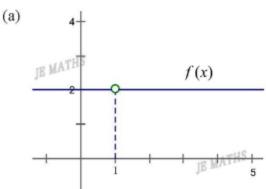
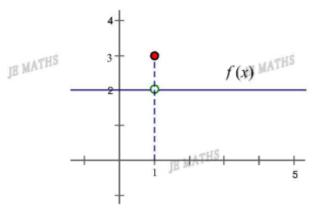
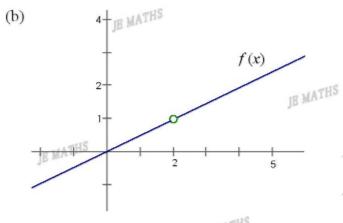
1. Given the graph of f(x), find the limit of f(x).



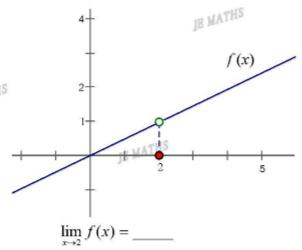


$$\lim_{x\to 1} f(x) = \underline{\hspace{1cm}}$$

 $\lim_{x \to 1} f(x) = \underline{\qquad}$ JE MATHS



 $\lim_{x \to 2} f(x) = \underline{\qquad} \qquad \text{JE MATHS}$



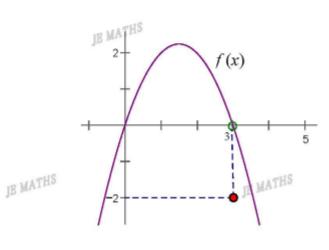
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f(x)

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 $\lim_{x \to 3} f(x) = \underline{\hspace{1cm}}$



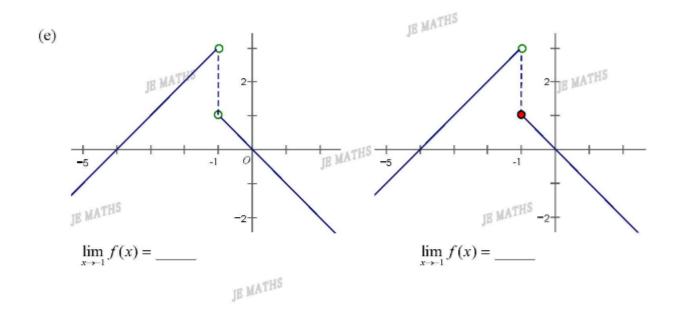
 $\lim_{x \to 3} f(x) = \underline{\hspace{1cm}}$

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 $\lim_{x\to -1} f(x) = \underline{\hspace{1cm}}$

 $\lim_{x \to -1} f(x) = \underline{\hspace{1cm}}$

JE MATHS



- 2. Sketch the graph and find the limit of each piecewise function.
 - (a) Let $f(x) = \begin{cases} x & \text{for } x > 0 \\ 2x & \text{for } x < 0 \end{cases}$ Find $\lim_{x \to 0} f(x)$.

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(b) Let
$$f(x) = \begin{cases} 3-x & for \ x \neq 1 \\ 4 & for \ x = 1 \end{cases}$$
.

Find $\lim_{x\to 1} f(x)$.

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(c) Let
$$f(x) = \begin{cases} x-1 & \text{for } x < 0 \\ x+2 & \text{for } x \ge 0 \end{cases}$$
.

Find $\lim_{x\to 0} f(x) MATHS$

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(d) Let
$$f(x) = \begin{cases} x-2 & \text{for } x > 2\\ 2-x & \text{for } x < 2\\ 3 & \text{for } x = 2 \end{cases}$$

Find $\lim_{x\to 2} f(x)$ MATHS

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- 3. Consider the function $f(x) = \frac{x^2 4}{x + 2}$.
 - (i) State the domain of f(x).

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(ii) Simplify f(x) and hence sketch the graph of f(x).

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(iii) Use the graph of f(x) to find $\lim_{x \to 2} \frac{x^2 - 4}{x + 2}$.

