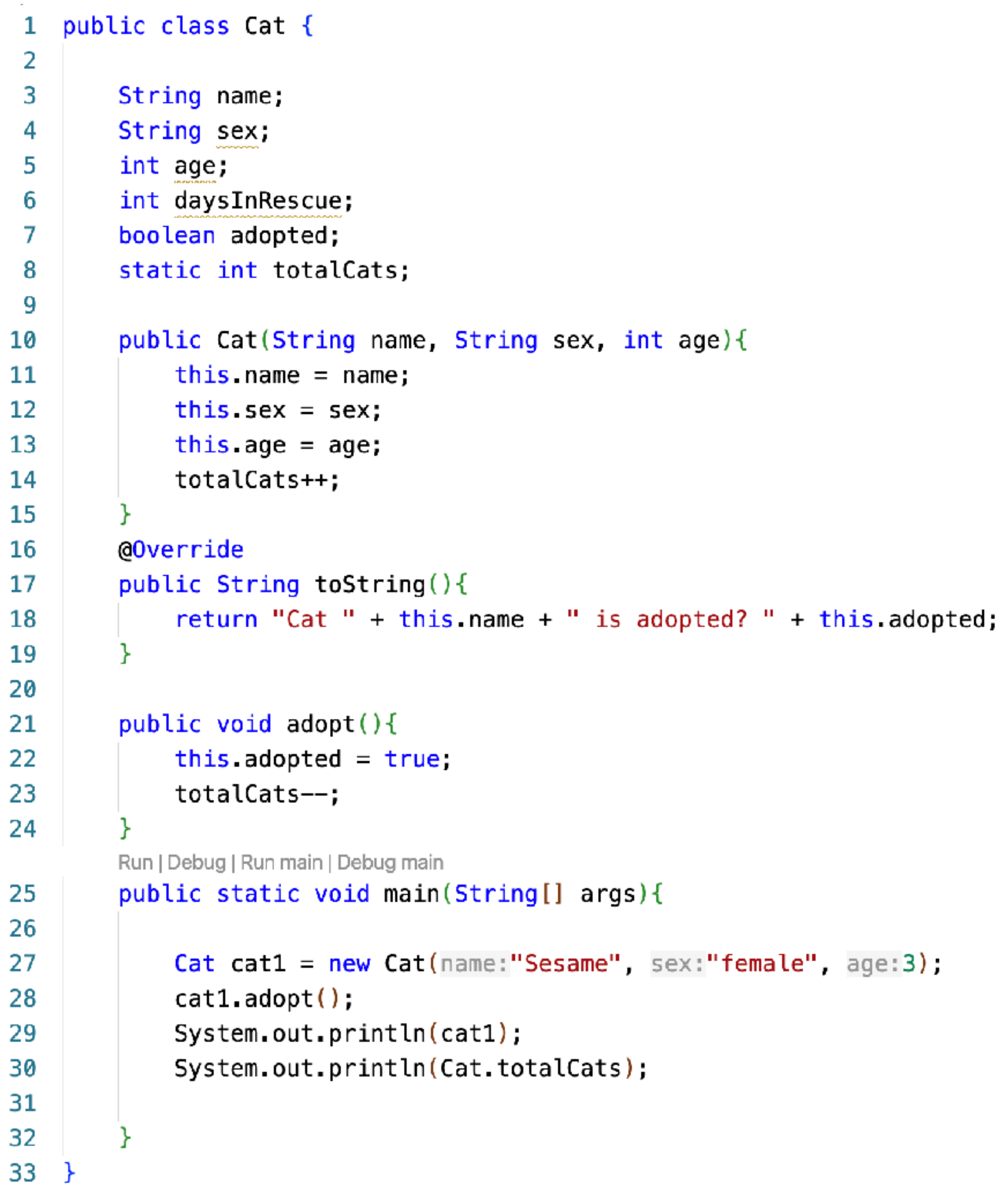
CS62 Class 3: Encapsulation, I/O streams

(and a last bit of Java syntax)

Java Fundamentals



```java
public class Cat {

    String name;
    String sex;
    int age;
    int daysInRescue;
    boolean adopted;
    static int totalCats;

    public Cat(String name, String sex, int age){
        this.name = name;
        this.sex = sex;
        this.age = age;
        totalCats++;
    }
    @Override
    public String toString(){
        return "Cat " + this.name + " is adopted? " + this.adopted;
    }

    public void adopt(){
        this.adopted = true;
        totalCats--;
    }
    Run | Debug | Run main | Debug main
    public static void main(String[] args){

        Cat cat1 = new Cat(name:"Sesame", sex:"female", age:3);
        cat1.adopt();
        System.out.println(cat1);
        System.out.println(Cat.totalCats);

    }
}
```

Last time review

- Java is OOP: constructors, instances, methods
- static variables have 1 value across the class. instance variables have a new value for each instance

Any questions?

