



NCERT Solutions for 11th Class Maths: Chapter 13-Limits and Derivatives



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NCERT Solutions for 11th Class Maths: Chapter 13-Limits and Derivatives

Class 11: Maths Chapter 13 solutions. Complete Class 11 Maths Chapter 13 Notes.

NCERT Solutions for 11th Class Maths: Chapter 13-Limits and Derivatives

NCERT 11th Maths Chapter 13, class 11 Maths Chapter 13 solutions

Exercise.13.1

Question-1

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Evaluate the Given limit: $\lim_{x \rightarrow 3} x + 3$

Ans.

Evaluate the Given limit: $\lim_{x \rightarrow \pi} \left(x - \frac{22}{7} \right)$

Question-2

Evaluate the Given limit: $\lim_{x \rightarrow \pi} \left(x - \frac{22}{7} \right)$

Ans.

$$\lim_{x \rightarrow \pi} \left(x - \frac{22}{7} \right) = \left(\pi - \frac{22}{7} \right)$$

Question-3

Evaluate the Given limit: $\lim_{r \rightarrow 1} \pi r^2$

Ans.

$$\lim_{r \rightarrow 1} \pi r^2 = \pi (1)^2 = \pi$$

Question-4

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Evaluate the Given limit: $\lim_{x \rightarrow 4} \frac{4x+3}{x-2}$

Ans.

$$\lim_{x \rightarrow 4} \frac{4x+3}{x-2} = \frac{4(4)+3}{4-2} = \frac{16+3}{2} = \frac{19}{2}$$

Question-5

Evaluate the Given limit: $\lim_{x \rightarrow -1} \frac{x^{10} + x^5 + 1}{x-1}$

Ans.

$$\lim_{x \rightarrow -1} \frac{x^{10} + x^5 + 1}{x-1} = \frac{(-1)^{10} + (-1)^5 + 1}{-1-1} = \frac{1-1+1}{-2} = -\frac{1}{2}$$

Question-6

Evaluate the Given limit: $\lim_{x \rightarrow 0} \frac{(x+1)^5 - 1}{x}$

Ans.

$$\lim_{x \rightarrow 0} \frac{(x+1)^5 - 1}{x}$$

Put $x + 1 = y$ so that $y \rightarrow 1$ as $x \rightarrow 0$.

$$\text{Accordingly, } \lim_{x \rightarrow 0} \frac{(x+1)^5 - 1}{x} = \lim_{y \rightarrow 1} \frac{y^5 - 1}{y - 1}$$

$$= \lim_{y \rightarrow 1} \frac{y^5 - 1^5}{y - 1}$$

$$= 5 \cdot 1^{5-1}$$

$$= 5$$

$$\left[\lim_{x \rightarrow a} \frac{x^n - a^n}{x - a} = na^{n-1} \right]$$

$$\therefore \lim_{x \rightarrow 0} \frac{(x+1)^5 - 1}{x} = 5$$

Question-7

Evaluate the Given limit: $\lim_{x \rightarrow 2} \frac{3x^2 - x - 10}{x^2 - 4}$

Ans.

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At $x = 2$, the value of the given rational function takes the form $\frac{0}{0}$.

$$\begin{aligned}\therefore \lim_{x \rightarrow 2} \frac{3x^2 - x - 10}{x^2 - 4} &= \lim_{x \rightarrow 2} \frac{(x-2)(3x+5)}{(x-2)(x+2)} \\ &= \lim_{x \rightarrow 2} \frac{3x+5}{x+2} \\ &= \frac{3(2)+5}{2+2} \\ &= \frac{11}{4}\end{aligned}$$

Question-8

Evaluate the Given limit: $\lim_{x \rightarrow 3} \frac{x^4 - 81}{2x^2 - 5x - 3}$

Ans.

At $x = 3$, the value of the given rational function takes the form $\frac{0}{0}$.

$$\begin{aligned}\therefore \lim_{x \rightarrow 3} \frac{x^4 - 81}{2x^2 - 5x - 3} &= \lim_{x \rightarrow 3} \frac{(x-3)(x+3)(x^2+9)}{(x-3)(2x+1)} \\ &= \lim_{x \rightarrow 3} \frac{(x+3)(x^2+9)}{2x+1} \\ &= \frac{(3+3)(3^2+9)}{2(3)+1} \\ &= \frac{6 \times 18}{7} \\ &= \frac{108}{7}\end{aligned}$$

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Question-9

Evaluate the Given limit: $\lim_{x \rightarrow 0} \frac{ax+b}{cx+1}$

Ans.

$$\lim_{x \rightarrow 0} \frac{ax+b}{cx+1} = \frac{a(0)+b}{c(0)+1} = b$$

Question-10

Evaluate the Given limit: $\lim_{z \rightarrow 1} \frac{z^{\frac{1}{3}}-1}{z^{\frac{1}{6}}-1}$

Ans.

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$$\lim_{z \rightarrow 1} \frac{z^{\frac{1}{3}} - 1}{z^{\frac{1}{6}} - 1}$$

At $z = 1$, the value of the given function takes the form $\frac{0}{0}$.

Put $z^{\frac{1}{6}} = x$ so that $z \rightarrow 1$ as $x \rightarrow 1$.

$$\begin{aligned} \text{Accordingly, } \lim_{z \rightarrow 1} \frac{z^{\frac{1}{3}} - 1}{z^{\frac{1}{6}} - 1} &= \lim_{x \rightarrow 1} \frac{x^2 - 1}{x - 1} \\ &= \lim_{x \rightarrow 1} \frac{x^2 - 1^2}{x - 1} \\ &= 2 \cdot 1^{2-1} \\ &= 2 \end{aligned}$$

$$\left[\lim_{x \rightarrow a} \frac{x^n - a^n}{x - a} = na^{n-1} \right]$$

$$\therefore \lim_{z \rightarrow 1} \frac{z^{\frac{1}{3}} - 1}{z^{\frac{1}{6}} - 1} = 2$$

Question-11

Evaluate the Given limit: $\lim_{x \rightarrow 1} \frac{ax^2 + bx + c}{cx^2 + bx + a}, a + b + c \neq 0$

Ans.

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$$\begin{aligned}\lim_{x \rightarrow 1} \frac{ax^2 + bx + c}{cx^2 + bx + a} &= \frac{a(1)^2 + b(1) + c}{c(1)^2 + b(1) + a} \\ &= \frac{a + b + c}{a + b + c} \\ &= 1 \quad [a + b + c \neq 0]\end{aligned}$$

Question-12

Evaluate the Given limit: $\lim_{x \rightarrow -2} \frac{\frac{1}{x} + \frac{1}{2}}{x + 2}$

Ans.

$$\lim_{x \rightarrow -2} \frac{\frac{1}{x} + \frac{1}{2}}{x + 2}$$

At $x = -2$, the value of the given function takes the form $\frac{0}{0}$.

$$\begin{aligned}\text{Now, } \lim_{x \rightarrow -2} \frac{\frac{1}{x} + \frac{1}{2}}{x + 2} &= \lim_{x \rightarrow -2} \frac{\left(\frac{2+x}{2x}\right)}{x + 2} \\ &= \lim_{x \rightarrow -2} \frac{1}{2x} \\ &= \frac{1}{2(-2)} = -\frac{1}{4}\end{aligned}$$

Question-13

Evaluate the Given limit: $\lim_{x \rightarrow 0} \frac{\sin ax}{bx}$

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Ans.

$$\lim_{x \rightarrow 0} \frac{\sin ax}{bx}$$

At $x = 0$, the value of the given function takes the form $\frac{0}{0}$.

$$\begin{aligned}\text{Now, } \lim_{x \rightarrow 0} \frac{\sin ax}{bx} &= \lim_{x \rightarrow 0} \frac{\sin ax}{ax} \times \frac{ax}{bx} \\ &= \lim_{x \rightarrow 0} \left(\frac{\sin ax}{ax} \right) \times \left(\frac{a}{b} \right) \\ &= \frac{a}{b} \lim_{ax \rightarrow 0} \left(\frac{\sin ax}{ax} \right) && [x \rightarrow 0 \Rightarrow ax \rightarrow 0] \\ &= \frac{a}{b} \times 1 && \left[\lim_{y \rightarrow 0} \frac{\sin y}{y} = 1 \right] \\ &= \frac{a}{b}\end{aligned}$$

Question-14

Evaluate the Given limit: $\lim_{x \rightarrow 0} \frac{\sin ax}{\sin bx}$, $a, b \neq 0$

Ans.