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- 4. Simplify each function first and then find the limit.
 - (a) $\lim_{x \to 0} \frac{x^2 + 3x}{x}$ JE MATHS

(b) $\lim_{x\to 4} \frac{(x-1)(x-4)}{x-4}$

(c)
$$\lim_{x \to 1} \frac{x^2 - 1}{x - 1}$$

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(d) $\lim_{x \to 3} \frac{x^2 - x - 6}{x - 3}$

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(e) $\lim_{x\to 0} \frac{3x}{x^2 - 2x}$

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(f) $\lim_{x \to -1} \frac{x+1}{x^2 - x - 2}$

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(g) $\lim_{x \to -1} \frac{x+1}{x^3+1}$

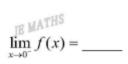
(h) $\lim_{\substack{x\to 2\\ \text{jB}}} \frac{x^3-8}{x+2}$

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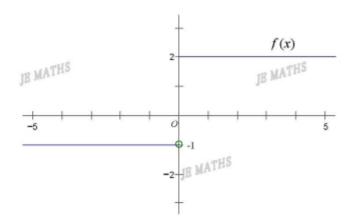
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- 1. Given the graph of f(x), find the limit of f(x).
 - (a) $\lim_{x\to 0^+} f(x) =$ _____



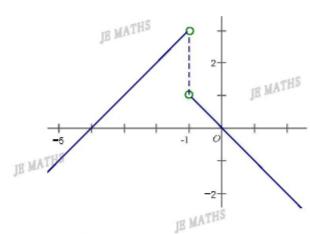




(b) $\lim_{x \to -1^+} f(x) =$ _____

$$\lim_{x \to -\Gamma} f(x) = \frac{1}{\text{IB MATHS}}$$

$$\lim_{x\to -1} f(x) = \underline{\hspace{1cm}}$$

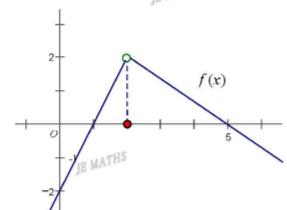


(c) $\lim_{x\to 2^+} f(x) =$ _____

$$\lim_{x \to 2} f(x) = \underline{\qquad} \qquad \text{JE MATHS}$$

$$\lim_{x\to 2} f(x) = \underline{\hspace{1cm}}$$

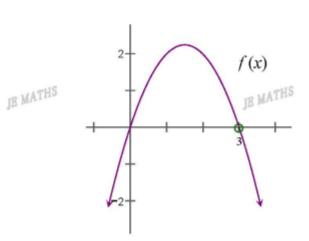
JE MATHS



(d) $\lim_{x \to 3^+} f(x) =$ _____

$$\lim_{x \to 3} f(x) = \underline{\hspace{1cm}}$$

 $\lim_{x \to 3} f(x) = \underline{\hspace{1cm}}$



- 2. Let $f(x) = \begin{cases} x & \text{for } x \ge 1 \\ -x & \text{for } x < 1 \end{cases}$.
 - (i) Find $\lim_{x\to 1^+} f(x)$ and $\lim_{x\to 1^-} f(x)$ by substitution.

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(ii) Hence, explain why $\lim_{x\to 1} f(x)$ does NOT exist.

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(iii) Sketch the graph of f(x) and confirm your results in part (i) (ii) by the graph.

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3. Let $f(x) = \begin{cases} x^2 + 1 & \text{for } x > 0 \\ 2 & \text{js MATHS} & \text{for } x < 0 \end{cases}$

JE MATHS

(i) Find $\lim_{x\to 0^+} f(x)$ and $\lim_{x\to 0^-} f(x)$ by substitution.

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JE MATHS

(ii) Hence, explain why $\lim_{x\to 0} f(x)$ does NOT exist.

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(iii) Sketch the graph of f(x) and confirm your results in part (i) (ii) by the graph.

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4. Let $f(x) = \begin{cases} 2x & \text{for } x > 1 \\ 4 - 2x & \text{for } x < 1 \end{cases}$

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(i) Find $\lim_{x\to \Gamma^i} f(x)$ and $\lim_{x\to \Gamma} f(x)$ by substitution.

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(ii) Hence, explain why $\lim_{x\to 1} f(x)$ does exist and find the value of it.

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(iii) Sketch the graph of f(x) and confirm your results in part (i) (ii) by the graph.

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5. Let f(x) = |x+2|.

(i) Express f(x) as a piecewise function.

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(ii) Find $\lim_{x\to 2^+} f(x)$ and $\lim_{x\to 2^-} f(x)$ by substitution.

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(iii) Does $\lim_{x\to -2} f(x)$ exist? If it does, find its value. If not, explain your reasons.

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(iv) Sketch the graph of f(x) and confirm your results in part (i) (ii) by the graph.