Lecture 3 agenda

- Encapsulation, access keywords & data hiding: `public` vs `private` keywords
- The last bit of more Java Syntax
- The last bit of more on Arrays
- File I/O, reading and writing files

Encapsulation

Data hiding (aka encapsulation)

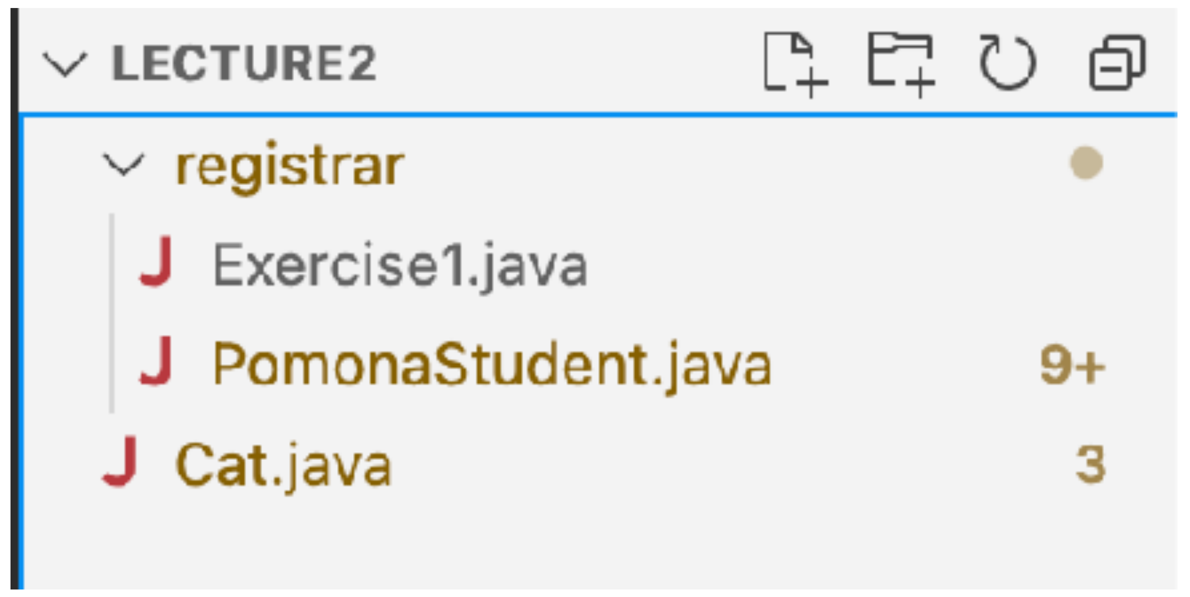
- Data hiding is a core concept in Object-Oriented Programming.
- We encapsulate data and related methods in one class and we restrict who can see and modify data.
  - For example, FERPA protects the privacy of students so the Registrar cannot share their academic record freely, even if it's their parents who request it.
- Java uses access modifiers to set the access level for classes, variables, methods and constructors.

Access Modifiers: public, private, default, protected

- You are already familiar with the public keyword. E.g., `public class PomonaStudent`.
- For classes, you can either use public or *default*:
    - public: The class is accessible by any other class. E.g.,
        - `public class PomonaStudent`
    - *default*: The class is only accessible by classes in the same package (think of it as in the same folder. More soon). This is used when you don't specify a modifier. E.g.,
        - `class PomonaStudent`
- For variables, methods, and constructors, you can use any of the following:
    - `public:` the code is accessible by any other class
    - `private`: The code is only accessible within the declared class
    - *default*: The code is only accessible in the same package. This is used when you don't specify a modifier
    - `protected:` The code is accessible in the same package and subclasses (more later).

Package

- A grouping of related classes that provides access protection and name space management. E.g.,
  - `java.lang` and `java.util` for fundamental classes or `java.io` for classes related to reading input and writing output.
- Packages correspond to folders/directories.
- Lower-case names. E.g.,
  - `package registrar;`
  - at top of file and file has to be within registrar folder
- `import java.util.*;`
  - for including all classes.
- or `import java.util.Arrays;`
  - for more specific access.



demo: using PomonaStudent in Exercise1, since they're both in the registrar package

https://docs.oracle.com/javase/tutorial/java/package/packages.html

Data Hiding

- To follow the concept of data hiding, we prefer to define instance variables as `private`.

