ECE 651
Development Environment Setup

This tutorial will walk you through setting up your development environment for ECE 651. Here are some options and how well they are supported by the course:

- Linux: well supported
  - Install Virtual Box on your computer and install Linux inside of it
  - Use an OIT VM (from vcm)
  - Install Linux directly on your computer (possibly dual booting)
- Mac OSX: fairly well supported[1].
- Windows: you are pretty much on your own here.

Note that Linux is most directly supported, as I can do a clean install of a VM, and follow the instructions exactly (with the system in the same state you will have it if you start from a clean install). Mac is fairly well supported, as I use a Mac. However, I cannot start from a clean install (I am not going to erase my computer), nor are you likely to start from a clean install. Accordingly, there might be some differences. I don't really use Windows, so it is the least supported. I'll try to sketch out generally what to do, but you are fairly on your own.

The general overview of what will happen in this walkthrough is:

1. Install your platform if needed (VirtualBox and/or Linux):
   - If you want to install VirtualBox, see Section 1
   - If you want to use an OIT VM, go to `http://vcm.duke.edu/` and choose "Reserve a VM". Select an Ubutnut 20 image. Once that is setup, go to Section 2.
   - If you want to install go to `https://ubuntu.com/tutorials/install-ubuntu-desktop#1-overview`. Please make sure you have a backup of any important data first. Once you have Linux installed, go to Section 2.
2. Install packages you need: emacs, JDK, gradle, git. Go to Section 2 directly if you do not need to install a platform.
   - You might also want clang/clang-format if you plan to do C (*e.g.*, for 650) in the same environment
3. Setup emacs (install packages, etc)
4. Walk through a small example of how to use Java, gradle, and JUnit.

[1]Note: we have not tried this on M1 and do not have an M1 to try it on, but think it should work

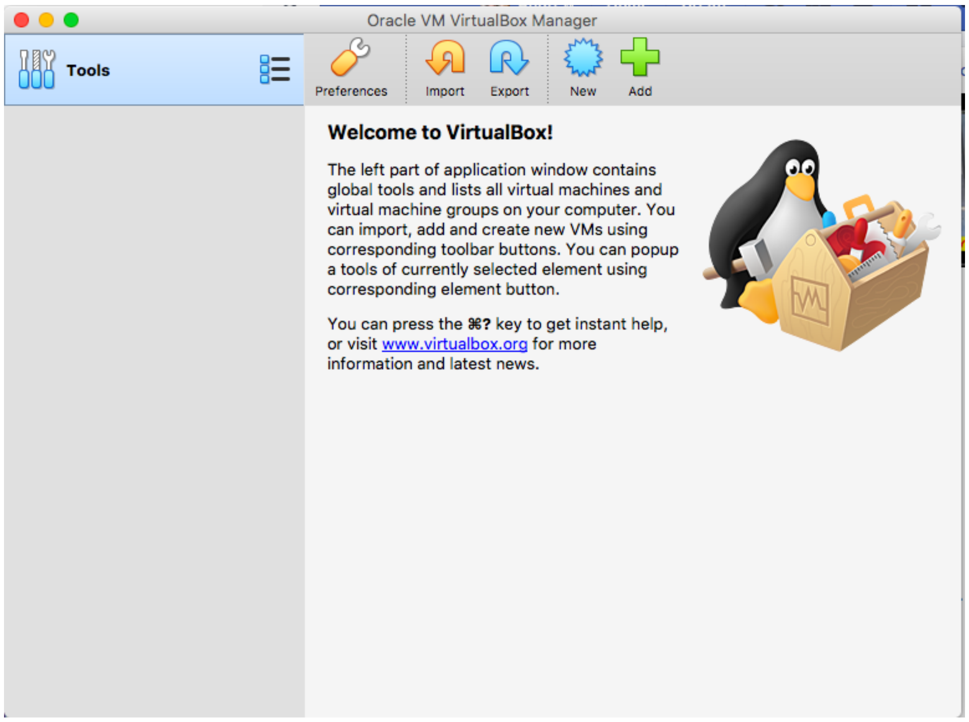
1 Installation of VirtualBox

VirtualBox is a program that emulates a computer (a virutal machine). If you want to go this route, you will basically have a virtual computer running on your computer. Note that this can be a bit resources intensive, as you need enough memory allocated to the VM to run its OS and programs.

The first thing you need is Virtual Box, which will run a virtual machine on your computer (effectively, it will pretend to be a computer). On the page linked above, you should see a section near the top called "VirtualBox 6.1.18 platform packages" with a list of operating systems under it. Choose your OS to download the appropriate Virtual Box installer. Once you have downloaded the Virtual Box installer, install it just like you would any other program on your computer.

Next, you need to go to and download Ubuntu 20.04.1 LTS (should be at the top of the page). This download may take a long time, as it is a 2.6 GB.

Now, you are ready to start Virtual Box, and set up a VM. Open the Virtual Box program you just installed, and you should see a screen like this (though it may look slightly different as Virtual Box has a new version since we originally wrote this):



Welcome to VirtualBox!

The left part of application window contains global tools and lists all virtual machines and virtual machine groups on your computer. You can import, add and create new VMs using corresponding toolbar buttons. You can popup a tools of currently selected element using corresponding element button.

You can press the ⌘? key to get instant help, or visit www.virtualbox.org for more information and latest news.

In the upper bar, towards the right is a "New" button (with a blue spiked circle icon). Click on that button and you will get a dialog to fill in some basic info. Fill it in as follows:

- Name: ECE 651
- Machine Folder: (whatever it gave you by default)

- Type: Linux
- Version: Ubuntu (64-bit)

The next screen will prompt you for memory size. What you put here depends on how much RAM your computer has. People have had problems installing with less than 2GB. 3GB is not too bad. If your computer has 8 or more GB of RAM, we recommend giving your VM at least 4GB. If you have a lot of RAM, giving even more can be great. The coloration under the slider indicates how much of a problem it will be for your computer to use that much of its RAM for the VM. If you pick things in the orange or red ranges, you may have trouble with anything outside the VM.

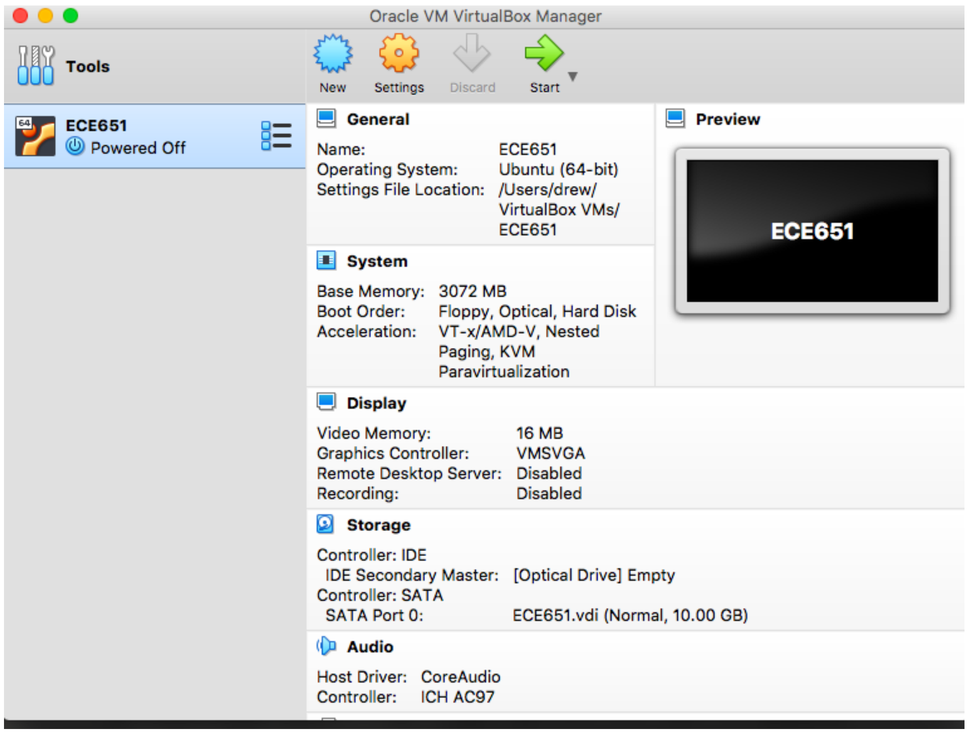
The next screen will ask about making a virtual hard disk. You want to choose "Create Virtual Hard Disk Now" (this should be checked by default).

Once you click "Next" you will be prompted for the Hard disk file type, the default ("VDI VirtualBox Disk Image) is fine, so just click "Next".

The next screen will ask you how to stor it, again the default ("Dynamically allocated") is fine, so just click "Next".

On the next screen, you will be asked for where to store the disk file (the default is fine), and how much space to put in the disk. The default is 10GB. You can get by with 10GB, but space may end up being tight. If you have plenty of free disk space on your computer, I would recommend going up to 15GB or even 20GB just to be safe.

