Computer Programming in Java
Bush School *CPJava Fall 2023*

Welcome to CPJava!

Dru & not Gru!

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Introductions!

1. State your name - how would you like to be addressed?
2. Your personal pronoun?
3. What are your hobbies?
4. Say something interesting or peculiar about yourself
5. Do you have any exposure to programming?
6. What made you choose this course?
7. What are your expectations from this course?
8.

A unique first course in programming with some advanced topics!

1. Visual and Project-based learning
2. Computing and the Web
3. Programming using Java
4. Simulate Natural Systems
5. Develop Games
6. Learn Math & Physics Concepts
7. Machine Learning (as time permits)
8. AP Exam preparation (optional)

Course Requirements

1. The CPJava course does not require you to have prior programming experience
2. Prerequisites include Algebra 1
3. For students wanting to take the APCS A exam there will some extra assignments that will need to complete. They will not need to do a Final Project.
4. Students not taking the APCS A will complete a Final Project

Expectations of Learning

- Advanced Java Programming
- Object Oriented including inheritance
- How to make and maintain your own website
- Some basic HTML & CSS
- How to use GitHub
- Searching and sorting
- Recursion
- Robust code design and style
- APCS A topics
- Code Vectors, Newton’s Laws, Machine Learning etc
- + Fun stuff like Asteroids, Super Mario Games and Computer Art that they don't teach you in college!

CPJava course is online!

- The complete 1-year coursework is online!
- We'll start at the top and work our way to the bottom through this course

You are here! Click here to access.
Bookmark this
You will need it every day!

Course Schedule

LESSON UNITS	APPROXIMATE DURATION	TOPICS
FALL 2023 SEMESTER	**12-Weeks**	**Sep 2023 to Jan 2024**
Unit 1	2-Weeks	Introduction to Java, Tools walkthrough, Classroom processes, Environment setup, Java Primitive types and Operators
Unit 2	2-Weeks	Objects, Methods, String, Pointers, Integer, Double, Math
Unit 3	2-Weeks	Control flow, Booleans, If statements, Object traversals, Integer, Double, Math
Unit 4	3-Weeks	Iteration, While loops, For loops, Nested Loops, Loop Analysis
Unit 5	3-Weeks	Anatomy of a class, Constructor, Accessor, Mutator Methods, this keyword
SPRING 2024 SEMESTER	**15-Weeks**	**Jan to June 2024**
Unit 6	2-Weeks	Arrays, Array Traversal, Data Structures, Project work
Unit 7	3-Weeks	Array List, Big data, Ethics of Data Collection, Privacy
Unit 8	2-Weeks	String, substring, Wrapper Classes, 2D Arrays, Table representations
Unit 9	3-Weeks	Inheritance, Encapsulation, Hierarchy, Polymorphism, Multi-part Project
Unit 10	3-Weeks	Recursion, Recursive Search. Recursive Sort
Unit 11	2-Weeks	Final Project Peer Sharing Final Project Presentation or APCSA Exam

A complete Syllabus is available at the CPJava Course website

Grading Policy

Points are assigned for:

Completing Classwork Exercises
Submitting Projects
Professionalism & Integrity

APCSA exam is on May 8th 2024
Talk to me if you are going to take it!

Grades

Grades are assessed each Semester

50% Projects

(Includes Final Project or APCSA Exam)

35% Classwork/Assignments

15% Student Portfolio

Details are available
at the CPJava Course website

How to succeed

Simply write lots of of Java code

Publish your work to the web (Github)

You cannot learn programming by reading or watching!

Make lots of mistakes - truly the best way to learn to code!

Working cooperatively with your peers - Pair Programming!

Don’t be afraid to try new things!

Professionalism

- How you conduct yourself during your work
- Includes (but not limited to)
  - Classroom etiquette
  - Reliability and accountability
  - Ethics
  - Working cooperatively with your peers

Office Hours and Class Assistance

- Conference Hours in Wis 207
  - Refer to Portal
- Class Assistance
  - Wyatt Thelan is the TA for this class!

