Welcome to CS143: Compilers

- Course Information
- Why Study Compilers?
- A Quick History of Compilers
- The Structure of a Compiler

Course Staff

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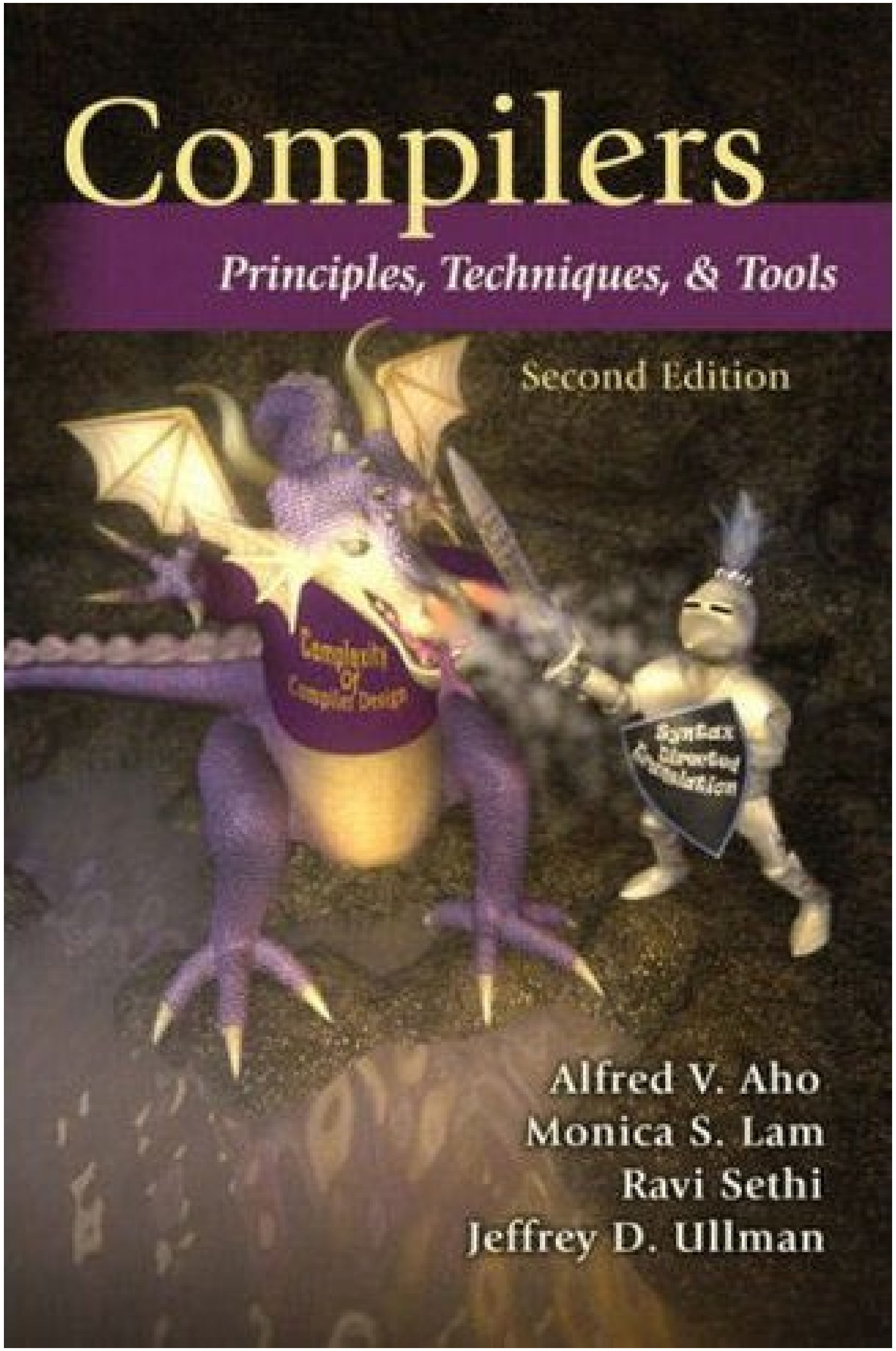
TA: Jinchao Ye
(jcye@stanford.edu)

TA: Naran Bayanbat
(narab@stanford.edu)

http://cs143.stanford.edu

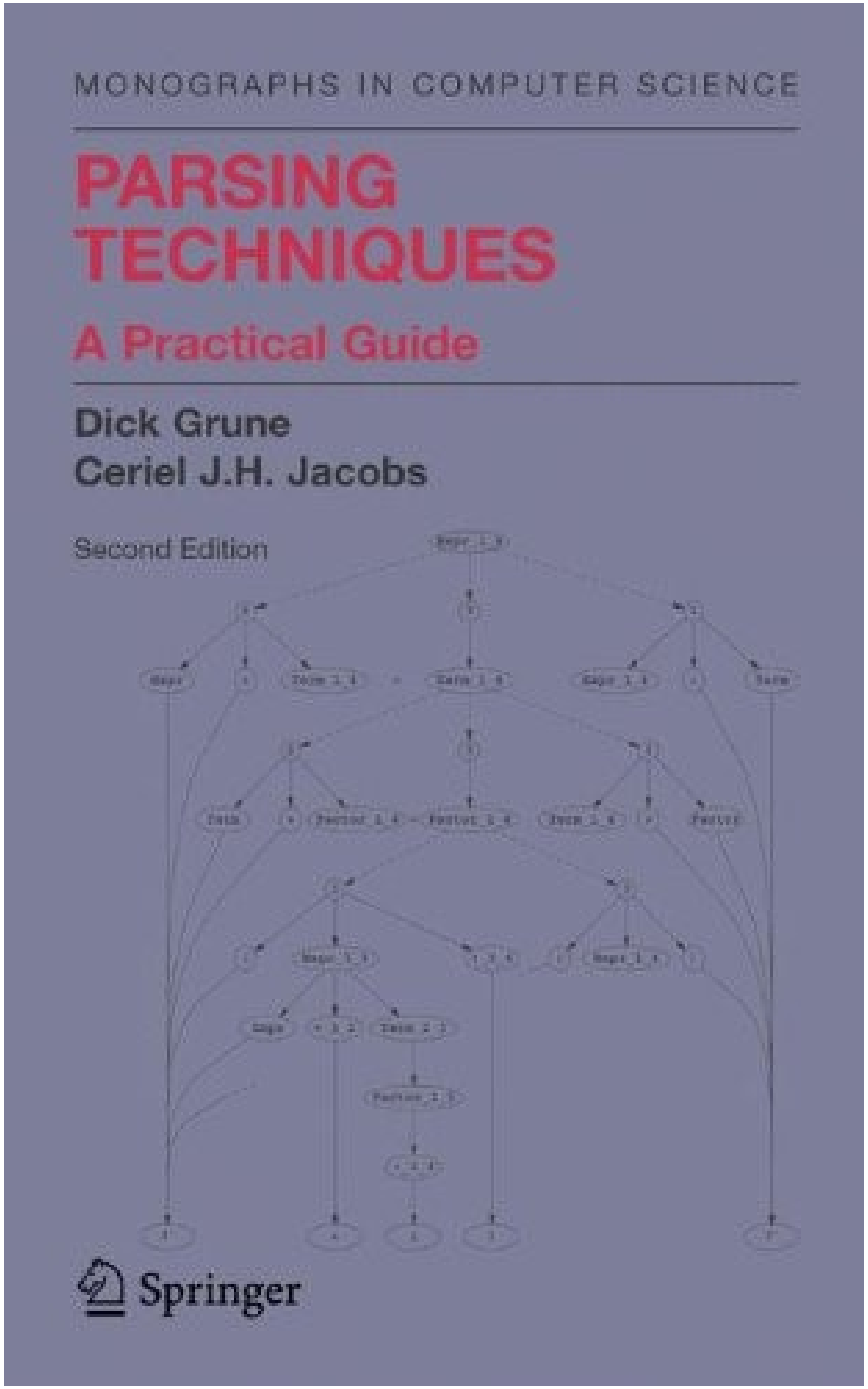


Compilers

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

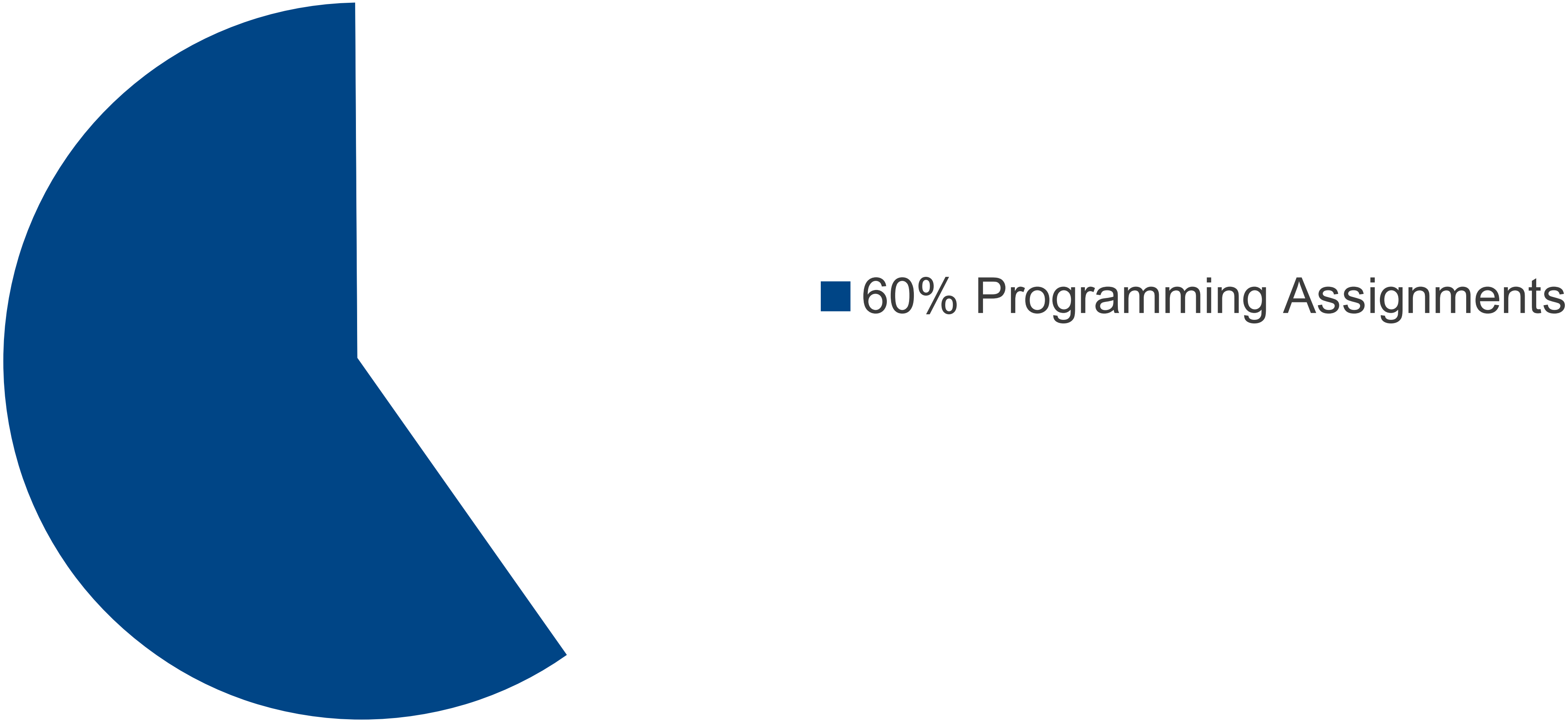
Dick Grune
Ceriel J.H. Jacobs

Second Edition

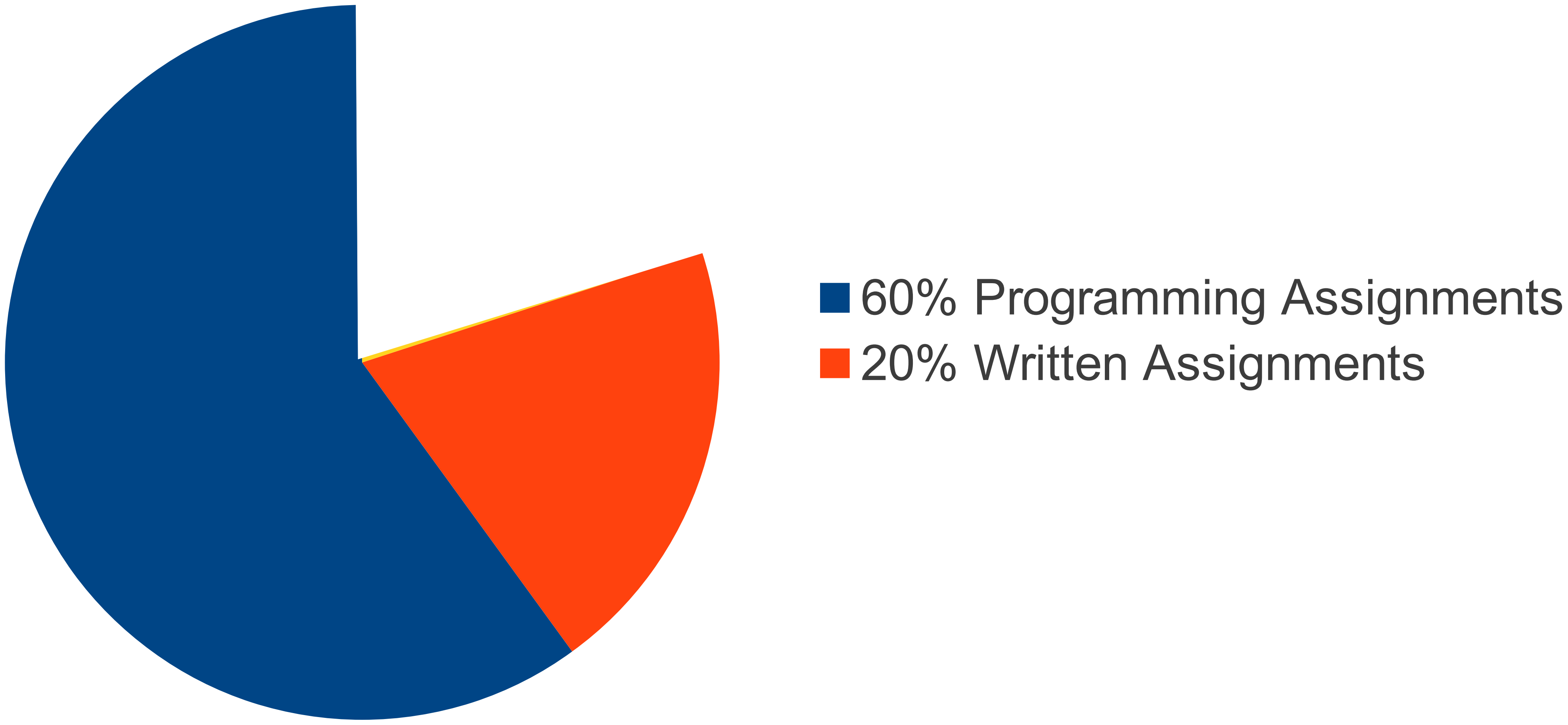
Springer

Grading Policies

Grading Policies



Grading Policies



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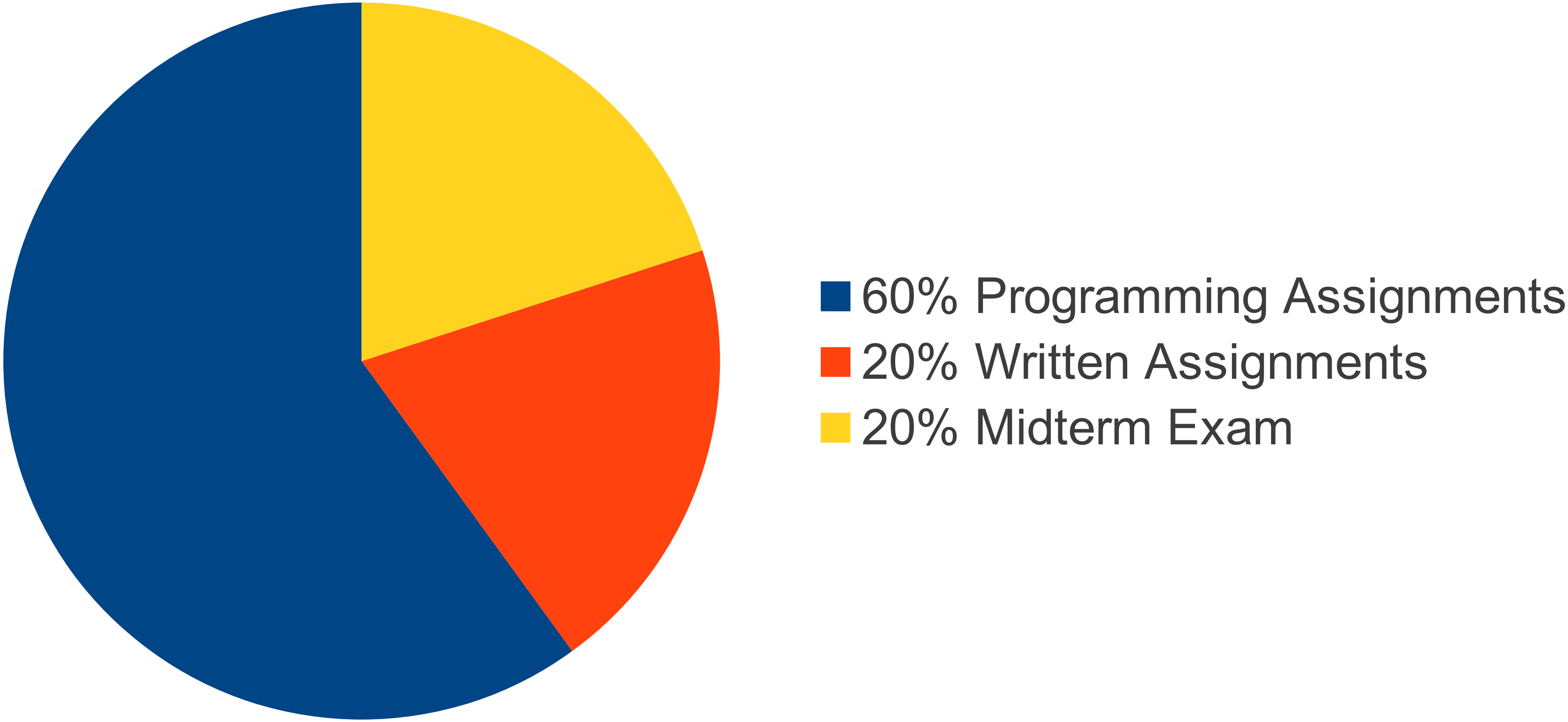

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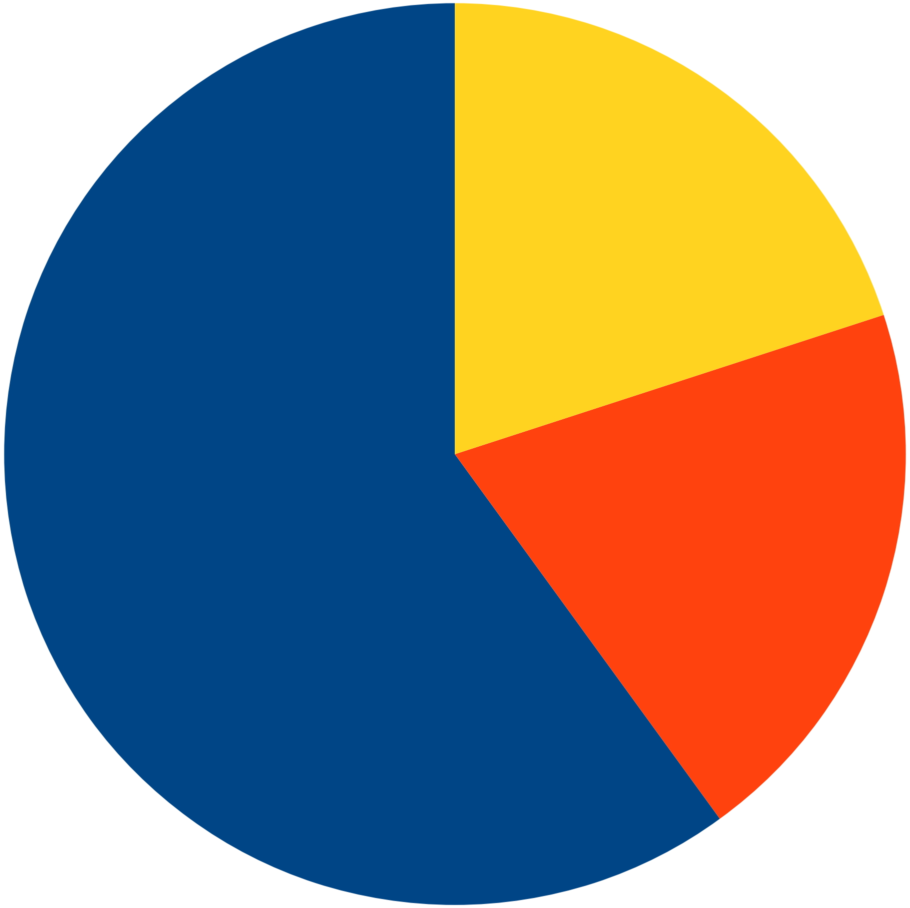


Midterm exam:
July 25,
11:00AM – 1:00PM,
Location TBA

A Word on the Honor Code…

Prerequisites

CS107

CS103

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.
- Programming expensive; 50% of costs for machines went into programming.