After you finish creation, you should be back ot the main Virtual Box screen with the information for your newly created VM displayed:



General

Name: ECE651
Operating System: Ubuntu (64-bit)
Settings File Location: /Users/drew/VirtualBox VMs/ECE651

System

Base Memory: 3072 MB
Boot Order: Floppy, Optical, Hard Disk
Acceleration: VT-x/AMD-V, Nested Paging, KVM Paravirtualization

Display

Video Memory: 16 MB
Graphics Controller: VMSVGA
Remote Desktop Server: Disabled
Recording: Disabled

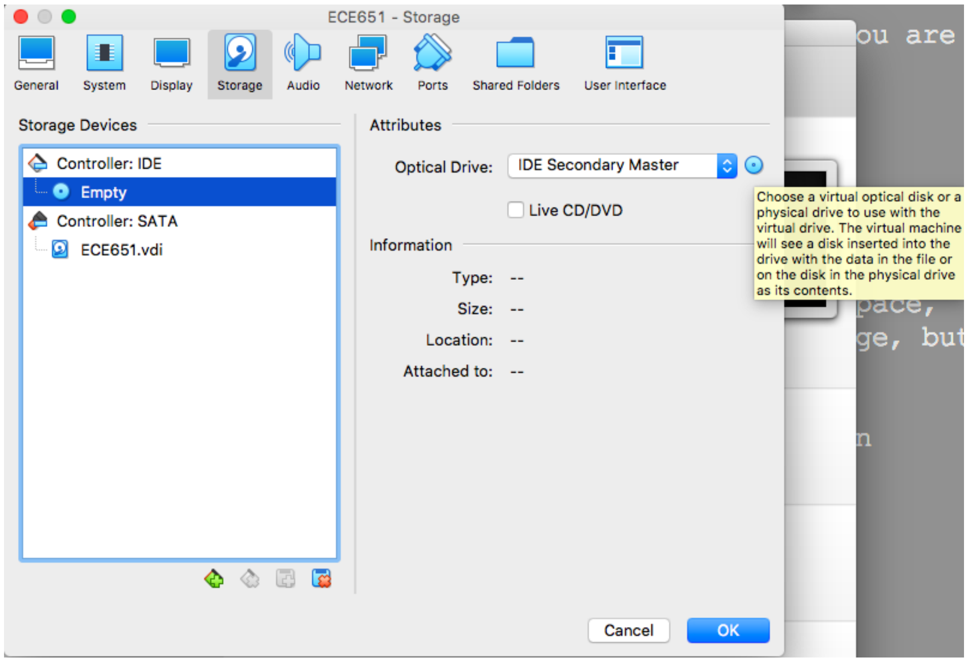
Storage

Controller: IDE
IDE Secondary Master: [Optical Drive] Empty
Controller: SATA
SATA Port 0: ECE651.vdi (Normal, 10.00 GB)

Audio

Host Driver: CoreAudio
Controller: ICH AC97

Before you power on the VM, you need to tell it to use the Ubuntu ISO as its CD drive. Go to “Settings” at the top, and then “Storage”. On the left, under “Controller IDE” select the CD drive which is labeled “Empty”. On the right is a small icon of a CD drive (near where the tool tip is displayed in the screen shot below). If you click on this icon, you should be able to “Choose/Create Virtual Optical Disk File” and then select the Ubuntu ISO you downloaded previously.


ECE651 - Storage

Optical Drive: IDE Secondary Master

Live CD/DVD

Choose a virtual optical disk or a physical drive to use with the virtual drive. The virtual machine will see a disk inserted into the drive with the data in the file or on the disk in the physical drive as its contents.

Information

Type: --

Size: --

Location: --

Attached to: --

After you accept these changes, you should be back at the main screen. Click “Start” (with the green arrow in the upper right corner) to boot the VM. You should see it boot up, and then give an Ubuntu loading screen. Followed by an install menu with “Try Ubuntu” or “Install Ubuntu” buttons. Choose “Install Ubuntu” (don’t worry, it will only install in the VM, everything on your regular computer will be left alone).

On the next screen, choose your keyboard layout. The screen after that asks you if you want a normal installation of a minimal installation. You can choose either, but the normal will take longer and give you a lot of things you don’t need for this class (like a music player, a word processor, etc). Do check the box for third party drivers at the bottom though.

The default option on the next (Erase disk and install Ubuntu) is fine (again, this just erases the virtual disk, not your real disk). Hit “Install Now”, and then “Continue”. Next you will pick your timezone, and then a user name and password. Hit “Continue” then you will wait a while as it installs everything.

Unless there are any problems, you should wait a while as Ubuntu copies and installs its files, then get a box asking you to restart now. After you click that box, Ubuntu will take a moment to shut down, and then prompt you with a screen to “Please remove your installation medium, then press ENTER”. You should be able to just press “Enter” as the installer should have automatically “ejected” the virtual disk.

The VM should reboot and after a brief bit of loading, display a screen for you to select which user you want to login as (there should be one choice, which is whatever user name you selected during setup). After you login, you will need to click through a few more setup screens.

Now click the 9 dots in the lower left corner (which says "Show Applications" when you mouse over). In the "Type to search" box at the top, type "xterm". The top result should be "Xterm: standard terminal emulator..." Choose that and you should get a button to install it. You will be prompted for your password—type your login password, and it will install xterm[2]. When that finishes click "Launch". You'll be using this enough that you should right click the icon on the dash (side bar), and choose "Add To Favorites".

In your xterm, do

```
sudo apt install gcc make perl
```

Now, you will want to take a second to install the "Virtual Box Guest Additions" (which is software to add features specific to running inside Virtual Box. Go to the "Devices" menu, then "Insert Guest Additions CD Image". When you do this, you should get a message box asking if you want to run what is on the CD. Accept this, and wait a minute while it installs. Then it will tell you to press Enter when you are done. Once this is installed, you will want to restart the VM for the updates to take effect. To do so, go to the menu in the upper right (that looks like a power button) and choose Power Off/Logut, then Power Off, then Restart. After restar, you will be able to (among other things) resize or full screen the VM window, and have it use the entire new window size. You might wish to full screen the VM (Host+F. On Mac, Host defaults to left command. On Windows, right control).

You will probably get a message about updating software. You can accept this at pretty much any time. It isn't urgent, but you should do it. We'll also note that if you are away from using the VM for a while, the screen in it will lock. If you click in it, it won't show a password box—just start typing your password and the box will appear. You might want to go to the "Devices" and choose "Shared Clipboard" and then select "Bidirectional" if you want to be able to copy/paste between the VM and the host.

Note that in Linux, copy is "highlight" and paste is "middle click." If you have a 3 button mouse, this should not be a problem. If you have a track pad, you may wish to bind a key on your keyboard (that you do not use often) to emulate middle click. If your host is a Mac, you can run the included `mac-paste.sh` which will rebind right option to be middle click inside the VM. If you are using Windows (or want a different key on Mac), you can adjust the script to whatever key code you want and then run it.

One quick note about the virtual machine: this software is emulating an entire computer. If you just close the VM, it is like ripping the power cord out of the wall on a physical computer—the OS has no time to flush its disk caches. Doing so can lead to corruption of files. To shut your VM down, you should go to the drop down in the upper right corner of the guest OS (Linux inside the VM) and Power Off/Logout, and select Power Off then shut down.

[2]If this does not show up for some reason, try "terminal" and then do 'sudo apt install xterm' in that terminal, then try again.

2 Install Git + Clone Repo

Next we need to install a bunch of packages. On Linux, this can be done with the `apt` package manager. On Mac, this can be done with Homebrew. On Windows, you are going to need to download and install a bunch of things yourself. For Mac and Linux, we have written some scripts that will install the appropriate packages for you. They are in a git repository, so the first thing you should do is install git.

For Linux:

```
sudo apt install git
```

For Mac: If you try to run git and it is not installed, you should be prompted to install it.
For Windows: Go to https://git-scm.com/book/en/v2/Getting-Started-Installing-Git and look for "Installing for Windows".

Now is a good time to setup some important git info too. You will need to run these two commands (put in your own name and email, as you want them to appear in commit messages):

```
git config --global user.name "Your Name Here"
git config --global user.email "Your Email Here"
```

You may also want to do

```
git config --global credential.helper store
```

This will make git remember your gitlab password. Note that it unfortunately stores it in plain-text, so you should only do this if the computer you are working from is completely secure.

Next, you can either just clone our repository, or you can make a fork of it. If you fork it, you will have your own version of it, and can push changes to it. Why would you want to do that? We are going to have a brief section on "upping your Emacs/git game" and you may wish to play around with it. If you want to fork, go to https://gitlab.oit.duke.edu/adh39/ece651-dev-setup in your web browser. Choose the **fork** button in the upper right, and follow the instructions. If you do this, get the "clone" URL from your own project and use it in the next step instead of ours.

Now do:

```
git clone https://gitlab.oit.duke.edu/adh39/ece651-dev-setup.git
```

If you cd into ece651-dev-setup, you will find a some shell scripts, and a doc directory with a copy of this pdf (and its LaTeXsource).

If you are on Linux, run `packages-linux.sh` script. Note that this script will ask if you want to update your DNS settings. VirtualBox has some weird default DNS setting that make name resolution slow. If you choose yes, you will get your DNS changed to use Google's DNS servers.

If you are on Mac, run the `packages-mac.sh` script. If you are on Windows, you will need to install the following:

Gradle Go to https://gradle.org/releases/. Choose version 6.3. It is *not* the latest, but more recent versions changed the layout of projects in ways that many tools do not yet support.

Emacs Go to https://www.gnu.org/software/emacs/download.html

Java Development Kit (JDK) Download and install https://download.java.net/openjdk/jdk14/ri/openjdk-14+36_windows-x64_bin.zip

Clang format If you want this to support C auto formatting (as in 551), you are on your own here, but https://llvm.org/builds/ might be a starting point.

3 Emacs Setup

Now, we need to do some Emacs setup. Emacs has its own package management and configuration. We need to install some Emacs packages and configure them to have the nice set of features you are used to. For Linux and Mac this is done for you if you just run the `emacs-config.sh` script we have provided.

If you are on Windows, you might look into how to run a bash script. If not, this works through a four step setup: (1) a minimal config file that sets up package management (2) installation of packages (3) installation of a custom package (4) setup of the main configuration file. You could probably work through them one by one by hand.

Please note that this configuration script assumes you are running in a new setup, and will **completely overwrite** your emacs configuration. If you have things there that you want to keep, please back them up first. You will need to integrate them manually into configuration file afterwards.

Now run the setup script:

```
./emacs-config.sh
```

At this point, you should have Emacs all setup and ready to try out.

4 Getting Started With Gradle

Next, let us take a moment to get acquainted with our Emacs setup for Java, and Gradle (which one of the two most commonly used build system for Java). Let us make a directory for "try-emacs", and initialize a gradle project in it. **Note:** many of the tools that we use will consider "top of the git repository" as the top-level of the project. If you make try-emacs inside of your ece651-dev-setup directory, then it will be under that git repo (which will be fine). If you do it directly in your home directory, you will need to "git init" so that it will be a git repo. Otherwise, it will make a mess of project discovery.

