Welcome to CS143: Compilers

- One Handout
- Today:
  - Course Information
  - Why Study Compilers?
  - A Quick History of Compilers
  - The Structure of a Compiler

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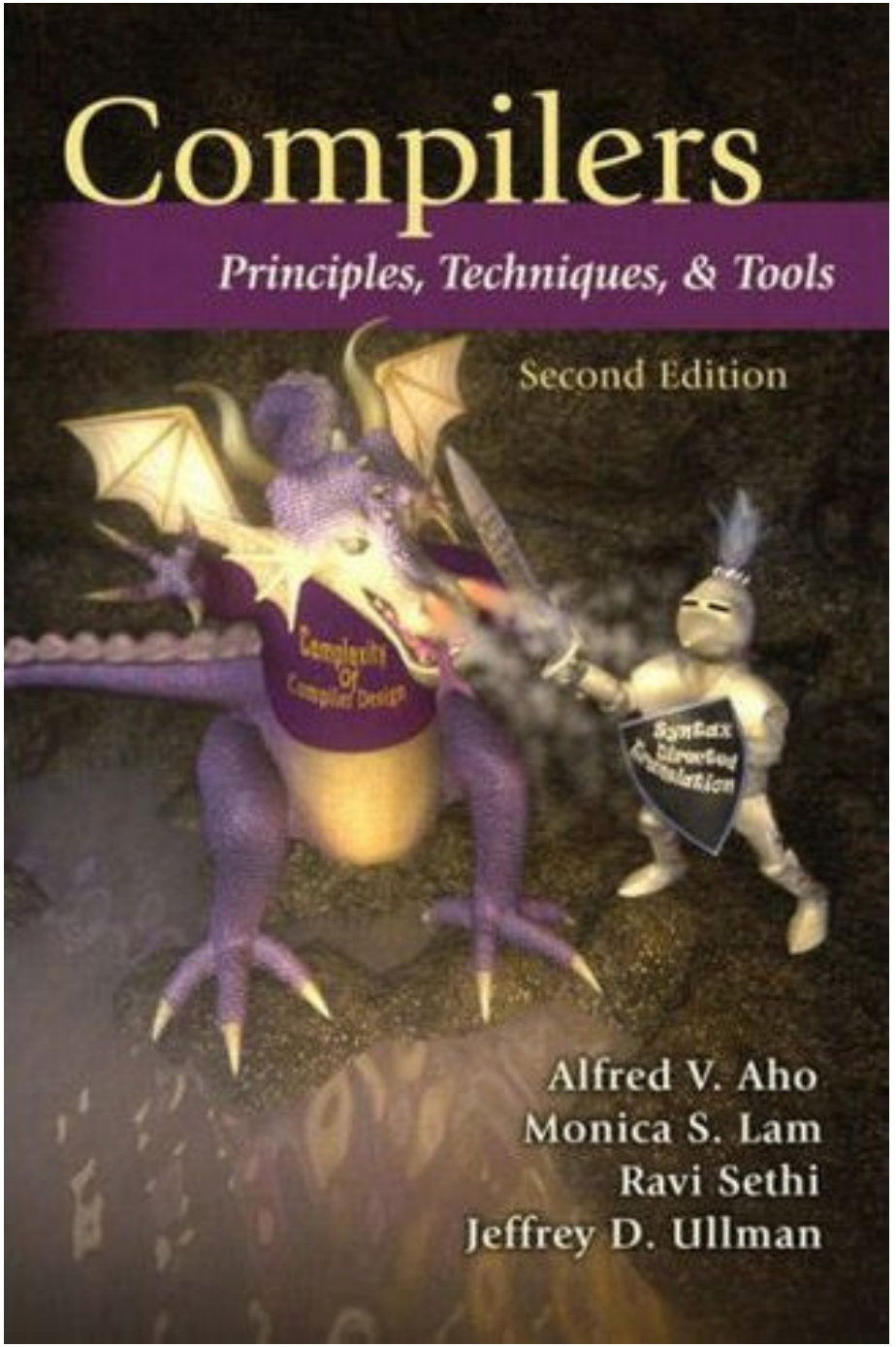

Compilers
Principles, Techniques, & Tools
Second Edition
Alfred V. Aho
Monica S. Lam
Ravi Sethi
Jeffrey D. Ullman

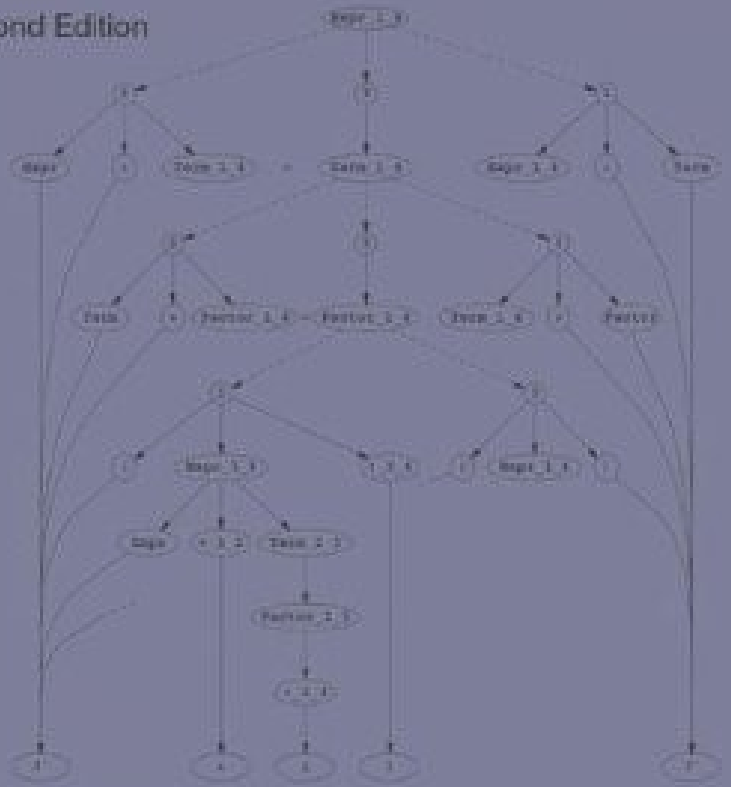
MONOGRAPHS IN COMPUTER SCIENCE

PARSING TECHNIQUES

A Practical Guide

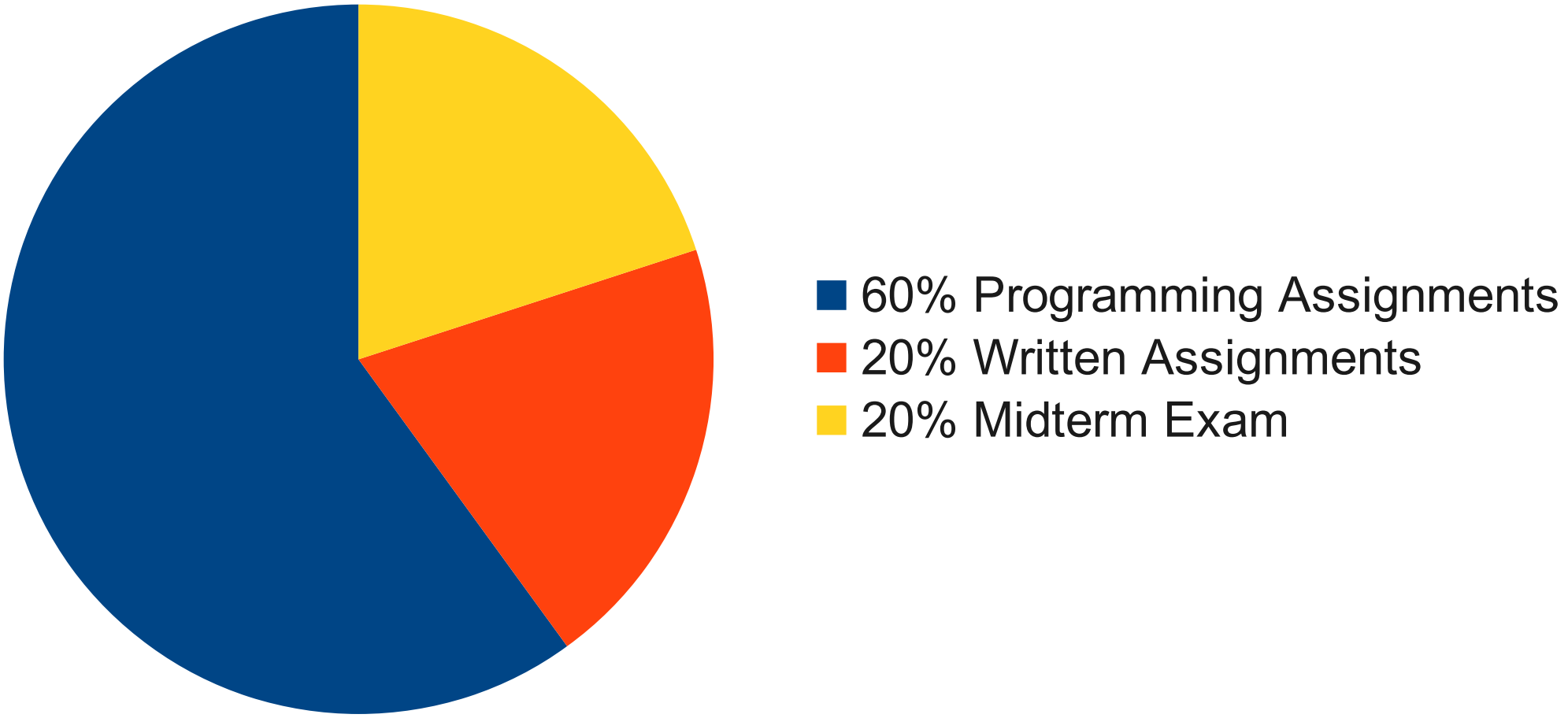
Dick Grune
Ceriel J.H. Jacobs

Second Edition



Springer

Grading Policies



A word on the honor code...

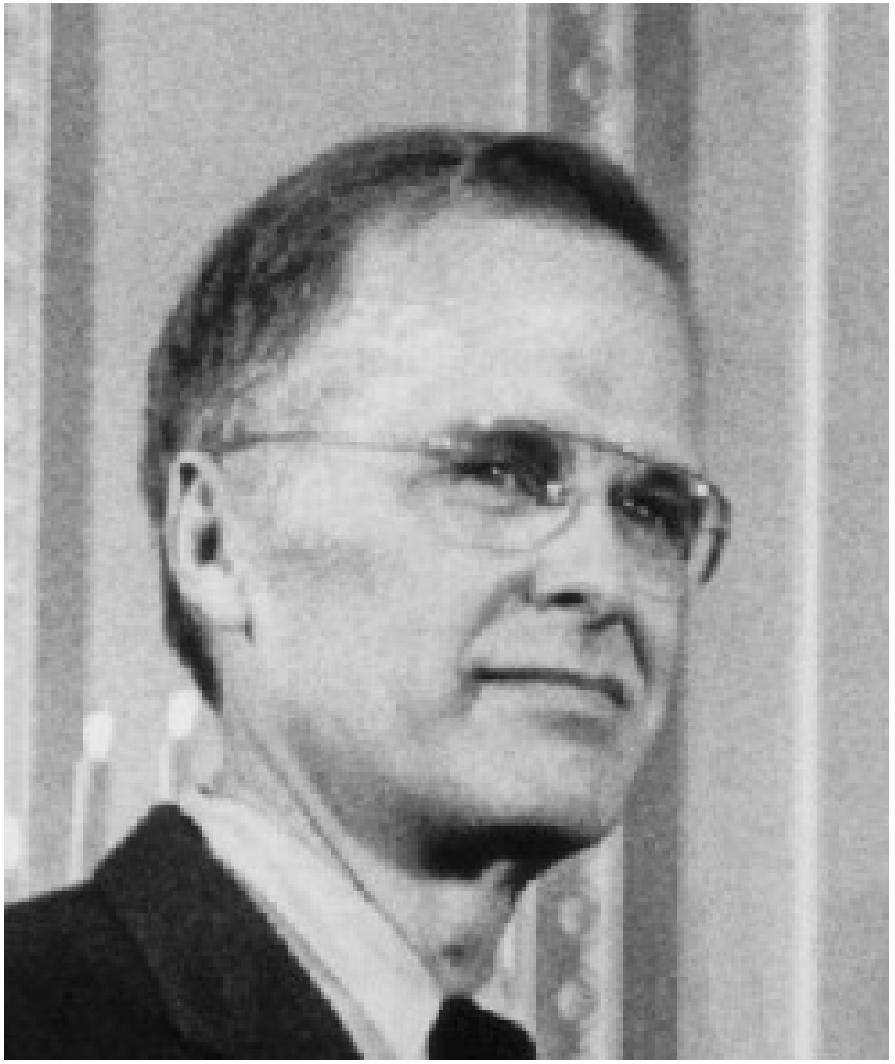
Why Study Compilers?

- Build a **large, ambitious software system**.
- See theory **come to life**.
- Learn how to **build programming languages**.
- Learn **how programming languages work**.
- Learn **tradeoffs in language design**.

A Short History of Compilers

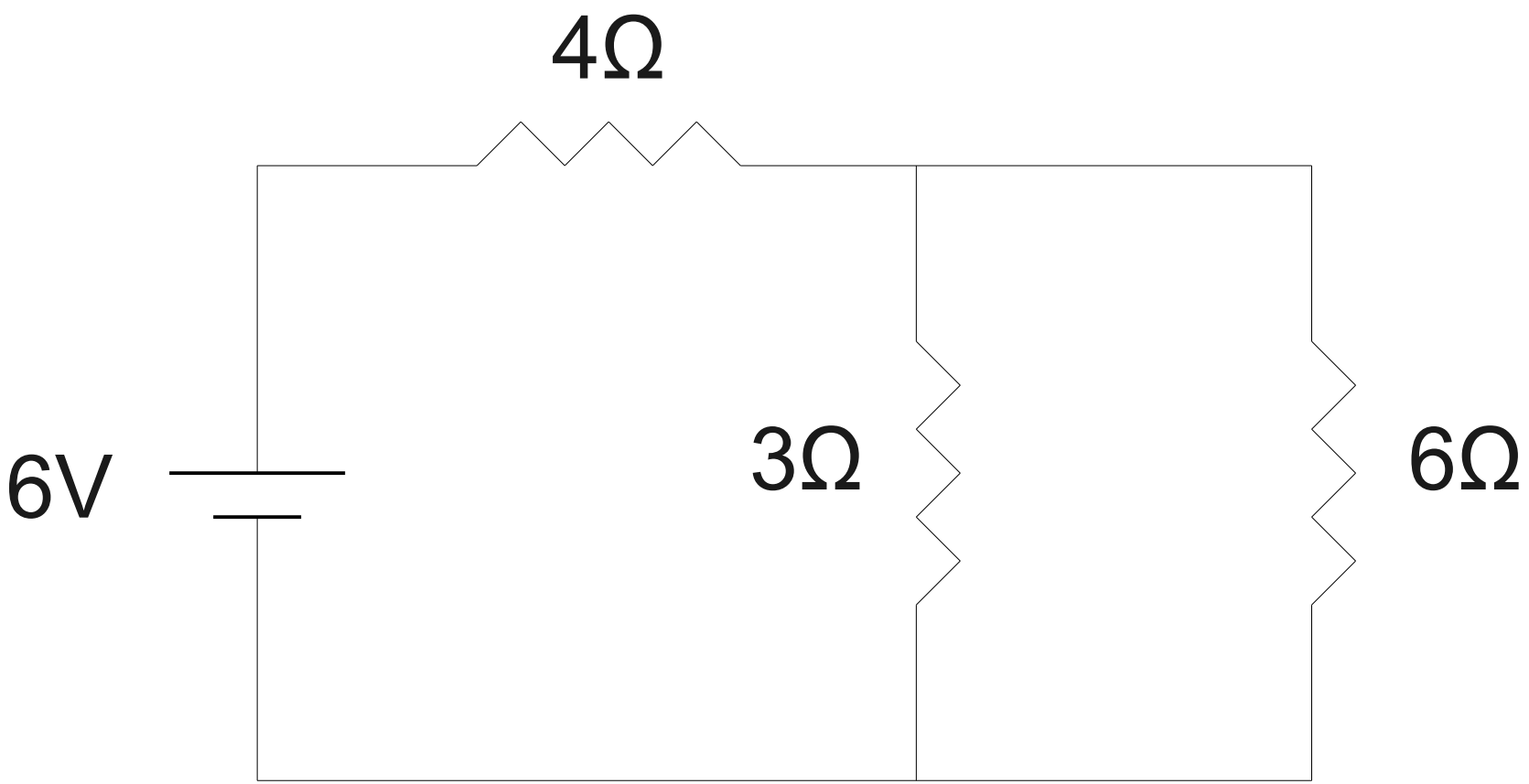
- First, there was nothing.
- Then, there was machine code.
- Then, there were assembly languages.
  - e.g. A-0, A-2
- Programming expensive; 50% of costs for machines went into programming.

