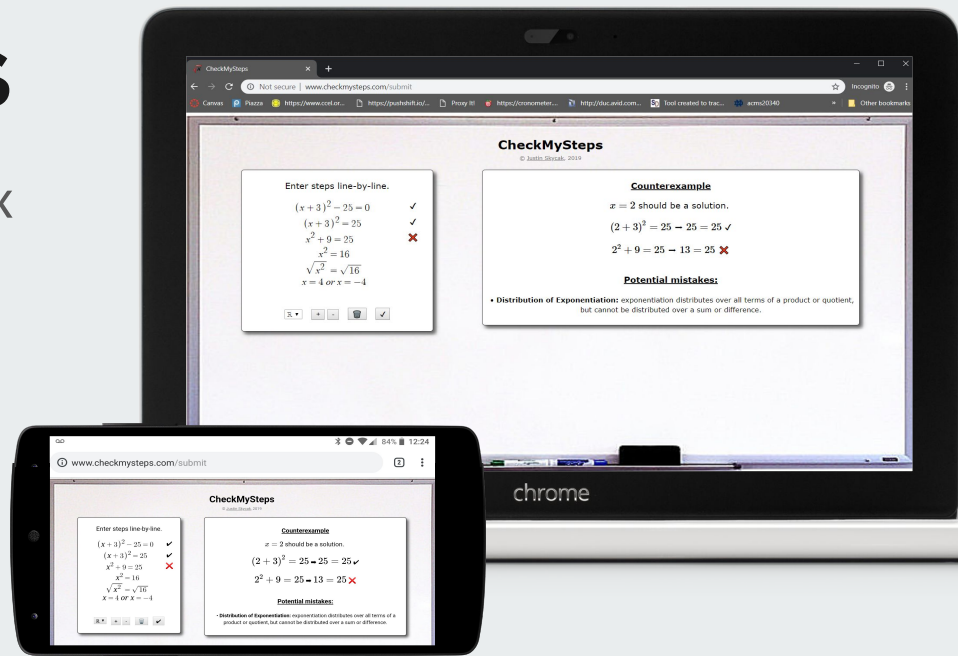




CheckMySteps

A Web App to Help Students Fix their Algebraic Mistakes

Justin Skycak, 2019
Georgia Institute of Technology



2 Categories of Math Mistakes



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Self-Correctable

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NON-Self-Correctable

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→ Student can correct with minimal help.

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↑ **Let’s automate!** ↑

CheckMySteps

© Justin Skycak, 2019

Enter steps line-by-line.

$$(x + 3)^2 - 25 = 0$$

$$(x + 3)^2 = 25$$

$$x^2 + 9 = 25$$

$$x^2 = 16$$

$$\sqrt{x^2} = \sqrt{16}$$

$$x = 4 \text{ or } x = -4$$



1. Students enter their steps line-by-line

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1. Students enter their steps line-by-line
2. Each line is checked against the previous line

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Counterexample

$x = 2$ should be a solution.

$$(2 + 3)^2 = 25 \rightarrow 25 = 25 \quad \checkmark$$

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3. If a mistake is detected, a counterexample is displayed

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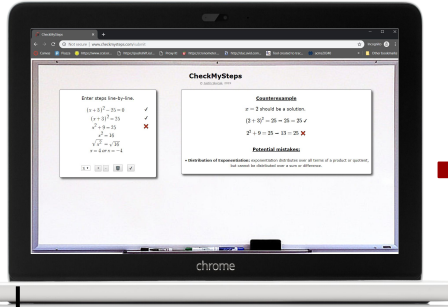
Potential mistakes:

- **Distribution of Exponentiation:** exponentiation distributes over all terms of a product or quotient, but cannot be distributed over a sum or difference.

1. Students enter their steps line-by-line
2. Each line is checked against the previous line
3. If a mistake is detected, a counterexample is displayed along with potential mistakes.

System Design

Deployment



Input

Enter steps line-by-line.

