CS 106A, Lecture 5
Booleans, Control Flow and Scope

suggested reading:
Java Ch. 3.4-4.6, 6.1

Plan For Today

- Announcements
- Recap: Java, Variables and Expressions
- Aside: Shorthand Operators + Constants
- Revisiting Control Flow
  - If and While
  - For
- Scope

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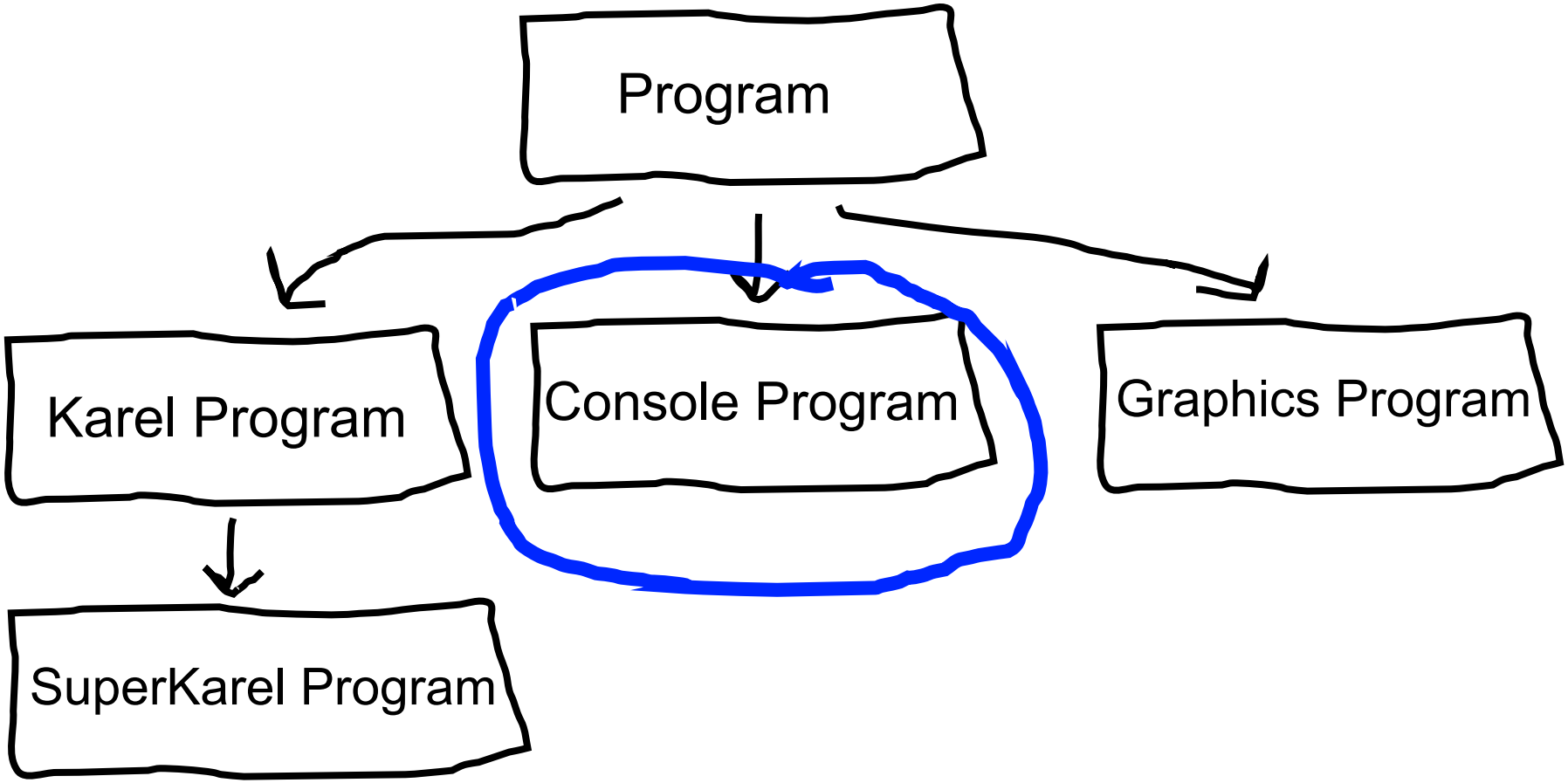
Java


Program
Karel Program
Console Program
Graphics Program
SuperKarel Program

Console Programs

```
import acm.program.*;

public class Name extends ConsoleProgram {
    public void run() {
        statements;
    }
}
```

- Unlike Karel, many programs produce their behavior as text.
- **console**: Text box into which the behavior is displayed.
  - *output:* Messages displayed by the program.
  - *input:* Data read by the program that the user types.

println

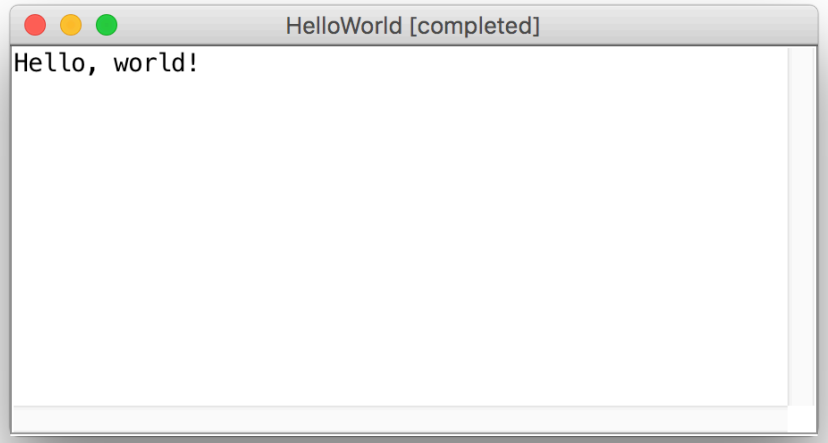
- A statement that prints a line of output on the console, and goes to the next line.
  - pronounced "print-linn"

- Two ways to use `println` :
  - `println("`***`text`***`");`
    - Prints the given message as output, and goes to the next line.
    - A message is called a *string*; it starts/ends with a `"` quote character.
    - The quotes do not appear in the output.
    - A string may not contain a `"` character.
  - `println();`

    Prints a blank line of output.

print

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



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

Expressions

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

+	Addition	*	Multiplication
–	Subtraction	/	Division
		%	Remainder

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

Type Interactions

`int` and `int` results in an `int`

`double` and `double` results in a `double`

`int` and `double` results in a `double`

`String` and `int` results in a `String`

etc.

* The general rule is: operations always return the most expressive type

Integer division

- When we divide integers, the quotient is also an integer.