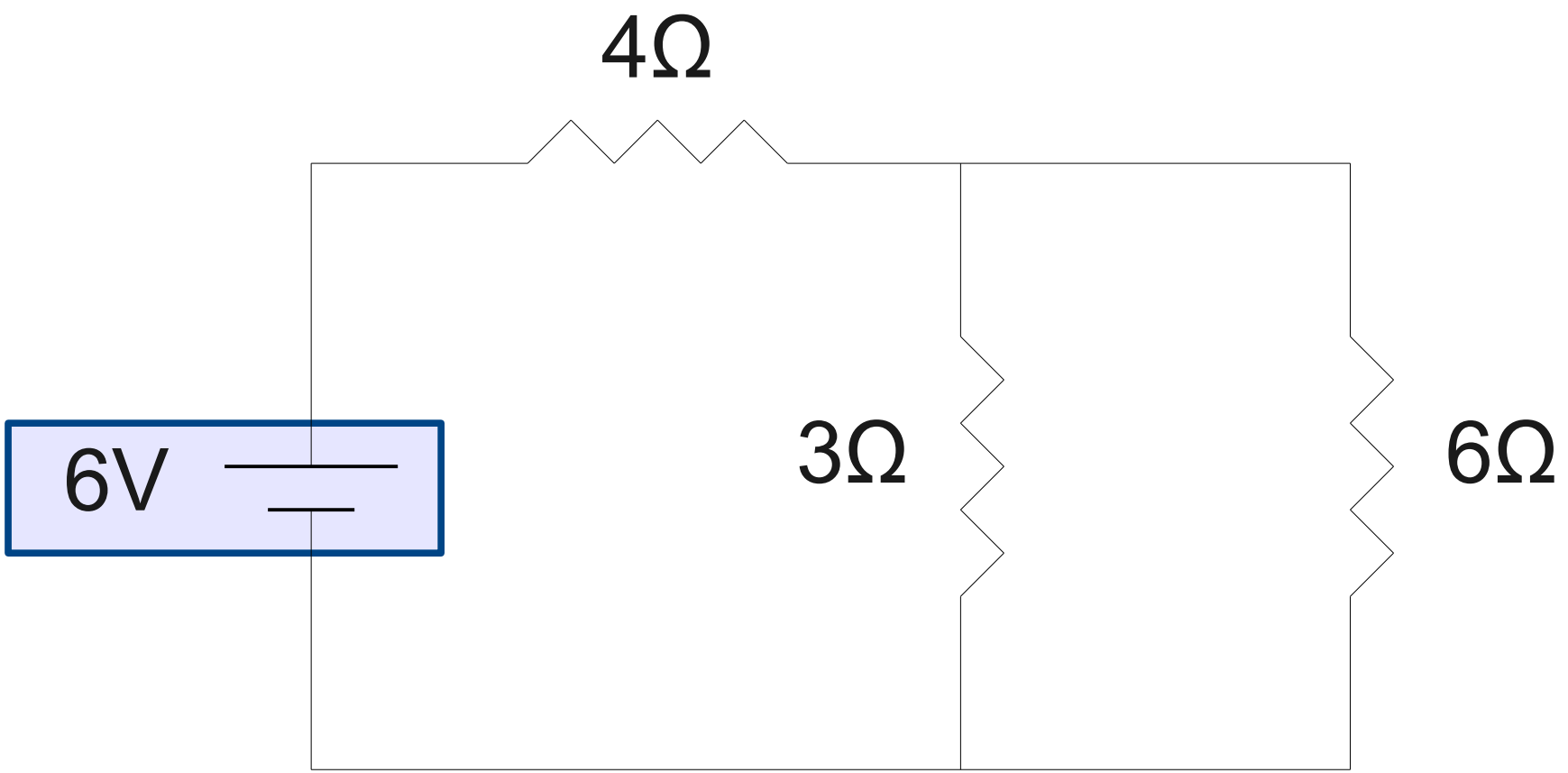
Enter John Backus



"I'm a terribly unscholarly person, and lazy. That was my motivating force in most of what I did, was how to avoid work"

- John Backus, interviewed in 2006


4Ω
6V
3Ω
6Ω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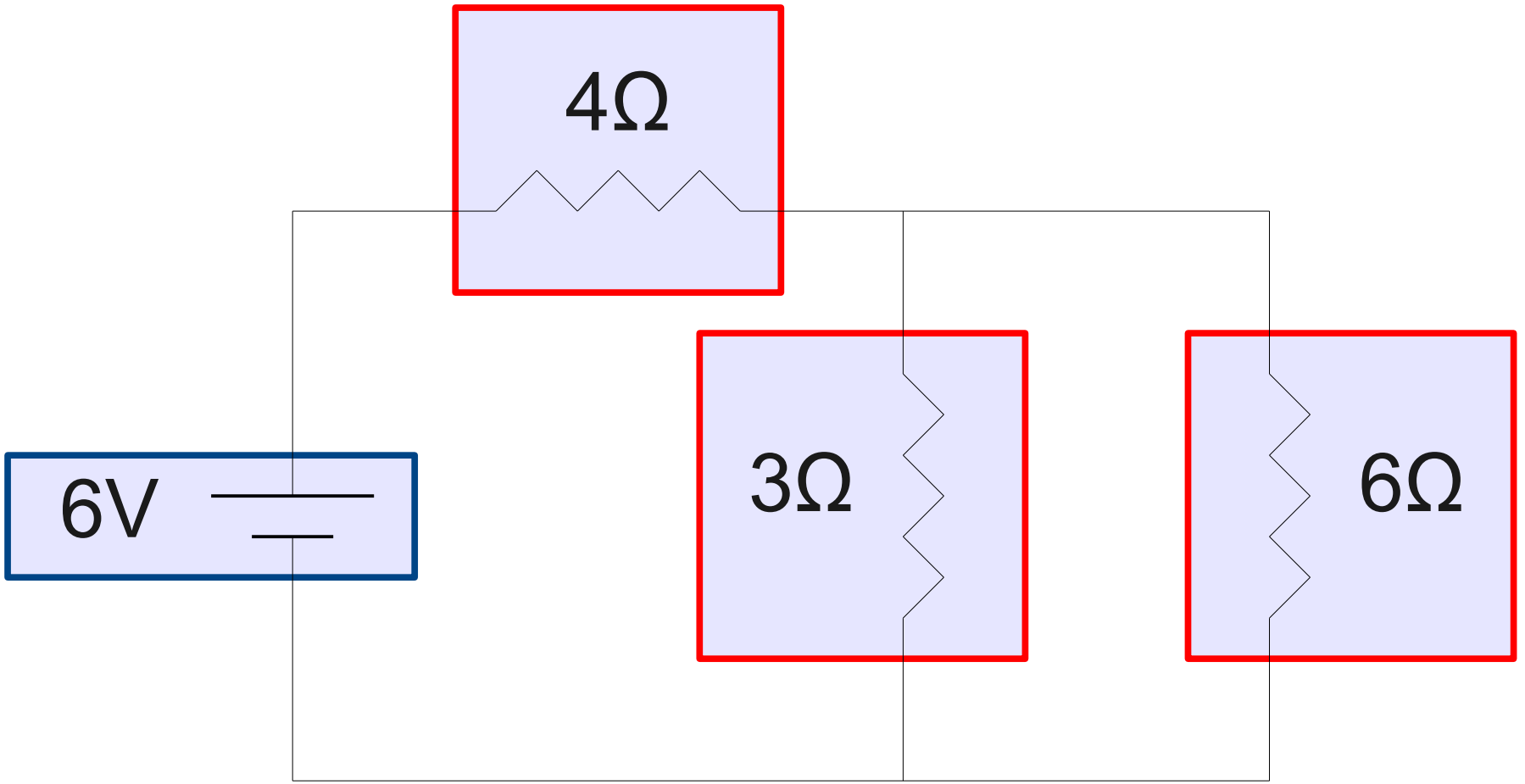
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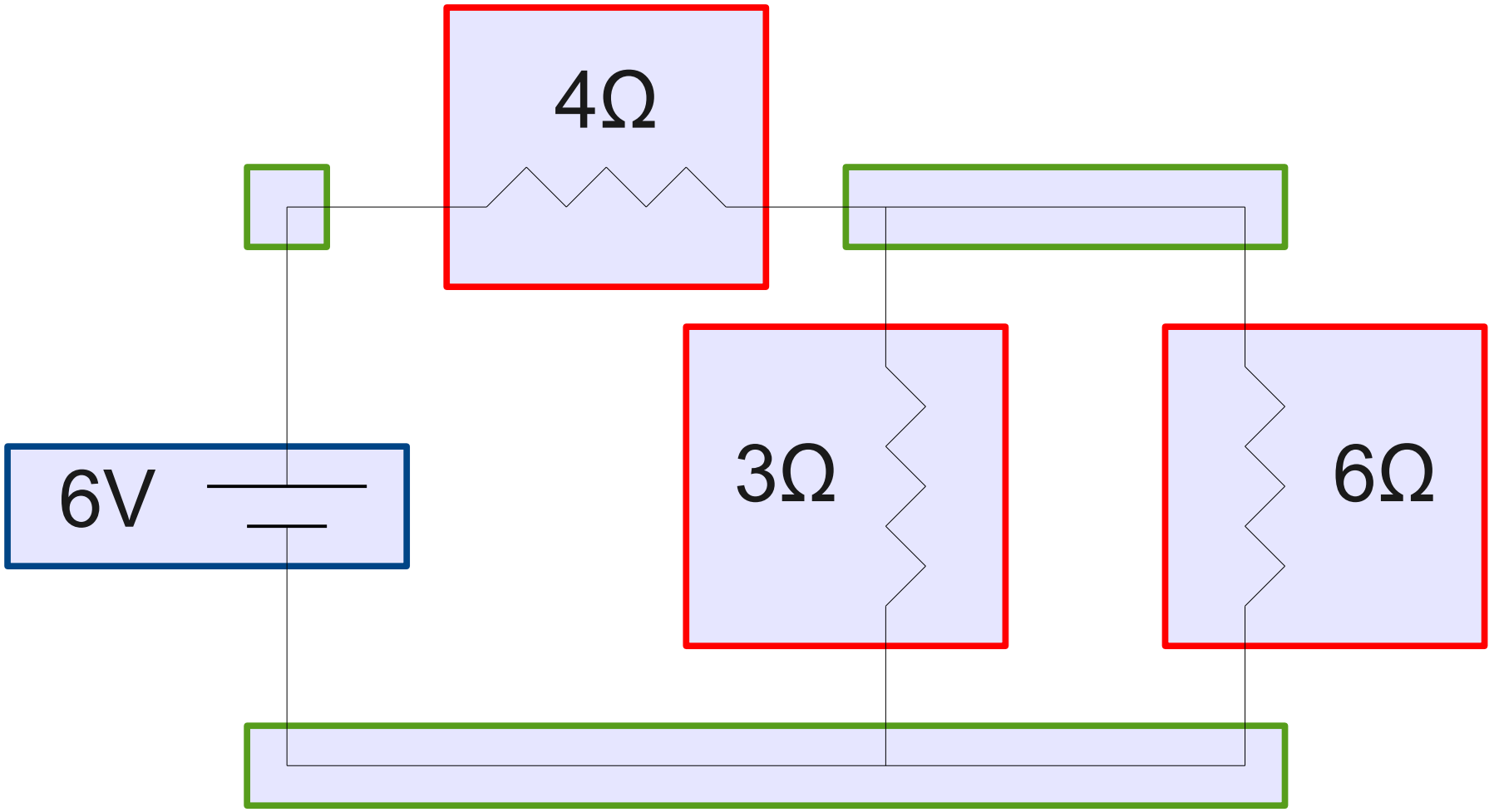
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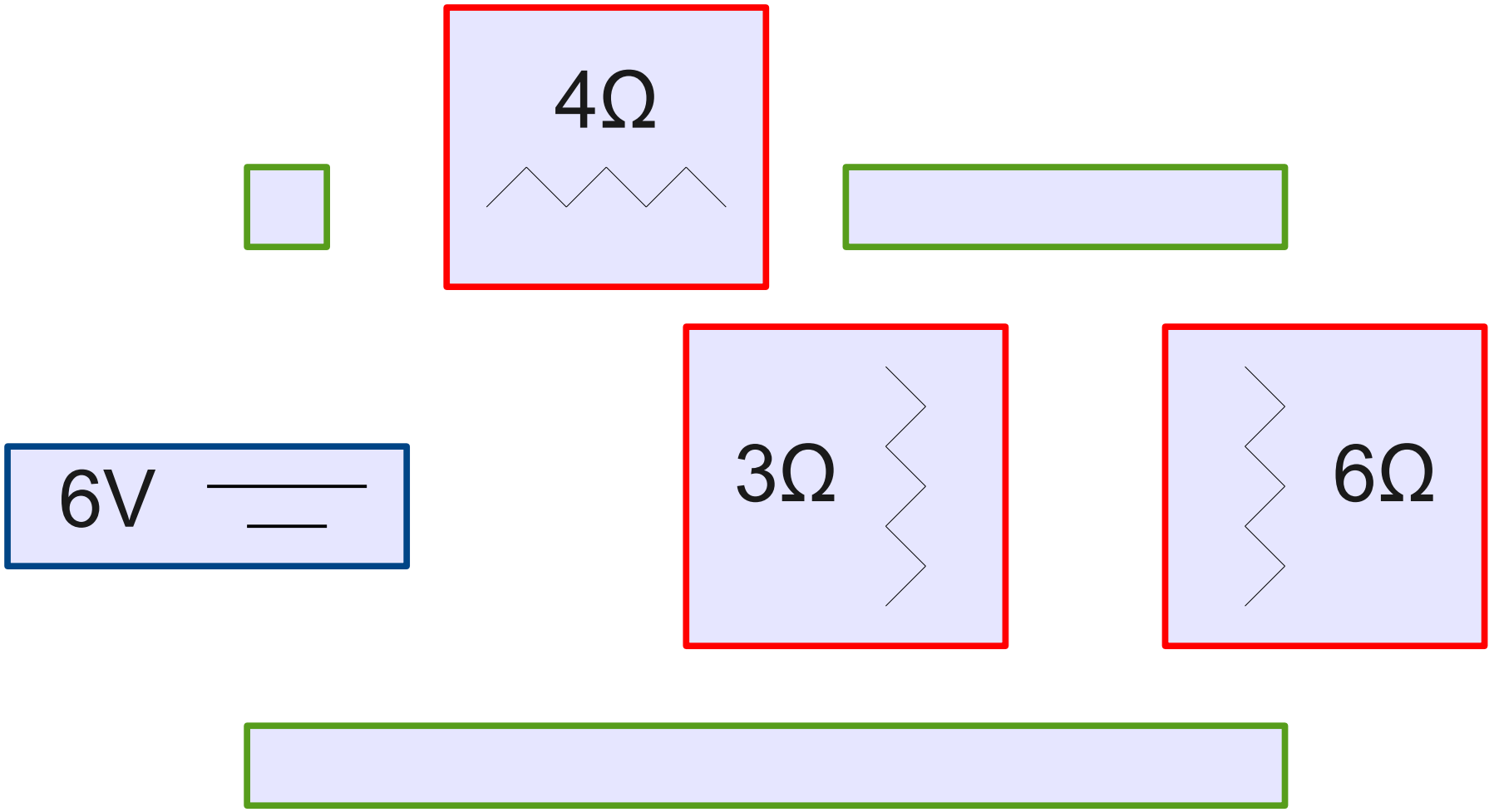
6V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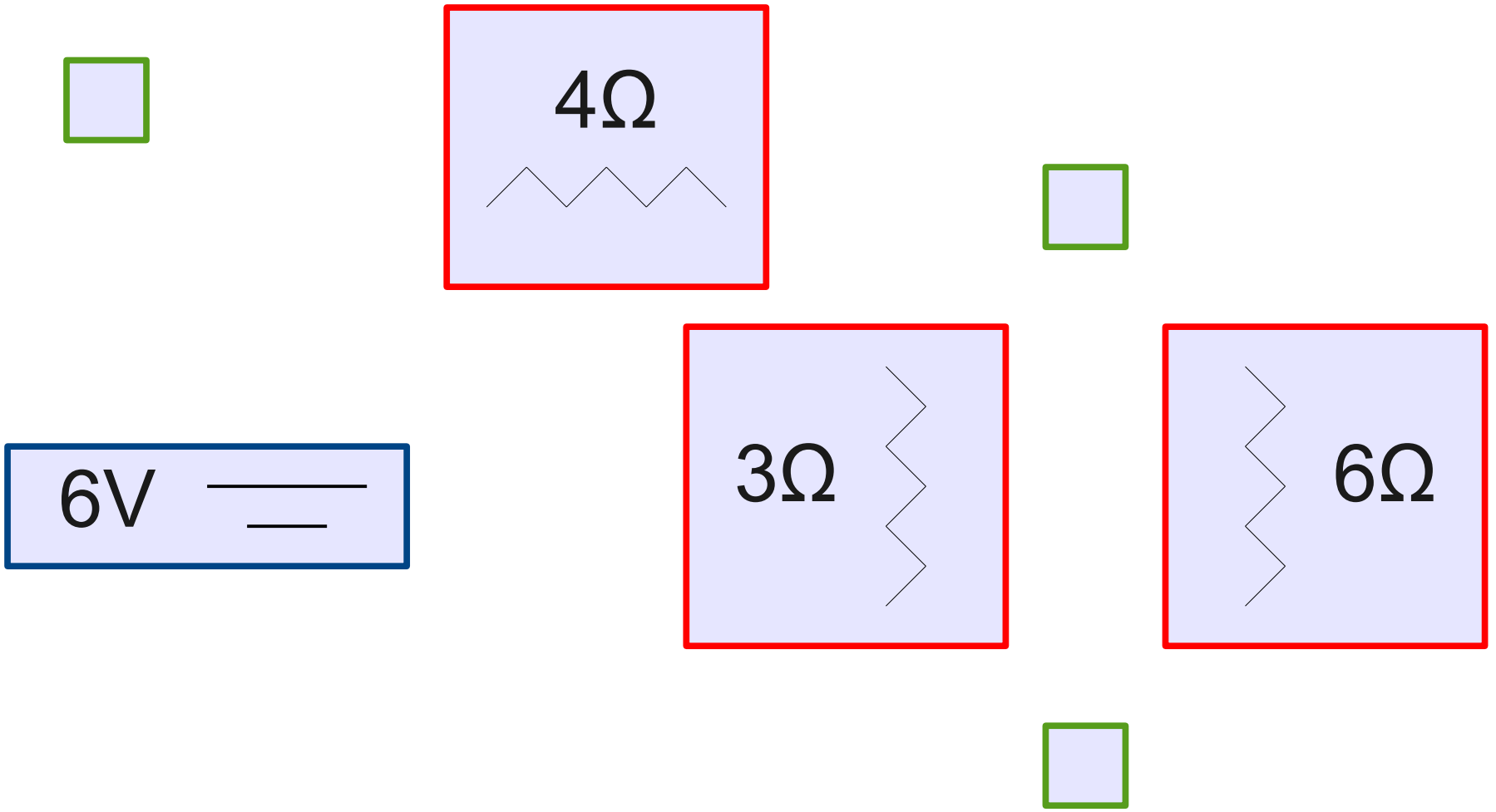
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6V
3Ω
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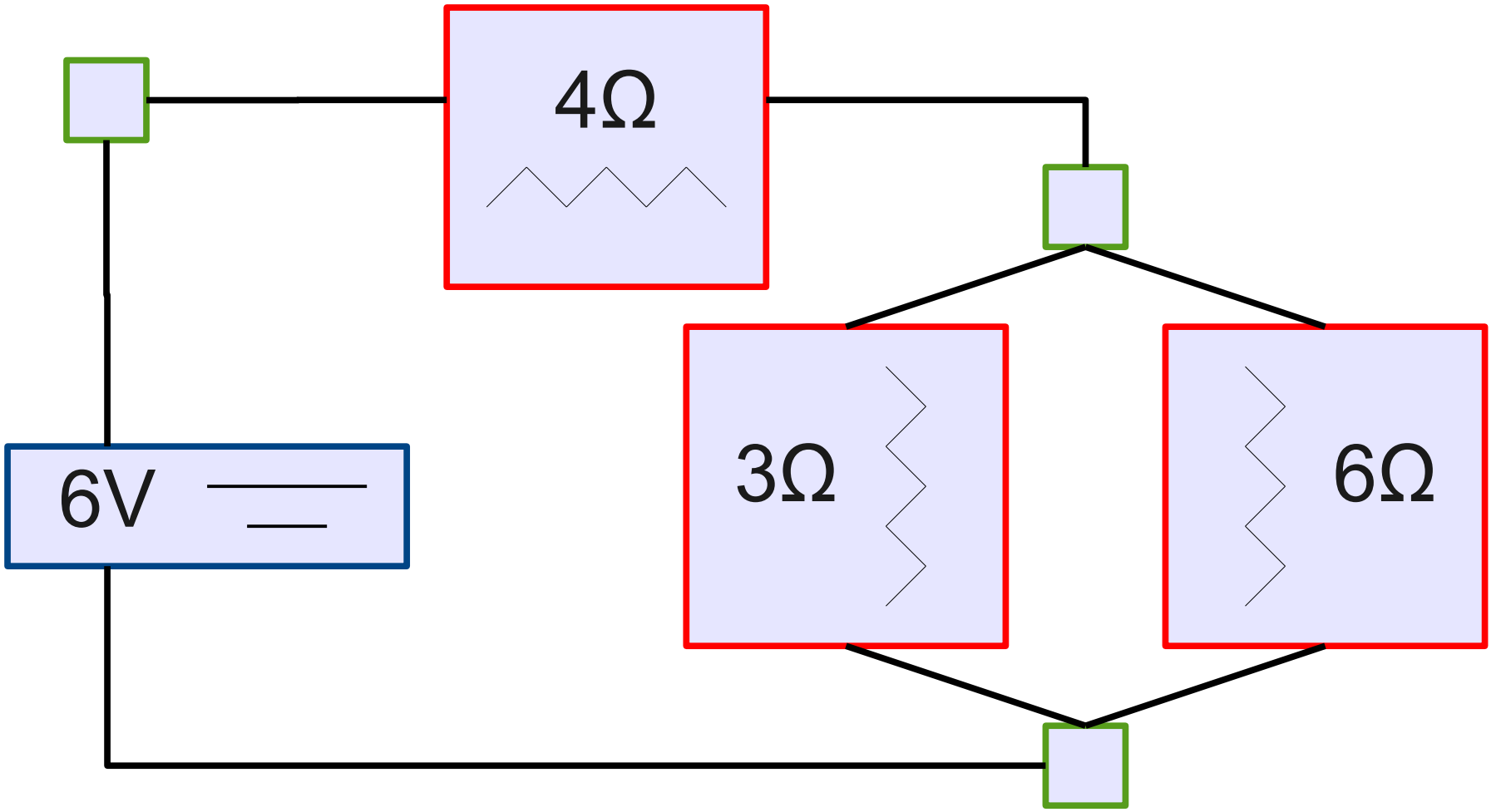
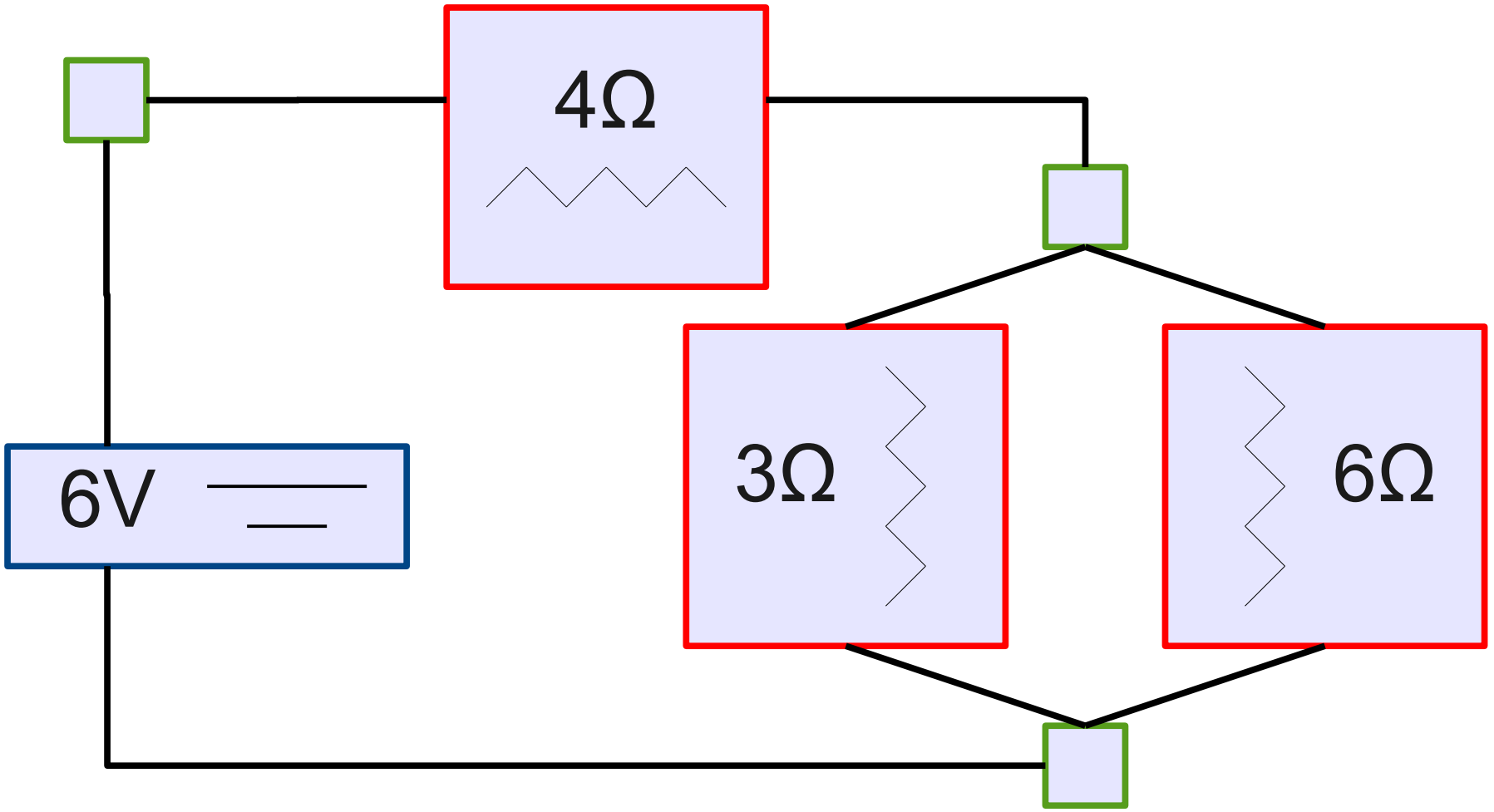
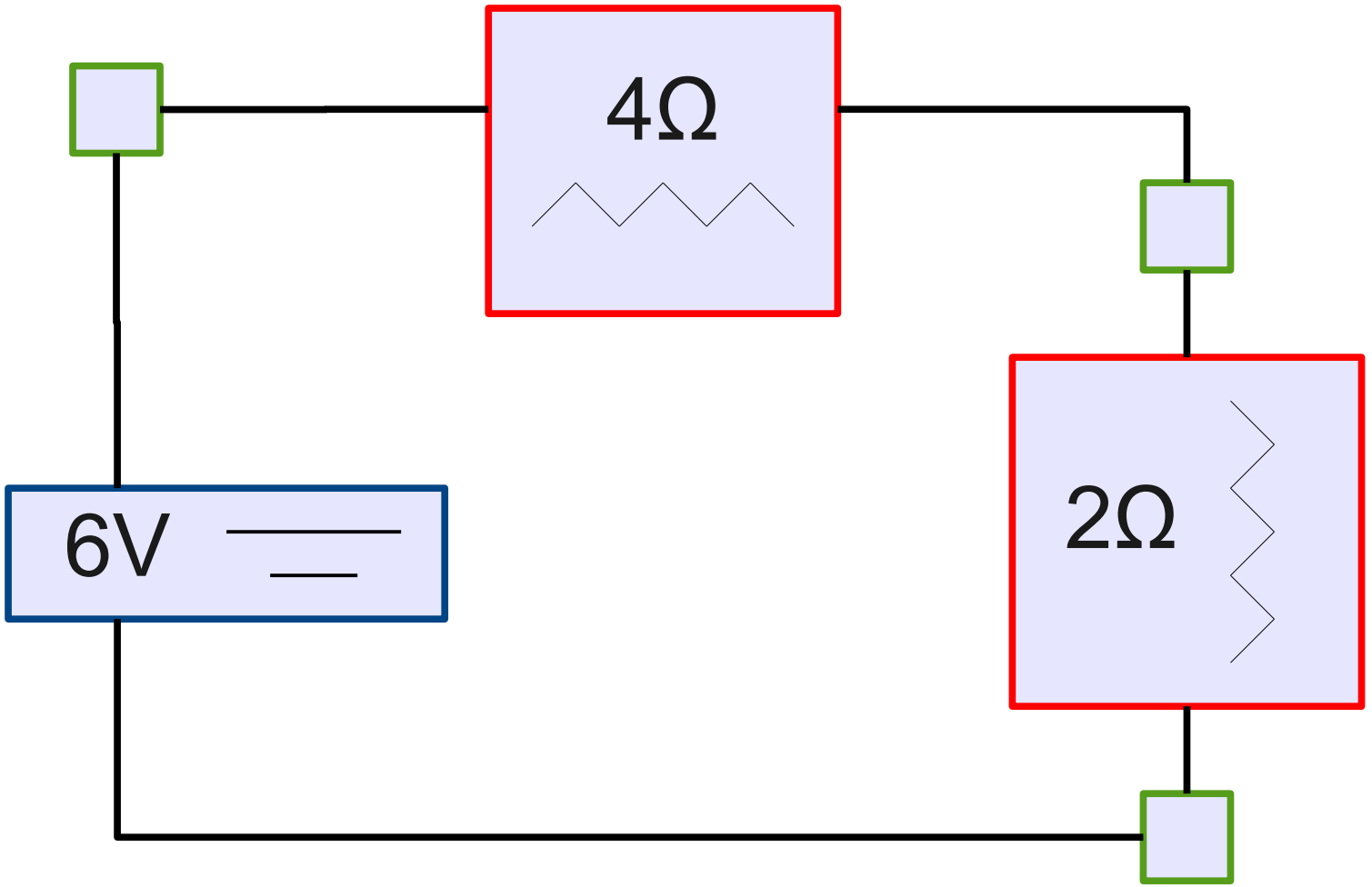

