

Differentiate the following functions:

$$1. \ f(x) = g(x)^{h(x)}.$$

Solution:

$$\begin{aligned} f(x) &= e^{\ln g(x)^{h(x)}} \\ &= e^{h(x) \ln g(x)} \\ f'(x) &= e^{h(x) \ln g(x)} (h'(x) \ln g(x) + h(x) \frac{g'(x)}{g(x)}) \\ &= g(x)^{h(x)} (h'(x) \ln g(x) + \frac{h(x)g'(x)}{g(x)}) \end{aligned}$$

$$2. \ y = \arcsin(x)$$

Solution:

$$\sin(y) = x$$

diff. w.r.t. x :

$$\begin{aligned} \cos y \frac{dy}{dx} &= 1 \\ \frac{dy}{dx} &= \frac{1}{\cos y} \\ &= \frac{1}{\sqrt{1 - \sin^2 y}} \\ &= \frac{1}{\sqrt{1 - x^2}}. \end{aligned}$$

$$3. \ y = \arccos x.$$

Solution: $\cos y = x$ diff. w.r.t. x :

$$\begin{aligned} -\sin y \frac{dy}{dx} &= 1 \\ \frac{dy}{dx} &= \frac{-1}{\sin y} \\ &= \frac{-1}{\sqrt{1 - \cos^2 y}} \\ &= \frac{-1}{\sqrt{1 - x^2}} \end{aligned}$$

$$4. \ y = \tan x$$

Solution:

$$\begin{aligned} y &= \tan x \\ &= \frac{\sin x}{\cos x} \\ \frac{dy}{dx} &= \frac{\cos x}{\cos x} + \sin x \times \frac{-1}{\cos^2 x} \times -\sin x \\ &= 1 + \tan^2 x \\ &= \sec^2 x. \end{aligned}$$

5. $y = \arctan x = \tan^{-1} x$

Solution:

$$\tan y = x$$

diff w.r.t. x :

$$\begin{aligned}\sec^2 y \frac{dy}{dx} &= 1 \\ \frac{dy}{dx} &= \frac{1}{\sec^2 y} \\ &= \frac{1}{1 + \tan^2 y} \\ &= \frac{1}{1 + x^2}\end{aligned}$$

6. $y = (\tan x)^{-1} = \cot x$

Solution:

$$\begin{aligned}\frac{dy}{dx} &= -(\tan x)^{-2} \sec^2 x \\ &= -\frac{\cos^2 x}{\sin^2 x} \cdot \frac{1}{\cos^2 x} \\ &= \frac{-1}{\sin^2 x} \\ &= -\csc^2 x.\end{aligned}$$

7. $y = \cos(x^2) \sin x.$

Solution:

$$\frac{dy}{dx} = -\sin(x^2)2x \sin x + \cos(x^2) \cos x$$

8. $y = (x+1) \ln(x+1).$

Solution:

$$\begin{aligned}\frac{dy}{dx} &= \ln(x+1) + \frac{x+1}{x+1} \\ &= 1 + \ln(x+1).\end{aligned}$$

9. $f(x) = g(x) \ln(g(x)).$

Solution:

$$\begin{aligned}f'(x) &= g'(x) \ln(g(x)) + \frac{g(x)}{g(x)} g'(x) \\ &= g'(x)(1 + \ln(g(x))).\end{aligned}$$

10. $y = \frac{\sin x}{x}.$

Solution:

$$\frac{dy}{dx} = \frac{\cos x}{x} - \frac{\sin x}{x^2}$$

$$11. \ y = \exp(4x)$$

Solution:

$$\frac{dy}{dx} = 4 \exp(4x)$$

$$12. \ y = \exp(3x + 2)$$

Solution:

$$\frac{dy}{dx} = 3 \exp(3x + 2)$$

$$13. \ y = x^3 + 4x^2 - x + 3$$

Solution:

$$\frac{dy}{dx} = 3x^2 + 8x - 1$$

$$14. \ y = 2x^3 + 6x - 1$$

Solution:

$$\frac{dy}{dx} = 6x^2 + 6 = 6(x + 1)$$