  `14 / 4` is `3`, not `3.5`. *(Java ALWAYS rounds down.)*

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

```
   4
10 ) 45
   40
    5
```

```
    52
27 ) 1425
   135
    75
    54
    21
```

- More examples:
  - `32 / 5` is `6`
  - `84 / 10` is `8`
  - `156 / 100` is `1`

  - Dividing by `0` causes an error when your program runs.

Practice

- 1 / 2
- 1.0 / 2
- 1 + 2 / 3
- "abc" + (4 + 2)
- "abc" + 4 + 2

Making a new Variable


```
int myVariable;
```

Variable Types

`int` – an integer number

`double` – a decimal number

Assignment

Existing variable name

value

```
myVariable = 2;
```

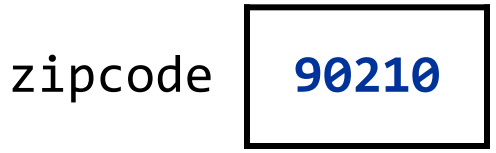
Assignment

- **assignment**: Stores a value into a variable.
  - The value can be an expression; the variable stores its result.

- Syntax:

```
name = expression;
```

```
int zipcode;
zipcode = 90210;
```




```
double myGPA;
myGPA = 1.0 + 2.25;
```

Declare / initialize

- A variable can be declared/initialized in one statement.
  - This is probably the most commonly used declaration syntax.

- Syntax:

```
type name = expression;
```

```
double tempF = 98.6;
```


```
int x = (12 / 2) + 3;
```

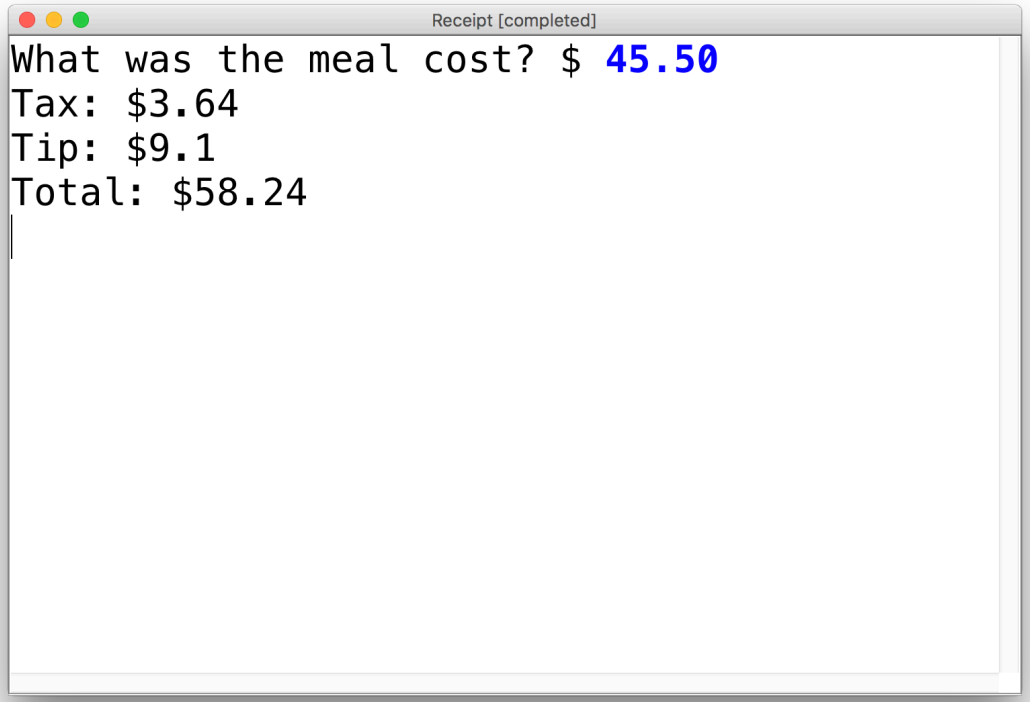
Using Variables

```
// Asks the user for an integer by
// displaying the given message
// and stores it in the variable 'a'
int a = readInt(message);

// Asks the user for a double by
// displaying the given message and
// stores it in the variable 'b'
double b = readDouble(message);
```

Practice: Receipt Program

- We wrote a ConsoleProgram called *Receipt* that calculates the tax, tip and total bill for us at a restaurant.
- The program asks the user for the subtotal, and then calculate and print out the tax, tip and total.



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Shorthand Operators

Shorthand	Equivalent longer version
variable += value;	*variable = variable + value;*
variable -= value;	*variable = variable - value;*
*variable *= value;*	*variable = variable * value;*
variable /= value;	*variable = variable / value;*
variable %= value;	*variable = variable % value;*
variable++;	*variable = variable + 1;*
variable--;	*variable = variable – 1;*
`x += 3;`	`// x = x + 3;`
`number *= 2;`	`// number = number * 2;`
`x++;`	`// x = x + 1;`

Constants

- **constant**: A variable that cannot be changed after it is initialized. Declared at the top of your class, *outside of the run() method*. Can be used anywhere in that class.

- Syntax:

```
private static final type name = value;
```

  - name is usually in ALL_UPPER_CASE

  - Examples:

```
private static final int DAYS_IN_WEEK = 7;
private static final double INTEREST_RATE = 3.5;
private static final int SSN = 658234569;
```

Receipt Program - Before

```
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);
  }
}
```

Receipt Program – After

```
public class Receipt extends ConsoleProgram {
  private static final double TAX_RATE = 0.08;
  private static final double TIP_RATE = 0.2;

  public void run() {
    double subtotal = readDouble("Meal cost? $");
    double tax = subtotal * TAX_RATE;
    double tip = subtotal * TIP_RATE;
    double total = subtotal + tax + tip;

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

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If/Else in Karel

```
if (condition) {
    statement;
    statement;
    ...
} else {
    statement;
    statement;
    ...
}
```

Runs the first group of statements if ***condition*** is true; otherwise, runs the second group of statements.

While Loops in Karel

```
while (condition) {
    statement;
    statement;
    ...
}
```

Repeats the statements in the body until ***condition*** is no longer true.

Each time, Karel executes *all statements*, and **then** checks the condition.

Conditions in Karel

```
while(frontIsClear()) {
    body
}
```

```
if(beepersPresent()) {
    body
}
```

Conditions in Java

```
while(condition) {
    body
}
```

```
if(condition) {
    body
}
```

The condition should be a “boolean” which is either **`true`** or **`false`**

Booleans

$1 < 2$

Booleans

$1 < 2$

`true`

Relational Operators

Operator	Meaning	Example	Value
==	equals	`1 + 1 == 2`	`true`
!=	does not equal	`3.2 != 2.5`	`true`
<	less than	`10 < 5`	`false`
>	greater than	`10 > 5`	`true`
<=	less than or equal to	`126 <= 100`	`false`
>=	greater than or equal to	`5.0 >= 5.0`	`true`

* All have equal precedence

Relational Operators

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>=	greater than or equal to	`5.0 >= 5.0`	`true`

* All have equal precedence

Relational Operators

```
if (1 < 2) {
    println("1 is less than 2!");
}
```

```
int num = readInt("Enter a number: ");
if (num == 0) {
    println("That number is 0!");
} else {
    println("That number is not 0.");
}
```

Practice: Sentinel Loops

- **sentinel**: A value that signals the end of user input.
  - **sentinel loop**: Repeats until a sentinel value is seen.

- Example: Write a program that prompts the user for numbers until the user types -1, then output the sum of the numbers.
  - In this case, -1 is the sentinel value.