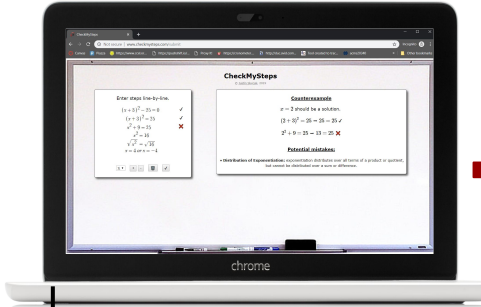
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Ⓜ + - 🗑️ ✓



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Step Checking

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Counterexample

$x = 2$ should be a solution.

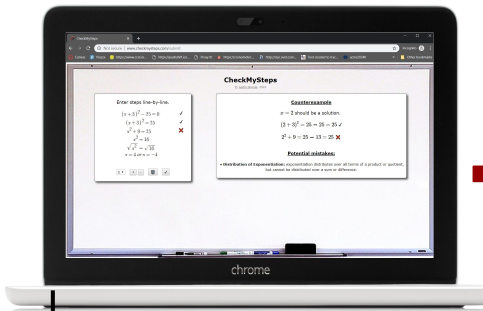
$(2 + 3)^2 = 25 \rightarrow 25 = 25$ ✓

$2^2 + 9 = 25 \rightarrow 13 = 25$ ✗

SymPy

System Design

Deployment



Input

Enter steps line-by-line.

$$(x + 3)^2 - 25 = 0$$
$$(x + 3)^2 = 25$$
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Step Checking

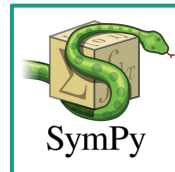
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SymPy

Mistake Classification



- Potential mistakes:**
- **Distribution of Exponentiation:** exponentiation distributes over all terms of a product or quotient, but cannot be distributed over a sum or difference.

System Design - Step Checking (Expressions)

Step

$$(x+3)^2$$

$$x^2 + 6x + 9$$

System Design - Step Checking (Expressions)