Tools/Resources for CPJava

CPJava website - Lesson Plans and Projects

Bush Portal - Course Syllabus, Schedule and Grades

CPJava Google Classroom - You should have received an invitation

CPJava Slack - You should have received an invitation

Applications for Laptop

- Github, Processing, Visual Code
- See Instructions in Google Classroom

CSAwesome Online

- Online Textbook, Lessons, Exercises, Detailed Reference

System Requirements

A laptop Computer - Mac or Windows (Chromebook may not be adequate)

Sufficient disk space, a functioning laptop battery fully charged!

Functioning Camera and Microphone - especially required for Paired Programming

Let’s run our first Java Program!

Bubbles - click to run the program

You can sort by color (key ’s’) and freeze each bubble by clicking on it

Can you freeze all the bubbles?

You will develop visual code like this in Java and much more!

Let’s modify our first Java Program!

Access and complete the First Hello and Sticks Google Classroom Assignment during class!

Java Basics
Unit 0

Unit 0-A

The common building blocks in programming languages are:

Variables
Loops
if statements
Functions (aka “methods”)

Over the next two weeks we’ll go over how these work in Java

A basic Java Hello program

- Click on the link to the "Four 4s Challenge" of just go to CP Java Website
- It might look complicated at first, but . . .

A basic Java program

- It turns out that this line is much more important than the others
- So in subsequent slides we can ignore everything except the code statements circled in green - Practice in Processing editor!

A basic Java program in Processing

- Ingnore any references to Trinket in the subsequent slides. Instead we will use Processing. It's Much easier!

Statements

- The circled code is an example of a *statement*
- It's like an English sentence
- A semi-colon marks the end of a Java statement

DO THIS —-->

NOT THIS

String

- **"Hello You!"** is a Java **String**
- A **String** is a collection of letters, digits, punctuation and/or spaces
- The beginning and end of the **String** are marked with double quotes (")

`print()` VS `println()`

- `System.out.println()` prints first and then goes to the next line

TopBottom.java

```
1  public class TopBottom
2  {
3    public static void main(String[] args)
4    {
5      System.out.println("Top");
6      System.out.println("Bottom");
7    }
8  }
9
```

Result

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```
Top
Bottom
```

`print()` vs `println()`

- `System.out.print()` prints, but it does NOT go to the next line
- If we change the first statement to `System.out.print()` `"Bottom"` is printed on the same line as `"Top"`

Comments

- Comments have no effect on the execution of the program, but they make it easier for other programmers (and your future self) to understand what you meant to do

Hello.java

```
1  public class Hello {
2
3      public static void main(String[] args) {
4          // generate some simple output
5          System.out.println("Hello, World!");
6      }
7  }
```

Escape Sequences

- Special characters
- In Java, Escape Sequences begin with a backslash \
- *A good way to remember the difference between a backslash and a forward slash is that a backslash leans backwards (\ ), while a forward slash leans forward (/)*

Common Java Escape Sequences

- `\n` Insert a newline in the text at this point

Common Java Escape Sequences

- `\t` Insert a tab in the text at this point

Common Java Escape Sequences

- `\'` Insert a single quote character
- `\"` Insert a double quote character
- `\\` Insert a backslash character

Debugging

- Errors in programs are called “bugs”
- The process of fixing program errors is called “debugging”
- It’s good to work around other programmers when you are learning a new programming language
- Asking for help with debugging is a part of learning

Errors

- When you write Java programs you will often get an error message
- When you are learning a new programming language, errors are a fact of life
- Errors are ok, just fix them and move on

Syntax error

- In this case I made a *syntax* error
- *Syntax* is the grammar and spelling of a computer language
- Here I forgot the double quotes around my name

Java beta Run Co

Hello.java

```
1 public class Hello {
2
3     public static void main(String[] args) {
4         System.out.print("Hello, my name is ");
5         System.out.println(Art)
6     }
7 }
```

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```
Hello.java:5: error: cannot find symbo
        System.out.println(Art);
                           ^
  symbol:   variable Art
  location: class Hello
1 error
```

Logic error

- This time I misspelled my name
- The computer doesn't know my name, so the program runs incorrectly without an error message

