

# COMP 1406

## Fall 2022 - Tutorial #1

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### Objectives

- Write, compile and run simple Java programs using the IntelliJ Idea IDE.
  - Practice writing basic Java code
  - Learn how to initialize your own objects with constructors
  - Practice writing instance methods to manipulate objects
  - Writing your own toString() methods
  - Dealing with NullPointerExceptions
- 

### Problem 1 (Getting Started with IntelliJ)

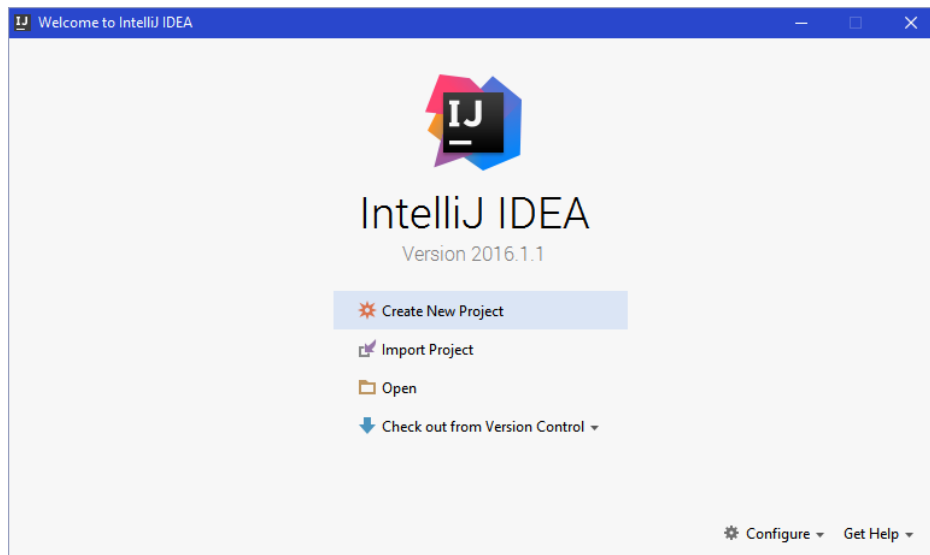


**IntelliJ Idea** is the IDE (Integrated Development Environment) that will be used throughout the course. **IntelliJ Idea Community Edition** is free and is available for Mac OS, Windows and Linux operating systems. You should use it to write all your programs in this course. You will be saving and zipping the project files to hand in for ALL your tutorials and assignments.

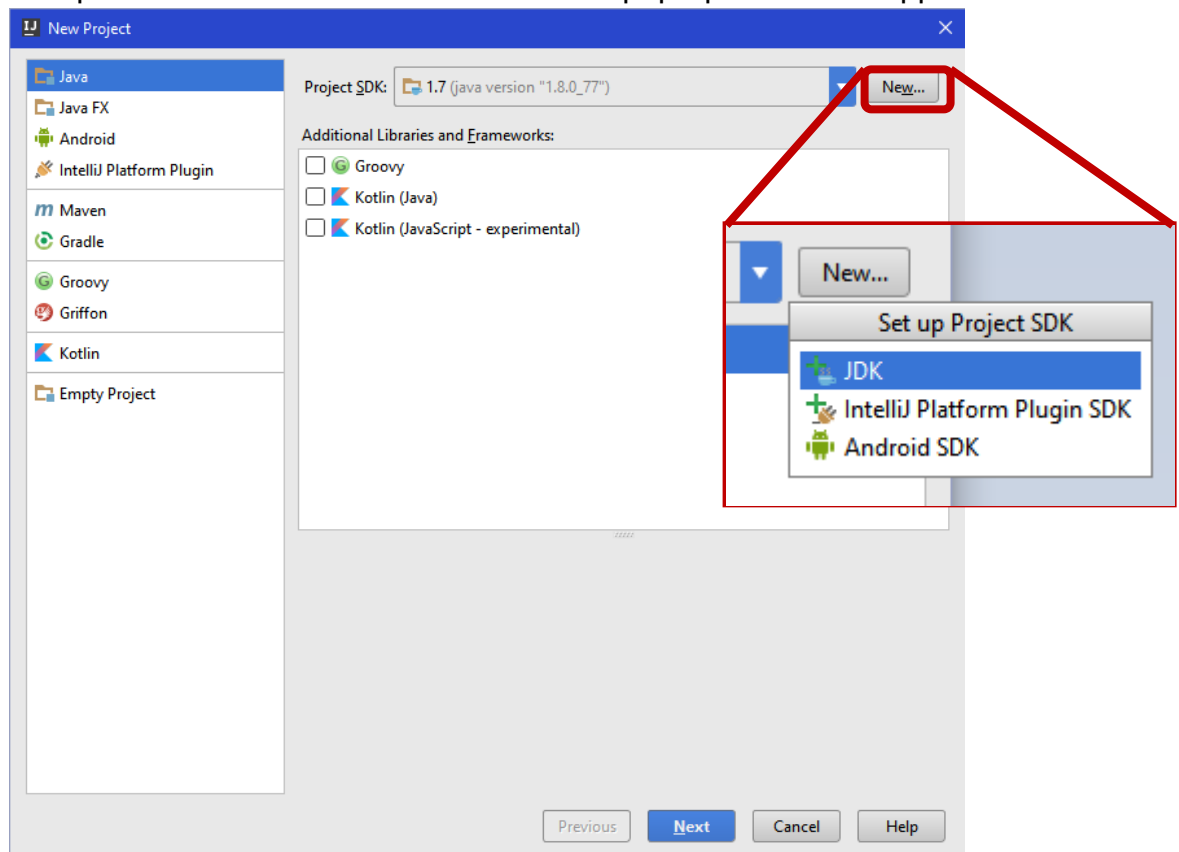
Upon starting the IntelliJ IDE, you should see a window like what is shown here:



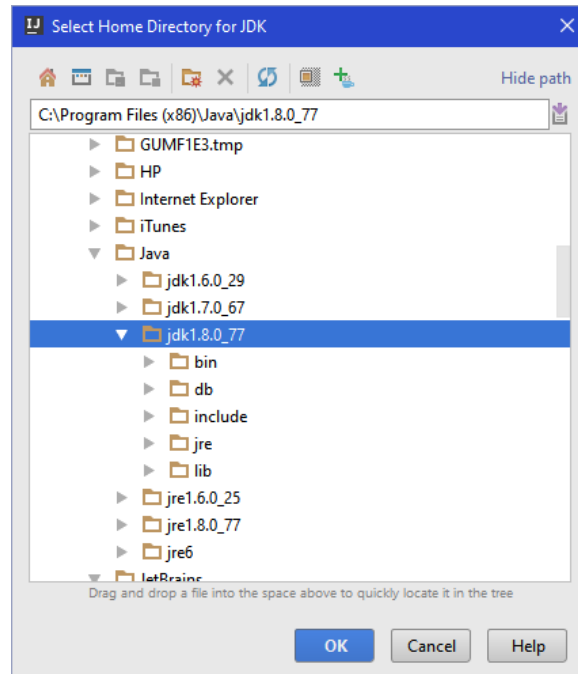
Once IntelliJ has started, you should see the following. Select "New Project" to continue.



