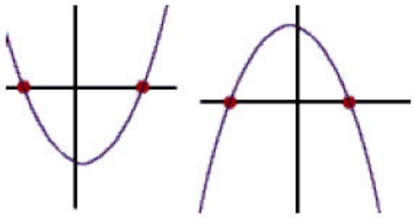
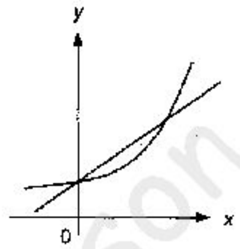
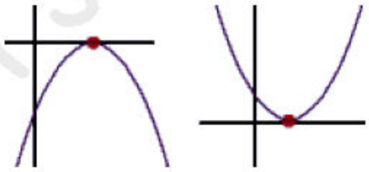
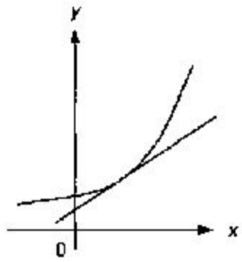
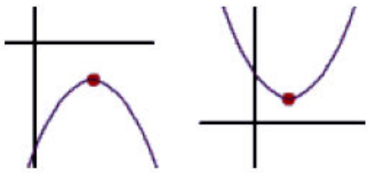
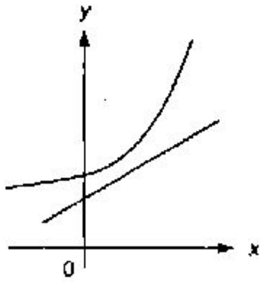
Tuition with Jason

A-Math Formula List - Additional Math (4049)

*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 Curve and line intersect at 2 points	  Intersection at two different points
$b^2 - 4ac = 0$ Real and Equal Roots/Repeat Roots/ Coincident Roots. Curve and line intersect at 1 point.	  c Tangency
$b^2 - 4ac < 0$ Imaginary roots Also known as Complex Roots. Curve and line intersect do not intersect.	  Non-intersection

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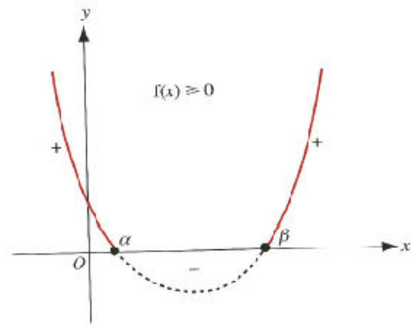
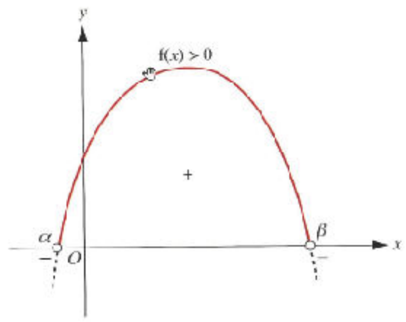
Quadratic Inequalities

When y > 0 (above the x-axis)

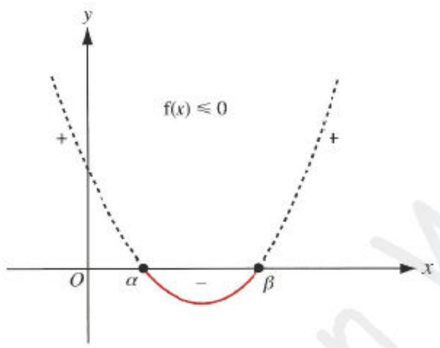


$x \leq \alpha$ or $x \geq \beta$

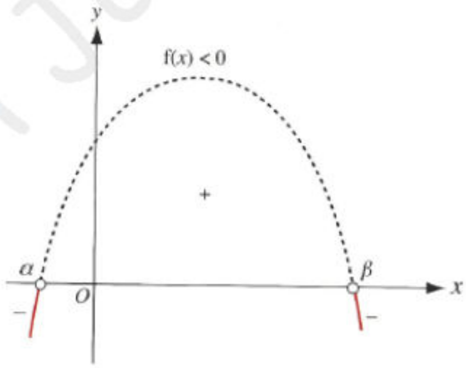


$\alpha < x < \beta$

When y < 0 (below the x-axis)



$\alpha \leq x \leq \beta$



$x < \alpha$ or $x > \beta$

Indices

Same base numbers	Same power	
$x^a \times x^b = x^{a+b}$ **Add** the powers	$a^m \times b^m = (a \times b)^m$ **Multiply** the base numbers	$x^0 = 1$ if $x \neq 0$ Note: $x^a + x^b \neq x^{a+b}$ $x^a - x^b \neq x^{a-b}$
Same base numbers $\dfrac{x^a}{x^b} = x^{a-b}$ **Subtract** the powers	**Same power** $\dfrac{a^m}{b^m} = \left(\dfrac{a}{b}\right)^m$ **Divide** the base numbers	$\left(x^a\right)^b \neq x^a \times x^b$ NOTE: $\left(x^a\right)^b = x^{a \times b}$

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Other Laws of Indices		
$x^{-a} = \frac{1}{x^a}$	$x^{\frac{1}{b}} = \sqrt[b]{x^1}$	$x^{\frac{a}{b}} = \sqrt[b]{x^a}$
$x^{-\frac{1}{b}} = \frac{1}{x^{\frac{1}{b}}} = \frac{1}{\sqrt[b]{x^1}}$	$\frac{1}{x^{-a}} = x^a$	$\left(\frac{x}{y}\right)^{-a} = \left(\frac{y}{x}\right)^a$
$x^{-\frac{a}{b}} = \frac{1}{x^{\frac{a}{b}}} = \frac{1}{\sqrt[b]{x^a}}$	NOTE: You can only use the laws of indices if either the base number or the power is the same.	