Step

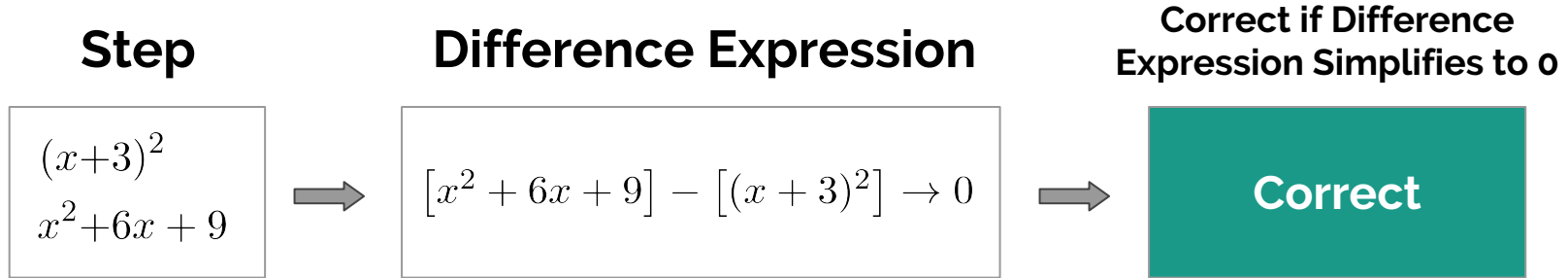
Difference Expression

$$\begin{array}{l} (x+3)^2 \\ x^2 + 6x + 9 \end{array}$$

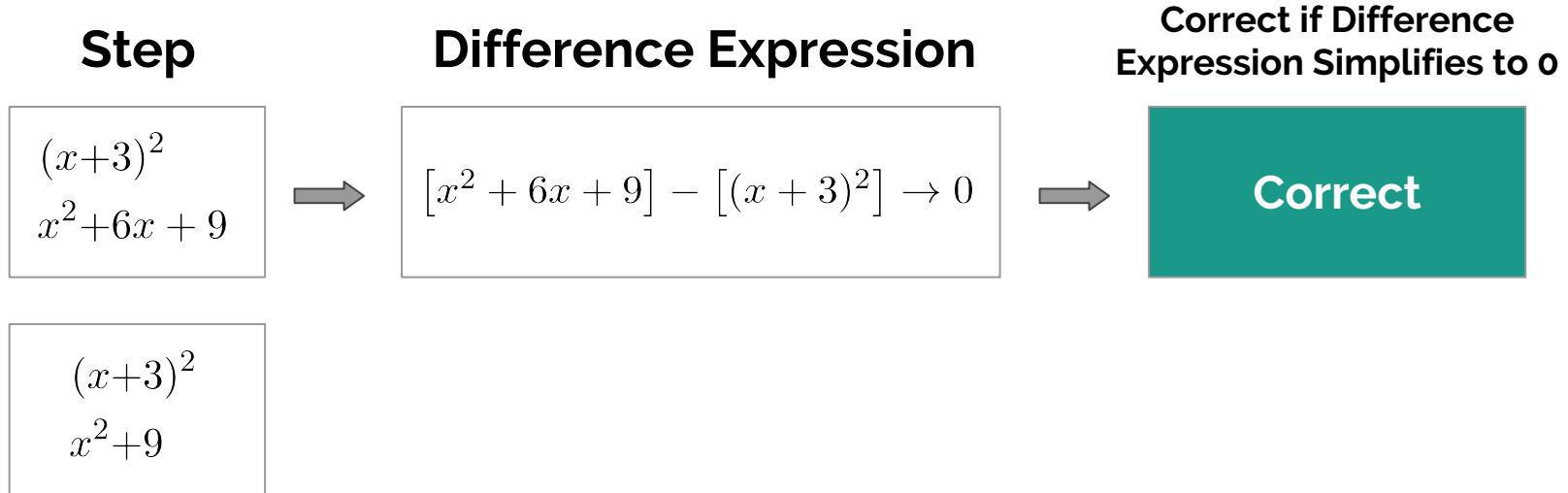


$$[x^2 + 6x + 9] - [(x + 3)^2] \rightarrow 0$$

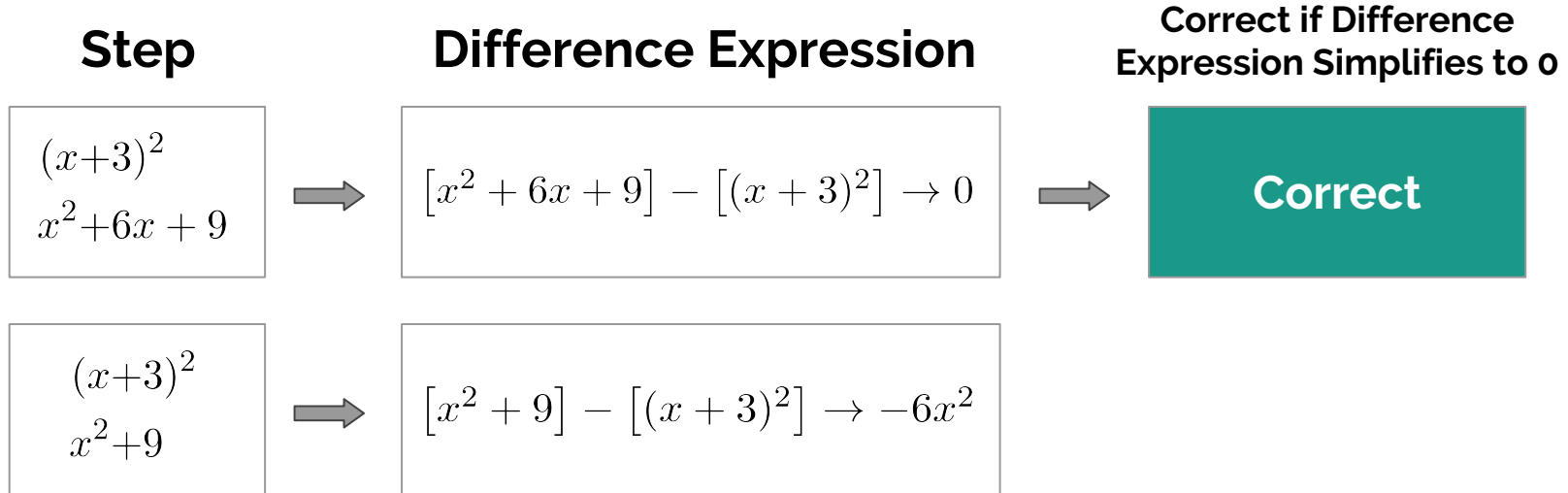