```
Type a number: 10
Type a number: 20
Type a number: 30
Type a number: -1
Sum is 60
```

Practice: Sentinel Loops

```
// fencepost problem!
// ask for number - post
// add number to sum - fence


int sum = 0;
int num = readInt("Enter a number: ");
while (num <= -1) {
      sum += num;
      num = readInt("Enter a number: ");
}
println("Sum is " + sum);
```

Practice: Sentinel Loops

```
// Solution #2 (ok, but #1 is better)


int sum = 0;
while (true) {
      int num = readInt("Enter a number: ");
      if (num == -1) {
            break;     // immediately exits loop
      }
      sum += num;
}
println("Sum is " + sum);
```

Compound Expressions

In order of precedence:

Operator	Description	Example	Result
!	not	`!(2 == 3)`	`true`
&&	and	`(2 == 3) && (-1 < 5)`	`false`
||	or	`(2 == 3) || (-1 < 5)`	`true`

Cannot "chain" tests as in algebra; use && or || instead

```
// assume x is 15
2 <= x <= 10
true   <= 10
Error!
```

```
// correct version
2 <= x && x <= 10
true   && false
false
```

Precedence Madness

Precedence: arithmetic > relational > logical

```
5 * 7 >= 3 + 5 * (7 - 1) && 7 <= 11
5 * 7 >= 3 + 5 * 6 && 7 <= 11
35    >= 3 + 30 && 7 <= 11
35    >= 33 && 7 <= 11
true && true
true
```

Boolean Variables

```
// Store expressions that evaluate to true/false
boolean x = 1 < 2;          // true
boolean y = 5.0 == 4.0;     // false
```

Boolean Variables

```
// Store expressions that evaluate to true/false
boolean x = 1 < 2;          // true
boolean y = 5.0 == 4.0;     // false

// Directly set to true/false
boolean isFamilyVisiting = true;
boolean isRaining = false;
```

Boolean Variables

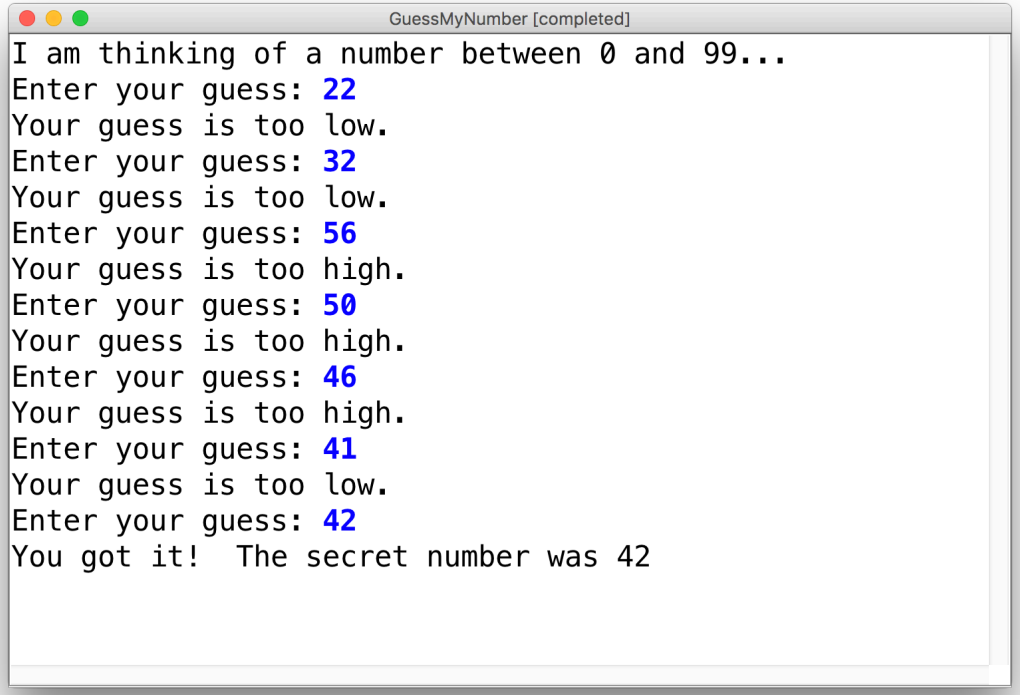
```
// Store expressions that evaluate to true/false
boolean x = 1 < 2;          // true
boolean y = 5.0 == 4.0;     // false

// Directly set to true/false
boolean isFamilyVisiting = true;
boolean isRaining = false;

// Ask the user a true/false (yes/no) question
boolean playAgain = readBoolean("Play again?");
if (playAgain) {
...
```

Practice: GuessMyNumber

- Let's write a program called *GuessMyNumber* that prompts the user for a number until they guess our secret number.
- If a guess is incorrect, the program should provide a hint; specifically, whether the guess is too high or too low.



Summary: Conditions

```
while(condition) {
    body
}
```

```
if(condition) {
    body
}
```

The condition should be a **boolean** which is either `true` or `false`

If/Else If/Else

```
if (condition1) {
    ...
} else if (condition2) {        // NEW
    ...
} else {
    ...
}
```

Runs the first group of statements if ***condition1*** is true; otherwise, runs the second group of statements if ***condition2*** is true; otherwise, runs the third group of statements.

You can have multiple else if clauses together.

If/Else If/Else

