Introduction to Java: Expressions and Variables

Lecture 4

CS106A, Summer 2019
Sarai Gould & Laura Cruz-Albrecht

With inspiration from slides created by Keith Schwarz, Mehran Sahami, Eric Roberts, Stuart Reges, Chris Piech and others.

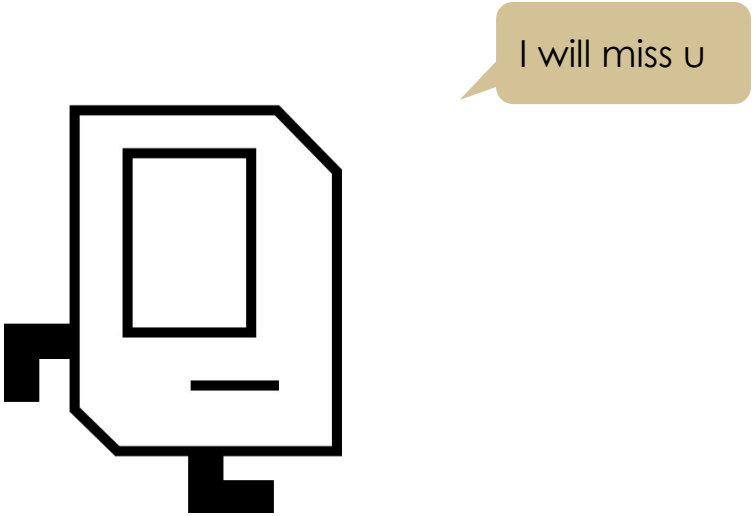
Announcements

- If you have midterm conflicts, email both instructors ASAP **and** fill out the following form (by July 8th at the latest):
  - http://bit.ly/CS106AMidtermConflicts
- Please email both instructors as soon as possible if you have academic accommodations from the OAE
- Assignment 1 out!
- "Extra" slides: treat these as required reading

Plan for Today

- Bye, Karel!
- Console programs
- Variables
- Expressions
- Practice: Receipt

Bye, Karel!



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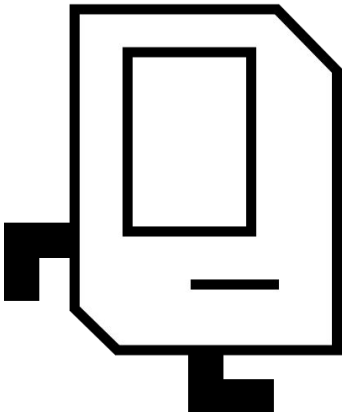

I will miss u

Enjoy Java!

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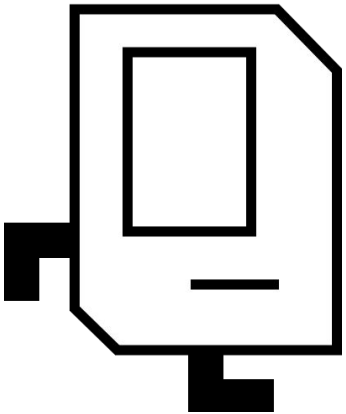

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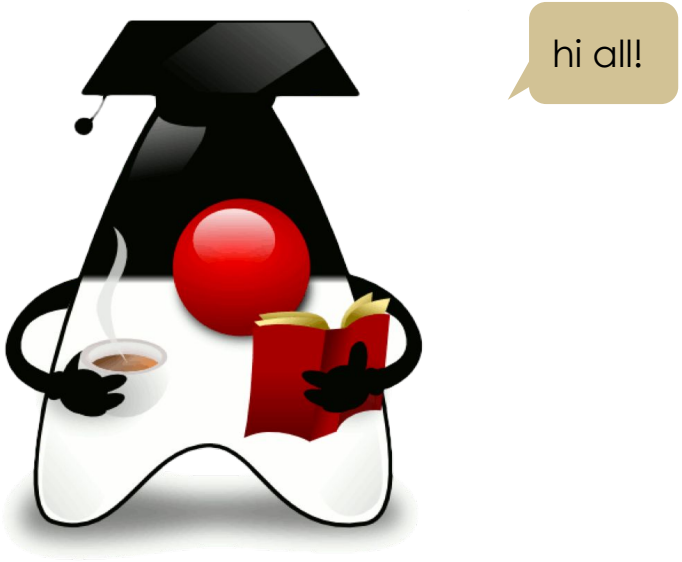
Enjoy Java!

See you on the midterm 😬

Hello, Java!



* fun fact: this is the official Java mascot

Hello, Java!

hi all!

I like Karel a latte ❤️
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Can't start your day
without me ☕

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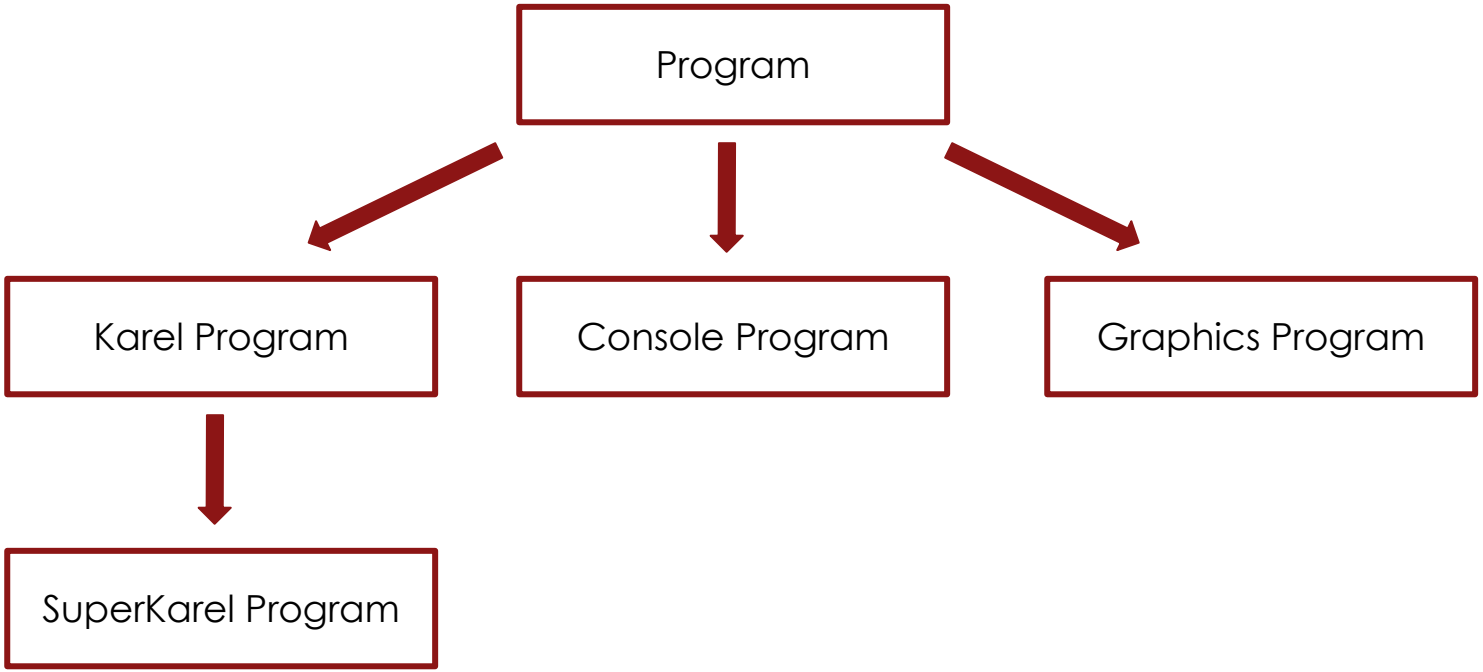
Types of Programs