- We provide more lax (i.e. `default`, `protected`, or `public`) getter and setter methods to access and update the value of a `private` variable.

PomonaStudent class with data hiding

```
package registrar;
public class PomonaStudent {

    private String name;
    private String email;
    private int id;
    private int yearEntered;
    private String academicStanding;
    private boolean graduated;
    private static int studentCounter;

    String getName() {
        return name;
    }

    void setName(String name) {
        this.name = name;
    }

    String getEmail() {
        return email;
    }


    void setEmail(String email) {
        this.email = email;
    }
…
```

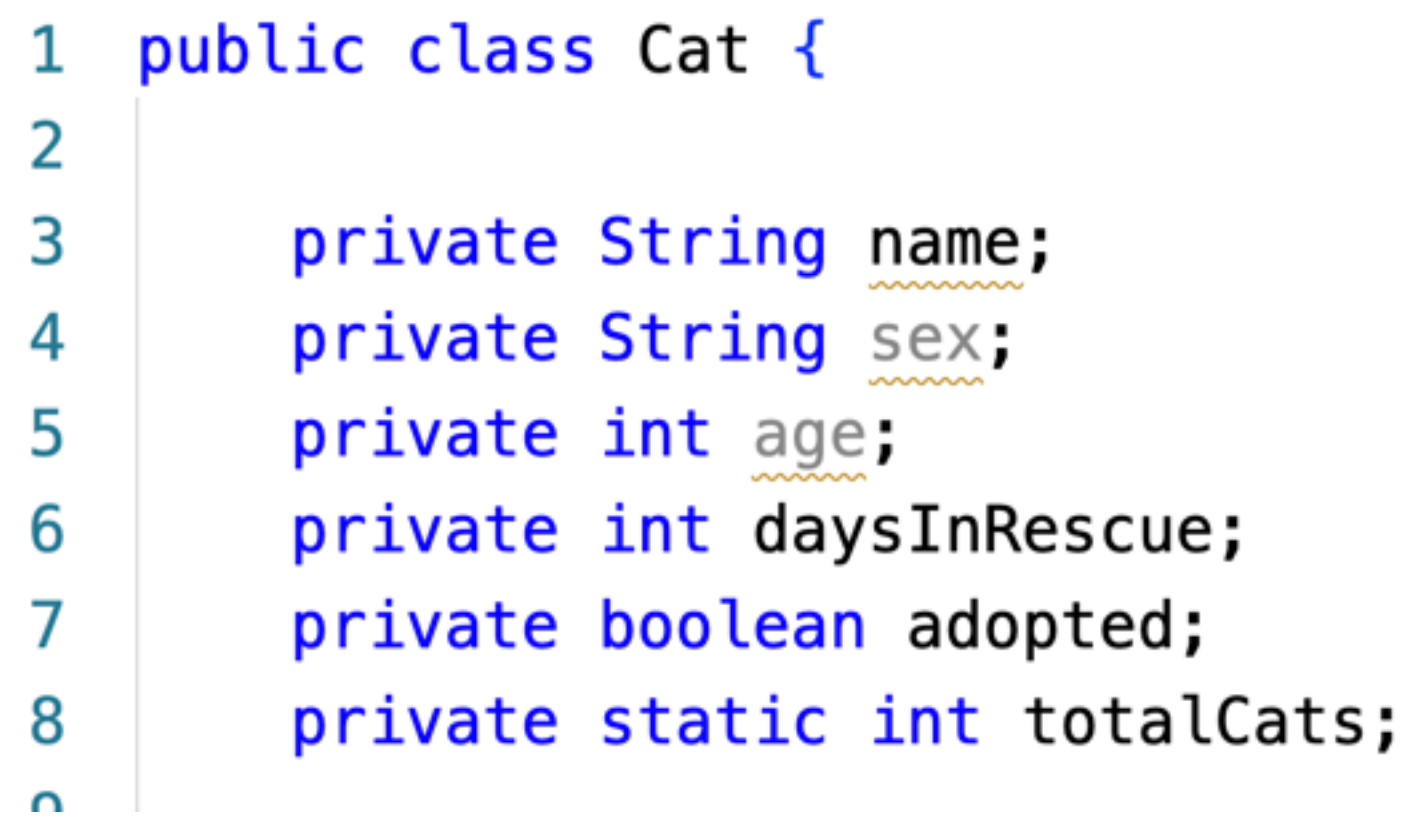
we have moved the file to the registrar/ folder and declared `package registrar`

all the instance variables have been declared `private`

getters and setters are `default` access (any code in the package can use them)