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

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

Note: $\sqrt{a+b}\neq\sqrt{a}+\sqrt{b}$ $\quad$ $\sqrt{a-b}\neq\sqrt{a}-\sqrt{b}$

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.

Logarithms	
$\log_a 1 = 0$	$\log_a a = 1$
Since lg = $\log_{10}$, ∴ lg 10 = 1	Since ln = $\log_e$, ∴ $\ln_e e = 1$
$\log_b m^a = a \times \log_b m$	$e^{\ln a} = a$
$\log_b m + \log_b n = \log_b (m \times n)$ Note: $\log_b m + \log_b n \neq \log_b m \times \log_b n$	
$\log_b m - \log_b n = \log_b \left(\frac{m}{n}\right)$ Note: $\log_b m - \log_b n \neq \frac{\log_b m}{\log_b n}$	
Change of Base $\log_v u = \frac{\log_a u}{\log_a v}$ $\quad$ $\log_v u = \frac{\log_u u}{\log_u v} = \frac{1}{\log_u v}$	

Tuition With Jason

If $\log_a b = x, \therefore b = a^x$

If $\log_a b = \log_a x, \therefore b = x$

Binomial Theorem

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

General Term

$$(a+b)^n \rightarrow \binom{n}{r}(a)^{n-r}(b)^r$$

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

Since:

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

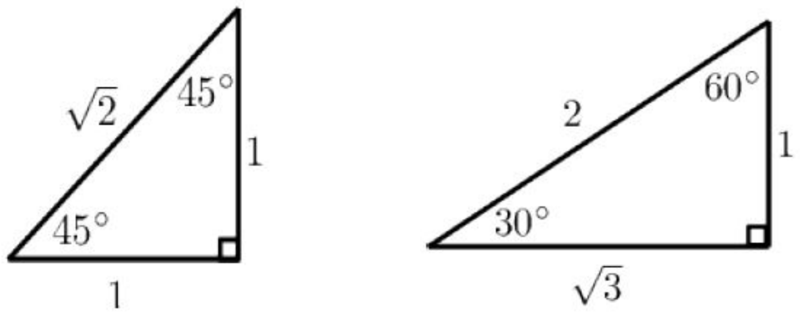
Therefore:

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

Alternate formula if a=1

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

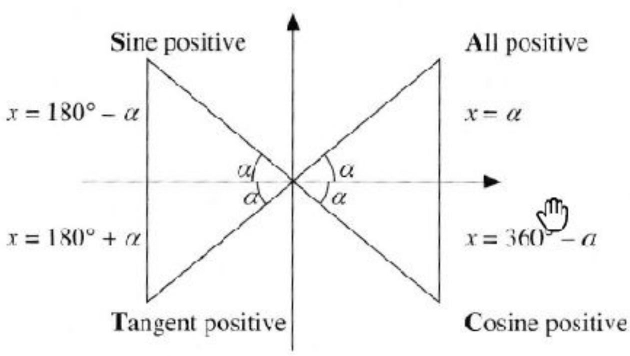
Trigonometry



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

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



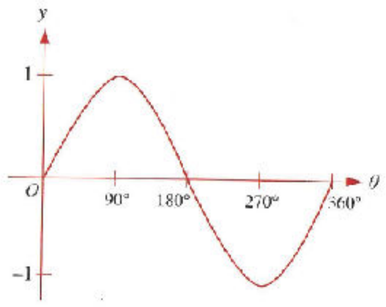
"Add Sugar To Coffee"

or

"All Science/Social Studies Teachers Crazy"

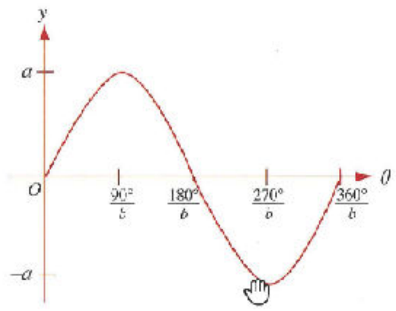
Tuition With Jason

1. (a) $y = \sin\theta$



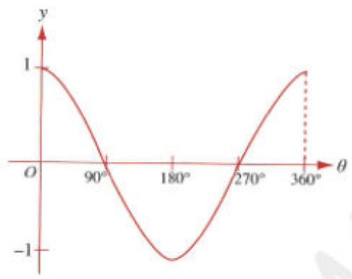
Period = 360° or 2π
Amplitude = 1

(b) $y = a\sin b\theta$



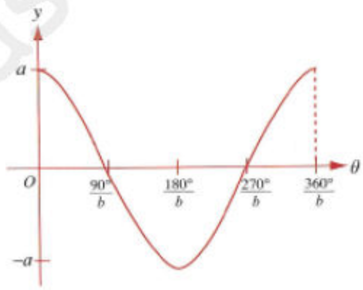
Period = $\frac{360°}{b}$ or $\frac{2\pi}{b}$
Amplitude = a