4Ω
3Ω
6Ω
6V



$$\frac{1}{\frac{1}{3\,\Omega}+\frac{1}{6\,\Omega}}=2\,\Omega$$



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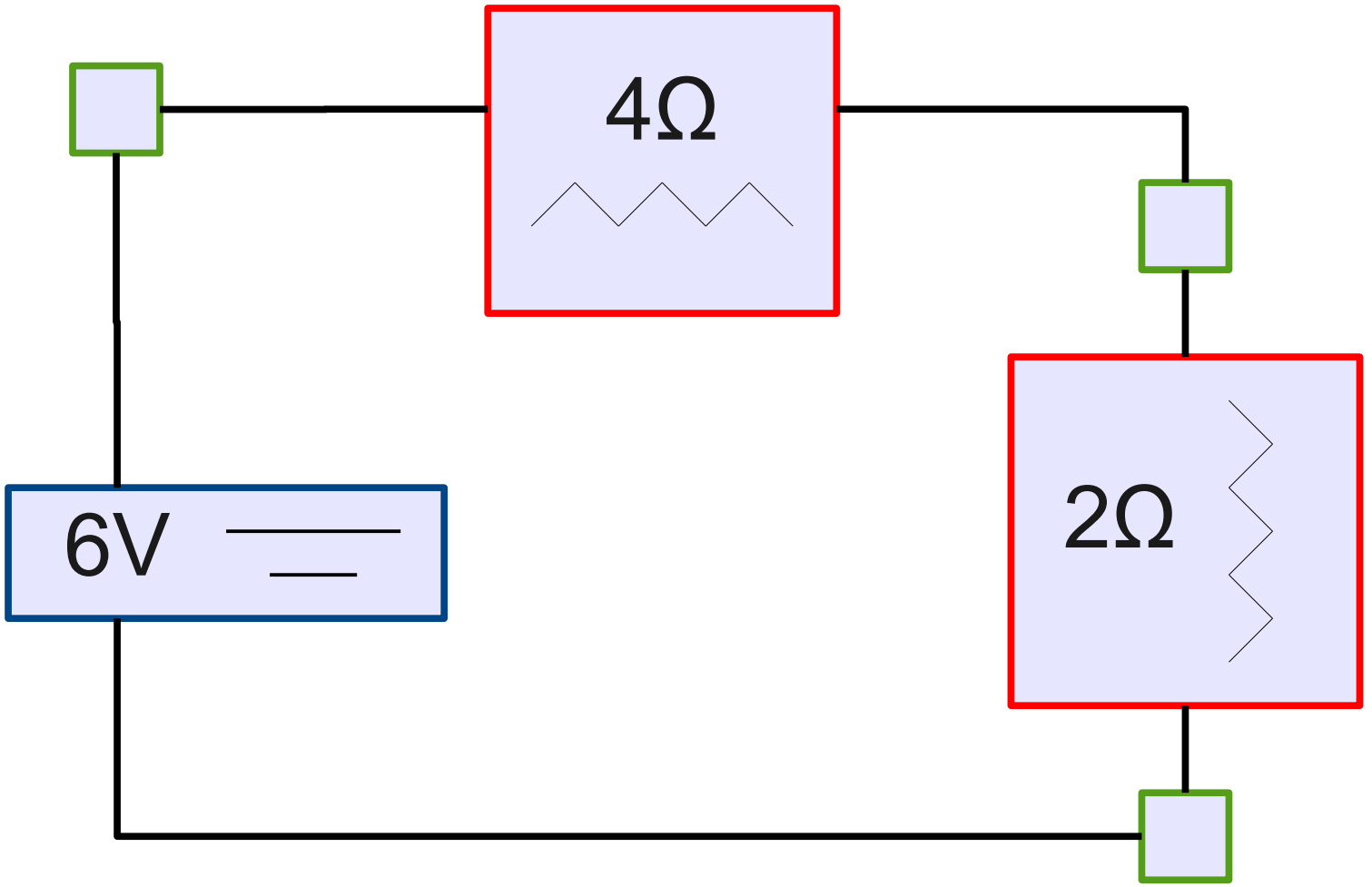
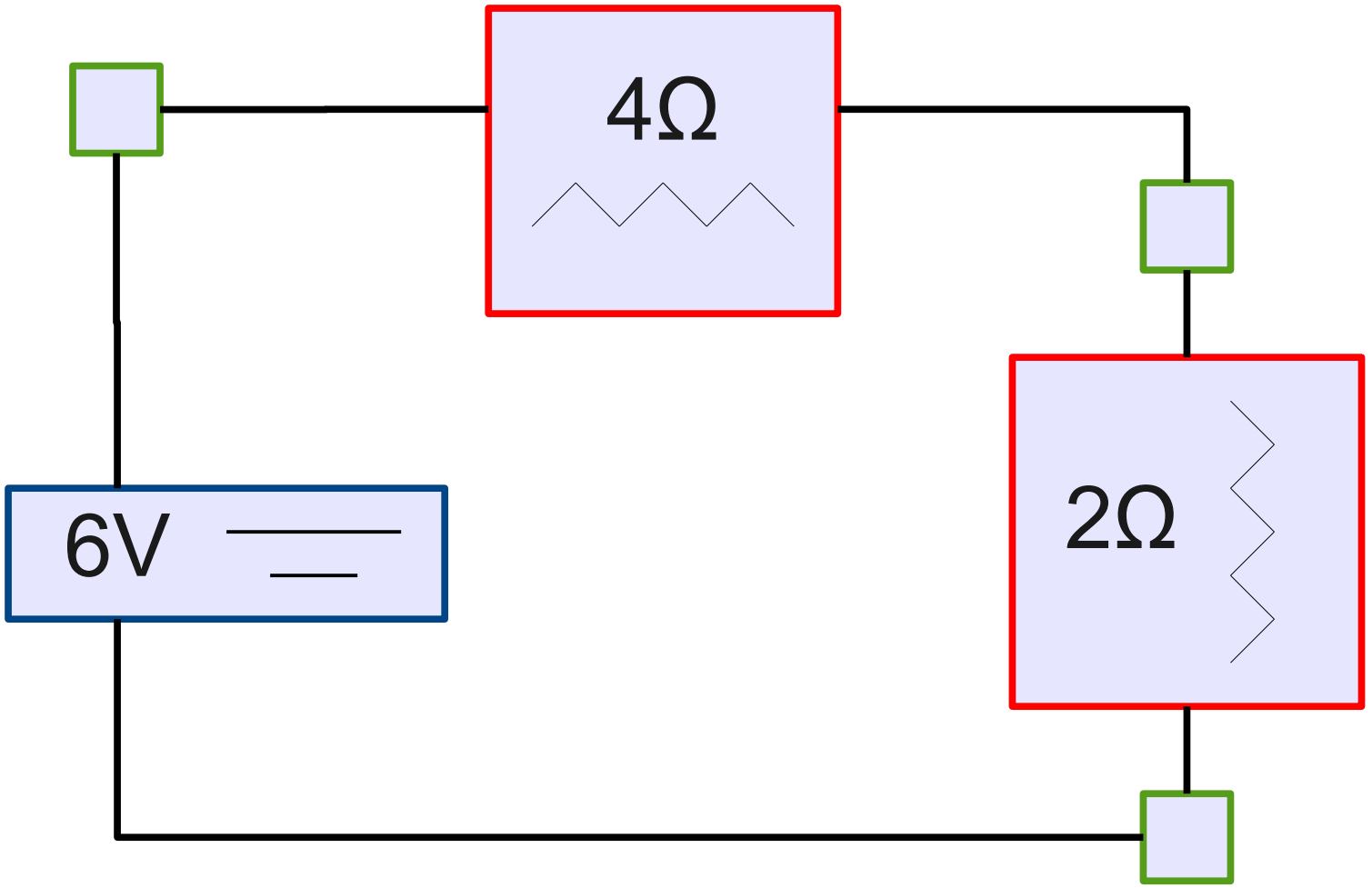
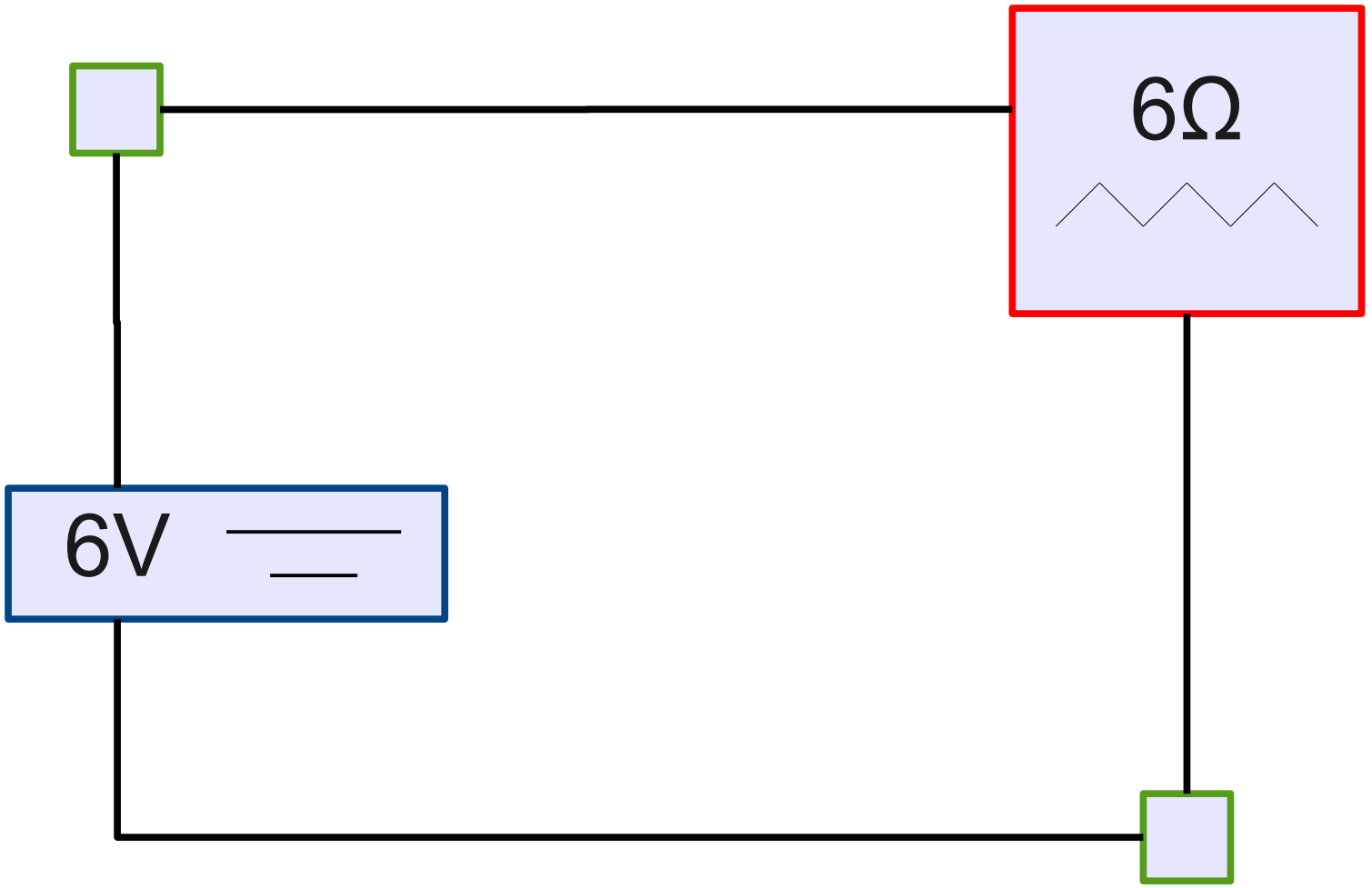