Java beta Run

Hello.java

```
1 public class Hello {
2
3     public static void main(String[] args) {
4         System.out.print("Hello, my name is ");
5         System.out.println("Arg")
6     }
7 }
```

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```
Hello, my name is Arg
```

(Run time) Exceptions

- Sometimes a logic error crashes the computer and stops the running program
- Here I made the logic error of dividing by zero

Java beta Run Copy

Hello.java

```
1 public class Hello {
2
3     public static void main(String[] args) {
4         // generate some simple output
5         System.out.println(1/0);
6     }
7 }
```

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```
Exception in thread "main"
java.lang.ArithmeticException: / by zero
        at Hello.main(Hello.java:5)
```

Arithmetic in Java

+ - * /

- Addition
- Subtraction
- Multiplication
- Division

Literals vs. Expressions

- Double quotes around text tells Java it is an expression
- Java will **`print`** an expression exactly as written

Literals vs. Expressions

- Here's an expression **`"4/4"`**
- Java **`prints`** it in exactly the same form

Java beta Run

Hello.java

```
1  public class Hello {
2
3      public static void main(String[] args) {
4          System.out.println("4/4");
5          System.out.println(4/4);
6      }
7  }
```

Powered

```
4/4
1
```

Literals vs. Expressions

- Here's an expression `4 / 4`
- Java evaluates it to get an answer 1
- And then **`print`**s it

Java beta Run

Hello.java

```
1  public class Hello {
2
3      public static void main(String[] args) {
4          System.out.println("4/4");
5          System.out.println(4/4);
6      }
7  }
```

Powered

```
4/4
1
```

Four 4s challenge

- Use exactly four **4**'s to write an expression that evaluates to every integer from 1 to 10, using only + − * / and ( )
- No decimals, factorials, square roots, exponents, etc.

Four 4s challenge

- Print 10 expressions that use arithmetic and four 4s that evaluate to 1 through 10
- Here's one way to do the first

Four 4s challenge

- Here's another way to do the first
- If you have extra time, try to get 11, 12, 13, etc.

Unit 0-B

Java Functions and Parameters

Functions ("methods")

- Organize code just like paragraphs organize writing
- Functions should do just one job or task
- Functions in Java are identified with parenthesis
- The parenthesis may or may not have something inside called an argument

```
System.out.println("Hello World");
in.nextInt();
```

argument

no argument

Functions can be used for an *effect* and/or *value*

- **`System.out.println()`** has an *effect,* it causes something to be displayed
- **`in.nextInt()`** is used to get the ***value*** of what the user typed
- Other functions that we will learn about in a couple days can be used to calculate mathematical ***value***s

void functions (aka methods)

- You can *define* (create) your own functions that are used for effect with the Java keyword **void**
- **Practice in Processing ignoring only the crossed out items! See next 2 slides**

Java beta Run

NewLine.java

```
1  public class NewLine {
2
3      public static void blah() {
4          System.out.println("blah, blah, blah");
5      }
6
7      public static void main(String[] args) {
8          blah();
9      }
10 }
```

Powered by trinket

```
blah, blah, blah
```

void functions (aka methods)

- It should look like this!
- **Follow same pattern for subsequent slides**

sketch_220913a | Processing 4.0b4

Java

sketch_220913a

```
void blah() {
  System.out.println("blah, blah, blah");
}

void setup() {
  blah();
}

void draw() {
}
```

This is a function or method

This setup() function calls the blah() function

The draw() function is doing nothing now

What is you moved the call for the blah() function from the setup() function() to the draw() function ??

```
blah, blah, blah
```

`void` functions (aka methods)

- Functions are like paragraphs of computer code
- Every Java program has a **`main`** function. There can be many other functions
- More on this later. For now we will use processing which does not need the main() function. Processing version of this code side-be-side

Function blah()

main()

No main() needed in processing!