High-Level Languages

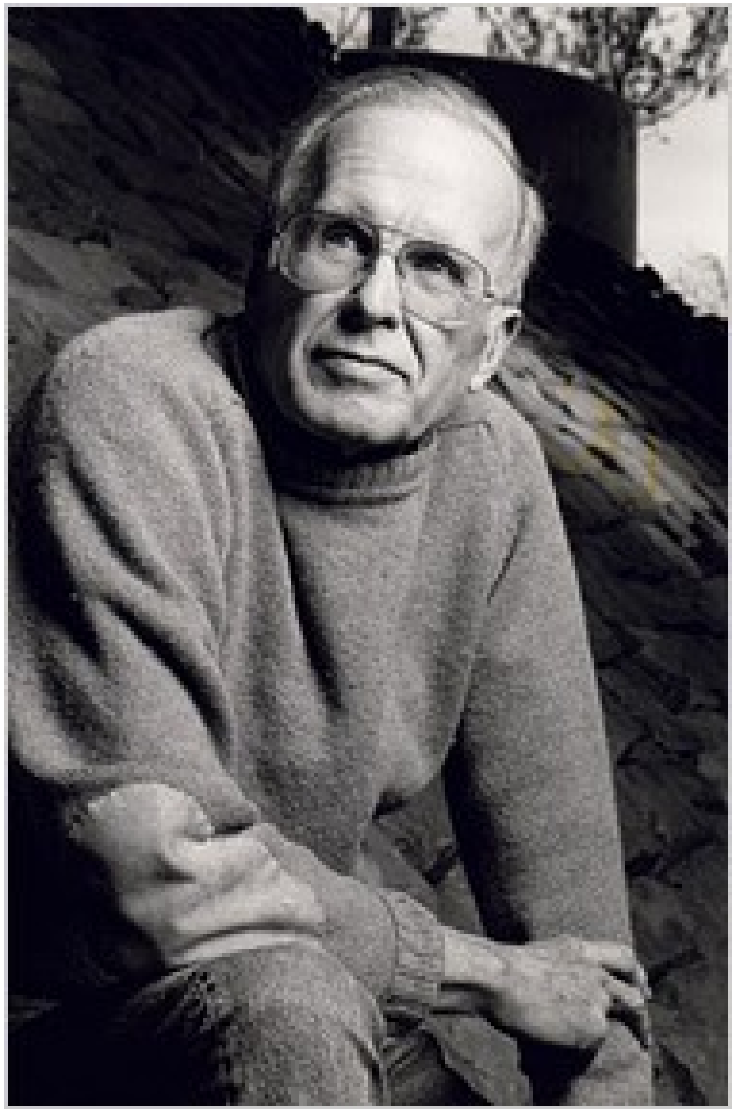
Image: http://upload.wikimedia.org/wikipedia/commons/thumb/5/55/Grace_Hopper.jpg/300px-Grace_Hopper.jpg
http://www.nytimes.com/2007/03/20/business/20backus.html

High-Level Languages

Rear Admiral **Grace Hopper**, inventor of A-0, COBOL, and the term "compiler."

Image: http://upload.wikimedia.org/wikipedia/commons/thumb/5/55/Grace_Hopper.jpg/300px-Grace_Hopper.jpg
http://www.nytimes.com/2007/03/20/business/20backus.html

High-Level Languages



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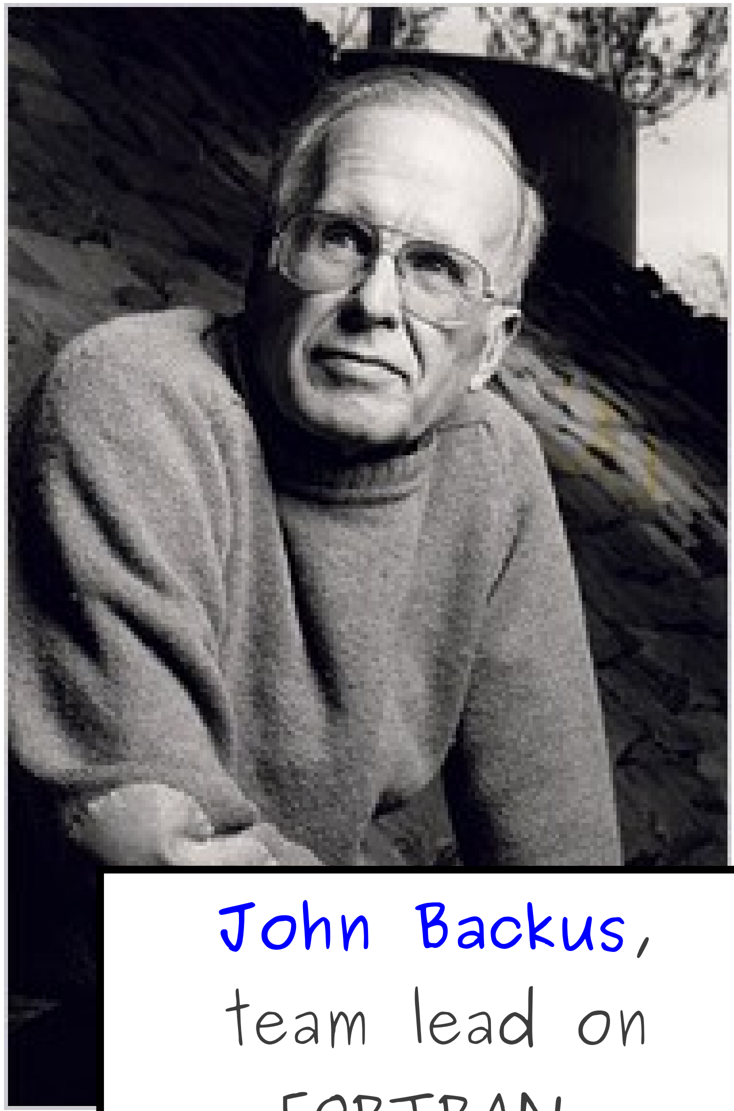
High-Level Languages

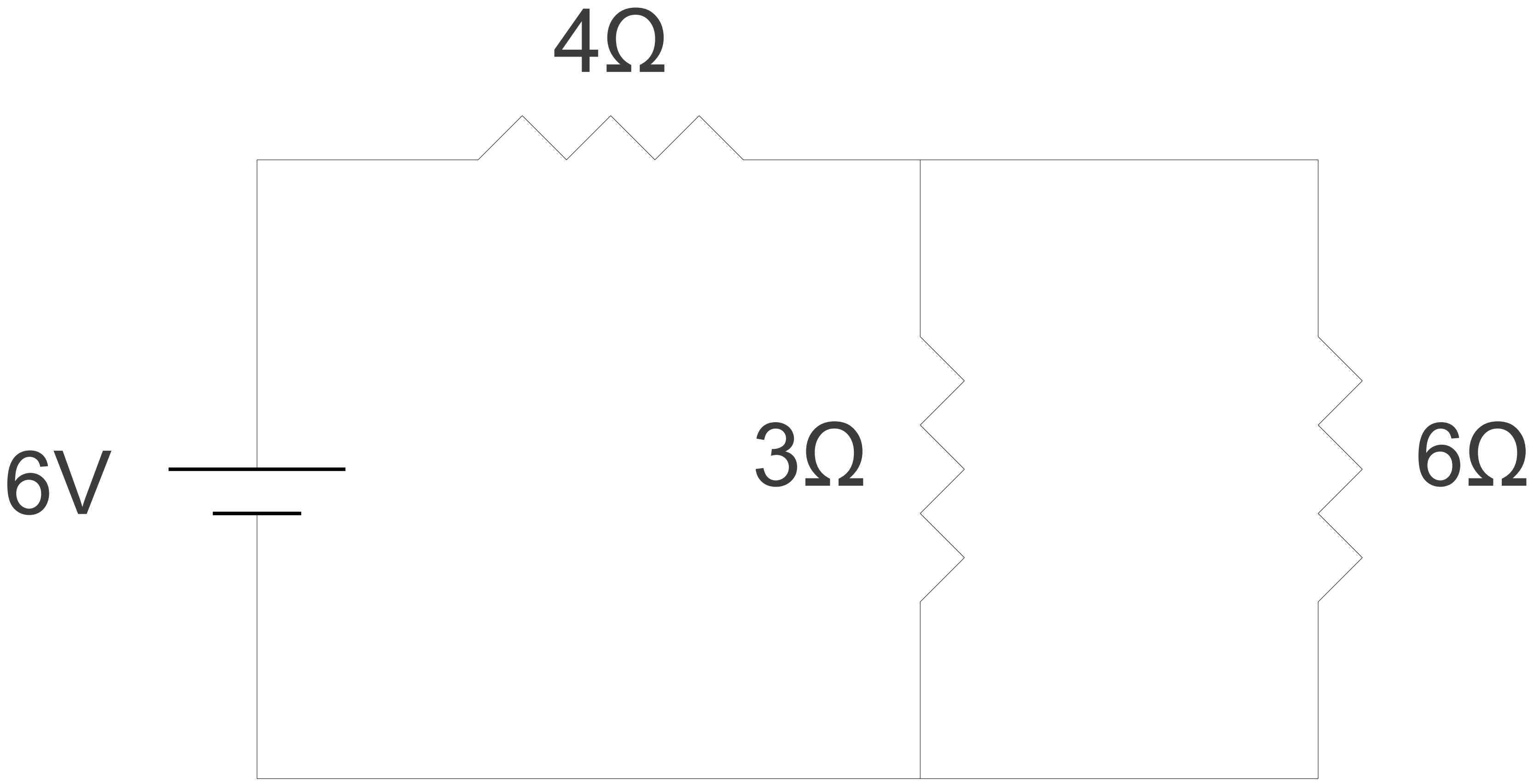


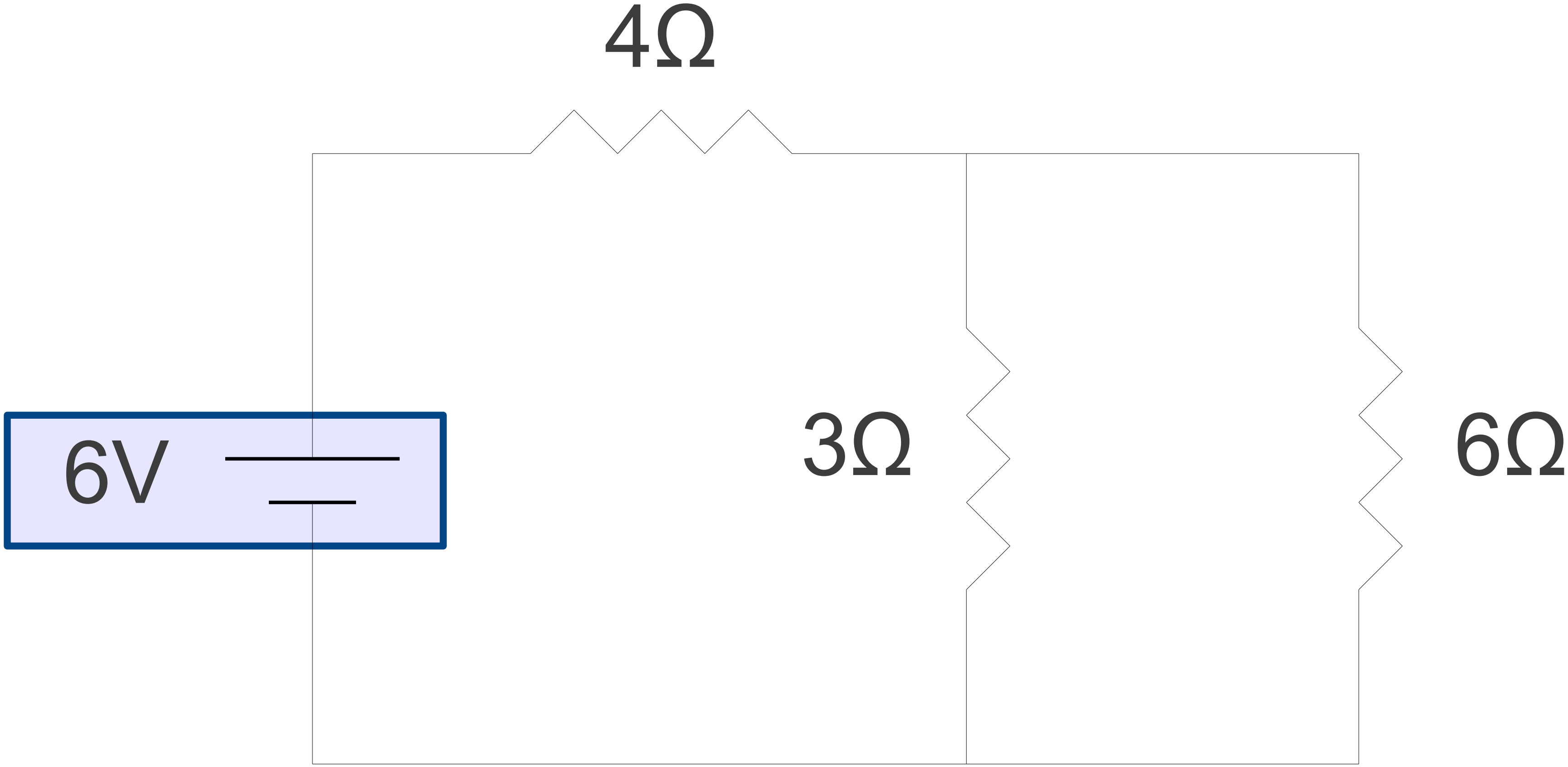
John Backus, team lead on FORTRAN.

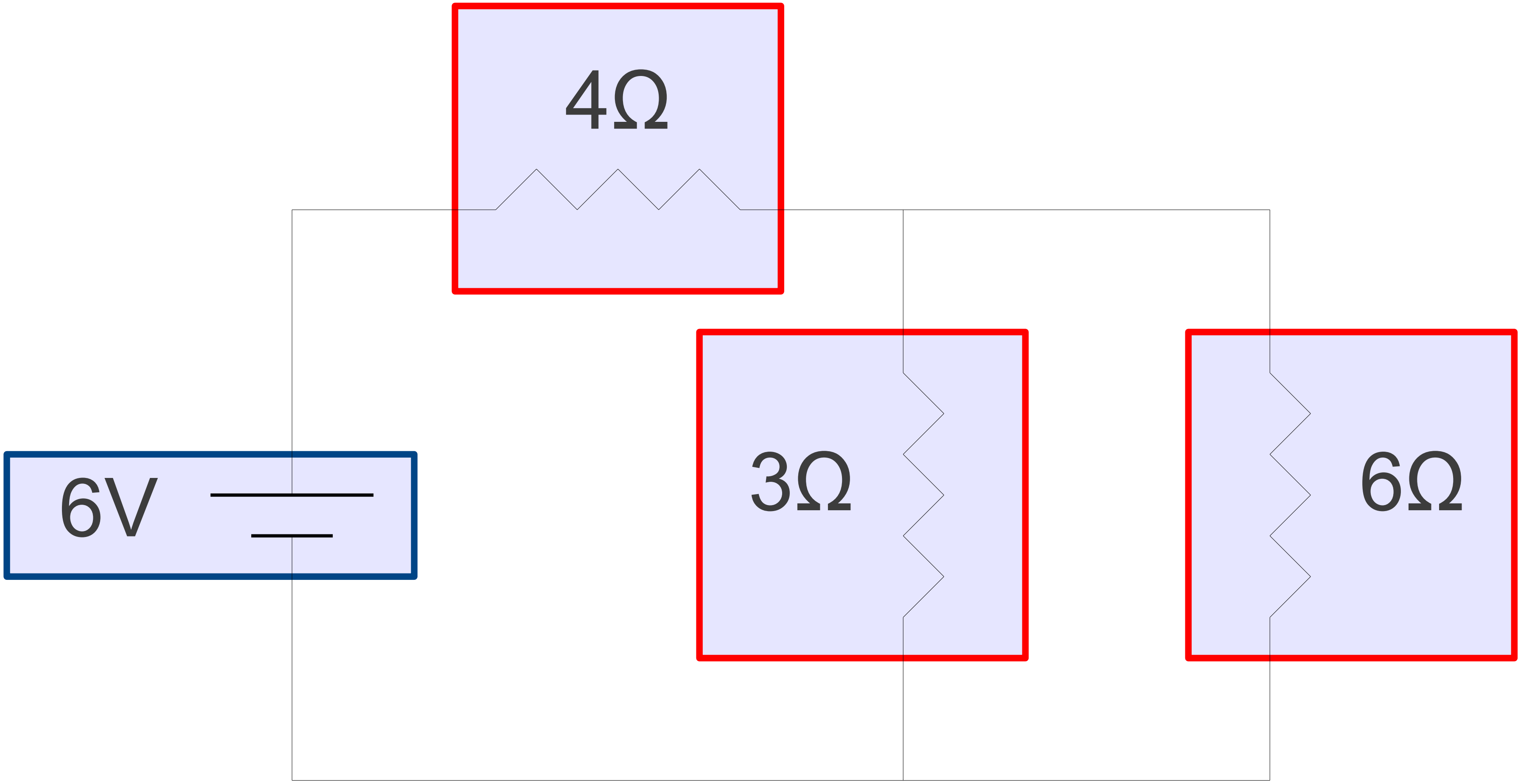
Image: http://upload.wikimedia.org/wikipedia/commons/thumb/5/55/ er.jpg