4Ω
2Ω
6V



$$4\,\Omega + 2\,\Omega = 6\,\Omega$$



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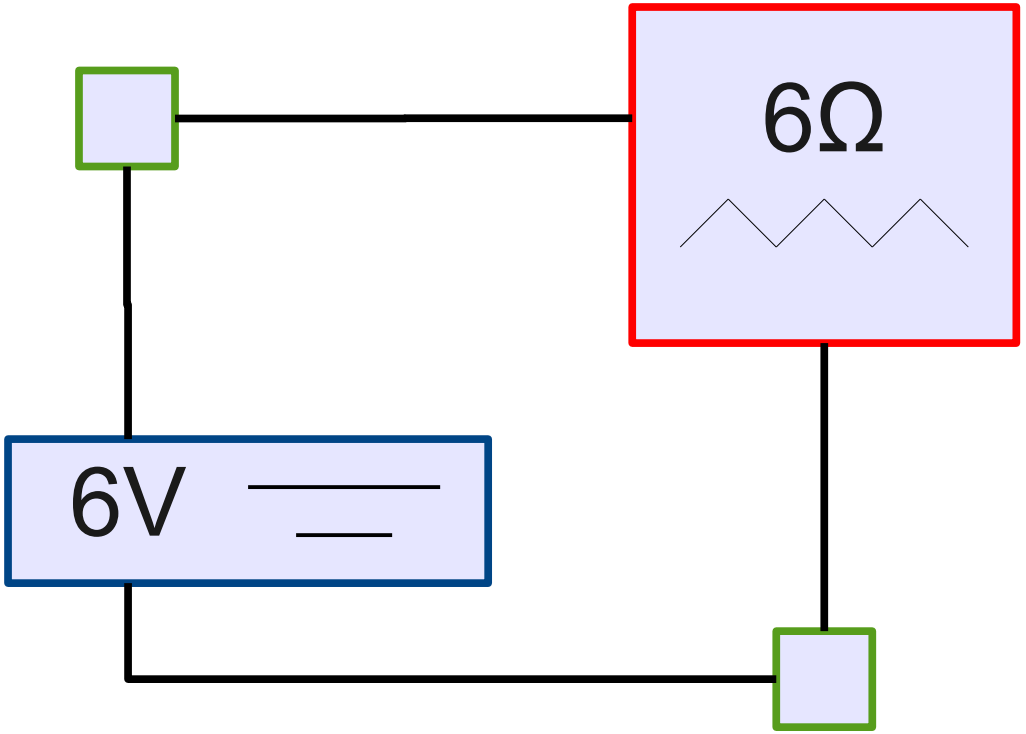
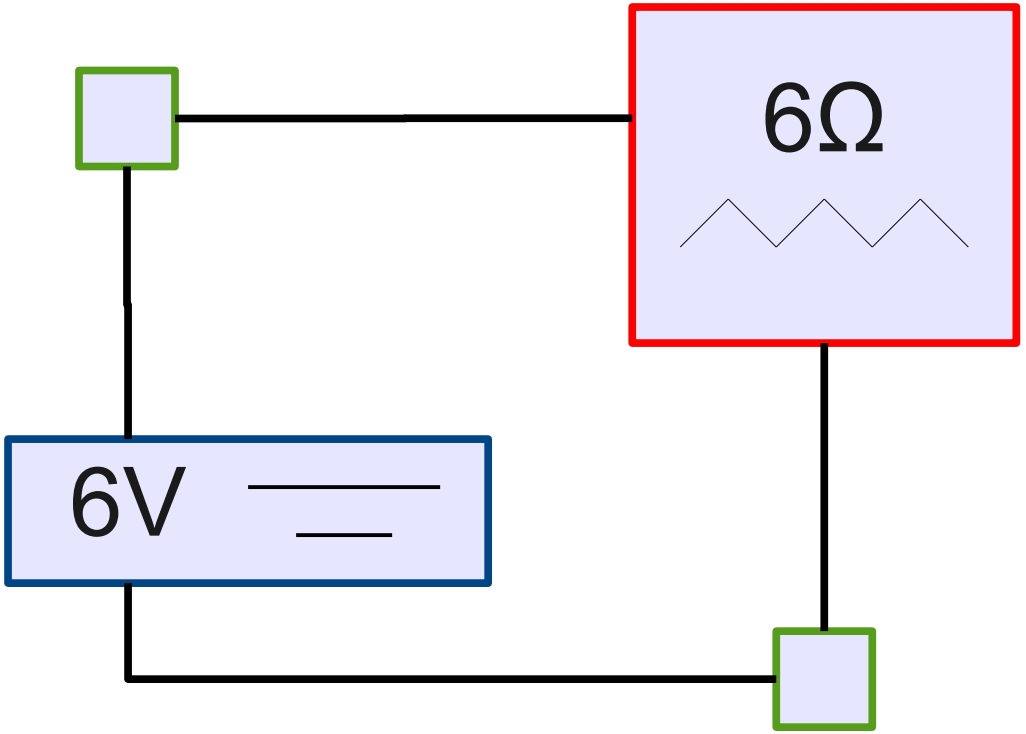

6Ω
6V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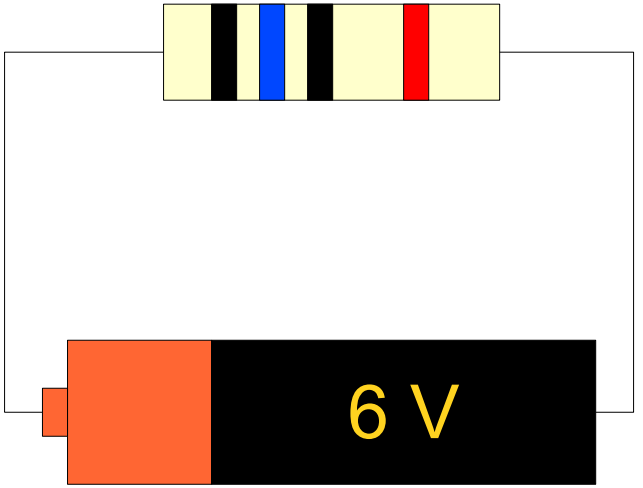
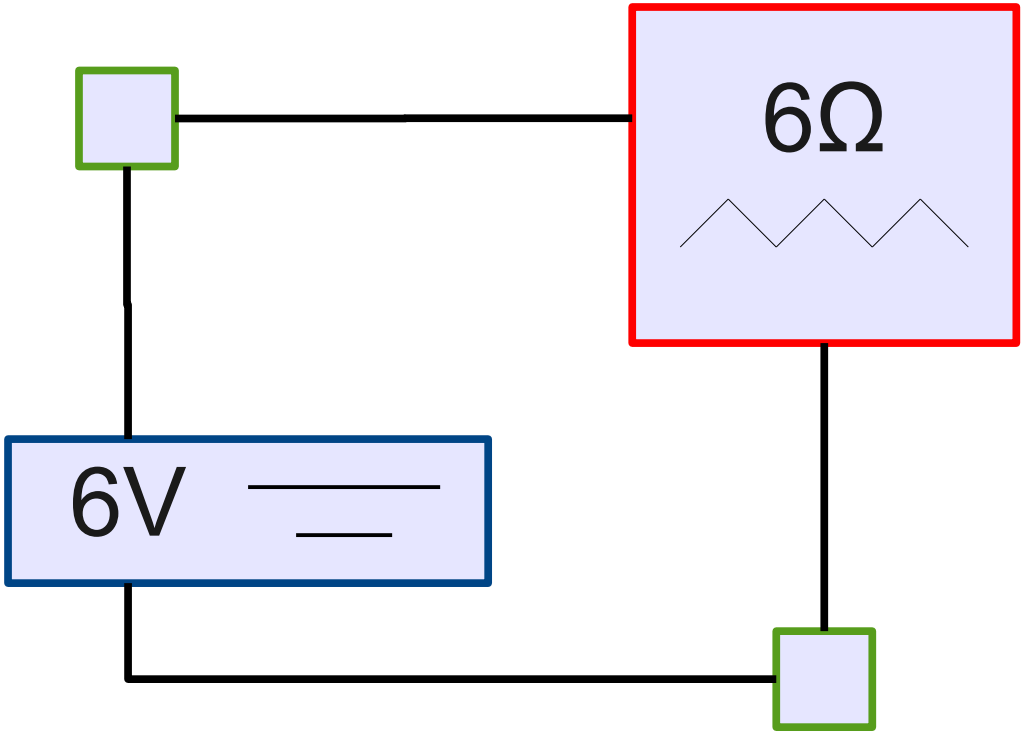
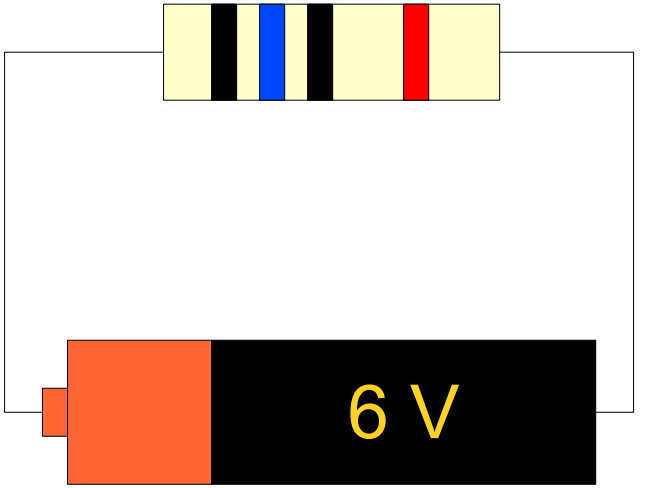
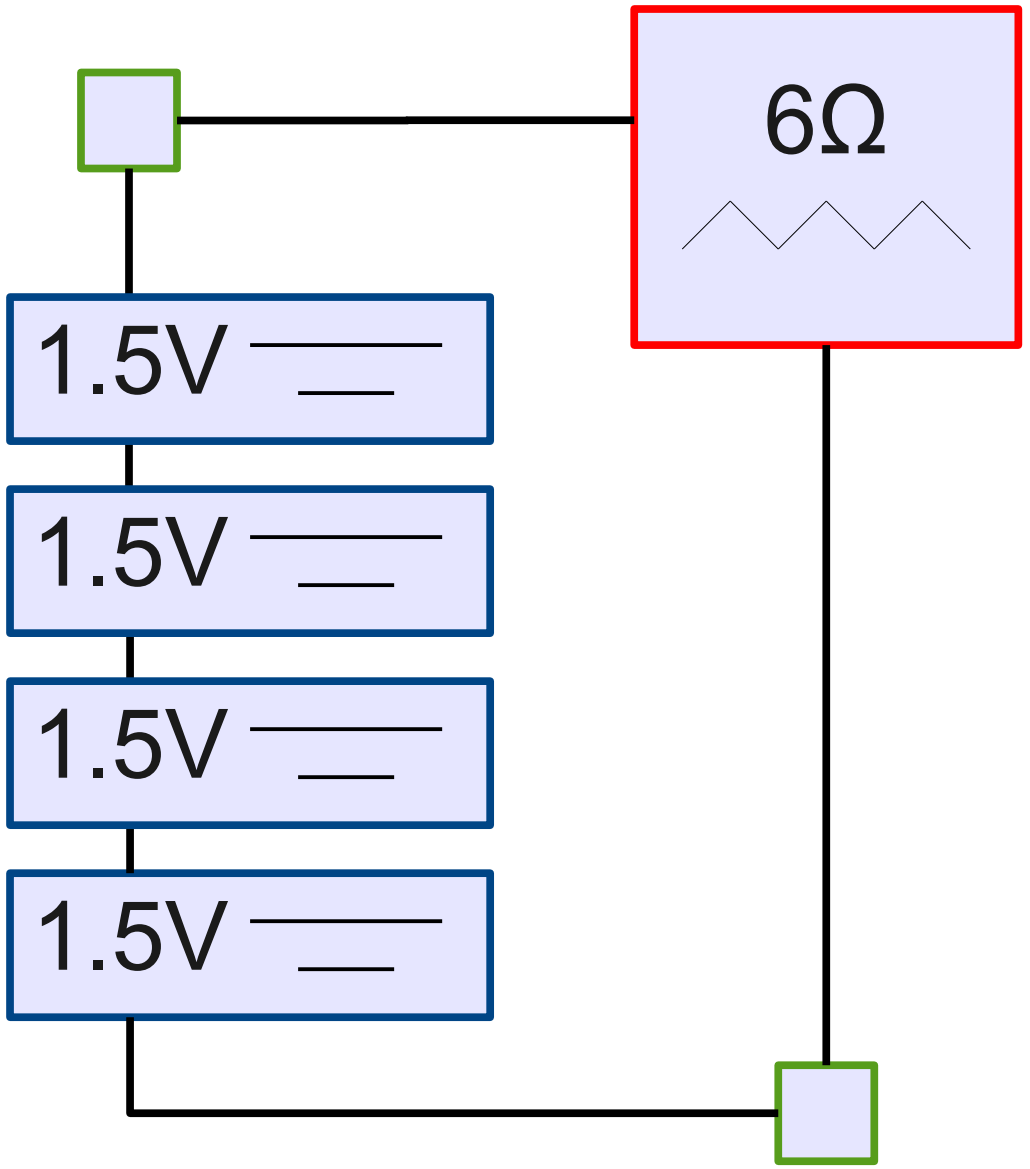
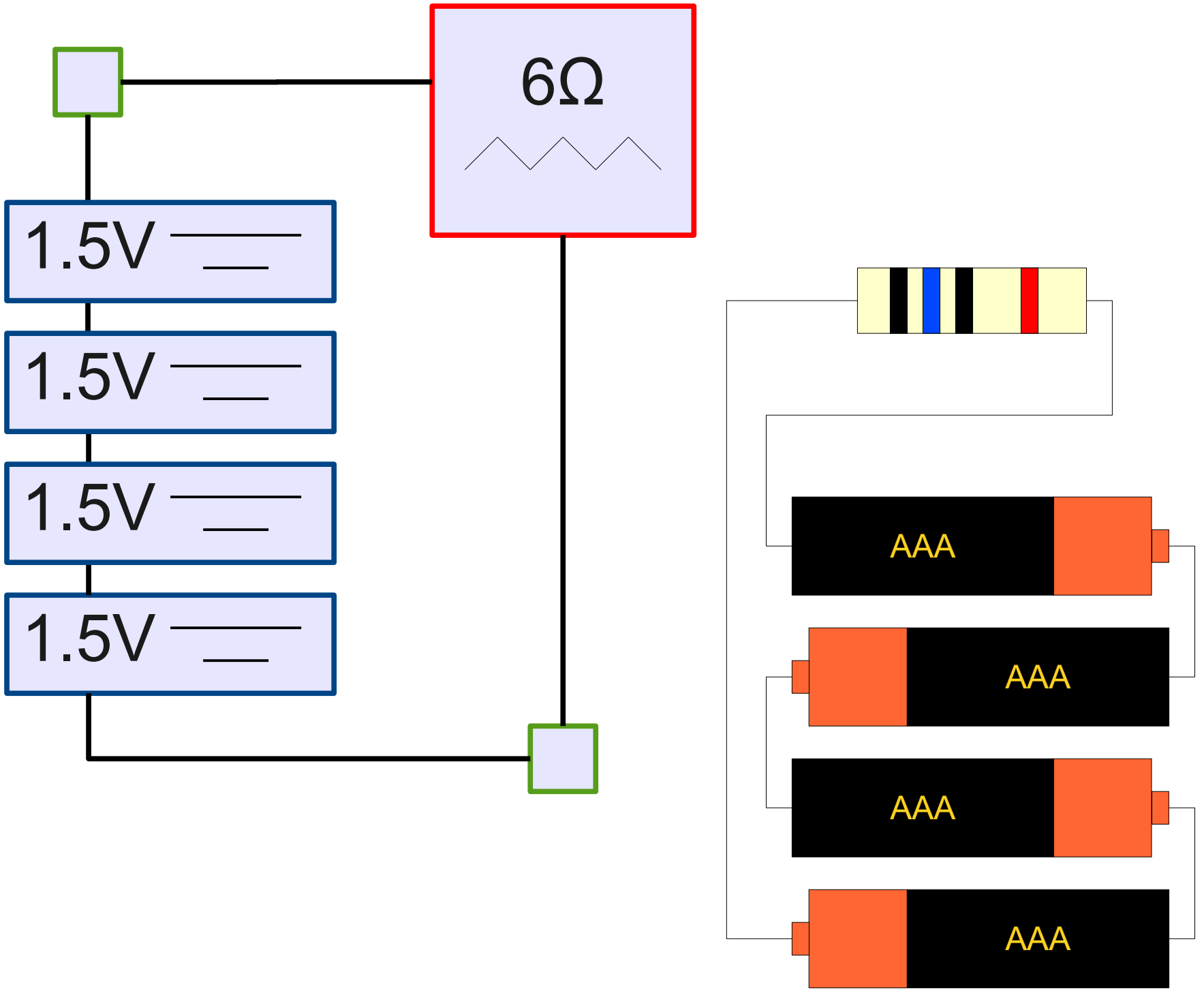