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$$\lim_{x \rightarrow 0} \frac{\sin ax}{\sin bx}, a, b \neq 0$$

At $x = 0$, the value of the given function takes the form $\frac{0}{0}$.

$$\begin{aligned} \text{Now, } \lim_{x \rightarrow 0} \frac{\sin ax}{\sin bx} &= \lim_{x \rightarrow 0} \frac{\left(\frac{\sin ax}{ax} \right) \times ax}{\left(\frac{\sin bx}{bx} \right) \times bx} \\ &= \left(\frac{a}{b} \right) \times \frac{\lim_{ax \rightarrow 0} \left(\frac{\sin ax}{ax} \right)}{\lim_{bx \rightarrow 0} \left(\frac{\sin bx}{bx} \right)} \quad \left[\begin{array}{l} x \rightarrow 0 \Rightarrow ax \rightarrow 0 \\ \text{and } x \rightarrow 0 \Rightarrow bx \rightarrow 0 \end{array} \right] \\ &= \left(\frac{a}{b} \right) \times \frac{1}{1} \quad \left[\lim_{y \rightarrow 0} \frac{\sin y}{y} = 1 \right] \\ &= \frac{a}{b} \end{aligned}$$

Question-15

Evaluate the Given limit: $\lim_{x \rightarrow \pi} \frac{\sin(\pi - x)}{\pi(\pi - x)}$

Ans.

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$$\lim_{x \rightarrow \pi} \frac{\sin(\pi - x)}{\pi(\pi - x)}$$

It is seen that $x \rightarrow \pi \Rightarrow (\pi - x) \rightarrow 0$

$$\begin{aligned}\therefore \lim_{x \rightarrow \pi} \frac{\sin(\pi - x)}{\pi(\pi - x)} &= \frac{1}{\pi} \lim_{(\pi - x) \rightarrow 0} \frac{\sin(\pi - x)}{(\pi - x)} \\ &= \frac{1}{\pi} \times 1 \quad \left[\lim_{y \rightarrow 0} \frac{\sin y}{y} = 1 \right] \\ &= \frac{1}{\pi}\end{aligned}$$

Question-16

Evaluate the given limit: $\lim_{x \rightarrow 0} \frac{\cos x}{\pi - x}$

Ans.

$$\lim_{x \rightarrow 0} \frac{\cos x}{\pi - x} = \frac{\cos 0}{\pi - 0} = \frac{1}{\pi}$$

Question-17

Evaluate the Given limit: $\lim_{x \rightarrow 0} \frac{\cos 2x - 1}{\cos x - 1}$

Ans.

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$$\lim_{x \rightarrow 0} \frac{\cos 2x - 1}{\cos x - 1}$$

At $x = 0$, the value of the given function takes the form $\frac{0}{0}$.

Now,

$$\begin{aligned} \lim_{x \rightarrow 0} \frac{\cos 2x - 1}{\cos x - 1} &= \lim_{x \rightarrow 0} \frac{1 - 2\sin^2 x - 1}{1 - 2\sin^2 \frac{x}{2} - 1} \quad \left[\cos x = 1 - 2\sin^2 \frac{x}{2} \right] \\ &= \lim_{x \rightarrow 0} \frac{\sin^2 x}{\sin^2 \frac{x}{2}} = \lim_{x \rightarrow 0} \frac{\left(\frac{\sin^2 x}{x^2} \right) \times x^2}{\left(\frac{\sin^2 \frac{x}{2}}{\left(\frac{x}{2} \right)^2} \right) \times \frac{x^2}{4}} \\ &= 4 \frac{\lim_{x \rightarrow 0} \left(\frac{\sin^2 x}{x^2} \right)}{\lim_{x \rightarrow 0} \left(\frac{\sin^2 \frac{x}{2}}{\left(\frac{x}{2} \right)^2} \right)} \\ &= 4 \frac{\left(\lim_{x \rightarrow 0} \frac{\sin x}{x} \right)^2}{\left(\lim_{\frac{x}{2} \rightarrow 0} \frac{\sin \frac{x}{2}}{\frac{x}{2}} \right)^2} \quad \left[x \rightarrow 0 \Rightarrow \frac{x}{2} \rightarrow 0 \right] \\ &= 4 \frac{1^2}{1^2} \quad \left[\lim_{y \rightarrow 0} \frac{\sin y}{y} = 1 \right] \\ &= 4 \end{aligned}$$

Question-18

Evaluate the Given limit: $\lim_{x \rightarrow 0} \frac{ax + x \cos x}{b \sin x}$

Ans.

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$$\lim_{x \rightarrow 0} \frac{ax + x \cos x}{b \sin x}$$

At $x = 0$, the value of the given function takes the form $\frac{0}{0}$.

Now,

$$\begin{aligned}\lim_{x \rightarrow 0} \frac{ax + x \cos x}{b \sin x} &= \frac{1}{b} \lim_{x \rightarrow 0} \frac{x(a + \cos x)}{\sin x} \\&= \frac{1}{b} \lim_{x \rightarrow 0} \left(\frac{x}{\sin x} \right) \times \lim_{x \rightarrow 0} (a + \cos x) \\&= \frac{1}{b} \times \frac{1}{\left(\lim_{x \rightarrow 0} \frac{\sin x}{x} \right)} \times \lim_{x \rightarrow 0} (a + \cos x) \\&= \frac{1}{b} \times (a + \cos 0) \quad \left[\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1 \right] \\&= \frac{a+1}{b}\end{aligned}$$

Question-19

Evaluate the Given limit: $\lim_{x \rightarrow 0} x \sec x$

Ans.

$$\lim_{x \rightarrow 0} x \sec x = \lim_{x \rightarrow 0} \frac{x}{\cos x} = \frac{0}{\cos 0} = \frac{0}{1} = 0$$

Question-20

Evaluate the Given limit: $\lim_{x \rightarrow 0} \frac{\sin ax + bx}{ax + \sin bx}$ $a, b, a+b \neq 0$

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Ans.

At $x = 0$, the value of the given function takes the form $\frac{0}{0}$.

Now,

$$\begin{aligned} & \lim_{x \rightarrow 0} \frac{\sin ax + bx}{ax + \sin bx} \\ &= \lim_{x \rightarrow 0} \frac{\left(\frac{\sin ax}{ax} \right) ax + bx}{ax + bx \left(\frac{\sin bx}{bx} \right)} \\ &= \frac{\left(\lim_{ax \rightarrow 0} \frac{\sin ax}{ax} \right) \times \lim_{x \rightarrow 0} (ax) + \lim_{x \rightarrow 0} bx}{\lim_{x \rightarrow 0} ax + \lim_{x \rightarrow 0} bx \left(\lim_{bx \rightarrow 0} \frac{\sin bx}{bx} \right)} \quad [\text{As } x \rightarrow 0 \Rightarrow ax \rightarrow 0 \text{ and } bx \rightarrow 0] \\ &= \frac{\lim_{x \rightarrow 0} (ax) + \lim_{x \rightarrow 0} bx}{\lim_{x \rightarrow 0} ax + \lim_{x \rightarrow 0} bx} \quad \left[\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1 \right] \\ &= \frac{\lim_{x \rightarrow 0} (ax + bx)}{\lim_{x \rightarrow 0} (ax + bx)} \\ &= \lim_{x \rightarrow 0} (1) \\ &= 1 \end{aligned}$$

Question-21

Evaluate the Given limit: $\lim_{x \rightarrow 0} (\operatorname{cosec} x - \cot x)$

Ans.

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At $x = 0$, the value of the given function takes the form $\infty - \infty$.

Now,

$$\begin{aligned} & \lim_{x \rightarrow 0} (\operatorname{cosec} x - \cot x) \\ &= \lim_{x \rightarrow 0} \left(\frac{1}{\sin x} - \frac{\cos x}{\sin x} \right) \\ &= \lim_{x \rightarrow 0} \left(\frac{1 - \cos x}{\sin x} \right) \\ &= \lim_{x \rightarrow 0} \frac{\left(\frac{1 - \cos x}{x} \right)}{\left(\frac{\sin x}{x} \right)} \\ &= \frac{\lim_{x \rightarrow 0} \frac{1 - \cos x}{x}}{\lim_{x \rightarrow 0} \frac{\sin x}{x}} \\ &= \frac{0}{1} \quad \left[\lim_{x \rightarrow 0} \frac{1 - \cos x}{x} = 0 \text{ and } \lim_{x \rightarrow 0} \frac{\sin x}{x} = 1 \right] \\ &= 0 \end{aligned}$$

Question-22

$$\lim_{x \rightarrow \frac{\pi}{2}} \frac{\tan 2x}{x - \frac{\pi}{2}}$$

Ans.

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$$\lim_{x \rightarrow \frac{\pi}{2}} \frac{\tan 2x}{x - \frac{\pi}{2}}$$

At $x = \frac{\pi}{2}$, the value of the given function takes the form $\frac{0}{0}$.

