

# Mathematical Concepts Presentation

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# Introduction & Objectives

## Presentation Goals:

- Introduce fundamental set theory concepts
- Explain common mathematical sets
- Demonstrate calculus product rule
- Show practical applications

## Key Topics:

- Sets and elements
- Special number sets ( $\mathbb{N}$ ,  $\mathbb{Z}$ ,  $\mathbb{Q}$ ,  $\mathbb{R}$ )
- Derivative product rule



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# Set Theory Fundamentals

## Basic Definitions:

- Set: Collection of objects
- Example:  
 $Z = \{\text{cow}, \text{pig}, \text{elephant}\}$
- Element:  $\text{cow} \in Z$
- Common sets:
  - $\mathbb{N} = \{1, 2, 3, \dots\}$  (Natural)
  - $\mathbb{Z} = \{\dots, -2, -1, 0, 1, 2, \dots\}$  (Integer)
  - $\mathbb{Q} = \{p/q : p, q \in \mathbb{Z}, q \neq 0\}$  (Rational)
  - $\mathbb{R} = \text{Decimal numbers}$  (Real)

## Set Operations:

- Union:  
 $A \cup B = \{x : x \in A \text{ or } x \in B\}$
- Intersection:  
 $A \cap B = \{x : x \in A \text{ and } x \in B\}$
- Difference:  
 $A \setminus B = \{x : x \in A \text{ and } x \notin B\}$

**Example:** If  $A = \{1, 2, 3\}$  and  $B = \{2, 3, 4\}$ :

- $A \cup B = \{1, 2, 3, 4\}$
- $A \cap B = \{2, 3\}$
- $A \setminus B = \{1\}$

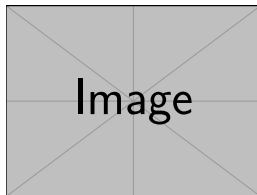
# Calculus: Product Rule

## Product Rule Formula:

$$\frac{d}{dx}[f(x)g(x)] = f'(x)g(x) + f(x)g'(x)$$

**Example:** For  $f(x) = x^2 \cdot \sin(x)$ :

$$\begin{aligned} f'(x) &= \frac{d}{dx}(x^2) \cdot \sin(x) + x^2 \cdot \frac{d}{dx}(\sin(x)) \\ &= 2x \cdot \sin(x) + x^2 \cdot \cos(x) \end{aligned}$$



Visual: Product rule

## Proof Outline:

- Start with definition:
$$f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$$
- For  $f(x) = g(x)h(x)$ :
- Add and subtract  $g(x+h)h(x)$
- Result:  $f'(x) = g(x)h'(x) + g'(x)h(x)$

**Key Insight:** The derivative of a product is NOT the product of derivatives!

$$(fg)' \neq f'g'$$

# Applications & Conclusion

## Applications:

- **Physics:** Motion equations, force calculations
- **Engineering:** Signal processing, control systems
- **Computer Science:** Algorithms, machine learning
- **Economics:** Optimization, modeling



## Key Takeaways:

- 1 Sets provide foundation for mathematical structures
- 2 Product rule is essential for calculus operations
- 3 These concepts enable real-world problem solving

**Thank You!**

Questions?

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