```
int num = readInt("Enter a number: ");
if (num > 0) {
      println("Your number is positive");
} else if (num < 0) {
      println("Your number is negative");
} else {
      println("Your number is 0");
}
```

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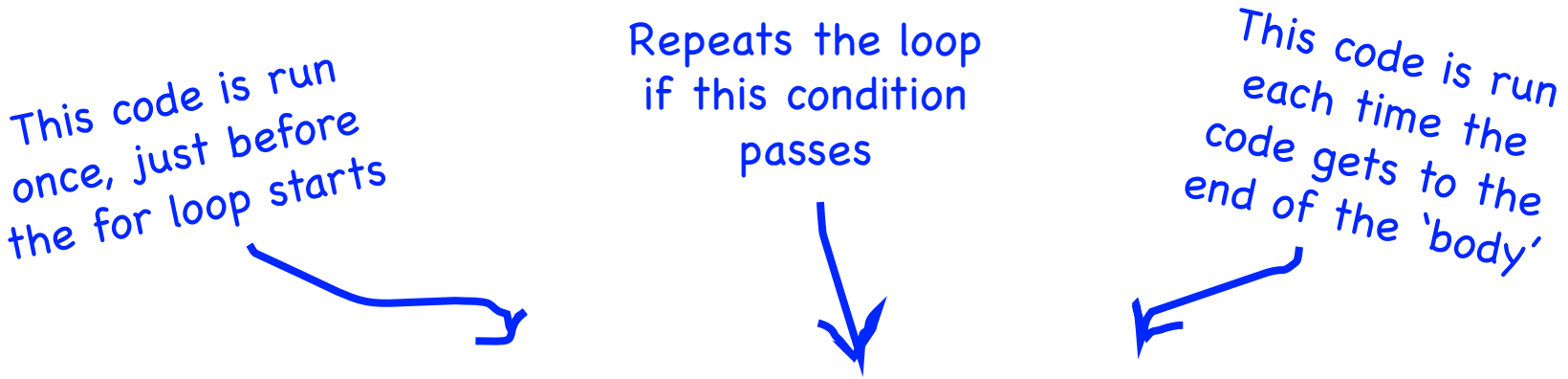
For Loops in Karel

```
for (int i = 0; i < max; i++) {
    statement;
    statement;
    ...
}
```

Repeats the statements in the body ***max*** times.

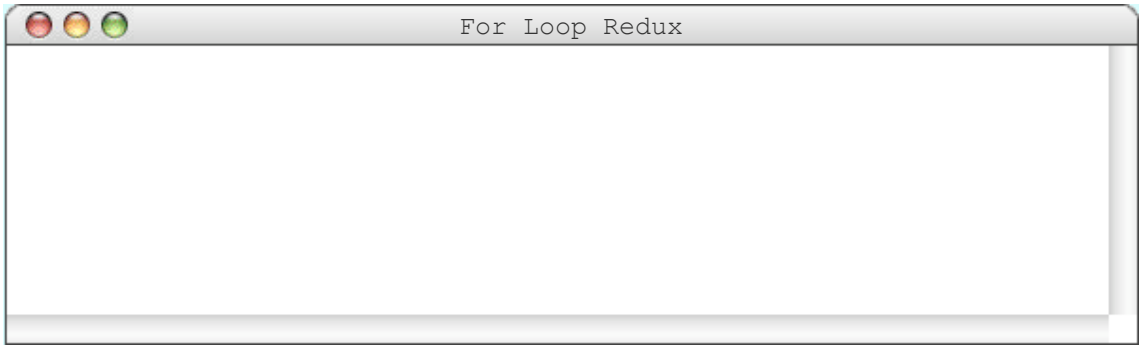
For Loops in Java




```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```

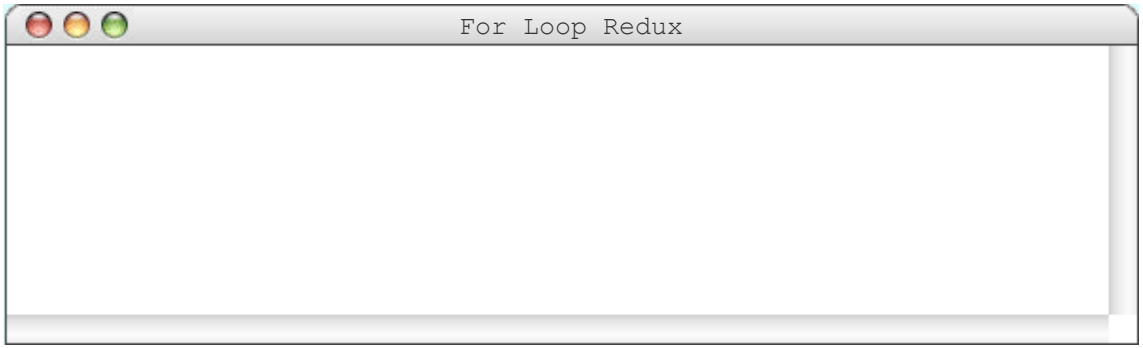
For Loops in Java

```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



For Loops in Java

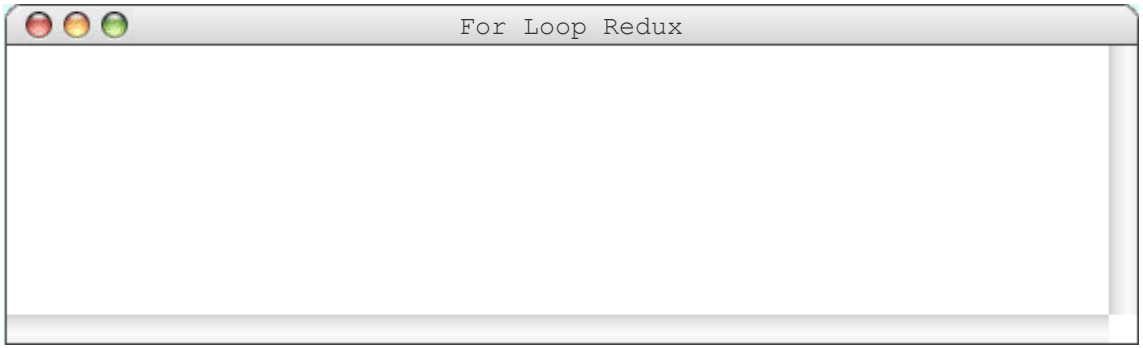