2. (a) $y = \cos\theta$



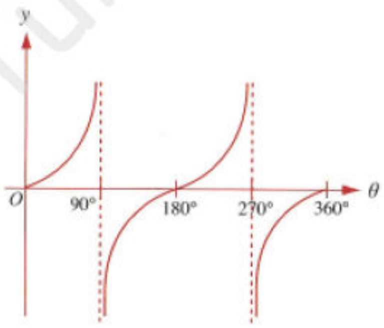
Period = 360° or 2π
Amplitude = 1

(b) $y = a\cos b\theta$



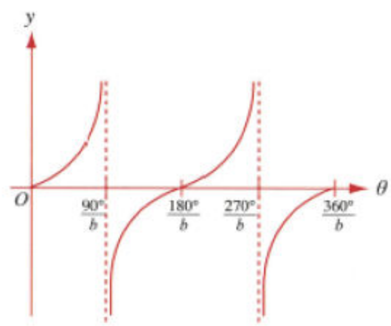
Period = $\frac{360°}{b}$ or $\frac{2\pi}{b}$
Amplitude = a

3. (a) $y = \tan\theta$



Period = 180° or π

(b) $y = a\tan b\theta$



Period = $\frac{180°}{b}$ or $\frac{\pi}{b}$

Tuition With Jason

Cos (-θ) = Cos θ	$\tan\theta = \dfrac{\sin\theta}{\cos\theta}$
Sin (-θ) = - Sin θ	$\sec\theta = \dfrac{1}{\cos\theta}$
Tan (-θ) = - Tan θ	$\operatorname{cosec}\theta = \dfrac{1}{\sin\theta}$
Cos (90° ± θ) = ∓ Sin θ	$\cot\theta = \dfrac{1}{\tan\theta} = \dfrac{\cos\theta}{\sin\theta}$
Sin (90° ± θ) = Cos θ	
Tan (90° ± θ) = ∓ Tan θ	

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

Compound Angle Formula

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

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

$\tan(A \pm B) = \dfrac{\tan A \pm \tan B}{1 \mp \tan A\tan B}$

Tuition With Jason

Double Angle Formula

$\sin 2A = 2\sin A\cos A$

$\cos 2A = 2\cos^2 A - 1$ / $\cos 2A = \cos^2 A - \sin^2 A$ / $\cos 2A = 1 - 2\sin^2 A$

$\tan 2A = \frac{2\tan A}{1-\tan^2 A}$

Half Angle Formula

$$\sin\frac{A}{2} = \pm\sqrt{\frac{1-\cos A}{2}}$$

$$\cos\frac{A}{2} = \pm\sqrt{\frac{1+\cos A}{2}}$$

$$\tan\frac{A}{2} = \sqrt{\frac{1-\cos A}{1+\cos A}} = \frac{1-\cos A}{\sin A}$$

Tuition With Jason

R-Formula

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

Coordinate Geometry

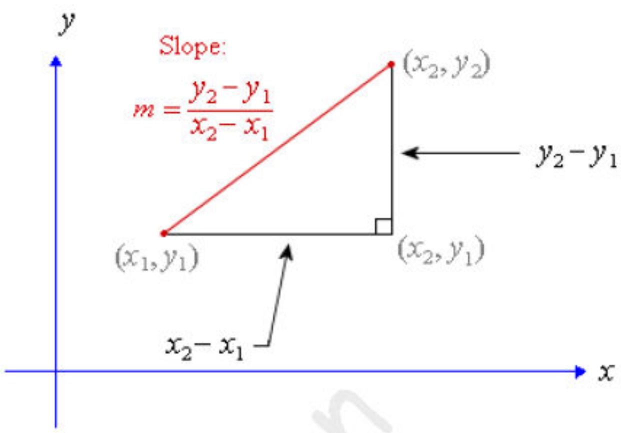
Gradient(m) = $\frac{y_2 - y_1}{x_2 - x_1}$

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

where (x_1, y_1) and (x_2, y_2) are

point on the graph.