Types of Programs



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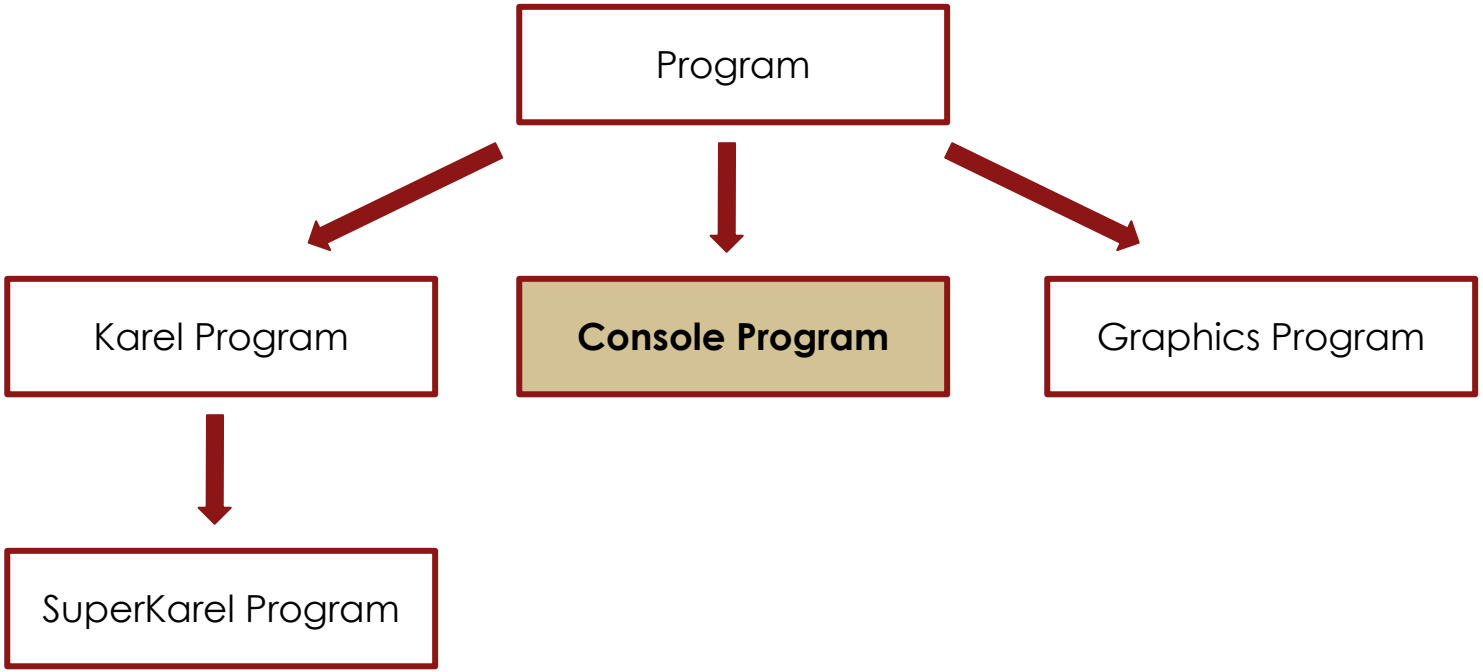
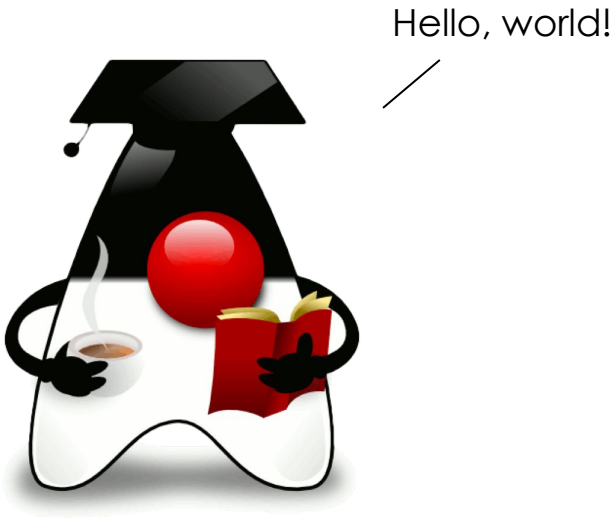


Our First Java Program

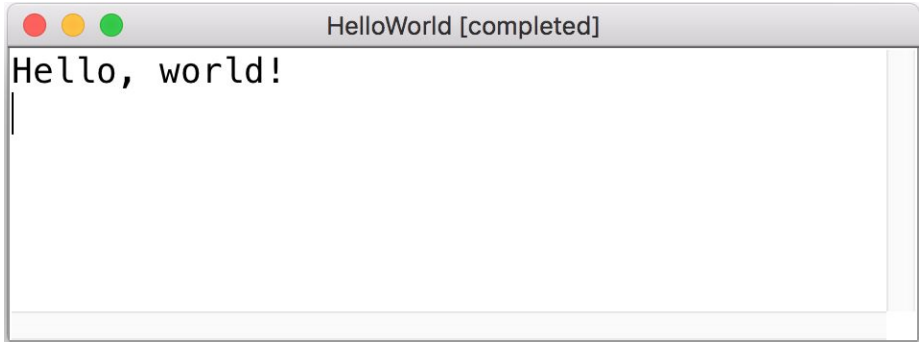


Hello, World

Our First Java Program

```
import acm.program.*;

public class HelloWorld extends ConsoleProgram {
    public void run() {
        println("Hello, world!");
    }
}
```



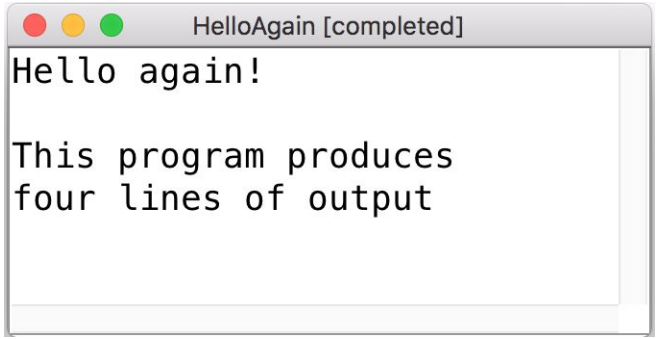
Console Programs

```
import acm.program.*;
public class Name extends ConsoleProgram {
    public void run() {
        statements;
    }
}
```

- Unlike Karel, many programs produce their behavior as text
- Console: textbox into which the behavior is displayed
  - *Output*: messages displayed by the program
  - *Input*: data read by the program that the user types

Console Programs

```
public class HelloAgain extends ConsoleProgram {
    public void run() {
        println("Hello again!");
        println();
        println("This program produces");
        println("four lines of output");
    }
}
```



Console Output: println

- `println`: a statement that prints a line of *output* on the console, and goes to the next line

- Two uses:

```
println("TEXT");    // prints the string TEXT
println();           // prints blank line
```

Console I/O

- I/O: **I**nput/**O**utput
- `println` allows out to output text to the user via the console
- We can also get input from the user via the console
  - But before we can get input from the user, we need a way to store it...

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What's a variable?

Variables = Boxes

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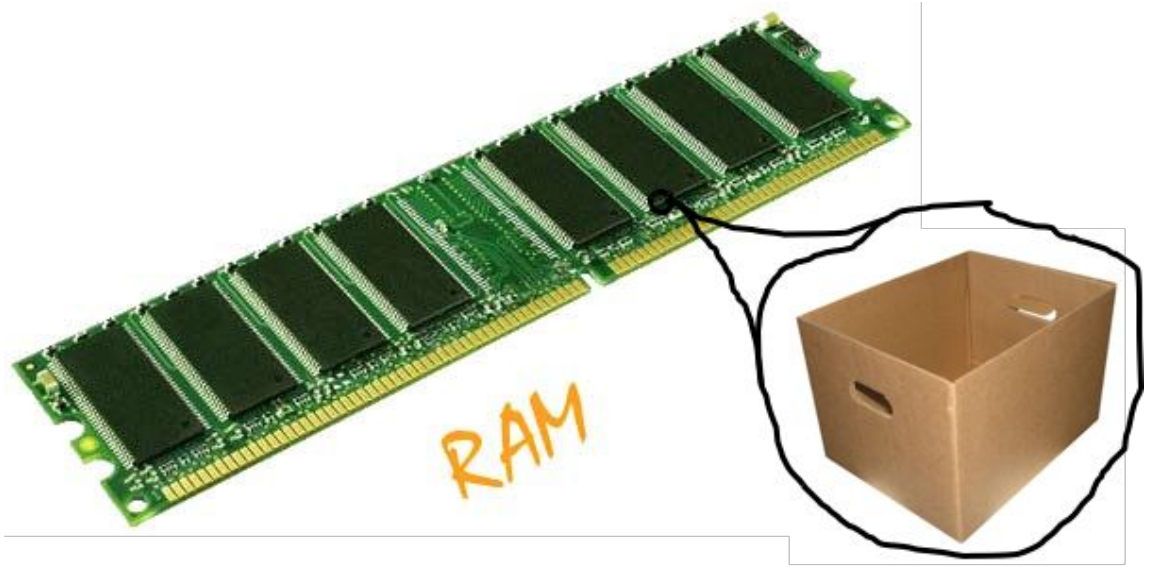