```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



For Loops in Java

i	0

```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



For Loops in Java

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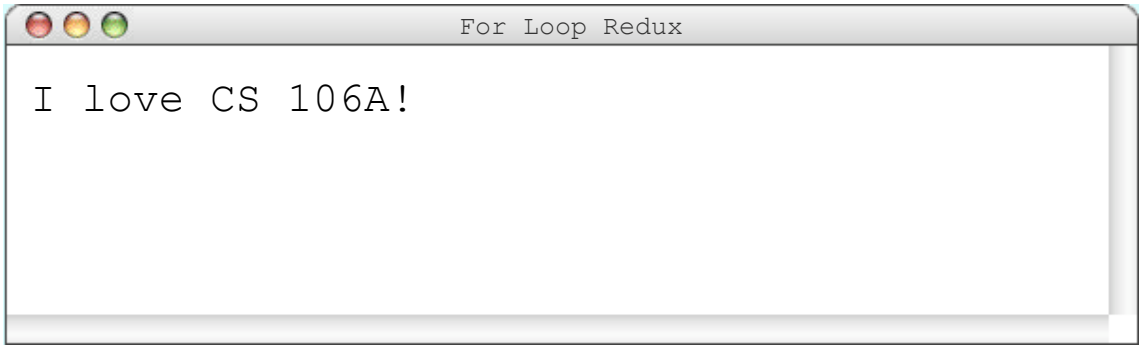
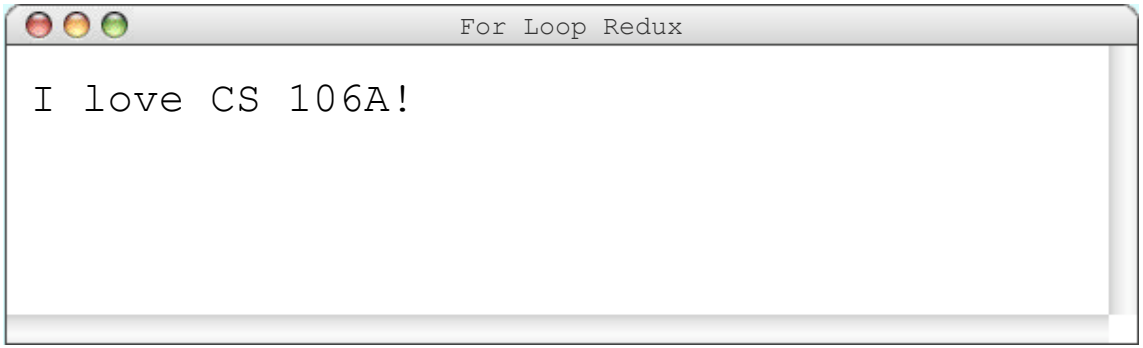
```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



For Loops in Java

i 0

```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



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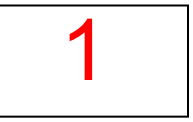
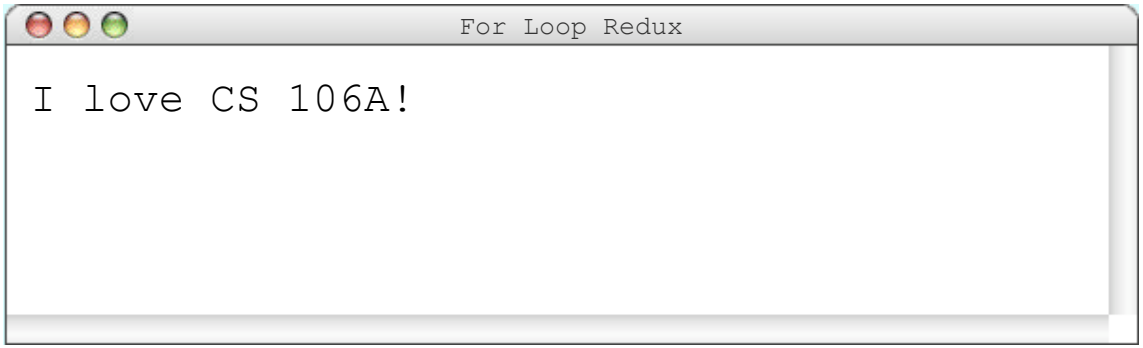



```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



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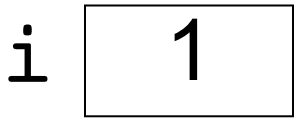
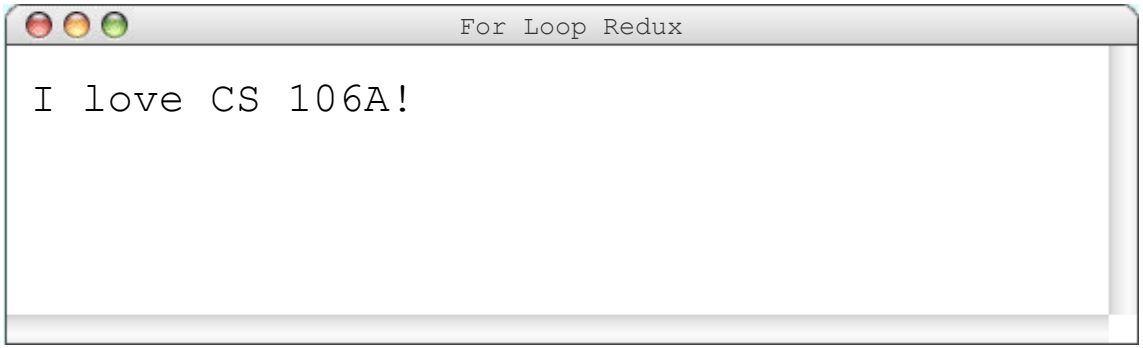



```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



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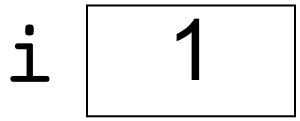
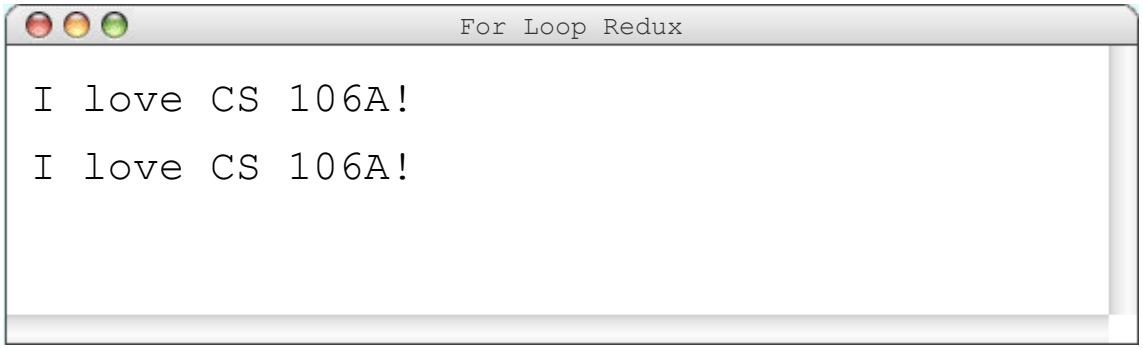


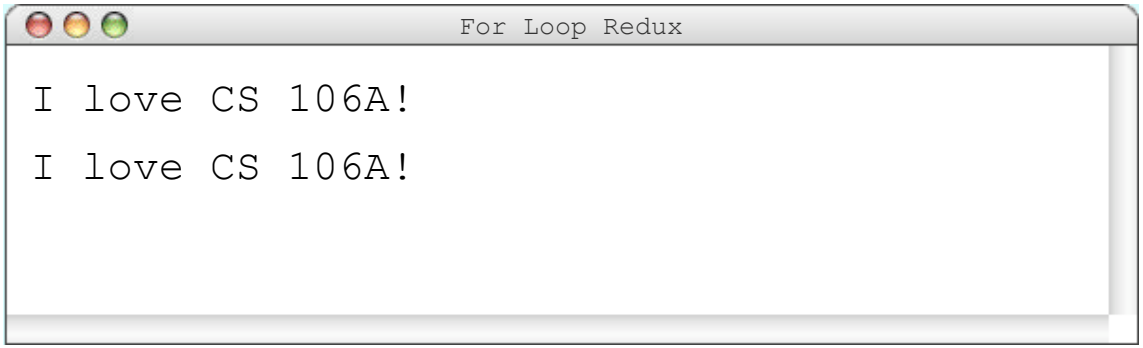