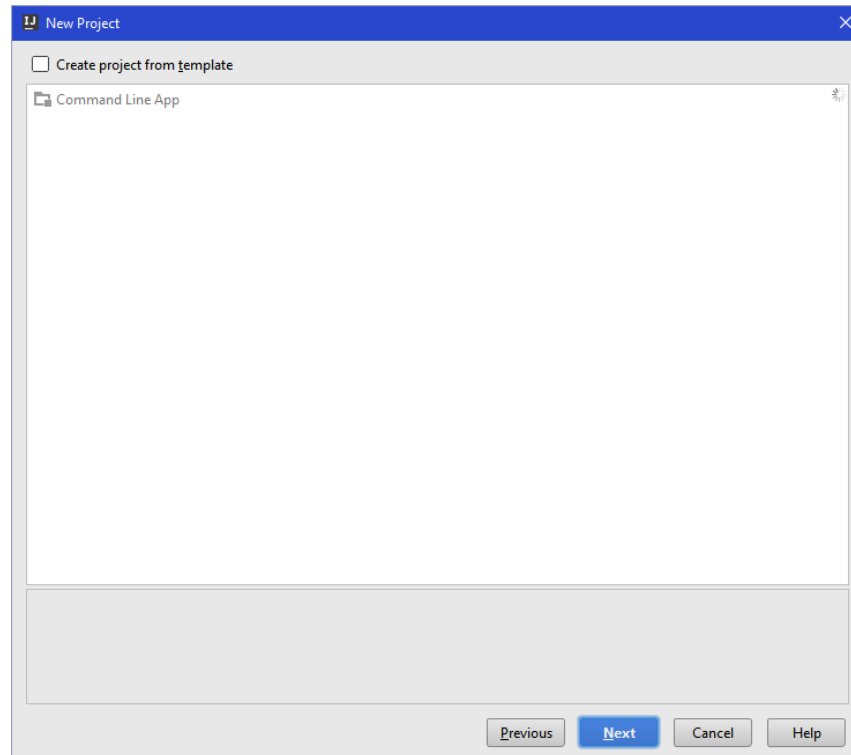
A dialog box will appear. Select **Java** in the left side panel. Then select the **New ...** button at the top of the window and select **JDK** in the pop-up menu that appears:



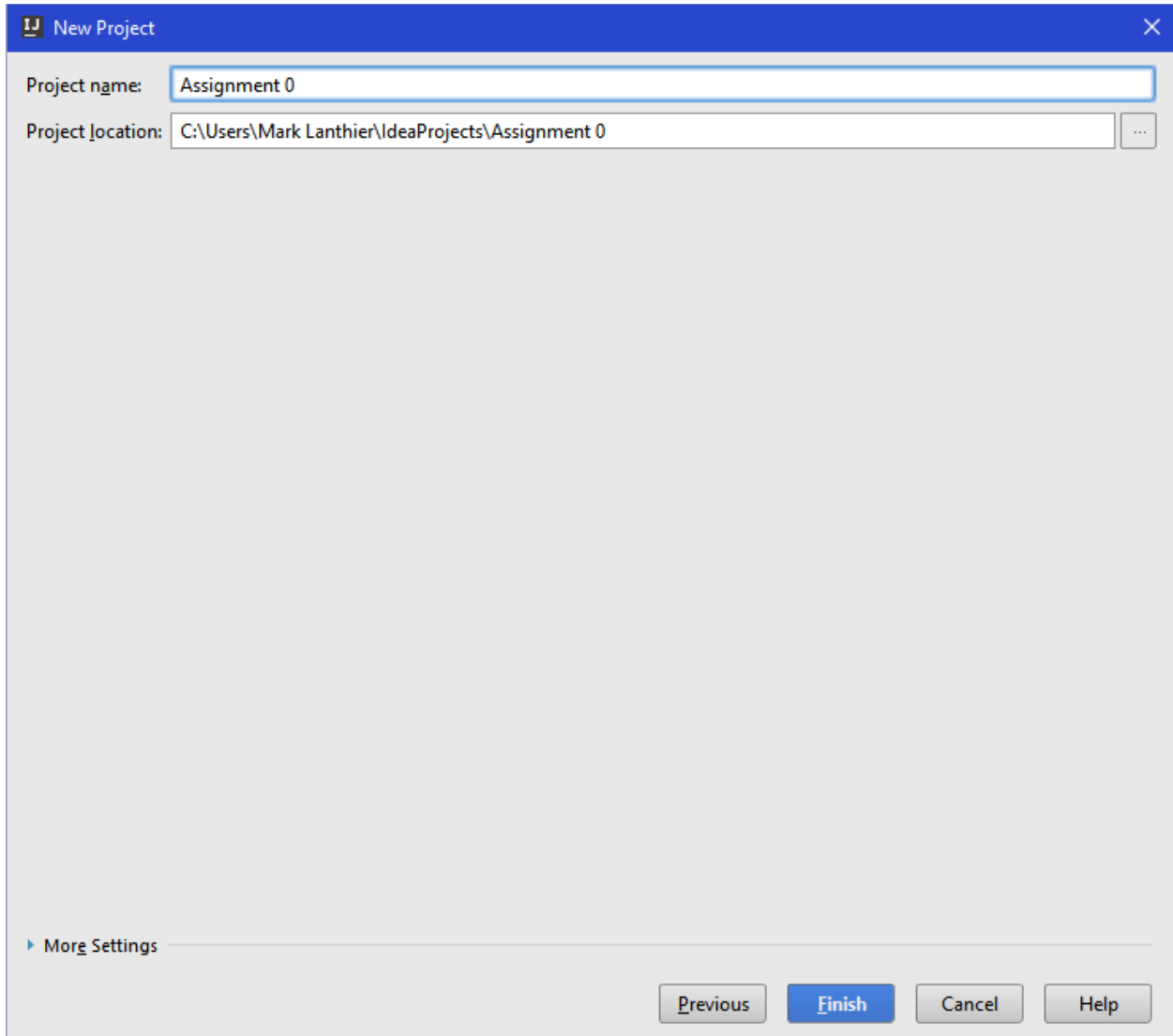
Select the latest JDK installed on your computer, if IntelliJ did not find it automatically, then press OK.



