Lecture 2: Intro to Java

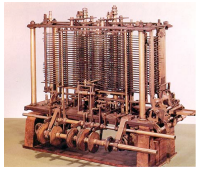
Why Programming?

Idealized computer. "Please simulate the motion of a system of N heavenly bodies, subject to Newton's laws of motion and gravity."

Prepackaged software solutions. Great, if it does exactly what you need.

Computer programming. Art of making a computer do what YOU want.

> "Instead of imagining that our main task is to instruct a computer what to do, let us concentrate rather on explaining to human beings what we want a computer to do." - *Donald Knuth*



Ada Lovelace (left), Analytic Engine (right).

Languages

Machine languages. Tedious and error-prone.

Natural languages. Ambiguous and hard for computer to parse.

- *Police Squad Helps Dog Bite Victim.*
- *Milk Drinkers Turn to Powder.*
- *Kids Make Nutritious Snacks.*
- *Red Tape Holds Up New Bridge.*
- *Tuna Biting Off Coast of Washington.*
- *Local High School Dropouts Cut in Half.*

Reference: Rich Pattis, CMU

High-level programming languages. Acceptable tradeoff.

Why Java?

Java features.

- Widely available.
- Widely used.
- Variety of automatic checks for mistakes in programs.
- Embraces full set of modern abstractions.

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Caveat.

"There are only two kinds of programming languages: those people always [gripe] about and those nobody uses." - *Bjorne Stroustrup*

"I'm one of the few crazies... who believes it's very possible the Internet has been underhyped instead of overhyped... I predict over the next 90 days Java is going to be like a drug you rub over venture capitalists and they go crazy." - *John Doerr*, May 1996

Why Java?

Java features.

- Widely available.
- Widely used.
- Variety of automatic checks for mistakes in programs.
- Embraces full set of modern abstractions.

Caveat. No perfect language.

Our approach.

- Minimal subset of Java.
- Develop general programming skills that are applicable to: C, C++, C#, Python, Matlab, FORTRAN, ...

A Rich Subset of the Java Language

Types	
int	double
long	String
char	

System
System.out.println()
System.out.print()
System.exit()

Math Library	
Math.sin()	Math.cos()
Math.log()	Math.exp()
Math.sqrt()	Math.pow()
Math.min()	Math.max()
Math.abs()	Math.PI

Primitive Numeric Types		
+	-	*
/	%	++
--	>	<
<=	>=	==
<<	>>	|
&	^	!=

Parsing
Integer.parseInt()
Double.parseDouble()
Long.parseLong()

Boolean	
true	false
||	&&
!	==

Punctuation	
{	}
(	)
,	;

Flow Control	
if	else
for	while
do	

String	
+	""
length()	compareTo()
charAt()	

Arrays
a[i]
new
a.length

Objects	
class	static
public	private
toString()	equals()
new	main()

2.1 Hello Java

Programming in Java

Programming in Java.

- Create the program by typing it into a text editor, and save it as `HelloWorld.java`

```
/*****************************************
 * Prints "Hello, World"
 * Everyone's first program.
 *****************************************/

public class HelloWorld {
   public static void main(String[] args) {
      System.out.println("Hello, World");
   }
}
```

HelloWorld.java

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- Create the program by typing it into a text editor, and save it as `HelloWorld.java`
- Compile it by typing at the command line:
  `javac HelloWorld.java`

command prompt

```
% javac HelloWorld.java
```

This creates a Java bytecode file named: `HelloWorld.class`

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  `java HelloWorld`

command prompt

```
% javac HelloWorld.java

% java HelloWorld
Hello, World
```


Hello, World

A few remarks.

- Name of class must match name of file.
- Comments between `/*` and `*/` are ignored by computer.
- Whitespace and indentation is for human readability.
- Syntax coloration auto-generated by editor.

```
/*****************************************
 * Prints "Hello, World"
 * Everyone's first program.
 *****************************************/

public class HelloWorld {
   public static void main(String[] args) {
      System.out.println("Hello, World");
   }
}
```

HelloWorld.java

2.2 Primitive Data Types

```
public class Addition {
   public static void main(String[] args) {
      int a = Integer.parseInt(args[0]);
      int b = Integer.parseInt(args[1]);
      int c = a + b;
      System.out.println(c);
   }
}
```


"Primitive" Data Types

Data type. A set of values and operations on those values.