```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



For Loops in Java

i 2

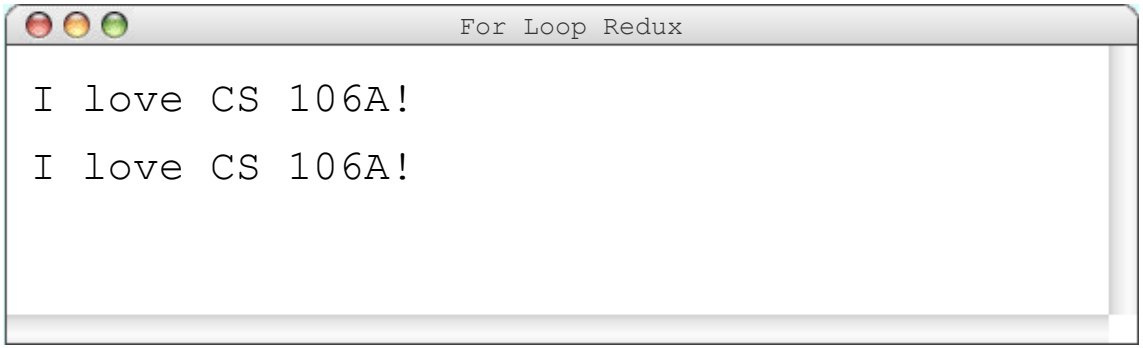
```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



For Loops in Java

i	2

```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



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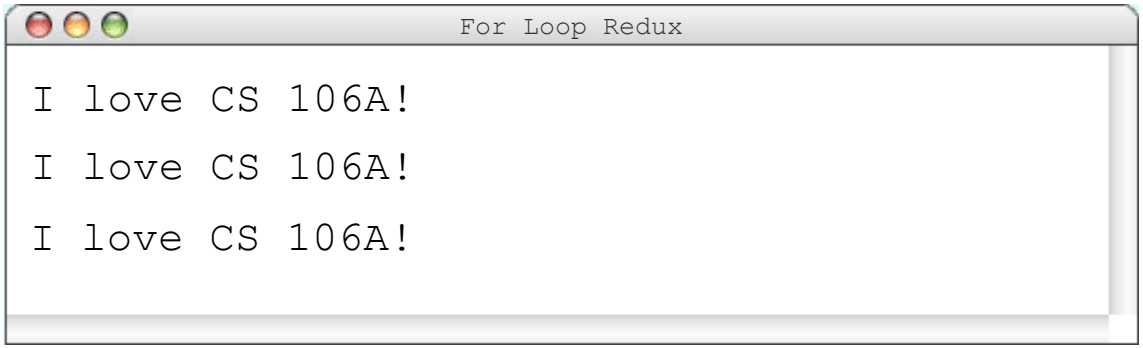
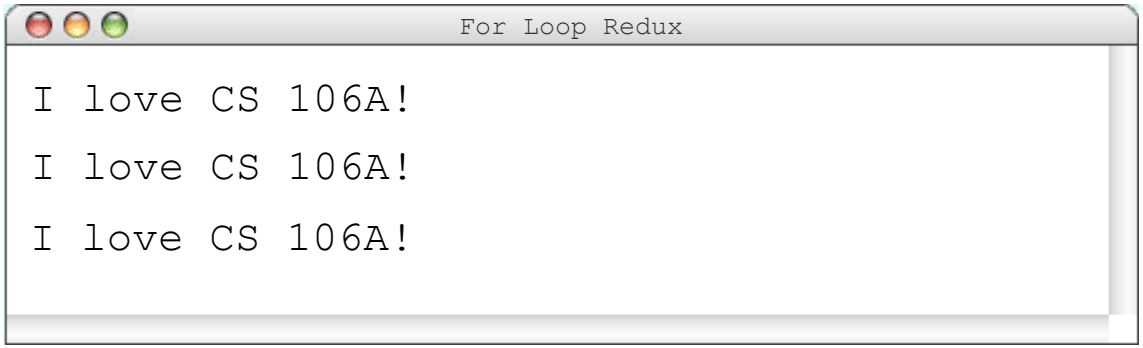
}
```



For Loops in Java

i 3

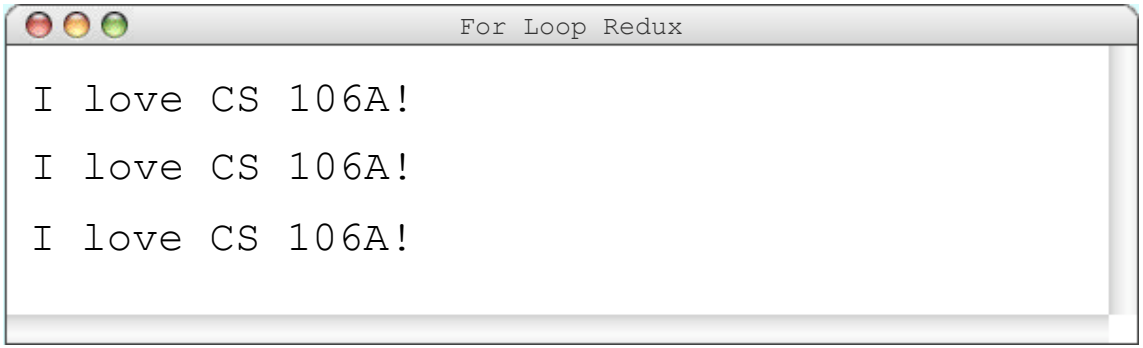
```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