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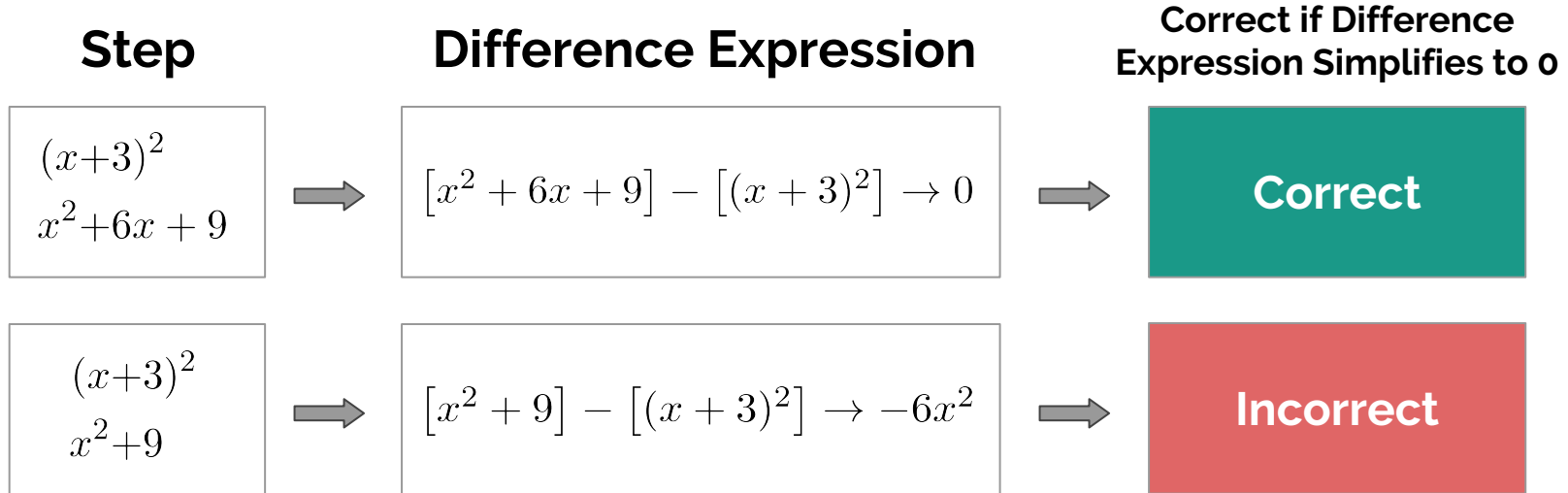
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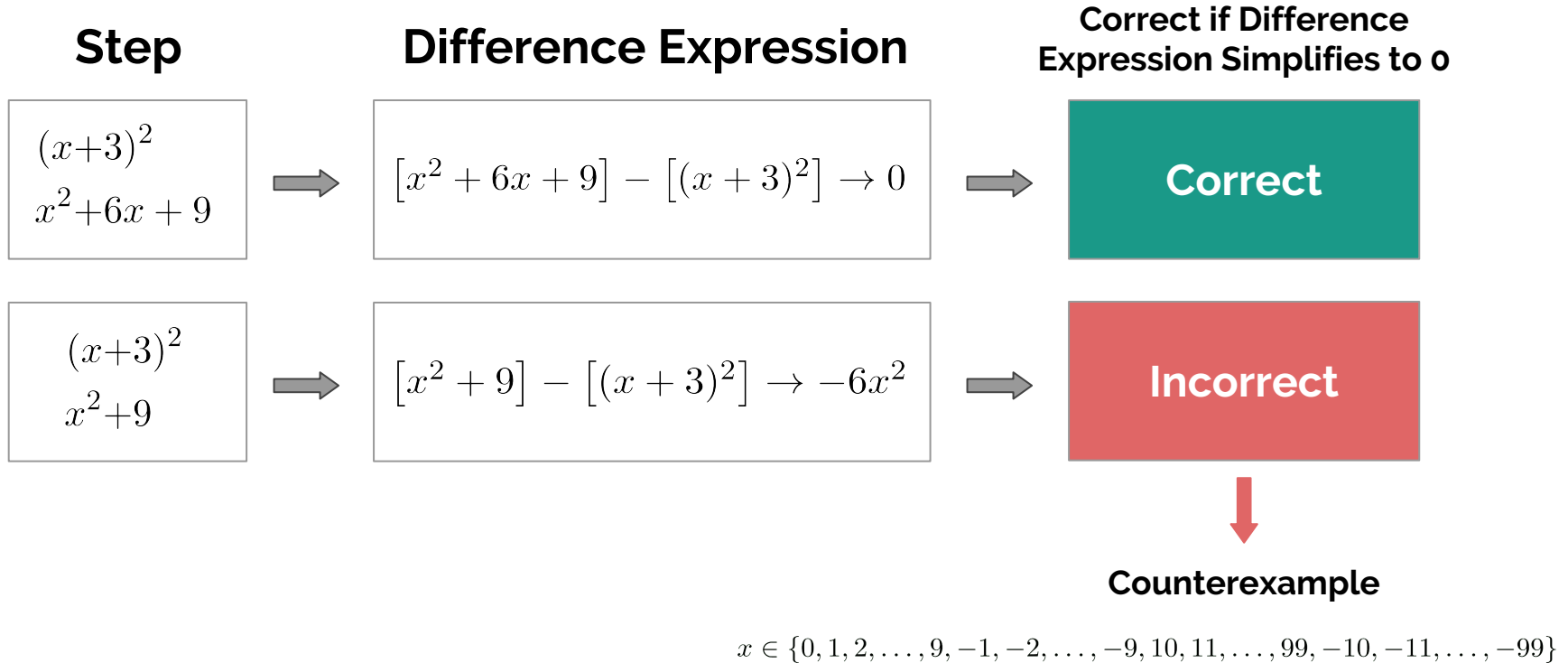
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System Design - Step Checking (Expressions)



