Variables
Chris Piech
CS106A, Stanford University
New Ability

Write a program that can turn a measurement of C14 into an estimate of age.

Radioactive molecule = C14
Halflife = 5730 years
C14 in living organisms = 13.6 dpm

What is the amount of C14 remaining in your sample: 10.2
Your sample is 2378.0 years old.
Review: Decomposition

1. Each method solves one “problem”
2. Methods should have good names
3. Comment each of your methods
4. Length of methods should be < 15 lines
5. Methods should ideally be generalizable
See You Later!

I will miss you.

Enjoy Java!

See you on the midterm 😭.
Java

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Today’s Goal

1. How do you make a box?
2. How do you see what is in a box?
3. What can you put in a box?
4. How do you change what is in a box?
Two Example Programs

This program adds two numbers.
Enter n1: 17
Enter n2: 25
The total is 42.

Programming is Awesome!
Types of Programs

Program

Karel Program

SuperKarel Program

Console Program

Graphics Program
import acm.program.*;

public class HelloProgram extends ConsoleProgram {
    public void run() {
        println("hello, world");
    }
}

First Console Program: Hello World
You had me at "Hello, world"
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 + ".");
    }
}

<table>
<thead>
<tr>
<th>n1</th>
<th>n2</th>
<th>total</th>
</tr>
</thead>
<tbody>
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This program adds two numbers.
Enter n1: 17
Enter n2: 25
The total is 42.
Today’s Route

The River of Variables

Access → Assign → Modify

Variables

You are here

Examples

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Programs are control flow and variables
What is a variable?
[suspense]
Variables are Like Boxes
My computer has space for about 2 billion boxes
Three Properties

name

descendants

- age

value: 29

parent

value

descendants

- type

(contains an int)
int age = 29;
Making a New Variable

```plaintext
int age = 29;
```

**type** | **name** | **Initial value**
When a line starts with a variable type, it is creating a new variable ...aka a box.

Example:

```
int myBox = 5;
```
// integer values
int num = 5;

// real values
double fraction = 0.2;

// letters
char letter = 'c';

// true or false
boolean isLove = true;

* Why is it called a double?
Double: How Much Do I Weigh?

* Answers could be real valued numbers
Int: How Many Children Do I Have?

* It is weird to say something like 1.7
public void run() {

    // integer values
    int age = 29;

    // real values
    double weight = 180.2;

}
Can you access the value in a variable (aka box)?
Outputting Variable Value

// creates a variable called // age with the value 29.
int age = 29;

// puts the value of the age // variable on the screen.
println(age);

* Fun fact. Chris turns 30 this year. He is young at heart.
// creates a variable called 
// age with the value 29.
int age = 29;

// puts the following on the 
// screen:
// age is <value>
println("age is: " + age);

* Fun fact. Chris turns 30 this year. He is young at heart.
What data can you put in a variable (aka box)?
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 + ".");
    }
}

This program adds two numbers.
Enter n1: 17
Enter n2: 25
The total is 42.
Making a New Variable

```
int myBox = user input;
```

**Type**: int

**Name**: myBox

**Initial Value**: user input
Making a New Variable

\[
\text{type} \quad \text{name} \\
\text{int} \quad \text{myBox} = \text{expression};
\]

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

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

// Haven’t you ever wondered, who was the first person to eat a carrot???
boolean edible = readBoolean("Subject alive?");
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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Binary Operators

+ Addition
– Subtraction
* Multiplication
/ Division
% Remainder

See you another day, tio.
Learn by examples
Order of Operation

// Mult before addition first!
int result = 4 + 2 * 3;  // 10

// Left to right!
int sum = 1 + 2 + (3 * 4);  // 15

<table>
<thead>
<tr>
<th>Priority</th>
<th>Operator</th>
<th>Tie breaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest</td>
<td>()</td>
<td>Left to right</td>
</tr>
<tr>
<td>Middle</td>
<td>* /</td>
<td>Left to right</td>
</tr>
<tr>
<td>Lowest</td>
<td>+ -</td>
<td>Left to right</td>
</tr>
</tbody>
</table>
What do you think this does?

```
// creates a variable called success rate
double successRate = 1 / 2;
```
// creates a variable called
// success rate
double successRate = 1 / 2;

0.0
All *binary operators* result in a value (like a temporary variable) which *has a type*. You need to know what type that will be.

Most important example:

```
int / int results in an int
```
Resulting Type

\[ \text{int} \div \text{int} \] results in an \text{int}

\[ \text{double} \times \text{double} \] results in a \text{double}

\[ \text{int} + \text{double} \] results in a \text{double}
Resulting Type of Binary Expression

All *binary operators* result in a value (like a temporary variable) which *has a type*. The general rule is: operations always return the *most expressive* type:

Expressive hierarchy:

\[
\text{boolean} < \text{char} < \text{int} < \text{double}
\]

Example:

\[
\text{int} / \text{double}
\]
results in a *double*
Even more examples...
Pitfalls of Integer Division

Convert 100° Celsius temperature to its Fahrenheit equivalent:

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

The computation consists of evaluating the following expression:

The problem arises from the fact that both 9 and 5 are of type int, which means that the result is also an int.
You can fix this problem by converting the fraction to a `double`, either by inserting decimal points or by using a type cast:

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

The computation now looks like this:
Practice

• $5 + \frac{3}{2} - 4 \quad \text{// 2}$
• $15 / 2.0 + 6 \quad \text{// 13.5}$
Can you change the value in a variable (aka box)?
Modifying a Variable

// creates a variable called age with the value 29.
int age = 29;

// this puts a new value in the box
age = 30;

// In what world does this make sense?
// Welcome to Java
age = age + 2;
1. A variable can't be used until it is assigned a value.

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

2. You may not declare the same variable twice.

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

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

```java
z = 10;  // Error: z cannot be resolved
```
Today’s Route

- Variables
- Access
- Assign
- Modify
- Examples

You are here

The River of Variables
Today’s Route

Examples

You are here

The River of Variables

Variables

Modify

Assign

Access

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Practice 1: 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.

What was the meal cost? $ 45.50
Tax: $3.64
Tip: $9.1
Total: $58.24
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Radioactive molecule = C14
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What is the amount of C14 remaining in your sample: 10.2
Your sample is 2378.0 years old.
Example: Carbon Dating

C14 = 1.2 dpm

C14 = 13.6 dpm
Carbon Dating Equation

\[ \text{age} = \frac{\log\left( \frac{c}{13.6} \right)}{\log\left( \frac{1}{2} \right)} \times 5730 \]

- Amount of C14 in your sample
- Amount of C14 in a living sample
- Half life of C14
- Age of the sample
- \( \frac{1}{2} \) because of half life convention

* Some of these values are constants
** Use the function: `Math.log( num )`