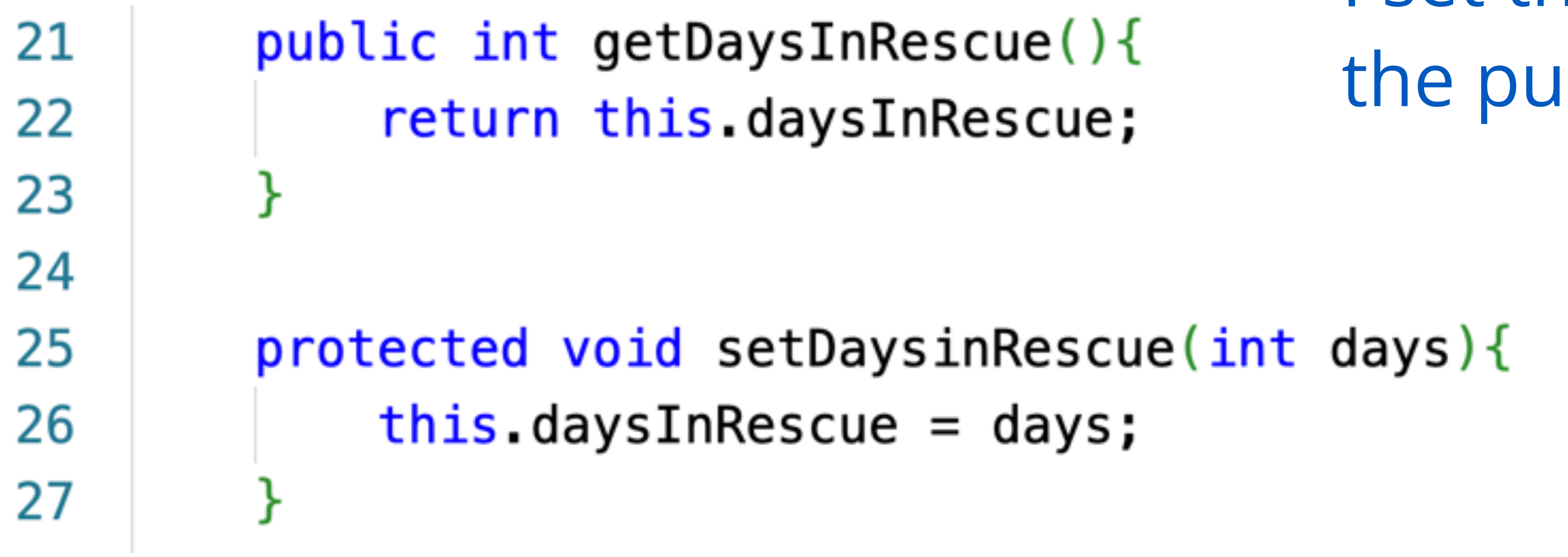
Worksheet time!

- Do problem 2 f-g on your worksheet (from last class). Work in a group of 2-4.
    a. Update all the instance variables to be private.
    b. Define a getter method that returns the days spent in rescue, and a setter method that updates the days spent. Make sure they have the correct access modifiers.
    c. Create a new cat, set it to have spent 20 days in rescue, and print out the number of days.



```java
public class Cat {

    private String name;
    private String sex;
    private int age;
    private int daysInRescue;
    private boolean adopted;
    private static int totalCats;
```