OR you may use Y = mX + c

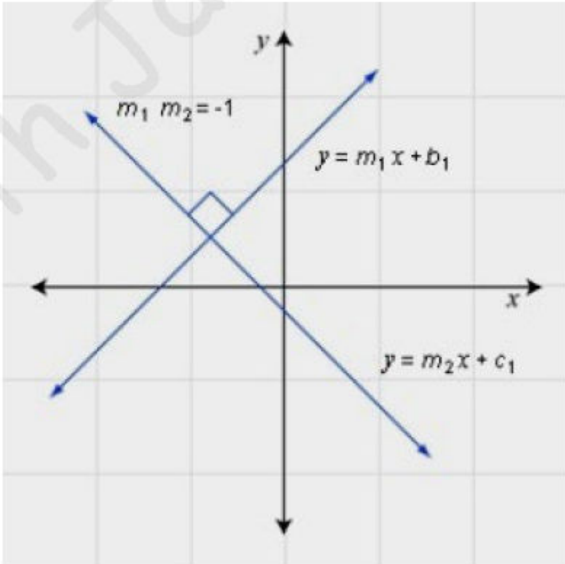


Mid-point of a line

$$(x_m = \frac{x_1 + x_2}{2}, y_m = \frac{y_1 + y_2}{2})$$

Distance between two points

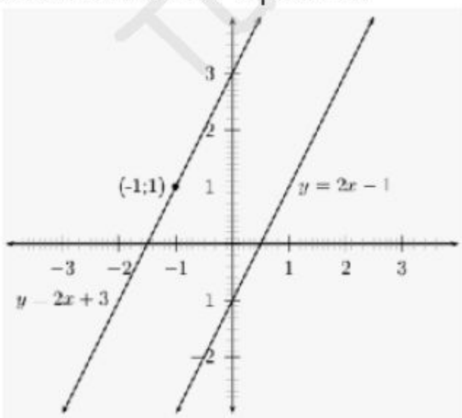
$$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$



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 are parallel



They have the same gradient (m)

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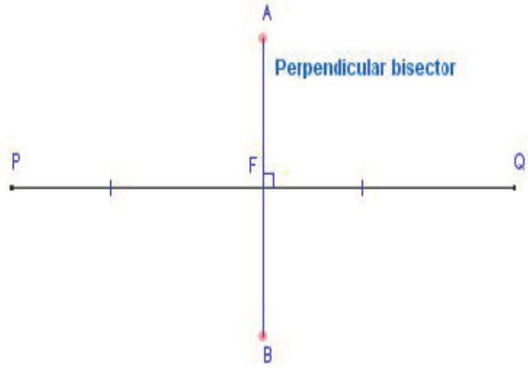
Perpendicular Bisector of line PQ $y = m_2x + c$

1. The perpendicular lines AB intersects PQ at 90°

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

$$or\ m_1 \times m_2 = -1$$



2. The perpendicular line AB cuts the mid-point of the line PQ.

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

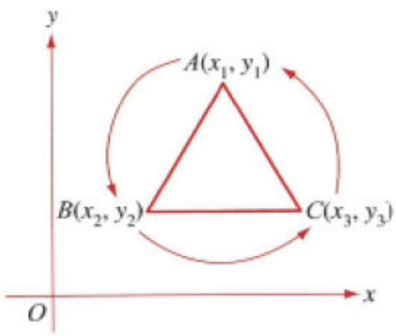
3. To find the y-intercept (c)

Substitute xm → x and ym → y into $y = m_2x + c$

Area of Plane Figure (Polygon Figure)

i. Area of $\triangle ABC = \frac{1}{2}\begin{vmatrix} x_1 & x_2 & x_3 & x_1 \\ y_1 & y_2 & y_3 & y_1 \end{vmatrix}$

$$= \frac{1}{2}(x_1y_2 + x_2y_3 + x_3y_1 - x_1y_3 - x_3y_2 - x_2y_1)$$



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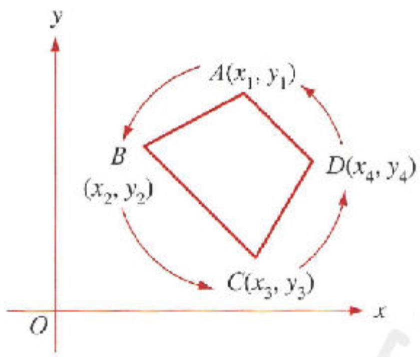
$$\text{Area of } ABCD = \frac{1}{2}\begin{vmatrix} x_1 & x_2 & x_3 & x_4 & x_1 \\ y_1 & y_2 & y_3 & y_4 & y_1 \end{vmatrix}$$

$$= \frac{1}{2}(x_1y_2 + x_2y_3 + x_3y_4 + x_4y_1 - x_1y_4 - x_4y_3 - x_3y_2 - x_2y_1)$$



Note: Remember to repeat the first set of coordinates (x_1 , y_1) in the formula.

It does not matter if you insert the coordinates clockwise or anti-clockwise into the formula. The |modulus| sign will convert any negative value positive while a positive value remains positive.

Circles

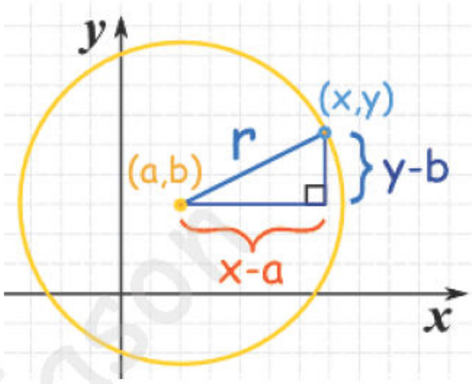
Equation of a Circle

(Standard Form)

$$(x-a)^2+(y-b)^2=r^2$$

$$r=\sqrt{(x-a)^2+(y-b)^2}$$

Where (a,b) are the coordinates of the centre of circle and r is the radius



(General Form)

$$x^2+y^2+2gx+2fy+c=0$$

where $a=-g,\ b=-f$

$$r=\sqrt{g^2+f^2-c}$$

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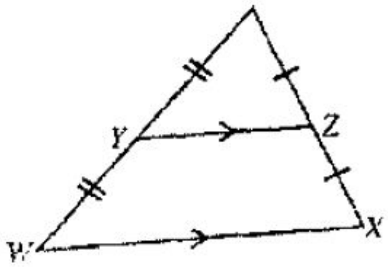
Proofs in Plane Geometry