A new window will appear. Just click **Next**.



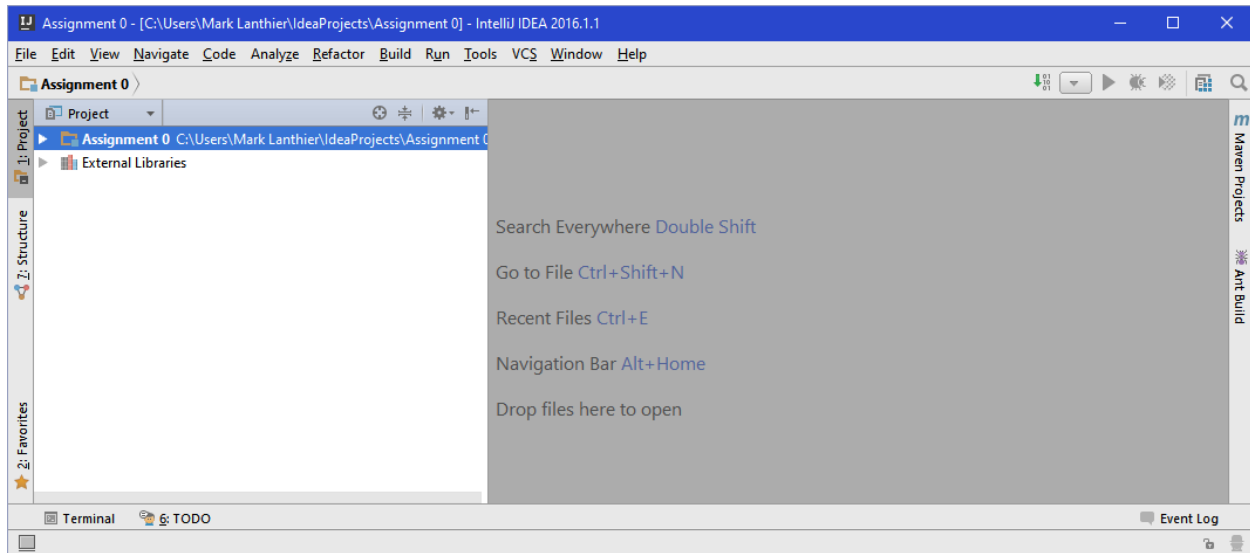
Type in a project name. For this tutorial, you can use the name **Tutorial1** as the Project name and then press **Finish**:



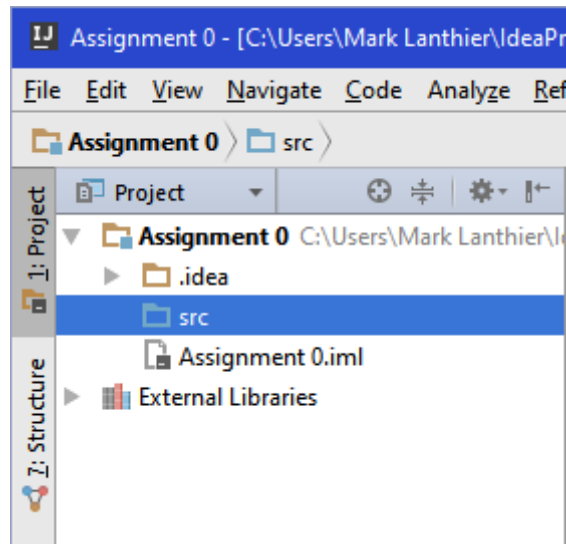
The screenshot shows the 'New Project' dialog box with the following details:

- Project name:** Assignment 0
- Project location:** C:\Users\Mark Lanthier\IdeaProjects\Assignment 0
- Buttons:** Previous, Finish (highlighted in blue), Cancel, Help
- Link:** More Settings

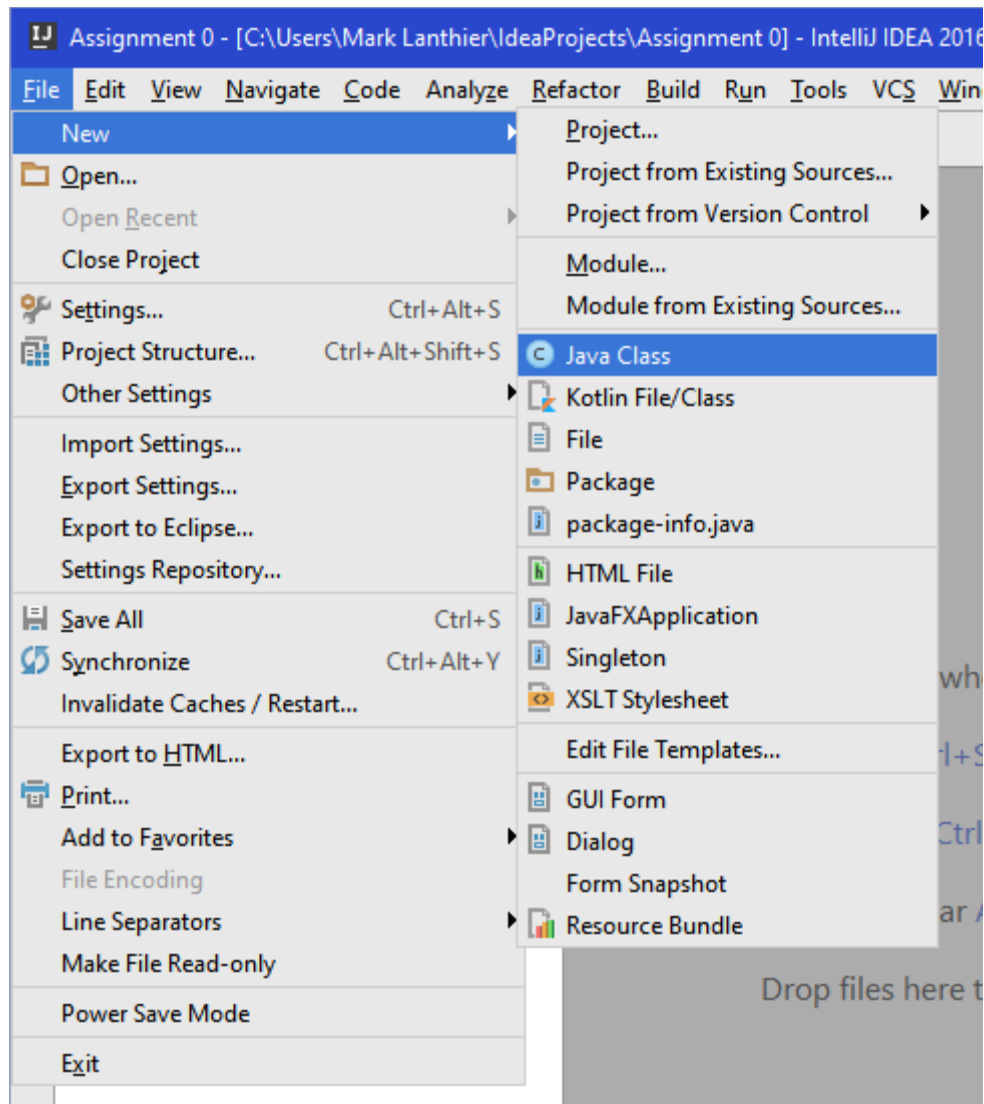
You should see the main workbench window appear, as below.