Data Type	Description	Examples	Common Operations
`char`	character	`'A'` `'@'`	compare
`String`	sequence of characters	`"Hello World"` `"CS is fun"`	concatenate, compare
`int`	integer	`17` `12345`	add, subtract, multiply, remainder
`double`	floating point number	`3.1415` `2.17`	add, subtract, multiply, divide
`boolean`	truth value	`true` `false`	and, or, not, xor

Text

The `String` data type.

- A sequence of Unicode characters.
- Each character internally stored as a sequence of 16 bits:

0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1

⬅ '1' in Unicode

- Not technically a primitive type, but special language support.

Ex: generate subdivisions of a ruler.

```
public class Ruler {
   public static void main(String[] args) {
      String ruler1 = "1 ";
      String ruler2 = ruler1 + "2 " + ruler1;
      String ruler3 = ruler2 + "3 " + ruler2;
      String ruler4 = ruler3 + "4 " + ruler3;
      String ruler5 = ruler4 + "5 " + ruler4;
      System.out.println(ruler5);
   }
}
```

⬆ string concatenation

```
1
1 2 1
1 2 1 3 1 2 1
```


Ruler

```
% javac Ruler.java

% java Ruler
1 2 1 3 1 2 1 4 1 2 1 3 1 2 1 5 1 2 1 3 1 2 1 4 1 2 1 3 1 2 1
```

Integers

The `int` data type.

- Set of values: integers between -2^{31} and $2^{31} - 1$, i.e. `-2147483648` and `2147483647`.
- Internally stored as a sequence of 32 bits:

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0

14_{10}

- Useful when expressing algorithms.

```
public class IntOps {
   public static void main(String[] args) {
      int a    = 1234;
      int b    = 99;
      int sum  = a + b;    1333
      int prod = a * b;    122166
      int quot = a / b;    12
      int rem  = a % b;    46
   }
}
                  1234 = 12*99 + 46
```


Initializing Variables

What happens if I forget to initialize the variable `a` or `b`?

- Java compiler does not allow this.
- Caveat: in other languages, variable initialized to arbitrary value.

Q. What is default value for Registrar's room assignment variables?

Initializing Variables

What happens if I forget to initialize the variable `a` or `b`?

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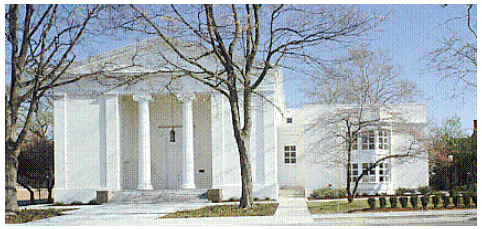
Q. What is default value for Registrar's room assignment variables?

A. 61 Nassau Street.



Nassau Presbyterian Church

Floating Point Numbers

The `double` data type.

- Represents floating point numbers.
- Internally stored as a sequence of 64 bits using scientific notation.
- Useful in scientific applications.
- Ex: solve quadratic equation $x^2 + bx + c = 0$.

$$\text{roots} = \frac{-b \pm \sqrt{b^2 - 4c}}{2}$$

```
public class Quadratic {
   public static void main(String[] args) {
      double b = Double.parseDouble(args[0]);
      double c = Double.parseDouble(args[1]);

      double sqroot = Math.sqrt(b*b - 4.0*c);
      double root1 = (-b + sqroot) / 2.0;
      double root2 = (-b - sqroot) / 2.0;

      System.out.println(root1);
      System.out.println(root2);
   }
}
```

read coefficients from command line

calculate roots

print them out

Command Line Arguments

Command line arguments.

- Simple method for processing a small amount of user input.

```
% java Quadratic -3.0 2.0
2.0                          <- command line arguments
1.0

% java Quadratic -1.0 -1.0
1.618033988749895  <- golden ratio
-0.6180339887498949

% java Quadratic 1.0 1.0
NaN  <- not a number
NaN

% java Quadratic 1.0 hello
java.lang.NumberFormatException: hello

% java Quadratic 1.0
java.lang.ArrayIndexOutOfBoundsException
```

$x^2 - 3x + 2$

$x^2 - x - 1$

$x^2 + x + 1$

Booleans and Comparisons

The `boolean` data type.