Midpoint Theorem



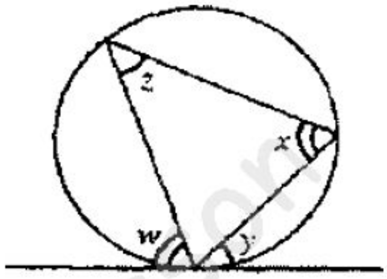
If X and Y are midpoints,

then YZ // WX

YZ = $\frac{1}{2}$ WX

Tangent -Chord Theorem

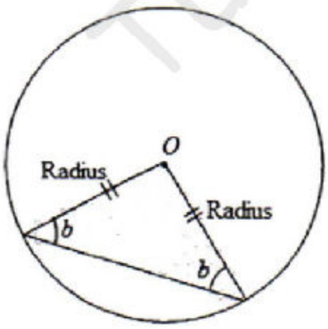
(Alternate Segment Theorem)



Angle W = Angle X

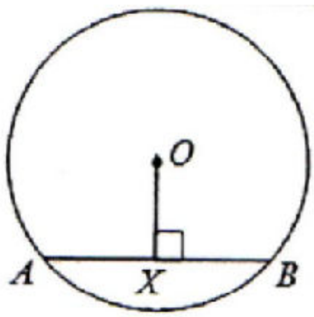
Angle Y = Angle Z

Isosceles Triangle



Perpendicular from Centre Bisects Chord

$\angle OXA = \angle OXB = 90^0$



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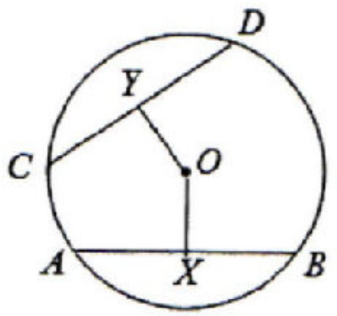
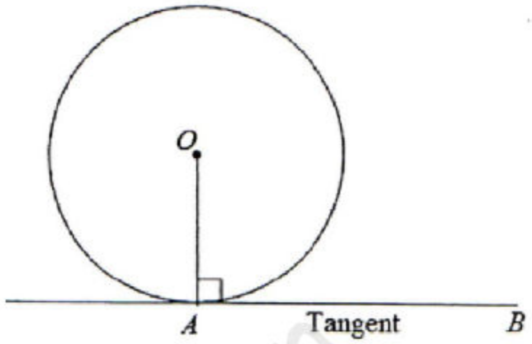
Equal Chord, Equal Distance from Centre



Tangent Perpendicular Radius

$\angle OAB = 90^0$

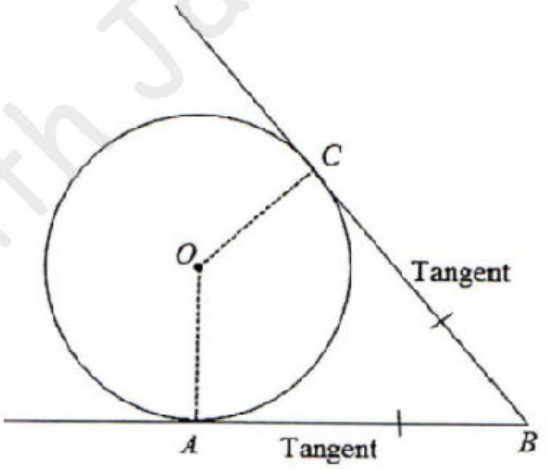


Tangents from External Point

BC=BA

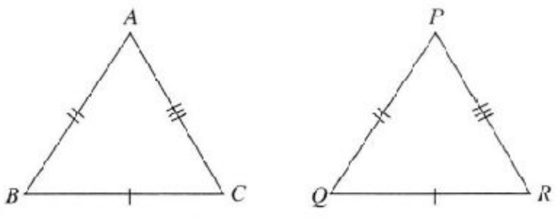
$\angle OCB = \angle OAB = 90^\circ$

OA = OC (radius)

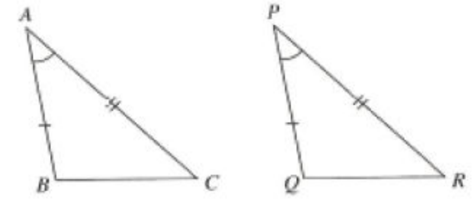


Congruent Triangles

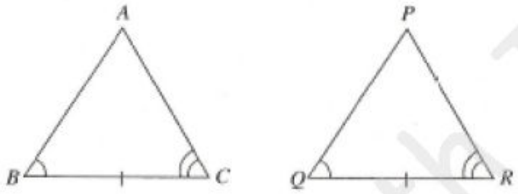
If $AB = PQ$, $BC = QR$ and $CA = RP$, then ΔABC is congruent to ΔPQR (SSS Congruence Test).



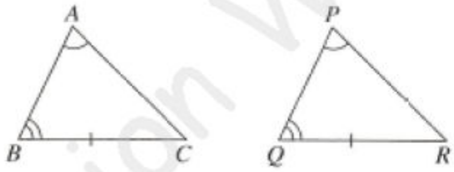
If $AB = PQ$, $AC = PR$ and $B\hat{A}C = Q\hat{P}R$, then ΔABC is congruent to ΔPQR (SAS Congruence Test).