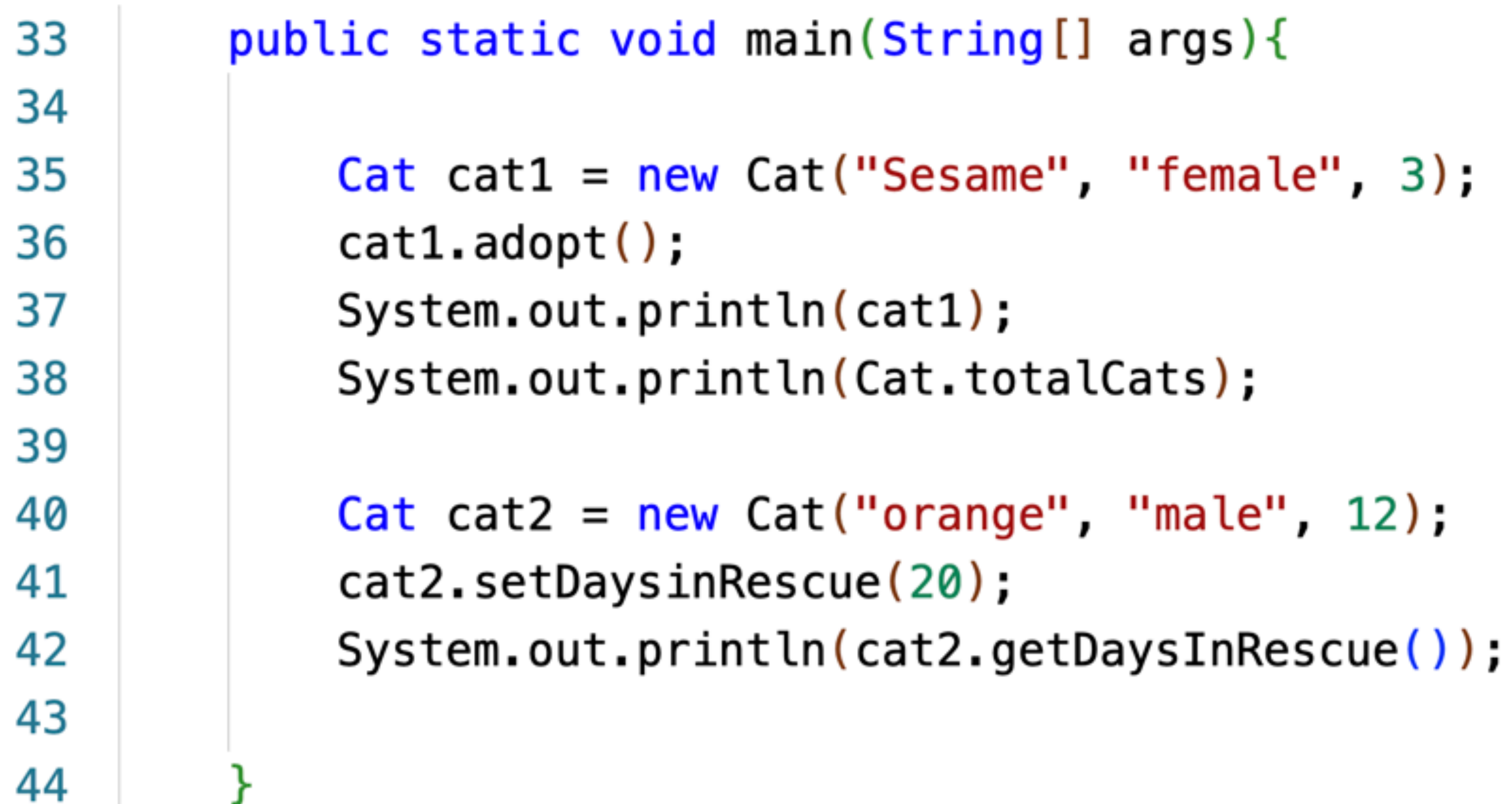


```java
    public int getDaysInRescue(){
        return this.daysInRescue;
    }

    protected void setDaysinRescue(int days){
        this.daysInRescue = days;
    }
```

I set the getter to public because it’s OK if the public can see this variable

It’s dangerous to set setters to public - what if there’s a data attack - so I chose protected, but default/private are also good



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

        Cat cat1 = new Cat("Sesame", "female", 3);
        cat1.adopt();
        System.out.println(cat1);
        System.out.println(Cat.totalCats);

        Cat cat2 = new Cat("orange", "male", 12);
        cat2.setDaysinRescue(20);
        System.out.println(cat2.getDaysInRescue());

    }
```

remember, we have to call getters and setters now - *technically* you could directly access cat2.daysInRescue since it’s all the Cat class, but it’s good programming practice to always use the getter/setter methods for private instance variables

Our last bit of Java syntax

Operators

Operator precedence

Higher on the table = evaluated earlier

Operators	Precedence
postfix	`expr++ expr--`
unary	`++expr --expr +expr -expr !expr`
multiplicative	`* / %`
additive	`+ -`
relational	`< > <= >=`
logical AND	`&&`
logical OR	`||`
ternary	`? :`
assignment	`= += -= *= /= %=`

Unary Operators

- Unary operators require only one operand.

Operator	Description	Example	
+	Unary plus operator; indicates positive value (not necessary to have)	`int x = +1;`	1
–	Unary minus operator; negates an expression	`x = -x;`	-1
++	Increment operator; increments a value by 1	`++x;`	0
––	Decrement operator; decrements a value by 1	`—x;`	-1
!	Logical complement operator; inverts the value of a boolean	`boolean success = false;` `!success;`	true

Pre vs post-fix operators

- The increment/decrement operators can be applied before (prefix) or after (postfix) the operand.

- The code `result++;` and `++result;` will both end in `result` being incremented by one. The only difference is that the prefix version (i.e. `++result`) evaluates to the incremented value, whereas the postfix version (i.e. `result++`) evaluates to the original value.

- If you are just performing a simple increment/decrement, it doesn't really matter which version you choose. But if you use this operator in part of a larger expression, the one that you choose may make a significant difference.

Pre vs post-fix operators example