* my computer has space for about 2 billion boxes

Making a New Variable

```
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(contains an `int`)

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3 Properties

type name value

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value

type

(contains an `int`)

name

Variable Types

```
// an integer number
int num = 5;

// a real (decimal) number
double fraction = 0.2;

// true or false
boolean isSummer = true;
```

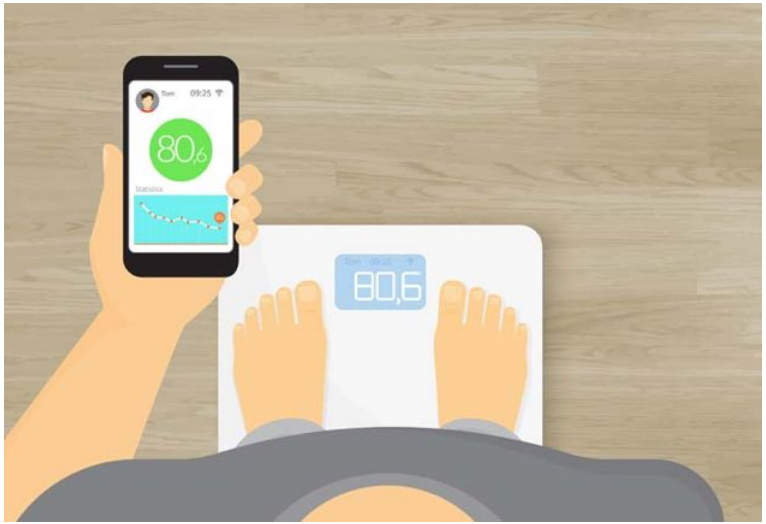
Variable Types

```
// a single character
char letter = 'c';

// a "string" of text
String phrase = "Hi!";
String alsoAString = "5"; // not an int!
```

Double vs. Int

Double - answer is a decimal
How much do I weigh?



Int - answer is an integer
How many pets do I have?

Making a Variable

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Making a Variable

```
int myVar;
myVar = 22;
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Making a Variable

```
int myVar;   // declare
myVar = 22; // assign
```

Declaration & Assignment

- **Declaration**: sets aside memory for storing a value
  - Variables must be declared before they can be used

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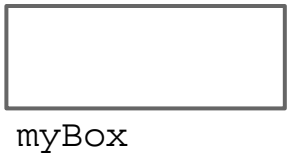

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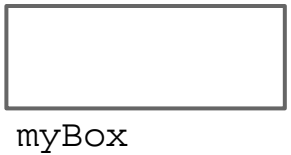

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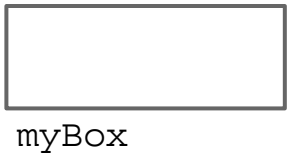

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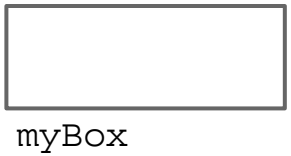

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double cost;          // declaration
cost = 1.5 + 0.75;    // assignment
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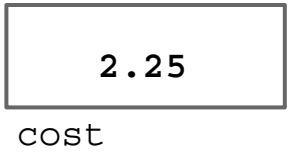

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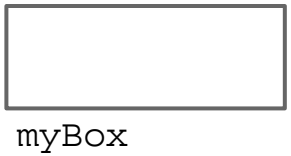

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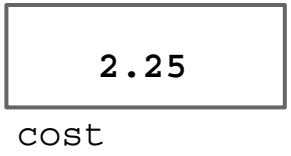

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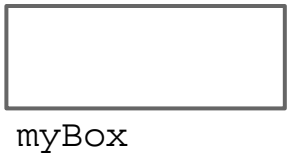

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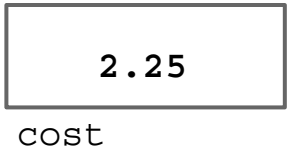
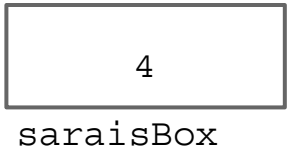


- Commonly, a variable is declared + initialized in one statement

```
int saraisBox = 4;
```



What Happens Here?

- What happens here?

```
int x = 3;
x = x + 2;   // ?
```

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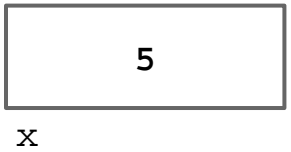
```
int x = 3;
x = x + 2;   // 5
```



'=' Means Assignment

- What happens here?

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int x = 3;
x = x + 2;   // 5
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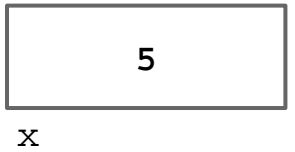

- Assignment uses =, but it's not an algebraic equation
  - = means: *store the value at right in the variable at left*
  - Right side expression evaluated first, then stored in variable at left

Outputting Variable Value

```
// creates variable called temperature with value 64.8
double temperature = (72.2 + 57.4) / 2.0;
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println(temperature);    // 64.8
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Outputting Variable Value

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// prints value of temperature variable to the console
println(temperature);    // 64.8

// can use + to print string and variable's value
println("avg temp is " + temperature);  // avg temp is 64.8
```

Using Variables

- Once given a value, variables can be used in expressions

```
int myVar = 22;
println(2 * myVar + 1);   // 45
```

Using Variables

- You can assign a value more than once

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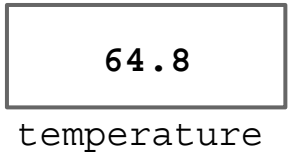


```
// declare
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Using Variables

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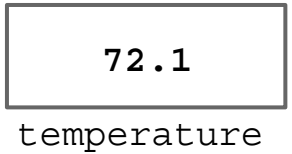


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// declare
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println("temp yesterday: " + temperature); // temp yesterday: 64.8

// reassign
temperature = 72.1;
```

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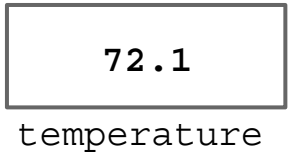


```
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double temperature = (72.2 + 57.4) / 2.0;
println("temp yesterday: " + temperature); // temp yesterday: 64.8

// reassign
temperature = 72.1;
println("temp today: " + temperature);     // temp today: 72.1
```

Assignment and Types

- A variable can only store a value of its own type

```
int x = 2.5;  // Error: incompatible types
```

Assignment and Types

- A variable can only store a value of its own type

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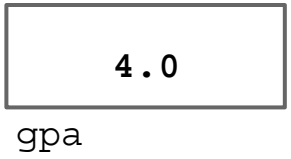
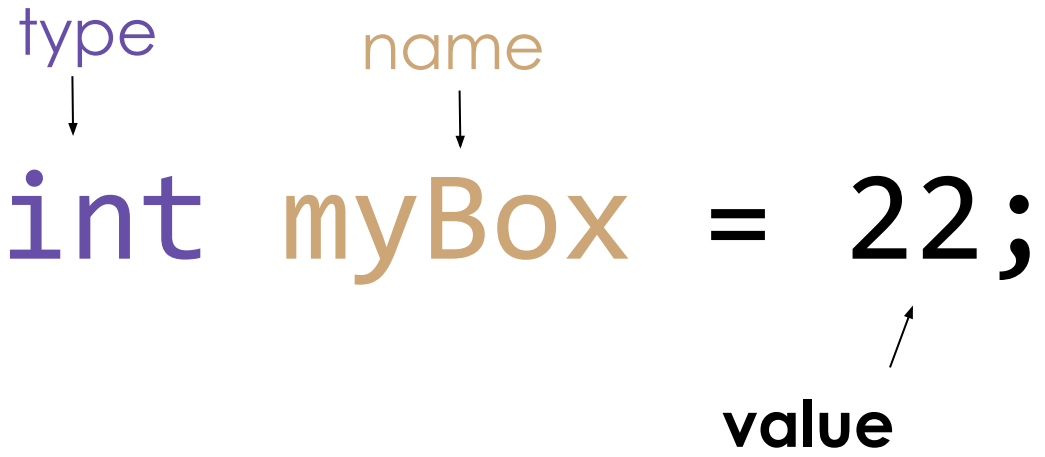
- An int value can be stored in a double variable
  - The value is converted into the equivalent real number

```
double gpa = 4;
```