System Design - Step Checking (Equations)

Step

$$x^2 - 1 = -(1 - x)$$

$$x^2 - 1 = -1 + x$$

System Design - Step Checking (Equations)

Step

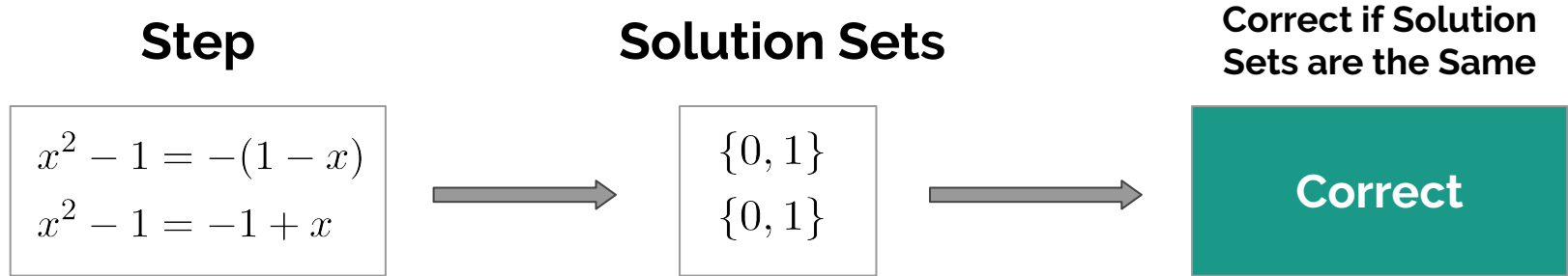
$$x^2 - 1 = -(1 - x)$$
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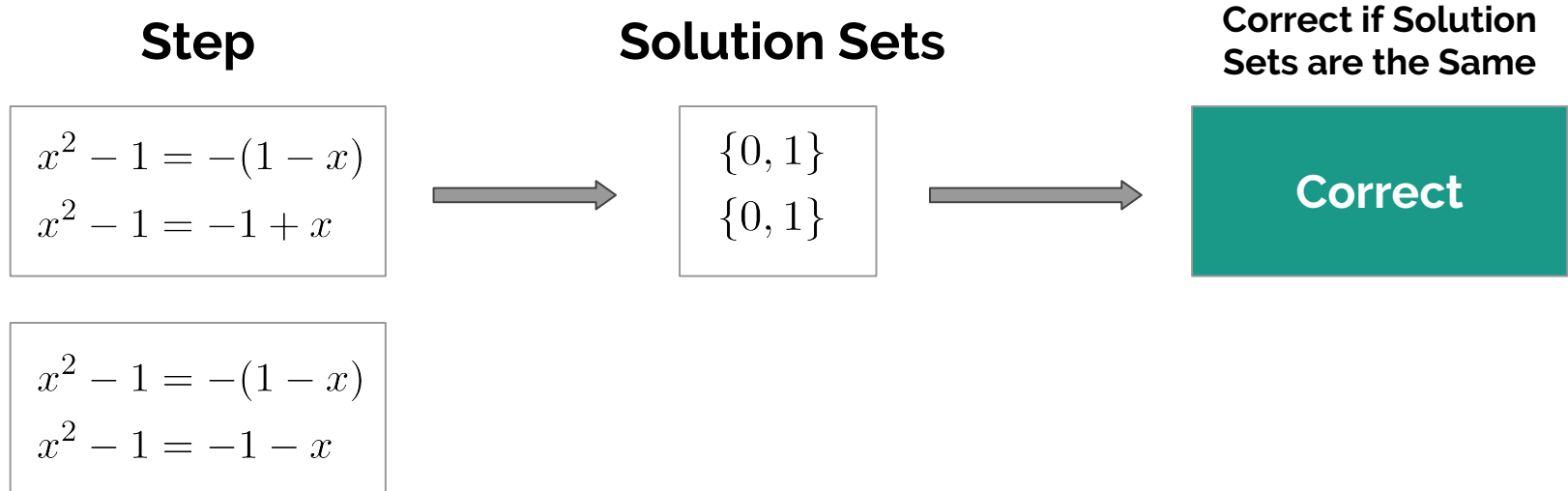
Solution Sets

