

## Order of Operations

J. Garvin



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## Number Systems

### Recap

To what number system(s) does the number  $-0.75$  belong?

Since  $-0.75$  can be represented as  $-\frac{75}{100} = -\frac{3}{4}$ ,  $-0.75$  is a rational number. It is also a real number.

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## Order of Operations

Consider the expression  $6 + 18 \div 2$ .

If we add 6 and 18, we obtain 24 which, when divided by 2, is 12.

If we divide 18 by 2, we obtain 9 which, when added to 6, is 15.

Clearly, if we want to ensure consistency when interpreting the expression, we need a set of rules to specify which operations are performed before others.

This set of rules is usually referred to as the "order of mathematical operations."

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## Order of Operations

### Order of Mathematical Operations

When evaluating a mathematical expression, perform operations in the following order:

- Brackets (inside)
- Exponents (and radicals)
- Division and Multiplication (left to right)
- Addition and Subtraction (left to right)

A *mnemonic* to remember this order is BEDMAS.

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## Order of Operations

### Example

Evaluate  $5 + 2 \times 3$ .

Since multiplication must be done before addition, perform  $2 \times 3$  first.

$$\begin{aligned} 5 + 2 \times 3 &= 5 + 6 \\ &= 11 \end{aligned}$$

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## Order of Operations

### Example

Evaluate  $10 \cdot (2 + 3)$ .

Recall that the dot is another symbol for multiplication. This time, however, we perform the addition inside of the brackets first.

$$\begin{aligned} 10 \cdot (2 + 3) &= 10 \cdot 5 \\ &= 50 \end{aligned}$$

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## Order of Operations

### Example

Evaluate  $\frac{17-5}{2+4}$ .

The horizontal bar represents division, but both the numerator and denominator *must* be evaluated first.

It is as if the expression were written  $\frac{(17-5)}{(2+4)}$ .

$$\begin{aligned}\frac{17-5}{2+4} &= \frac{12}{6} \\ &= 2\end{aligned}$$

## Order of Operations

### Example

Evaluate  $30 \div 5 \times 3 + 7$ .

Both multiplication and division appear in the expression. Perform them left to right.

$$\begin{aligned}30 \div 5 \times 3 + 7 &= 6 \times 3 + 7 \\ &= 18 + 7 \\ &= 25\end{aligned}$$

If we had multiplied before dividing, we would have obtained the different (and wrong) answer below.

$$\begin{aligned}30 \div 5 \times 3 + 7 &\neq 30 \div 15 + 7 \\ &\neq 2 + 7 \\ &\neq 9\end{aligned}$$

## Order of Operations

### Example

Evaluate  $3(9-4)^2$ .

Perform the subtraction inside of the brackets first, followed by exponentiation, and then multiplication.

$$\begin{aligned}3(9-4)^2 &= 3(5)^2 \\ &= 3 \times 25 \\ &= 75\end{aligned}$$

A common mistake is to multiply before exponentiation, producing an incorrect answer.

$$\begin{aligned}3(9-4)^2 &= 3(5)^2 \\ &\neq 15^2 \\ &\neq 225\end{aligned}$$

## Questions?