Setting Variable Values



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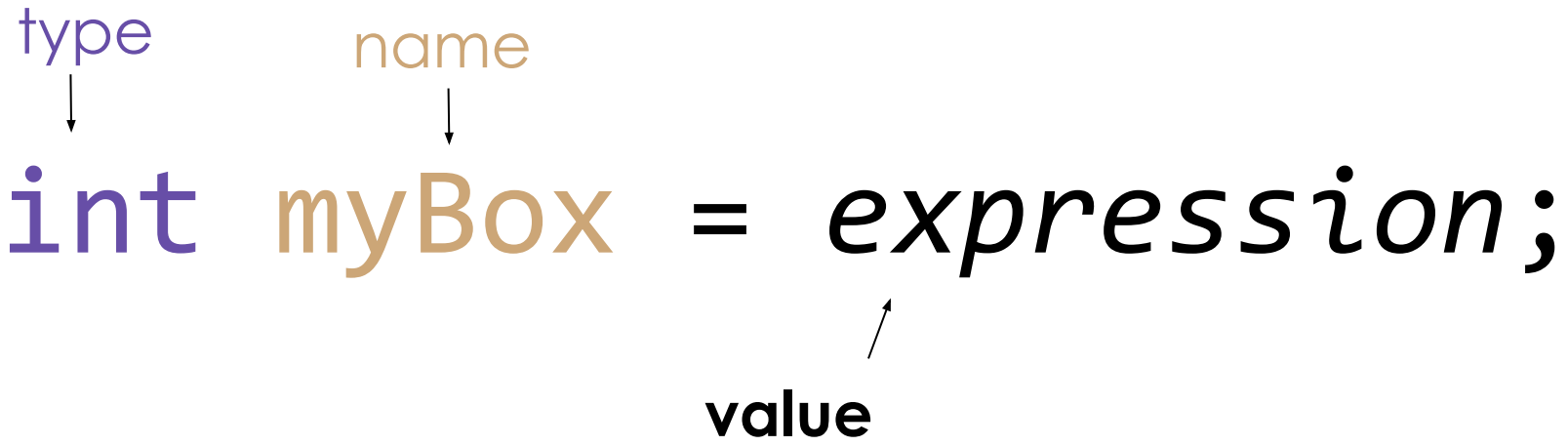

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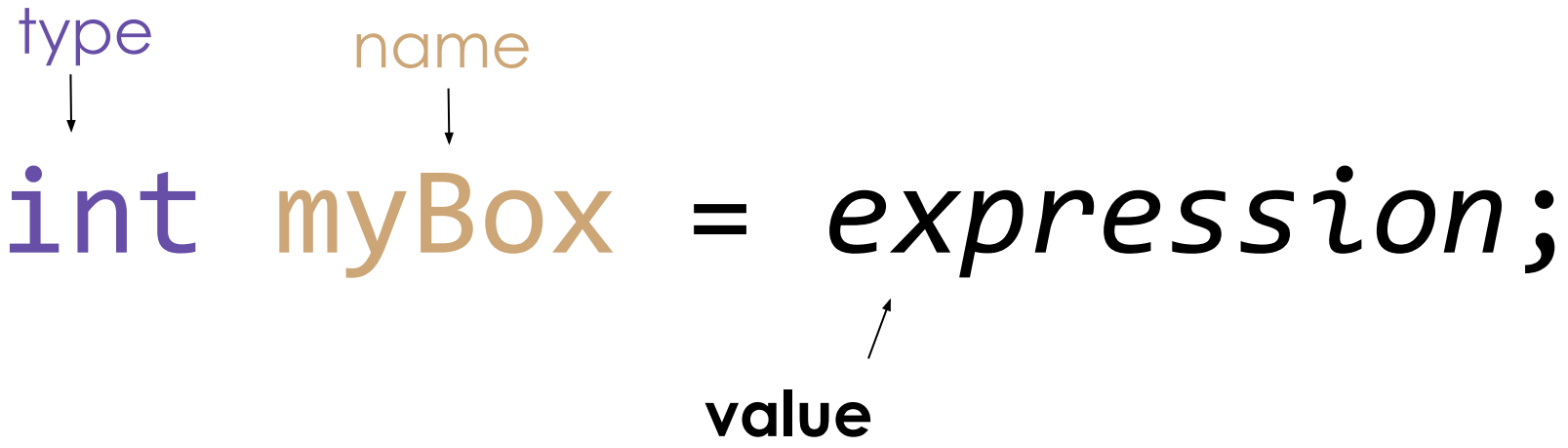

example:

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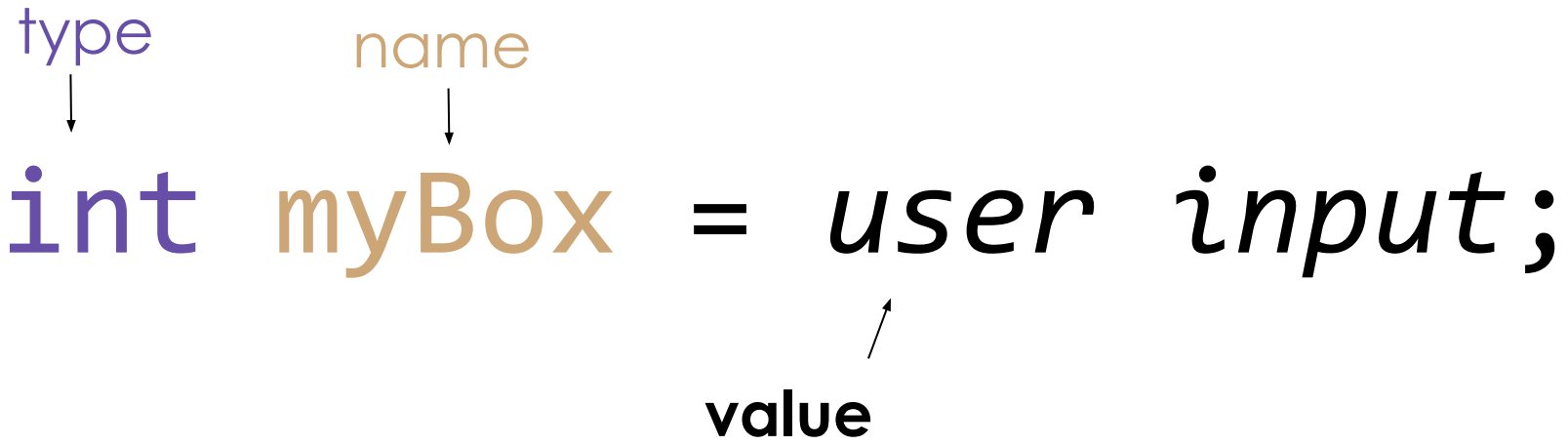
double temperature = (72.2 + 57.4) / 2.0;  // 64.8
```

Let's now get values from user input!

Setting Variable Values



Values from User Input

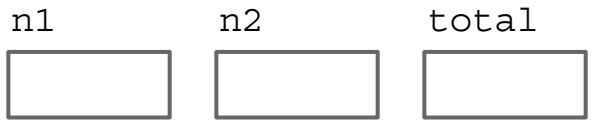
```
// Prompts user for a whole number. Stores result
// in a variable (aka a box).
int pets = readInt("How many pets? ");

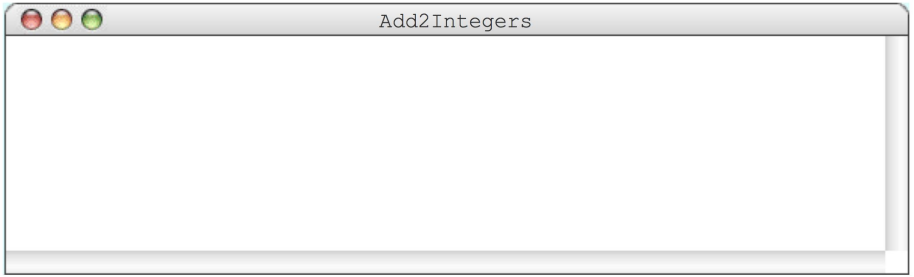
// Prompts user for a decimal number. Stores result
// in a variable (aka a box).
double tip = readDouble("Tip? $ ");

// Prompts user for a boolean & stores result in variable.
boolean isSunny = readBoolean("Sun shining? ");
```

Add2Integers