Go back into the ece651-dev-setup directory, and do:

```
mkdir try-emacs
cd try-emacs
gradle init
```

Gradle will ask you some questions, you want to answer them as follows (you don't need to type what is in parenthesis, those are just there to make sure the number matches what you see)

type of project 2 (application)

implementation language 3 (Java)

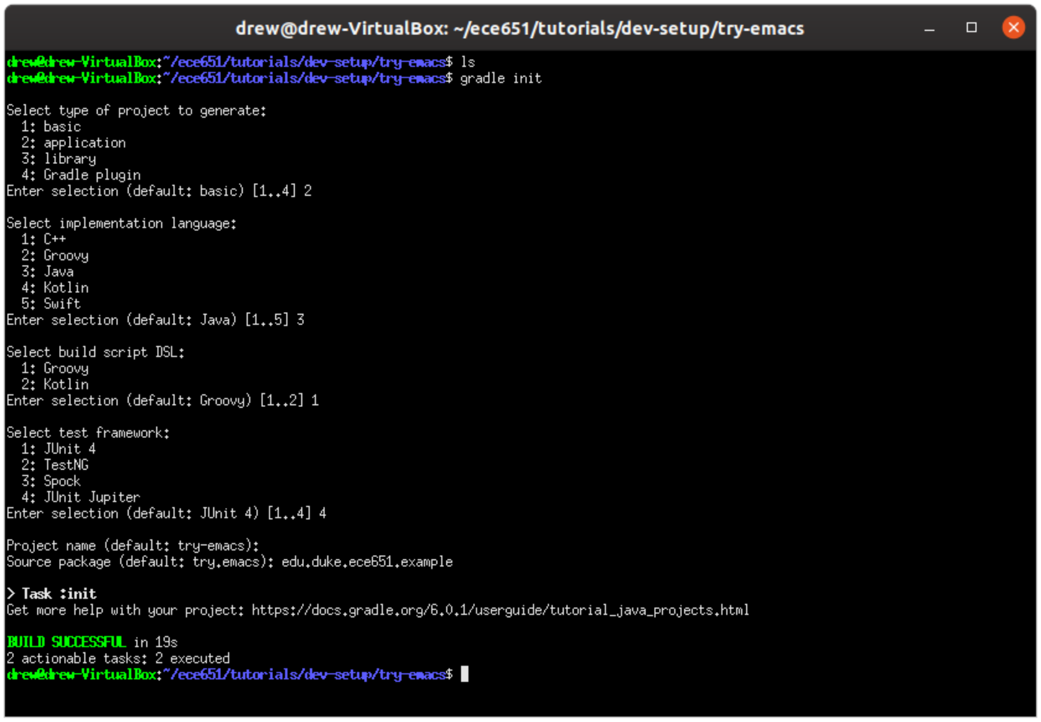
build script DSL 1 (Groovy)

test framework 4 (JUnit Jupiter)

project name enter (default is fine)

source package edu.duke.ece651.example

Overall, this should have looked like this:


drew@drew-VirtualBox: ~/ece651/tutorials/dev-setup/try-emacs

```
drew@drew-VirtualBox:~/ece651/tutorials/dev-setup/try-emacs$ ls
drew@drew-VirtualBox:~/ece651/tutorials/dev-setup/try-emacs$ gradle init

Select type of project to generate:
  1: basic
  2: application
  3: library
  4: Gradle plugin
Enter selection (default: basic) [1..4] 2

Select implementation language:
  1: C++
  2: Groovy
  3: Java
  4: Kotlin
  5: Swift
Enter selection (default: Java) [1..5] 3

Select build script DSL:
  1: Groovy
  2: Kotlin
Enter selection (default: Groovy) [1..2] 1

Select test framework:
  1: JUnit 4
  2: TestNG
  3: Spock
  4: JUnit Jupiter
Enter selection (default: JUnit 4) [1..4] 4

Project name (default: try-emacs):
Source package (default: try.emacs): edu.duke.ece651.example

> Task :init
Get more help with your project: https://docs.gradle.org/6.0.1/userguide/tutorial_java_projects.html

BUILD SUCCESSFUL in 19s
2 actionable tasks: 2 executed
drew@drew-VirtualBox:~/ece651/tutorials/dev-setup/try-emacs$ 
```

If you do "ls" you will see some gradle configuration files, and a "src" directory. Before we go any further, we want to add a couple quick things to our build.gradle file (which is analogous to a Makefile). In the `plugins` section, add

```
    id 'com.bmuschko.clover' version '2.2.3'
```

In the `dependencies` section, add

```
    clover 'org.openclover:clover:4.3.1'
```

These changes add "clover" to the project, which is the library we will be using to determine coverage of test cases.

Finally, add these two blocks at the top-level, after the close curly brace of dependencies is a great place):

```
test {
    testLogging {
        showStandardStreams = true
        exceptionFormat = 'full'
    }
}
clover {
    compiler{
        additionalArgs = "-g:lines,source,vars"
    }
}
```

The first of these will make it so that when you run test cases, you will see any output you create on stdout and/or stderr, and fully detailed exception traces. The second of these will make it so that when we compile, we will get debugging information in the class files[3].

Before going any further, run

```
gradle build
```

to make sure that everything is OK with your gradle file. This will take a while the first time, as gradle will download various things your project depends on (clover, junit, etc). It will go much faster the next time.

If you look in the `src` directory, you will see that it is organized like this

```
 - src
   |
   +--main
   |  |
   |  +-java
   |    |
   |    +-edu
   |      |
   |      +-duke
```

[3]This is the default out of the box, but clover overrides these, so we have to set them back.

```
|        |
|        +-ece651
|          |
|          +-example
|            |
|            +-App.java
+--test
   |
   +-java
     |
     +-edu
       |
       +-duke
         |
         +-ece651
           |
           +-example
             |
             +-AppTest.java
```

Note: if it is not organized like this (or src is not directly inside of try-emacs) then you have installed a different version of gradle that changed the project layout. This different layout will likely cause a lot of problems. We strongly recommend making sure you are using 6.3.

The `main/test` division separates the main code (the stuff you actually want to run and deploy) from the testing code. Inside each of those is a `java` directory since our code is in Java. If we had other languages, we could put other directories alongside those for the other languages. Each of those directories then has a path corresponding to the package name.

In Java, classes are organized into packages. You will quickly become familiar with many standard packages, such as `java.util` and `java.lang`. However, the code you write also should be in packages. Proper naming of a Java package, starts with the internet name of the organization that created it, written in reverse. In particular, this means that any package you write for this class should start with `edu.duke.ece651`, for example. The directory structure mirrors the package name, with each component (as separate by a dot) being a directory. So the code for the package `edu.duke.ece651.example` will be in the directory `edu/duke/ece651/example`.

5 Emacs for Java

Most of your favorite editing commands from 551 will work just as you expect, including auto-complete from company (complete-anything)! However, we've set you up with some Java-specific features (mostly from the lsp-java and dap-java packages). We are going to go give you an introduction to those here.

Note that we give you a quick reference in Section 7. This quick reference covers all the commands we discuss in this walk-through, as well as a few others that are useful, but we don't think require much explanation (*e.g.*, "format buffer").

Let us create a file called `Thing.java` inside our package:

```
emacs src/main/java/edu/duke/ece651/example/Thing.java
```

Hopefully from 551, you remember that you should use TAB completion extensively in the shell, i.e., you should have typed that as:

```
emacs sr(TAB)m(TAB)j(TAB)(TAB)(TAB)(TAB)(TAB)Thing.java
```

Note that if you add an `&` to the end of the command, bash will run emacs in the background and give you the prompt back. This works fine with graphical emacs, and leaves the shell available in another window in case you need it. If you are running on an OIT VM, you probably want to give `-nw` to emacs to ensure it does not try to run across an exported graphical connection.

At this point, you should be looking at an Emacs window with a dark background[4], and nothing in it.

For the very first Java file that you open, the LSP-java package should need to download a bunch of stuff. This should only happen one time, but takes a while. It is going to ask you what server you need to install (you might have some other message, but clicking into the window or doing anything should prompt you), and you should type

```
jdtls
```

You aren't going to be able to tell much about what it is doing (unless there is an error)—it will jsut say something like "Wrote /tmp/lsp-java-installXXXX/pom.xml" and sit there for a while. Get up, have a coffee, stretch, and come back in a few minutes (this literally took me 6 minutes).

When this finishes successfully, it will prompt you with

```
Things.java is not part of any project. Selection action:
i ==> Import project root ~/ece651-dev-setup/try-emacs/.
I ==> Import project root by selected root directory interactively.
(some other options).
```

When you open a file from a new project (meaning anything that LSP-java does not know about the project setup yet), you will get prompted for how LSP-java should identify the project. You will typically want either 'i' (if the listed directory is correct) or 'I' if it is not. Here "correct" means the directory which has everything for this project and nothing from any other project (typically where your build.gradle is). This project setup selection will put everything under the directory into this project. A few important things can go wrong here:

[4]We set you up with the Dracula theme by default. If you want to change the theme, please see the instructions at the end of this document

- If the directory listed for 'i' (or that you pick with 'I') is too high up (e.g., your entire home directory) then code you write for other projects will be treated as part of this project.
- If the directory listed for 'i' is too deep (*e.g.*, is inside the src directory) then various tools will not be able to find all the parts of the project.