Now, put $x - \frac{\pi}{2} = y$ so that $x \rightarrow \frac{\pi}{2}$, $y \rightarrow 0$.

$$\begin{aligned} \therefore \lim_{x \rightarrow \frac{\pi}{2}} \frac{\tan 2x}{x - \frac{\pi}{2}} &= \lim_{y \rightarrow 0} \frac{\tan 2\left(y + \frac{\pi}{2}\right)}{y} \\ &= \lim_{y \rightarrow 0} \frac{\tan(\pi + 2y)}{y} \\ &= \lim_{y \rightarrow 0} \frac{\tan 2y}{y} \quad [\tan(\pi + 2y) = \tan 2y] \\ &= \lim_{y \rightarrow 0} \frac{\sin 2y}{y \cos 2y} \\ &= \lim_{y \rightarrow 0} \left(\frac{\sin 2y}{2y} \times \frac{2}{\cos 2y} \right) \\ &= \left(\lim_{2y \rightarrow 0} \frac{\sin 2y}{2y} \right) \times \lim_{y \rightarrow 0} \left(\frac{2}{\cos 2y} \right) \quad [y \rightarrow 0 \Rightarrow 2y \rightarrow 0] \\ &= 1 \times \frac{2}{\cos 0} \quad \left[\lim_{x \rightarrow 0} \frac{\sin x}{x} = 1 \right] \\ &= 1 \times \frac{2}{1} \\ &= 2 \end{aligned}$$

Question-23

Find $\lim_{x \rightarrow 0} f(x)$ and $\lim_{x \rightarrow 1} f(x)$, where $f(x) = \begin{cases} 2x + 3, & x \leq 0 \\ 3(x + 1), & x > 0 \end{cases}$

Ans.

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The given function is

$$f(x) = \begin{cases} 2x+3, & x \leq 0 \\ 3(x+1), & x > 0 \end{cases}$$

$$\lim_{x \rightarrow 0^-} f(x) = \lim_{x \rightarrow 0} [2x+3] = 2(0)+3 = 3$$

$$\lim_{x \rightarrow 0^+} f(x) = \lim_{x \rightarrow 0} 3(x+1) = 3(0+1) = 3$$

$$\therefore \lim_{x \rightarrow 0^-} f(x) = \lim_{x \rightarrow 0^+} f(x) = \lim_{x \rightarrow 0} f(x) = 3$$

$$\lim_{x \rightarrow 1^-} f(x) = \lim_{x \rightarrow 1} 3(x+1) = 3(1+1) = 6$$

$$\lim_{x \rightarrow 1^+} f(x) = \lim_{x \rightarrow 1} 3(x+1) = 3(1+1) = 6$$

$$\therefore \lim_{x \rightarrow 1^-} f(x) = \lim_{x \rightarrow 1^+} f(x) = \lim_{x \rightarrow 1} f(x) = 6$$

Question-24

Find $\lim_{x \rightarrow 1} f(x)$, where $f(x) = \begin{cases} x^2 - 1, & x \leq 1 \\ -x^2 - 1, & x > 1 \end{cases}$

Ans.

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The given function is

$$f(x) = \begin{cases} x^2 - 1, & x \leq 1 \\ -x^2 - 1, & x > 1 \end{cases}$$

$$\lim_{x \rightarrow 1^-} f(x) = \lim_{x \rightarrow 1^-} [x^2 - 1] = 1^2 - 1 = 1 - 1 = 0$$

$$\lim_{x \rightarrow 1^+} f(x) = \lim_{x \rightarrow 1^+} [-x^2 - 1] = -1^2 - 1 = -1 - 1 = -2$$

It is observed that $\lim_{x \rightarrow 1^-} f(x) \neq \lim_{x \rightarrow 1^+} f(x)$.

Hence, $\lim_{x \rightarrow 1} f(x)$ does not exist.

Question-25

Evaluate $\lim_{x \rightarrow 0} f(x)$, where $f(x) = \begin{cases} \frac{|x|}{x}, & x \neq 0 \\ 0, & x = 0 \end{cases}$

Ans.

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$$f(x) = \begin{cases} \frac{|x|}{x}, & x \neq 0 \\ 0, & x = 0 \end{cases}$$

$$\begin{aligned} \lim_{x \rightarrow 0^-} f(x) &= \lim_{x \rightarrow 0^-} \left[\frac{|x|}{x} \right] \\ &= \lim_{x \rightarrow 0^-} \left(\frac{-x}{x} \right) \quad \left[\text{When } x \text{ is negative, } |x| = -x \right] \\ &= \lim_{x \rightarrow 0^-} (-1) \\ &= -1 \end{aligned}$$

$$\begin{aligned} \lim_{x \rightarrow 0^+} f(x) &= \lim_{x \rightarrow 0^+} \left[\frac{|x|}{x} \right] \\ &= \lim_{x \rightarrow 0^+} \left[\frac{x}{x} \right] \quad \left[\text{When } x \text{ is positive, } |x| = x \right] \\ &= \lim_{x \rightarrow 0^+} (1) \\ &= 1 \end{aligned}$$

It is observed that $\lim_{x \rightarrow 0^-} f(x) \neq \lim_{x \rightarrow 0^+} f(x)$.

Hence, $\lim_{x \rightarrow 0} f(x)$ does not exist.

Question-26

Find $\lim_{x \rightarrow 0} f(x)$, where $f(x) = \begin{cases} \frac{x}{|x|}, & x \neq 0 \\ 0, & x = 0 \end{cases}$

Ans.

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The given function is

$$f(x) = \begin{cases} \frac{x}{|x|}, & x \neq 0 \\ 0, & x = 0 \end{cases}$$

$$\begin{aligned} \lim_{x \rightarrow 0^-} f(x) &= \lim_{x \rightarrow 0^-} \left[\frac{x}{|x|} \right] \\ &= \lim_{x \rightarrow 0^-} \left[\frac{x}{-x} \right] \quad \left[\text{When } x < 0, |x| = -x \right] \\ &= \lim_{x \rightarrow 0^-} (-1) \\ &= -1 \end{aligned}$$

$$\begin{aligned} \lim_{x \rightarrow 0^+} f(x) &= \lim_{x \rightarrow 0^+} \left[\frac{x}{|x|} \right] \\ &= \lim_{x \rightarrow 0^+} \left[\frac{x}{x} \right] \quad \left[\text{When } x > 0, |x| = x \right] \\ &= \lim_{x \rightarrow 0^+} (1) \\ &= 1 \end{aligned}$$

It is observed that $\lim_{x \rightarrow 0^-} f(x) \neq \lim_{x \rightarrow 0^+} f(x)$.

Hence, $\lim_{x \rightarrow 0} f(x)$ does not exist.

Question-27

Find $\lim_{x \rightarrow 5} f(x)$, where $f(x) = |x| - 5$

Ans.

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The given function is $f(x) = |x| - 5$.

$$\begin{aligned}\lim_{x \rightarrow 5^-} f(x) &= \lim_{x \rightarrow 5^-} [|x| - 5] \\ &= \lim_{x \rightarrow 5} (x - 5) \quad \left[\text{When } x > 0, |x| = x \right] \\ &= 5 - 5 \\ &= 0\end{aligned}$$

$$\begin{aligned}\lim_{x \rightarrow 5^+} f(x) &= \lim_{x \rightarrow 5^+} (|x| - 5) \\ &= \lim_{x \rightarrow 5} (x - 5) \quad \left[\text{When } x > 0, |x| = x \right] \\ &= 5 - 5 \\ &= 0\end{aligned}$$

$$\therefore \lim_{x \rightarrow 5^-} f(x) = \lim_{x \rightarrow 5^+} f(x) = 0$$

$$\text{Hence, } \lim_{x \rightarrow 5} f(x) = 0$$

Question-28

$$\text{Suppose } f(x) = \begin{cases} a + bx, & x < 1 \\ 4, & x = 1 \\ b - ax, & x > 1 \end{cases} \text{ and if } \lim_{x \rightarrow 1} f(x) = f(1) \text{ what are possible values of } a \text{ and } b?$$

Ans.

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The given function is

$$f(x) = \begin{cases} a + bx, & x < 1 \\ 4, & x = 1 \\ b - ax & x > 1 \end{cases}$$

$$\lim_{x \rightarrow 1^-} f(x) = \lim_{x \rightarrow 1^-} (a + bx) = a + b$$

$$\lim_{x \rightarrow 1^+} f(x) = \lim_{x \rightarrow 1^+} (b - ax) = b - a$$

$$f(1) = 4$$

It is given that $\lim_{x \rightarrow 1} f(x) = f(1)$.

$$\therefore \lim_{x \rightarrow 1^-} f(x) = \lim_{x \rightarrow 1^+} f(x) = \lim_{x \rightarrow 1} f(x) = f(1)$$

$$\Rightarrow a + b = 4 \text{ and } b - a = 4$$

On solving these two equations, we obtain $a = 0$ and $b = 4$.