```
public class Add2Integers extends ConsoleProgram {
    public void run() {
        println("This program adds two numbers.");
        int n1 = readInt("Enter n1: ");
        int n2 = readInt("Enter n2: ");
        int total = n1 + n2;
        println("The total is " + total + ".");
    }
}
```





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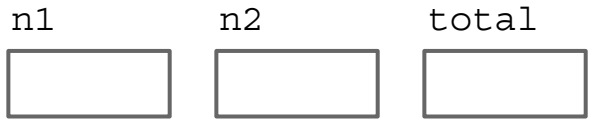

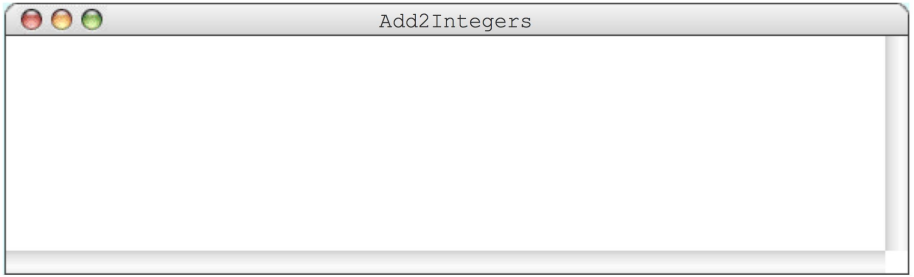

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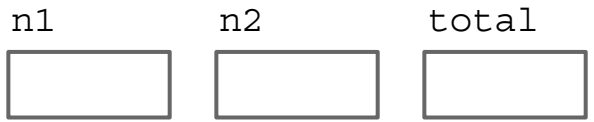

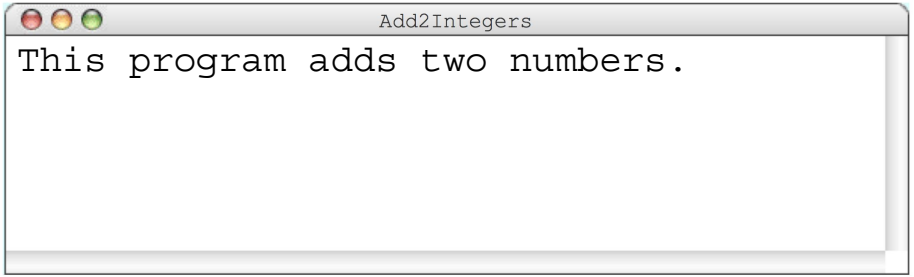

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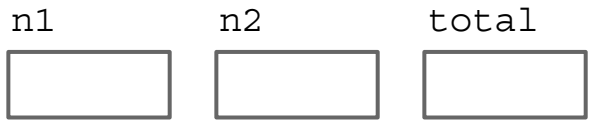

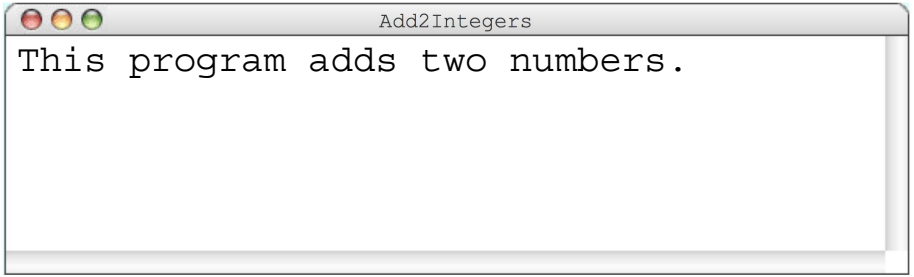

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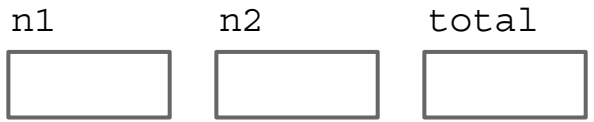

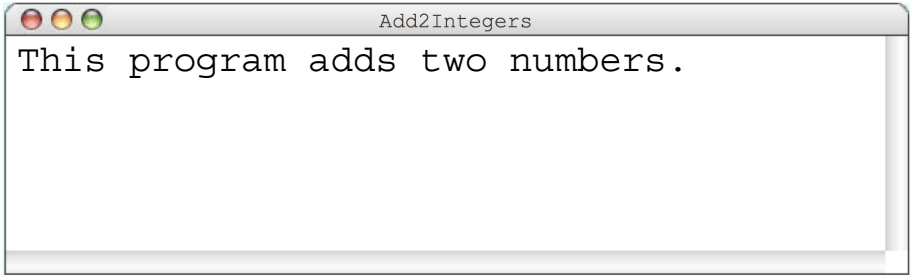

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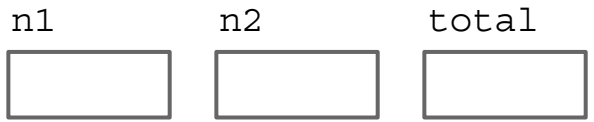

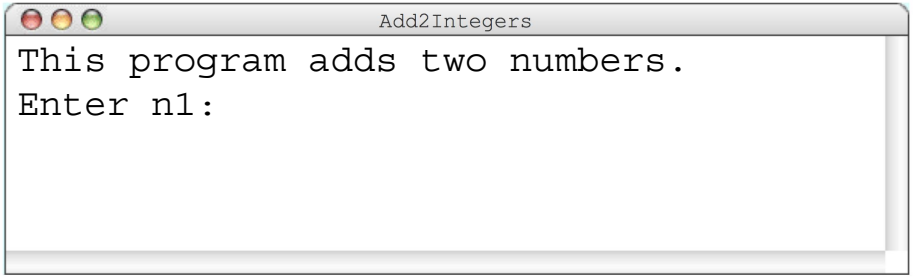

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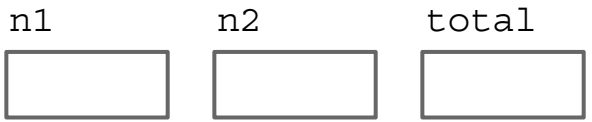

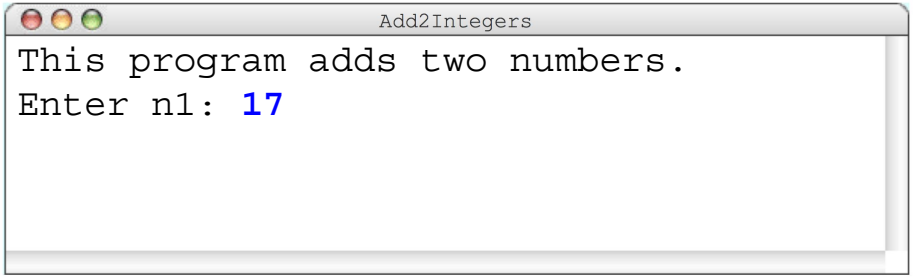