In the future, when you start Emacs, LSP-java will not need to download this stuff again. However, for your first Java file in an Emacs session, it will take 2–5 seconds to start up. You'll see a message at the bottom that says something like

```
LSP :: Connected to [jdtls:6395 status: starting].
```

then a few seconds later

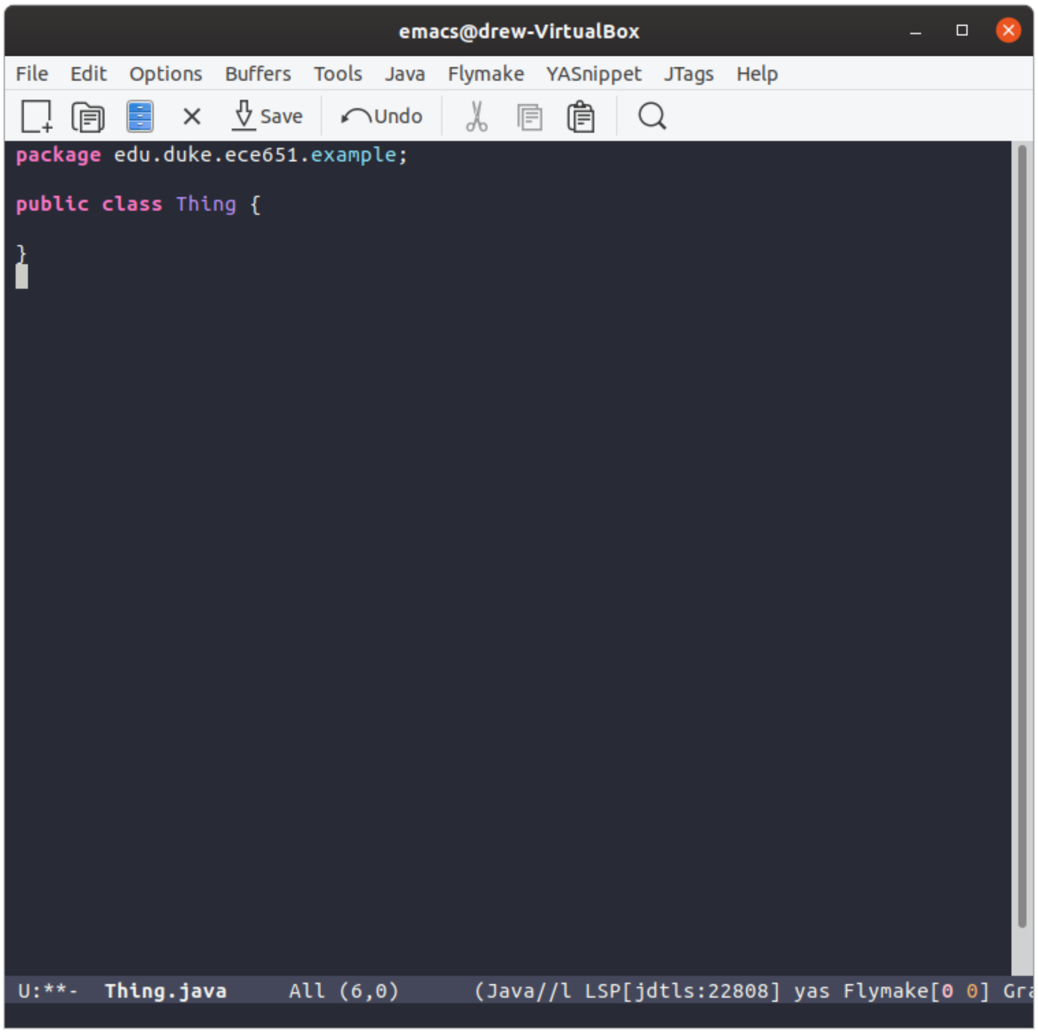
```
LSP :: jdtls initialized successfully
```

Before you see the "initialized successfully" message, many of the Java-specific features we are about to describe won't work. We just recommend waiting for LSP-java to initialize. We will also note that it will display in the status bar as either `LSP[jdtls:6395]` if it is ready, or `LSP[jdtls:6396 status:starting]` while starting up. Note that this startup only needs to happen for the first Java file you open in an Emacs session (really the first within a project), so if you just keep Emacs open and open other files with C-x C-f, you will not have to wait for this startup much.

A small bit of trouble shooting advice before we proceed. If LSP has problems, the first thing to check is that you setup the project right. In whatever Java buffer you are working from, do M-x lsp-describe-session. You should get a buffer that lists the session(s) by their project's root directory name. Make sure that the root directory for your project is correct. If the file is not in a project at all (you typically get a message when you open it), you can try M-x lsp to reselect the project setup. If the project root directory is wrong, you can do M-x lsp-workspace-folders-remove to delete the bogus project, then M-x lsp to add reselect the project anew.

If lsp-describe-session does not work, or LSP is having other problems, you might need to restart LSP with M-x lsp-workspace-restart. In very rare cases, you may need to restart Emacs.

Let us fix the "nothing in it" aspect of this Java source file by pressing "C-c C-s" (reminder: control c, control s). The "s" here stands for "skeleton" as this command will generate a skeleton for the java file you are in. This command should generate:


emacs@drew-VirtualBox
File Edit Options Buffers Tools Java Flymake YASnippet JTags Help
Save
Undo

```
package edu.duke.ece651.example;

public class Thing {

}
```

```
U:**-  Thing.java      All (6,0)      (Java//l LSP[jdtls:22808] yas Flymake[0 0] Gra
```

Note that this has declared the package, and the class, but nothing else. Lets write some code in it. First, let us declare a field called `x`:

```
private int x;
```

And a constructor:

```
public Thing(int x) {
  this.x = x;
}
```

And finally a method:

```
public int myFunction(int a, int b) {
  if (a <= 4) {
    return 2 * a + b * x;
  } else {
      return a * x - b;
    }
  }
}
```

As you type, note that flycheck will complain about anything that is illegal. When you finish this, we of course need some test cases!

In Java, our testing is structured slightly differently than in C. Fro each class X, in the "main" source, we are going to write a testing class XTest in the "testing" source. In this case, our main class is Test, so we are going to make ThingTest. We could use C-c C-f to open the ThingTest file (editing the path to be in the test part of our source tree), but we have a special key combination to switch between Java code and its matching test code. Press "C-x t" (control x, then t without control).

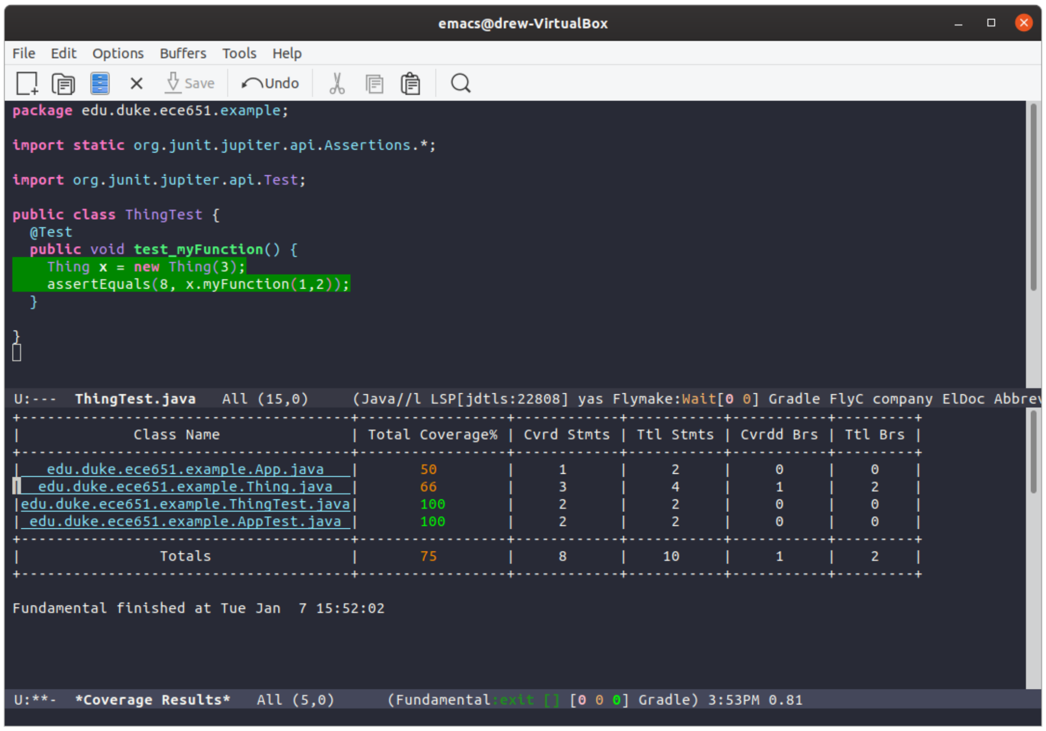
You should now be looking at ThingTest.java. Unlike before, this file is not empty. The "C-x t" command realizes when you are making a new testing file, and fills it in with an appropriate skeleton. Note that this skeleton looks a little bit different. You should see:

```
package edu.duke.ece651.example;

import static org.junit.jupiter.api.Assertions.*;

import org.junit.jupiter.api.Test;

public class ThingTest {
  @Test
  public void test_() {
  }
}
```

Note that this time, Emacs imported some java packages (that you will almost certainly need), and created one method with the `@Test` annotation. When you are using JUnit, you need each of your test methods annotated with `@Test`. The method name is not yet completed, and the point is waiting at the end of the name so you can finish it. Let's call this method `test_myFunction`. We'll make this test case create a `Thing` object, call `myFunction` on it, and check if the result is right. We use `assertEquals` to check that the result is a particular value. Let us write the following:

```
  @Test
  public void test_myFunction() {
    Thing x = new Thing(3);
    assertEquals(8, x.myFunction(1,2));
  }
```

Great, we have one test case, so everything is good, right? Of course not. First we need to run it, and we probably need some more cases... Hit "C-c C-t". You will get a compilation window while gradle compiles your code. When it finishes, you will be presented with a code coverage report, and see that the lines in your code have been colored according to if they were covered by your test cases. When I finish, I see[5]:



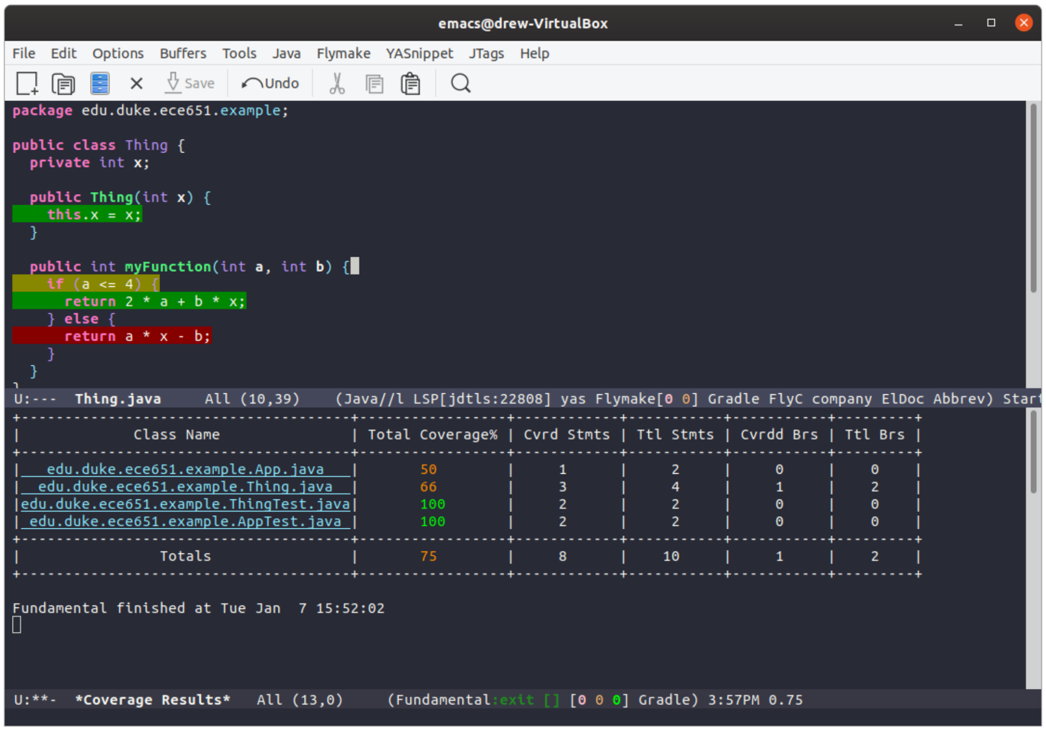
```
package edu.duke.ece651.example;

import static org.junit.jupiter.api.Assertions.*;

import org.junit.jupiter.api.Test;

public class ThingTest {
  @Test
  public void test_myFunction() {
    Thing x = new Thing(3);
    assertEquals(8, x.myFunction(1,2));
  }

}

U:---  ThingTest.java   All (15,0)     (Java//l LSP[jdtls:22808] yas Flymake:Wait[0 0] Gradle FlyC company ElDoc Abbrev
+-------------------------------------+----------------+------------+-----------+-----------+---------+
|             Class Name              | Total Coverage% | Cvrd Stmts | Ttl Stmts | Cvrdd Brs | Ttl Brs |
+-------------------------------------+----------------+------------+-----------+-----------+---------+
|   edu.duke.ece651.example.App.java  |       50       |     1      |     2     |     0     |    0    |
|  edu.duke.ece651.example.Thing.java |       66       |     3      |     4     |     1     |    2    |
|edu.duke.ece651.example.ThingTest.java|      100       |     2      |     2     |     0     |    0    |
| edu.duke.ece651.example.AppTest.java|      100       |     2      |     2     |     0     |    0    |
+-------------------------------------+----------------+------------+-----------+-----------+---------+
|               Totals                |       75       |     8      |    10     |     1     |    2    |
+-------------------------------------+----------------+------------+-----------+-----------+---------+

Fundamental finished at Tue Jan  7 15:52:02

U:**-  *Coverage Results*   All (5,0)     (Fundamental:exit [] [0 0 0] Gradle) 3:53PM 0.81
```

Note that this report includes the "App" and "AppTest" classes that gradle generated (which we haven't done anything with). The green highlights in the code mean those lines were executed. Of course, seeing that the test code was executed doesn't help that much. We'd like to know about the main code. In the coverage report, each of the class names is a clickable link to that particular java source file. Put the point on `Thing.java` and hit enter [6]. Of course, you can still change buffers normally with "C-x b" or toggle between main and test code with "C-x t".

Now, you should see something like this:

[5]Note, after writing this, I configured dcoverage to strip off the .java, and also the leading edu.duke.ece651., so you won't see those parts of the name.

[6]In theory, a mouse click should work too. This isn't working for me as I write this walk-through. I will try to fix this soon, especially if people feel it is important.


emacs@drew-VirtualBox
File Edit Options Buffers Tools Java Flymake YASnippet JTags Help
Save
Undo

```
package edu.duke.ece651.example;

public class Thing {
  private int x;

  public Thing(int x) {
    this.x = x;
  }

  public int myFunction(int a, int b) {
    if (a <= 4) {
      return 2 * a + b * x;
    } else {
      return a * x - b;
    }
  }
U:---  Thing.java     All (10,39)    (Java//l LSP[jdtls:22808] yas Flymake[0 0] Gradle FlyC company ElDoc Abbrev) Star
+-------------------------------------+-----------------+-------------+------------+------------+----------+
|              Class Name             | Total Coverage% | Cvrd Stmts  | Ttl Stmts  | Cvrdd Brs  | Ttl Brs  |
+-------------------------------------+-----------------+-------------+------------+------------+----------+
|    edu.duke.ece651.example.App.java  |       50        |      1      |     2      |     0      |    0     |
|   edu.duke.ece651.example.Thing.java |       66        |      3      |     4      |     1      |    2     |
|edu.duke.ece651.example.ThingTest.java|      100        |      2      |     2      |     0      |    0     |
|  edu.duke.ece651.example.AppTest.java|      100        |      2      |     2      |     0      |    0     |
+-------------------------------------+-----------------+-------------+------------+------------+----------+
|                Totals               |       75        |      8      |     10     |     1      |    2     |
+-------------------------------------+-----------------+-------------+------------+------------+----------+

Fundamental finished at Tue Jan  7 15:52:02

U:**-  *Coverage Results*   All (13,0)     (Fundamental:exit [] [0 0 0] Gradle) 3:57PM 0.75
```

Note that the various lines of code are colored in three different colors:

Green The line of code was covered. For a branch this means you covered both directions. For a non-branch, this means you executed that line.

Yellow This line of code was a partially covered branch. This means that you went one direction of the branch, but not the other.

Red This line of code was not covered at all.

If we look at our coverage results for Thing.java, we will see that we did not cover the case where `a>4`, so let us write a test case where `a` is 5.

We'll go back to ThingTest.java (C-x t) and add this to our method:

```
assertEquals(42, x.myFunction(5,6));
```

When you are editing code, you may find having the test coverage colors displayed annoying. You can remove them with "C-c -" (that is control c control minus—think of minus for removing things).

Now hit "C-c C-t" again to build and run your test cases (if you didn't already save, you will get prompted to).

This time, we get a failed test case:

```
example.ThingTest > test_myFunction() FAILED
  org.opentest4j.AssertionFailedError: expected: <42> but was: <9>
   expected:<40> but was:<39> at org.junit.jupiter.api.AssertionUtils.fail(AssertionUtil
   ...
   at edu.duke.ece651.example.ThingTest.test_myFunction(ThingTest.java:12)
```

Note that in reading each test failure, we are most interested in the first two lines, and the last line. The first line tells us the class (`ThingTest`) and method (`test_myFunction`) that failed. The next line tells us what in particular failed—usually this is an AssertionError, which tells us the expected value (42) and the actual value (9). The remaining lines are the call stack to get there, with the deepest calls at the top, and the outermost calls at the bottom. The last line of this call stack shows us that we called on ThingTest.java line 12. That line called assertEquals, which is in JUnit, and the remaining lines are all inside JUnit.

In this case, our code is completely contrived (just a small made up example for you to work with your development environment), so what we do to "fix" this doesn't really matter. However, this is a great chance to talk about using the debugger.

5.1 Debugging

Debugging in Emacs for Java is going to be based primarily around failed test cases. That is, we will run a particular test method (with `@Test` on it) as the starting point for where execution of our code in the debugger.

Unfortunately, clover's instrumentation (what it adds to the classes to figure out our coverage) does not play nicely with the debugger. Hit "C-c x" (not "C-c C-x", just "C-c x") for "gradle clean and compile". This will remove the already built classes, and recompile.

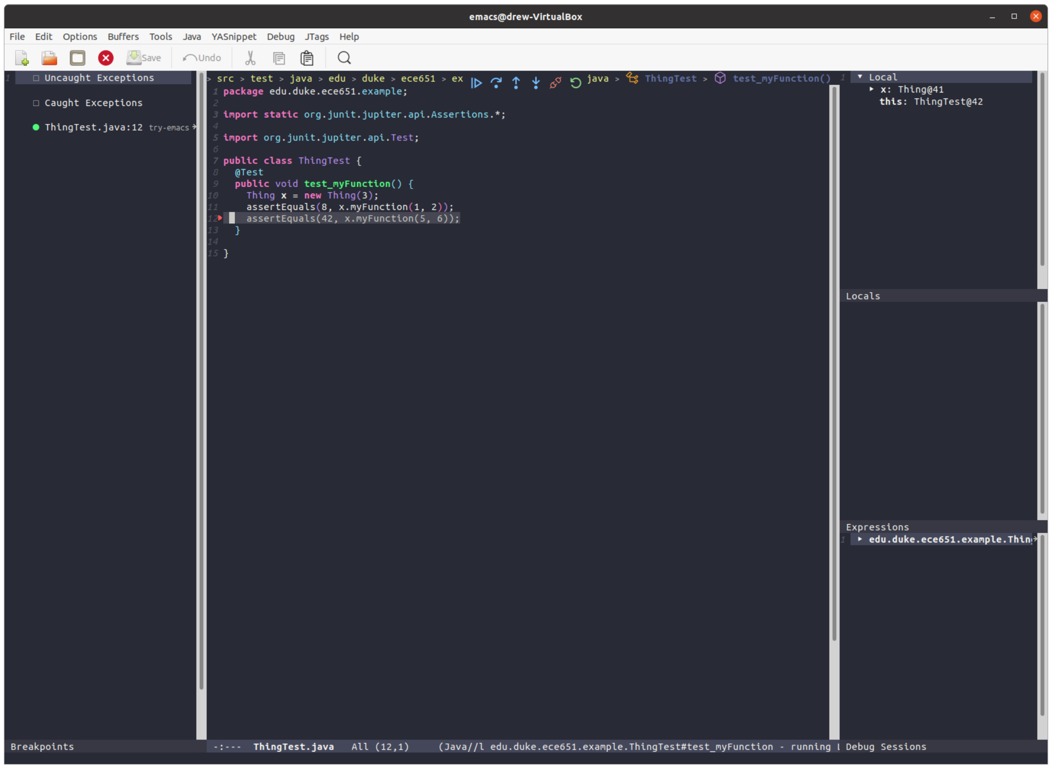
Now we are ready to debug.