6 V



Total Cost: $4.75




6Ω
1.5V
1.5V
1.5V
1.5V


6Ω
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1.5V
1.5V
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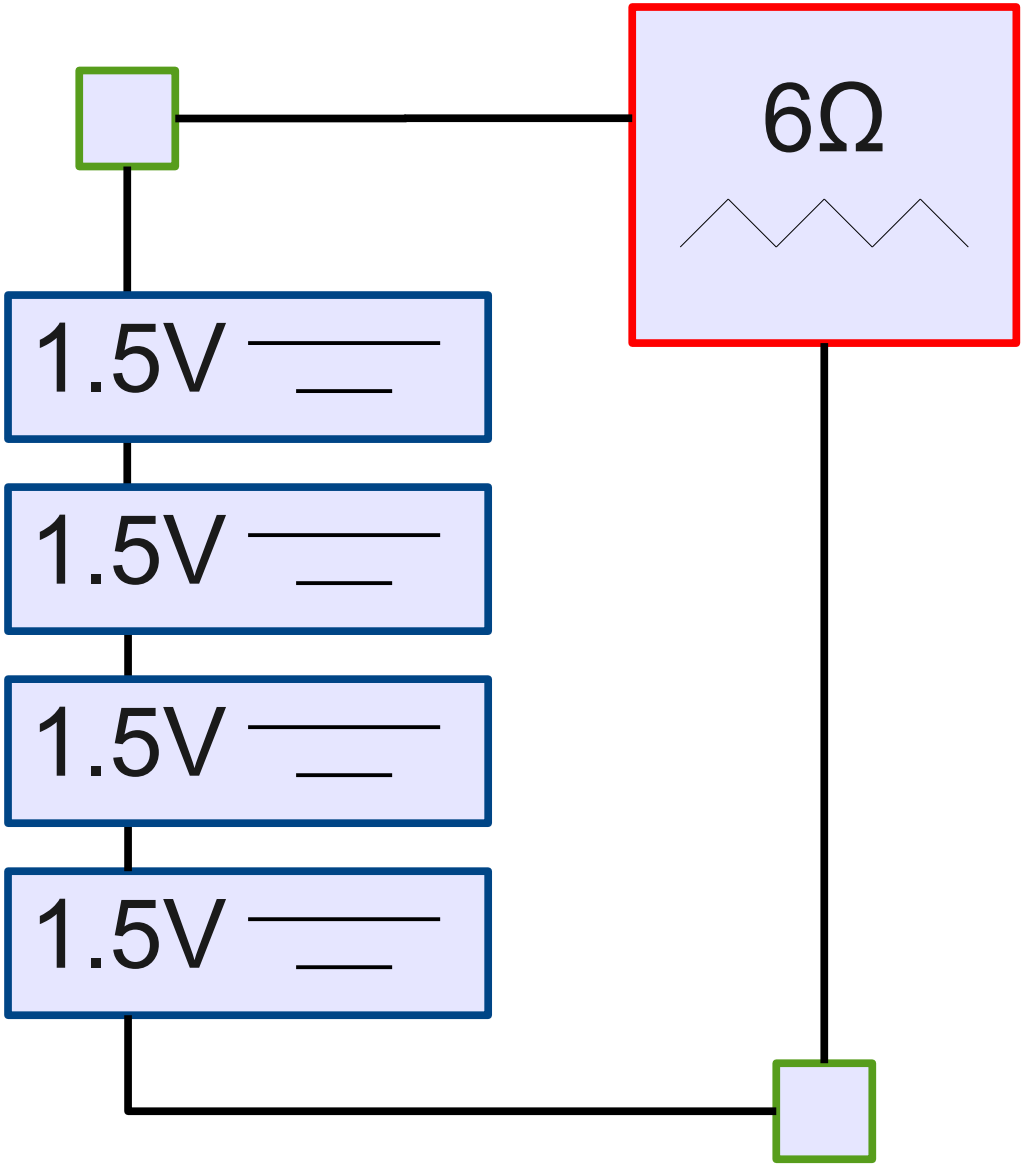
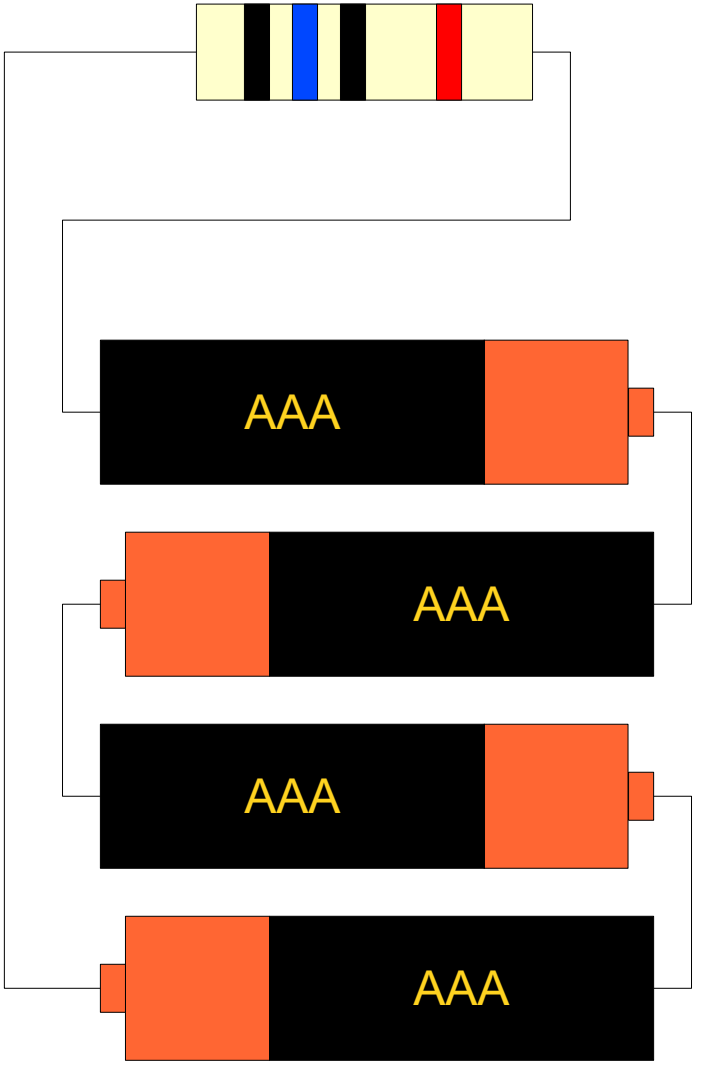


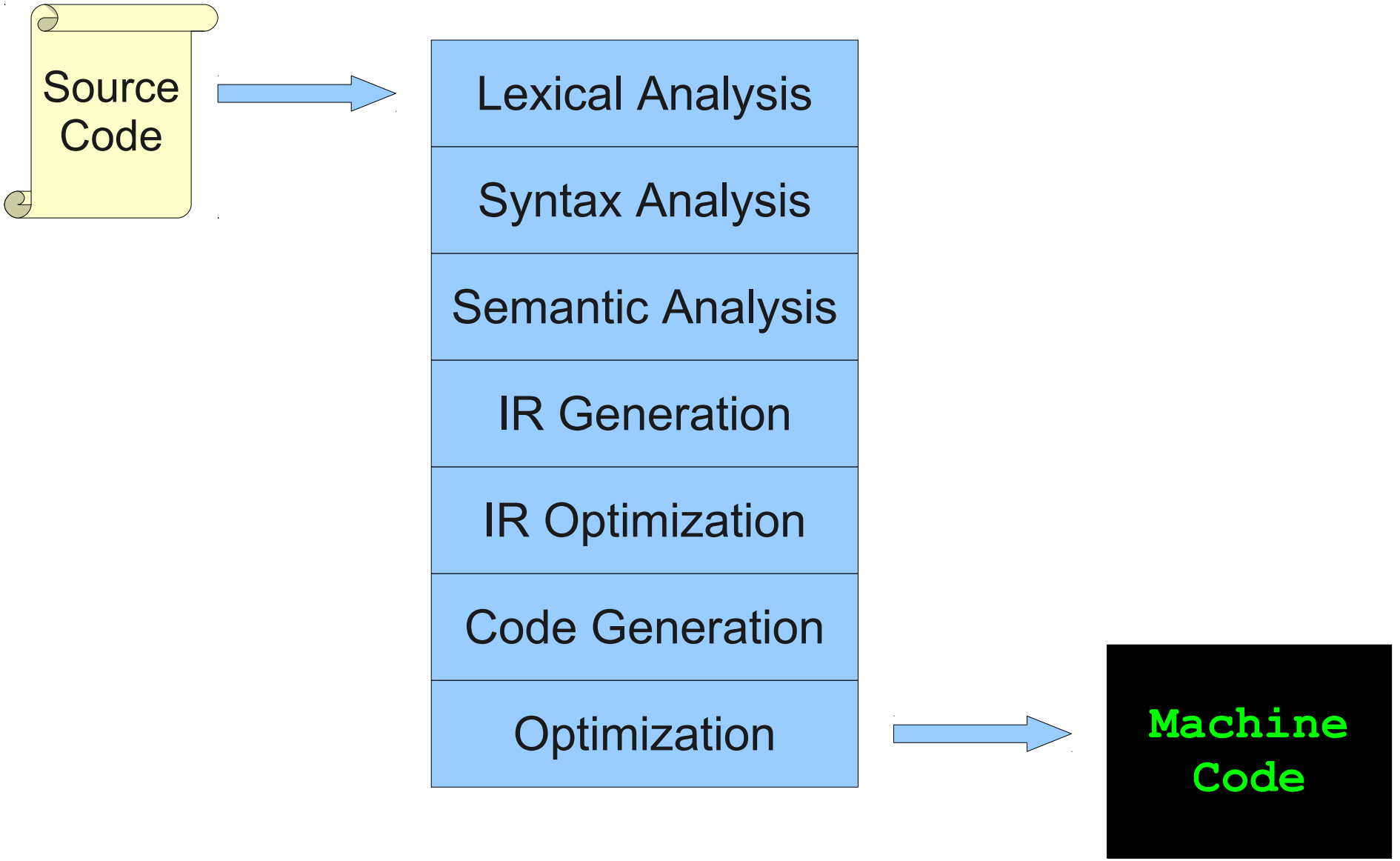


Total Cost: $1.00

From Description to Implementation

- **Lexical analysis:** Identify logical pieces of description
- **Syntax analysis:** Identify how those pieces relate to each other.
- **Semantic analysis:** Identify the meaning of those relations.
- **IR Optimization:** Simplify the intended structure.
- **Code Generation:** Fabricate the structure.
- **Optimization:** Improve the resulting structure.

The Structure of a Modern Compiler



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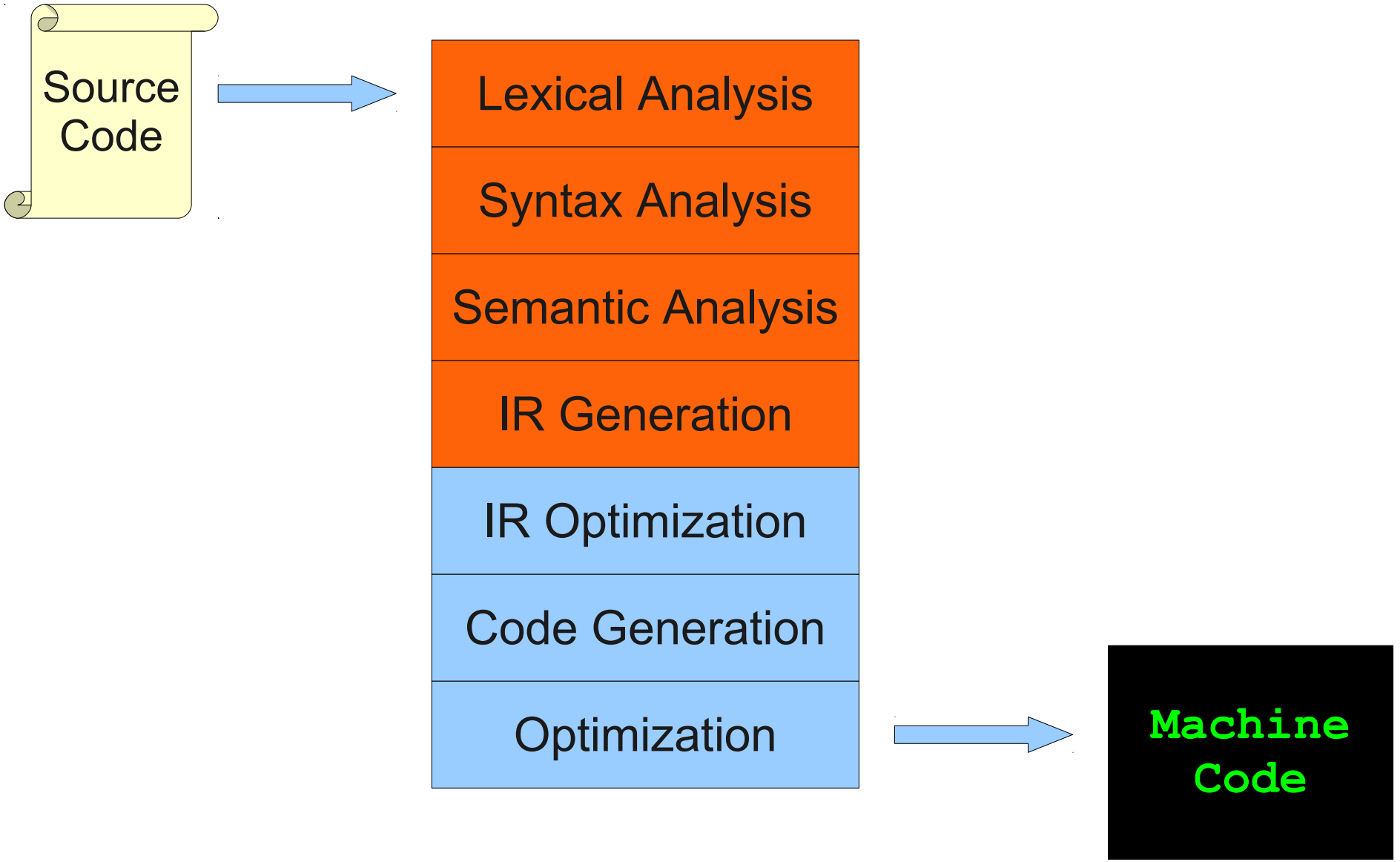