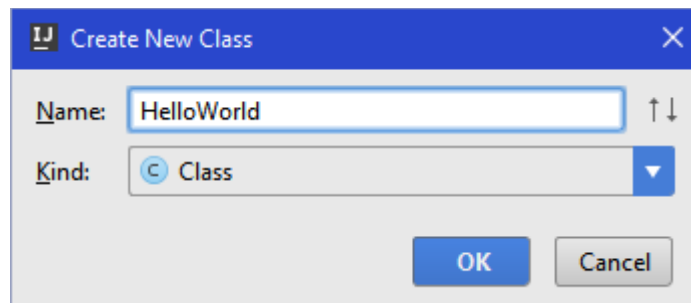
Expand the project by clicking the triangle to the left of the **Tutorial1** project. Then click the **src** folder:



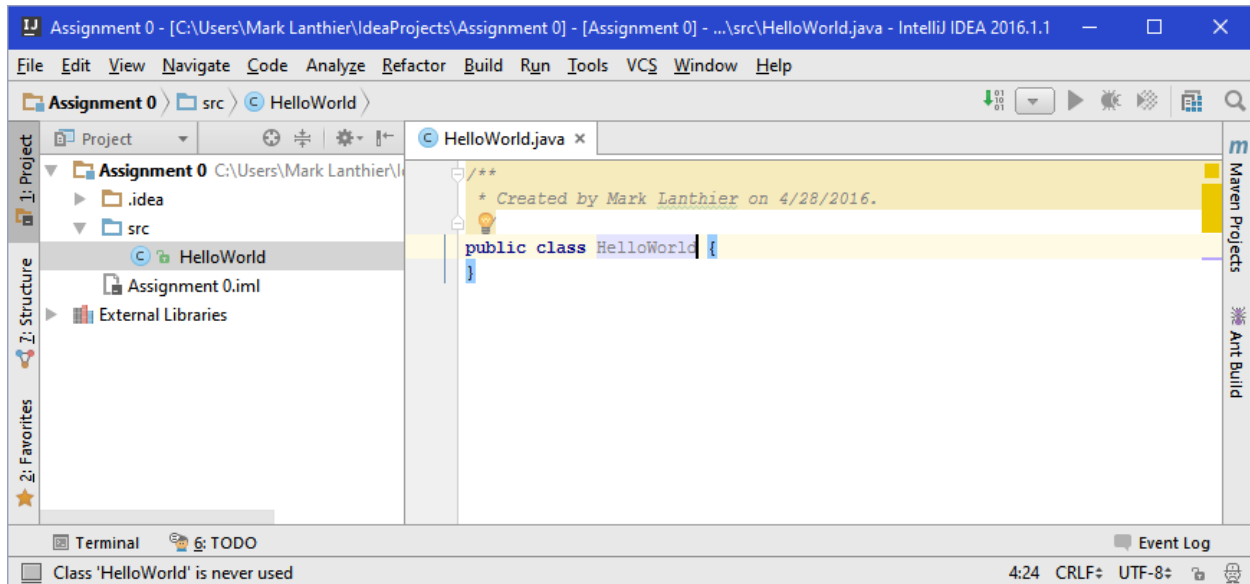
From the **File** menu, select **New** and then **Java Class**.



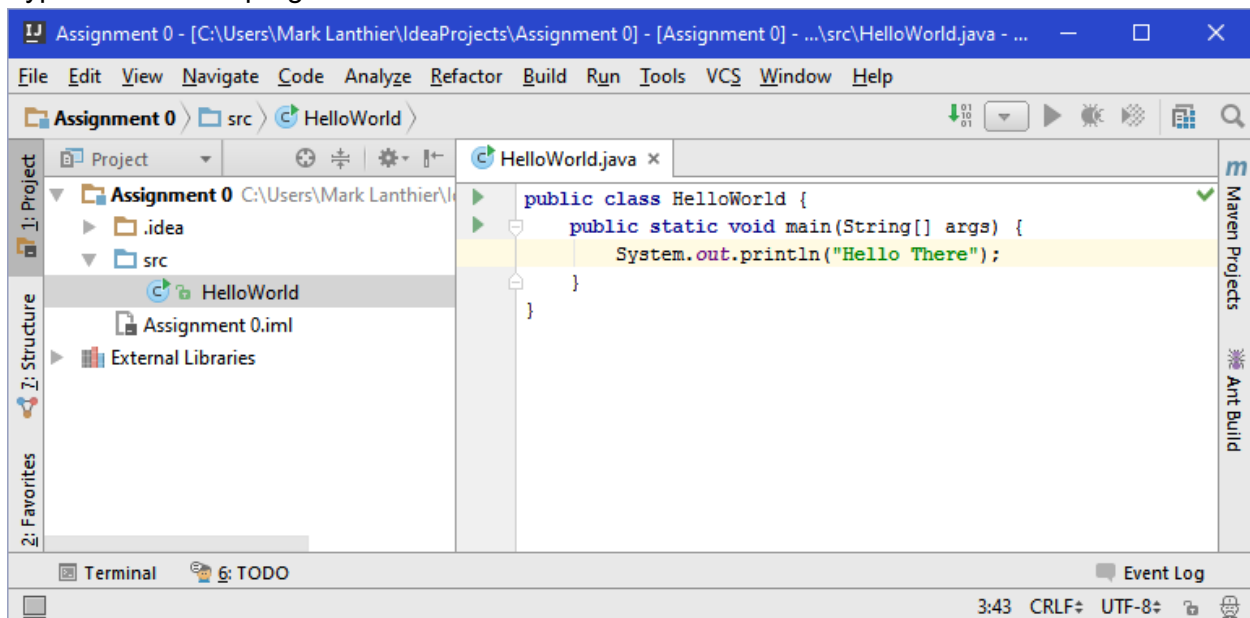
Enter **HelloWorld** as the class name:



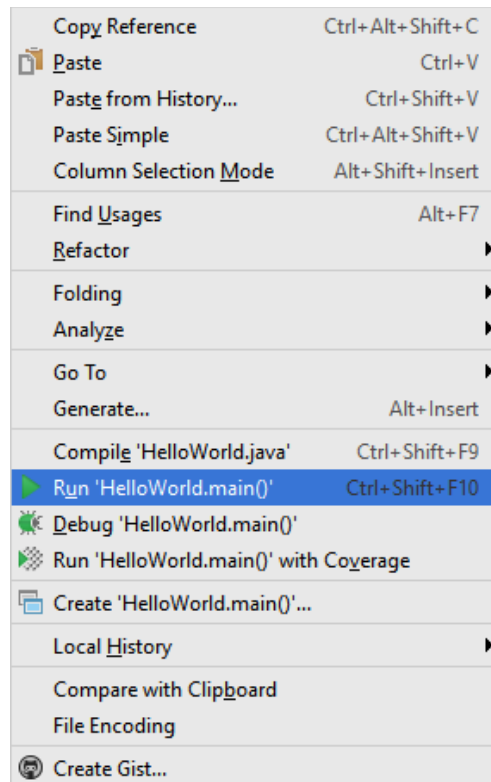
You should see a class template similar to the one in the picture below:



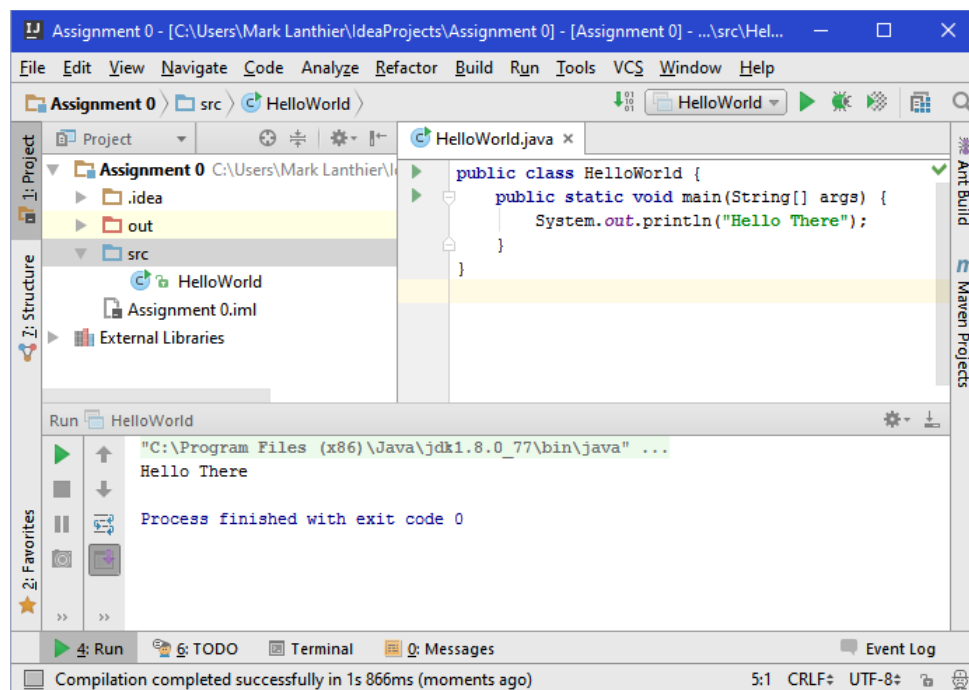
Type in the whole program as shown here:



**Right-click** on the program panel (i.e., on the panel that contains your code) and select **Run 'HelloWorld.main()'** from the pop-up menu.



Your program should now run and the result should appear in the bottom Console pane.





## Problem 2 (Tax Program)

Within the same project, create a class called **TaxProgram** with the code shown below. It should compile and run. Currently, the program just asks the user for their *taxable income* and then the *number of dependents* that they have.

```
import java.util.Scanner;

public class TaxProgram {
    public static void main(String args[]) {
        double income, fedTax, provTax;
        int dependents;

        Scanner input = new Scanner(System.in);

        System.out.print("Please enter your taxable income: ");
        income = input.nextDouble();
        System.out.println();

        System.out.print("Please enter your number of dependents: ");
        dependents = input.nextInt();
        System.out.println();

        fedTax = 0.0;
        provTax = 0.0;

        // Add code here
    }
}
```

Making use of the **income** and **fedTax** variables in the code, insert code at the end of the program so that it computes and displays the **fedTax** using the rules shown below:

- If the income is less than or equal to \$29,590, the **federal tax** should be  
**17% of the income**
- If the income is in the range from \$29,590.01 to \$59,179.99 then the **federal tax** should be: **(17% of \$29,590 + (26% of (the income minus \$29,590))**
- If the income is \$59,180 or more then the **federal tax** should be:  
**(17% of \$29,590) + (26% of \$29,590) + (29% of (the income minus \$59,180))**

Test your code with the following values to make sure that it is correct before you continue:

| Income | \$25,000 | \$53,000    | \$65,000    |
|--------|----------|-------------|-------------|
| FedTax | \$4,250  | \$11,116.90 | \$14,411.50 |

Insert code at the end of the program so that it computes and displays the **provincial tax** and finally the **total tax** using the rules shown below:

- The **base** provincial tax will be:  
**42.5% of the federal tax**
- The **deductions** for the provincial tax will be:  
**\$160.50 + \$328 per dependent**
- The **provTax** is then calculated as \$0 if the base provincial tax is less than the deductions, otherwise as follows:  
**base - deductions**
- The **total tax** is the sum of the **fedTax** and the **provTax**.