To get started, put your point on the line that says

```
    assertEquals(42, x.myFunction(5,6));
```

And hit "C-c C-d". This command is basically "start the debugger for the current test method, and set a breakpoint on the current line." Emacs[7] will take few seconds while it starts up the debugger (you may see a window or two flash up and vanish—this is no big deal). When everything is ready, you should see:

[7]One time I had a problem where it told me it had no handler for resolving the classpath. Restarting Emacs fixed this.


emacs@drew-VirtualBox
File Edit Options Buffers Tools Java YASnippet Debug JTags Help
Save
Undo
Uncaught Exceptions
Caught Exceptions
ThingTest.java:12 try-emacs
src > test > java > edu > duke > ece651 > ex
java > ThingTest > test_myFunction()
Local
x: Thing@41
this: ThingTest@42
Locals
Expressions
edu.duke.ece651.example.Thin
Breakpoints
Debug Sessions

```
package edu.duke.ece651.example;

import static org.junit.jupiter.api.Assertions.*;

import org.junit.jupiter.api.Test;

public class ThingTest {
  @Test
  public void test_myFunction() {
    Thing x = new Thing(3);
    assertEquals(8, x.myFunction(1, 2));
    assertEquals(42, x.myFunction(5, 6));
  }

}
```

```
-:---  ThingTest.java   All (12,1)     (Java//l edu.duke.ece651.example.ThingTest#test_myFunction - running
```

The middle part shows your code, with execution stopped at the breakpopint on the assertEquals (set by hitting C-c C-d). The left shows some things related to exceptions (which we won't go into here). On the right, you should have Local variables at the top, and a few other things below it.

If you are running in a graphical emacs, there will be a small row of buttons at the top to continue execution, step over the current statement, go up a frame, step into the current call, disconnect the debugger, or restart[8]. You should also have a hydra visible at the bottom of the window. A hydra is basically a different remapping of keys. While the hydra is open, the keys that it lists will behave differently. You can use C-c C-h to toggle whether the hydra is active.

You should be in the main code window (if not, go back into it). Either hit the "down arrow pointing at a dot" button if you prefer the graphical buttons, or if you are using the hydra, hit 'i' (for step in).

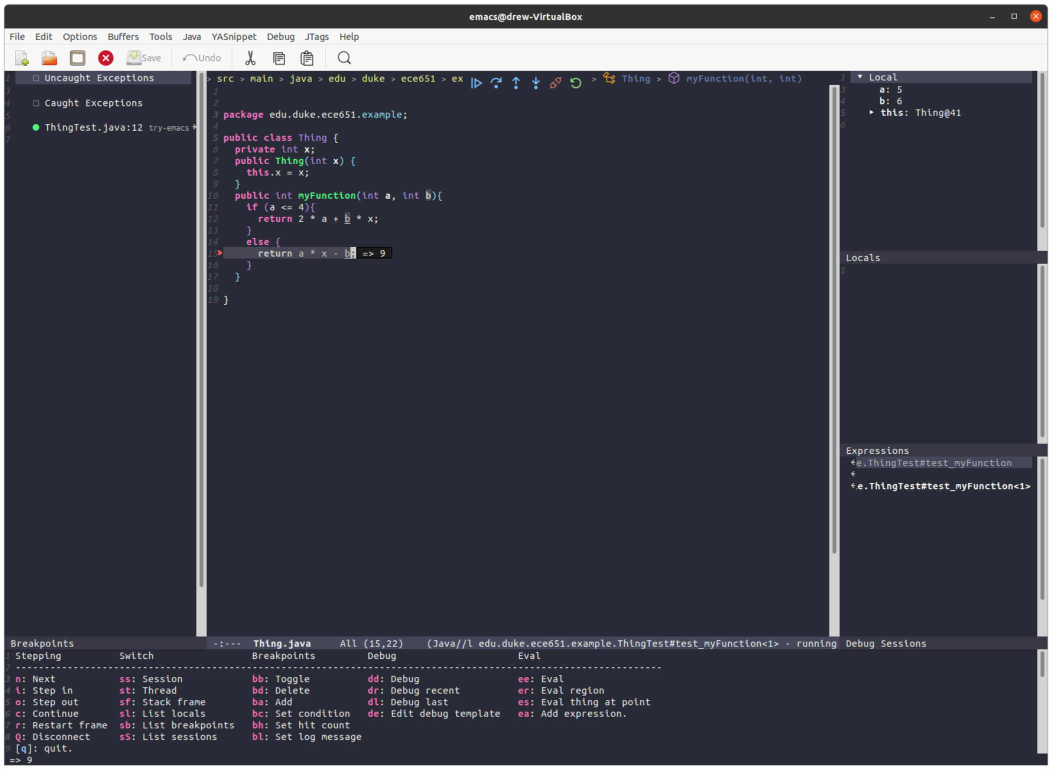
This should step inside the call to myFunction. Emacs will change to displaying Thing.java, and the execution will be in the start of myFunction. Note that the local variables on the right also changed. Of course, now `this` is our Thing object, which has `x=3`. You can see that if you expand `this=` on the right.

Now, let us go to the next line. If you are using the hydra, hit `n`. If you are using the buttons at the top, hit the one that looks like an arrow arcing over a dot. Now we are on

[8]If you use this, it will display an extra window with the debugger process. You can hide that with C-x 0.

the line of code that computes the return value. In gdb, you would use “print” (or “p”) to see the value a variety of things. Here, you are going to use one of the “e” commands on the right of the hydra (there is no equivalent to this in the buttons—the hydra provides many more options).

You can use “er” (Eval region) to evaluate an expression in a region you have selected. Set the mark at the start of the expression, then move the point to the end. Now hit “er” (with the hydra active). If you do this on the expression `a*x-b` in this code, you will see => 9 showing you that this expression evaluates to 9 (right next to it). You can see this behavior here:


emacs@drew-VirtualBox
File Edit Options Buffers Tools Java YASnippet Debug JTags Help
Save
Undo
Uncaught Exceptions
Caught Exceptions
ThingTest.java:12 try-emacs
src > main > java > edu > duke > ece651 > ex
Thing > myFunction(int, int)
Local
Locals
Expressions
Breakpoints
Debug Sessions

```
package edu.duke.ece651.example;

public class Thing {
  private int x;
  public Thing(int x) {
    this.x = x;
  }
  public int myFunction(int a, int b){
    if (a <= 4){
      return 2 * a + b * x;
    }
    else {
      return a * x - b; => 9
    }
  }

}
```

```
a: 5
b: 6
this: Thing@41
```

```
e.ThingTest#test_myFunction
e.ThingTest#test_myFunction<1>
```

```
-:---  Thing.java    All (15,22)    (Java//l edu.duke.ece651.example.ThingTest#test_myFunction<1> - running
```

```
Stepping          Switch               Breakpoints          Debug                     Eval
--------------------------------------------------------------------------------------------------
n: Next           ss: Session          bb: Toggle           dd: Debug                 ee: Eval
i: Step in        st: Thread           bd: Delete           dr: Debug recent          er: Eval region
o: Step out       sf: Stack frame      ba: Add              dl: Debug last            es: Eval thing at point
c: Continue       sl: List locals      bc: Set condition    de: Edit debug template   ea: Add expression.
r: Restart frame  sb: List breakpoints bh: Set hit count
Q: Disconnect     sS: List sessions    bl: Set log message
[q]: quit.
=> 9
```

Many of the other commands are familiar, even if by a slightly different name. The “o” command (step out) is “finish” (run until the current function returns). There are a variety of breakpoint commands in the “Breakpoints” column. When you are done debugging hit “Q”.

One thing about the “hydra” is that it is great when you want those keys to control the debugger, but terrible if you want to do anything else (like change buffers, edit code, etc), as the hydra intercepts those key strokes. You can pause/resume the hydra with C-c C-h (the h is for hydra). Note that you will be reminded of this as the debugging starts. So pause the hydra whenever you want to do anything else. You can also hide the hydra with “q”. If you want to quit the debugger, use ’Q’ in the hydra, or the “disconnect” button at the top (it looks like an orange plug being pulled out).

Let us wrap this “Debugging” up by “fixing” our contrived code by adding “+33” to the end of that line:

```
  return a * x + b + 33;
```

Now press "C-c C-t" again to see test coverage. At this point, we should have 100% coverage on Thing.java, and all the lines turned green–yay!

5.2 Having Emacs Do The Boring Stuff

So far, you have not needed to import any other packages (other than a few that were automatically setup for JUnit). However, as you develop with Java, you are going to find that you generally import many many packages. Let us write some code that needs to have an import from java.util. Go into Thing.java, and add another method:

```
 public int computeStuff(ArrayList<Integer> a,
                         ArrayList<Integer> b) {
}
```

As you type this, you will notice that flycheck puts a red underline under ArrayList[9], and a red `>>` on the left of the buffer to show you the problems. If you rest the point on the word ArrayList, you will get the message from flycheck that "ArrayList cannot be resolved to a type".

You can have Emacs import the packages that you need by hitting C-c TAB. You will see that your code got modified to have

```
import java.util.ArrayList;
```

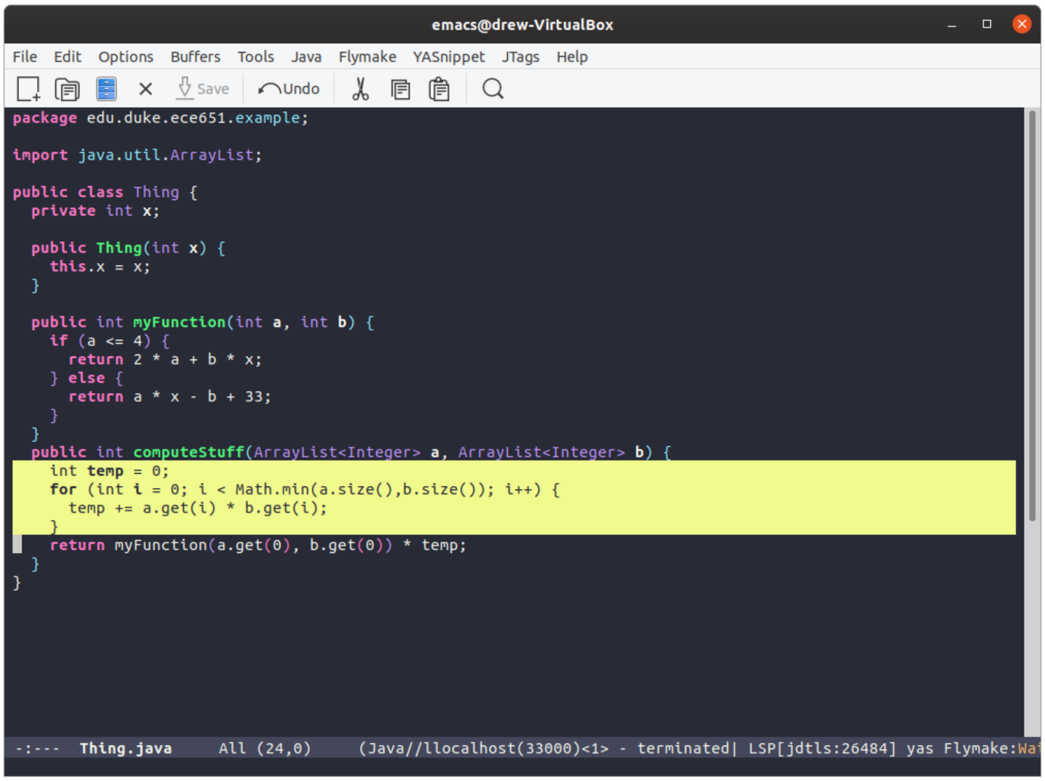
at the top. That is great, but flycheck is still unhappy with our method. If you rest the point on any of the underlined code, you will see that it is because we need to return an int, and we don't return anything yet.