$$\{0, 1\}$$
$$\{0, 1\}$$

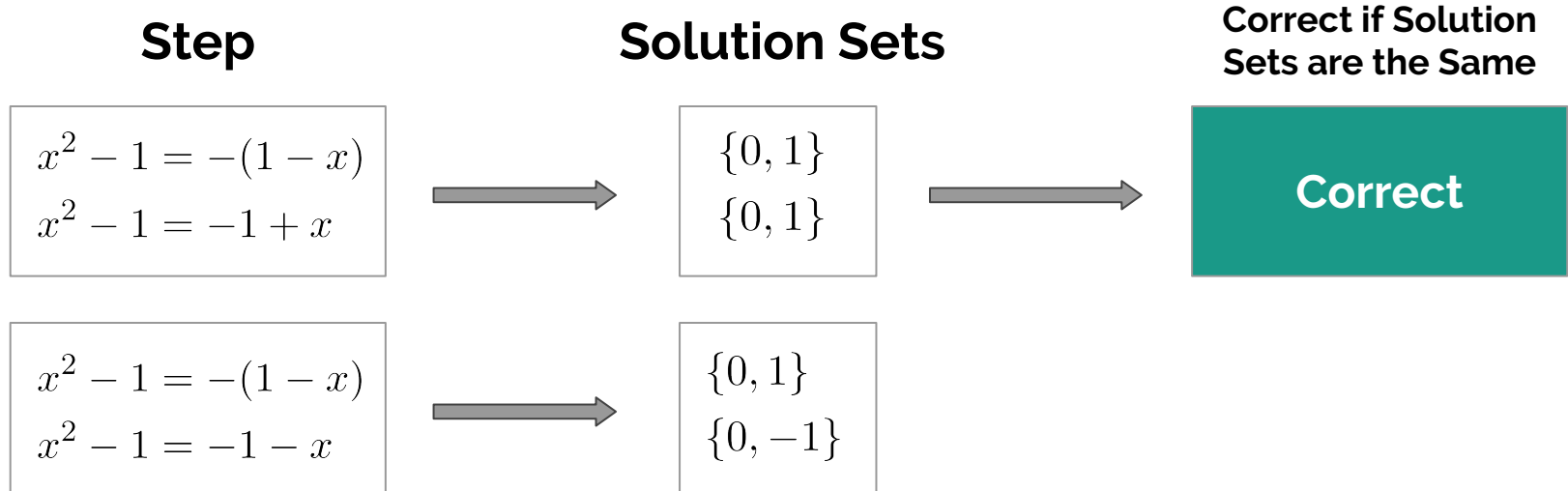
System Design - Step Checking (Equations)