For Loops in Java

i	3

```
for (int i = 0; i < 3; i++) {
    println("I love CS 106A!");
}
```



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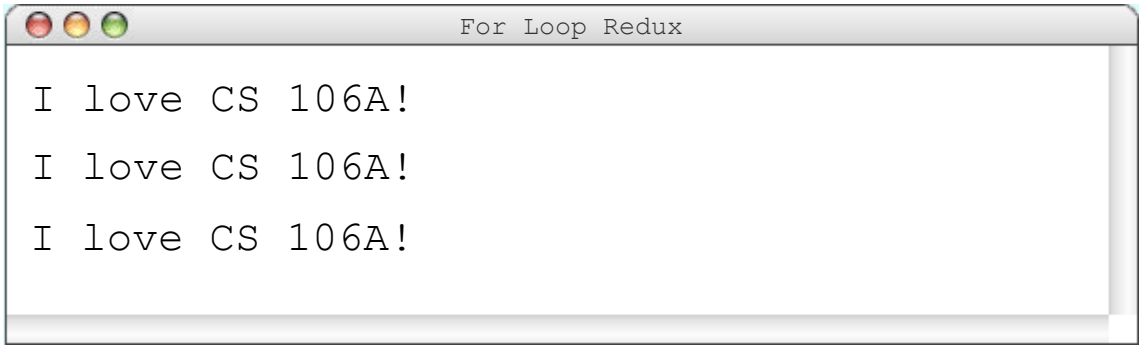

For Loops in Java

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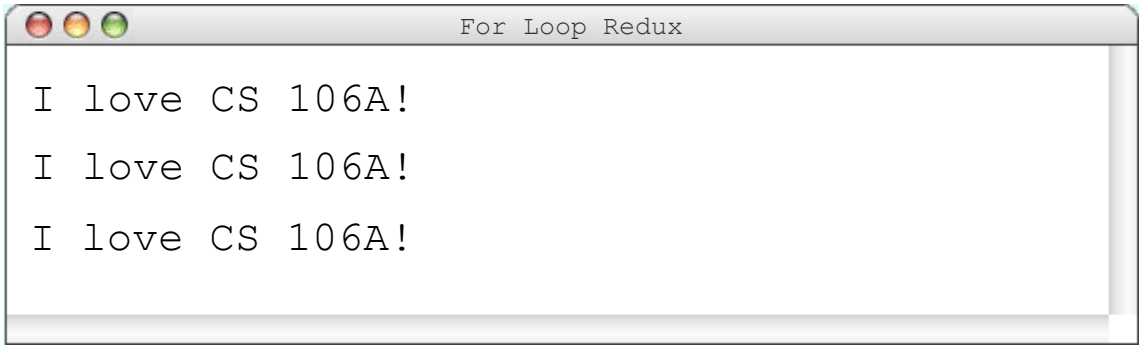


Using the For Loop Variable

```
// prints the first 100 even numbers
for(int i = 0; i < 100; i++) {
    println(i * 2);
}
```

Using the For Loop Variable

```
// Launch countdown
for(int i = 10; i >= 1; i--) {
    println(i * 2);
}
println("Blast off!");
```

Output:

```
10
9
8
…
Blast off!
```

Using the For Loop Variable

```
// Adds up the first 100 numbers
int sum = 0;
for(int i = 0; i < 100; i++) {
     sum += i;
}
println("The sum is " + sum);
```

Nested loops

- **nested loop**: A loop placed inside another loop.

```
for (int i = 1; i <= 5; i++) {
    for (int j = 1; j <= 10; j++) {
        print("*");
    }
    println();   // to end the line
}
```

- Output:

```
**********
**********
**********
**********
**********
```

- The outer loop repeats 5 times; the inner one 10 times.

Nested loop question

- **Q:** What output is produced by the following code?

```
for (int i = 1; i <= 5; i++) {
    for (int j = 1; j <= i; j++) {
        print("*");
    }
    println();
}
```

A.
```
*****
*****
*****
*****
*****
```

B.
```
*****
****
***
**
*
```

C.
```
*
**
***
****
*****
```

D.
```
1
22
333
4444
55555
```

E.
```
12345
```

(How would you modify the code to produce each output above?)

Plan For Today

- Announcements
- Recap: Variables and Expressions
- Aside: Shorthand Operators + Constants
- Revisiting Control Flow
  - If and While
  - For
- Scope

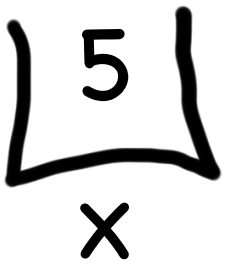
A Variable love story

By Chris Piech

Once upon a time…

...x was looking for love!