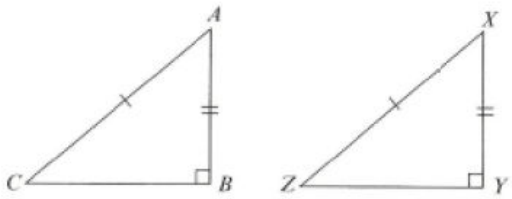
If $A\hat{B}C = P\hat{Q}R$, $A\hat{C}B = P\hat{R}Q$ and $BC = QR$, then ΔABC is congruent to ΔPQR (ASA Congruence Test).



If $B\hat{A}C = Q\hat{P}R$, $A\hat{B}C = P\hat{Q}R$ and $BC = QR$, then ΔABC is congruent to ΔPQR (AAS Congruence Test).

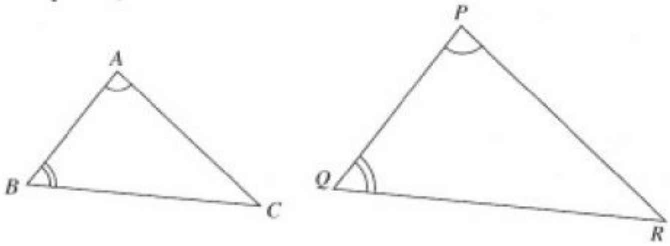


If $AC = XZ$, $AB = XY$ or $BC = YZ$, and $A\hat{B}C = X\hat{Y}Z = 90°$, then ΔABC is congruent to ΔXYZ (RHS Congruence Test).

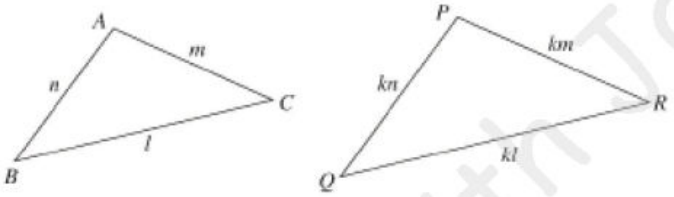


Similar Triangles

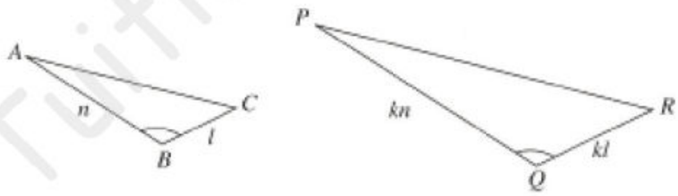
If $B\hat{A}C = Q\hat{P}R$ and $A\hat{B}C = P\hat{Q}R$, then ΔABC is similar to ΔPQR (AA Similarity Test).



If $\frac{PQ}{AB} = \frac{QR}{BC} = \frac{RP}{CA}$, then ΔABC is similar to ΔPQR (SSS Similarity Test).

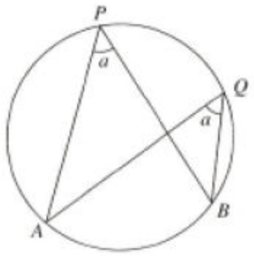


If $\frac{PQ}{AB} = \frac{QR}{BC}$ and $A\hat{B}C = P\hat{Q}R$, then ΔABC is similar to ΔPQR (SAS Similarity Test).

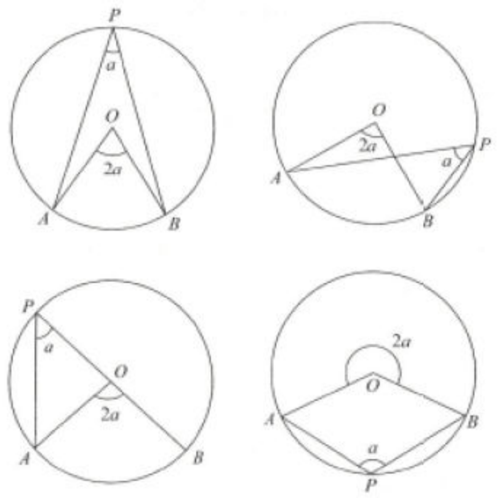


Angle Properties of Circles

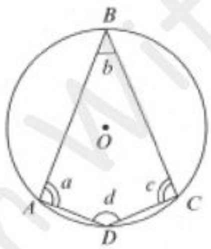
Angles in the same segment are equal, i.e. $\angle APB = \angle AQB$.



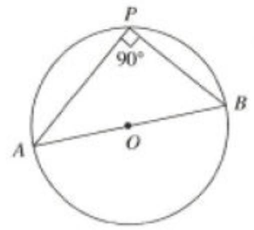
An angle at the centre of a circle is twice that of any angle at the circumference subtended by the same arc, i.e. $\angle AOB = 2 \times \angle APB$.



Angles in opposite segments are supplementary, i.e. $\angle a + \angle c = 180°$; $\angle b + \angle d = 180°$.



An angle in a semicircle is always equal to 90°, i.e. AOB is a diameter $\Leftrightarrow \angle APB = 90°$.