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- 6. Find $\lim_{x\to 0^+} f(x)$ if f(x) = x + 3:
 - (a) for domain all real x

(b) for domain such that x > 0

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- JE MATHS
- 7. Find each one-sided limit:

(a)
$$\lim_{x \to 0^+} \frac{x}{|x|}$$

(b) $\lim_{x\to 0^-} \frac{x}{|x|}$ JE MATHS

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(c)
$$\lim_{x \to 2^+} \frac{|x-2|}{x-2}$$

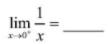
$$\text{JE MATHS}$$

(d) $\lim_{x\to 2^{-}} \frac{|x+2|}{x-2}$

(e)
$$\lim_{x \to 2^+} \sqrt{x-2}$$

JB MATHS (f)
$$\lim_{x\to\Gamma} \sqrt{1-x^2}$$

1. Given the graph of the function $f(x) = \frac{1}{x}$, find:



$$\lim_{x\to 0^-} \frac{i^{\mathbb{E}} MATHS}{x} = \underline{\hspace{1cm}}$$

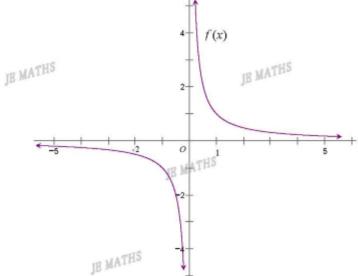
$$\lim_{x \to +\infty} \frac{1}{x} = \underline{\hspace{1cm}}$$

$$\lim_{x \to -\infty} \frac{1}{x} = \underline{\hspace{1cm}}$$



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2. Given the graph of the function $f(x) = \frac{1}{x+2}$, find:

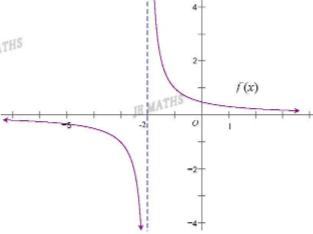
$$\lim_{x \to -2^+} \frac{1}{x+2} = \underline{\hspace{1cm}}$$

$$\lim_{x \to -2^{-}} \frac{1}{x+2} = \underline{\hspace{1cm}}$$

$$\lim_{x \to +\infty} \frac{\int_{\mathbb{R}} \prod_{i=1}^{MATHS}}{x+2} = \underline{\hspace{1cm}}$$

$$\lim_{x\to\infty}\frac{1}{x+2}=\underline{\hspace{1cm}}$$





3. Given the graph of the function $f(x) = \frac{1}{3-x}$, find:

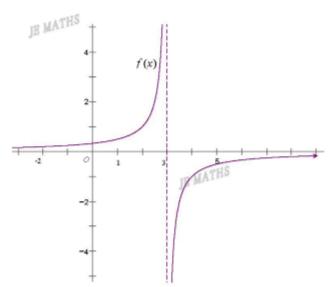
$$\lim_{x \to 3^+} \frac{1}{3 - x} = \underline{\qquad}_{\text{JE}} \text{MATHS}$$

$$\lim_{x \to 3^{-}} \frac{1}{3-x} =$$

$$\lim_{x \to +\infty} \frac{\text{JE } \mathbb{I}^{\text{ATHS}}}{3-x} = \underline{\hspace{1cm}}$$

$$\lim_{x\to\infty}\frac{1}{3-x}=$$





- 4. Find the limit of each function:
 - (a) $\lim_{x \to \infty} \frac{1}{x 1}$

(b) $\lim_{x\to\infty} \frac{1}{x+4}$

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- (c) $\lim_{x\to\infty}\frac{1}{2x+3}$
- JE MATHS
- (d) $\lim_{x\to\infty} \frac{1}{5-x}$ $\int_{\mathbb{R}} MATHS$

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(e) $\lim_{x\to\infty} \frac{x-1}{x+1}$ IB MATHS

(f) $\lim_{x \to \infty} \frac{x}{2x+3}$

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- (g) $\lim_{x \to \infty} \frac{x-1}{5-x}$
- JE MATHS
- (h) $\lim_{x \to \infty} \frac{3x 1}{x + 4}$

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(i) $\lim_{x\to\infty}\frac{1}{x^2+1}$

 $(j) \lim_{x\to\infty}\frac{2x}{x^2+1}$

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$$(k) \lim_{x\to\infty} \frac{3x^2}{x^2+1}$$