Thus, the respective possible values of a and b are 0 and 4.

Question-29

Let $a_1, a_2, \dots, a_n$ be fixed real numbers and define a function

$$f(x) = (x - a_1)(x - a_2) \dots (x - a_n)$$

What is $\lim_{x \rightarrow a_1} f(x)$? For some $a \neq a_1, a_2, \dots, a_n$, compute $\lim_{x \rightarrow a} f(x)$

Ans.

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The given function is $f(x) = (x - a_1)(x - a_2) \dots (x - a_n)$.

$$\begin{aligned}\lim_{x \rightarrow a_1} f(x) &= \lim_{x \rightarrow a_1} [(x - a_1)(x - a_2) \dots (x - a_n)] \\ &= \left[\lim_{x \rightarrow a_1} (x - a_1) \right] \left[\lim_{x \rightarrow a_1} (x - a_2) \right] \dots \left[\lim_{x \rightarrow a_1} (x - a_n) \right] \\ &= (a_1 - a_1)(a_1 - a_2) \dots (a_1 - a_n) = 0\end{aligned}$$

$$\therefore \lim_{x \rightarrow a_1} f(x) = 0$$

$$\begin{aligned}\text{Now, } \lim_{x \rightarrow a} f(x) &= \lim_{x \rightarrow a} [(x - a_1)(x - a_2) \dots (x - a_n)] \\ &= \left[\lim_{x \rightarrow a} (x - a_1) \right] \left[\lim_{x \rightarrow a} (x - a_2) \right] \dots \left[\lim_{x \rightarrow a} (x - a_n) \right] \\ &= (a - a_1)(a - a_2) \dots (a - a_n)\end{aligned}$$

$$\therefore \lim_{x \rightarrow a} f(x) = (a - a_1)(a - a_2) \dots (a - a_n)$$

Question-30

$$\text{If } f(x) = \begin{cases} |x| + 1, & x < 0 \\ 0, & x = 0 \\ |x| - 1, & x > 0 \end{cases}.$$

For what value (s) of a does $\lim_{x \rightarrow a} f(x)$ exists?

Ans.

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When $a < 0$,

$$\begin{aligned}\lim_{x \rightarrow a^-} f(x) &= \lim_{x \rightarrow a^-} (|x| + 1) \\ &= \lim_{x \rightarrow a^-} (-x + 1) \quad [x < a < 0 \Rightarrow |x| = -x] \\ &= -a + 1\end{aligned}$$

$$\begin{aligned}\lim_{x \rightarrow a^+} f(x) &= \lim_{x \rightarrow a^+} (|x| + 1) \\ &= \lim_{x \rightarrow a^+} (-x + 1) \quad [a < x < 0 \Rightarrow |x| = -x] \\ &= -a + 1\end{aligned}$$

$$\therefore \lim_{x \rightarrow a^-} f(x) = \lim_{x \rightarrow a^+} f(x) = -a + 1$$

Thus, limit of $f(x)$ exists at $x = a$, where $a < 0$.

When $a > 0$

$$\begin{aligned}\lim_{x \rightarrow a^-} f(x) &= \lim_{x \rightarrow a^-} (|x| - 1) \\ &= \lim_{x \rightarrow a^-} (x - 1) \quad [0 < x < a \Rightarrow |x| = x] \\ &= a - 1\end{aligned}$$

$$\begin{aligned}\lim_{x \rightarrow a^+} f(x) &= \lim_{x \rightarrow a^+} (|x| - 1) \\ &= \lim_{x \rightarrow a^+} (x - 1) \quad [0 < a < x \Rightarrow |x| = x] \\ &= a - 1\end{aligned}$$

$$\therefore \lim_{x \rightarrow a^-} f(x) = \lim_{x \rightarrow a^+} f(x) = a - 1$$

Thus, limit of $f(x)$ exists at $x = a$, where $a > 0$.

Thus, $\lim_{x \rightarrow a} f(x)$ exists for all $a \neq 0$.

The given function is

$$f(x) = \begin{cases} |x| + 1, & x < 0 \\ 0, & x = 0 \\ |x| - 1, & x > 0 \end{cases}$$

When $a = 0$,

$$\begin{aligned} \lim_{x \rightarrow 0^-} f(x) &= \lim_{x \rightarrow 0^-} (|x| + 1) \\ &= \lim_{x \rightarrow 0^-} (-x + 1) \quad [\text{If } x < 0, |x| = -x] \\ &= -0 + 1 \\ &= 1 \end{aligned}$$

$$\begin{aligned} \lim_{x \rightarrow 0^+} f(x) &= \lim_{x \rightarrow 0^+} (|x| - 1) \\ &= \lim_{x \rightarrow 0^+} (x - 1) \quad [\text{If } x > 0, |x| = x] \\ &= 0 - 1 \\ &= -1 \end{aligned}$$

Here, it is observed that $\lim_{x \rightarrow 0^-} f(x) \neq \lim_{x \rightarrow 0^+} f(x)$.

$\therefore \lim_{x \rightarrow 0} f(x)$ does not exist.

Question-31

If the function $f(x)$ satisfies $\lim_{x \rightarrow 1} \frac{f(x) - 2}{x^2 - 1} = \pi$, evaluate $\lim_{x \rightarrow 1} f(x)$.

Ans.

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$$\begin{aligned}\lim_{x \rightarrow 1} \frac{f(x) - 2}{x^2 - 1} &= \pi \\ \Rightarrow \frac{\lim_{x \rightarrow 1} (f(x) - 2)}{\lim_{x \rightarrow 1} (x^2 - 1)} &= \pi \\ \Rightarrow \lim_{x \rightarrow 1} (f(x) - 2) &= \pi \lim_{x \rightarrow 1} (x^2 - 1) \\ \Rightarrow \lim_{x \rightarrow 1} (f(x) - 2) &= \pi(1^2 - 1) \\ \Rightarrow \lim_{x \rightarrow 1} (f(x) - 2) &= 0 \\ \Rightarrow \lim_{x \rightarrow 1} f(x) - \lim_{x \rightarrow 1} 2 &= 0 \\ \Rightarrow \lim_{x \rightarrow 1} f(x) - 2 &= 0 \\ \therefore \lim_{x \rightarrow 1} f(x) &= 2\end{aligned}$$

Question-32

If $f(x) = \begin{cases} mx^2 + n, & x < 0 \\ nx + m, & 0 \leq x \leq 1 \\ nx^3 + m, & x > 1 \end{cases}$. For what integers m and n does $\lim_{x \rightarrow 0} f(x)$ and $\lim_{x \rightarrow 1} f(x)$ exist?

Ans.

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The given function is

$$f(x) = \begin{cases} mx^2 + n, & x < 0 \\ nx + m, & 0 \leq x \leq 1 \\ nx^3 + m, & x > 1 \end{cases}$$

$$\begin{aligned} \lim_{x \rightarrow 0^-} f(x) &= \lim_{x \rightarrow 0^-} (mx^2 + n) \\ &= m(0)^2 + n \\ &= n \end{aligned}$$

$$\begin{aligned} \lim_{x \rightarrow 0^+} f(x) &= \lim_{x \rightarrow 0^+} (nx + m) \\ &= n(0) + m \\ &= m. \end{aligned}$$

Thus, $\lim_{x \rightarrow 0} f(x)$ exists if $m = n$.

$$\begin{aligned} \lim_{x \rightarrow 1^-} f(x) &= \lim_{x \rightarrow 1^-} (nx + m) \\ &= n(1) + m \\ &= m + n \end{aligned}$$

$$\begin{aligned} \lim_{x \rightarrow 1^+} f(x) &= \lim_{x \rightarrow 1^+} (nx^3 + m) \\ &= n(1)^3 + m \\ &= m + n \end{aligned}$$

$$\therefore \lim_{x \rightarrow 1^-} f(x) = \lim_{x \rightarrow 1^+} f(x) = \lim_{x \rightarrow 1} f(x).$$

Thus, $\lim_{x \rightarrow 1} f(x)$ exists for any integral value of m and n .

NCERT 11th Maths Chapter 13, class 11 Maths Chapter 13 solutions

Exercise.13.2

Question-1

Find the derivative of $x^2 - 2$ at $x = 10$.

Ans.