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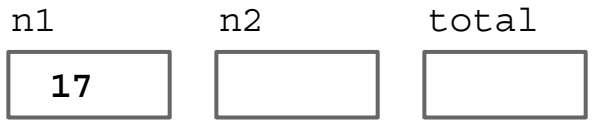

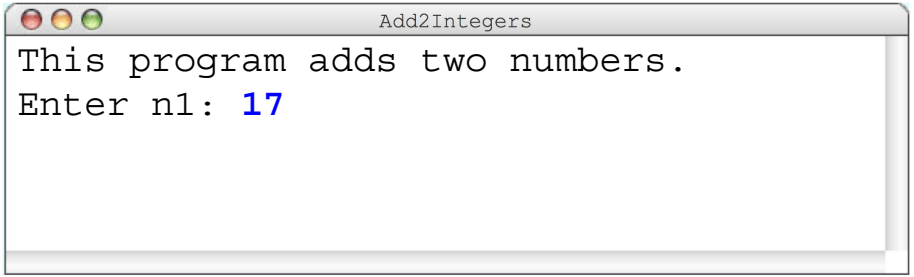

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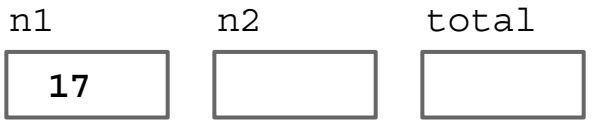

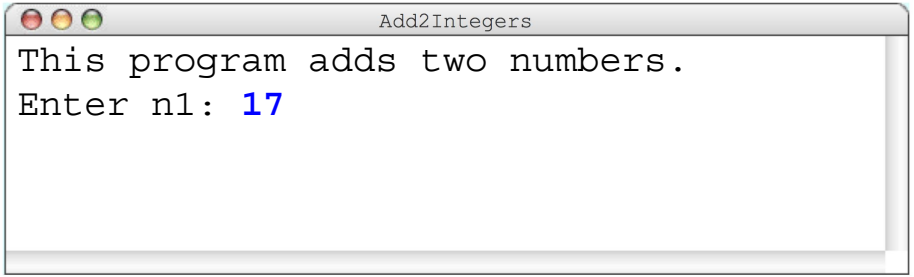

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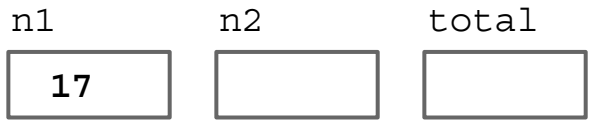

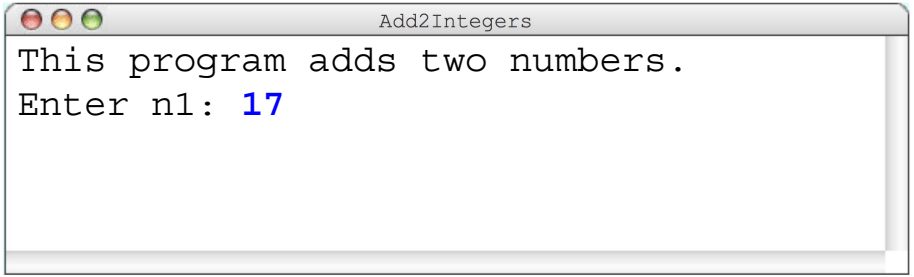

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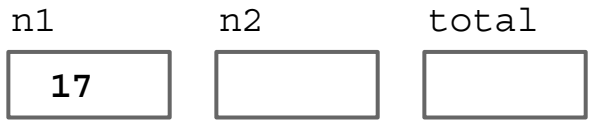

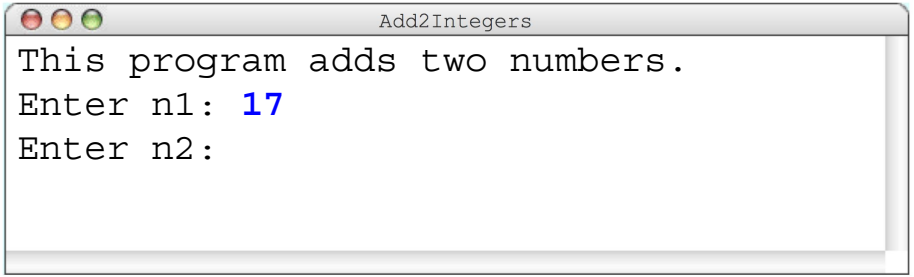

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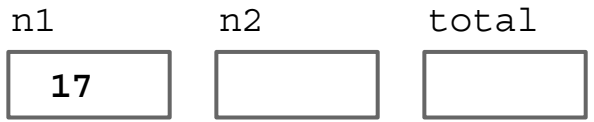

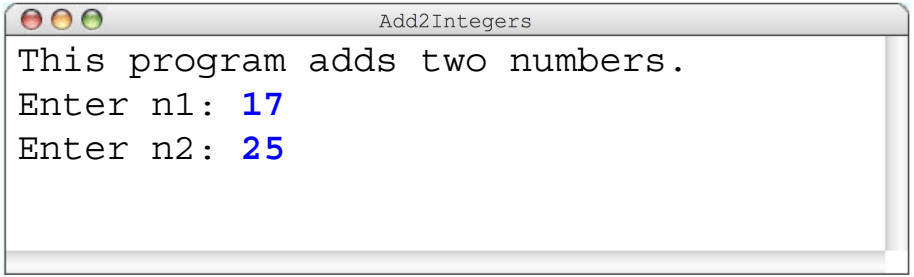

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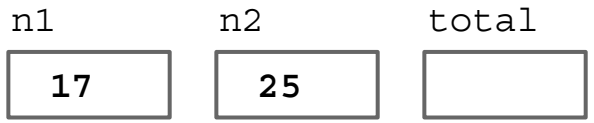

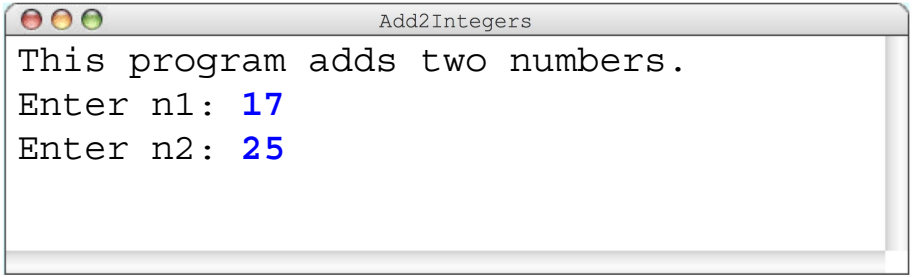

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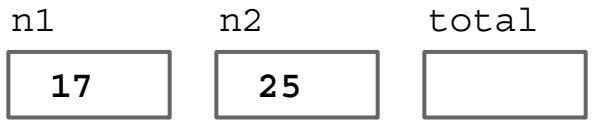

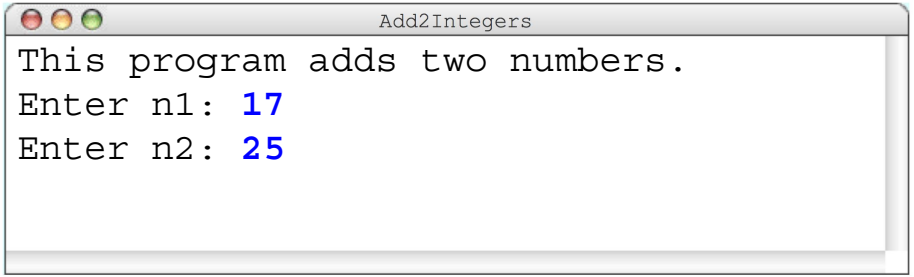

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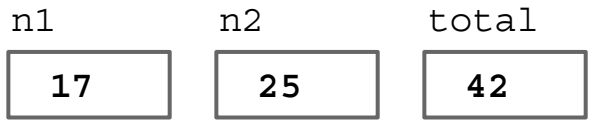

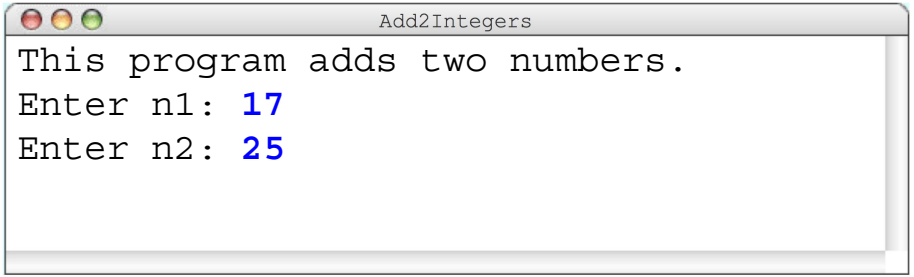

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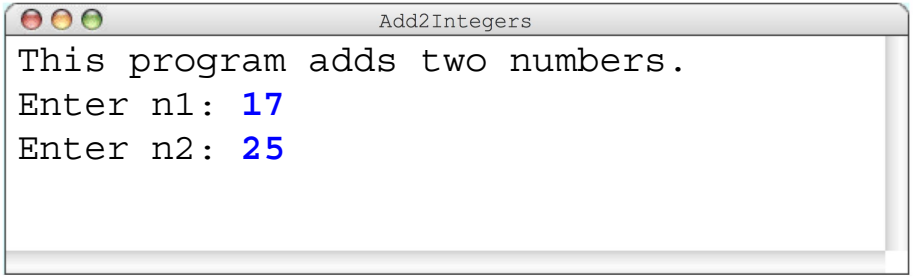
```