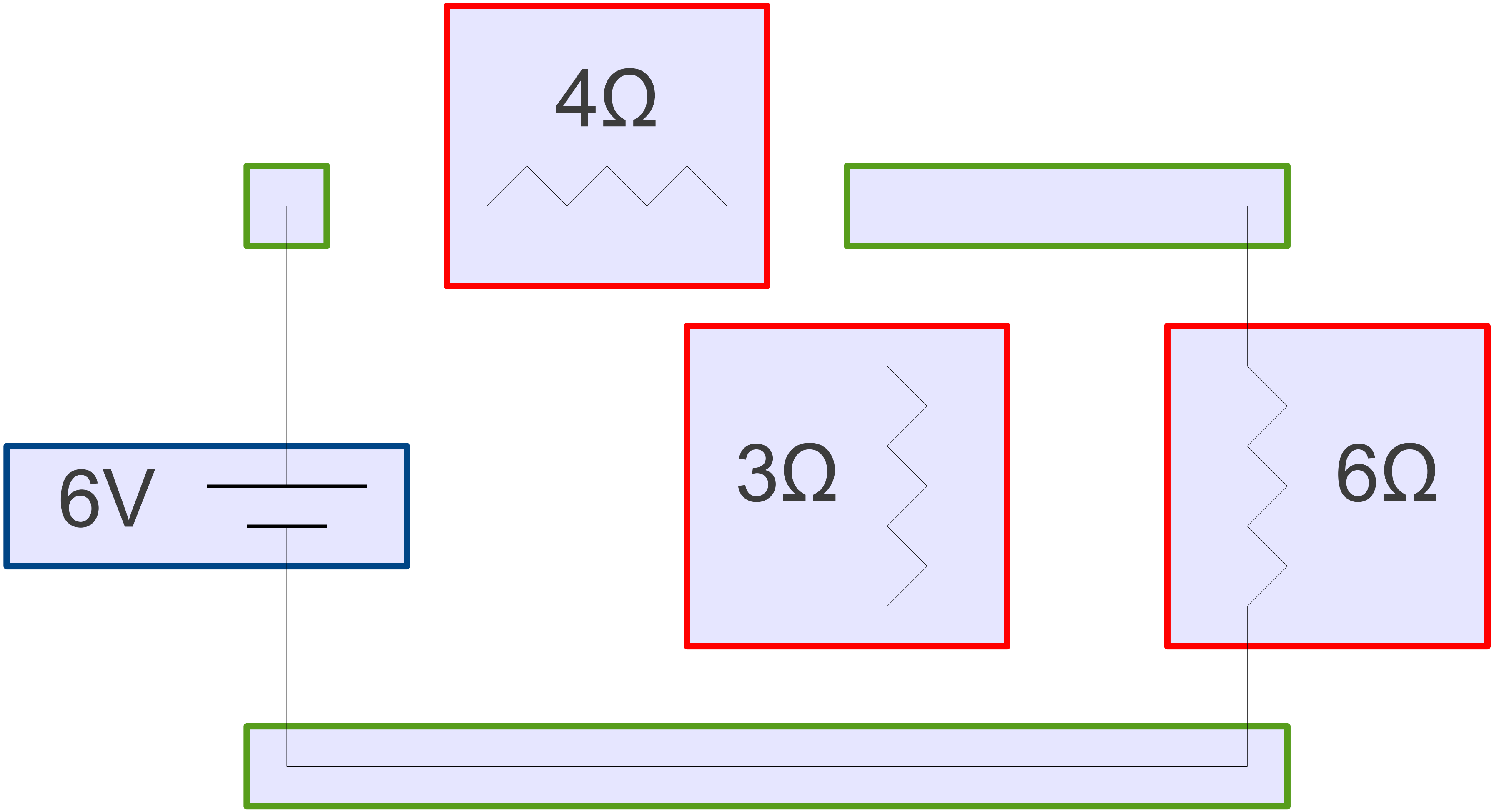
http://www.nytimes.com/2007/03/20/business/20backus.html

How does a compiler work?


4Ω
6V
3Ω
6Ω


4Ω
6V
3Ω
6Ω


4Ω
6V
3Ω
6Ω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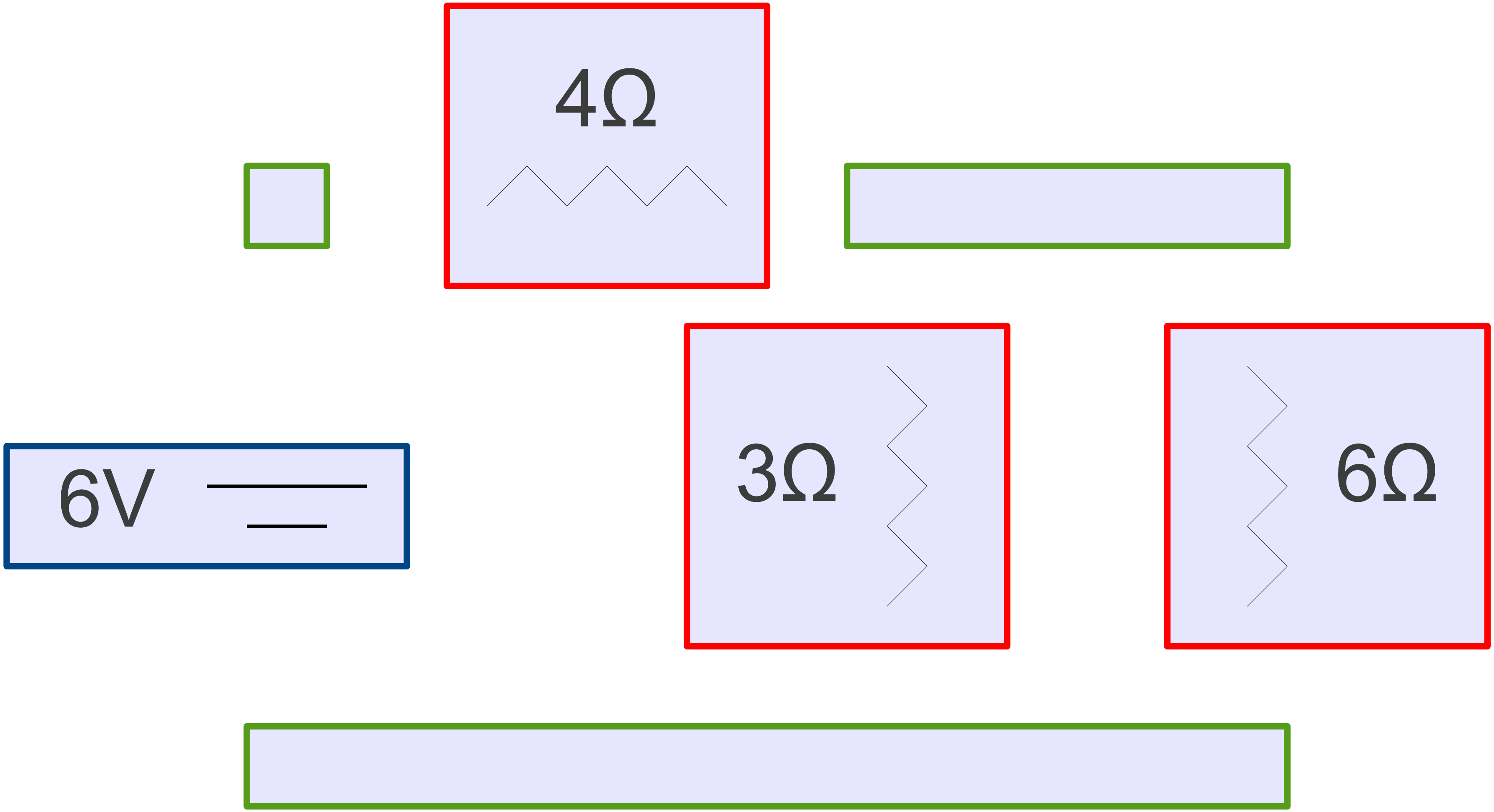
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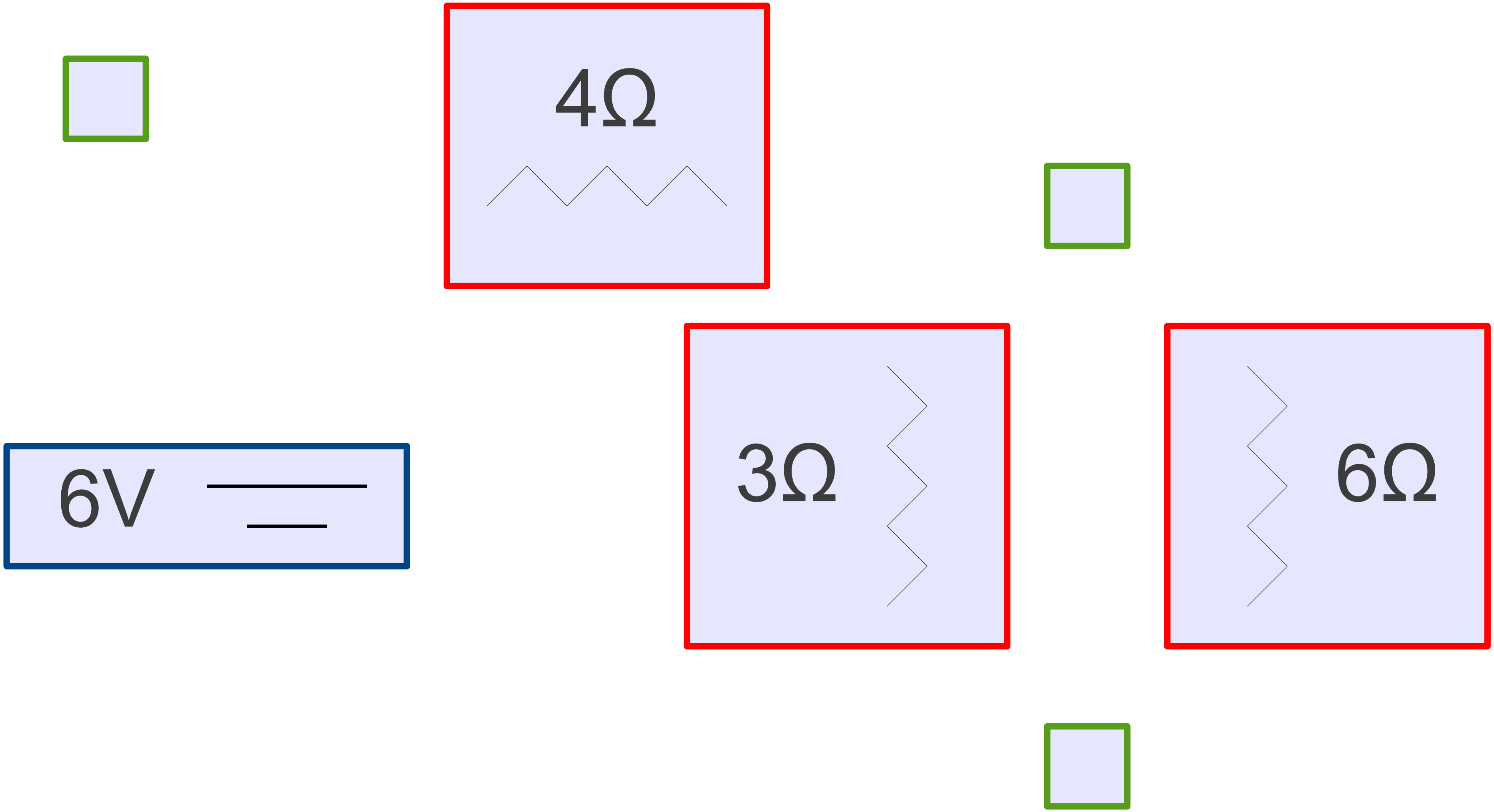
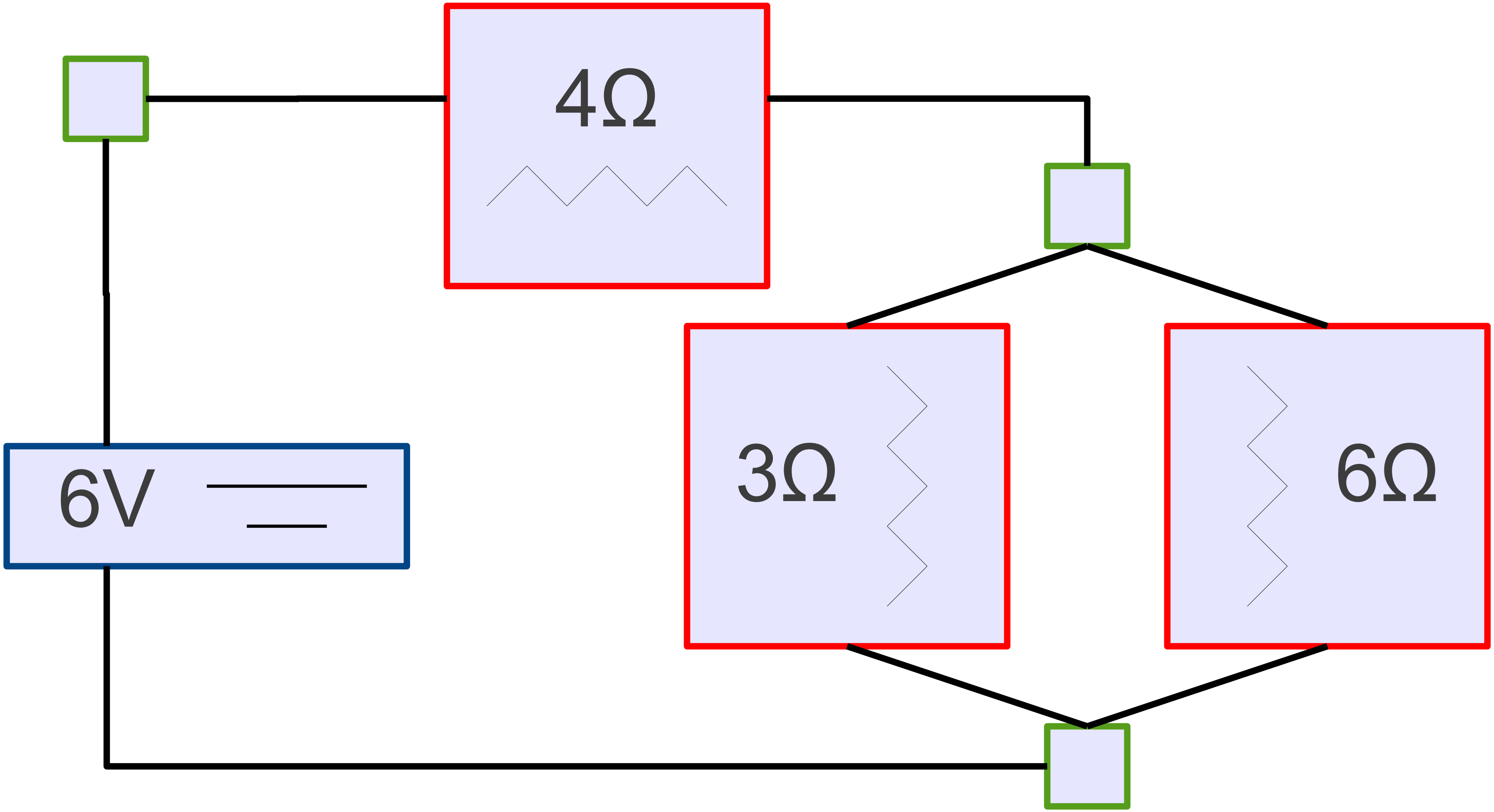
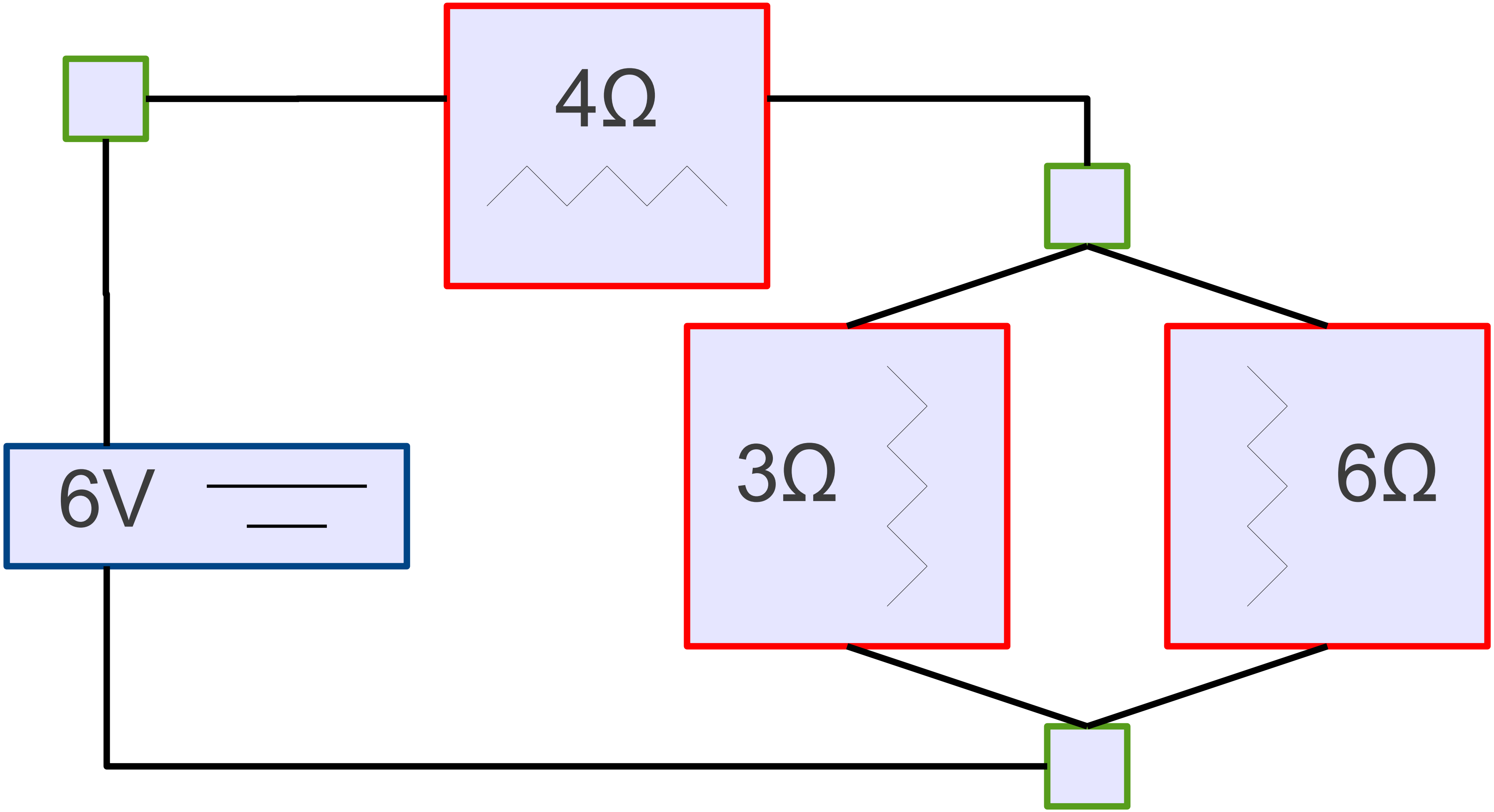
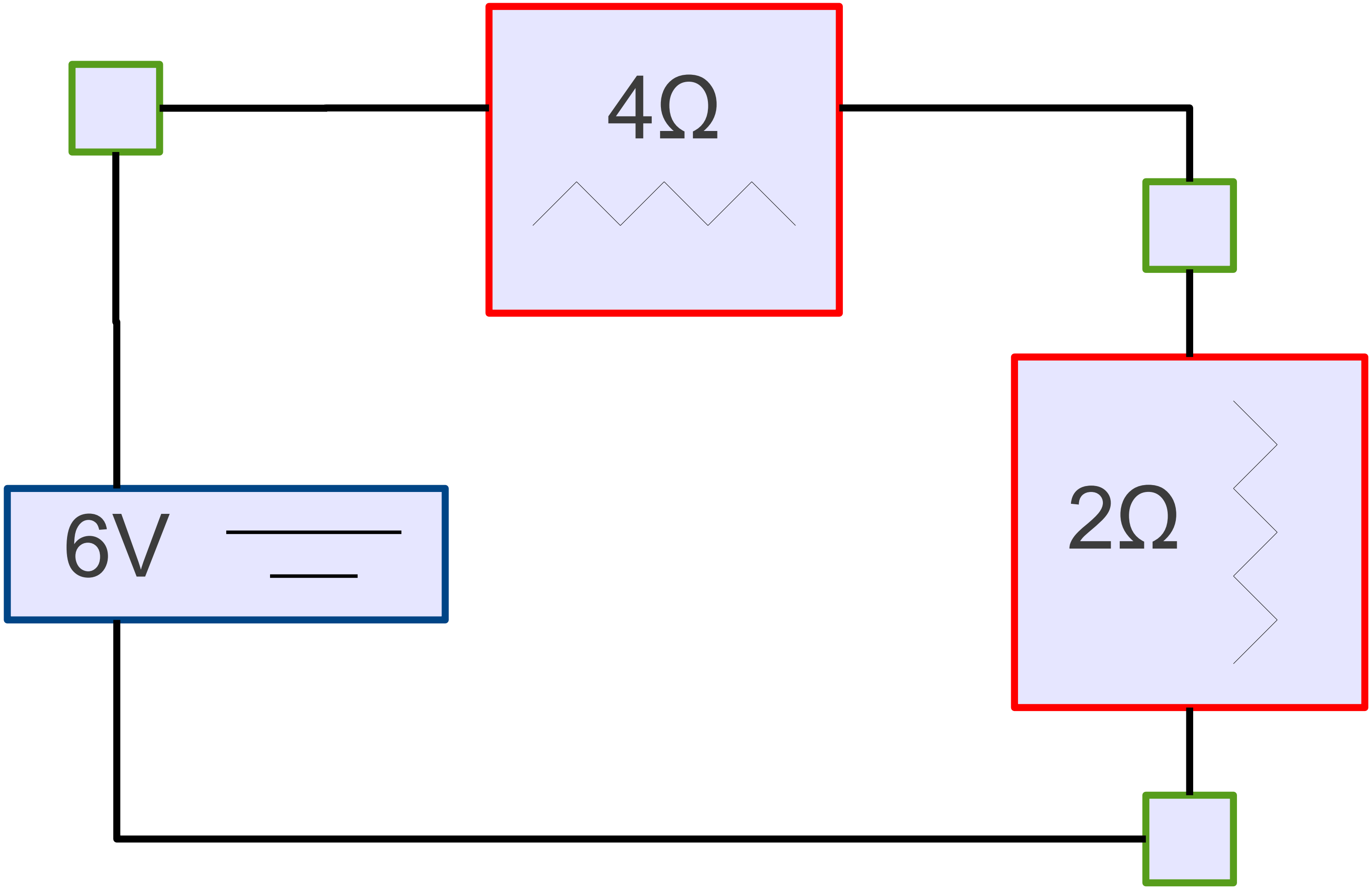