(1)
$$\lim_{x \to \infty} \frac{x^2 + x}{x^2 + 1}$$

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5. Find the limit of each function:

(a)
$$\lim_{x \to 1^+} \frac{1}{x - 1}$$

(b)
$$\lim_{x \to 1^-} \frac{1}{x - 1}$$

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(c)
$$\lim_{x \to 4^+} \frac{1}{x+4}$$

JE MATHS (d)
$$\lim_{x\to 4} \frac{1}{x+4}$$

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(e)
$$\lim_{x \to 2^+} \frac{1}{2x - 4}$$

(f)
$$\lim_{x\to 2^-} \frac{1}{2x-4}$$

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(g)
$$\lim_{x \to \frac{1}{3}} \frac{1}{1 - 3x}$$

$$\text{JB MATHS}$$

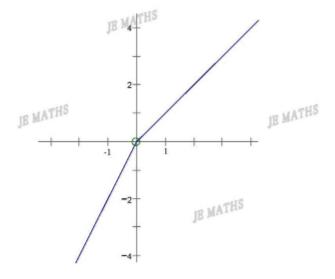
(h)
$$\lim_{x \to \frac{1}{3}} \frac{1}{1 - 3x}$$

1.

- (a) (2), (2)
- (b) (1), (1)
- (c)(0),(0)
- (d) (-3), (-3)
- (e) (not exist), (not exist)

2.

(a) $\lim_{x\to 0} f(x) = 0$



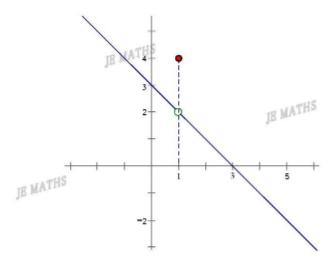
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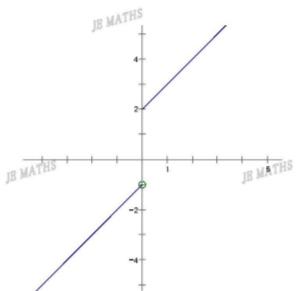
(b) $\lim_{x \to 1} f(x) = 2$

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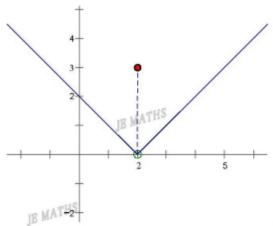
(c) $\lim_{x\to 0} f(x)$ does NOT exist

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$$(d) \lim_{x \to 2} f(x) = 0$$



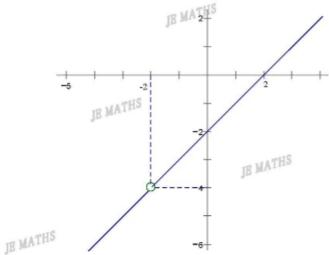
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3. $(x \neq -2)$ $(f(x) = x - 2 \text{ for } x \neq -2)$

$$\lim_{x \to -2} \frac{x^2 - 4}{x + 2} = \lim_{x \to -2} (x - 2) = -2 - 2 = -4$$

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4.

(a)
$$\lim_{x \to 0} \frac{x^2 + 3x}{4x^{1/3}} = \lim_{x \to 0} (x+3) = 0+3=3$$

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(b)
$$\lim_{x \to 4} \frac{(x-1)(x-4)}{x-4} = \lim_{x \to 4} (x-1) = 4-1 = 3$$

(c)
$$\lim_{x \to 1} \frac{x^2 - 1}{x - 1} = \lim_{x \to 1} (x + 1) = 1 + 1 = 2$$

(d)
$$\lim_{x \to 3} \frac{x^2 - x - 6}{x - 3} = \lim_{x \to 3} \frac{(x - 3)(x + 2)}{x - 3} = \lim_{x \to 3} (x + 2) = 3 + 2 = 5$$

(e)
$$\lim_{x\to 0} \frac{3x}{x^2 - 2x} = \lim_{x\to 0} \frac{3x}{x(x-2)} = \lim_{x\to 0} \frac{3}{x-2} = \frac{3}{0-2} = -\frac{3}{2}$$

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

(g)
$$\lim_{x \to -1} \frac{x+1}{x^3+1} = \lim_{x \to -1} \frac{x+1}{(x+1)(x^2-x+1)} = \lim_{x \to -1} \frac{1}{x^2-x+1} = \frac{1}{1+1+1} = \frac{1}{3}$$

(h)
$$\lim_{x\to 2} \frac{x^3 - 8}{x - 2} = \lim_{x\to 2} \frac{(x - 2)(x^2 + 2x + 4)}{x - 2} = \lim_{x\to 2} (x^2 + 2x + 4) = 4 + 4 + 4 = 12$$

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Stage 3

1.