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Let $f(x) = x^2 - 2$. Accordingly,

$$\begin{aligned}f'(10) &= \lim_{h \rightarrow 0} \frac{f(10+h) - f(10)}{h} \\&= \lim_{h \rightarrow 0} \frac{[(10+h)^2 - 2] - (10^2 - 2)}{h} \\&= \lim_{h \rightarrow 0} \frac{10^2 + 2 \cdot 10h + h^2 - 2 - 10^2 + 2}{h} \\&= \lim_{h \rightarrow 0} \frac{20h + h^2}{h} \\&= \lim_{h \rightarrow 0} (20 + h) = (20 + 0) = 20\end{aligned}$$

Thus, the derivative of $x^2 - 2$ at $x = 10$ is 20.

Question-2

Find the derivative of $99x$ at $x = 100$.

Ans.

Let $f(x) = 99x$. Accordingly,

$$\begin{aligned}f'(100) &= \lim_{h \rightarrow 0} \frac{f(100+h) - f(100)}{h} \\&= \lim_{h \rightarrow 0} \frac{99(100+h) - 99(100)}{h} \\&= \lim_{h \rightarrow 0} \frac{99 \times 100 + 99h - 99 \times 100}{h} \\&= \lim_{h \rightarrow 0} \frac{99h}{h} \\&= \lim_{h \rightarrow 0} (99) = 99\end{aligned}$$

Thus, the derivative of $99x$ at $x = 100$ is 99.

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Question-3

Find the derivative of x at $x = 1$.

Ans.

Let $f(x) = x$. Accordingly,

$$\begin{aligned}f'(1) &= \lim_{h \rightarrow 0} \frac{f(1+h) - f(1)}{h} \\&= \lim_{h \rightarrow 0} \frac{(1+h) - 1}{h} \\&= \lim_{h \rightarrow 0} \frac{h}{h} \\&= \lim_{h \rightarrow 0} (1) \\&= 1\end{aligned}$$

Thus, the derivative of x at $x = 1$ is 1.

Question-4

Find the derivative of the following functions from first principle.

(i) $x^3 - 27$ (ii) $(x - 1)(x - 2)$

(iii) $\frac{1}{x^2}$ (iv) $\frac{x+1}{x-1}$

Ans.

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(i) Let $f(x) = x^3 - 27$. Accordingly, from the first principle,

$$\begin{aligned}f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\&= \lim_{h \rightarrow 0} \frac{[(x+h)^3 - 27] - (x^3 - 27)}{h} \\&= \lim_{h \rightarrow 0} \frac{x^3 + h^3 + 3x^2h + 3xh^2 - x^3}{h} \\&= \lim_{h \rightarrow 0} \frac{h^3 + 3x^2h + 3xh^2}{h} \\&= \lim_{h \rightarrow 0} (h^2 + 3x^2 + 3xh) \\&= 0 + 3x^2 + 0 = 3x^2\end{aligned}$$

(ii) Let $f(x) = (x - 1)(x - 2)$. Accordingly, from the first principle,

$$\begin{aligned}f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\&= \lim_{h \rightarrow 0} \frac{(x+h-1)(x+h-2) - (x-1)(x-2)}{h} \\&= \lim_{h \rightarrow 0} \frac{(x^2 + hx - 2x + hx + h^2 - 2h - x - h + 2) - (x^2 - 2x - x + 2)}{h} \\&= \lim_{h \rightarrow 0} \frac{(hx + hx + h^2 - 2h - h)}{h} \\&= \lim_{h \rightarrow 0} \frac{2hx + h^2 - 3h}{h} \\&= \lim_{h \rightarrow 0} (2x + h - 3) \\&= (2x + 0 - 3) \\&= 2x - 3\end{aligned}$$

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(iii) Let $f(x) = \frac{1}{x^2}$. Accordingly, from the first principle,

$$\begin{aligned} f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\ &= \lim_{h \rightarrow 0} \frac{\frac{1}{(x+h)^2} - \frac{1}{x^2}}{h} \\ &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{x^2 - (x+h)^2}{x^2 (x+h)^2} \right] \\ &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{x^2 - x^2 - h^2 - 2hx}{x^2 (x+h)^2} \right] \\ &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{-h^2 - 2hx}{x^2 (x+h)^2} \right] \\ &= \lim_{h \rightarrow 0} \left[\frac{-h - 2x}{x^2 (x+h)^2} \right] \\ &= \frac{0 - 2x}{x^2 (x+0)^2} = \frac{-2}{x^3} \end{aligned}$$

(iv) Let $f(x) = \frac{x+1}{x-1}$. Accordingly, from the first principle,

$$\begin{aligned} f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\ &= \lim_{h \rightarrow 0} \frac{\left(\frac{x+h+1}{x+h-1} - \frac{x+1}{x-1} \right)}{h} \\ &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{(x-1)(x+h+1) - (x+1)(x+h-1)}{(x-1)(x+h-1)} \right] \\ &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{(x^2 + hx + x - x - h - 1) - (x^2 + hx - x + x + h - 1)}{(x-1)(x+h-1)} \right] \\ &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{-2h}{(x-1)(x+h-1)} \right] \\ &= \lim_{h \rightarrow 0} \left[\frac{-2}{(x-1)(x+h-1)} \right] \\ &= \frac{-2}{(x-1)(x-1)} = \frac{-2}{(x-1)^2} \end{aligned}$$

Question-5

For the function

$$f(x) = \frac{x^{100}}{100} + \frac{x^{99}}{99} + \dots + \frac{x^2}{2} + x + 1$$

Prove that $f'(1) = 100f'(0)$

Ans.

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The given function is

$$f(x) = \frac{x^{100}}{100} + \frac{x^{99}}{99} + \dots + \frac{x^2}{2} + x + 1$$

$$\frac{d}{dx} f(x) = \frac{d}{dx} \left[\frac{x^{100}}{100} + \frac{x^{99}}{99} + \dots + \frac{x^2}{2} + x + 1 \right]$$

$$\frac{d}{dx} f(x) = \frac{d}{dx} \left(\frac{x^{100}}{100} \right) + \frac{d}{dx} \left(\frac{x^{99}}{99} \right) + \dots + \frac{d}{dx} \left(\frac{x^2}{2} \right) + \frac{d}{dx} (x) + \frac{d}{dx} (1)$$

On using theorem $\frac{d}{dx} (x^n) = nx^{n-1}$, we obtain

$$\begin{aligned} \frac{d}{dx} f(x) &= \frac{100x^{99}}{100} + \frac{99x^{98}}{99} + \dots + \frac{2x}{2} + 1 + 0 \\ &= x^{99} + x^{98} + \dots + x + 1 \end{aligned}$$

$$\therefore f'(x) = x^{99} + x^{98} + \dots + x + 1$$

At $x = 0$,

$$f'(0) = 1$$

At $x = 1$,

$$f'(1) = 1^{99} + 1^{98} + \dots + 1 + 1 = [1 + 1 + \dots + 1 + 1]_{100 \text{ terms}} = 1 \times 100 = 100$$

Thus, $f'(1) = 100 \times f'(0)$

Question-6

Find the derivative of $x^n + ax^{n-1} + a^2x^{n-2} + \dots + a^{n-1}x + a^n$ for some fixed real number a .

Ans.

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Let $f(x) = x^n + ax^{n-1} + a^2x^{n-2} + \dots + a^{n-1}x + a^n$

$$\begin{aligned}\therefore f'(x) &= \frac{d}{dx}(x^n + ax^{n-1} + a^2x^{n-2} + \dots + a^{n-1}x + a^n) \\ &= \frac{d}{dx}(x^n) + a \frac{d}{dx}(x^{n-1}) + a^2 \frac{d}{dx}(x^{n-2}) + \dots + a^{n-1} \frac{d}{dx}(x) + a^n \frac{d}{dx}(1)\end{aligned}$$

On using theorem $\frac{d}{dx}x^n = nx^{n-1}$, we obtain

$$\begin{aligned}f'(x) &= nx^{n-1} + a(n-1)x^{n-2} + a^2(n-2)x^{n-3} + \dots + a^{n-1} + a^n(0) \\ &= nx^{n-1} + a(n-1)x^{n-2} + a^2(n-2)x^{n-3} + \dots + a^{n-1}\end{aligned}$$

Question-7

For some constants a and b , find the derivative of

(i) $(x-a)(x-b)$ (ii) $(ax^2+b)^2$ (iii) $\frac{x-a}{x-b}$

Ans.