`void` functions (aka methods)

- You can ***call*** (use) your function by typing its name without **`void`**

`void` functions (aka methods)

- Note that the order the functions are *defined* is unimportant
- Java always runs the **`main`** function first

`void` functions (aka methods)

- The order of the function *calls* is important
- Functions can be reused as many times as you want

sketch_220914a

```
  blah();
  boring();
  blah();
}
void blah() {
  System.out.println("blah, blah, blah");
}
void boring() {
  System.out.println("boooooring ...");
}
```

```
blah, blah, blah
boooooring ...
blah, blah, blah
```

- Variable declarations in the parenthesis of the function definition are called *parameters*
- The function call has matching *arguments*
- The values in variables **h** & **m** are copied into variables **hour** & **minute**

Arguments must match Parameters in number, order and type

- What's the problem?
- Order, the parameters are `int String` order but the arguments are in `String int` order

some_function

```
1  void someFunction(int num, String word) {
2    System.out.println(num + ", " + word);
3  }
4
5  void setup() {
6    int n = 1;
7    String w = "one";
8    someFunction(w, n);
9  }
10
11 void draw() {
12 }
13
```

The function "someFunction()" expects parameters like: "someFunction(int, String)"

Variables can only be used int the function where they are declared

- What's the problem?
- **n** and **w** were declared in the **main** function and are not available in **someFunction**

Now the program is correct

- The arguments match the parameters in number order and type
- The correct variables are used in each function

some_function

```
1  void someFunction(int num, String word) {
2    System.out.println(num + ", " + word);
3  }
4
5  void setup() {
6    int n = 1;
7    String w = "one";
8    someFunction(n, w);
9  }
10
11 void draw() {
12 }
13
```

Problem Tab

PrintTime Function Assignment

Complete the PrintTime Function Assignment by typing in code below plus your code individually. Submit to slack. Complete the Google Classroom Assignment

print_time

```
1  void printEuropeanTime(int hour, int minute) {
2    // Your Java code
3  }
4
5  void printAmericanTime(int hour, int minute) {
6    // Your Java code
7  }
8
9  void setup() {
10   String dy = "Wednesday";
11   String mn = "September";
12   int dt = 20;
13   int yr = 1961;
14   int h = 7;
15   int m = 35;
16   // Insert Function call to printAmericanTime
17   // Insert Functioncall to printEuropeanTime
18 }
```

Problem	Tab	Line
The value of the parameter hour is not used	print_time	1
The value of the parameter minute is not used	print_time	1
The value of the parameter hour is not used	print_time	5

Console Errors

Unit 0-C
Variables Types and Operators

Unit 0-C

- Variables
- Types
- Declarations
- Initializations
- Comments
- `%` (modulus) and Integer division
- `+` and `String`s

Variables

- Think of a variable as a place to store a value that you will use later
- The value of a variable can ***change*** (think *vary*)
- A Java variable has size limits for its ***type*** (for example, integers are limited to values between -2,147,483,648 and 2,147,483,647)
- Every Java variable has a ***type*** and a ***name***

Variables: Parking space analogy

- Like a parking space, a variable can store a value (think *vehicle*) until you need it later

Variables: Parking space analogy

- Parking spaces are often labeled so you can find your car later when you need it
- Lets say that **`G210`** is the *name* of this parking space

Variables: Parking space analogy

- In addition to a ***name,*** parking spaces can have a ***type*** that sets size limits

What is the error?

- We are trying to print an integer that is too large for Java's integer size

too_large | Processing 4.0b2

Java

too_large

```
1  void setup() {
2    System.out.println(12345678901234567 89);
3  }
4
5  void draw() {
6  }
7
8
9
10
11
12
13
```

The literal 1234567890123456789 of type int is out of range

Problem	Tab	Line
The literal 1234567890123456789 of type int is out of range	too_large	2

Console Errors

Primitive data types

- In Java (unlike Python or JavaScript) variables have ***types***
- Each type has size limits
- For this class, you need to know 5 basic (aka "primitive") types:
  - `int`
  - `float`
  - `double`
  - `boolean`
  - `char`