4Ω
6V
3Ω
6Ω


4Ω
6V
3Ω
6Ω



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



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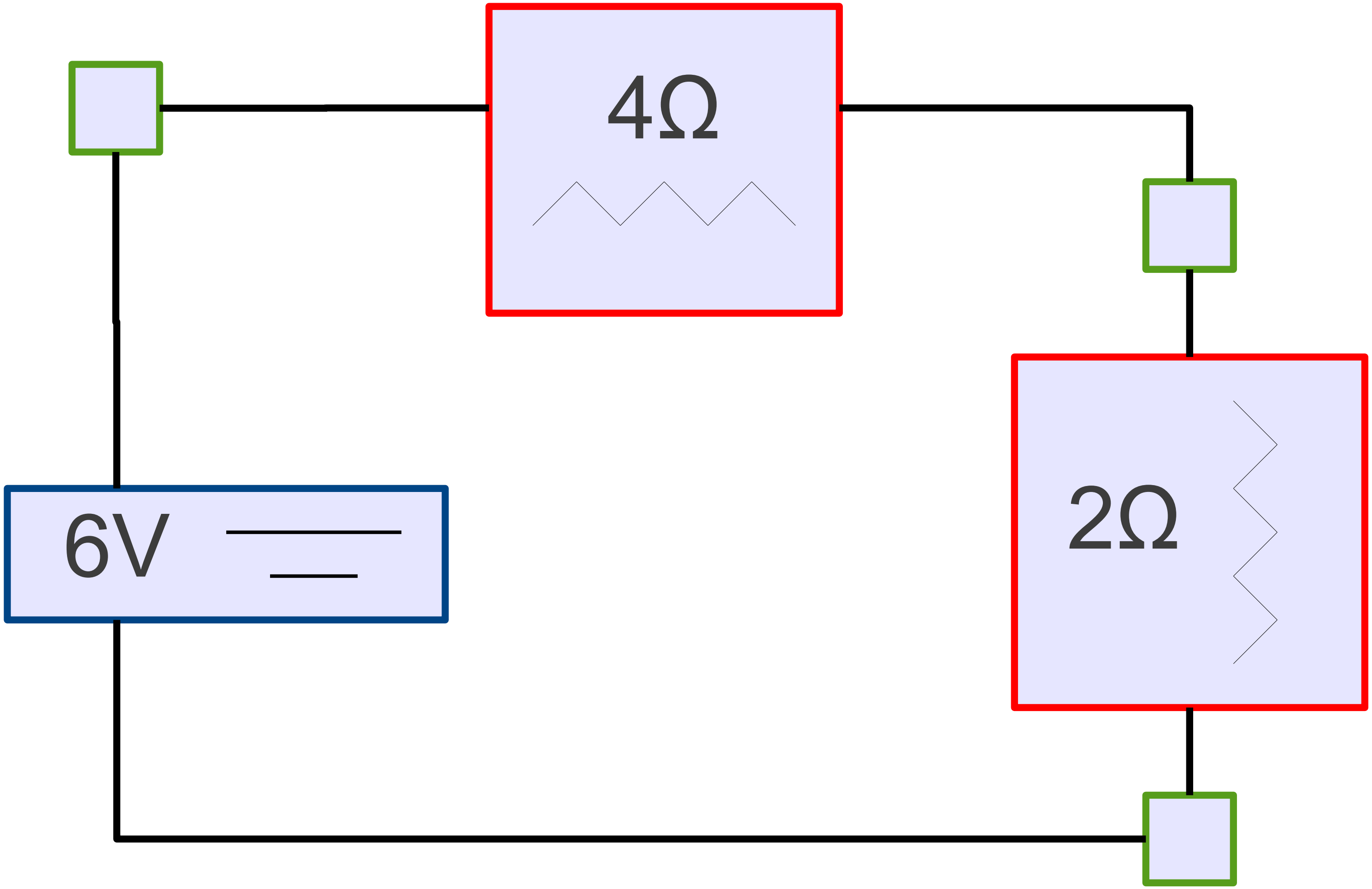
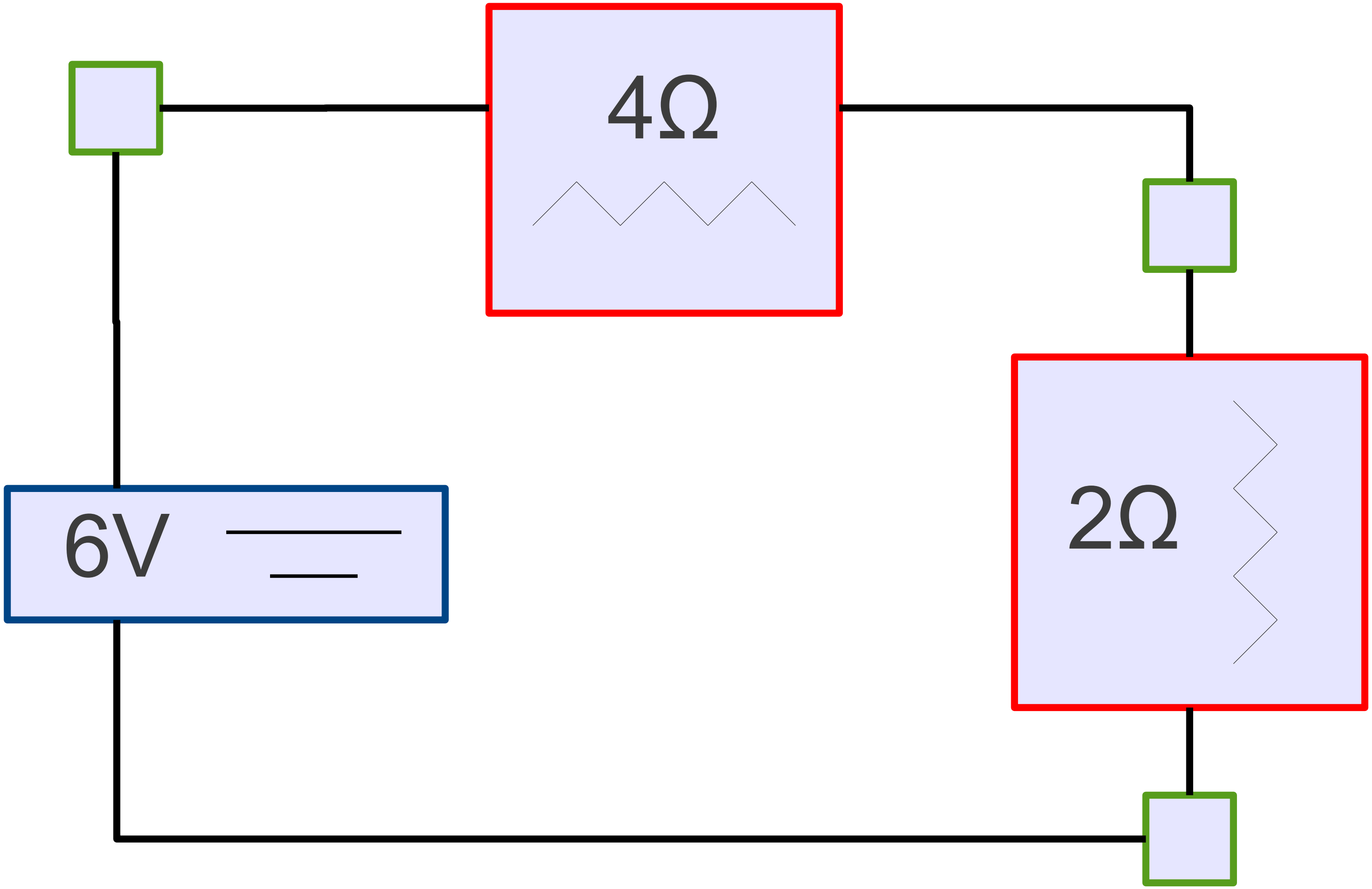
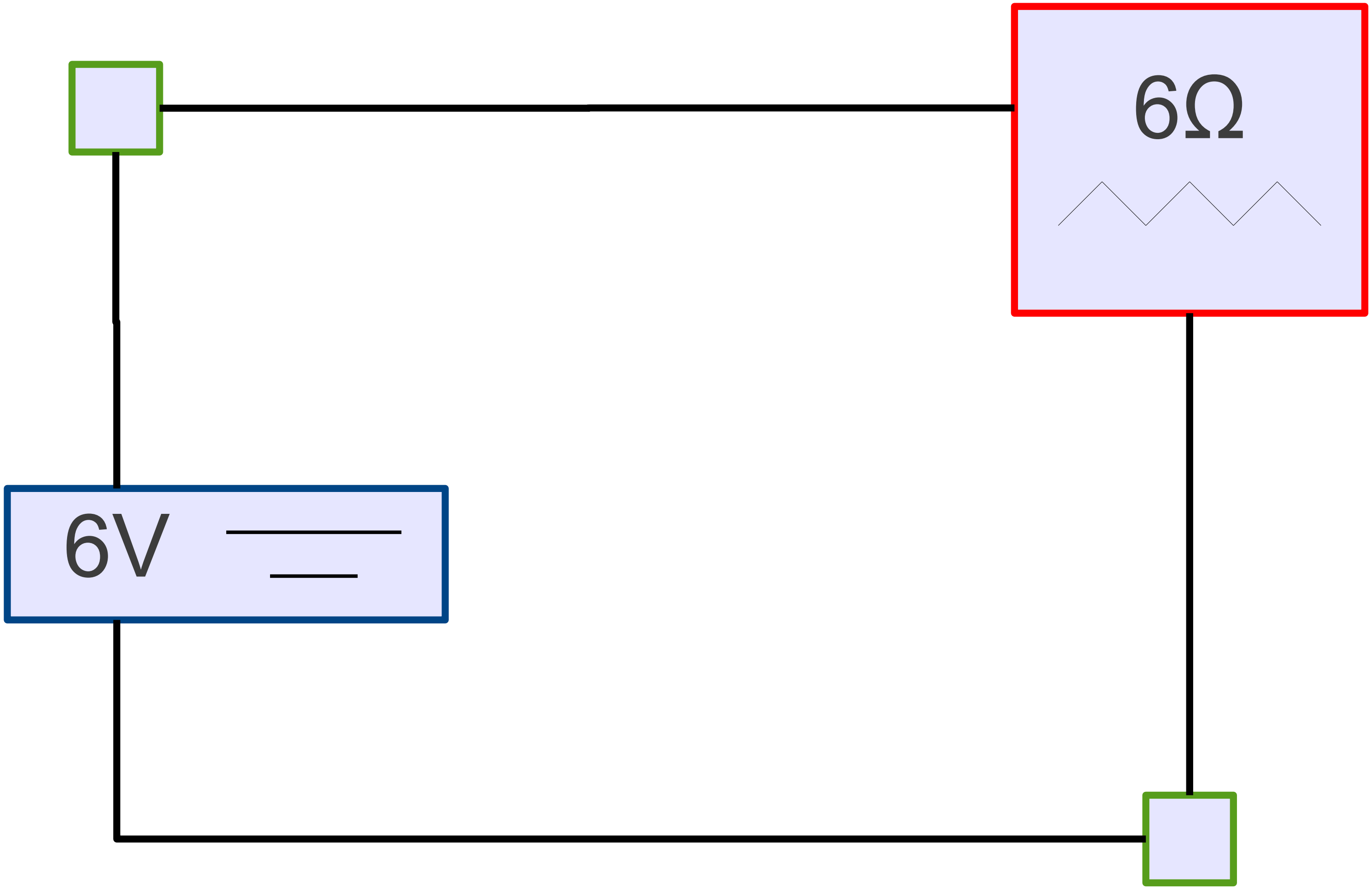

4Ω
6V
2Ω



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



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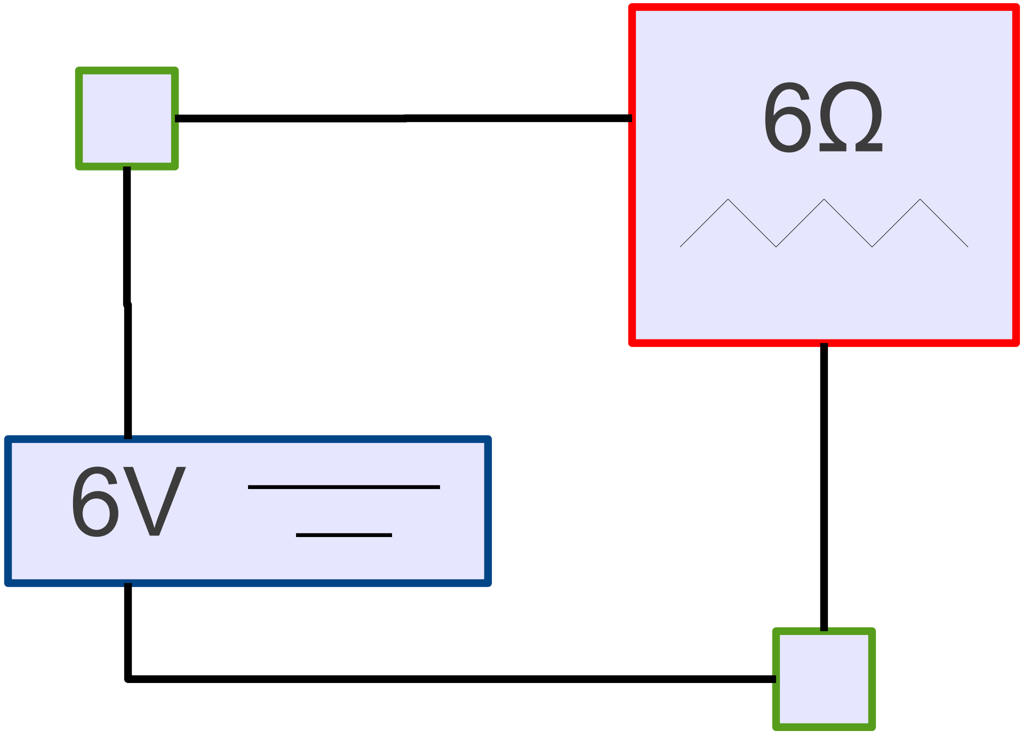
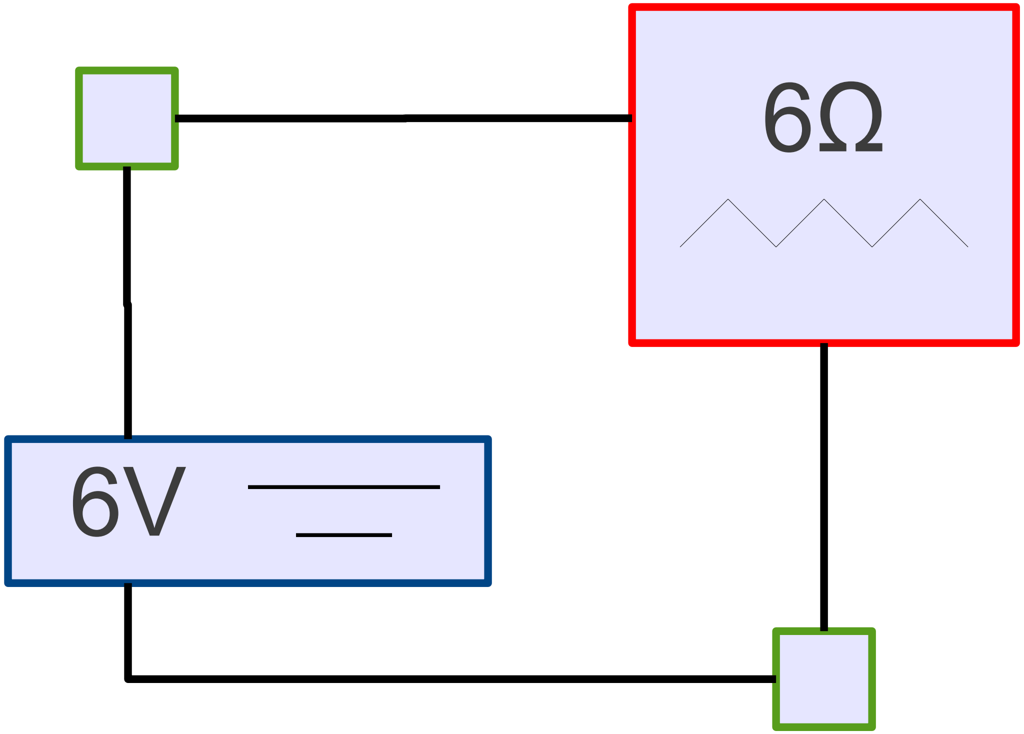