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(i) Let $f(x) = (x - a)(x - b)$

$$\Rightarrow f(x) = x^2 - (a + b)x + ab$$

$$\begin{aligned}\therefore f'(x) &= \frac{d}{dx}(x^2 - (a + b)x + ab) \\ &= \frac{d}{dx}(x^2) - (a + b)\frac{d}{dx}(x) + \frac{d}{dx}(ab)\end{aligned}$$

On using theorem $\frac{d}{dx}(x^n) = nx^{n-1}$, we obtain

$$f'(x) = 2x - (a + b) + 0 = 2x - a - b$$

(ii) Let $f(x) = (ax^2 + b)^2$

$$\Rightarrow f(x) = a^2x^4 + 2abx^2 + b^2$$

$$\therefore f'(x) = \frac{d}{dx}(a^2x^4 + 2abx^2 + b^2) = a^2\frac{d}{dx}(x^4) + 2ab\frac{d}{dx}(x^2) + \frac{d}{dx}(b^2)$$

On using theorem $\frac{d}{dx}x^n = nx^{n-1}$, we obtain

$$\begin{aligned}f'(x) &= a^2(4x^3) + 2ab(2x) + b^2(0) \\&= 4a^2x^3 + 4abx \\&= 4ax(ax^2 + b)\end{aligned}$$

(iii) Let $f(x) = \frac{(x-a)}{(x-b)}$

$$\Rightarrow f'(x) = \frac{d}{dx}\left(\frac{x-a}{x-b}\right)$$

By quotient rule,

$$\begin{aligned}f'(x) &= \frac{(x-b)\frac{d}{dx}(x-a) - (x-a)\frac{d}{dx}(x-b)}{(x-b)^2} \\&= \frac{(x-b)(1) - (x-a)(1)}{(x-b)^2} \\&= \frac{x-b-x+a}{(x-b)^2} \\&= \frac{a-b}{(x-b)^2}\end{aligned}$$

Question-8

Find the derivative of $\frac{x^n - a^n}{x - a}$ for some constant a .

Ans.

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$$\text{Let } f(x) = \frac{x^n - a^n}{x - a}$$

$$\Rightarrow f'(x) = \frac{d}{dx} \left(\frac{x^n - a^n}{x - a} \right)$$

By quotient rule,

$$\begin{aligned} f'(x) &= \frac{(x-a) \frac{d}{dx}(x^n - a^n) - (x^n - a^n) \frac{d}{dx}(x-a)}{(x-a)^2} \\ &= \frac{(x-a)(nx^{n-1} - 0) - (x^n - a^n)}{(x-a)^2} \\ &= \frac{nx^n - anx^{n-1} - x^n + a^n}{(x-a)^2} \end{aligned}$$

Question-9

Find the derivative of

(i) $2x - \frac{3}{4}$ (ii) $(5x^3 + 3x - 1)(x - 1)$

(iii) $x^{-3}(5 + 3x)$ (iv) $x^5(3 - 6x^{-9})$

(v) $x^{-4}(3 - 4x^{-5})$ (vi) $\frac{2}{x+1} - \frac{x^2}{3x-1}$

Ans.

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(i) Let $f(x) = 2x - \frac{3}{4}$

$$\begin{aligned}f'(x) &= \frac{d}{dx} \left(2x - \frac{3}{4} \right) \\&= 2 \frac{d}{dx}(x) - \frac{d}{dx} \left(\frac{3}{4} \right) \\&= 2 - 0 \\&= 2\end{aligned}$$

(ii) Let $f(x) = (5x^3 + 3x - 1)(x - 1)$

By Leibnitz product rule,

$$\begin{aligned}f'(x) &= (5x^3 + 3x - 1) \frac{d}{dx}(x - 1) + (x - 1) \frac{d}{dx}(5x^3 + 3x - 1) \\&= (5x^3 + 3x - 1)(1) + (x - 1)(15x^2 + 3 - 0) \\&= (5x^3 + 3x - 1) + (x - 1)(15x^2 + 3) \\&= 5x^3 + 3x - 1 + 15x^3 + 3x - 15x^2 - 3 \\&= 20x^3 - 15x^2 + 6x - 4\end{aligned}$$

(iii) Let $f(x) = x^{-3} (5 + 3x)$

By Leibnitz product rule,

$$\begin{aligned}f'(x) &= x^{-3} \frac{d}{dx}(5 + 3x) + (5 + 3x) \frac{d}{dx}(x^{-3}) \\&= x^{-3} (0 + 3) + (5 + 3x) (-3x^{-3-1}) \\&= x^{-3} (3) + (5 + 3x) (-3x^{-4}) \\&= 3x^{-3} - 15x^{-4} - 9x^{-3} \\&= -6x^{-3} - 15x^{-4} \\&= -3x^{-3} \left(2 + \frac{5}{x} \right) \\&= \frac{-3x^{-3}}{x} (2x + 5) \\&= \frac{-3}{x^4} (5 + 2x)\end{aligned}$$

(iv) Let $f(x) = x^5 (3 - 6x^{-9})$

By Leibnitz product rule,

$$\begin{aligned}f'(x) &= x^5 \frac{d}{dx}(3 - 6x^{-9}) + (3 - 6x^{-9}) \frac{d}{dx}(x^5) \\&= x^5 \{ 0 - 6(-9)x^{-9-1} \} + (3 - 6x^{-9})(5x^4) \\&= x^5 (54x^{-10}) + 15x^4 - 30x^{-5} \\&= 54x^{-5} + 15x^4 - 30x^{-5} \\&= 24x^{-5} + 15x^4 \\&= 15x^4 + \frac{24}{x^5}\end{aligned}$$

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(v) Let $f(x) = x^{-4} (3 - 4x^{-5})$

By Leibnitz product rule,

$$\begin{aligned}f'(x) &= x^{-4} \frac{d}{dx}(3 - 4x^{-5}) + (3 - 4x^{-5}) \frac{d}{dx}(x^{-4}) \\&= x^{-4} \{0 - 4(-5)x^{-5-1}\} + (3 - 4x^{-5})(-4)x^{-4-1} \\&= x^{-4} (20x^{-6}) + (3 - 4x^{-5})(-4x^{-5}) \\&= 20x^{-10} - 12x^{-5} + 16x^{-10} \\&= 36x^{-10} - 12x^{-5} \\&= -\frac{12}{x^5} + \frac{36}{x^{10}}\end{aligned}$$

(vi) Let $f(x) = \frac{2}{x+1} - \frac{x^2}{3x-1}$

$$f'(x) = \frac{d}{dx}\left(\frac{2}{x+1}\right) - \frac{d}{dx}\left(\frac{x^2}{3x-1}\right)$$

By quotient rule,

$$\begin{aligned}f'(x) &= \left[\frac{(x+1) \frac{d}{dx}(2) - 2 \frac{d}{dx}(x+1)}{(x+1)^2} \right] - \left[\frac{(3x-1) \frac{d}{dx}(x^2) - x^2 \frac{d}{dx}(3x-1)}{(3x-1)^2} \right] \\&= \left[\frac{(x+1)(0) - 2(1)}{(x+1)^2} \right] - \left[\frac{(3x-1)(2x) - (x^2)(3)}{(3x-1)^2} \right] \\&= \frac{-2}{(x+1)^2} - \left[\frac{6x^2 - 2x - 3x^2}{(3x-1)^2} \right] \\&= \frac{-2}{(x+1)^2} - \left[\frac{3x^2 - 2x^2}{(3x-1)^2} \right] \\&= \frac{-2}{(x+1)^2} - \frac{x(3x-2)}{(3x-1)^2}\end{aligned}$$

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Question-10

Find the derivative of $\cos x$ from first principle.

Ans.

Let $f(x) = \cos x$. Accordingly, from the first principle,

$$\begin{aligned}f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\&= \lim_{h \rightarrow 0} \frac{\cos(x+h) - \cos x}{h} \\&= \lim_{h \rightarrow 0} \left[\frac{\cos x \cos h - \sin x \sin h - \cos x}{h} \right] \\&= \lim_{h \rightarrow 0} \left[\frac{-\cos x(1 - \cos h) - \sin x \sin h}{h} \right] \\&= \lim_{h \rightarrow 0} \left[\frac{-\cos x(1 - \cos h)}{h} - \frac{\sin x \sin h}{h} \right] \\&= -\cos x \left(\lim_{h \rightarrow 0} \frac{1 - \cos h}{h} \right) - \sin x \lim_{h \rightarrow 0} \left(\frac{\sin h}{h} \right) \\&= -\cos x(0) - \sin x(1) \quad \left[\lim_{h \rightarrow 0} \frac{1 - \cos h}{h} = 0 \text{ and } \lim_{h \rightarrow 0} \frac{\sin h}{h} = 1 \right] \\&= -\sin x \\ \therefore f'(x) &= -\sin x\end{aligned}$$

Question-11

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Find the derivative of the following functions:

(i) $\sin x \cos x$ (ii) $\sec x$ (iii) $5 \sec x + 4 \cos x$

(iv) $\operatorname{cosec} x$ (v) $3 \cot x + 5 \operatorname{cosec} x$

(vi) $5 \sin x - 6 \cos x + 7$ (vii) $2 \tan x - 7 \sec x$

Ans.