n1	n2	total
17	25	42



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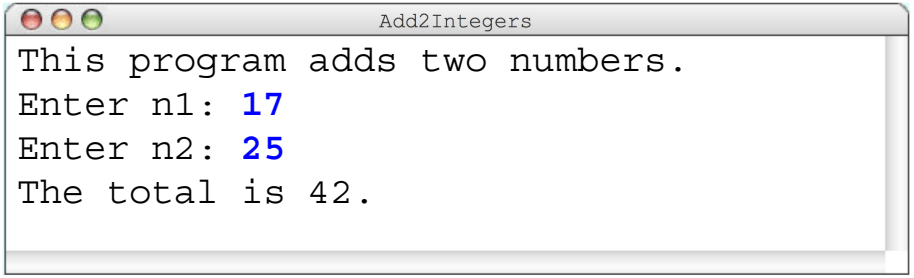

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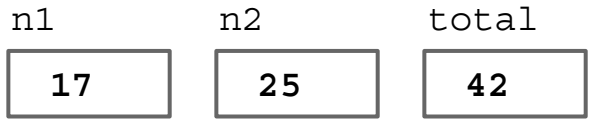

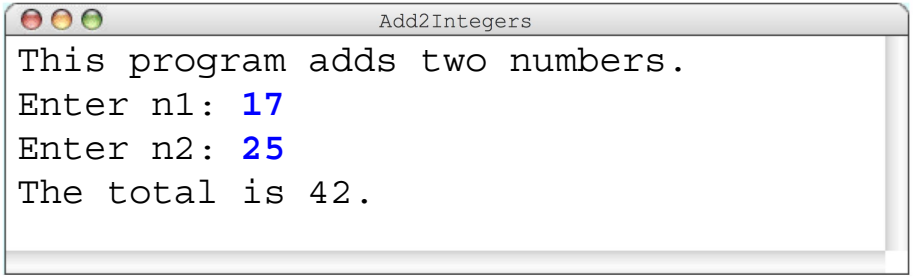

Compiler Errors

1. A variable can't be used until it is assigned a value

```
int x;
println(x);        // Error: x has no value
```

2. You may not declare the same variable twice

```
int y = 3;
int y = 5;         // Error: y already exists
```

3. You may not use a variable until it is declared

```
z = 10;            // Error: z cannot be resolved
```

Plan for Today

- Bye, Karel!
- Console programs
- Variables
- Expressions
- Practice: Receipt

Expressions

- You can combine literals or variables together into ***expressions*** using *binary operators*:

+	Addition	*	Multiplication
-	Subtraction	/	Division
		%	Remainder

Order of Operations

```
int result = 4 + 2 * 3;
```

Priority	Operator	Tie breaker
Highest	()	Left to right
Middle	* / %	Left to right
Lowest	+ -	Left to right

Order of Operations

```
// Multiplication before addition
int result = 4 + 2 * 3;       // 10
```

Priority	Operator	Tie breaker
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Order of Operations

```
// Multiplication before addition
int result = 4 + 2 * 3;       // 10

// Parens first, then left to right
int tot = 1 + 2 + (3 * 4);    // 15
```

Priority	Operator	Tie breaker
Highest	()	Left to right
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Expressions

- You can combine literals or variables together into ***expressions*** using *binary operators*:

+	Addition	*	Multiplication
-	Subtraction	/	Division
		%	**Remainder**

%: Integer Remainder or Modulus

- The % operator computes the remainder from integer division

```
14 % 4 is 2

     3
  ------
4 ) 14
    12
    --
     2
```

```
218 % 5 is 3

     43
  ------
5 ) 218
    20
    --
     18
     15
     --
      3
```

%: Integer Remainder or Modulus

- The % operator computes the remainder from integer division

`14 % 4` is `2`

```
    3
4 ) 14
    12
    (2)
```

`218 % 5` is `3`

```
   43
5 ) 218
   20
   18
   15
   (3)
```

- Applications of % operator:
  - Obtain last digit of a number: `857 % 10` is `7`
  - Obtain last 3 digits: `26489 % 1000` is `489`
  - See if a number is odd or even: `7 % 2` is `1`, but `42 % 2` is `0`

What do you think this does?

```
double successRate = 1 / 2;
```

AHHHHH!

```
double successRate = 1 / 2;
```

successRate

Integer Division

- When we divide integers, the quotient is also an integer
  - 14 / 4 is 3, not 3.5 (Java always rounds down)

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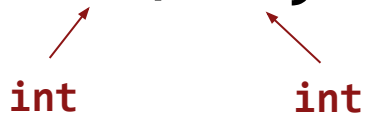

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1 / 2 → would be 0.5 → truncated to **0**
14 / 4 → would be 3.5 → truncated to **3**
199 / 100 → would be 1.99 → truncated to **1**

Type Interactions

`int` and `int` returns an `int`	`7 / 2`	→ `3`
`int` and `double` returns a `double`	`7 / 2.0`	→ `3.5`
`double` and `double` returns a `double`	`4.4 * 0.5`	→ `2.2`

* operations return the most expressive type

`String` > `double` > `int` > `char` > `boolean`

Pitfalls of Integer Division

Convert 100˚ Celsius temperature to its Fahrenheit equivalent:

```
double c = 100;
double f = 9 / 5 * c + 32;
```

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Pitfalls of Integer Division

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```

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Pitfalls of Integer Division

Convert 100˚ Celsius temperature to its Fahrenheit equivalent:

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double c = 100;
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```

1

How can we fix it?

```
double c = 100;
double f = 9.0 / 5 * c + 32;
```

Pitfalls of Integer Division

Convert 100˚ Celsius temperature to its Fahrenheit equivalent:

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double c = 100;
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1

How can we fix it?

```
double c = 100;
double f = 9.0 / 5 * c + 32;    // 212.0
```

1.8

Pitfalls of Integer Division

Convert 100˚ Celsius temperature to its Fahrenheit equivalent:

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double c = 100;
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```

1

How can we fix it?

```
double c = 100;
double f = 9.0 / 5 * c + 32;    // 212.0
```

1.8

* You can fix this problem by converting the fraction to a **double**, either by inserting decimal points or by using a type cast

Practice

- 5 + 3 / 2 - 4
- 15 / 2.0 + 6
- 1 * 2 + 3 * 5 % 4
- “abc” + 1 + 2
- “abc” + (1 + 2)

Practice

- 5 + 3 / 2 - 4 2
- 15 / 2.0 + 6
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Practice

- 5 + 3 / 2 - 4 — 2
- 15 / 2.0 + 6 — 13.5
- 1 * 2 + 3 * 5 % 4
- “abc” + 1 + 2
- “abc” + (1 + 2)

Practice

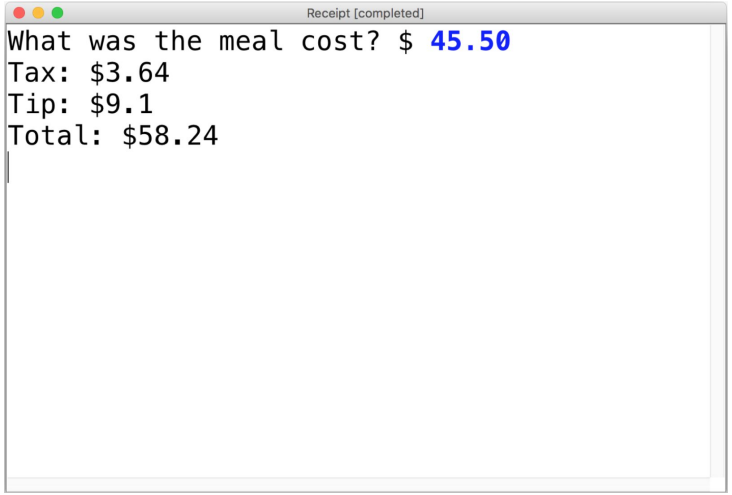
- 5 + 3 / 2 - 4 — 2
- 15 / 2.0 + 6 — 13.5
- 1 * 2 + 3 * 5 % 4 — 5
- “abc” + 1 + 2 — "abc12"
- “abc” + (1 + 2) — "abc3"

Plan for Today

- Bye, Karel!
- Console programs
- Variables
- Expressions
- Practice: Receipt

Practice: Receipt Program

- Let's write a ConsoleProgram that calculates the tax, tip and total bill for us at a restaurant.
- The program should ask the user for the subtotal, and then calculate and print out the tax, tip and total.