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Differentiation

$\frac{dy}{dx}(ax^n) = anx^{n-1}$ Where' a' and 'n' are constants.	Differentiate Constant $\frac{dy}{dx}(a) = 0$	Sum / Difference of Function $\frac{d}{dx}(u \pm v) = \frac{du}{dx} \pm \frac{dv}{dx}$
Chain Rule $\frac{dy}{dx} = \frac{dy}{du} \times \frac{du}{dx}$		Quotient Rule $\frac{d}{dx}\left(\frac{u}{v}\right) = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$
Product Rule $\frac{d}{dx}(uv) = u\frac{dv}{dx} + v\frac{du}{dx}$		
Differentiation of Trigonometry $\frac{d}{dx}(\sin x) = \cos x$	$\frac{d}{dx}(\tan x) = \sec^2 x$	$\frac{d}{dx}(\cos x) = -\sin x$
Use Chain Rule to differentiate the functions below. $\frac{d}{dx}\left[a\sin\left(bx+c\right)\right] = a \times \cos(bx+c) \times b$ $\frac{d}{dx}\left[a\cos\left(bx+c\right)\right] = a \times -\sin(bx+c) \times b$		

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$\frac{d}{dx}\left[a\tan(bx+c)\right]=a\times\sec^2(bx+c)\times b$	
$\frac{d}{dx}\left[a\sin^n(bx+c)\right]=a\times n\times\sin^{n-1}(bx+c)\times\cos(bx+c)\times b$ $\frac{d}{dx}\left[a\cos^n(bx+c)\right]=a\times n\times\cos^{n-1}(bx+c)\times-\sin(bx+c)\times b$ $\frac{d}{dx}\left[a\tan^n(bx+c)\right]=a\times n\times\tan^{n-1}(bx+c)\times\sec^2(bx+c)\times b$	
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)	$\frac{d}{dx}\left[\ln(ax+b)\right]=\frac{a}{ax+b}$ (where ax +b>0)

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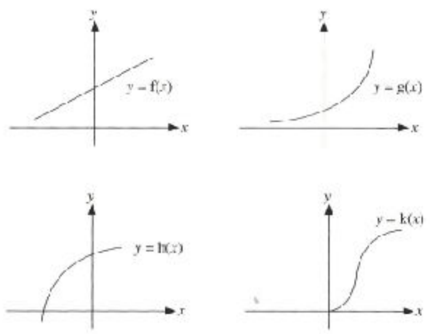
Increasing Function

If y is an increasing function (y increases as x increases), the gradient is positive,

i.e. $\frac{dy}{dx} > 0$.

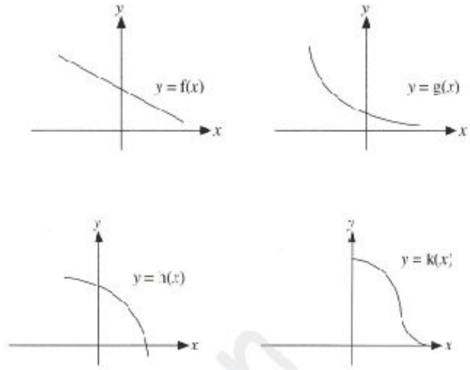
e.g.



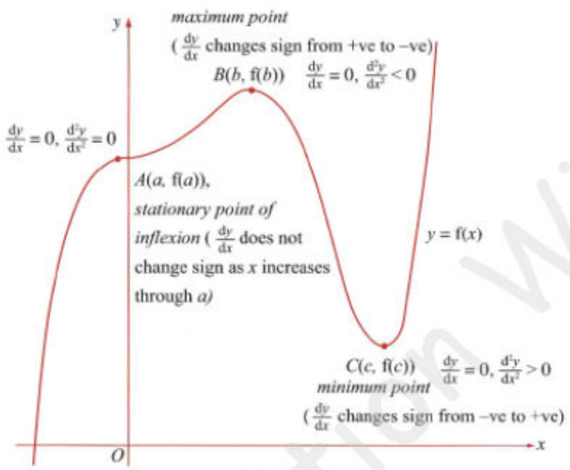
Decreasing Function

If y is a decreasing function (y decreases as x increases), the gradient is negative,

i.e. $\frac{dy}{dx} < 0$.



Turning & Inflexion Points



Note:

When $\frac{d^2y}{dx^2} = 0$ it does not necessarily mean that it is a point of inflexion. There are some graphs that will show $\frac{d^2y}{dx^2} = 0$ even though they are turning points (maximum or minimum point). You will then need to carry out a 1st order derivative test.