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(i) Let $f(x) = \sin x \cos x$. Accordingly, from the first principle,

$$\begin{aligned} f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\ &= \lim_{h \rightarrow 0} \frac{\sin(x+h) \cos(x+h) - \sin x \cos x}{h} \\ &= \lim_{h \rightarrow 0} \frac{1}{2h} [2 \sin(x+h) \cos(x+h) - 2 \sin x \cos x] \\ &= \lim_{h \rightarrow 0} \frac{1}{2h} [\sin 2(x+h) - \sin 2x] \\ &= \lim_{h \rightarrow 0} \frac{1}{2h} \left[2 \cos \frac{2x+2h+2x}{2} \cdot \sin \frac{2x+2h-2x}{2} \right] \\ &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\cos \frac{4x+2h}{2} \sin \frac{2h}{2} \right] \\ &= \lim_{h \rightarrow 0} \frac{1}{h} [\cos(2x+h) \sin h] \\ &= \lim_{h \rightarrow 0} \cos(2x+h) \cdot \lim_{h \rightarrow 0} \frac{\sin h}{h} \\ &= \cos(2x+0) \cdot 1 \\ &= \cos 2x \end{aligned}$$

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(ii) Let $f(x) = \sec x$. Accordingly, from the first principle,

$$\begin{aligned} f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\ &= \lim_{h \rightarrow 0} \frac{\sec(x+h) - \sec x}{h} \\ &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{1}{\cos(x+h)} - \frac{1}{\cos x} \right] \\ &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\cos x - \cos(x+h)}{\cos x \cos(x+h)} \right] \\ &= \frac{1}{\cos x} \cdot \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{-2 \sin\left(\frac{x+x+h}{2}\right) \sin\left(\frac{x-x-h}{2}\right)}{\cos(x+h)} \right] \\ &= \frac{1}{\cos x} \cdot \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{-2 \sin\left(\frac{2x+h}{2}\right) \sin\left(-\frac{h}{2}\right)}{\cos(x+h)} \right] \\ &= \frac{1}{\cos x} \cdot \lim_{h \rightarrow 0} \left[\frac{\sin\left(\frac{2x+h}{2}\right) \frac{\sin\left(\frac{h}{2}\right)}{\left(\frac{h}{2}\right)}}{\cos(x+h)} \right] \end{aligned}$$

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$$\begin{aligned}
 &= \frac{1}{\cos x} \cdot \lim_{h \rightarrow 0} \left[\frac{\sin\left(\frac{2x+h}{2}\right) \sin\left(\frac{h}{2}\right)}{\left(\frac{h}{2}\right)} \right] \\
 &= \frac{1}{\cos x} \cdot \lim_{\frac{h}{2} \rightarrow 0} \frac{\sin\left(\frac{h}{2}\right)}{\left(\frac{h}{2}\right)} \cdot \lim_{h \rightarrow 0} \frac{\sin\left(\frac{2x+h}{2}\right)}{\cos(x+h)} \\
 &= \frac{1}{\cos x} \cdot 1 \cdot \frac{\sin x}{\cos x} \\
 &= \sec x \tan x
 \end{aligned}$$

(iii) Let $f(x) = 5 \sec x + 4 \cos x$. Accordingly, from the first principle,

$$\begin{aligned}
 f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\
 &= \lim_{h \rightarrow 0} \frac{5 \sec(x+h) + 4 \cos(x+h) - [5 \sec x + 4 \cos x]}{h} \\
 &= 5 \lim_{h \rightarrow 0} \frac{[\sec(x+h) - \sec x]}{h} + 4 \lim_{h \rightarrow 0} \frac{[\cos(x+h) - \cos x]}{h} \\
 &= 5 \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{1}{\cos(x+h)} - \frac{1}{\cos x} \right] + 4 \lim_{h \rightarrow 0} \frac{1}{h} [\cos(x+h) - \cos x] \\
 &= 5 \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\cos x - \cos(x+h)}{\cos x \cos(x+h)} \right] + 4 \lim_{h \rightarrow 0} \frac{1}{h} [\cos x \cos h - \sin x \sin h - \cos x]
 \end{aligned}$$

$$\begin{aligned}
 &= \frac{5}{\cos x} \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{-2 \sin\left(\frac{x+x+h}{2}\right) \sin\left(\frac{x-x-h}{2}\right)}{\cos(x+h)} \right] + 4 \lim_{h \rightarrow 0} \frac{1}{h} [-\cos x (1 - \cos h) - \sin x \sin h] \\
 &= \frac{5}{\cos x} \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{-2 \sin\left(\frac{2x+h}{2}\right) \sin\left(-\frac{h}{2}\right)}{\cos(x+h)} \right] + 4 \left[-\cos x \lim_{h \rightarrow 0} \frac{(1 - \cos h)}{h} - \sin x \lim_{h \rightarrow 0} \frac{\sin h}{h} \right] \\
 &= \frac{5}{\cos x} \lim_{h \rightarrow 0} \left[\frac{\sin\left(\frac{2x+h}{2}\right) \cdot \frac{\sin\left(\frac{h}{2}\right)}{\frac{h}{2}}}{\cos(x+h)} \right] + 4 [(-\cos x) \cdot (0) - (\sin x) \cdot 1] \\
 &= \frac{5}{\cos x} \left[\lim_{h \rightarrow 0} \frac{\sin\left(\frac{2x+h}{2}\right)}{\cos(x+h)} \cdot \lim_{h \rightarrow 0} \frac{\sin\left(\frac{h}{2}\right)}{\frac{h}{2}} \right] - 4 \sin x \\
 &= \frac{5}{\cos x} \cdot \frac{\sin x}{\cos x} \cdot 1 - 4 \sin x \\
 &= 5 \sec x \tan x - 4 \sin x
 \end{aligned}$$

$$\begin{aligned}
 &= \frac{5}{\cos x} \cdot \lim_{h \rightarrow 0} \left[\frac{\sin\left(\frac{2x+h}{2}\right) \cdot \frac{\sin\left(\frac{h}{2}\right)}{\frac{h}{2}}}{\cos(x+h)} \right] + 4[(-\cos x) \cdot (0) - (\sin x) \cdot 1] \\
 &= \frac{5}{\cos x} \cdot \left[\lim_{h \rightarrow 0} \frac{\sin\left(\frac{2x+h}{2}\right)}{\cos(x+h)} \cdot \lim_{h \rightarrow 0} \frac{\sin\left(\frac{h}{2}\right)}{\frac{h}{2}} \right] - 4 \sin x \\
 &= \frac{5}{\cos x} \cdot \frac{\sin x}{\cos x} \cdot 1 - 4 \sin x \\
 &= 5 \sec x \tan x - 4 \sin x
 \end{aligned}$$

(iv) Let $f(x) = \operatorname{cosec} x$. Accordingly, from the first principle,

$$\begin{aligned}
 f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\
 f'(x) &= \lim_{h \rightarrow 0} \frac{1}{h} [\operatorname{cosec}(x+h) - \operatorname{cosec} x] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{1}{\sin(x+h)} - \frac{1}{\sin x} \right] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\sin x - \sin(x+h)}{\sin(x+h) \sin x} \right] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{2 \cos\left(\frac{x+x+h}{2}\right) \cdot \sin\left(\frac{x-x-h}{2}\right)}{\sin(x+h) \sin x} \right]
 \end{aligned}$$

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$$\begin{aligned}
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{2 \cos \left(\frac{2x+h}{2} \right) \sin \left(-\frac{h}{2} \right)}{\sin(x+h) \sin x} \right] \\
 &\quad - \cos \left(\frac{2x+h}{2} \right) \cdot \frac{\sin \left(\frac{h}{2} \right)}{\left(\frac{h}{2} \right)} \\
 &= \lim_{h \rightarrow 0} \frac{-\cos \left(\frac{2x+h}{2} \right) \sin \left(\frac{h}{2} \right)}{\sin(x+h) \sin x} \\
 &= \lim_{h \rightarrow 0} \left(\frac{-\cos \left(\frac{2x+h}{2} \right)}{\sin(x+h) \sin x} \right) \cdot \lim_{\frac{h}{2} \rightarrow 0} \frac{\sin \left(\frac{h}{2} \right)}{\left(\frac{h}{2} \right)} \\
 &= \left(\frac{-\cos x}{\sin x \sin x} \right) \cdot 1 \\
 &= -\operatorname{cosec} x \cot x
 \end{aligned}$$

(v) Let $f(x) = 3 \cot x + 5 \operatorname{cosec} x$. Accordingly, from the first principle,

$$\begin{aligned}
 f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\
 &= \lim_{h \rightarrow 0} \frac{3 \cot(x+h) + 5 \operatorname{cosec}(x+h) - 3 \cot x - 5 \operatorname{cosec} x}{h} \\
 &= 3 \lim_{h \rightarrow 0} \frac{1}{h} [\cot(x+h) - \cot x] + 5 \lim_{h \rightarrow 0} \frac{1}{h} [\operatorname{cosec}(x+h) - \operatorname{cosec} x] \quad \dots(1)
 \end{aligned}$$