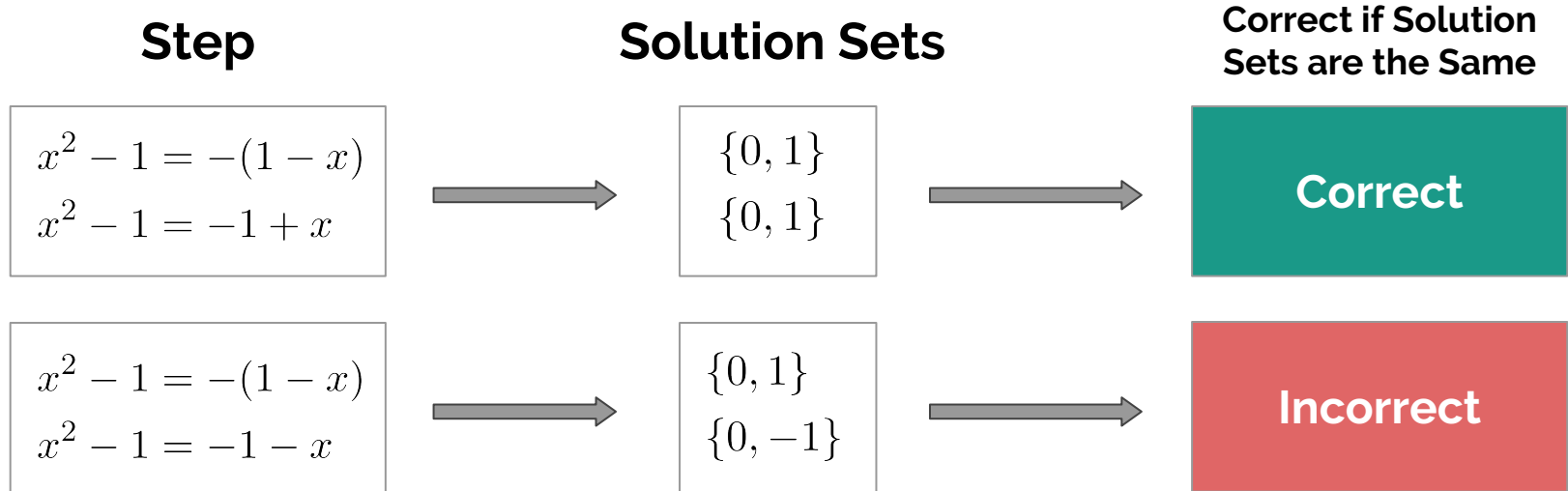
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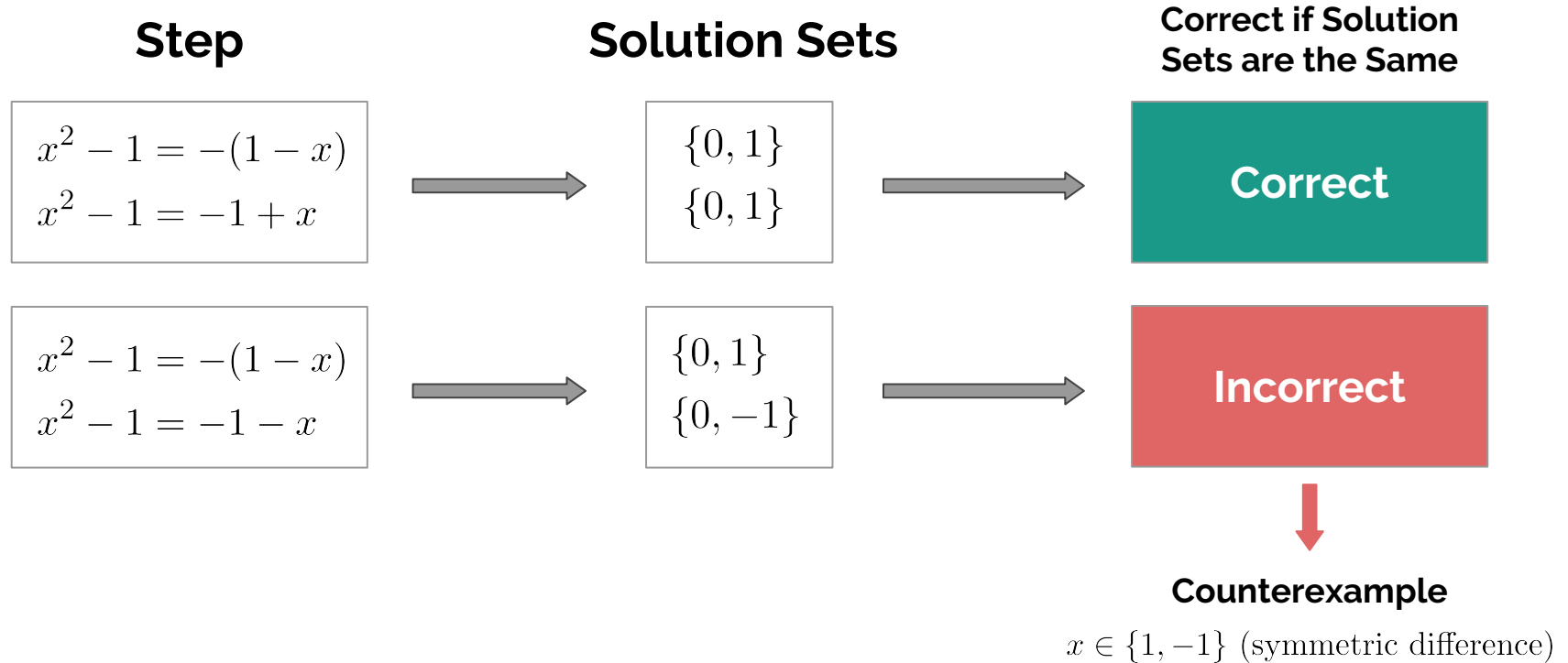
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System Design - Mistake Classification