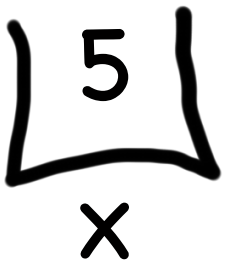
```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```



...x was looking for love!

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

x was definitely looking for love



And met y.

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

And met y.

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

“Wow!”

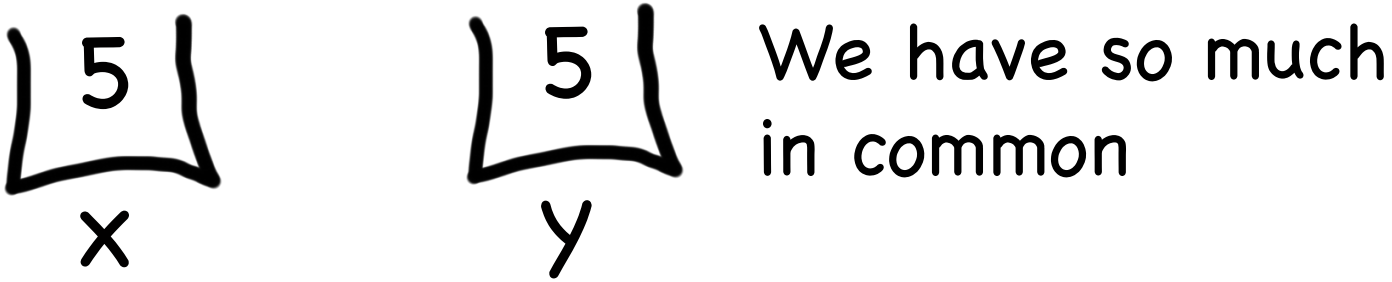
And met y.

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

Wow

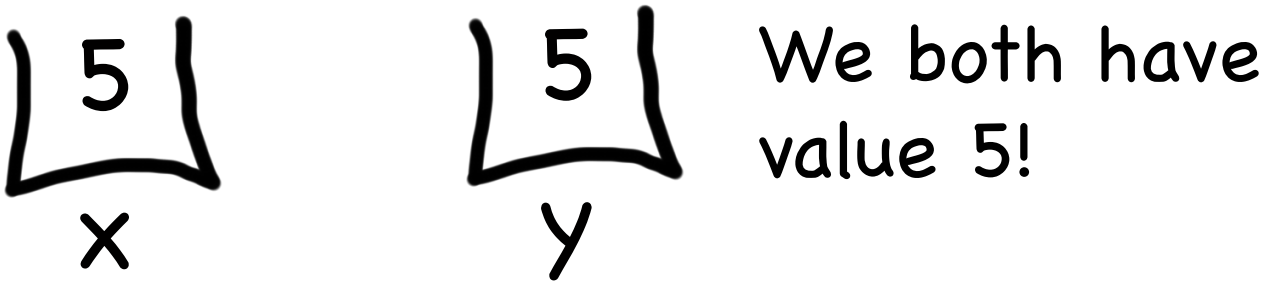
And met y.

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```



And met y.

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

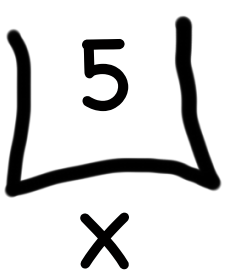


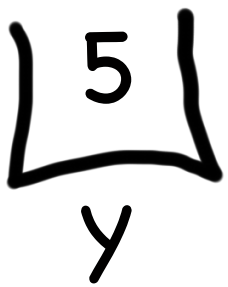
And met y.

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

And met y.

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```





println together?

And met y.

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

It was a beautiful match…

…but then tragedy struck.

Tragedy Strikes

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

Tragedy Strikes

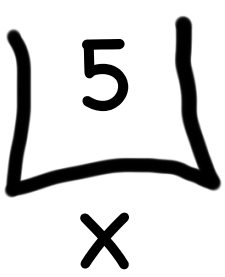
```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

Noooooooooooooooo!

You see…
when a program exits a code block,
all variables declared inside that block go away!

Since y is inside the if-block…

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```



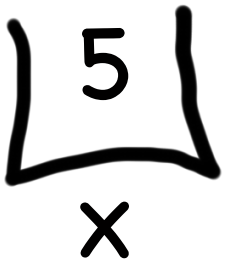
...it goes away here...

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

...and doesn't exist here.

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
}
println(x + y);
```

Error. Undefined variable y.



The End

Sad times ☹

Variable Scope

Variables have a lifetime (called scope):

```
public void run(){
    double v = 8;
    if(condition){
        v = 4;
        … some code
    }
    … some other code
}
```

Variable Scope

Variables have a lifetime (called scope):

```
public void run(){
    double v = 8;
    if(condition){
        v = 4;
        … some code
    }
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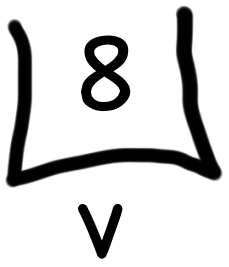
}
```

Variable Scope

Variables have a lifetime (called scope):

```
public void run(){
    double v = 8;
    if(condition){
        v = 4;
        … some code
    }
    … some other code
}
```

Comes to life here

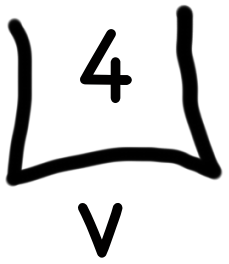


Variable Scope

Variables have a lifetime (called scope):

```
public void run(){
    double v = 8;
    if(condition){
        v = 4;
        … some code
    }
    … some other code
}
```

This is the **inner most** code block in which it was declared….

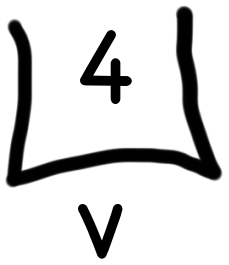


Variable Scope

Variables have a lifetime (called scope):

```
public void run(){
    double v = 8;
    if(condition){
        v = 4;
        … some code
    }
    … some other code
}
```

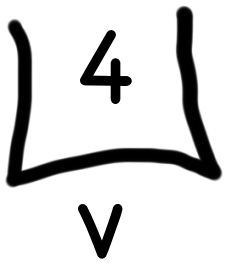
Still alive here…



Variable Scope

Variables have a lifetime (called scope):

```
public void run(){
    double v = 8;
    if(condition){
        v = 4;
        … some code
    }
    … some other code
}
```



It goes away here (at the end of its code block)

Variable Scope

Variables have a lifetime (called scope):

```
public void run(){
    double v = 8;
    if(condition){
        v = 4;
        … some code
    }
    … some other code
}
```

It goes away here (at the end of its code block)

Variable Scope

Variables have a lifetime (called scope):

```
public void run(){
    … some code
    if(condition){
        int w = 4;
        … some code
    }
    … some other code
}
```

This is the scope of **w**

Variable Scope

Variables have a lifetime (called scope):

```
public void run(){
    … some code
    if(condition){
        int w = 4;
        … some code
    }
    … some other code
}
```

w is created here

w goes away here (at the end of its code block)

A Variable love story

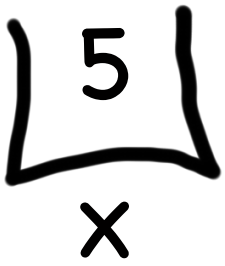
Chapter 2

By Chris

The programmer fixed their bug

...x was looking for love!

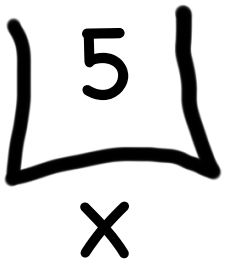
```
int x = 5;
if(lookingForLove()) {
    int y = 5;
    println(x + y);
}
```



...x was looking for love!

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
    println(x + y);
}
```

x was definitely looking for love



And met y.

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
    println(x + y);
}
```

Since they were both "in scope"…

```
int x = 5;
if(lookingForLove()) {
    int y = 5;
    println(x + y);
}
```

…they lived happily ever after.
The end.

Variable Scope

- The **scope** of a variable refers to the section of code where a variable can be accessed.
- **Scope starts** where the variable is declared.
- **Scope ends** at the termination of the code block in which the variable was declared.

- A **code block** is a chunk of code between { } brackets

Recap

- Announcements
- Recap: Variables and Expressions
- Aside: Shorthand Operators + Constants
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Next time: Methods in Java