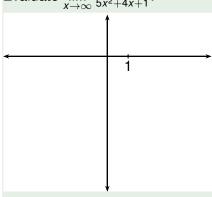
Calculus I

Type 1: $\lim_{x\to\infty}$ of rational function.

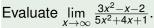
Todor Milev

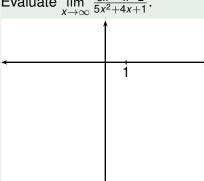
2019

Evaluate $\lim_{x\to\infty} \frac{3x^2-x-2}{5x^2+4x+1}$.

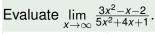


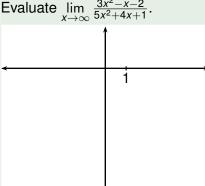
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)}$$



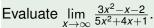


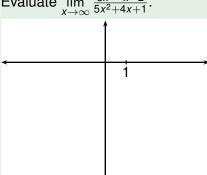
$$\lim_{x\to\infty}\frac{\left(3x^2-x-2\right)}{\left(5x^2+4x+1\right)}$$





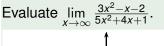
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

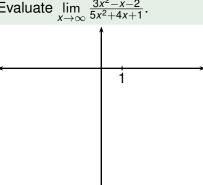




$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

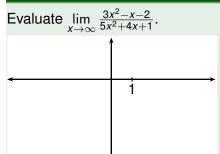
$$= \lim_{x \to \infty} \frac{?}{}$$





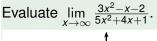
denominator.
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

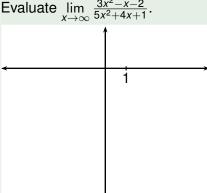
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{\frac{1}{x^2}}$$



denominator.
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

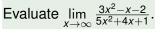
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{?}$$

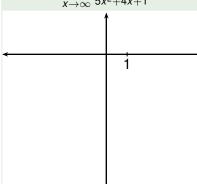




$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$



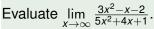


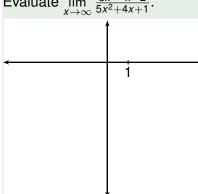
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} 3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}$$

$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$



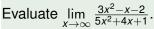


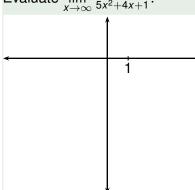
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} \frac{3 - \lim_{x \to \infty} \frac{1}{x} - 2\lim_{x \to \infty} \frac{1}{x^2}}{\lim_{x \to \infty} 5 + 4\lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}}$$

$$= \frac{? - ? - ?}{? + ? + ?}$$





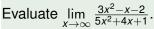
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

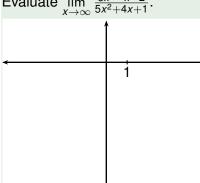
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} 3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}$$

$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$

$$= \frac{3 - ? - ?}{? + ? + ?}$$





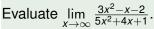
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

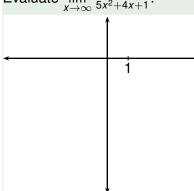
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} 3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}$$

$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$

$$= \frac{3 - ? - ?}{? + ? + ?}$$





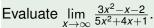
$$\lim_{x \to \infty} \frac{\left(3x^2 - x - 2\right)}{\left(5x^2 + 4x + 1\right)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

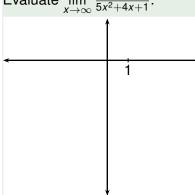
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} 3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}$$

$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$

$$= \frac{3 - 0 - ?}{? + ? + ?}$$





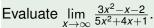
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

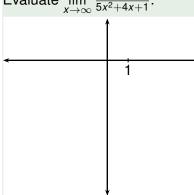
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

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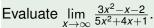
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

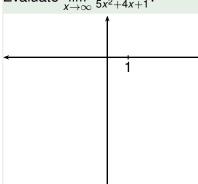
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} 3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}$$

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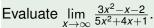
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

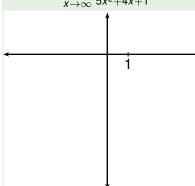
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$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$

$$= \frac{3 - 0 - 0}{? + ? + ?}$$





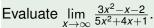
$$\lim_{x \to \infty} \frac{\left(3x^2 - x - 2\right)}{\left(5x^2 + 4x + 1\right)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

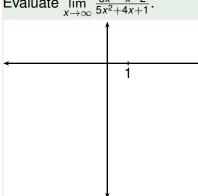
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

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$$= \frac{3 - 0 - 0}{5 + ? + ?}$$





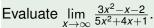
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

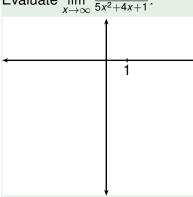
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} 3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}$$

$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$

$$= \frac{3 - 0 - 0}{5 + \frac{2}{x^2} + \frac{2}{x^2}}$$





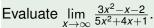
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

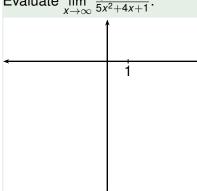
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} 3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}$$

$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$

$$= \frac{3 - 0 - 0}{5 + 0 + ?}$$





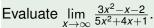
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

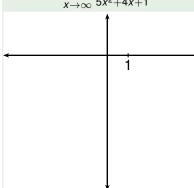
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} 3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}$$

$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$

$$= \frac{3 - 0 - 0}{5 + 0 + ?}$$





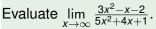
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

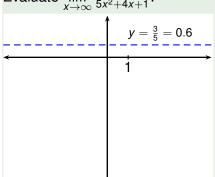
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$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$

$$= \frac{3 - 0 - 0}{5 + 0 + 0}$$





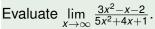
$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

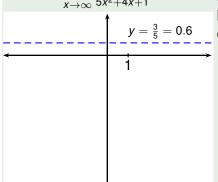
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$$= \lim_{x \to \infty} 3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}$$

$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$

$$= \frac{3 - 0 - 0}{5 + 0 + 0} = \frac{3}{5}$$





A similar calculation shows that the limit as $x \to -\infty$ is also $\frac{3}{5}$.

$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

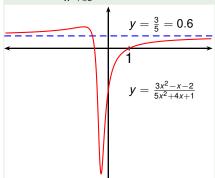
$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} 3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}$$

$$\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}$$

$$= \frac{3 - 0 - 0}{5 + 0 + 0} = \frac{3}{5}$$

Evaluate $\lim_{x\to\infty} \frac{3x^2-x-2}{5x^2+4x+1}$.



A similar calculation shows that the limit as $x \to -\infty$ is also $\frac{3}{5}$.

$$\lim_{x \to \infty} \frac{(3x^2 - x - 2)}{(5x^2 + 4x + 1)} \cdot \frac{\frac{1}{x^2}}{\frac{1}{x^2}}$$

$$= \lim_{x \to \infty} \frac{3 - \frac{1}{x} - \frac{2}{x^2}}{5 + \frac{4}{x} + \frac{1}{x^2}}$$

$$= \lim_{x \to \infty} \frac{3 - \lim_{x \to \infty} \frac{1}{x} - 2 \lim_{x \to \infty} \frac{1}{x^2}}{\lim_{x \to \infty} 5 + 4 \lim_{x \to \infty} \frac{1}{x} + \lim_{x \to \infty} \frac{1}{x^2}}$$

$$= \frac{3 - 0 - 0}{5 + 0 + 0} = \frac{3}{5}$$