While we are at it, let us take a moment to have Emacs open up the Javadoc (documentation) for ArrayList. Put the point on the word ArrayList, and press "C-c C-j". You will get prompted for the class name you want to lookup, with java.util.ArrayList at the first and in bold. Hit enter, and your default browser (likely Firefox) will load the page with the documentation for ArrayList. Note this might take a second as Firefox loads. After finding the methods that we need from this documentation, we write:

```
  public int computeStuff(ArrayList<Integer> a,
                          ArrayList<Integer> b) {
    int temp = 0;
    for (int i = 0; i < Math.min(a.size(),b.size()); i++) {
      temp += a.get(i) * b.get(i);
    }
    return myFunction(a.get(0), b.get(0)) * temp;
  }
```

[9]ArrayList is like std::vector from C++. Java also has Vector. The difference is that Vector locks a mutex for each method. Unless you need the mutex, use ArrayList.

Before we move on, we think “hey, maybe we should pull that first bit of code out into its own method, since it computes a dot product.. we might want to do that again”. Fortunately, Emacs can do this for you. Select that region of code:

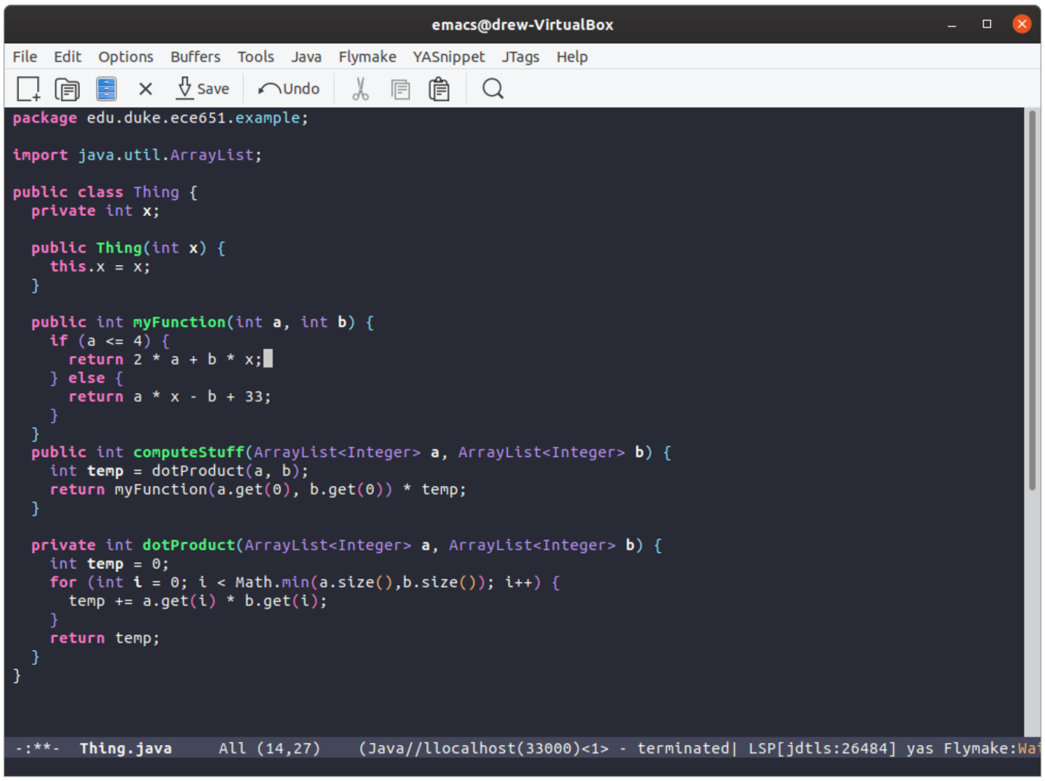

emacs@drew-VirtualBox
File Edit Options Buffers Tools Java Flymake YASnippet JTags Help
Save
Undo

```java
package edu.duke.ece651.example;

import java.util.ArrayList;

public class Thing {
  private int x;

  public Thing(int x) {
    this.x = x;
  }

  public int myFunction(int a, int b) {
    if (a <= 4) {
      return 2 * a + b * x;
    } else {
      return a * x - b + 33;
    }
  }
  public int computeStuff(ArrayList<Integer> a, ArrayList<Integer> b) {
    int temp = 0;
    for (int i = 0; i < Math.min(a.size(),b.size()); i++) {
      temp += a.get(i) * b.get(i);
    }
    return myFunction(a.get(0), b.get(0)) * temp;
  }
}
```

```
-:---  Thing.java     All (24,0)     (Java//llocalhost(33000)<1> - terminated| LSP[jdtls:26484] yas Flymake:Wa
```

Now hit “C-c C-e” (the e is for extract method). Emacs will prompt you for the name of the extracted method (the default is “extracted”—lets change that to “dotProduct”, then hit enter).

Now you should have code that looks like this:


emacs@drew-VirtualBox
File Edit Options Buffers Tools Java Flymake YASnippet JTags Help
Save
Undo

```
package edu.duke.ece651.example;

import java.util.ArrayList;

public class Thing {
  private int x;

  public Thing(int x) {
    this.x = x;
  }

  public int myFunction(int a, int b) {
    if (a <= 4) {
      return 2 * a + b * x;
    } else {
      return a * x - b + 33;
    }
  }
  public int computeStuff(ArrayList<Integer> a, ArrayList<Integer> b) {
    int temp = dotProduct(a, b);
    return myFunction(a.get(0), b.get(0)) * temp;
  }

  private int dotProduct(ArrayList<Integer> a, ArrayList<Integer> b) {
    int temp = 0;
    for (int i = 0; i < Math.min(a.size(),b.size()); i++) {
      temp += a.get(i) * b.get(i);
    }
    return temp;
  }
}

-:**-  Thing.java    All (14,27)    (Java//llocalhost(33000)<1> - terminated| LSP[jdtls:26484] yas Flymake:Wa
```

Note that if your code has syntax errors, extract method will not work. The error message you get will be a little misleading, as it says that the operation is unsupported.

Before we proceed, our code needs to be tidied up. Hit C-c C-f to autoformat the code.

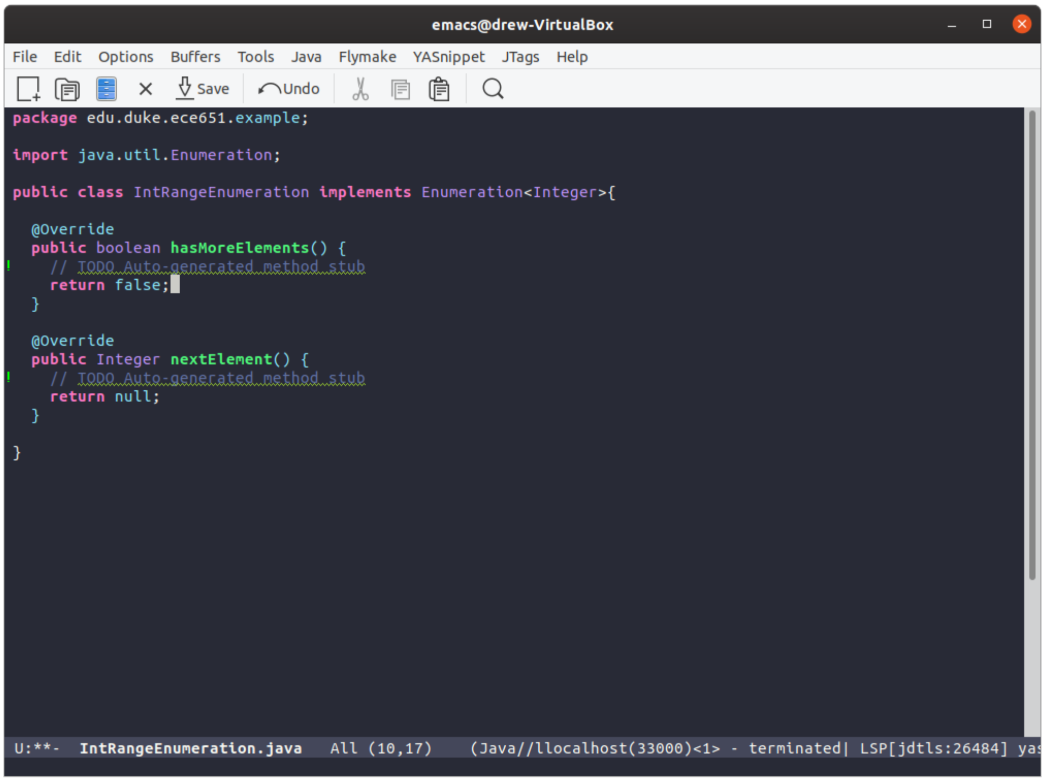
At this point, you can write a test case of your own for this method! Go back to the ThingTest.java class (C-x t), and add a new method. Write one or more test cases in this method. Note that you will need to use `new` to make ArrayLists. You might want to look in the Javadocs to find how to add items to the ArrayList. When you are done, run your test cases and look at your coverage.