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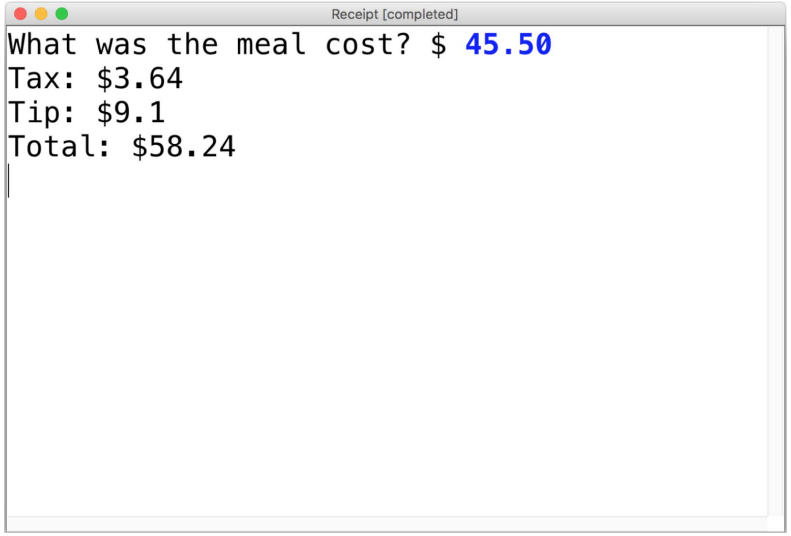

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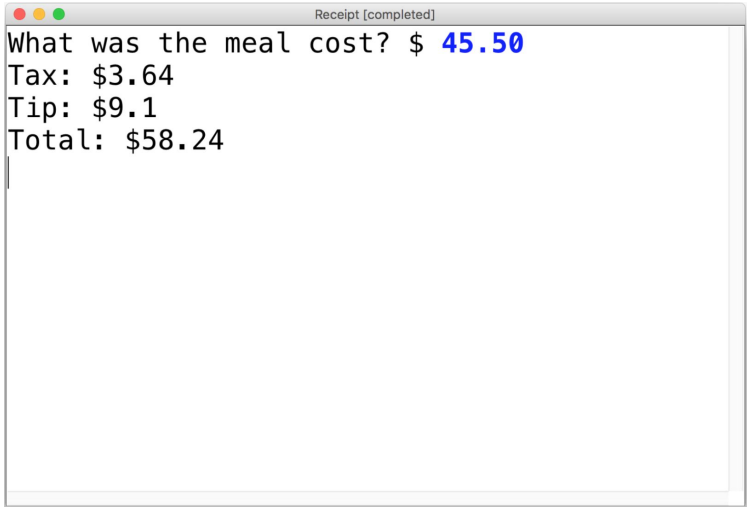


What's the Pseudocode?

Ask user for meal cost (store in variable)
Calculate tax (make variable!)
Calculate tip (make variable)
Calculate total (make variable)
Print out tax, tip, and total

Let’s Code It!

Practice: Receipt Program

```
public class Receipt extends ConsoleProgram {
    public void run() {
        double subtotal = readDouble("Meal cost? $");
        double tax = subtotal * 0.08;
        double tip = subtotal * 0.20;
        double total = subtotal + tax + tip;

        println("Tax: $" + tax);
        println("Tip: $" + tip);
        println("Total: $" + total);
    }
}
```

Recap

- Bye, Karel!
- Console programs
- Variables
- Expressions
- Practice: Receipt

Next time: Control flow in Java

[Extra] More on Precedence

- precedence: Order in which operators are evaluated.
  - Generally operators evaluate left-to-right.

    `1 - 2 - 3` is `(1 - 2) - 3` which is `-4`

  - But * / % have a higher level of precedence than + -

    ```
    1 + 3 * 4          is 13
    6 + 8 / 2 * 3
    6 +   4   * 3
    6 +       12       is 18
    ```

  - Parentheses can alter order of evaluation, but spacing does not:

    `(1 + 3) * 4` is `16`

    `1+3 * 4-2` is `11`

[Extra] String Concatenation

- string concatenation: Using + between a string and another value to make a longer string.

```
"hello" + 42     is "hello42"
1 + "abc" + 2    is "1abc2"
"abc" + 1 + 2    is "abc12"
1 + 2 + "abc"    is "3abc"
"abc" + 9 * 3    is "abc27"
"1" + 1          is "11"
4 - 1 + "abc"    is "3abc"
```

- Use + to print a string and an expression's value together.

```
println("Average: " + (95.1 + 71.9) / 2);   // Output: Average: 83.5
```

[Extra] Practice

- 5 + 3 / 2 - 4
- 15 / 2.0 + 6
- 1 * 2 + 3 * 5 % 4
- “abc” + 1 + 2
- “abc” + (1 + 2)

[Extra] Practice

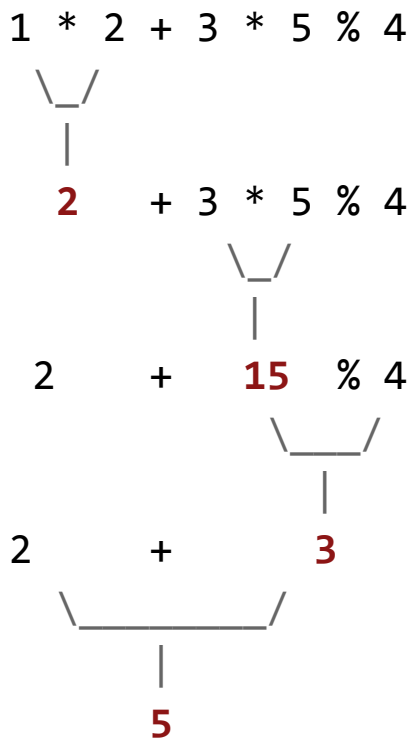
- 5 + 3 / 2 - 4 — 2
- 15 / 2.0 + 6 — 13.5
- 1 * 2 + 3 * 5 % 4 — 5
- “abc” + 1 + 2 — "abc12"
- “abc” + (1 + 2) — "abc3"

[Extra] Precedence Examples

```
1 * 2 + 3 * 5 % 4
```

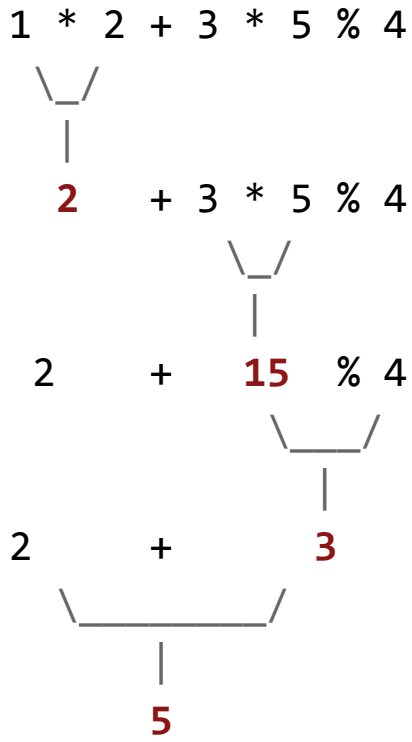
```
“abc” + 1 + 2
```

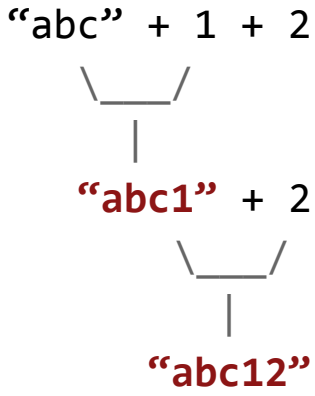
[Extra] Precedence Examples



“abc” + 1 + 2

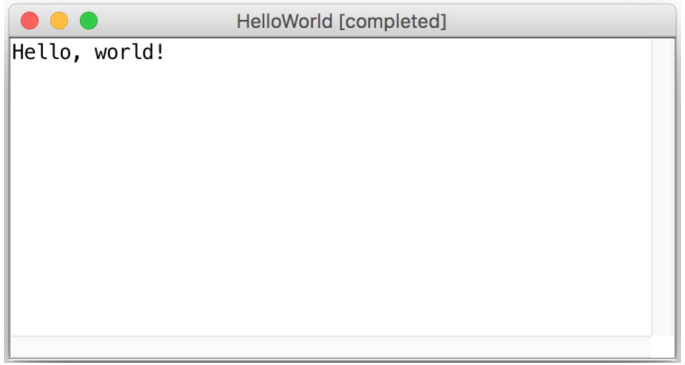
[Extra] Precedence Examples





[Extra] Print

```
public class HelloWorld extends ConsoleProgram {
     public void run() {
          print("Hello, ");
          print("world!");
     }
}
```



Same as println, but does not go to the next line.

[Extra] Escape Sequences

- **escape sequence**: A special sequence of characters used to represent certain special characters in a string.

`\t`	tab character
`\n`	new line character
`\"`	quotation mark character
`\\`	backslash character

  - Example:

```
println("\\hello\nhow\tare \"you\"?\\\\");
```

  - Output:

```
\hello
how     are "you"?\\
```