- (a) (2)
 - (-1)

(not exist)

(b) (1) MATHS (not exist)

- (c) (2)
 - (2)
 - (2)
- (d) (0)
 - (0)
 - (0)

2. (i) $\lim_{x \to 1^+} f(x) = \lim_{x \to 1^+} x = 1$

 $\lim_{x \to \Gamma} f(x) = \lim_{x \to \Gamma} (-x)^{\frac{1}{2}} = -1$

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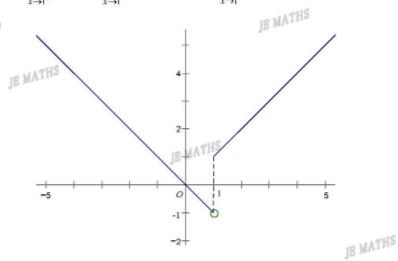
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JE MATHS

(ii) As $\lim_{x \to 1^+} f(x) \neq \lim_{x \to 1^-} f(x)$, hence $\lim_{x \to 1} f(x)$ does NOT exist.

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(iii)



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From the graph, $\lim_{x\to 1} f(x)$ does NOT exist.

3. (i) $\lim_{x \to 0^+} f(x) = \lim_{x \to 0^+} (x^2 + 1) = 0 + 1 = 1$

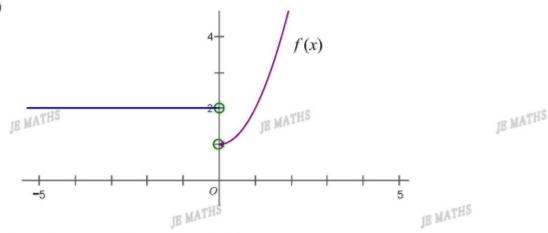
 $\lim_{x \to 0^{-}} f(x) = \lim_{x \to 0^{-}} 2 = 2$

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(ii) As $\lim_{x\to 0^+} f(x) \neq \lim_{x\to 0^-} f(x)$, hence $\lim_{x\to 0} f(x)$ does NOT exist.

(iii)



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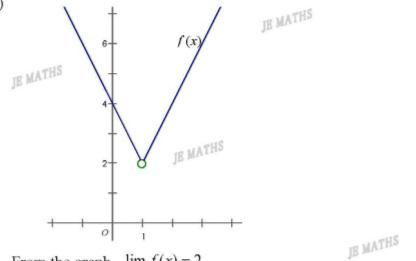
From the graph, $\lim_{x\to 0} f(x)$ does NOT exist.

4. (i)
$$\lim_{x \to 1^+} f(x) = \lim_{x \to 1^+} (2x) = 2 \times 1 = 2$$

$$\lim_{x \to 1^{-}} f(x) = \lim_{x \to 1^{-}} (4 - 2x) = 4 - 2 \times 1 = 2$$

JE MATHS (ii) As $\lim_{x \to 1^+} f(x) = \lim_{x \to 1^-} f(x) = 2$, hence $\lim_{x \to 0} f(x)$ does exist and $\lim_{x \to 1} f(x) = 2$.

(111)



From the graph, $\lim_{x \to a} f(x) = 2$.

5. (i)
$$f(x) = \begin{cases} x+2 & \text{for } x \ge -2 \\ -x-2 & \text{for } x < -2 \end{cases}$$

(ii)
$$\lim_{x \to -2^+} f(x) = \lim_{x \to -2^+} (x+2) = -2 + 2 = 0$$

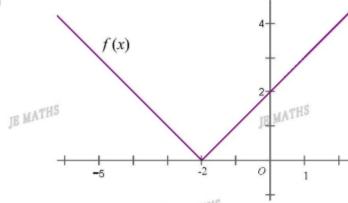
$$\lim_{x \to -2^{-}} f(x) = \lim_{x \to -2^{-}} (-x - 2) = -(-2) - 2 = 0$$

(iii) yes,
$$\lim_{x \to -2} f(x)$$
 does exist as $\lim_{x \to -2^+} f(x) = \lim_{x \to 2^-} f(x) = 0$.

$$\lim_{x \to -2} f(x) = 0$$

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(iii)



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From the graph, $\lim_{x\to -2} f(x) \stackrel{\text{def}}{=} 0$.