6Ω
6V


6Ω
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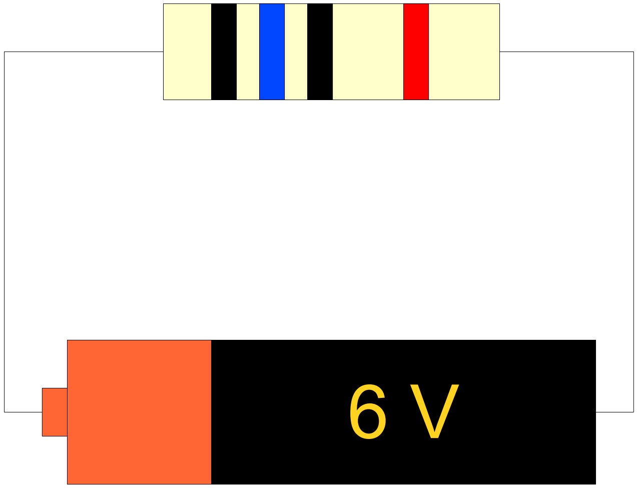
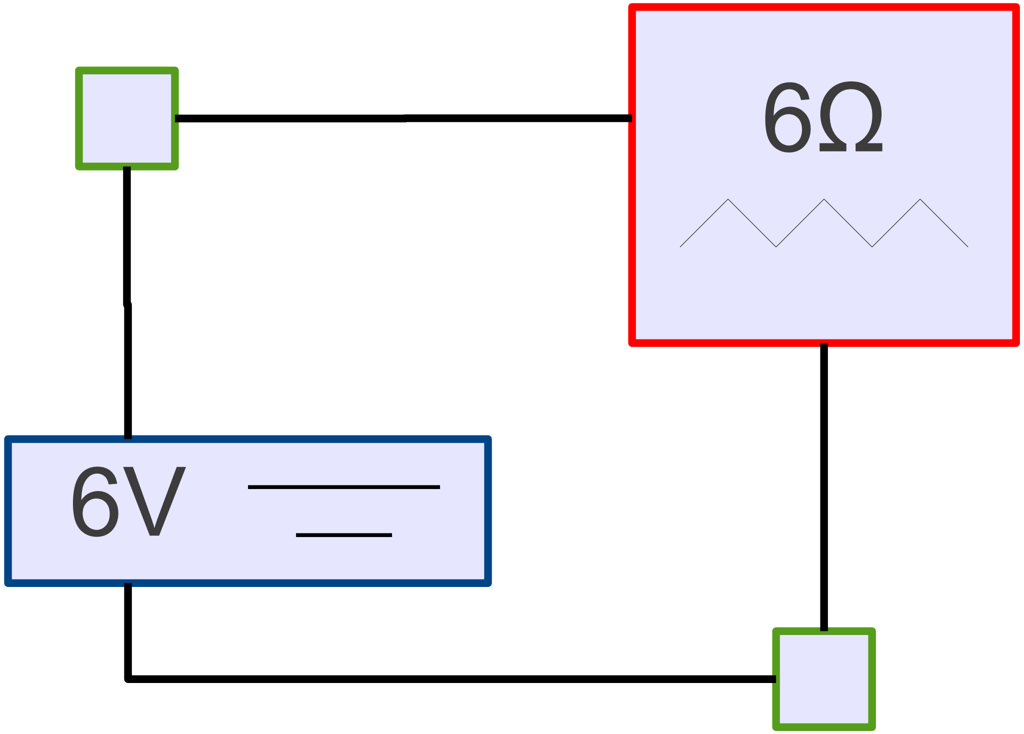
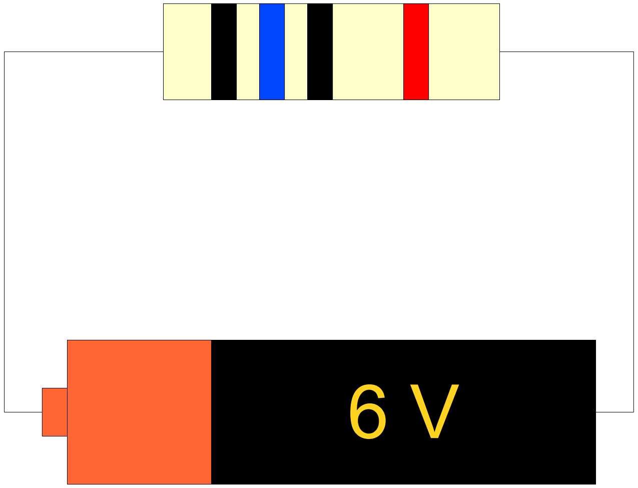
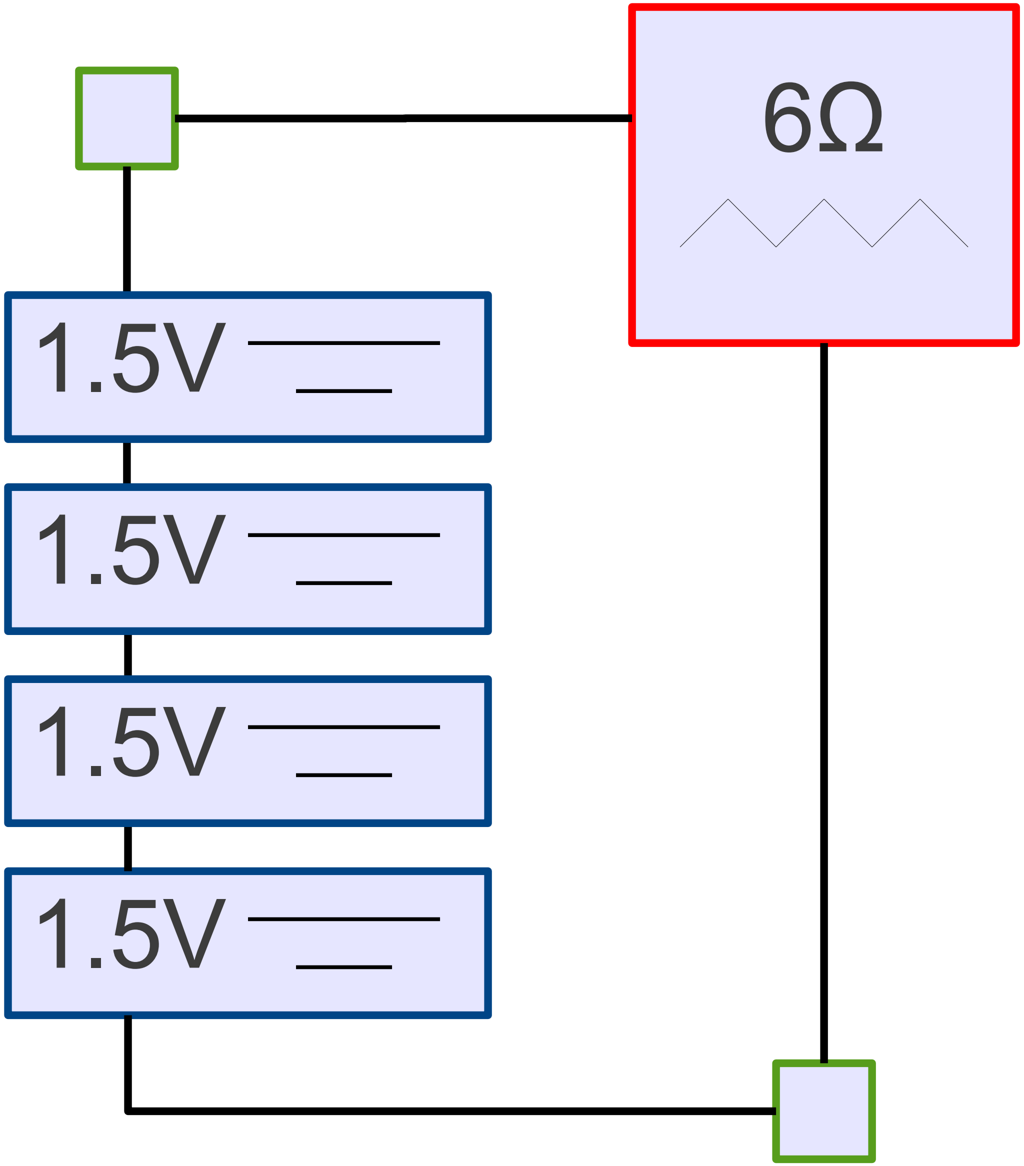

6 V





Total Cost: $4.75


6Ω
1.5V
1.5V
1.5V
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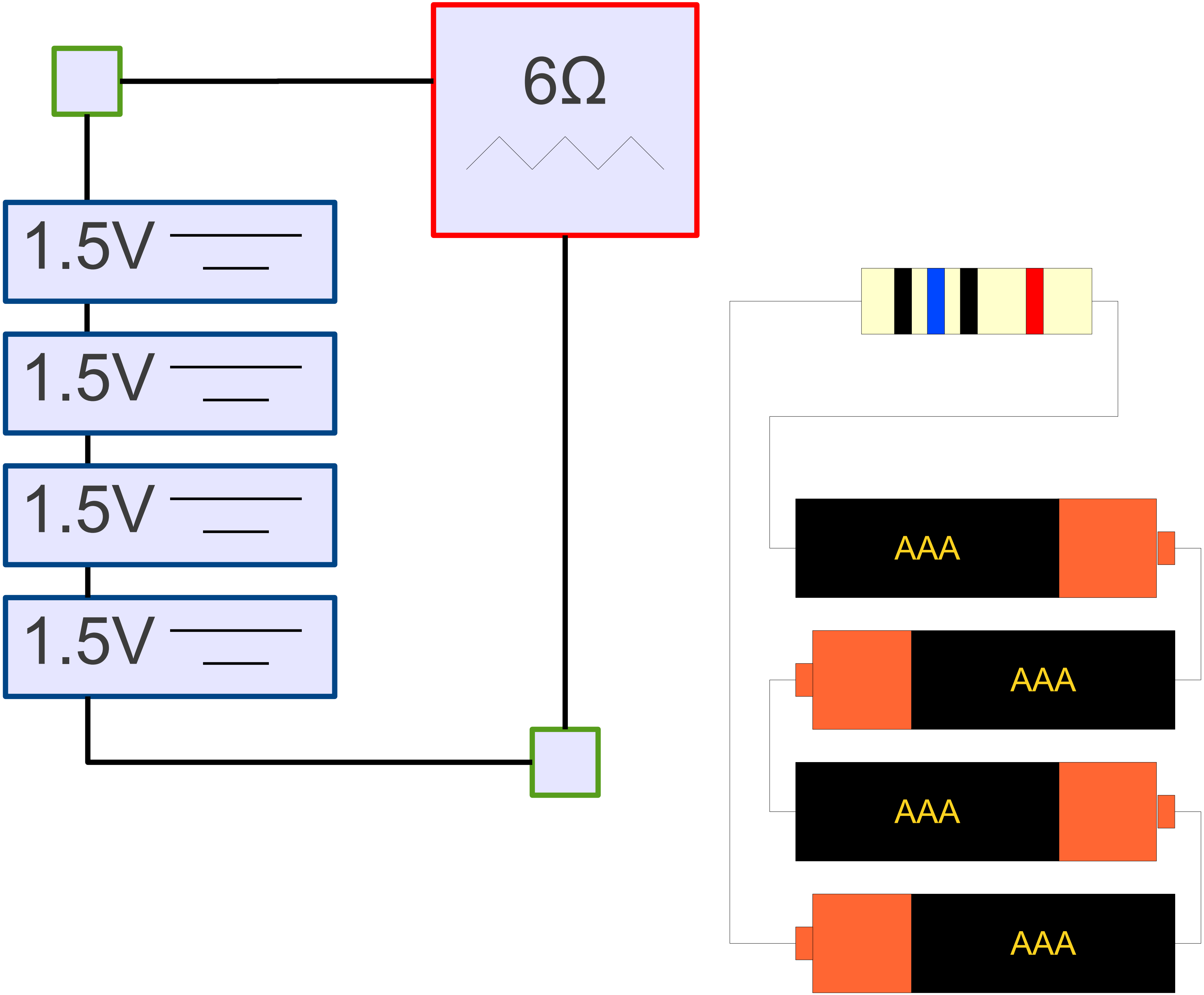
6Ω
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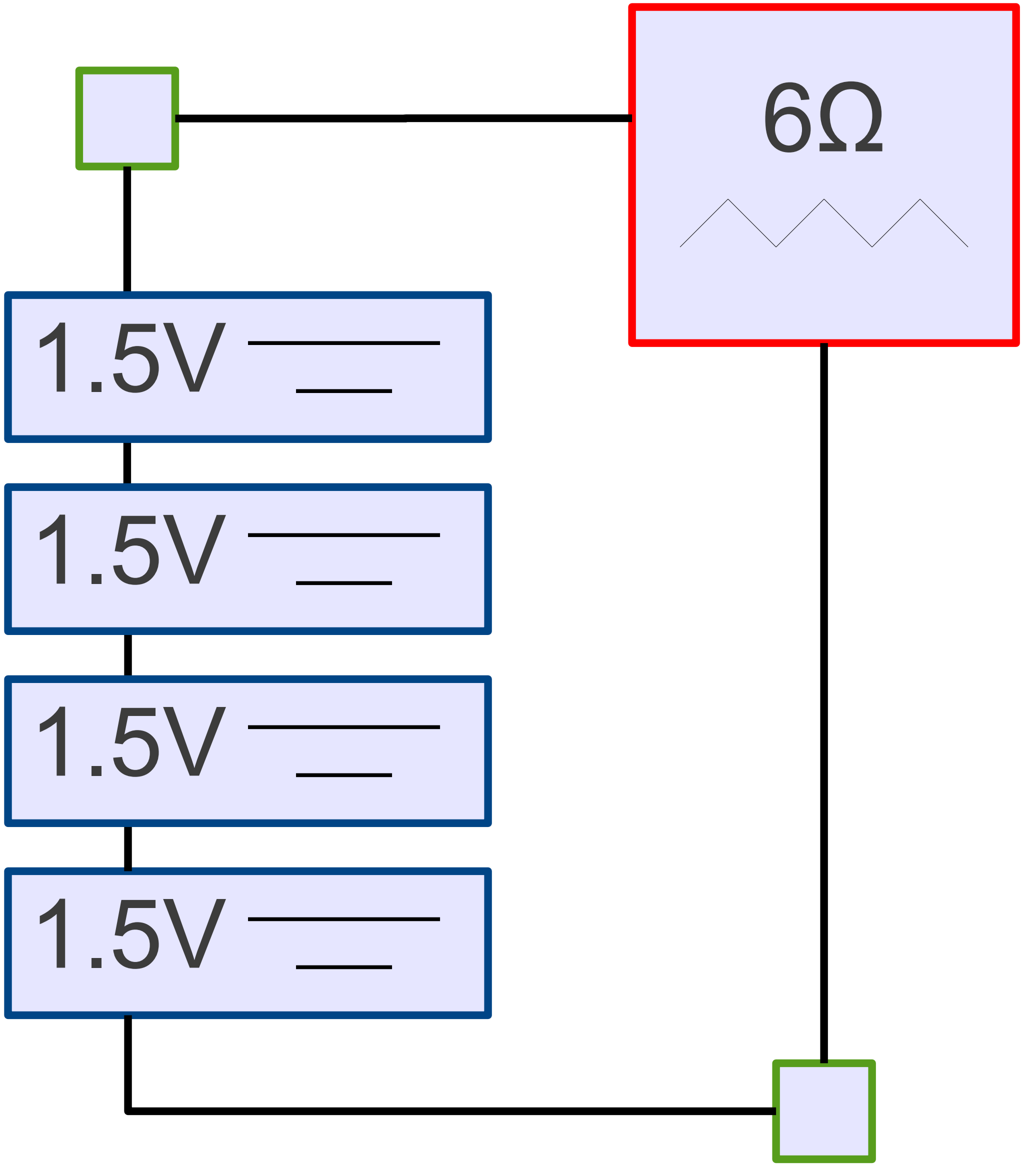
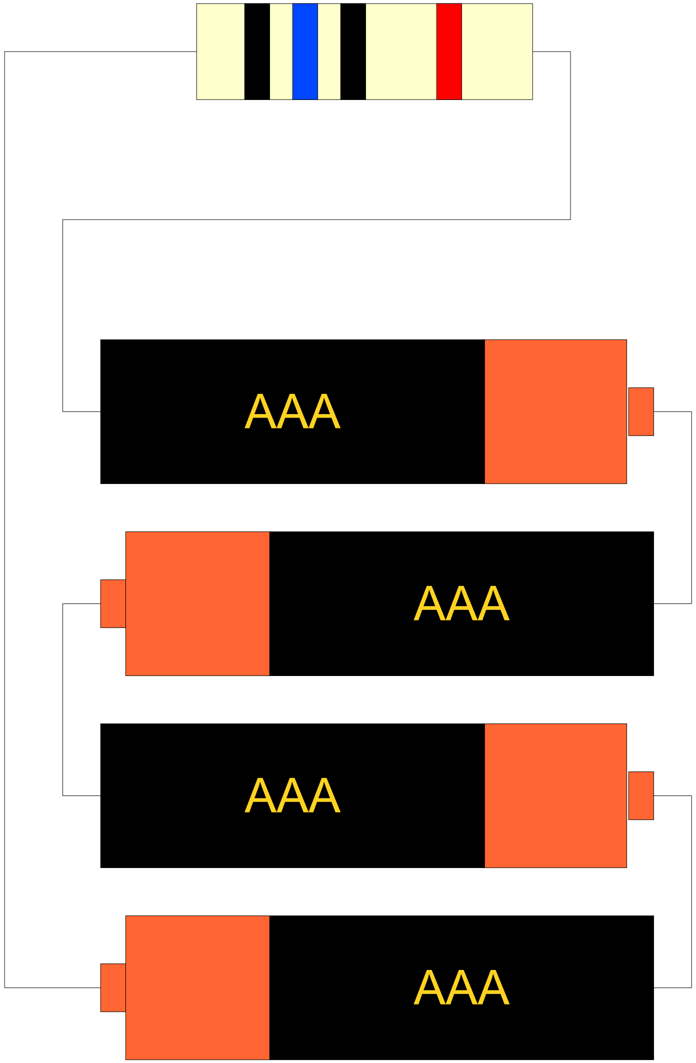
AAA
AAA
AAA
AAA



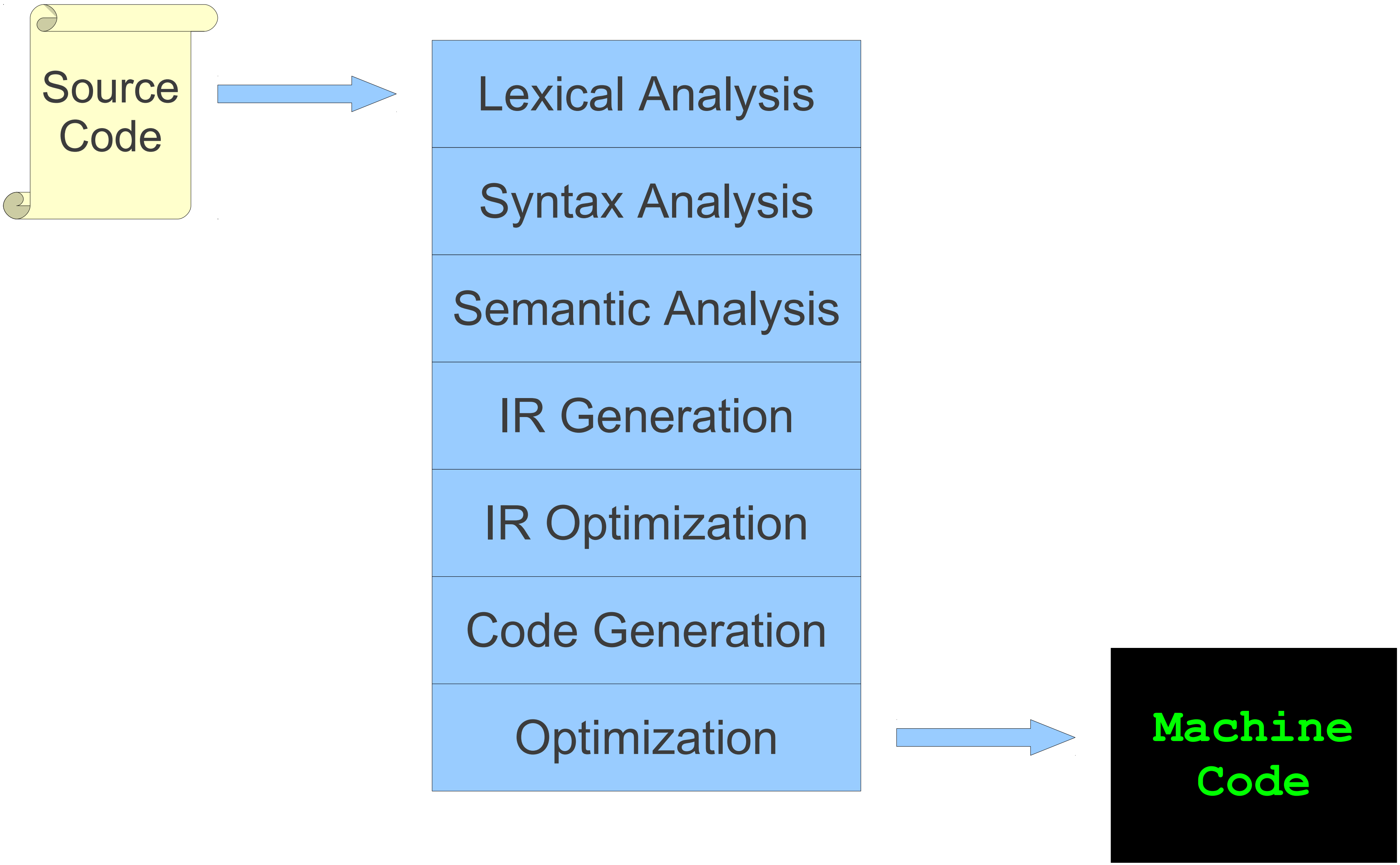


Total Cost: $1.00

From Description to Implementation

- **Lexical analysis (Scanning):** Identify logical pieces of the description.
- **Syntax analysis (Parsing):** Identify how those pieces relate to each other.
- **Semantic analysis:** Identify the meaning of the overall structure.
- **IR Generation:** Design one possible structure.
- **IR Optimization:** Simplify the intended structure.
- **Generation:** Fabricate the structure.
- **Optimization:** Improve the resulting structure.