- Classification rules use the content of the lines preceding and following the mistake.

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- Example:

Positive or Negative Root: if $x^2 = a$, then $x = \pm\sqrt{a}$

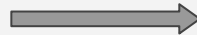
Detection Rule: Previous line is an equation which contains an exponent, and a nonzero current solution is the negative of a previous solution.

Example:

Step

$$x^2 = 3$$

$$x = \sqrt{3}$$



Solution Sets

$$\{\sqrt{3}, -\sqrt{3}\}$$

$$\{\sqrt{3}\}$$

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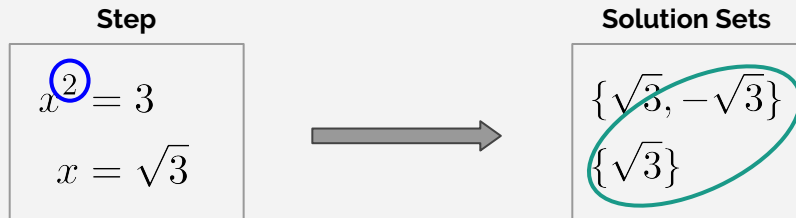
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Example:



Validation

- Test each mistake class on a manually generated example.

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Validation

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- Test CheckMySteps on a sample of algebraic errors generated by a tutor unfamiliar with CheckMySteps.
 - ◆ Sample based on tutor's experiences with real-life students.
 - ◆ CheckMySteps detected a relevant mistake class for **10 of the 14** errors.

Future Work

- More granular mistake classes
 - ◆ E.g. “Negative Sign” mistake class could be separated into “Dropped a Negative Sign” and “Added an Unnecessary Negative Sign.”

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 - ◆ Highlight specific term(s) where mistake occurred.
- Handling equations which can't be solved using standard algebraic techniques
 - ◆ Students not likely to encounter them, but should should handle them in a way more gracefully than timing out.