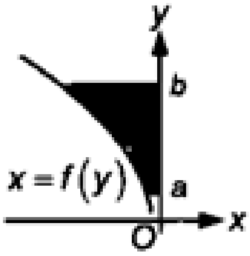
Area between Curve and Y-axis

$$\int_a^b f(y)dy$$



Area between Curve and Y-axis

$$-\int_a^b f(y)dy$$



Kinematics

Velocity is the RATE of CHANGE of Displacement

$$v = \frac{ds}{dt}$$ or

$$v = \int a\,dt = \int \frac{dv}{dt}\,dt$$

where v:velocity, s:displacement, t:time

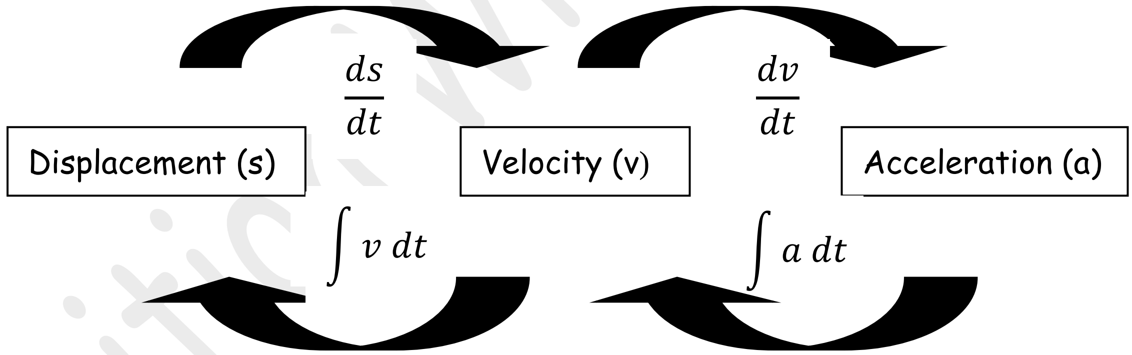
Acceleration is the RATE of CHANGE of Velocity

$$a = \frac{dv}{dt}$$

where a:accleration

Some other methods to find acceleration

$$a = \frac{d^2s}{dt^2} \qquad a = \frac{dv}{ds} \times \frac{ds}{dt}$$



The End