Tuition With Jason

1st order derivative test

Maximum point

	x^-	x_0	x^+
$\frac{dy}{dx}$	>0	0	<0
slope	/	–	\
stationary point			

Minimum point

	x^-	x_0	x^+
$\frac{dy}{dx}$	<0	0	>0
slope	\	–	/
stationary point			

Point of inflexion

	x^-	x_0	x^+
$\frac{dy}{dx}$	>0	0	>0
slope	/	–	/
stationary point			

Point of inflexion

	x^-	x_0	x^+
$\frac{dy}{dx}$	<0	0	<0
slope	\	–	\
stationary point			

Integration

$$\int ax^n \, dx = \frac{ax^{n+1}}{n+1} + c$$

where n≠-1

Integrate Constant

$$\int a \, dx = ax + c$$

Product rule n≠1, a≠0; a & b are constants

$$\int (ax+b)^n \, dx = \frac{(ax+b)^{n+1}}{(n+1)(a)} + c$$

Product of constant and a function

$$\int af(x)dx = a\int f(x)dx$$

Sum and Difference of function

$$\int [\alpha f(x) \pm \beta g(x)]dx = \alpha \int f(x)dx \pm \beta \int g(x)dx$$

Integration of Trigonometry

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

Integration of exponential and Ln

$\int \frac{1}{x}\,dx = \ln x + c$ where x>0	$\int \frac{1}{ax+b}\,dx = \frac{\ln(ax+b)}{a} + C$

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

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

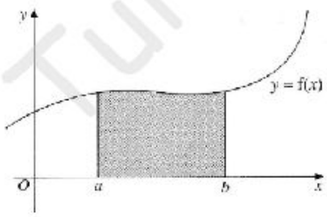
$$\int e^{ax^n+b}\,dx = \frac{e^{ax^n+b}}{a \times n \times x^{n-1}} + C$$

Basic Properties of Definite Integral

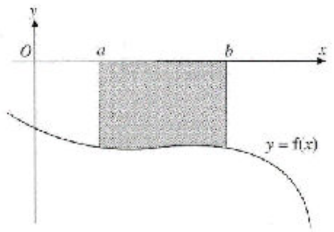
$\int_a^a f(x)\,dx = 0$	$\int_a^b f(x)\,dx = -\int_b^a f(x)\,dx$	$\int_a^b f(x)\,dx = \int_c^b f(x)\,dx + \int_a^c f(x)\,dx$

Integration of Area

For a region above the x-axis:
Area bounded by the curve $y = f(x)$, the lines $x = a$ and $x = b$ and the x axis is $\int_a^b f(x)\,dx$.

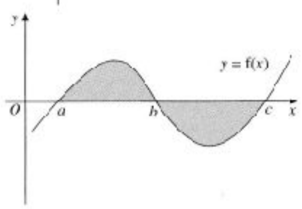


For a region below the x-axis:
Area bounded by the curve $y = f(x)$, the lines $x = a$ and $x = b$ and the x-axis is $\left|\int_a^b f(x)\,dx\right|$.



For an area enclosed above and below the x-axis:
Area bounded by the curve $y = f(x)$ and the x-axis as shown below is

$\int_a^b f(x)\,dx + \left|\int_b^c f(x)\,dx\right|$



Note:

The |modulus sign| convert a negative value to positive, and if the value is positive, it remains positive.

Area cannot have a negative value.

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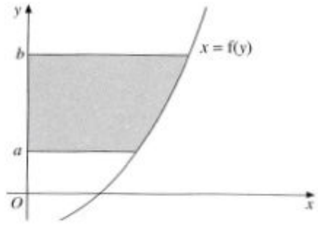
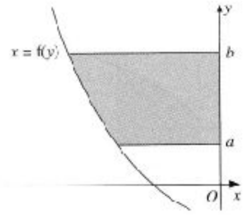
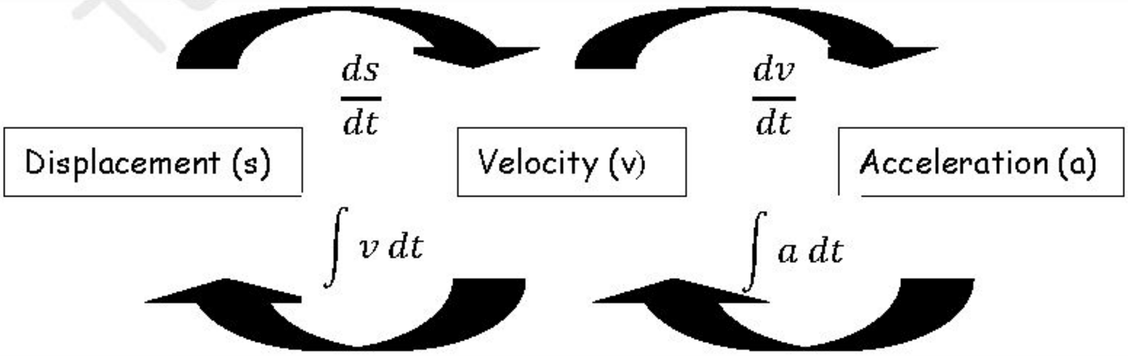
For a region on the right side of the y-axis: Area bounded by the curve $x = f(y)$, the lines $y = a$ and $y = b$ and the y-axis is $\int_a^b f(y)\,dy$. 	**For a region on the left side of the y-axis:** Area bounded by the curve $x = f(y)$, the lines $y = a$ and $y = b$ and the y-axis is $\left\|\int_a^b f(y)\,dy\right\|$. 

Kinematics

Velocity is the RATE of CHANGE of Displacement	Acceleration is the RATE of CHANGE of Velocity
$v = \frac{ds}{dt}$ or $v = \int a\,dt$	$a = \frac{dv}{dt}$
Where v is velocity, s is displacement, t is time & a is accleration.	Alternate methods to find acceleration $a = \frac{d^2 s}{dt^2}$ $a = \frac{dv}{ds} \times \frac{ds}{dt}$



The End

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