Today is the last day of drop/add
It is almost too late…

- You cannot switch your section without a permission number.
- DO NOT drop your section until you can get a perm number for the other section
- Go to https://www.cs.duke.edu/undergrad/registration
- Scroll down below office hours til you see Permission number for Spring 2020 courses
- Then fill out that form
- You must use permission number today!
- We will not be handing them out after 5pm

D is for …
- Debugging
  - A key skill in making your programs correct, your program will run without this skill
- Digital
  - All about the 1s and 0s

Plan for Today
- What work is here, what work is coming
  - P0, P1, APTs
- Understanding arrays and ArrayList: Tradeoffs
  - APTS always use arrays, convert to ArrayList?
- Reasoning empirically and analytically
  - Working well enough and working at scale
Announcements

• Assignment P0 due last week
  • No late penalty since first assignment til Jan 24
• APT-1 **now due** Thurs, January 23
  • Can still turn in Friday til 11:59pm
• Discussion 3 on January 27
  • Prediscussion, do before, out by Friday
• APT-2 out today, due January 28 (short 1 due)
• Assignment P1 out Friday, due Thursday, Jan 30
• Reading on calendar
  • Slowing down …..
  • try to read by date posted, ok if you need a few more days

Visualizations Help Understanding?

• **Javatutor** to visualize code: [http://pythontutor.com/java.html](http://pythontutor.com/java.html)
  • Using the java.awt.Color class
  • Both String and Color are **immutable**
    • Once created, cannot ever change

```
import java.awt.*;

public class ObjectColorDemo {
    public static void main(String[] args) {
        Color c = Color.RED;
        Color d = c;
        Color e = c.darker();
        Color f = new Color(255,0,0);
        System.out.println("%s\n%s\n%s\n",c,d,e,f);
    }
}
```

Arrays and APIs

• Accessing a list of sandwich ingredients [https://www2.cs.duke.edu/csed/newapt/sandwichbar.html](https://www2.cs.duke.edu/csed/newapt/sandwichbar.html)
  • Ingredients specified as string "lettuce tomato"
  • String split method
    ```
    String[] d = "lettuce tomato".split(" ")
    ```
  • d is
    ```
    [ “lettuce”, “tomato” ]
    ```
APTs: parsing/processing data

- String <-> String[]: parameter and return types
  ```java
  String s = "apple pear lemon orange";
  String[] ar = s.split(" ");
  ```

- Bridge from array to string?
  ```java
  String[] a = {"one", "two", "three"}
  String b = String.join(" ", a);
  ```

Helper methods
Creating your own API

- SandwichBar APT writeup
  [https://www2.cs.duke.edu/csed/newapt/sandwichbar.html](https://www2.cs.duke.edu/csed/newapt/sandwichbar.html)
  - Clue/hint that indexing loop appropriate
  - Helper function: array of strings contains all strings. Be creative in wanting an API for that

WOTO SandwichBar

- How to test locally?
  - Write main method. Create new object …
  - Faster to debug locally, even use debugger?

```java
public static void main(String[] args) {
    SandwichBar sb = new SandwichBar();
    String[] av = {"cheese", "cheese", "cheese", "tomato"};
    String[] orders = {"ham ham ham", "water", "pork", "bread",
                       "cheese tomato cheese", "tomato lettuce"};
    int dex = sb.whichOrder(av, orders);
    System.out.printf("index = %d\n", dex);
}
```
Helper methods
Creating your own API

• **SandwichBar APT** writeup
  • **Helper function**: array of strings contains all strings. Be creative in wanting an API for that

```
public class SandwichBar {
    public int whichOrder(String[] available, String order) {
        for (int k=0; k< orders.length; k++) {
            String sandwich = orders[k];
            if (canMake(available, sandwich)) {
                return k;
            }
        }
    }
}
```

Scoring WOTOs going forward

• Each regular WOTO form is worth 2 pts
• If 2 WOTOs in a lecture, each worth 2 pts
• Some WOTO forms correctness will count and each problem is worth pts (likely 1 pt each)
• We are dropping all WOTOs done before today

• SUBMIT ALL WOTO FORMS – they count!
• Work Together with others
Nancy Leveson: Software Safety

- (@MIT) Mathematical and engineering aspects, invented the discipline
- Air traffic control
- Microsoft word
  - “There will always be another software bug; never trust human life solely on software” huffington post?
- Therac 25: Radiation machine
  - Paper on this: http://bit.ly/5qOjoH
- Software and steam engines

Source Code, Byte Code

- High level languages compiled to low level languages
  - In C/C++ low-level specific to platform
  - In Java byte code is low-level
- Execute by machine: real or virtual
- JVMs must be ported to platform
- Android doesn’t use JVM
  - Dalvik and now ARM
- Be grateful!!!!!
  - High level source code

From Hello.java to Hello.class

```java
public class Hello {
    public static void main(String[] args){
        System.out.println("hello world");
    }
}
```

Code:

```
0: aload_0
1: invokespecial #1
4: return
```

Code:

```
0: getstatic #2
3: ldc #3
5: invokevirtual #4
8: return
```
Project P1 out soon

- See course website for details, discussion D3
  - Not quite this, but …
    https://www.youtube.com/watch?v=DoLe1c-eokI
- Read assignment before starting to code
  - Think before fingers on keys
- Use Piazza and Helper Hours

Projects in 201: Review

- Start with GitLab project, fork repository
  - Starter code and cloud-based storage for projects
  - Clone repo to your machine: you need Git for this
- You use Duke Compsci GitLab website
  - You manage your code/projects with GitLab
- Make changes, complete project
  - Push changes frequently using Git … hourly/daily

What is Git?

- Git is a free and open source distributed version control system designed to handle everything from small to very large projects with speed and efficiency. https://git-scm.com/
- In teams, huge win. Individually, huge win
  - Git is complicated when it doesn't work, lots of commands
  - Git relies on SSH to be secure

Assignments P0 and P1

- Simple Java class with driver programs
  - How is a program run? What is main?
  - Testing methods and testing classes
- Example of 201 work-flow
  - GitLab for starter code and your code
  - Using SSH and GitLab together
  - Submitting via Gradescope, Analysis
What is a static method?

- Objects are instances of a class
  - Thus objects have instance variables
  - Typically private, accessed in methods

- Static method belongs to class, not object
  - No instance variables
  - Accesses static variables and methods
  - More on this later, for now? …

Static Methods

- The class Math has many (java.lang)
  - `sqrt`, `cos`, `abs`, …
- The class Arrays has many (java.util)
  - `sort`, `fill`, `toString`, `asList`, …

- Invoke as `Math.sqrt(25.0)` or `String.join(…)`
  - Math is a class. Convention for name?
  - There aren't different Math objects, none!
    - No state needed, all code in methods

WOTO: Correctness Counts