The Structure of a Modern Compiler



Source Code

Lexical Analysis

Syntax Analysis

Semantic Analysis

IR Generation

IR Optimization

Code Generation

Optimization

Machine Code

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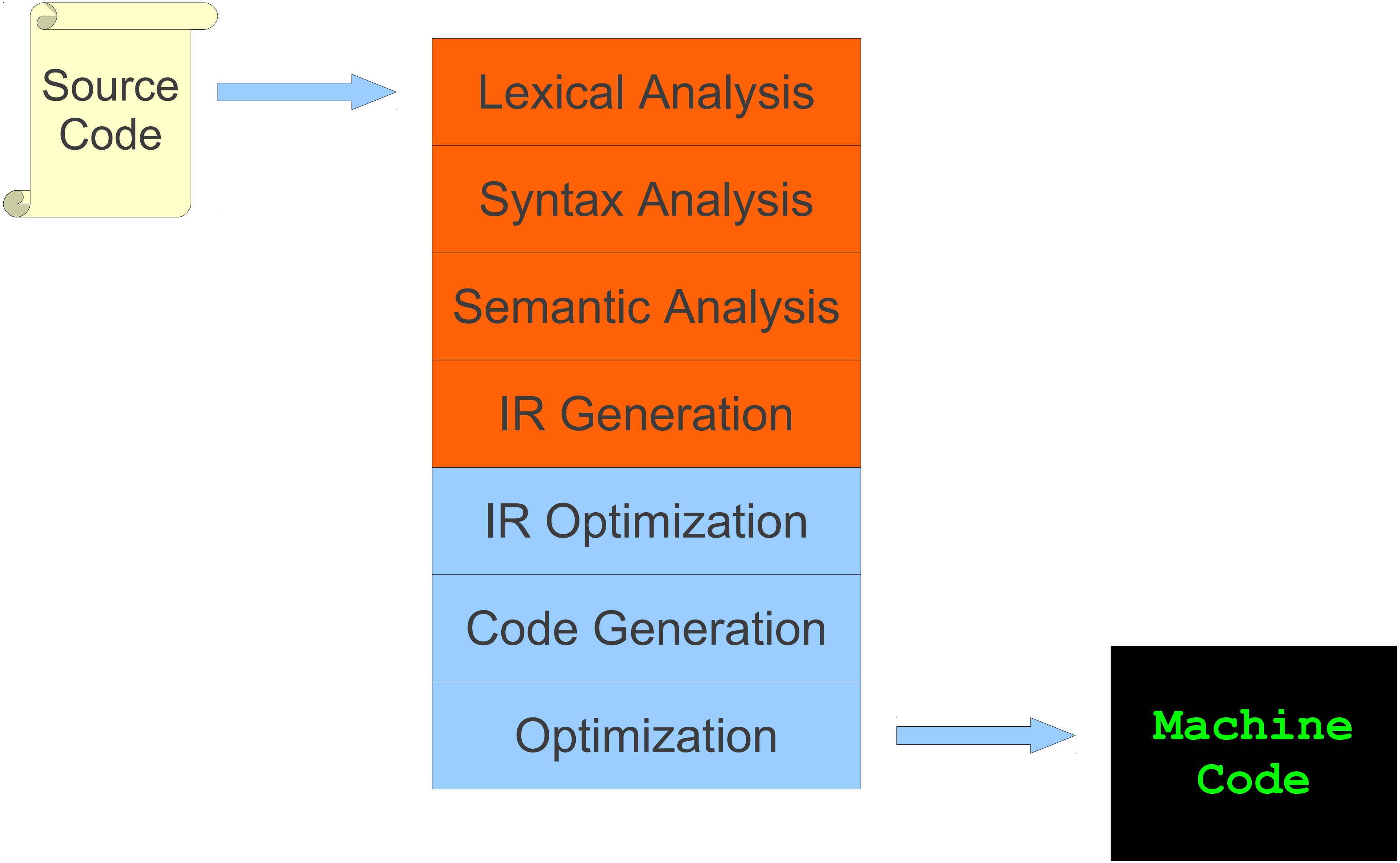