Primitive data types

- **`int`** holds a single integer value between -2,147,483,648 and 2,147,483,647
- **`float`** a decimal value with up to 7 digits
- **`double`** a decimal value with up to 15 digits
- A **`boolean`** can only hold values that evaluate to either **`true`** or **`false`**
- **`char`** holds a single letter, digit, space or punctuation mark and must be enclosed in *single quotes*, like this: **`'G'`**

float vs. double

- **float** is short for *floating point*, another name for *decimal point*
- **double** gets its name because of its size, it has about twice as many digits as a **float**

sketch_220914e | Processing 4.0b2

Java

sketch_220914e

```
double dNum = 5/9.0;
System.out.println(dNum);
System.out.println((float)dNum);
```

```
0.5555555820465088
0.5555556
```

Console Errors

String variables

- A **String** variable can store text with any number of letters, digits, punctuation marks and spaces
- The beginning and end of the text is marked with double quotes (")

sketch_220914f

```
1  void setup() {
2    String greeting = "Hey, gimme 5!";
3    System.out.println(greeting);
4  }
5
6  void draw() {
7  }
8
9
10
11
12
```

```
Hey, gimme 5!
```

+ and String

- Using + with String isn't addition arithmetic, it's called *concatenation*
- That's a fancy word that means making bigger String out of little ones

sketch_220914f

```
1  void setup() {
2    String greeting = "Hey, gimme 5!";
3    System.out.println(greeting);
4    System.out.println("a" + "123");
5  }
6
7  void draw() {
8  }
9
10
11
12
```

```
Hey, gimme 5!
a123
```

+ and Strings

- Java executes from left to right so, **`1 + 2`** is **`3`**, and **`3 + "Hello"`** is **`"3Hello"`**
- **`"Hello" + 1`** is **`"Hello1"`**, and **`"Hello1"`** + **`2`** is **`"Hello12"`**
- **`What's the output?`**

```
System.out.println(1 + 2 + "Hello");
// the output is [redacted]

System.out.println("Hello" + 1 + 2);
// the output is [redacted]
```

Unique way to make 11 using four 4s

- We could make **11** with four 4s by putting an empty **String** in the middle
- (**String** *concatenation is not allowed in the rules of the four 4s challenge though)*

Run

sketch_220914f

```
1  void setup() {
2    String greeting = "Hey, gimme 5!";
3    System.out.println(greeting);
4    System.out.println("a" + "123");
5    System.out.println(4/4 + "" + 4/4);
6  }
7
8  void draw() {
9  }
10
11
12
```

```
Hey, gimme 5!
a123
11
```

A Java variable declaration

- The Java statement that sets up a variable is called a ***declaration***
- Here's an example declaration

```
int num;
```

- The first word of the declaration is the type
- The second word is the name that the programmer chooses

Variable names and keywords

- You can pretty much choose any name you want for a variable with a few limitations:
  - Variable names cannot
    - start with a number
    - contain a space
    - have a special meaning in Java
- Java has about 50 reserved words or *keywords* that you are not allowed to use as variable names such as **`public`**, **`class`**, **`static`**, **`void`**, **`int`** …

camelCase

- Because a Java variable name can't have spaces, a style called **camelCase** is usually used for variable names with more than one word
- **camelCase** capitalizes the first letter of each word except the first word
- Examples: **`firstName`**, **`numberOfDogs`**
- Java variable names are case-sensitive, so **`firstName`** is not the same as **`firstname`** or **`FirstName`**.

What's the error?

var_init

```
1  int num;
2  System.out.println(num);
3
4
5
6
7
8
9
10
11
12
```

The local variable "num" may not have been initialized

Variable initialization

- After a Java variable is declared, it needs to be *initialized*

var_init

```
1  int num = 5;
2  System.out.println(num);
3
4
5
6
7
8
9
10
11
12
```

Variable initialization

- The English word "initial" means *first*
- We initialize a variable by assigning ("setting it equal to") its *first* value

var_init

```
int num ;

void setup() {
  num = 17;
  System.out.println("num = " + num);
}
```

```
num = 17
```

Declare *and* initialize

- You can declare and initialize a variable with one line of code:

```
int num = 3;
```

- Just remember that the one line of code is doing two different steps: the ***declaration*** and the ***initialization***

Comments

```
//Single Line
/*
Multi
Line
*/
```

- Tells the computer to ignore some text

Used to:

- Write notes to yourself or other programmers
- Temporarily disable code

Kahoot!