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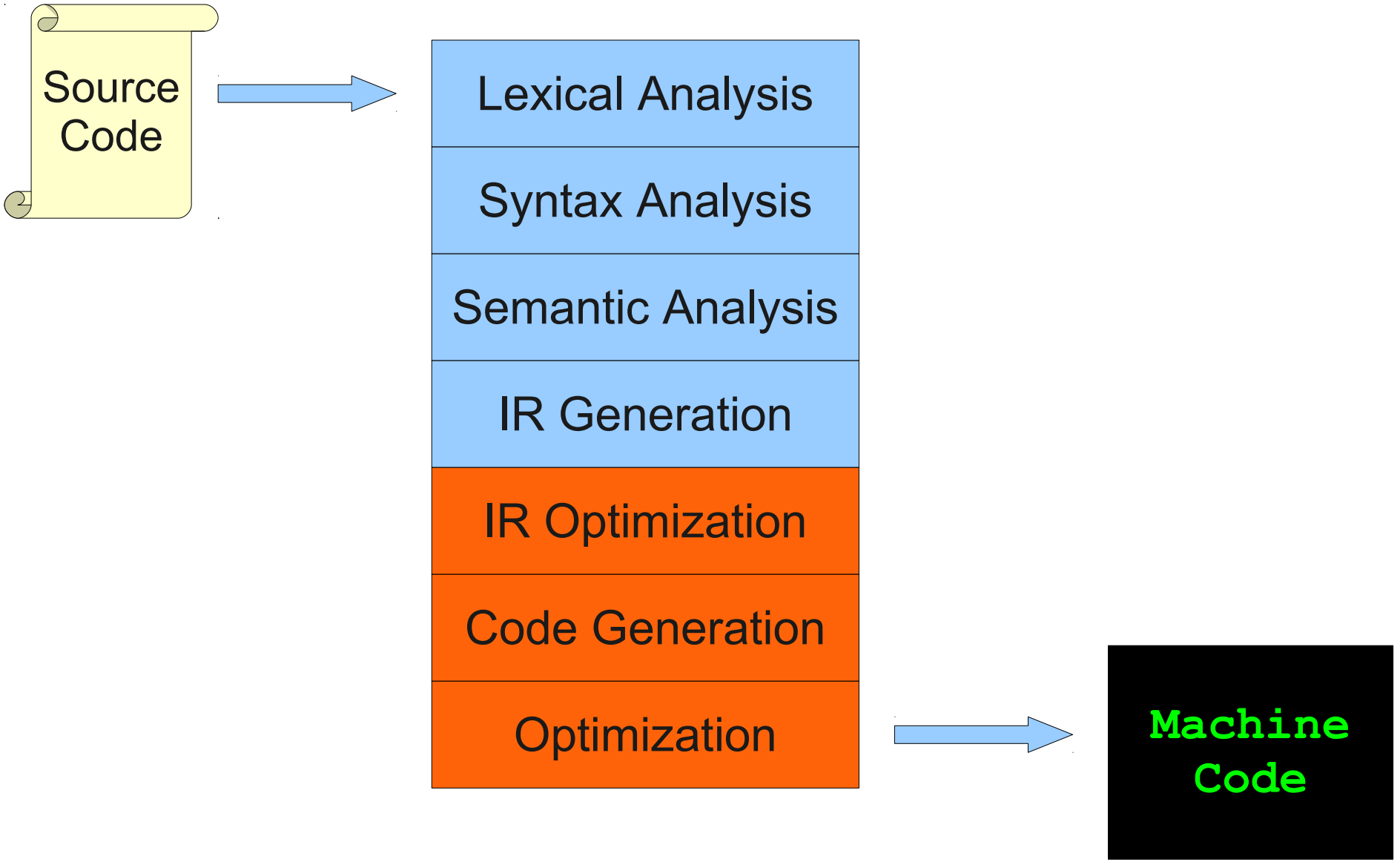

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while (y < z) {
    int x = a + b;
    y += x;
}
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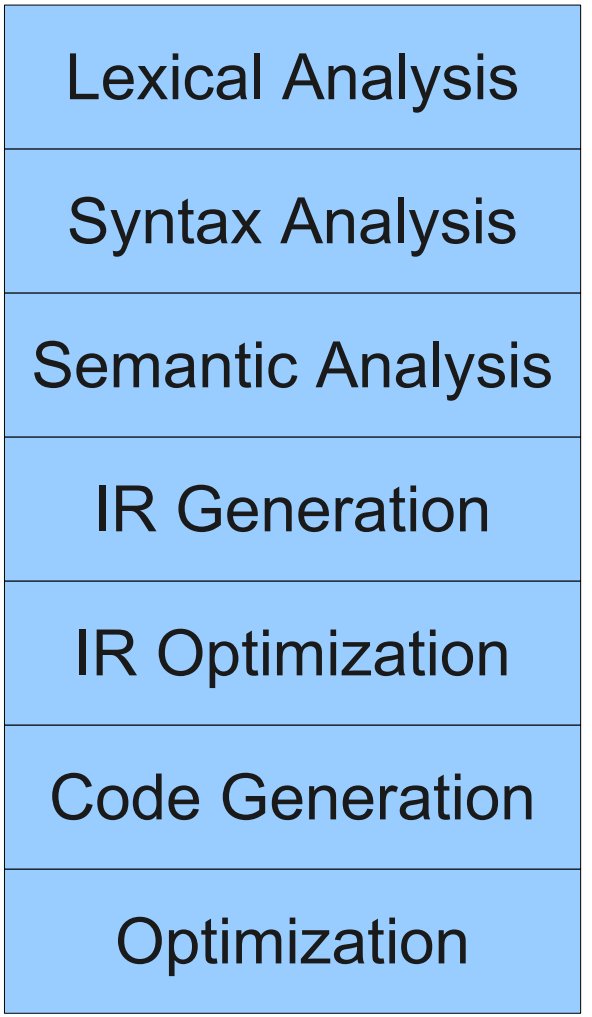

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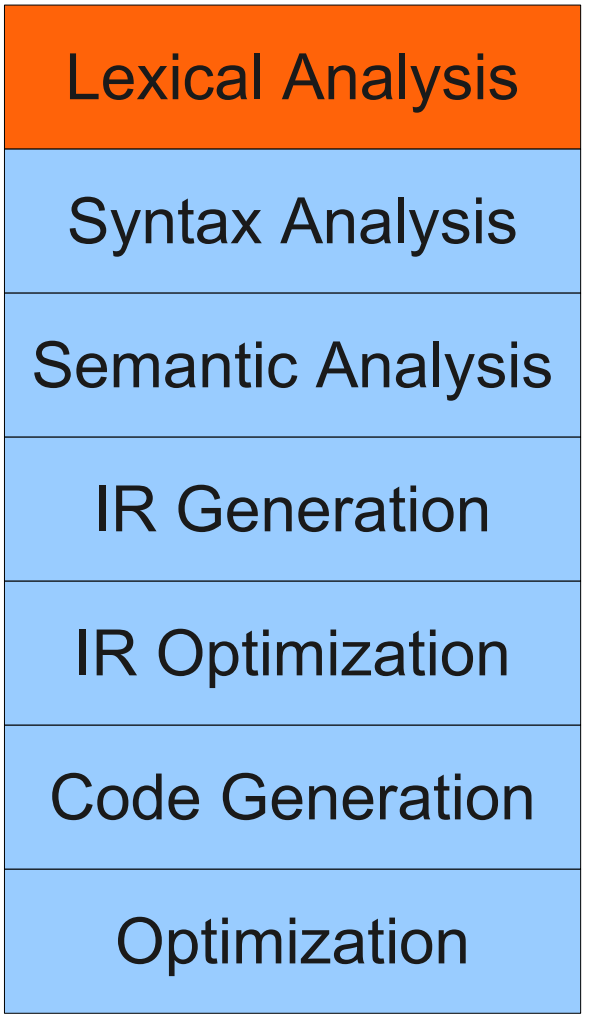

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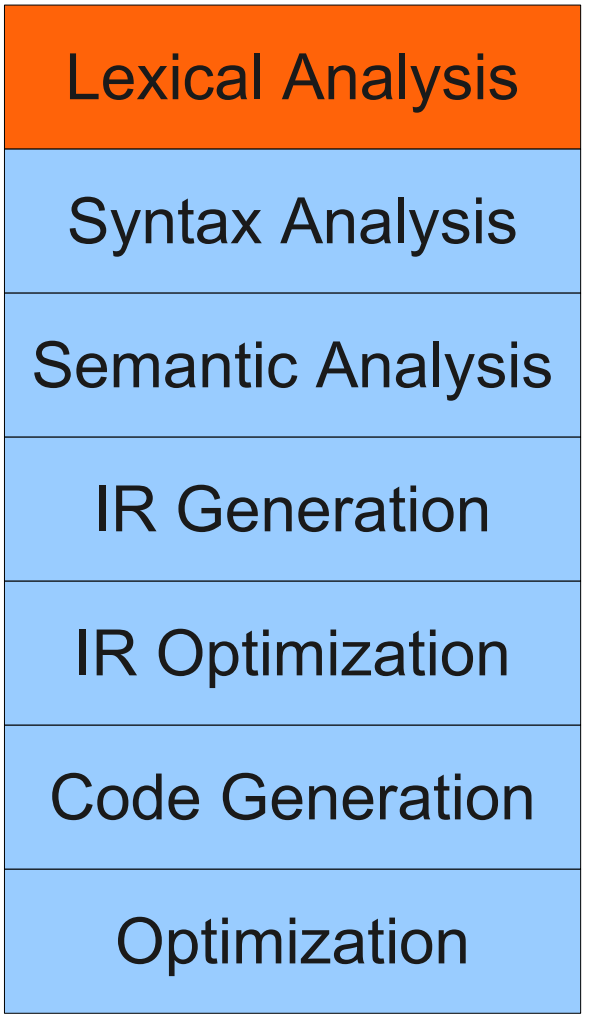
```
T_While
T_LeftParen
T_Identifier y
T_Less
T_Identifier z
T_RightParen
T_OpenBrace
T_Int
T_Identifier x
T_Assign
T_Identifier a
T_Plus
T_Identifier b
T_Semicolon
T_Identifier y
T_PlusAssign
T_Identifier x
T_Semicolon
T_CloseBrace
```



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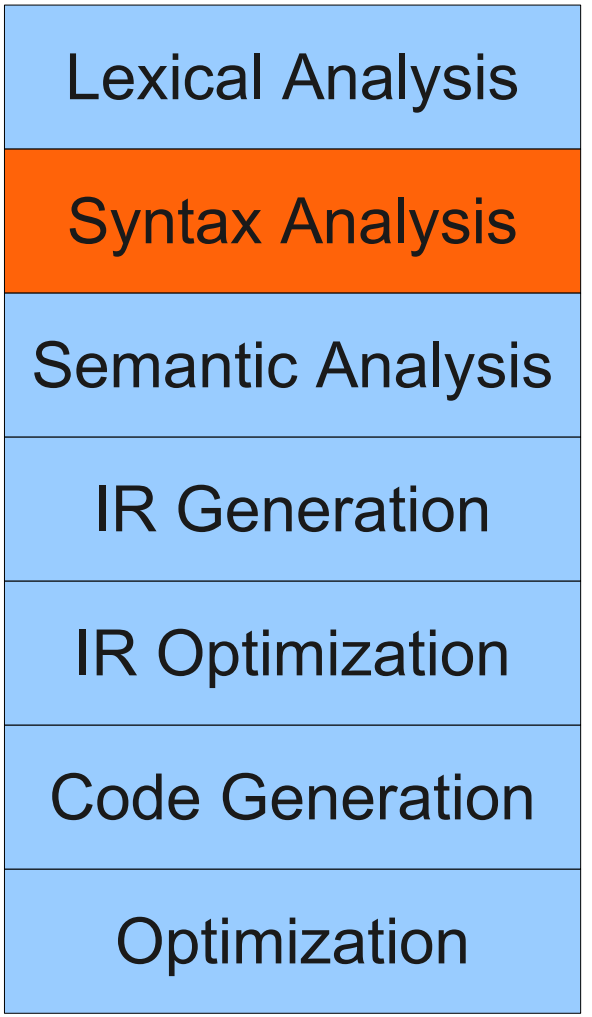

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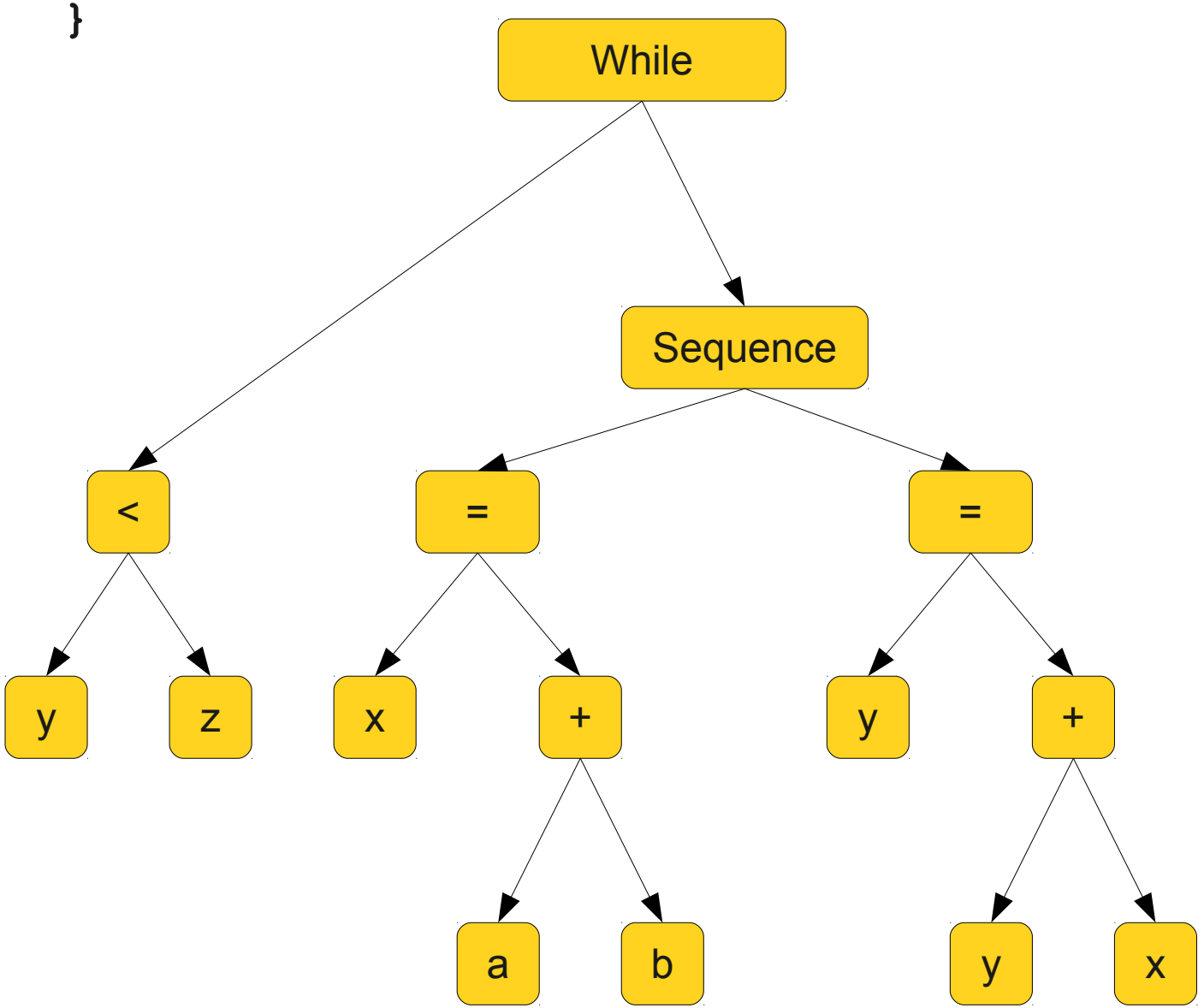

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- **Syntax Analysis**
- Semantic Analysis
- IR Generation
- IR Optimization
- Code Generation
- Optimization

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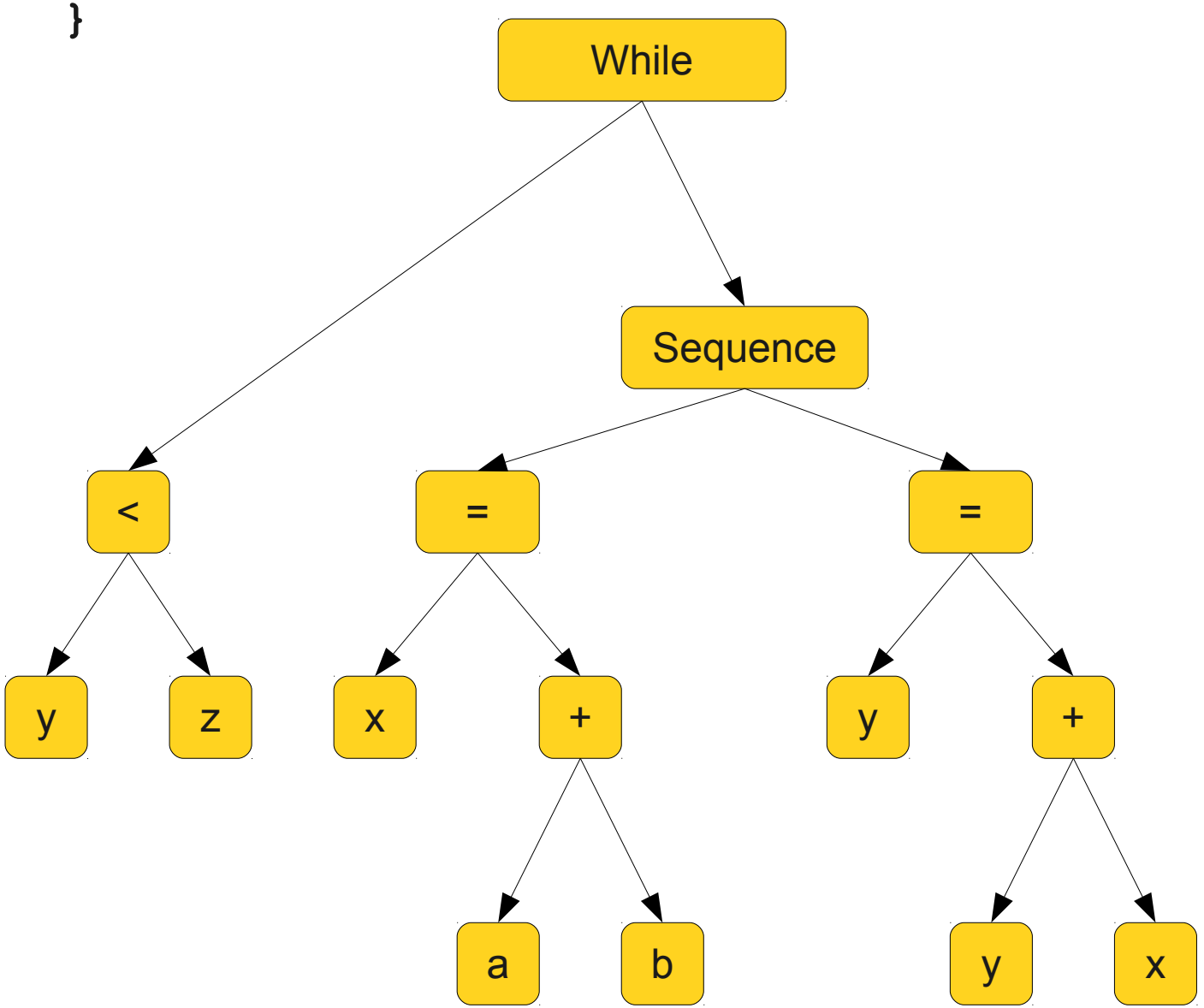