Test your code with the following values to make sure that it is correct:

| Income     | \$25,000   | \$53,000    | \$65,000    |
|------------|------------|-------------|-------------|
| Dependants | 1          | 2           | 3           |
| FedTax     | \$4,250    | \$11,116.90 | \$14,411.50 |
| ProvTax    | \$1,317.75 | \$3,908.18  | \$4,980.39  |
| TotalTax   | \$5,567.75 | \$15,025.08 | \$19,391.89 |

Adjust your code above so that it displays with the following output format by using **System.out.println()** statements as well as **String.format()** (see Chapter 1 of [Mark Lanthier's notes](#) for details on String.format()):

```
Please enter your taxable income: 25000
Please enter your number of dependents: 1

Here is your tax breakdown:

Income           $25,000.00
Dependants         1
-----
Federal Tax      $4,250.00
Provincial Tax   $1,317.75
=====
Total Tax        $5,567.75
```

### Problem 3 (Arrays and Problem Solving)

Download and open the ArrayPractice.java file from Brightspace. The main method of this Java file creates several arrays and calls several methods to perform operations on those arrays. You must write the implementation for each of the five methods so that the correct values are returned. A description of each method is included in comments within the file. Remember to break the problems down and identify what information/variables you need to solve the problem. If you are completely stuck on

either of these methods, check the end of the tutorial document for some hints (try to use as few hints as possible).

## Problem 4 (Basic Class Creation and Manipulation)

Create a new **Java Class** called **Customer**. The code for the **Customer** class should simply be:

```
public class Customer {

}
```

Let's make the **Customer** object more interesting by adding some attributes (also known as *instance variables*). Assume that you want to specify the name of the **Customer**. Create a class called **CustomerTestProgram** as follows:

```
public class CustomerTestProgram {
    public static void main(String args[]) {
        Customer    c;

        c = new Customer();
        c.name = "Bob";
        System.out.println(c.name);
    }
}
```

The dot `.` after the variable `c` means that we are trying to access a piece (or attribute) of the object - in this case the customer's **name**. The code generates a compile error which says:

```
! cannot find symbol
  symbol:   variable name
  location: variable c of type Customer
```

This error occurs because you have not told JAVA that your **Customer** objects are supposed to have names. You need to go back to your **Customer** class definition and add an attribute called **name**.

Go to your **Customer** class. Add an instance variable (or attribute) called **name** which is of type **String** as follows:

```
public class Customer {
    String name;
}
```

Go back and run the **CustomerTestProgram** class. It should work now, displaying **Bob**.

Add 2 more attributes (instance variables) to keep track of the Customer's **age** (an **int**) and **money** (a **float**). Now test the following code:

```

public class CustomerTestProgram {
    public static void main(String args[]) {
        Customer    c;

        c = new Customer();
        c.name = "Bob";
        System.out.println(c.name);
        System.out.println(c.age);
        System.out.println(c.money);
    }
}

```

The code should compile and run. Notice the values of the name, age, and money variables. In JAVA, all unassigned variables are set to a default value (e.g., 0 for numbers, null for objects). Try assigning values to the variables so that **Bob** is a **27** year old with **\$50**. Then re-run to see the results. Try adding a second customer and giving that customer object its own attribute values. You will see that each instance of an object that you create contains its own copies of each attribute.

## Problem 5 (Constructors)

Now let's see how to initialize our objects by using constructors. Create a class called **CustomerConstructorTestProgram** with the code shown below:

```

public class CustomerConstructorTestProgram {
    public static void main(String args[]) {
        Customer    c1, c2, c3;
        // Create Bob
        c1 = new Customer();
        c1.name = "Bob";
        c1.age = 17;
        c1.money = 10;

        // Create Dottie
        c2 = new Customer();
        c2.name = "Dottie";
        c2.age = 3;
        c2.money = 0;

        // Create blank customer
        c3 = new Customer();

        System.out.println("Bob looks like this: " + c1.name + ", " +
            c1.age + ", " + c1.money);
        System.out.println("Dottie looks like this: " + c2.name + ", "
            + c2.age + ", " + c2.money);
        System.out.println("Customer 3 looks like this: " + c3.name +
            ", " + c3.age + ", " + c3.money);
    }
}


```

Compile and run the code. Notice that we explicitly specified the **name**, **age**, and **money** for both customers. This is called *initializing* the object and it is usually done at the point that we create the object. Unfortunately, it takes **3** lines of JAVA code to initialize each customer. This is a little annoying and tedious, but recall that if we did not set the values, they would be set to zero by default.

The preferred way to initialize an object is to create our own *constructor*. Recall that a constructor is a special block of code that takes **0** or more *parameters* and it is called automatically when we create a new object. Let's make a constructor that takes a single **name** parameter. Write the following code in your **Customer** class just below the list of instance variables:

```
public Customer(String initName) {  
  
}
```

Go to the **CustomerConstructorTestProgram** and re-compile it. You should get 3 errors like this:



```
java: constructor Customer in class Customer cannot be applied to given types;  
required: java.lang.String  
found: no arguments  
reason: actual and formal argument lists differ in length
```

What happened? Well, because you created your own constructor, JAVA decided that you are no longer allowed to use the default constructor (i.e., the one that it provided to you before you wrote your own). Notice that your test code calls **new Customer()** which takes no parameters. However, the constructor that you just made requires a **String** parameter, so JAVA does not recognize it.

You can call your new constructor by supplying a **String**, which should be the name of the customer. So, change the line **c1 = new Customer();** to **c1 = new Customer("Bob");** and re-compile. You will now see that only 2 errors remain, because JAVA now understands that you are calling your newly created constructor in the first line. Fix the remaining two errors by supplying two Strings **"Dottie"** and **"Jane"** to the other two constructor calls. The code should now compile. However, the code from your CustomerTestProgram will no longer work. You will need to supply a String name for that constructor call as well.

Of course though, your constructor does not really do anything yet. Assume that we moved the line **c1.name = "Bob";** into the constructor within the Customer class. Can you explain why the code below would not compile?

```
public Customer(String initName) {  
    c1.name = "Bob";  
}
```

Right! **c1** is not defined here in the **Customer** class because **c1** is just a *variable* that we are using in our test program. Change the constructor code to be as shown below, then the code will compile:

```
public Customer(String initName) {
    name = "Bob";
}
```

Go back to the test code and remove the following 2 lines that set the name:

```
c1.name = "Bob";
c2.name = "Dottie";
```

Run the test code and look at the output. You should notice that everyone is called "Bob". That is because our constructor for the **Customer** object assigns the name attribute to be "Bob".

Change your code to use the parameter **initName** instead of the fixed String "Bob" as follows:

```
public Customer(String initName) {
    name = initName;
}
```

Now run the test code again. The three unique customer names should now be correct.

In a similar way, we can set the initial values for all of the other attributes as well. You can create as many constructors as you want, as long as their list of parameters is different (why do you think the parameter list has to be different?). **It is always a good idea to set ALL of the attribute values in each of your constructors. If the attribute value is not supplied as a parameter, set the attribute to some default value.**

Properly complete your **Customer** class constructor as follows:

```
public Customer(String initName) {
    name = initName;
    age = 0;
    money = 0.0f;
}
```

Run the test program again. You should notice that customer **c3** has the same default values now as indicated in the constructor. Why don't customers **c1** and **c2** have these default values? Do you know? Make sure to ask a TA if you don't understand.