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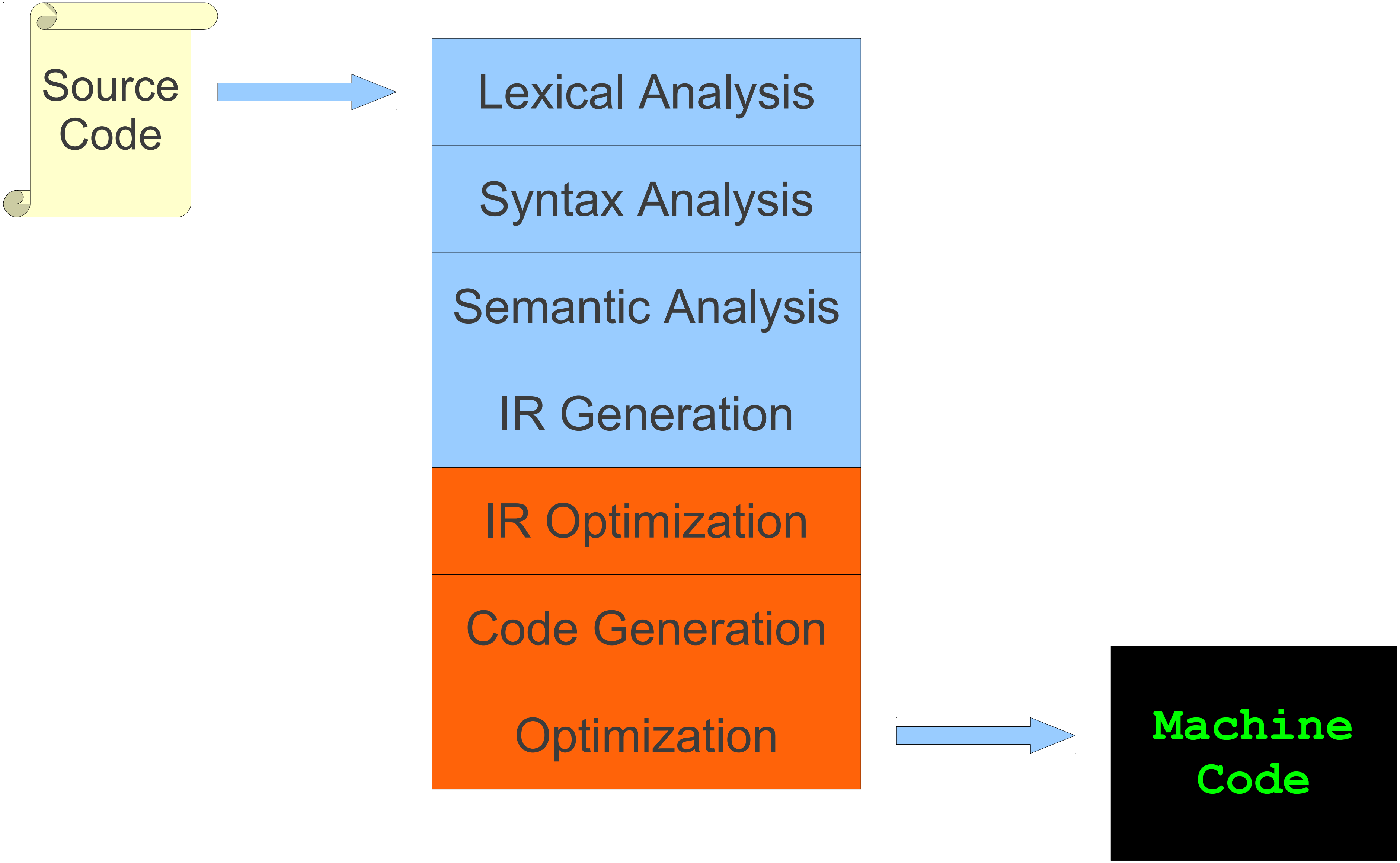

```
while (y < z) {
    int x = a + b;
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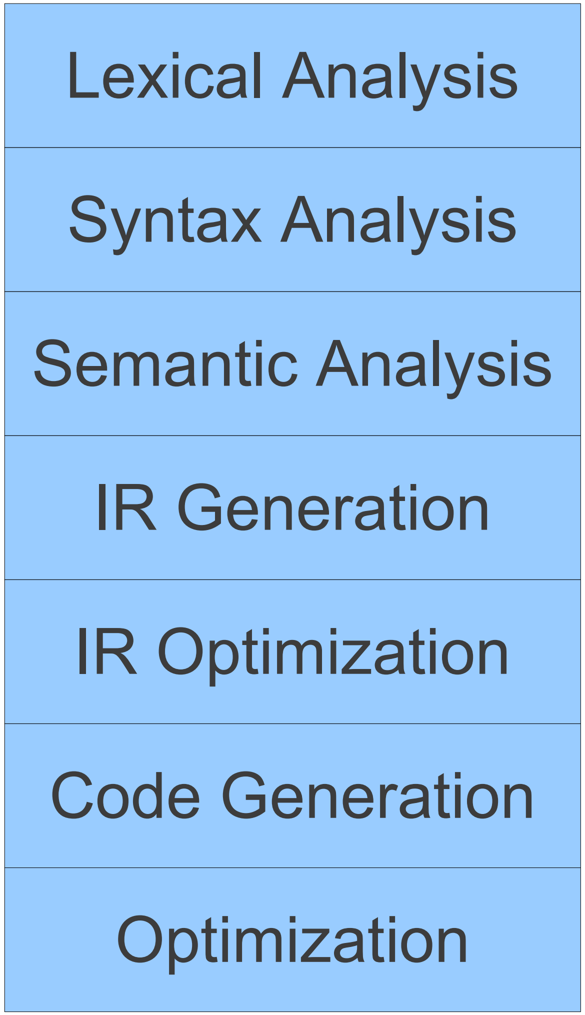

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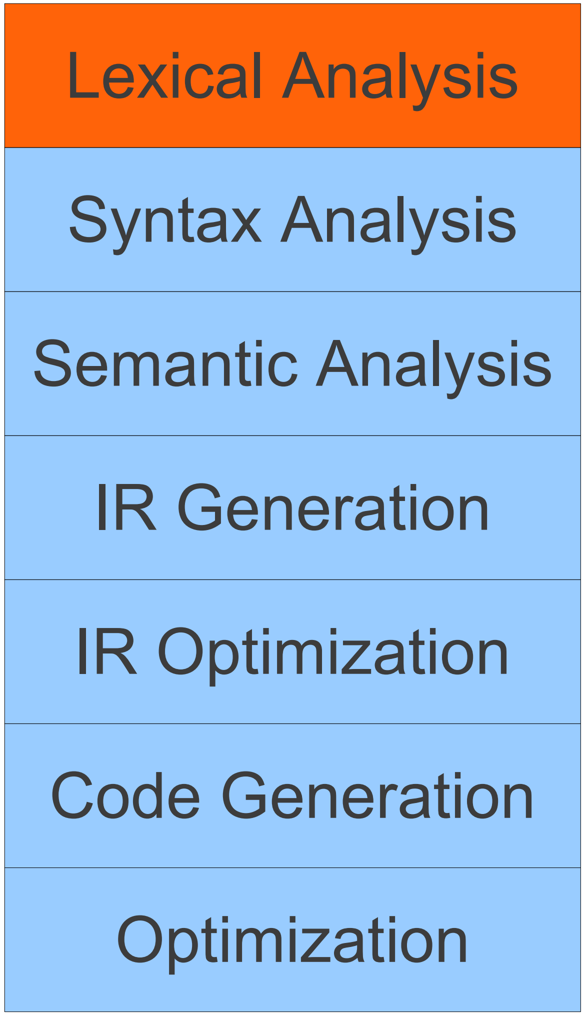

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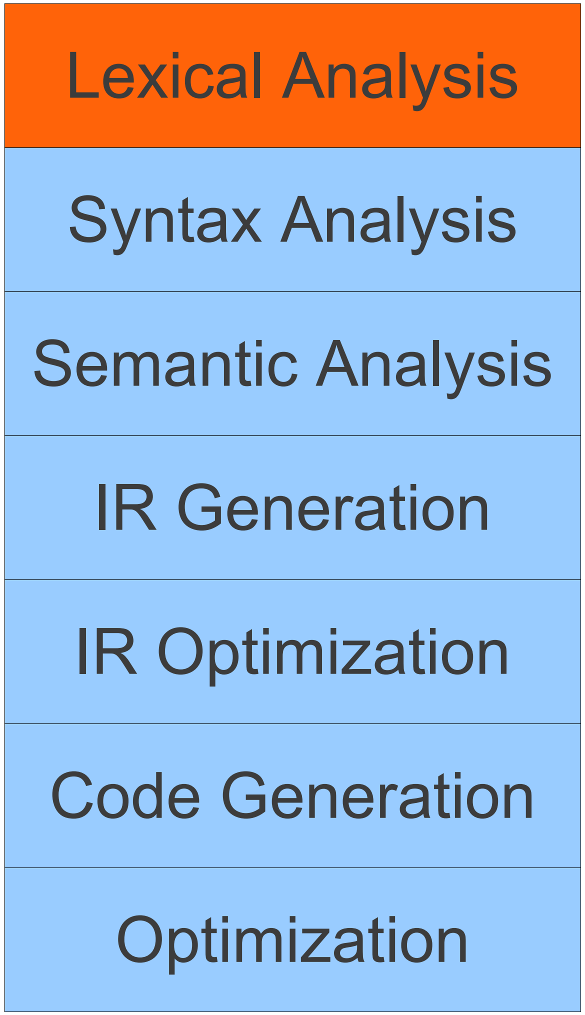
```
T_While
T_LeftParen
T_Identifier y
T_Less
T_Identifier z
T_RightParen
T_OpenBrace
T_Int
T_Identifier x
T_Assign
T_Identifier a
T_Plus
T_Identifier b
T_Semicolon
T_Identifier y
T_PlusAssign
T_Identifier x
T_Semicolon
T_CloseBrace
```



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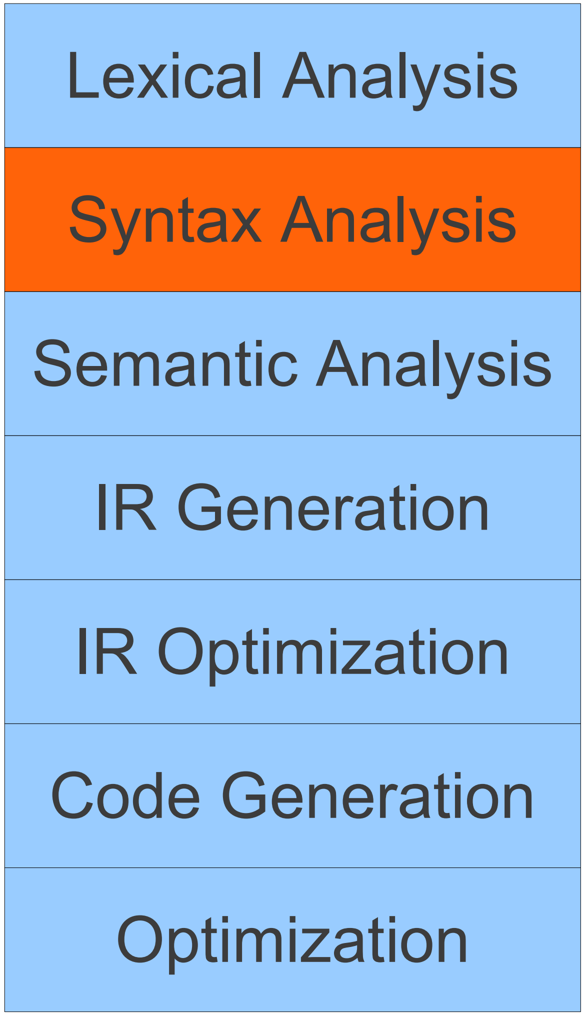

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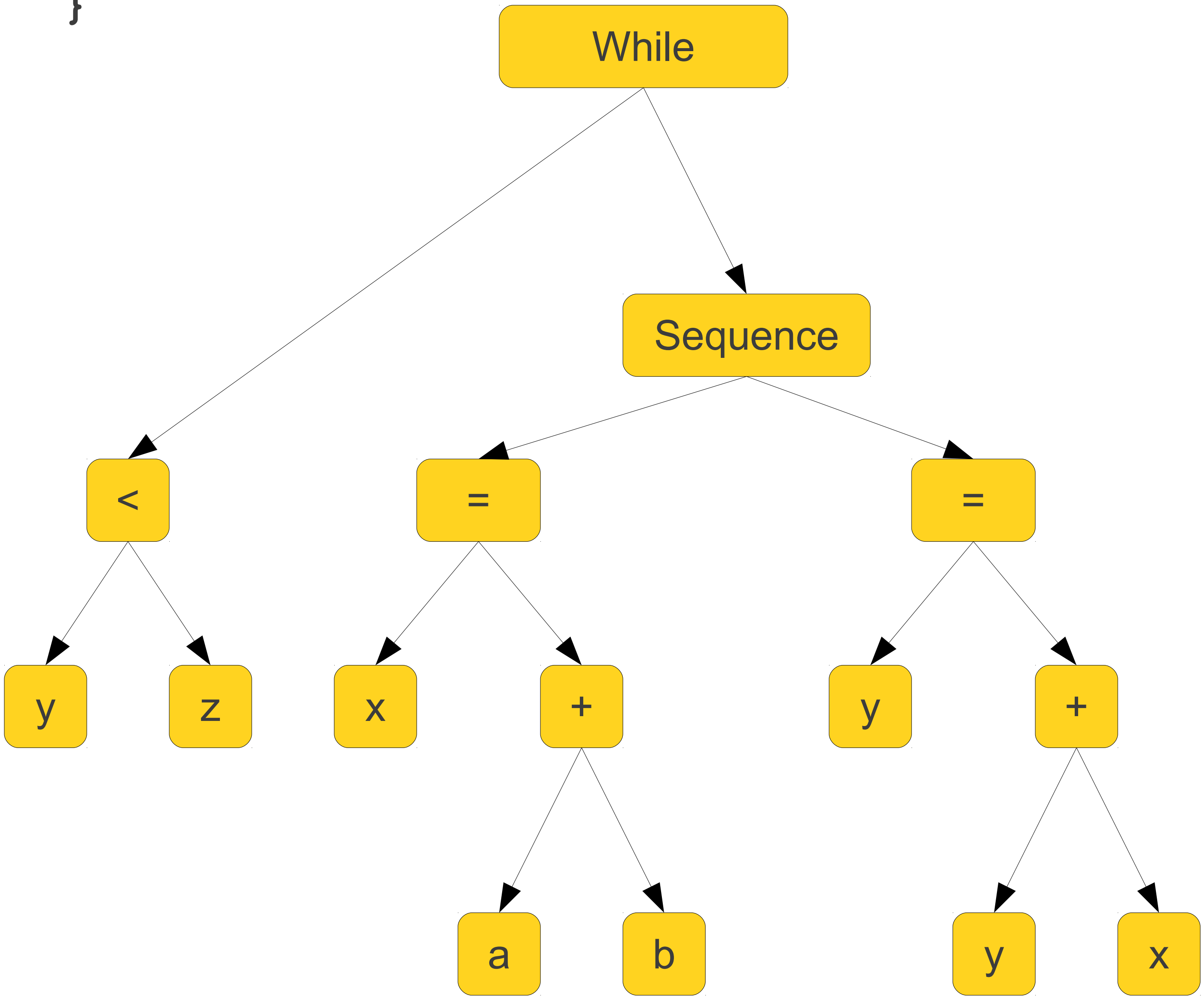

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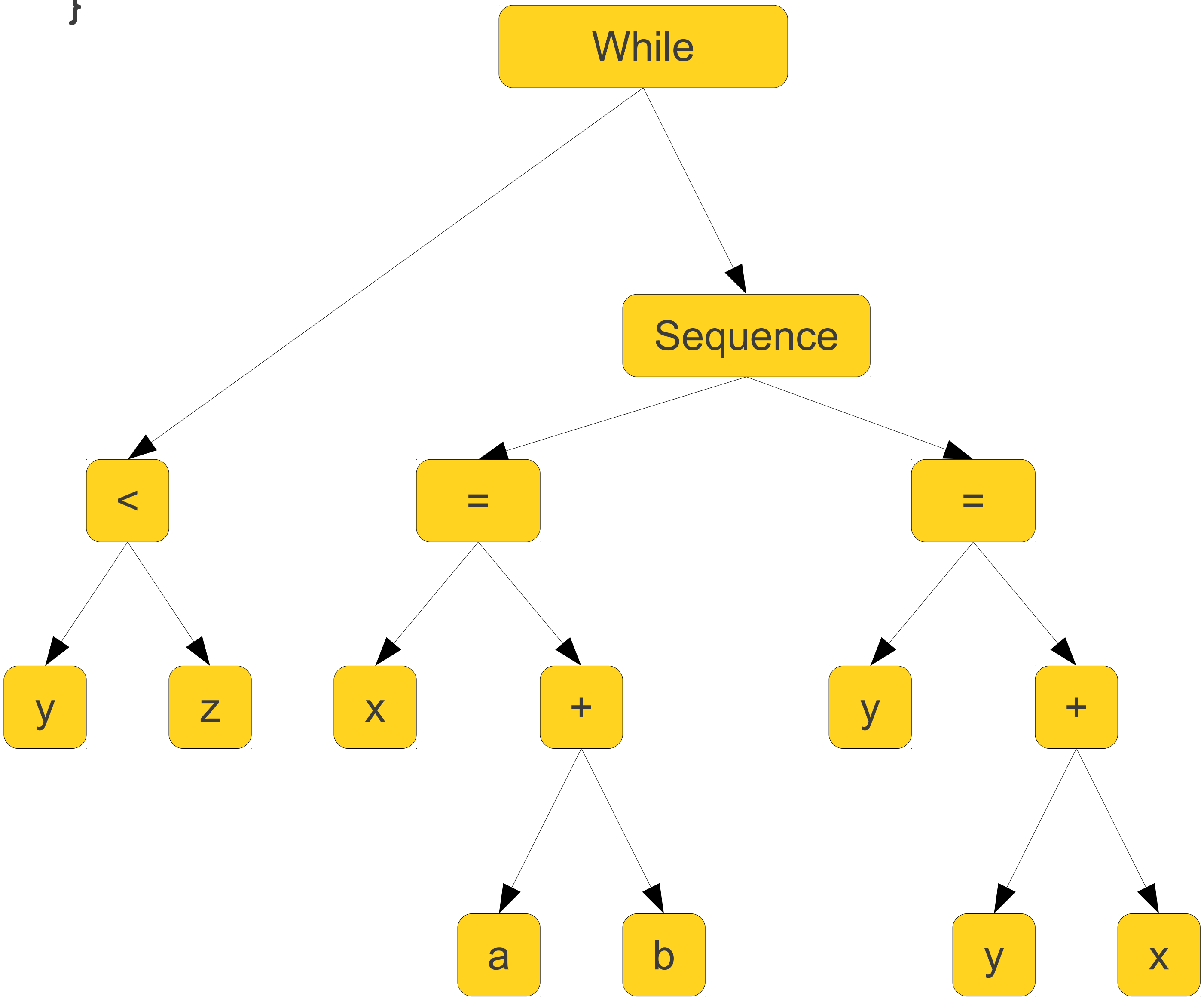

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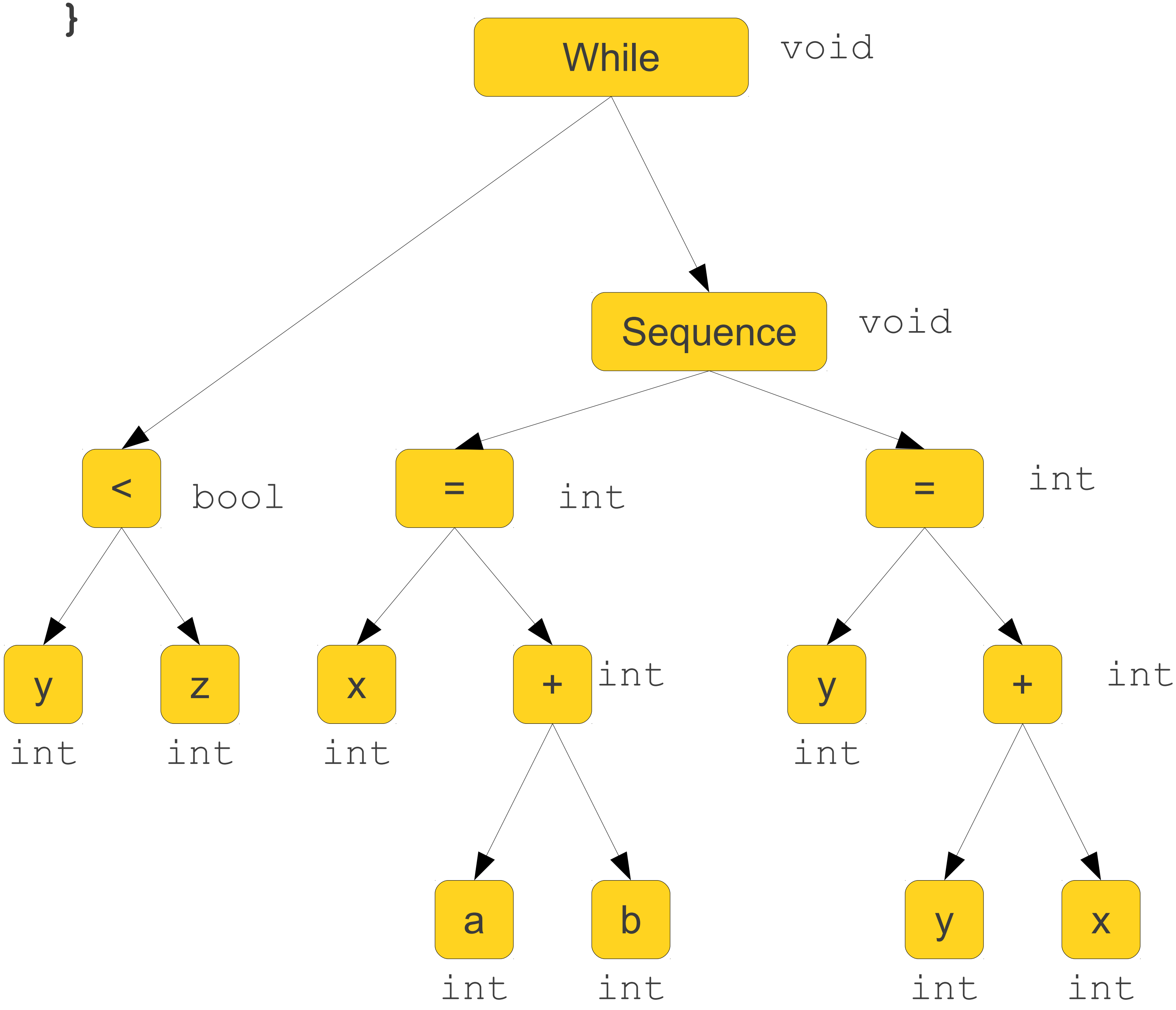

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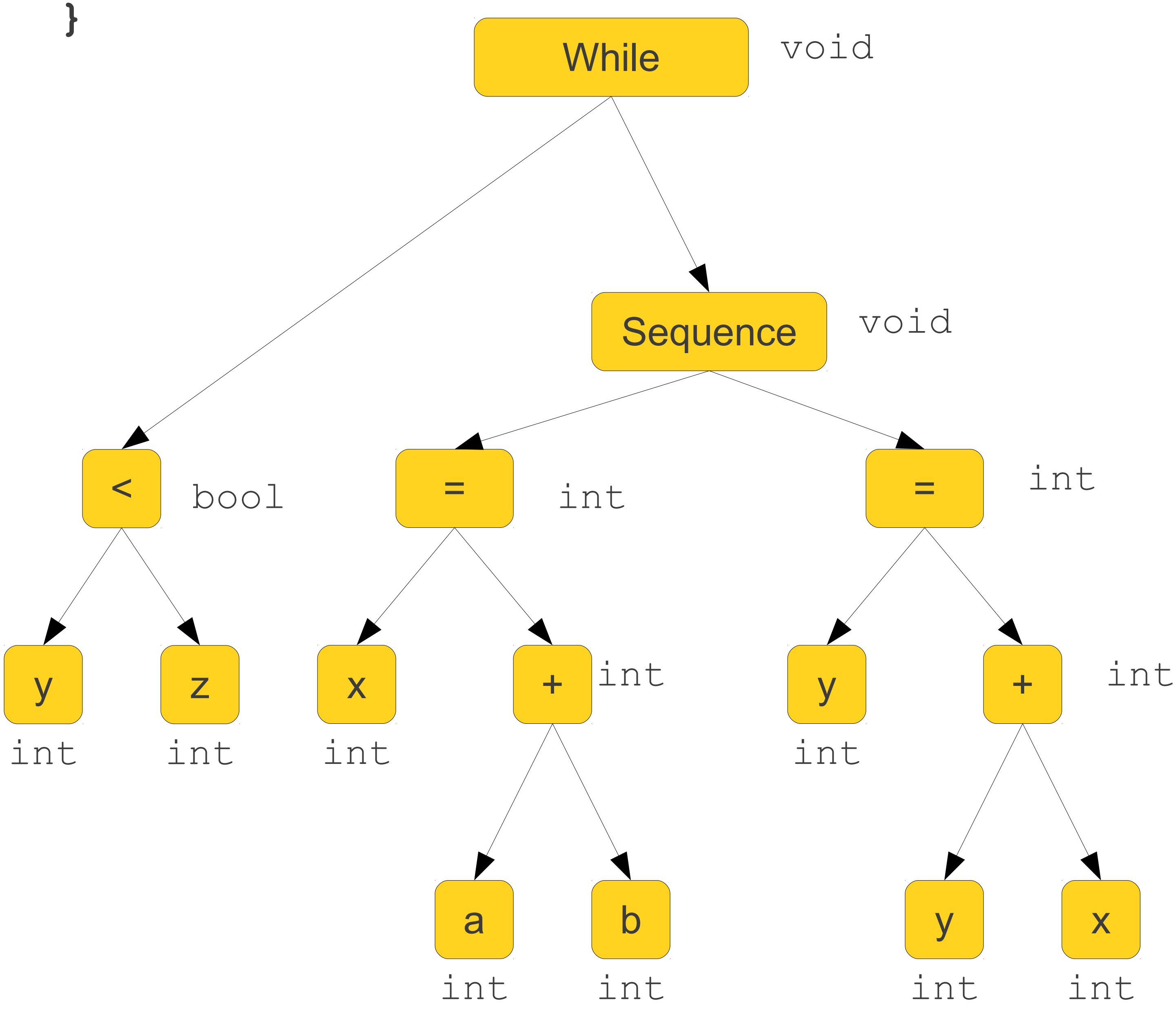

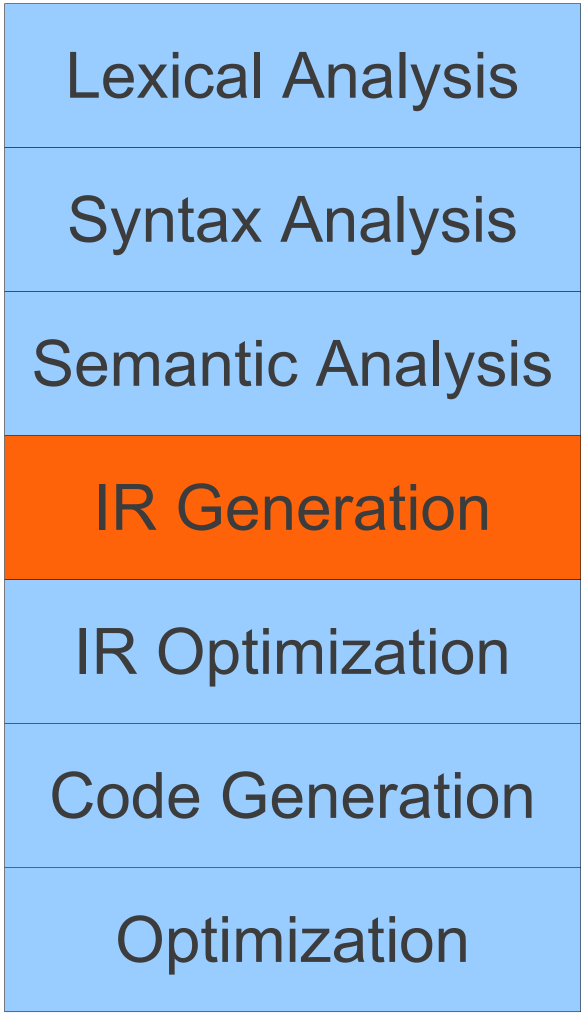
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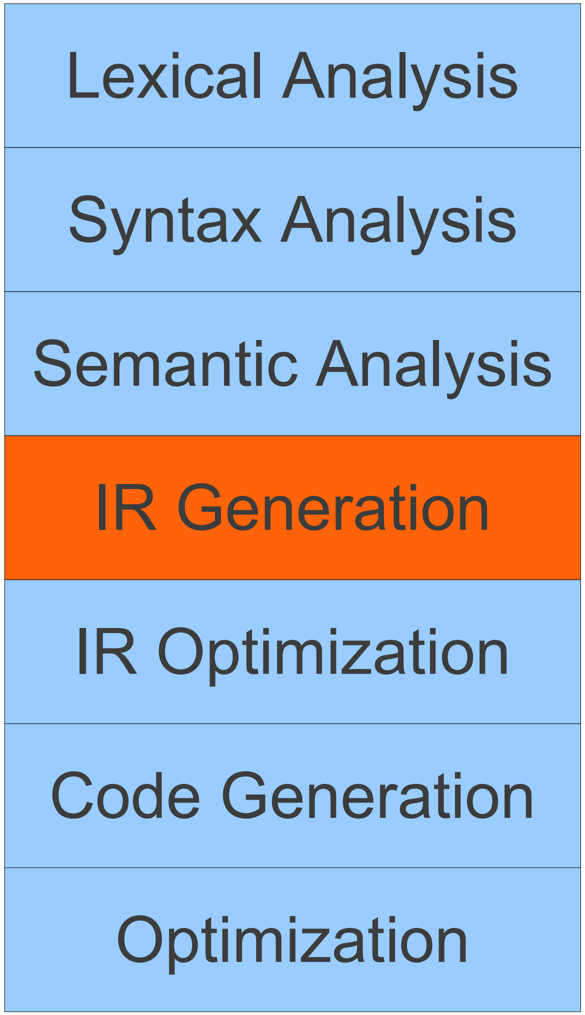
```
Loop: x   = a + b
      y   = x + y
      _t1 = y < z
      if _t1 goto Loop
```



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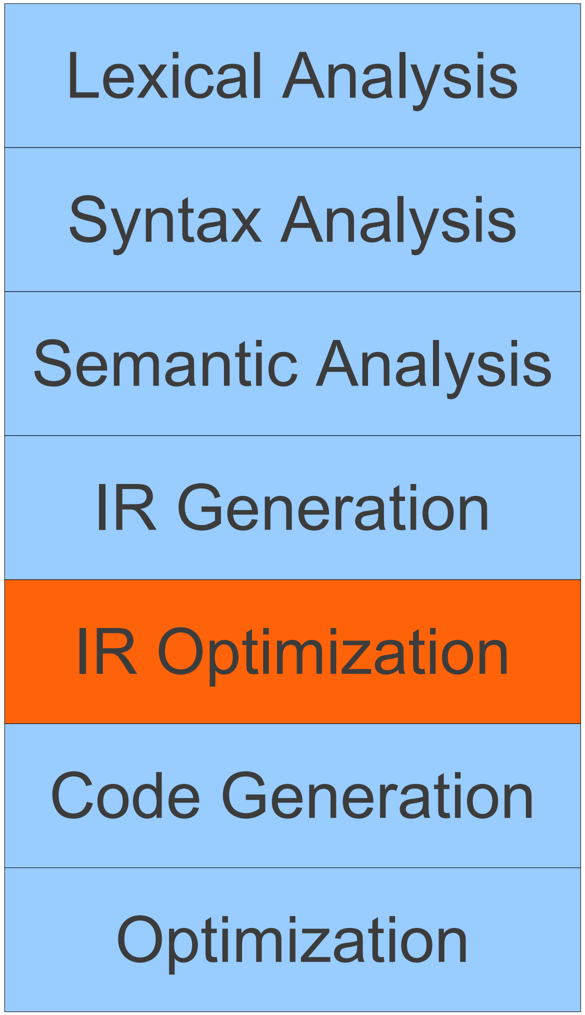

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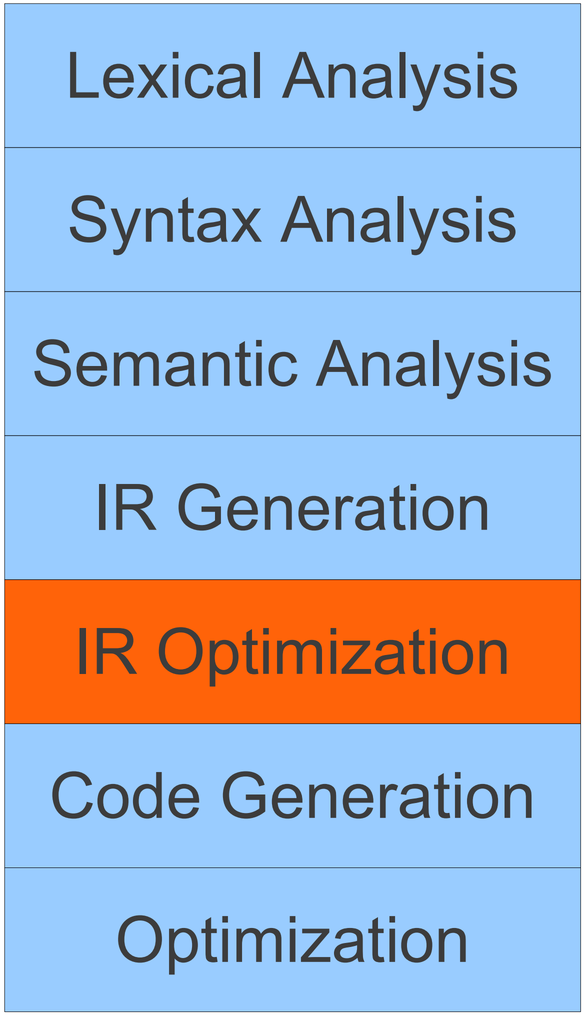

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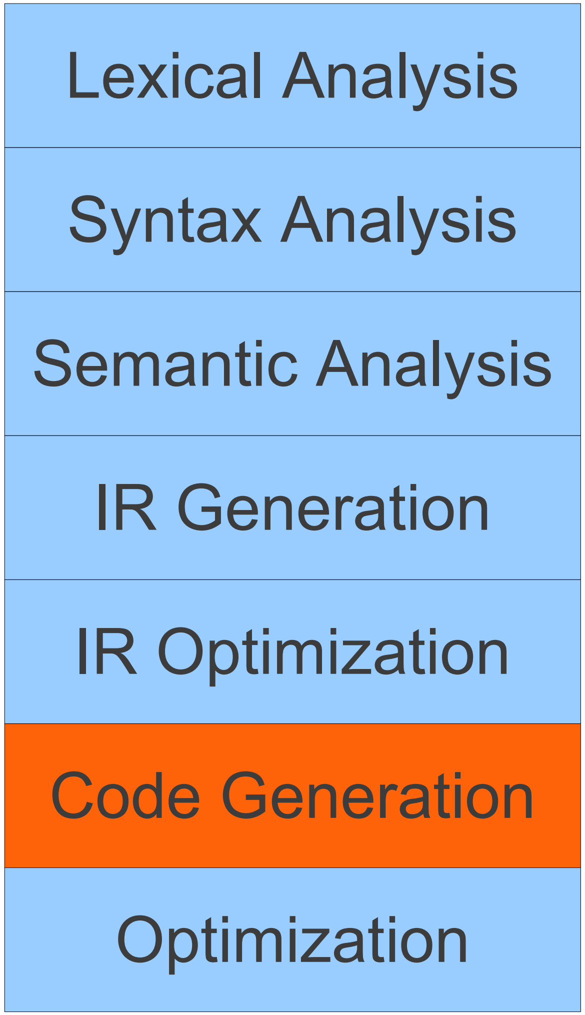

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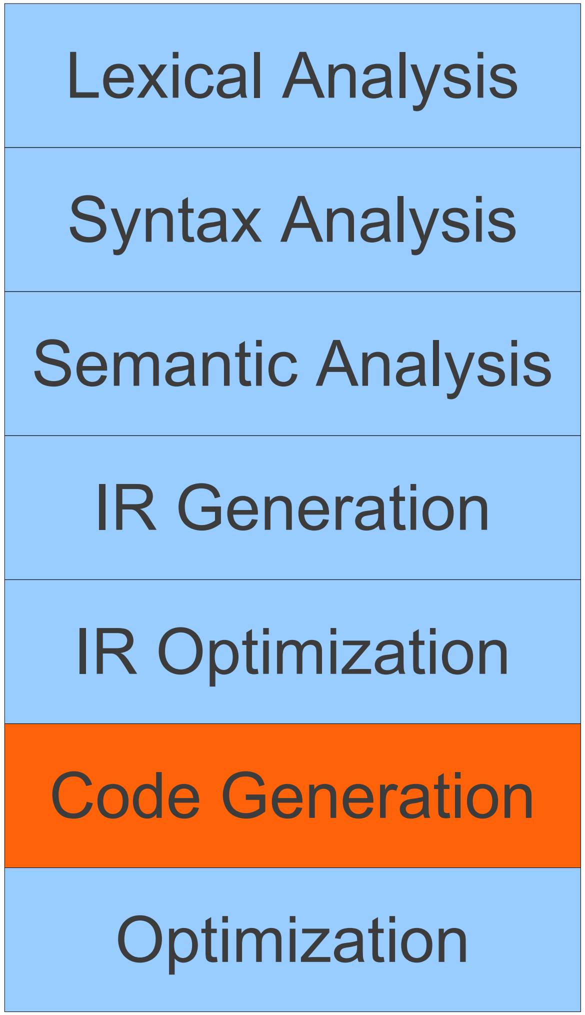
```
while (y < z) {
    int x = a + b;
    y += x;
}
```