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- 6. (a) $\lim_{x \to 0^+} f(x) = \lim_{x \to 0^+} (x+3) = 0 + 3 = 3$ (for domain all real x)
 - (b) $\lim_{x\to 0^+} f(x) = \lim_{x\to 0^+} (x+3) = 0+3=3$ (for domain such that x>0)

7.

- (a) $\lim_{x \to 0^+} \frac{x}{|x|} = \lim_{x \to 0^+} \frac{x}{x} = \lim_{x \to 0^+} 1 = 1$ (as when $x \to 0^+$, x > 0 and |x| = x)
- (b) $\lim_{x \to 0} \frac{x}{|x|} = \lim_{x \to 0} \frac{x}{-x} = \lim_{x \to 0} (-1) = -1$ (as when $x \to 0^-$, x < 0 and |x| = -x)
- (c) $\lim_{x \to 2^+} \frac{|x-2|}{x-2} = \lim_{x \to 2^+} \frac{x-2}{x-2} = \lim_{x \to 2^+} 1 = 1$ (as when $x \to 2^+$, x > 2 and |x-2| = x 2)
- (d) $\lim_{x \to 2^-} \frac{|x-2|}{x-2} = \lim_{x \to 2^-} \frac{-(x-2)}{x-2} = \lim_{x \to 2^-} (-1) = -1$ (as when $x \to 2^-$, x < 2 and |x-2| = -(x-2))
- (e) $\lim_{x\to 2^+} \sqrt{x-2} = \sqrt{2-2} = 0$
- (f) $\lim_{x \to 1^{-}} \sqrt{1 x^2} = \sqrt{1 1} = 0$

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Stage 4

1.
$$\lim_{x \to 0^+} \frac{1}{x} = \frac{1}{0^+} = +\infty$$
$$\lim_{x \to 0^-} \frac{1}{x} = \frac{1}{0^-} = -\infty$$

$$\lim_{x \to +\infty} \frac{1}{x} = \frac{1}{x} = 0$$

$$\lim_{x \to -\infty} \frac{1}{x} = \frac{1}{-\infty} = 0$$

2.
$$\lim_{x \to -2^+} \frac{1}{x+2} = \frac{1}{(-2)^+ + 2} = \frac{1}{0^+} = +\infty$$

$$\lim_{x \to 2^{-}} \frac{1}{x+2} = \frac{1}{(-2)^{-} + 2} = \frac{1}{0^{-}} = -\infty$$

$$\lim_{x \to +\infty} \frac{1}{x+2} = \frac{1}{+\infty + 2} = \frac{1}{+\infty} = 0$$

$$\lim_{x \to -\infty} \frac{1}{x+2} = \frac{1}{-\infty + 2} = \frac{1}{-\infty} = 0$$

3.
$$\lim_{x \to 3^+} \frac{1}{3 - x} = \frac{1}{3 - 3^+} = \frac{1}{0^-} = -\infty$$

$$\lim_{x \to 3^-} \frac{1}{3 - x} = \frac{1}{3 - 3^-} = \frac{1}{0^+} = +\infty$$

$$\lim_{x \to +\infty} \frac{1}{3 - (+\infty)} = \frac{1}{-\infty} = 0$$

$$\lim_{x \to \infty} \frac{1}{3 - x} = \frac{1}{3 - (-\infty)} = \frac{1}{+\infty} = 0$$

(a)
$$\lim_{x\to\infty} \frac{1}{x-1} = \frac{1}{\infty - 1} = \frac{1}{\infty} = 0 \text{ JB MATHS}$$

(b)
$$\lim_{x\to\infty} \frac{1}{x+4} = \frac{1}{\infty+4} = \frac{1}{\infty} = 0$$

(c)
$$\lim_{x\to\infty} \frac{1}{2x+3} = \frac{1}{2\times\infty+3} = \frac{1}{\infty} = 0$$

(d)
$$\lim_{x \to \infty} \frac{1}{5 - x} = \frac{1}{5^{||| - \infty||}} \frac{1}{-\infty} = 0$$

(e)
$$\lim_{x \to \infty} \frac{x-1}{x+1} = \lim_{x \to \infty} \frac{1 - \frac{1}{x}}{1 + \frac{1}{x}} = \frac{1 - \frac{1}{\infty}}{1 + \frac{1}{\infty}} = \frac{1 - 0}{1 + 0} = 1$$