## Problem 6 (More Constructors)

Create 3 more constructors with parameters as follows (make sure to complete the code in each one so that each one has exactly 3 lines of code that set the values of all 3 attributes to proper values):

- One that takes the name and age of the customer:

```
public Customer(String initName, int initAge) {...}
```

- One that takes the initial **name**, **age**, and **money** values of the customer.

```
public Customer(String initName, int initAge, float
initMoney) {...}
```

- One that takes *no parameters* (i.e., uses default values that are reasonable)

```
public Customer() {...}
```

Make sure to write the missing code in all three of the above constructors. Then change your test code to look as follows (copy/paste it):

```
public class CustomerConstructorTestProgram {
    public static void main(String args[]) {
        Customer c1, c2, c3, c4;

        c1 = new Customer("Bob", 17);
        c2 = new Customer("Dottie", 3, 10);
        c3 = new Customer("Jane");
        c4 = new Customer();

        System.out.println("Bob looks like this:      " + c1.name +
            ", " + c1.age + ", " + c1.money);
        System.out.println("Dottie looks like this:   " + c2.name +
            ", " + c2.age + ", " + c2.money);
        System.out.println("Jane looks like this:     " + c3.name +
            ", " + c3.age + ", " + c3.money);
        System.out.println("Customer 4 looks like this: " + c4.name +
            ", " + c4.age + ", " + c4.money);
    }
}
```

This test code should compile and run. If the values are not all set properly, you likely made some mistakes in your constructor code. Notice how "clean" it looks when compared to our initial testing code that set each value explicitly on separate lines.

## Problem 7 (Adding Methods)

Consider now writing some instance methods for the **Customer** class. In the **Customer** class, create a method called **computeFee()** that returns a float:

```
public float computeFee() {
}
```

Complete the method so that a customer's fee will be returned as follows. The basic adult fee is **\$12.75** and applies to anyone **18** years of age or older. Children **3** and under have no fee and anyone of age **65** or older receives a **50%** discount. Children and youths (between the age of **4** to **17** inclusively) pay only **\$8.50**.

Test your code by adding the following lines to the end of your **CustomerConstructorTestProgram**:

```

System.out.println("Bob's fee is $" + c1.computeFee());
System.out.println("Dottie's fee is $" + c2.computeFee());
c3.age = 23;
System.out.println("Jane's fee is $" + c3.computeFee());
c4.age = 67;
System.out.println("No Name's fee is $" + c4.computeFee());

```

In the **Customer** class, create a method called **spend(float amount)** that allows the customer to spend the amount of money indicated in the parameter. If the customer has enough money, the money should be spent and the customer should have that amount of money less. If the **Customer** did not have enough money, no spending should take place. Test your code by adding the following to the bottom of your test program:

```

c2.spend(3);
System.out.println("Dottie's money remaining is $" + c2.money);

```

Consider what would happen if you added these lines to your test program:

```

c2.spend(-80);
System.out.println("Dottie's money remaining is $" + c2.money);

```

Can you account for this situation and deal with it appropriately?

When we call the **spend()** method, we do not really know if the operation was ignored (due to insufficient funds) or if the operation was successful. It is better to give some kind of "feedback" to the test method to indicate whether or not the spending operation was successful. One way of doing this is to simply examine the customer's money variable *before* the call and then *after* the call and compare them to see if there was a change but this is cumbersome. A better way to provide feedback to the caller of the method (i.e., the test program) would be to return a value from the method to indicate whether or not it worked. We can return a **boolean** indicating whether or not the spending was successful. Modify your **spend()** method so that it returns **true** if the spending was successful and **false** otherwise. Create, save, compile and run the following test program to test your new code:

```

public class CustomerSpendingTestProgram {
    public static void main(String args[]) {
        Customer c1, c2, c3;

        c1 = new Customer("Bob", 25, 50.00f);
        System.out.println(c1.money);

        c2 = new Customer("Dottie", 53, 100.00f);
        System.out.println(c2.money);

        c3 = new Customer("Jane", 21, 25.00f);
        System.out.println(c3.money);

        if (!c1.spend(10.00f))
            System.out.println("Unable to spend $10");
        if (!c1.spend(4.75f))

```



```

        System.out.println("Unable to spend $4.75");
    if (!c1.spend(15.25f))
        System.out.println("Unable to spend $15.25");
    if (!c1.spend(100.00f))
        System.out.println("Unable to spend $100");

    System.out.println(c1.money);
}
}

```

In the **Customer** class, create a method called **hasMoreMoneyThan(Customer c)** that returns a boolean value of **true** if the customer has more money than the customer passed in as parameter **c** and **false** otherwise. Add the following two lines of code to the bottom of your **CustomerSpendingTestProgram** to make sure that the answers are **false** and **true**, respectively:

```

System.out.println("Bob has more money than Dottie: " +
c1.hasMoreMoneyThan(c2));
System.out.println("Dottie has more money than Jane: " +
c2.hasMoreMoneyThan(c3));

```

Now we will modify our test code to make use of our **computeFee()** method to gain admission into an event (i.e., such as a circus or movie). Below is the test code that we would like to have working. Create that test program, but it will not yet compile. Notice that there is a new method called **payAdmission()** which simulates a person paying admission to the circus.

```

public class CustomerAdmissionTestProgram {
    public static void main(String args[]) {
        Customer c1, c2, c3, c4;

        c1 = new Customer("Bob", 17, 100);
        c2 = new Customer("Dottie", 3, 10);
        c3 = new Customer("Jane", 24, 40);
        c4 = new Customer("Sam", 72, 5);

        System.out.println("Here is the money before going into the
circus:");
        System.out.println("  Bob has $" + c1.money);
        System.out.println("  Dottie has $" + c2.money);
        System.out.println("  Jane has $" + c3.money);
        System.out.println("  Sam has $" + c4.money);

        // Simulate people going into the circus
        c1.payAdmission();
        c2.payAdmission();
        c3.payAdmission();
        c4.payAdmission();

        System.out.println("Here is the money after going into the
circus:");
        System.out.println("  Bob has $" + c1.money);
        System.out.println("  Dottie has $" + c2.money);
    }
}

```

```

        System.out.println("    Jane has $" + c3.money);
        System.out.println("    Sam has $" + c4.money);
    }
}

```

Write the **payAdmission()** method. It should have a **void** return type. Your method should be one line long and make use of the **computeFee()** and **spend()** methods that you wrote earlier. Compile your code, test it by running the **CustomerAdmissionTestProgram** and then examine the output to make sure that it is correct.