```
int i = 3;
i++;
System.out.println(i);  // prints i (4)
++i;
System.out.println(i);  // prints i (5)
System.out.println(++i); // first increments to 6 then
prints it (6)
System.out.println(i++); // first prints i (6) then
increments i to 7
System.out.println(i); // prints i (7)
```

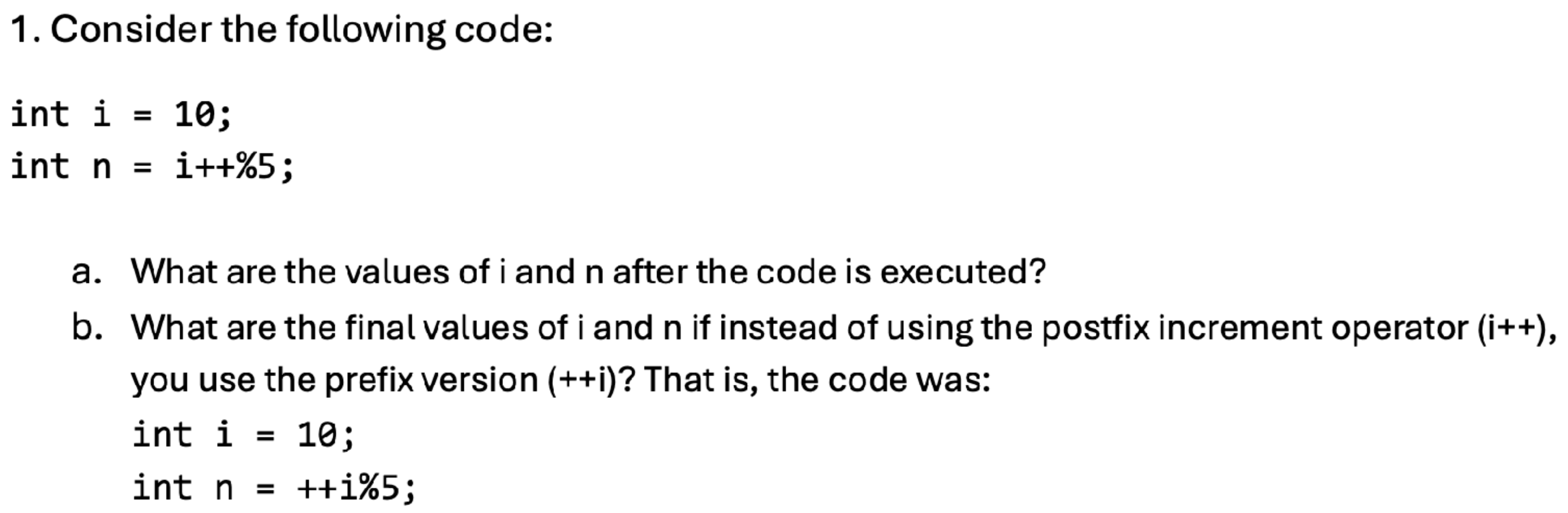
Conditional operators

- The && and || operators perform Conditional-AND and Conditional-OR operations on two boolean expressions. Remember your truth tables!

exp1	exp2	exp1 && exp2	exp1 || exp2
`true`	`true`	`true`	`true`
`true`	`false`	`false`	`true`
`false`	`true`	`false`	`true`
`false`	`false`	`false`	`false`

Worksheet time!

- Do problem 1 on the new lecture 3 worksheet.



1. Consider the following code:

```
int i = 10;
int n = i++%5;
```

a. What are the values of i and n after the code is executed?

b. What are the final values of i and n if instead of using the postfix increment operator (i++), you use the prefix version (++i)? That is, the code was:

```
int i = 10;
int n = ++i%5;
```

Worksheet answers

- a. i is 11, n is 0 (since i++ evaluates first, then increments i)
- b. i is 11, n is 1 (since ++i increments i before evaluation)

Even more control flow

`do-while` loop

- Variant of `while` loop that will execute the block of code in the `do` code block once, before it checks if the condition is `true`. It will then proceed as usual.
- Basic syntax:

```
do {

  // code block to be executed

} while(condition);
```

- Make sure your condition terminates otherwise you will enter an infinite loop.

do–while loop example

```
int j = 3;
do {
    System.out.println("This is the best semester ever");
    j++;
}
while(j>5);
```

- Will print

```
This is the best semester ever
```

even though the condition never got satisfied

`break`

- Exits completely out of a `for`, `while`/`do-while` loop.

break example