- Set of values: `true` or `false`.
- Internally represented as one bit.
- Useful to control logic and flow of a program.

false → 0, true → 1

Logical Operators

a	b	a && b	a || b
false	false	false	false
false	true	false	true
true	false	false	true
true	true	true	true

a	! a
false	true
true	false

Comparison Operators

op	Description	true	false
==	equal	2 == 2	2 == 3
!=	not equal	2 != 3	2 != 2
<	less	2 < 3	3 < 2
<=	less or equal	2 <= 3	3 <= 2
>	greater	3 > 2	2 > 3
>=	greater or equal	3 >= 3	2 >= 3

Booleans and Comparisons

Q. Is a year a leap year?

A. Yes if divisible by 400, or divisible by 4 but not 100.

```
public class LeapYear {
   public static void main(String[] args) {
      int year = Integer.parseInt(args[0]);
      boolean isLeapYear;

      // divisible by 4 but not 100
      isLeapYear = (year % 4 == 0) && (year % 100 != 0);

      // or divisible by 400
      isLeapYear = isLeapYear || (year % 400 == 0);

      System.out.println(isLeapYear);
   }
}
```

```
% java LeapYear 2004
true
% java LeapYear 1900
false
% java LeapYear 2000
true
```


Type Conversion

Type conversion: convert from one type of data to another.

- Automatic: no loss of precision; or with Strings.
- Explicit: cast; or method.

Ex: generate a pseudo-random number between 0 and N-1.

- `Math.random` outputs a `double` between 0.0 and 1.0.

```
public class RandomInteger {
   public static void main(String[] args) {
      int N = Integer.parseInt(args[0]);
      double r = Math.random();
      int n = (int) (r * N);
      System.out.println("random integer is: " + n);
   }
}
```

String to int (method)

double to int (cast)

int to double (automatic)

int to String (automatic)

Summary

A data type is a set of values and operations on those values.

- `String`: text processing.
- `double`, `int`: mathematical calculator.
- `boolean`: basis for decision making.

Be aware.

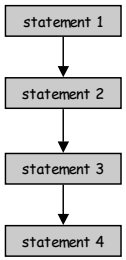
- Declare type of values.
- Convert between types when necessary.

2.3 Flow Control

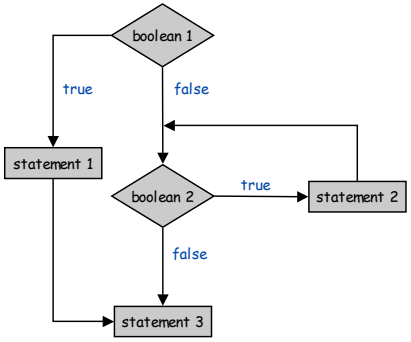
Flow-Of-Control

Flow-of-control.

- Sequence of statements that are actually executed in a program.
- Conditionals and loops: enable us to harness power of the computer.



straight-line flow-of-control



flow-of-control with conditionals and loops

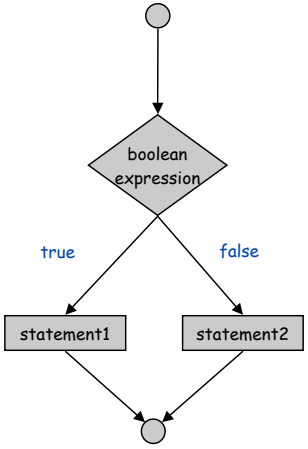
If-Else

The `if-else` statement is a common branching structure.

- Check boolean condition.
- If true, execute some statements.
- Otherwise, execute other statements.

```
if (boolean expression)
   statement1
                        can be a block
else                    of statements
   statement2
```

if-else syntax



if-else flow chart

If-Else: Leap Year

If-else example: print informative text.

- Different operation is performed depending on value of variable.
  - if `isLeapYear` is `true`, then print `" is a "`
  - otherwise, print `" isn't a "`

```
System.out.print(year);

if (isLeapYear) {
   System.out.print(" is a ");
}
else {
   System.out.print(" isn't a ");
}

System.out.println("leap year");
```


Oblivious Sorting

Read in 3 integers and rearrange ascending order.

```
public class Sort3 {
   public static void main(String[] args) {

      int A = Integer.parseInt(args[0]);
      int B = Integer.parseInt(args[1]);
      int C = Integer.parseInt(args[2]);

      if (B < A) { int t = B; B = A; A = t; }
      if (C < B) { int t = C; C = B; B = t; }
      if (B < A) { int t = B; B = A; A = t; }

      System.out.println(A + " " + B + " " + C);
   }
}
```

read in 3 integers

swap A and B

```
% java Sort3 9 8 7
7 8 9

% java Sort3 2 1 7
1 2 7
```

Puzzle 1: sort 4 integers with 5 compare-exchanges.

Puzzle 2: sort 6 integers with 12.