(f)
$$\lim_{x \to \infty} \frac{x}{2x+3} = \lim_{x \to \infty} \frac{1}{2+\frac{3}{x}} = \lim_{x \to \infty} \frac{1}{2+\frac{3}{\infty}} = \frac{1}{2+0} = \frac{1}{2}$$

JE MATHS

JE MATHS

JE MATHS

(g)
$$\lim_{x \to \infty} \frac{x-1}{5-x} = \lim_{x \to \infty} \frac{1-\frac{1}{x}}{\frac{5}{x}-1} = \frac{1-\frac{1}{\infty}}{\frac{5}{\infty}-1} = \frac{1-0}{0-1} = -1$$

(h)
$$\lim_{x \to \infty} \frac{3x-1}{x+4} = \lim_{x \to \infty} \frac{3-\frac{1}{x}}{1+\frac{4}{x}} = \frac{3-\frac{1}{\infty}}{1+\frac{4}{\infty}} = \frac{3-0}{1+0} = 3_{\text{EMATHS}}$$

JE MATHS

(i)
$$\lim_{x \to \infty} \frac{1}{x^2 + 1} = \frac{1}{\infty^2 + 1} = \frac{1}{\infty} = 0$$

(j)
$$\lim_{x \to \infty} \frac{2x}{x^2 + 1} = \lim_{x \to \infty} \frac{2}{x + \frac{1}{x}} = \frac{\sqrt{2} \, \text{MATHS}}{\infty + \frac{1}{\infty}} = \frac{2}{\infty + 0} = \frac{2}{\infty} = 0$$

JE MATHS

(k)
$$\lim_{x \to \infty} \frac{3x^2}{x^2 + 1} = \lim_{x \to \infty} \frac{3}{1 + \frac{1}{x^2}} = \frac{3}{1 + \frac{1}{\infty^2}} = \frac{3}{1 + 0} = 3$$

IN MATHS

(1)
$$\lim_{x \to \infty} \frac{x^2 + x}{x^2 + 1} = \lim_{x \to \infty} \frac{1 + \frac{1}{x}}{1 + \frac{1}{x^2}} = \frac{1 + \frac{1}{\infty}}{1 + \frac{1}{\infty^2}} = \frac{1 + 0}{1 + 0} = 1$$

5.

(a)
$$\lim_{x\to 1^+} \frac{1}{x-1} = \frac{1}{1^+-1} = \frac{1}{0^+} = +\infty$$

JE MATHS

(b)
$$\lim_{x\to 1^-} \frac{1}{x-1} = \frac{1}{1-1} = \frac{1}{0} = -\infty$$

(c)
$$\lim_{x \to -1^+} \frac{1}{x+4} = \frac{1}{(-4)^+ + 4} = \frac{1}{0^+} = \frac{1}{1} = \frac{1}$$

(d)
$$\lim_{x \to -1} \frac{1}{x+4} = \frac{1}{(-4)^{-} + 4} = \frac{1}{0^{-}} = -\infty$$

(e)
$$\lim_{x\to 2^+} \frac{1}{2x-4} = \frac{1}{2\times 2^+ - 4} = \frac{1}{4^+ - 4} = \frac{1}{0^+} = +\infty$$

JE MATHS

JE MATHS

(f)
$$\lim_{x\to 2^{-}} \frac{1}{2x-4} = \frac{1}{2\times 2^{-}-4} = \frac{1}{4^{-}-4} = \frac{1}{0^{-}} = -\infty$$

(g)
$$\lim_{x \to \frac{1}{3}^+} \frac{1}{1 - 3x} = \frac{1}{1 - 3 \times \left(\frac{1}{3}\right)^+} = \frac{1}{1 - 1^+} = \frac{1}{0^-} = -\infty$$

(h)
$$\lim_{x \to \frac{1}{3}^{-}} \frac{\text{MATHS}}{1 - 3x} = \frac{1}{1 - 3 \times \left(\frac{1}{3}\right)^{-}} = \frac{1}{1 - 1^{-}} = \frac{1}{0^{+}} = \frac{1}{1 - 1} = \frac{1}{0^{+}} = \frac{1}{1 - 1} = \frac{1}{0^{+}} = \frac{1}{1 - 1} = \frac{1}{0 + 1} = \frac{1}{1 - 1} = \frac{$$