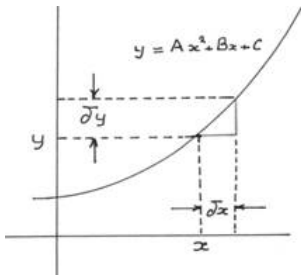


# DIFFERENTIATION

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## Introduction



Let 'f' be a given function, then the derivative of 'f' is denoted by  $f'(x)$  and is defined as,

$$f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$

The process of finding derivative is called [differentiation](#).

The derivative of a [function](#) can be denoted in different ways, they are  $y'$ ,  $y_1$ ,  $dy/dx$  etc.

The derivative of a function at 'c' is denoted as  $f'(c)$  and is defined as

$$f'(c) = \lim_{h \rightarrow 0} \frac{f(c+h) - f(c)}{h}$$

The process of finding the derivative using definition is called the first principle of differentiation

Example: Using 1<sup>st</sup> principle of differentiation, find the derivative of  $(x+2)^2$

Let  $f(x) = (x + 2)^2$ ,  $f(x + h) = (x + h + 2)^2$

$$= \lim_{h \rightarrow 0} \frac{f(x + h) - f(x)}{h}$$

$$= \lim_{h \rightarrow 0} \frac{(x + h + 2)^2 - (x + 2)^2}{h}$$

$$= \lim_{h \rightarrow 0} \frac{x^2 + h^2 + 4 + 2 \times h + 4h + 4x - x^2 - 4x - 4}{h}$$

$$= \lim_{h \rightarrow 0} \frac{h^2 + 2xh + 4h}{h}$$

$$= \lim_{h \rightarrow 0} h + 2x + 4$$

$$= 0 + 2x + 4$$

$$= 2(x + 2)$$

## List of derivatives of certain standard functions

S. No.	f (x)	f' (x)
1	$x^n$	$nx^{n-1}$
2	$\sin x$	$\cos x$
3	$\cos x$	$-\sin x$
4	$\tan x$	$\sec^2 x$
5	$\cot x$	$-\operatorname{cosec}^2 x$
6	$\sec x$	$\sec x \tan x$
7	$\operatorname{cosec} x$	$-\operatorname{cosec} x \cot x$
8	$\log x$	$1/x$
9	a constant	Zero
10	$e^x$	$e^x$
11	$a^x$	$a^x \log a$
12	$\sqrt{x}$	$1 / (2\sqrt{x})$

## Product Rule of Differentiation

If 'u' and 'v' are functions of 'x' then

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

Derivative of product of two functions is "(first function) x (derivative of second) + (second function) x (derivative of first)"

If u, v and w are functions of 'x' then

$$\frac{d(uvw)}{dx} = uv \frac{dw}{dx} + uw \frac{dv}{dx} + vw \frac{du}{dx}$$

## Quotient Rule of Differentiation

If 'u' and 'v' are functions of 'x' and v ≠ 0, then [quotient rule](#) is

$$\begin{aligned} \frac{d}{dx} \left( \frac{u}{v} \right) &= \frac{v \left( \frac{du}{dx} \right) - u \left( \frac{dv}{dx} \right)}{v^2} \\ &= \frac{v u' - u v'}{v^2} \end{aligned}$$

Important Notes:

- (i)  $(u \pm v)' = u' \pm v'$
- (ii) If a function 'f' is differentiable at a point 'c' then it is continuous at that point.
- (iii) Every differentiable function is continuous.

## Chain Rule of Differentiation

[Chain Rule](#) is applicable only for the [composition of functions](#). Let 'y' be a composition of two functions 'f' and 'g'.

$$y = f \circ g = f[g(x)]$$

Take  $y = f(u)$  where  $u = g(x)$  so that we can find

$dy/du$  and  $du/dx$  [Since 'y' is a function of 'u' we get  $dy/du$  and 'u' is a function of 'x' we get  $du/dx$ ]

$$\text{Hence } \frac{dy}{dx} = \frac{dy}{du} \times \frac{du}{dx}$$

If 'y' is the composition of three functions 'f', 'g' and 'u' then

$$\begin{aligned} y &= f \circ g \circ u \\ &= f\{g[u(x)]\} \end{aligned}$$

Take  $v = u(x)$ ,  $t = g(v)$  and  $y = f(t)$

Find  $dv/dx$ ,  $dt/dv$  and  $dy/dt$

$$\frac{dy}{dx} = \frac{dy}{dt} \times \frac{dt}{dv} \times \frac{dv}{dx}$$

Example: Find the derivative of  $\cos(3x + 5)$

Solution: Let  $y = \cos(3x + 5)$

Take  $y = \cos(u)$  where  $u = 3x + 5$

$$\frac{dy}{du} = -\sin(u) \text{ and } \frac{du}{dx} = 3$$

$$\frac{dy}{dx} = \left(\frac{dy}{du}\right) \times \left(\frac{du}{dx}\right) = -3 \sin(u)$$

$$\frac{dy}{dx} = -3 \sin(3x+5) \quad [u = 3x + 5]$$

Now try it yourself! Should you still need any help, [click here](#) to schedule live online session with e Tutor!

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## Reference Links :

- <http://en.wikipedia.org/wiki/Derivative>
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- [http://en.wikipedia.org/wiki/Chain\\_rule](http://en.wikipedia.org/wiki/Chain_rule)
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