```
      add $1, $2, $3
Loop: add $4, $1, $4
      slt $6, $1, $5
      beq $6, loop
```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    int x = a + b;
    y += x;
}
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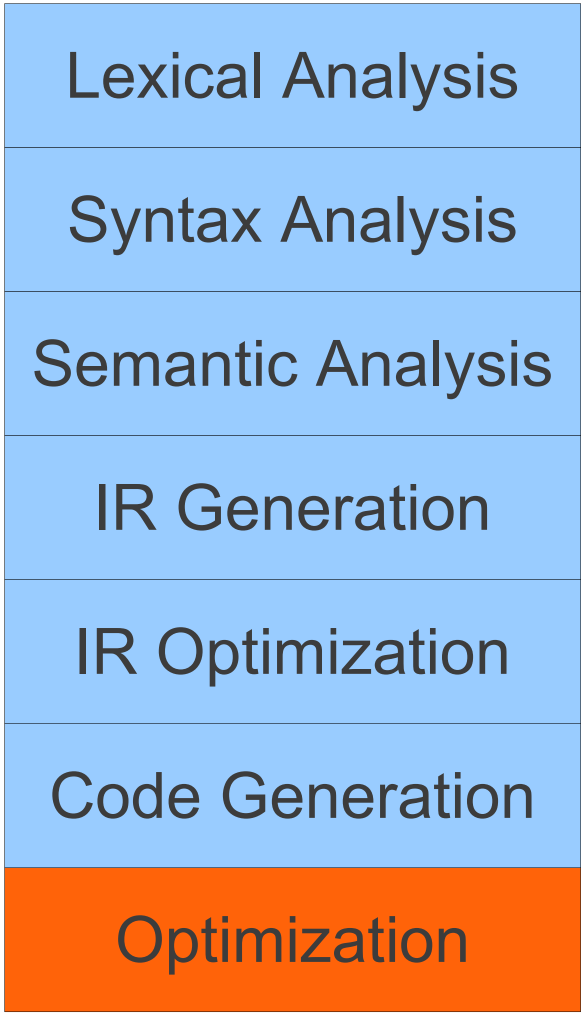
      add $1, $2, $3
Loop: add $4, $1, $4
      slt $6, $1, $5
      beq $6, loop
```



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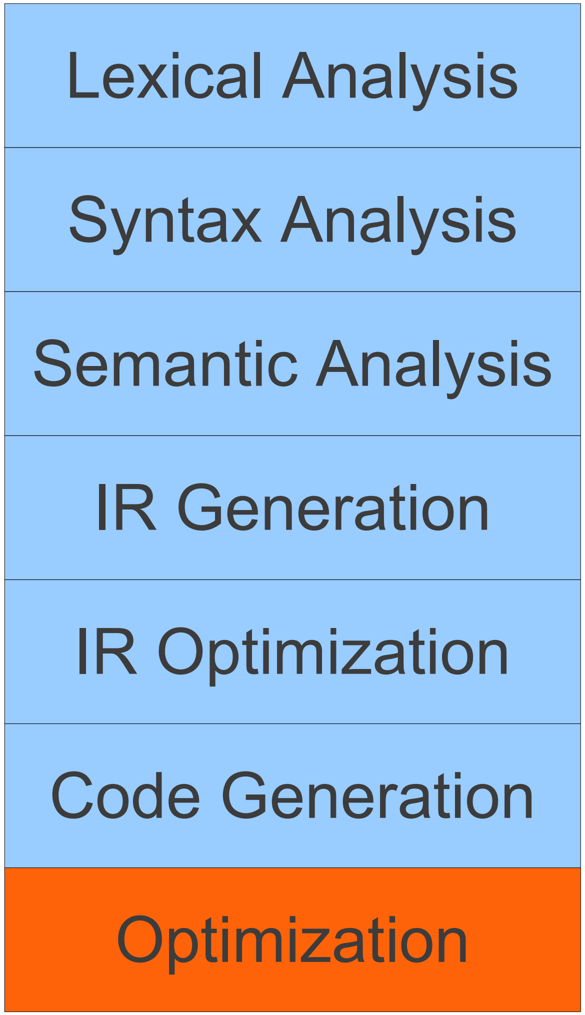
    y += x;
}
```

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



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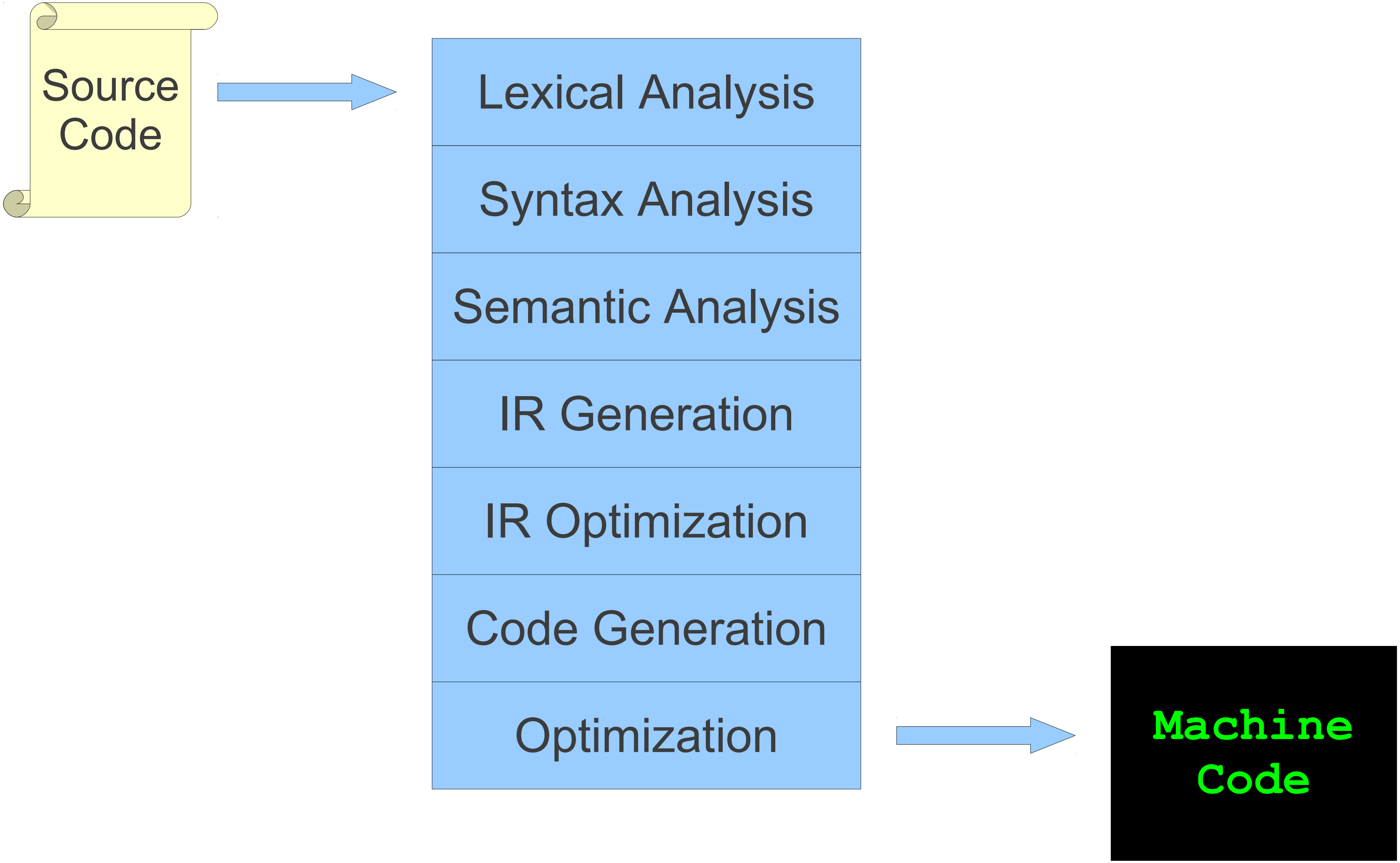
The Course Project: **Decaf**

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

Programming Assignments



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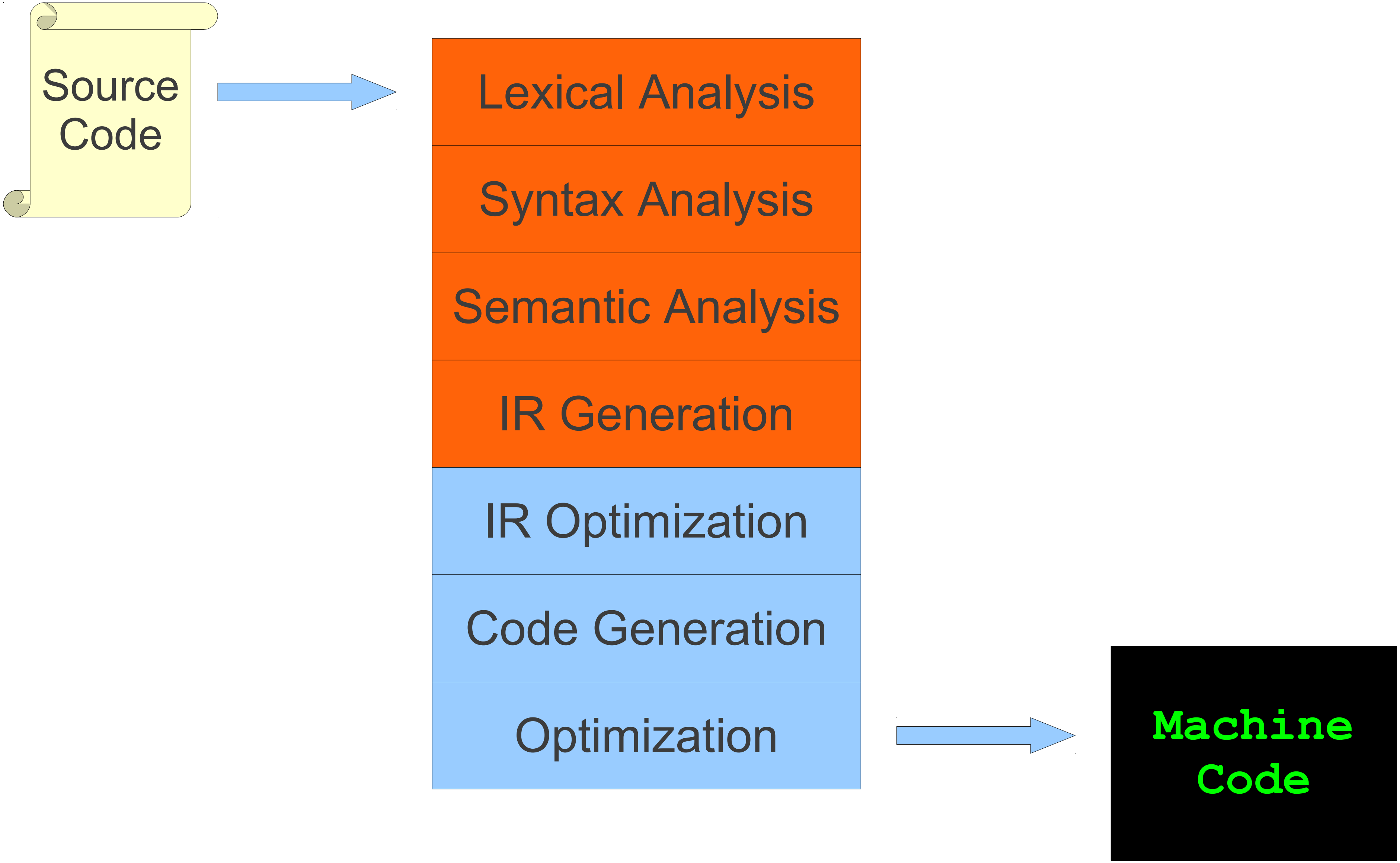

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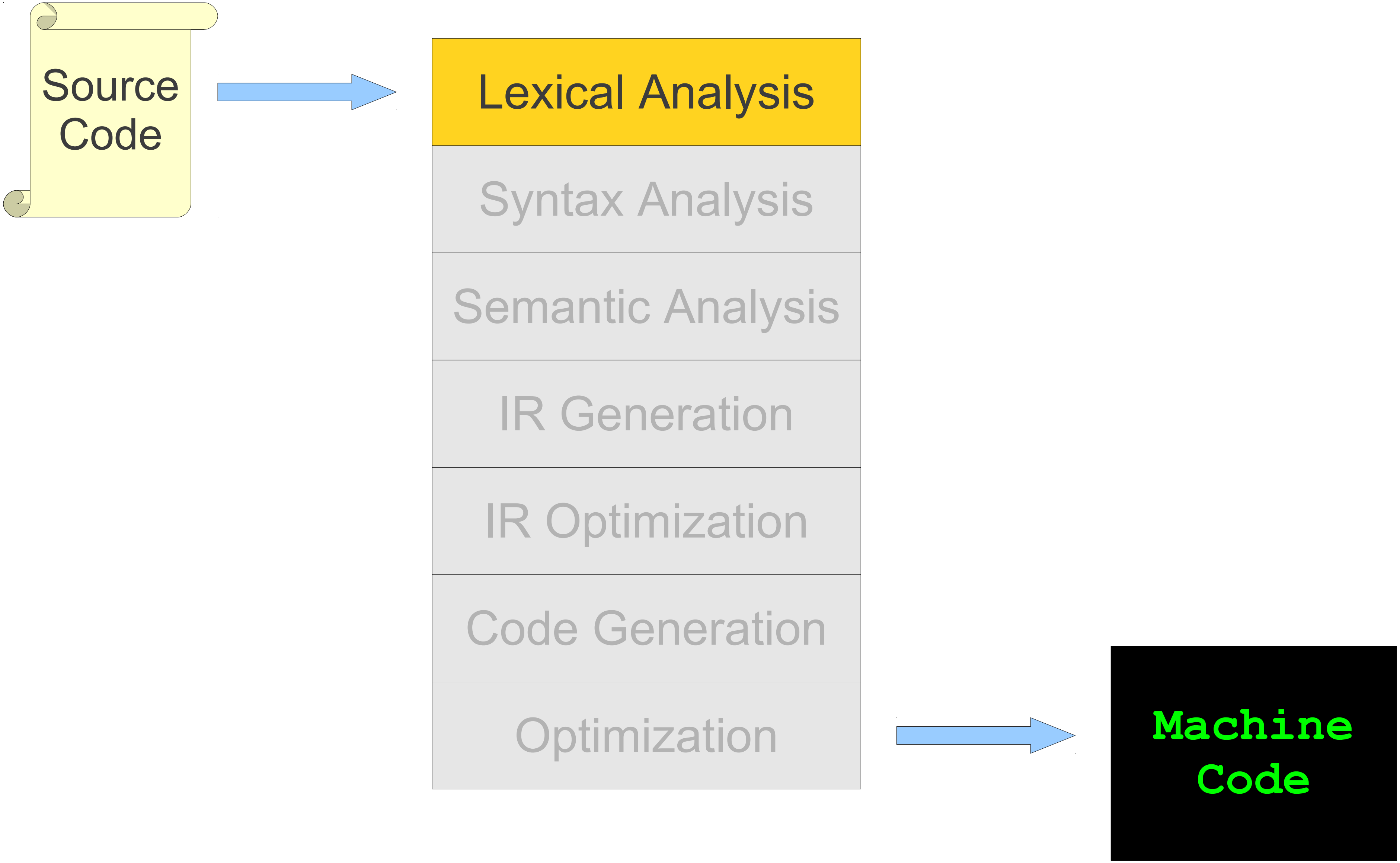
Next Time...


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