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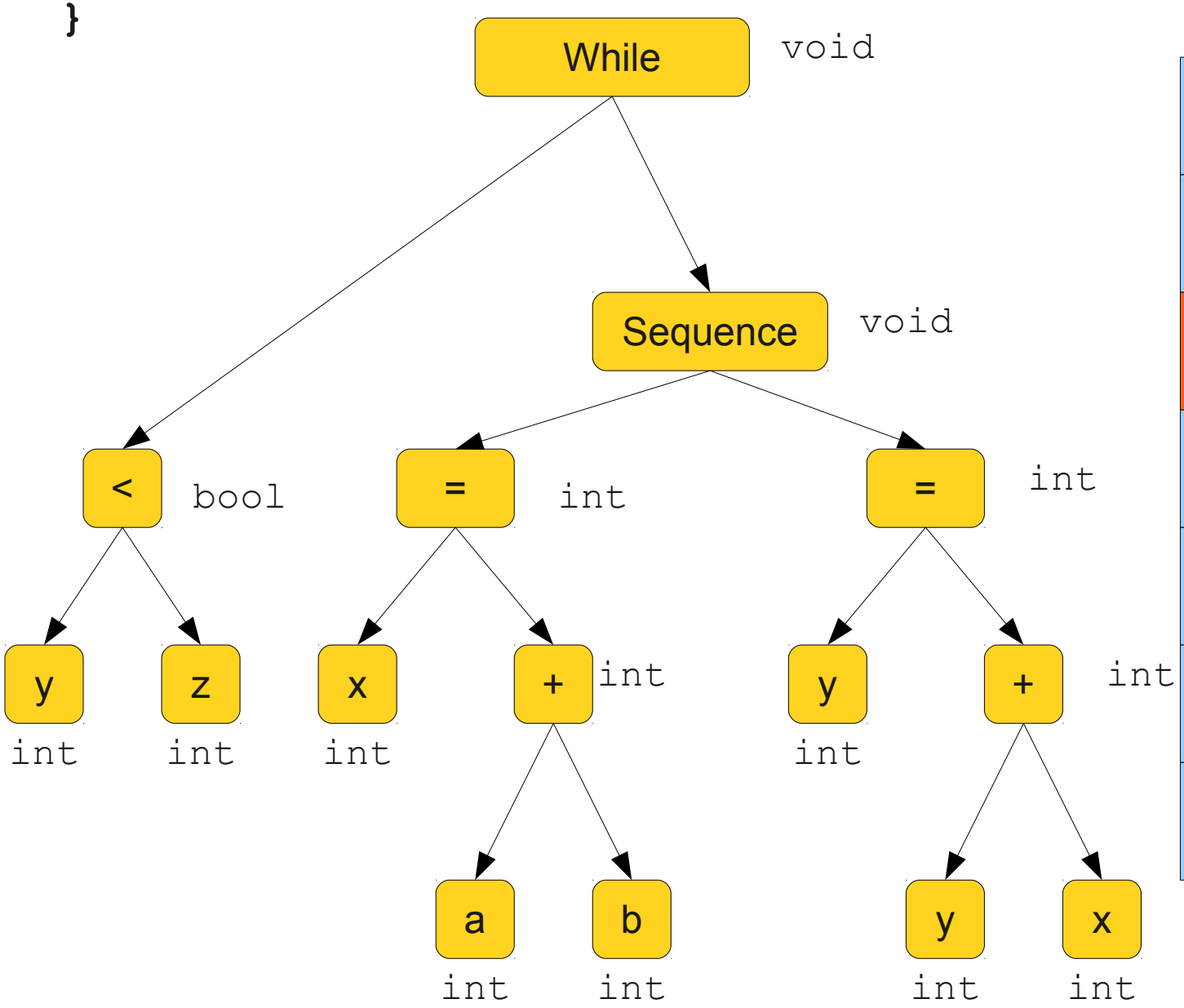

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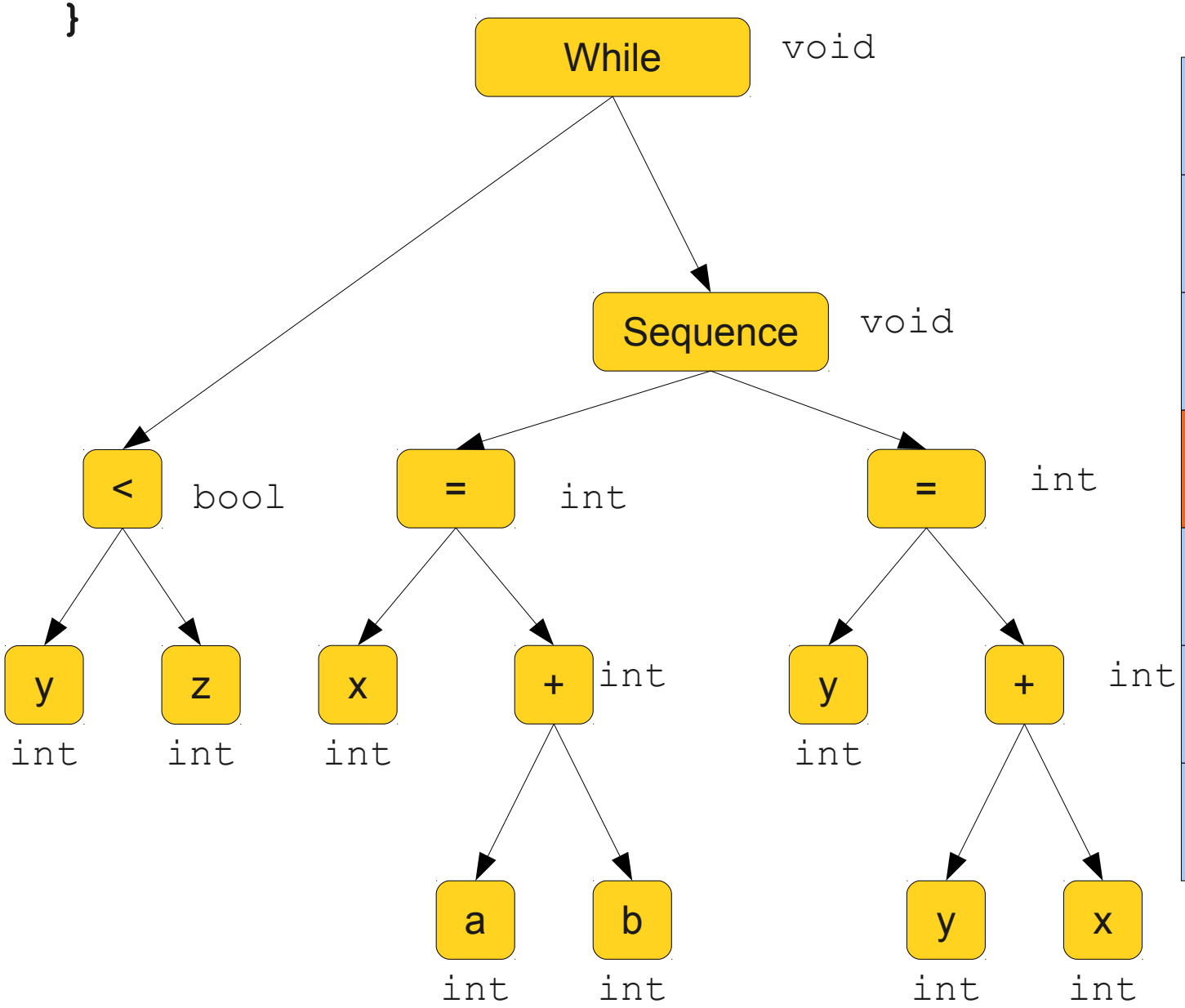

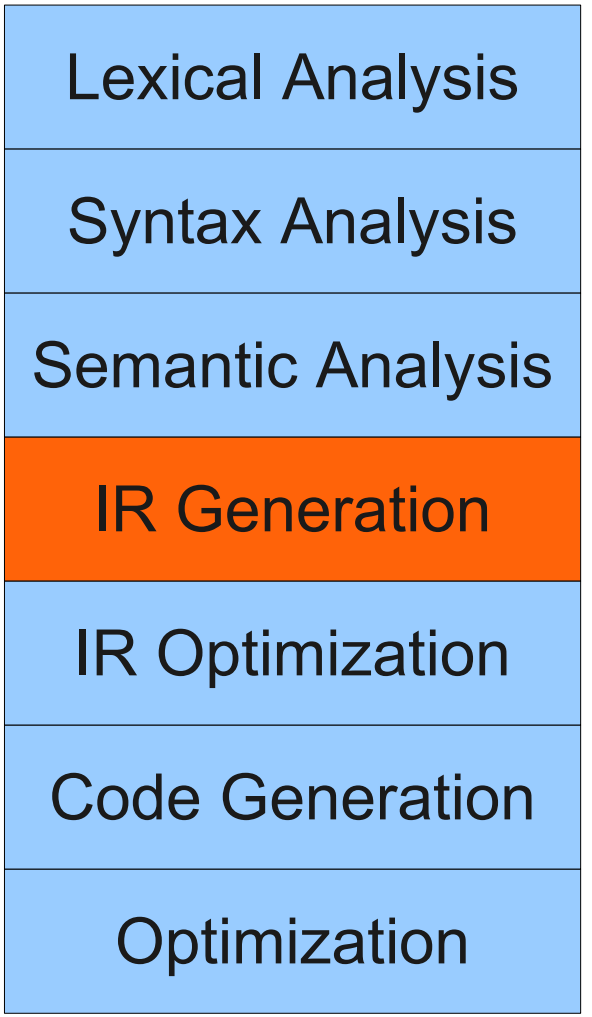

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while (y < z) {
    int x = a + b;
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```
Loop: x   = a + b
      y   = x + y
      _t1 = y < z
      if _t1 goto Loop
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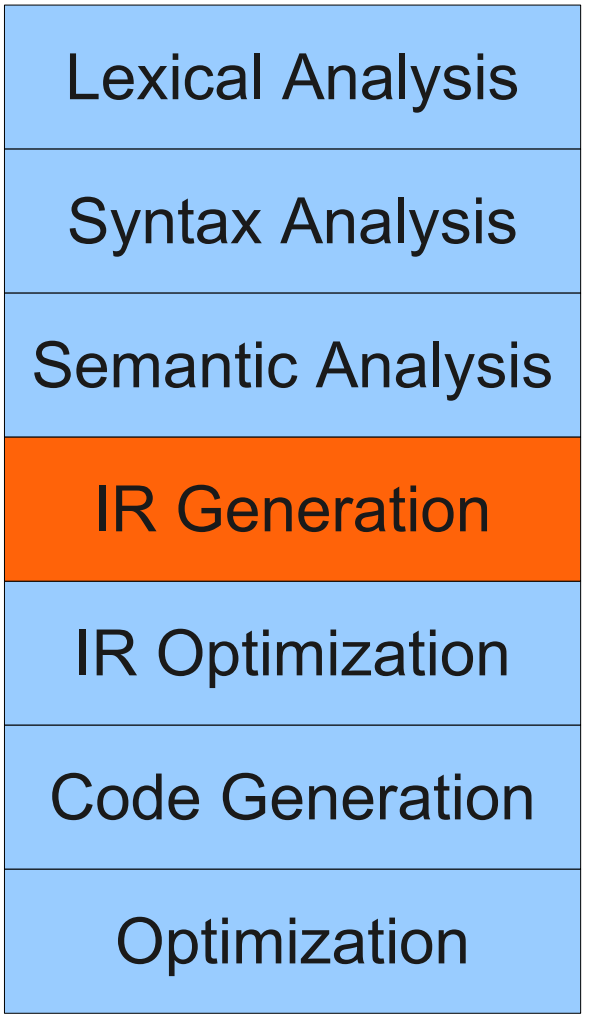

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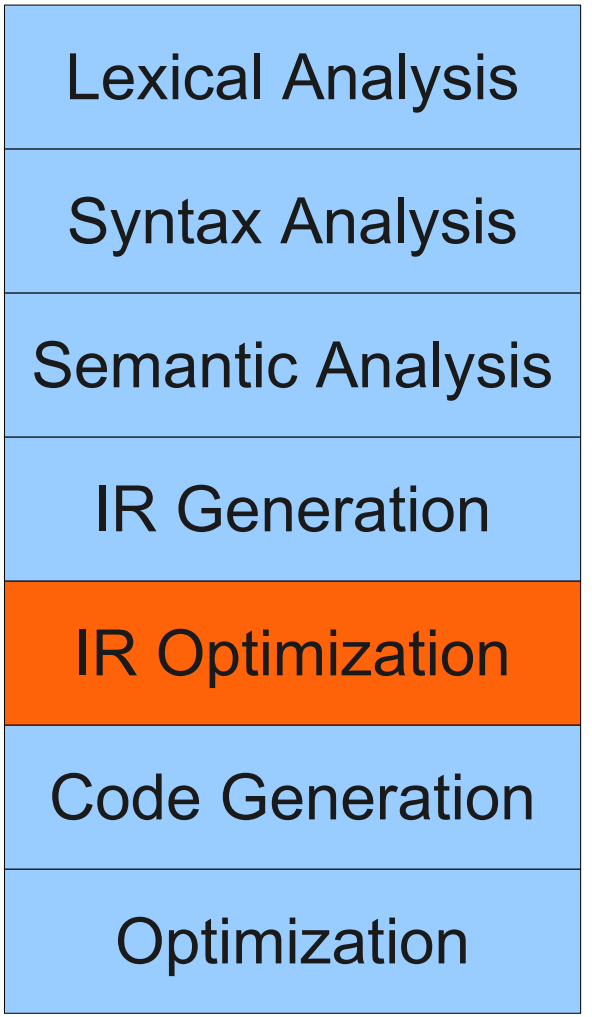

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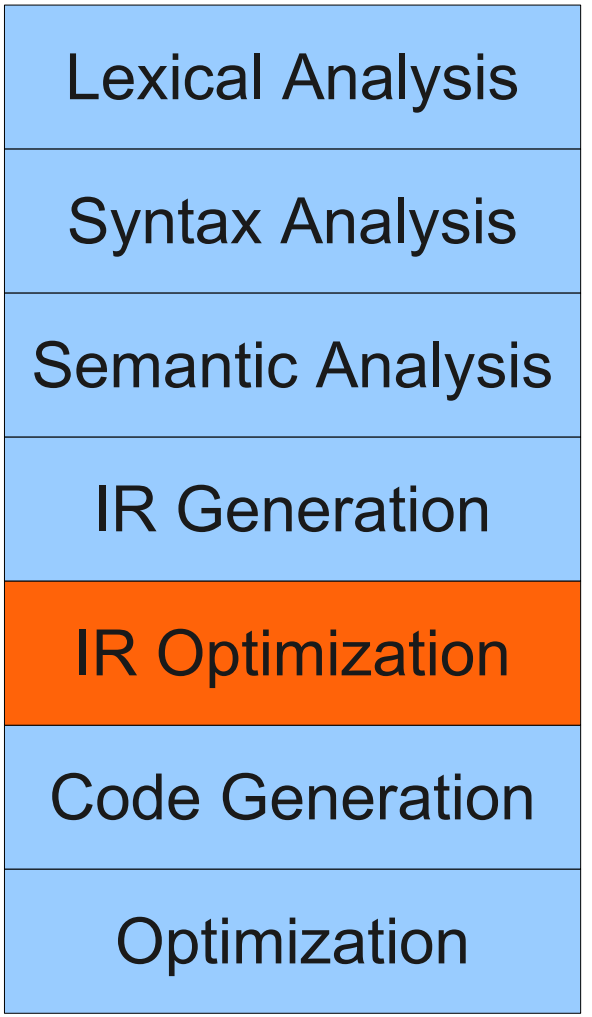