Next, let us see how to auto-generate method stubs for methods that are required by an interface or abstract parent class. Let us start by making an IntRangeEnumeration class. Create IntRangeEnumeration.java in the **main** source directory (inside the example package). The easiest way to make sure you create this in the right place is to go back to Thing.java (which is in the directory you want) and C-x C-f from there. Remember that you can create the skeleton of this class with “C-c C-s”. Now add `implements Enumeration<Integer>` after the class name. Once you do that, you should have this:

```
pubic class IntRangeEnumeration implements Enumeration<Integer> {

}
```

notice that Enumeration is underlined in red. We need to import something, so we hit C-c TAB.

After that import is added, you will see that IntRangeEnumeration is underlined. The error now is that our class has to implement the methods that the interface requires ("implement the inherited abstract method XXX"). With the point anywhere on the method declaration line, hit "C-c C-a" (the a is for "add") to add stubs for the unimplemented methods. Now you should see:


emacs@drew-VirtualBox
File Edit Options Buffers Tools Java Flymake YASnippet JTags Help
Save
Undo

```
package edu.duke.ece651.example;

import java.util.Enumeration;

public class IntRangeEnumeration implements Enumeration<Integer>{

  @Override
  public boolean hasMoreElements() {
    // TODO Auto-generated method stub
    return false;
  }

  @Override
  public Integer nextElement() {
    // TODO Auto-generated method stub
    return null;
  }

}
```

```
U:**-  IntRangeEnumeration.java   All (10,17)    (Java//llocalhost(33000)<1> - terminated| LSP[jdtls:26484] yas
```

Note that there are green exclamation marks on the lines with TODO comments. These are there to make it easier to find things marked with TODO. Also note that these methods have the `@Override` annotation.

What do these methods need to do? Our idea for this class is that it should enumerate integers in a range. To see how that works with the methods required by the Enumeration interface, remember we can put the point on Enumeration and hit "C-c C-j" to read its Javadoc.

Accordingly, we might write:

```
public class IntRangeEnumeration implements Enumeration<Integer>{
  private int current;
  private int max;
  public IntRangeEnumeration(int low, int high) {
    this.current = low;
    this.max = high;
  }
  @Override
  public boolean hasMoreElements() {
    return current < max;
  }

  @Override
  public Integer nextElement() {
    if (current >= max) {
      throw new NoSuchElementException("No more elements in range");
    }
    int temp = current;
    current++;
    return temp;
  }

}
```

We again see that NoSuchElementException needs an import, so we hit C-c TAB to have Emacs automatically import it.

Of course, now you should create a test class (remember that C-x t will make the right file, and create the skeleton for a JUnit test for you), write some test cases, and run them. Are you happy with this code?

You can also have Emacs generate one particular method override from a parent class ("C-c C-o" the o is for override–you will be prompted to select which method to override) and getters/setters for a class ("M-g g", that is ESC g g—the g g is for "generate getters"). However, use the last with care. If you find yourself often making classes that expose many of their fields through getters/setters, you are probably doing something wrong in terms of design. If you use the generate getters/setters and have multiple fields that do not yet have getters and setters, you will get prompted for which one(s) you want. If you just want one, cursor down to the desired one and hit enter. If you want to select a few, go to the ones you want, and hit C-space on their lines. If you want all visible candidates, hit M-a to select all (you could select all then deselect a few). One you have the right selections, hit enter. If you have many selections to choose from, you can start typing the name of the field you want to narrow down what is shown.

5.3 Peeking

If you want to find the place(s) that something is defined or used (referenced), then you can "peek" at them with "C-c d" (for definitions) and "C-c u" (for uses). Note that both of these don't have control on the second character. Peeking at them means that emacs will put up a couple smaller windows. The right one will show you the files and the places in them that the definitions/uses are found (expand/collapse the files with enter). The left will show you the code around that definition/use.

If you hit enter on a particular use, you will stop peeking and switch your main code to view that use. If you want to stop peeking and stay where you are, just hit C-g (which you should remember from 551 cancels most things in Emacs).

6 Upping your Emacs/Git Game

At this point, you have the basics of your Java development setup. You should be able to work on your assignments in this class in Emacs and have all the basic features you need (if you want more, install the appropriate packages!). However, you may wish to have better git/Emacs integration. In this section, we will give you a quick introduction to `magit`, a powerful package that integrates git with Emacs. Later in the semester (when you start working in teams), we will come back and show you how to use `forge` (which works with magit) to integrate with GitLab's issue tracking/code review/pull request features. If you don't want to use git inside of emacs, you can continue to use it on the command line, and can do all of the issue tracking/code review/merge request activities from the GitLab website.

Before you start, we recommend that you do the following command:

```
git config --global status.showUntrackedFiles all
```

To start, hit "C-c g" which opens the magit status buffer. This buffer is where you will work from for most git things you need to do. This buffer will have various section for "Untracked files", "Unstaged changes", "Staged changes", etc. If you have been following along, you have many untracked files inside of the "try-emacs" directory. Magit will show that directory as something expandable/collapsable. If it is collapsed, move the point onto it and hit TAB. You should add things like build.gradle, and the src directroy (adding src will add all files inside it), but not things like "build" which were generated by gradle.

To add a file (or directory), move the point onto the line for that file in Unstaged changes list. Now hit "s" to stage You will see that it got moved to "Staged changes". Note that this action was basically like doing "git add" on that file. If you want to unstage this change, you can move the point onto the line for that file in the Staged Changes section and hit "u".

Let us suppose that you want to check exactly what you changed before you commit this change. Move the point onto the line for the file and hit TAB. In magit, TAB is expand/collapse. For a file with changes, expanding it shows the differences—things that were removed are in red with a - at the front, and things that were added are in green with a + at the front. You can collapse the changes back with TAB again. You can also use TAB to expand/collapse other things, like each of the sections (if you put the point on the section name). In our current situation, this is not super useful, as the changes are all "created the entire file"—but as you develop larger pieces of software over the semester, this will be a great feature.

Now let us commit our changes. Hit "c" in the magit status buffer. It will pop up a window at the bottom with various options and types of commits you can make. We want to make just a plain ordinary commit, so hit "c" again. You will now end up with the differences showing on the left, and the commit message on the right. Go ahead and write a commit message[10](such as "Wrote test cases for the Thing class: reached 100% coverage"). Unlike 551 where you would save and quit, when you are done, hit C-c C-c. This will finish the commit message and have magit make the commit.

Now, we'd like to push (assuming you forked the repo, instead of just cloning it). To push, hit "P" (case matters) and you will see a window at the bottom for various push options. We want to just push to origin (where we cloned from), so hit "u". You will then see

```
Running git push -v origin master:refs/heads/master
```

and if there are no problems, after a little while, it will switch to

```
Git finished
```

Of course, the other major operation you will want to do at this point is `git pull`. To do that, hit "F" and you will get the window for git pull. Hit "u" to pull from origin, and you will see similar messages as with pushing.

For quick reference on magit commands, please see: https://magit.vc/manual/magit-refcard.pdf

7 New Feature Quick Reference

Generating Things

```
C-c C-s Create class skeleton
C-c TAB Add missing imports
C-c C-a Add unimplemented methods
C-c C-o Add override
M-g g Add getters/setters
```

Changing Things

```
C-c C-e Extract method (from selected region)
C-c r   Rename symbol at point
C-c C-f Format buffer
```

Testing + Debugging

```
C-x t   Switch between main and test code
C-c C-t Run tests and show coverage
C-c -   Remove coverage colors
C-c C-d Debug current test method with breakpoint at point
C-c C-h Pause/resume debugger hydra
```

[10]I know many of you wrote really bad commit messages in 551. Now is the time to get in the habit of writing good ones, since you are about to work in teams...

Gradle Build

`C-c C-v`	`Gradle build`
`C-c x`	`Gradle clean + build`
`C-c C-r`	`Gradle build + run`

Finding Things

`C-c C-j`	`Javadoc lookup`
`C-c u`	`Peek at uses`
`C-c d`	`Peek at definitions`
`C-c i`	`Goto implementation (of method at point)`
`C-c t`	`Goto type definition (of type name/var name at point)`
	`(for variables: goes to definition of its static type)`

Git

`C-c g`	`Magit status buffer`

8 Customizing Emacs

We've tried to set you up with a good base setup, however, you may want to customize a lot of things. Feel free! If you have particularly nice customizations, or packages you really like, post them on Piazza. If something is very popular, we will consider including it in future setups.

8.1 Themes

If you do not like the Dracula theme that we picked, there are many other themes to choose from. You can start by looking at `https://emacsthemes.com/popular/index.html`. If you find a theme that you like, go into Emacs and hit

```
M-x list-packages
```

Give the package list a moment to load, then his C-s to incrementally search, and start typing the name of the theme. When you find it, click it and click "install". Then edit your `~/.emacs` file, and find

```
(load-theme 'dracula)
```

at the end. Change that to the name of the theme you installed. Your changes should take effect when you start Emacs.

8.2 Customization variables

If you hit `M-x customize` you will get the Emacs customization interface. Many packages provide a wide array of customizable settings. For example, if you change your theme and find that the code coverage coloration does not work well with your theme's colors, you might want to change the code coverage colors. The code coverage is provided by the dcoverage package, so type do `M-x customize` then type "dcoverage" into the search box. The first option will be "dcoverage covered statement color", which is the color for statements that got covered. If you expand this, you will see that it has the color (written as a hex value) and a "Choose" button. If you press the Choose button, you can select from about 500 pre-defined colors. You can, of course, also write in an RGB value in hex if you prefer.

8.3 Key bindings

We tried to set up a variety of useful key bindings. However, if you have other features you use often, or if these clash with key bindings you setup in 551 that you want to keep using, you can change them. Some key bindings are provided by packages (e.g., "C-c C-t" is provided by dcoverage) and may be customizable through `M-x customize`. Others we setup in the Java mode hooks, so just edit your `.emacs` file and look for the `local-set-key` commands in the Java mode hook.

8.4 Dcoverage

If you have feature requests for dcoverage, post them on Piazza. If they seem good, I'll implement them as time permits.