We will now adjust our **Customer** object so that we can keep track of who has paid for their admission and who has not. Add a **boolean** attribute (i.e., instance variable) to the **Customer** class called **admitted**. Set this attribute to **false** in ALL of your constructors.

Modify your **payAdmission()** method so that this variable is set to **true** when the customer has successfully paid the proper **fee** amount. Adjust your **CustomerAdmissionTestProgram** code to display this new attribute after each call to **payAdmission()** so that you can see if it is set properly. Here is the portion of code to change:

```

// Simulate people going into the circus
System.out.println("    Bob has been admitted ... " + c1.admitted);
System.out.println("    Dottie has been admitted ... " + c2.admitted);
System.out.println("    Jane has been admitted ... " + c3.admitted);
System.out.println("    Sam has been admitted ... " + c4.admitted);

c1.payAdmission();
System.out.println("Bob has been admitted ... " + c1.admitted);
c2.payAdmission();
System.out.println("Dottie has been admitted ... " + c2.admitted);
c3.payAdmission();
System.out.println("Jane has been admitted ... " + c3.admitted);
c4.payAdmission();
System.out.println("Sam has been admitted ... " + c4.admitted);

System.out.println("    Bob has $" + c1.money);
System.out.println("    Dottie has $" + c2.money);
System.out.println("    Jane has $" + c3.money);
System.out.println("    Sam has $" + c4.money);

```

Try adjusting the **money** amounts and see what happens.

## Problem 8 (Adding a toString Method)

Now we will adjust how a **Customer** object appears when displayed. We saw earlier that a **Customer** object appears like this when displayed: **Customer@140e19d**. We change the "look" of the customer by defining the String that will be returned when the customer is displayed. We do this through the **toString()** method. Write a **toString()** method so that customers appear in this format when displayed (color added for emphasis):

```
Customer Bob: a 17 year old with $0.0 who has not been admitted
```

Customer **Dottie**: a 3 year old with \$10.0 who has been admitted

Test your code by adding these lines to the bottom of your **CustomerAdmissionTestProgram**:

```
System.out.println(c1);
System.out.println(c2);
System.out.println(c3);
System.out.println(c4);
```

## Problem 9 (Null Pointer Exceptions)

Let us look further now into what can go wrong with **null** objects. Add a variable **c5** to the list of **Customer** variables in the **CustomerAdmissionTestProgram**. Add the following line to the end of the program:

```
System.out.println("Customer 5 looks like this: " + c5);
```

Compile the code. You should get a compile error saying:

 **Error:(36, 61) java: variable c5 might not have been initialized**

Change **c5** to **c5 = null** where you declared the variable, and then re-compile. Run the test program. Did you expect **null** to be returned? Change the last line to this:

```
System.out.println("Customer 5 looks like this: " + c5.toString());
```

Re-compile and run the code. You should see this error occur:

```
java.lang.NullPointerException
  at CustomerAdmissionTestProgram.main(CustomerAdmissionTestProgram.java:36)
  at sun.reflect.NativeMethodAccessorImpl.invoke0(Native Method)
  at
  sun.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:62)
  at
  sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:43)
  at java.lang.reflect.Method.invoke(Method.java:498)
  at com.intellij.rt.execution.application.AppMain.main(AppMain.java:144)
```

Notice that the error is called a **NullPointerException**. JAVA is telling you that you are trying to access an attribute or a method for an object that is actually **null** - that is, you are trying to *use* an undefined object (i.e., before you created it). Notice in the code that we did not create a **Customer** object for **c5**, we only reserved space *to hold* a Customer object (i.e., we only *declared* the variable). The error message even tells us the exact line that the error occurred at (line 36 in my case, but it may differ in your program). If you go to that line, you will see that we are indeed trying to call **toString()** on **c5**, which is **null**. **You may get lots of NullPointerException errors in this course. It ALWAYS means that something in front of the dot . operator is not yet defined. It means that you forgot to create/initialize an object somewhere in your code.** Remove the line of code that causes the **NullPointerException** before submitting.

## Submission

All tutorial submissions, unless otherwise stated, will be a single zip file containing a complete IntelliJ project – this makes it easier for the TAs to compile and execute your code. The IntelliJ IDE has built-in functionality to save your project as a zip. While your project is open in IntelliJ, go to the File menu, then the Export sub-menu, and then select Project to Zip File... Save the zip file as tutorial1.zip.

Submit your tutorial1.zip file using the submission link available on Brightspace. After you submit the file, download your submission from Brightspace and confirm that it is a zip file called tutorial1.zip. Extract the contents of the zip and try opening the folder as a project in IntelliJ (File → Open, then select the folder that was contained in the zip). Occasionally, there can be a problem during the upload process and files can become corrupted. **Downloading, verifying, and executing your submissions ensures that the files were uploaded correctly. Submissions that are corrupted or missing files will be penalized – make sure that you double-check your submissions.** If you are unsure whether your submission was uploaded correctly, stop by office hours and ask a TA to double-check the submission for you.

## Problem 3 Merge Hints

- 1) The size of the result array must be equal to the sum of the sizes of a and b. Use the length property of Java arrays.
- 2) As both argument arrays are sorted in increasing order, the problem can be solved by repeatedly copying the next largest item that has not been copied yet from a or b into the proper place in the resulting array.
- 3) To do this, you can use three index values: current index in a, current index in b, current index in result. As you copy items into the result array, you increase the associated index. As you copy items from a or b, you increase their respective index (basically, moving to the next item in the array).
- 4) At any point, you have three possible cases: a has been copied completely, b has been copied completely, a and b both have elements left to copy.
- 5) If a has been copied completely, you need to copy the next element from b (and vice versa). If neither have been copied completely, you need to compare the current elements of each and take the lowest one.

## Problem 3 Sequence Hints

- 1) You need to keep track of the longest sequence you have found while iterating over the array.
- 2) The first element in the array is automatically considered increasing (there are no preceding elements).

- 3) Each successive item in the list either continues the previous increasing sequence (i.e., is larger than the number before it), or starts a new sequence.
- 4) You will need a variable to keep track of how long the current sequence is.
- 5) Any time a sequence ends (and when you reach the end of the array), you must compare your sequence length to the longest length and possibly update the longest sequence variable.
- 6) Once a sequence ends, you start over at the current element. Remember to count the current element as part of the new sequence.