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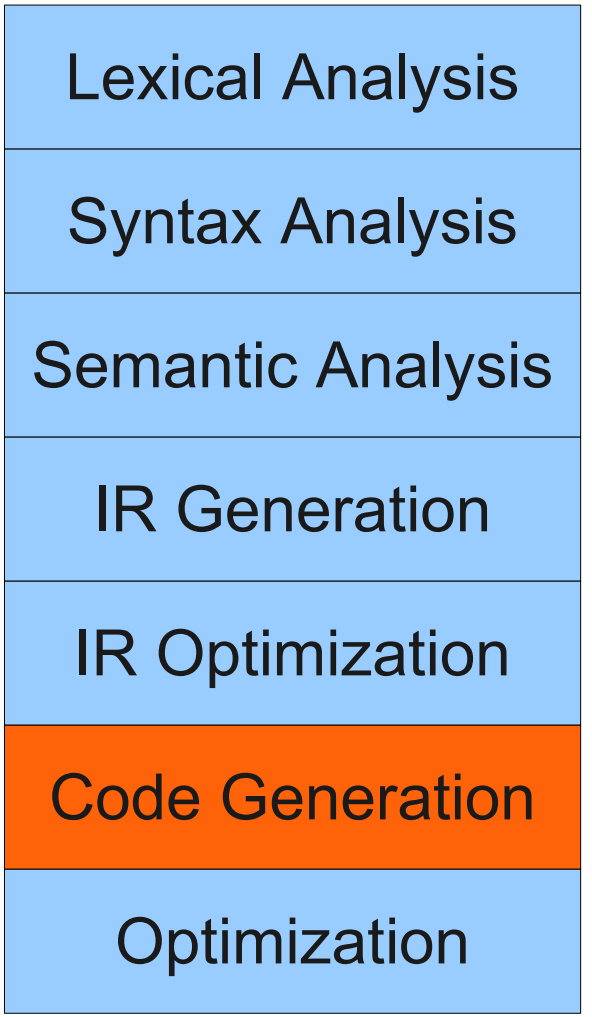

```
while (y < z) {
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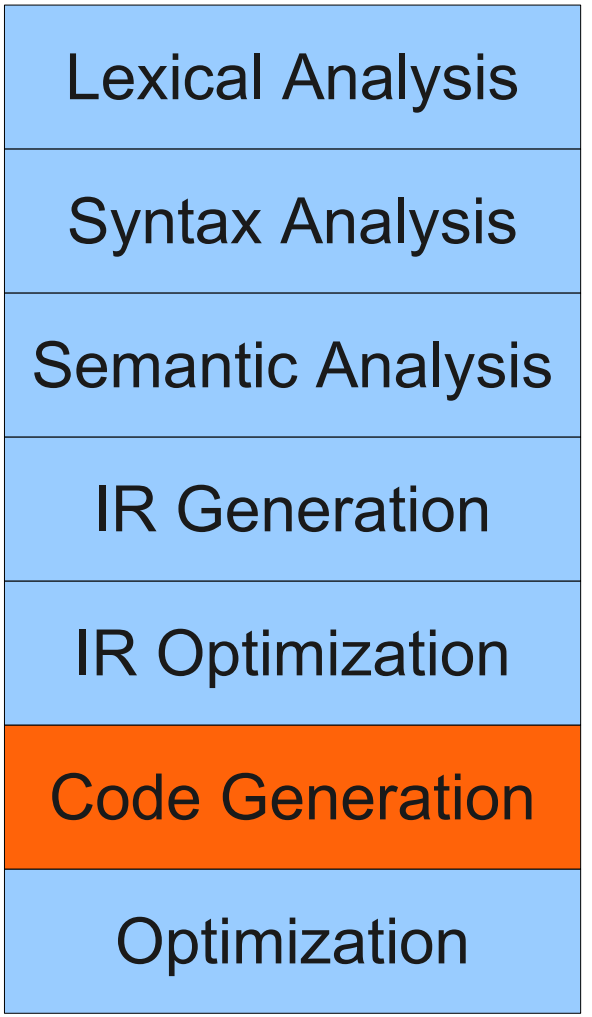
    y += x;
}
```

```
        add $1, $2, $3
Loop:   add $4, $1, $4
        slt $6, $1, $5
        beq $6, loop
```



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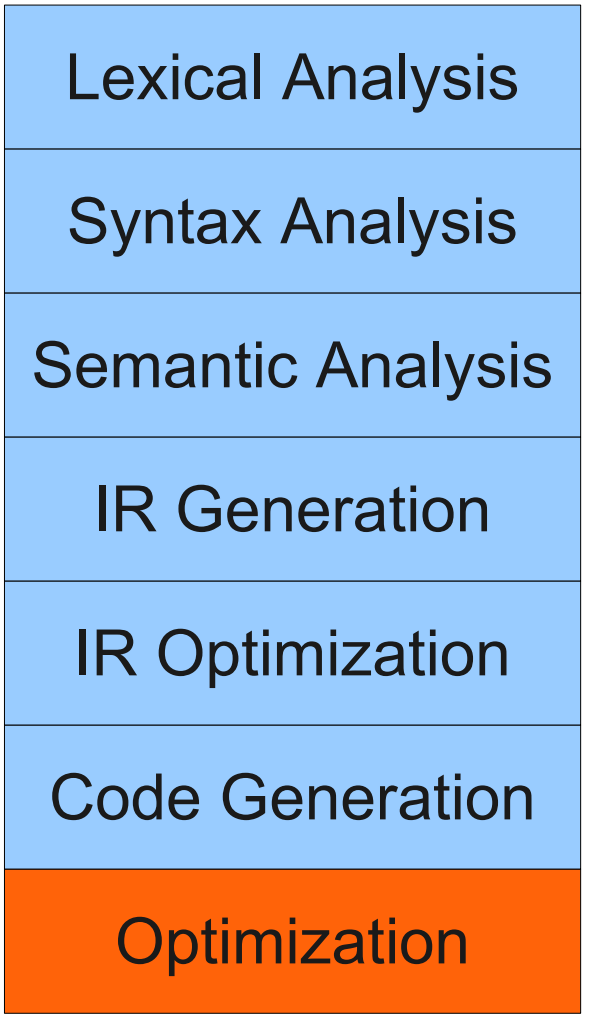

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while (y < z) {
    int x = a + b;
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}
```
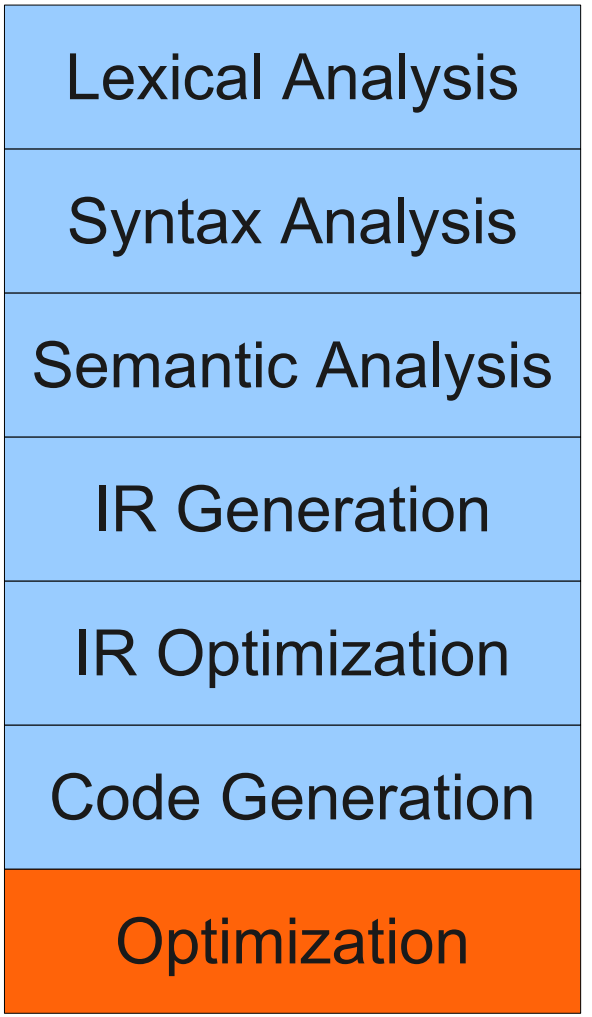
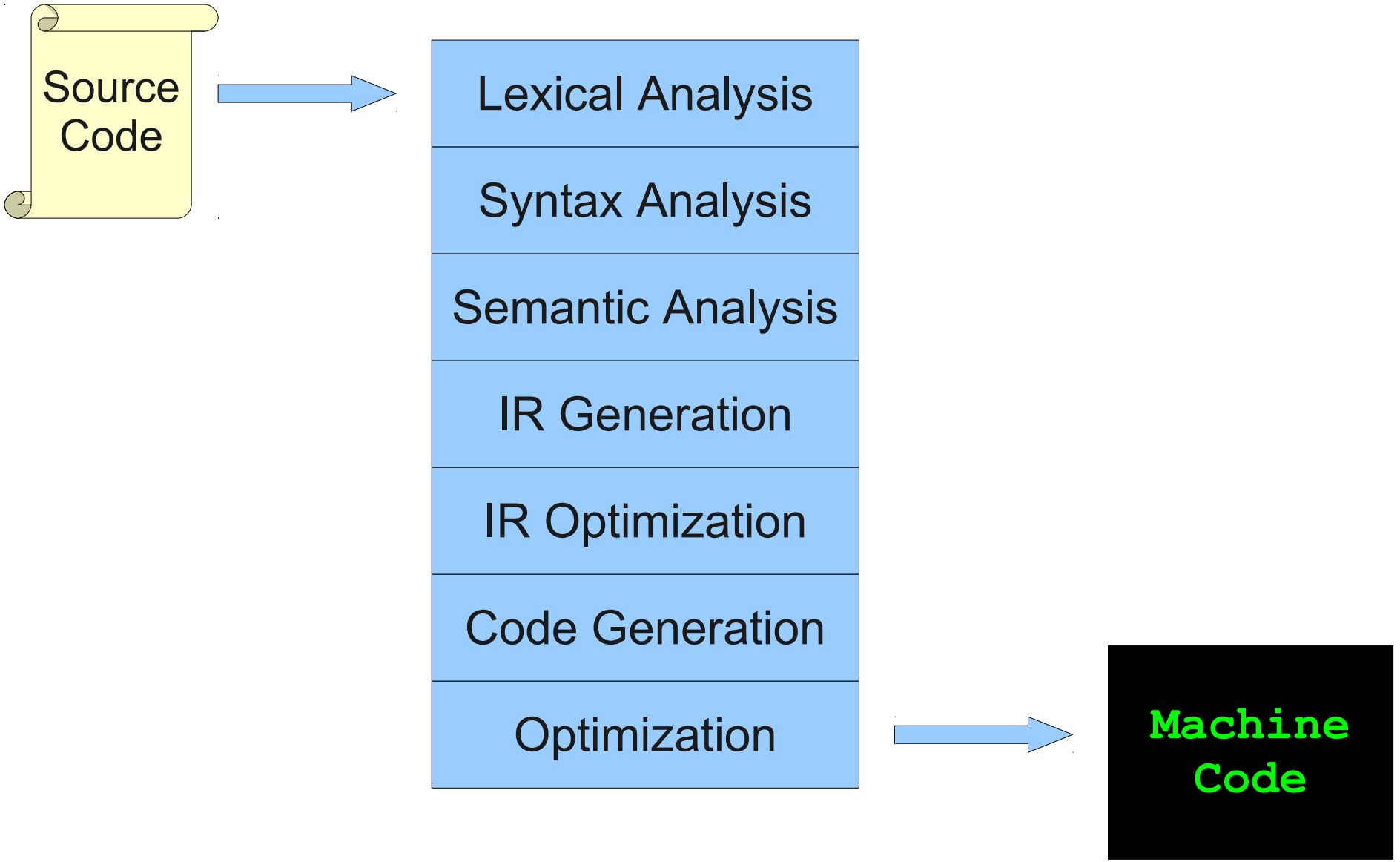

```
        add $1, $2, $3
Loop:   add $4, $1, $4
        blt $1, $5, loop
```



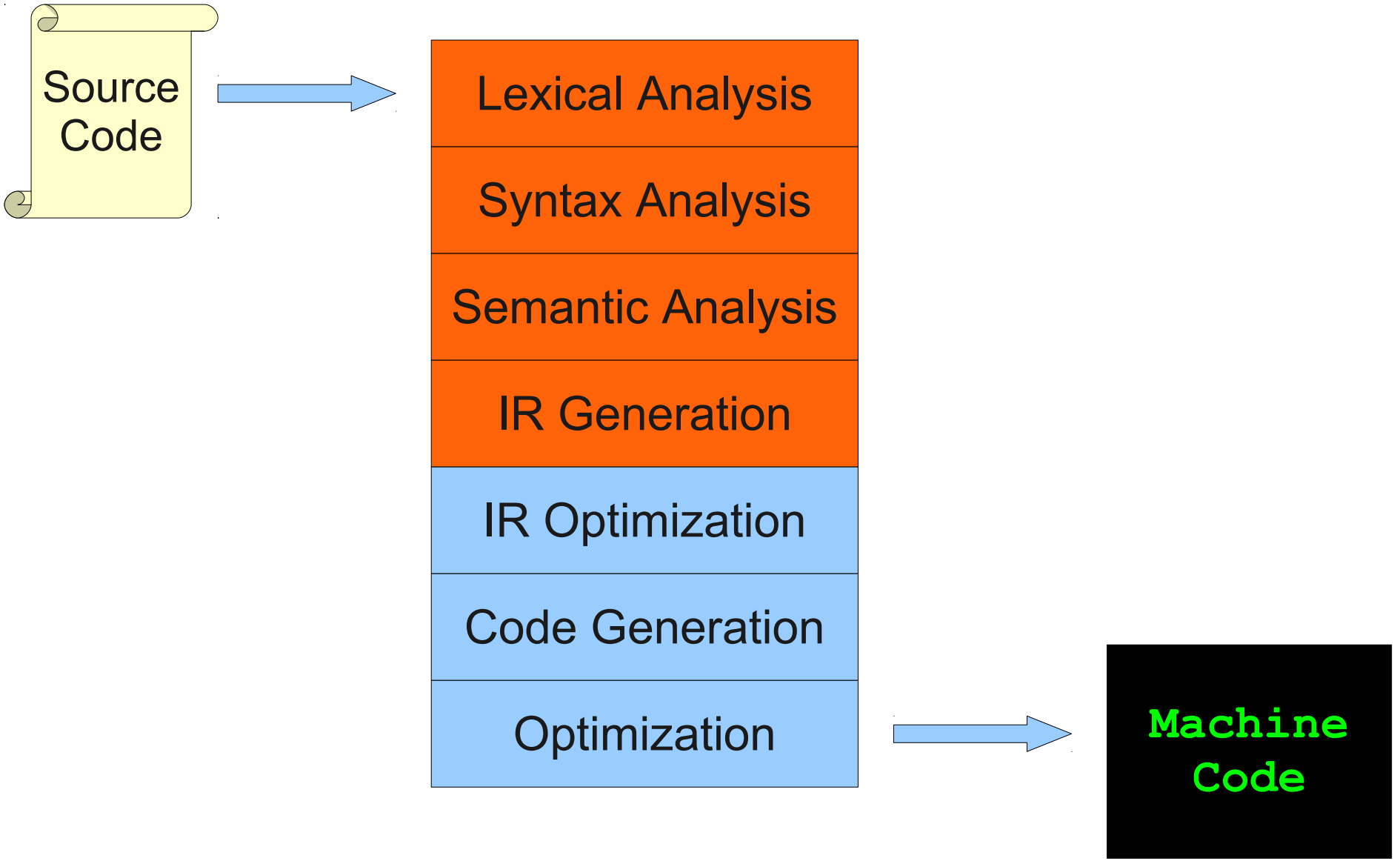
The Course Project: **Decaf**

- Custom programming language similar to Java or C++.
- Object-oriented with free functions.
- Single inheritance with interfaces.

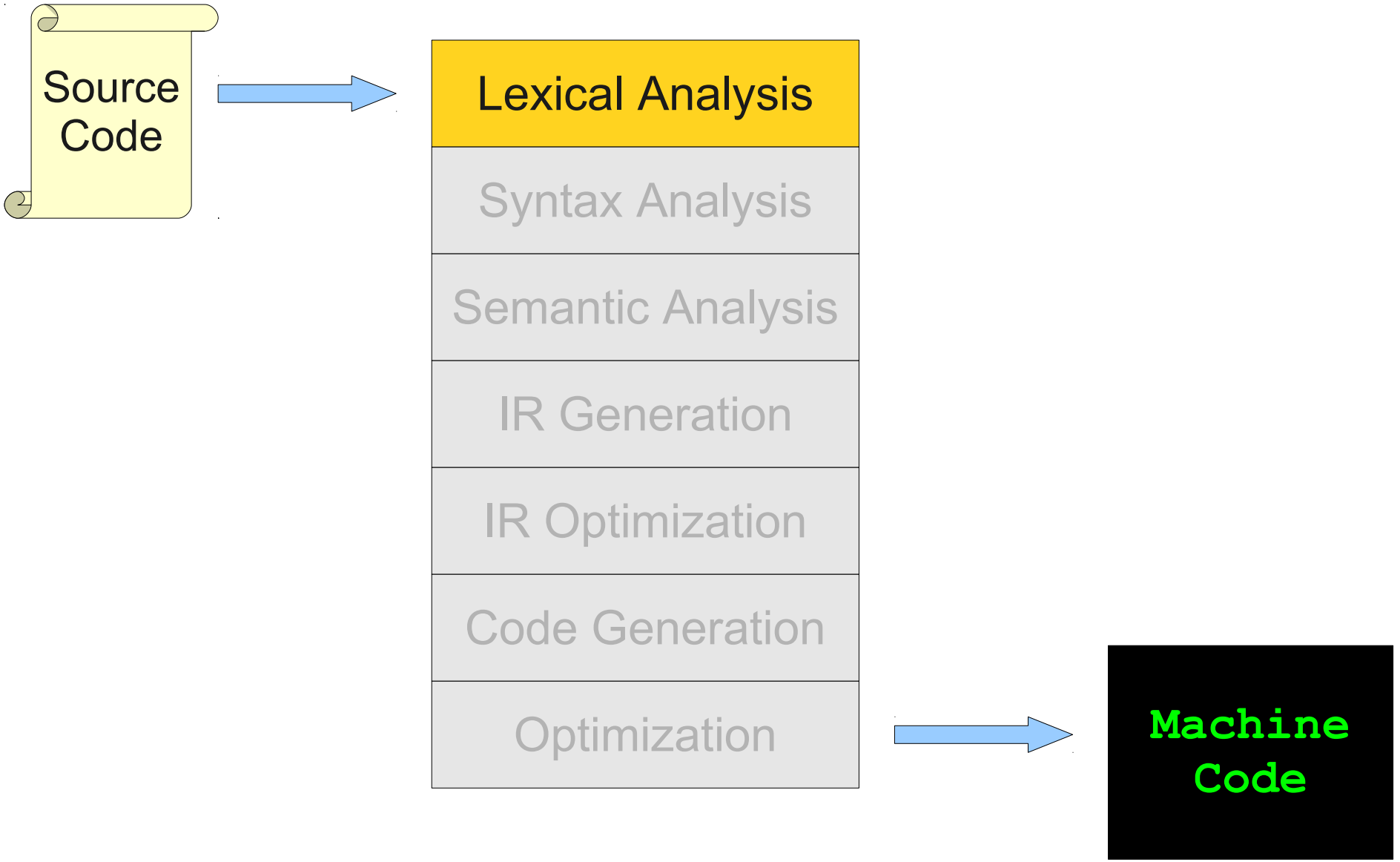
Programming Assignments



Programming Assignments



Next Time...


Source Code
Lexical Analysis
Syntax Analysis
Semantic Analysis
IR Generation
IR Optimization
Code Generation
Optimization
Machine Code