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$$\begin{aligned}
 \text{Now, } \lim_{h \rightarrow 0} \frac{1}{h} [\cot(x+h) - \cot x] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\cos(x+h)}{\sin(x+h)} - \frac{\cos x}{\sin x} \right] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\cos(x+h) \sin x - \cos x \sin(x+h)}{\sin x \sin(x+h)} \right] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\sin(x-x-h)}{\sin x \sin(x+h)} \right] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\sin(-h)}{\sin x \sin(x+h)} \right] \\
 &= - \left(\lim_{h \rightarrow 0} \frac{\sin h}{h} \right) \cdot \left(\lim_{h \rightarrow 0} \frac{1}{\sin x \cdot \sin(x+h)} \right) \\
 &= -1 \cdot \frac{1}{\sin x \cdot \sin(x+0)} = \frac{-1}{\sin^2 x} = -\operatorname{cosec}^2 x \quad \dots(2)
 \end{aligned}$$

$$\begin{aligned}
 \lim_{h \rightarrow 0} \frac{1}{h} [\operatorname{cosec}(x+h) - \operatorname{cosec} x] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{1}{\sin(x+h)} - \frac{1}{\sin x} \right] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\sin x - \sin(x+h)}{\sin(x+h) \sin x} \right] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{2 \cos\left(\frac{x+x+h}{2}\right) \cdot \sin\left(\frac{x-x-h}{2}\right)}{\sin(x+h) \sin x} \right] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{2 \cos\left(\frac{2x+h}{2}\right) \sin\left(-\frac{h}{2}\right)}{\sin(x+h) \sin x} \right]
 \end{aligned}$$

$$\begin{aligned}
 & -\cos\left(\frac{2x+h}{2}\right) \cdot \frac{\sin\left(\frac{h}{2}\right)}{\left(\frac{h}{2}\right)} \\
 & = \lim_{h \rightarrow 0} \frac{\sin(x+h) \sin x}{-\cos\left(\frac{2x+h}{2}\right) \cdot \frac{\sin\left(\frac{h}{2}\right)}{\left(\frac{h}{2}\right)}} \\
 & = \lim_{h \rightarrow 0} \left(\frac{-\cos\left(\frac{2x+h}{2}\right)}{\sin(x+h) \sin x} \right) \cdot \lim_{\frac{h}{2} \rightarrow 0} \frac{\sin\left(\frac{h}{2}\right)}{\left(\frac{h}{2}\right)} \\
 & = \left(\frac{-\cos x}{\sin x \sin x} \right) \cdot 1 \\
 & = -\operatorname{cosec} x \cot x \quad \dots(3)
 \end{aligned}$$

From (1), (2), and (3), we obtain

$$f'(x) = -3\operatorname{cosec}^2 x - 5\operatorname{cosec} x \cot x$$

(vi) Let $f(x) = 5\sin x - 6\cos x + 7$. Accordingly, from the first principle,

$$\begin{aligned}
 f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} [5\sin(x+h) - 6\cos(x+h) + 7 - 5\sin x + 6\cos x - 7] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} [5\{\sin(x+h) - \sin x\} - 6\{\cos(x+h) - \cos x\}] \\
 &= 5 \lim_{h \rightarrow 0} \frac{1}{h} [\sin(x+h) - \sin x] - 6 \lim_{h \rightarrow 0} \frac{1}{h} [\cos(x+h) - \cos x] \\
 &= 5 \lim_{h \rightarrow 0} \frac{1}{h} \left[2 \cos\left(\frac{x+h+x}{2}\right) \sin\left(\frac{x+h-x}{2}\right) \right] - 6 \lim_{h \rightarrow 0} \frac{\cos x \cos h - \sin x \sin h - \cos x}{h}
 \end{aligned}$$

$$\begin{aligned}
 &= 5 \lim_{h \rightarrow 0} \left[\cos \left(\frac{2x+h}{2} \right) \frac{\sin \frac{h}{2}}{\frac{h}{2}} \right] - 6 \lim_{h \rightarrow 0} \left[\frac{-\cos x (1 - \cos h)}{h} - \frac{\sin x \sin h}{h} \right] \\
 &= 5 \left[\lim_{h \rightarrow 0} \cos \left(\frac{2x+h}{2} \right) \right] \left[\lim_{\frac{h}{2} \rightarrow 0} \frac{\sin \frac{h}{2}}{\frac{h}{2}} \right] - 6 \left[(-\cos x) \left(\lim_{h \rightarrow 0} \frac{1 - \cos h}{h} \right) - \sin x \lim_{h \rightarrow 0} \left(\frac{\sin h}{h} \right) \right] \\
 &= 5 \cos x \cdot 1 - 6 [(-\cos x) \cdot (0) - \sin x \cdot 1] \\
 &= 5 \cos x + 6 \sin x
 \end{aligned}$$

(vii) Let $f(x) = 2 \tan x - 7 \sec x$. Accordingly, from the first principle,

$$\begin{aligned}
 f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} [2 \tan(x+h) - 7 \sec(x+h) - 2 \tan x + 7 \sec x] \\
 &= \lim_{h \rightarrow 0} \frac{1}{h} [2 \{ \tan(x+h) - \tan x \} - 7 \{ \sec(x+h) - \sec x \}] \\
 &= 2 \lim_{h \rightarrow 0} \frac{1}{h} [\tan(x+h) - \tan x] - 7 \lim_{h \rightarrow 0} \frac{1}{h} [\sec(x+h) - \sec x] \\
 &= 2 \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\sin(x+h)}{\cos(x+h)} - \frac{\sin x}{\cos x} \right] - 7 \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{1}{\cos(x+h)} - \frac{1}{\cos x} \right] \\
 &= 2 \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\sin(x+h) \cos x - \sin x \cos(x+h)}{\cos x \cos(x+h)} \right] - 7 \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\cos x - \cos(x+h)}{\cos x \cos(x+h)} \right] \\
 &= 2 \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{\sin(x+h-x)}{\cos x \cos(x+h)} \right] - 7 \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{-2 \sin \left(\frac{x+x+h}{2} \right) \sin \left(\frac{x-x-h}{2} \right)}{\cos x \cos(x+h)} \right]
 \end{aligned}$$

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$$\begin{aligned}
 &= 2 \lim_{h \rightarrow 0} \left[\left(\frac{\sin h}{h} \right) \frac{1}{\cos x \cos(x+h)} \right] - 7 \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{-2 \sin \left(\frac{2x+h}{2} \right) \sin \left(-\frac{h}{2} \right)}{\cos x \cos(x+h)} \right] \\
 &= 2 \lim_{h \rightarrow 0} \left[\left(\frac{\sin h}{h} \right) \frac{1}{\cos x \cos(x+h)} \right] - 7 \lim_{h \rightarrow 0} \frac{1}{h} \left[\frac{-2 \sin \left(\frac{2x+h}{2} \right) \sin \left(-\frac{h}{2} \right)}{\cos x \cos(x+h)} \right] \\
 &= 2 \left(\lim_{h \rightarrow 0} \frac{\sin h}{h} \right) \left(\lim_{h \rightarrow 0} \frac{1}{\cos x \cos(x+h)} \right) - 7 \left(\lim_{\frac{h}{2} \rightarrow 0} \frac{\sin \frac{h}{2}}{\frac{h}{2}} \right) \left(\lim_{h \rightarrow 0} \frac{\sin \left(\frac{2x+h}{2} \right)}{\cos x \cos(x+h)} \right) \\
 &= 2 \cdot 1 \cdot \frac{1}{\cos x \cos x} - 7 \cdot 1 \left(\frac{\sin x}{\cos x \cos x} \right) \\
 &= 2 \sec^2 x - 7 \sec x \tan x
 \end{aligned}$$



Chapterwise NCERT Solutions for Class 11 Maths :

- Chapter 1-Sets
- Chapter 2-Relations and Functions
- Chapter 3-Trigonometric Functions
- Chapter 4-Principle of Mathematical Induction
- Chapter 5-Complex Numbers and Quadratic Equations
- Chapter 6-Linear Inequalities
- Chapter 7-Permutation and Combinations
- Chapter 8-Binomial Theorem
- Chapter 9-Sequences and Series
- Chapter 10-Straight Lines
- Chapter 11-Conic Sections
- Chapter 12-Introduction to three Dimensional Geometry
- Chapter 13-Limits and Derivatives
- Chapter 14-Mathematical Reasoning
- Chapter 15-Statistics
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