```
for (int l = 0; l < 10; l++) {

    if (l == 4) {

        System.out.println("I am out of here");

        break;

    }

    System.out.println(l);

}
```

- Will print

```
0
1
2
3
I am out of here
```

`continue`

- Will skip the current iteration of a `for`, `while`/`do–while` loop.

continue example

```
for (int x = 0; x < 5; x++) {

    if (x == 3) {

       System.out.println("I am skipping this step");

       continue;

    }

    System.out.println(x);

}
```

- Will print:

```
0
1
2
I am skipping this step
4
```

`switch` statement

- Use instead of writing many if-else statements.
- Evaluate expression and compare it with the values of each case
- Works with `byte`, `short`, `char`, `int`, and `String`.
- Basic syntax:

```
switch(expression) {
  case x:
    // code block
    break;
  case y:
    // code block
    break;
  default:
    // code block
}
```

switch example

```
int finger = 4;
switch (finger) {
  case 1:
    System.out.println("thumb");
    break;
  case 2:
    System.out.println("index");
    break;
  case 3:
    System.out.println("middle");
    break;
  case 4:
    System.out.println("ring");
    break;
  case 5:
    System.out.println("pinky");
    break;
  default:
    System.out.println("Not a valid number”);
}
```

`break` and `default`

- When Java reaches a `break` keyword, it breaks out of the switch block and does not execute the rest of the code.
  - You need to add a `break` statement otherwise you will go through all the remaining cases!
- The `default` keyword specifies what code to run if there is no case match.

What would happen if we didn’t include break?

```
int finger = 2;
switch (finger) {
  case 1:
    System.out.println("thumb");
 case 2:
    System.out.println("index");
 case 3:
    System.out.println("middle");
 case 4:
    System.out.println("ring");
 case 5:
    System.out.println("pinky");
 default:
    System.out.println("Not a valid number”);
}
```

It will print :

index

middle

ring

pinky

Not a valid number

Ternary operator

- `?:` A conditional operator that is a shorthand for the `if-else` statement.
- Basic syntax:

```
variable = expression1 ? expression2: expression3
```

- Equivalent to:

```
if (expression1) {
    variable = expression2;
}
else {
    variable = expression3;
}
```

Ternary operator example

```
int n1 = 32;

int n2 = 47;

int max;



// Largest among n1 and n2

max = (n1 > n2) ? n1 : n2;



// Print the largest number

System.out.println("Maximum is = " + max);
```

Worksheet time!

- Do problem 2 on your worksheet:
- What does this print?

```
int n1 = 10;
int n2 = 47;
int n3 = 4;
System.out.println((n1%n3>n2%n3) ? (n1+n2):(n1-n2));
```

Worksheet answers

- `(n1%n3>n2%n3) ? (n1+n2):(n1-n2)`
- 10%4 = 2, 47%4 = 3. 2 > 3 is false, so we evaluate n1-n2, or 10-47, so it prints **-37**.

Even more arrays

Review: working with arrays

- Creating a variable to refer to an array

```
int[] numArray; // declares a variable to refer to an array of ints
int numArray[]; //also works but discouraged
```

- Creating and initializing an array

```
int[] numArray = new int[10]; // allocates an array for 10 integers
```

- Creating and initializing an array - shorthand

```
int[] numArray = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};
```

Multi-dimensional arrays

- An array of arrays. Each array, will have its own set of curly braces. E.g.,
  - `int[][] myNumbers = { {1, 2, 3, 4}, {5, 6, 7} };`
- To access the elements of a multi-dimensional array, you need first to specify the array and then the element of the array. For example:
  - `System.out.println(myNumbers[1][2]); // Outputs 7`
  - We still count starting at 0!
- To change the value of an element in a multi-dimensional array, you have to index it as above. For example:
  - `myNumbers[1][2] = 9;`
  - `System.out.println(myNumbers[1][2]); // Outputs 9 instead of 7`

https://www.w3schools.com/java/java_arrays.asp

Looping through Arrays: Using a for loop and length

- Arrays have fixed length so a for loop makes sense. E.g.,

```
String[] cars = {"Volvo", "BMW", "Ford", "Mazda"};
for (int i = 0; i < cars.length; i++) {
  System.out.println(cars[i]);
}
```

- Will print

```
Volvo
BMW
Ford
Mazda
```

For-each loop

- A new way of looping through arrays that doesn't need an iteration counter.
- Basic syntax:

```
for (type variableName : arrayName) {
     ...
}
```

- For example:

```
String[] cars = {"Volvo", "BMW", "Ford", "Mazda"};
for (String car : cars) {
      System.out.println(car);
} //works same as before
```

compare to Python:

```
cars = [“Volvo”, “BMW”, …]
for car in cars:
    print(car)
```

Worksheet time!

- Declare and initialize an array of strings with all the classes you are taking this semester.
  - Remember the word `class` is a reserved word, you cannot use it to name your variables.
- Write a for loop that loops through each class
- If a class is called “CS62” you need to print “CS62: This is the best class ever, no need to see more” and break the for loop.
  - We will use the equals method to compare equality among Strings.
  - e.g., someString.equals(someOtherString)
- Otherwise, if a class is called “CS101”, you need to print “CS101: New CS achievement unlocked” and continue to the next iteration.
- Otherwise, print the name of the class.

Worksheet answers

- You could have also used a regular for loop instead of a for-each loop.

```
String[] classes = {"PHYS32", "CS101", "ANTH51", "CS62", "IMAG2"};
for(String myClass:classes){
    if(myClass.equals(”CS62”)){
         System.out.println("CS62: This is the best class ever, no need to see more");
         break;
    }
    else if(myClass.equals(“CS101”)){
        System.out.println("CS101: New CS achievement unlocked");
        continue;
    }
    System.out.println(myClass);
}
```

do you need the continue statement?

I/O Streams

I/O streams

In Python, it was open()... read()... write()...

- Input stream: a stream from which a program reads its input data
- Output stream: a stream to which a program writes its output data
- Error stream: output stream used to output error messages or diagnostics
- Stream sources and destinations include disk files, keyboard, peripherals, memory arrays, other programs, etc.
- Data stored in variables, objects and data structures are temporary and lost when the program terminates. Streams allow us to save them in files, e.g., on disk or flash drive or even a CD (!)
- Streams can support different kinds of data: bytes, characters, objects, etc.

https://docs.oracle.com/javase/tutorial/essential/io/streams.html

Files

- Every file is placed in a directory in the file system.
- Absolute file name: the file name with its complete path and drive letter. E.g.,
  - On Windows: `C:\jli\somefile.txt`
  - On Mac/Unix: `/~/jli/somefile.txt`
- **CAUTION: DIRECTORY SEPARATOR IN WINDOWS IS \, WHICH IS A SPECIAL CHARACTER IN JAVA. SHOULD BE "\\" INSTEAD.**
- `File` class: contains methods for obtaining file properties, renaming, and deleting files. Not for reading/writing!

Writing data to a text file

- `PrintWriter output = new PrintWriter(new File("filename"));`
- If the file already exists, it will overwrite it. Otherwise, new file will be created.
- Invoking the constructor may throw an IOException so we will need to follow the catch or specify rule.
- `output.print` and `output.println` work with Strings, and primitives.
- Always close a stream!

https://docs.oracle.com/javase/7/docs/api/java/io/PrintWriter.html

Writing data to a text file

```
import java.io.File;
import java.io.IOException;
import java.io.PrintWriter;

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

        PrintWriter output = null;
        try {
            output = new PrintWriter(new File("addresses.txt"));
            // Write formatted output to the file
            output.print("Alexandra Papoutsaki ");
            output.println(222);
            output.print(“Jingyi Li ");
            output.println(111);

        } catch (IOException e) {
            System.err.println(e.getMessage());
        } finally {
            if (output != null)
                output.close();
        }
    }
}
```

need to import relevant classes

call .print or .println to write to file

catch IOException for any errors

.close() the I/O stream

https://liveexample.pearsoncmg.com/html/WriteData.html

Reading data

- `java.util.Scanner` reads Strings and primitives and breaks input into tokens, denoted by whitespaces.
- To read from keyboard: `Scanner inputStream = new Scanner(System.in);`
  - `String input = inputStream.nextLine();`
  - `input` is a String. If you want to convert it into a number, you will need to use the wrapper class of the primitive you want, e.g., `Integer.parseInt(input);`
- To read from file: `Scanner inputStream = new Scanner(new File("filename"));`
- Need to close stream as before.
- `inputStream.hasNext()` tells us if there are more tokens in the stream. `inputStream.next()` returns one token at a time.
  - Variations of next are `nextLine()`, `nextByte()`, `nextShort()`, etc.

Reading data from a text file

```java
import java.io.File;
import java.io.IOException;
import java.util.Scanner;

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

      Scanner input = null;
      // Create a Scanner for the file
      try {
         input = new Scanner(new File("addresses.txt"));

         // Read data from a file
         while (input.hasNext()) {
            String firstName = input.next();
            String lastName = input.next();
            int room = input.nextInt();
            System.out.println(firstName + " " + lastName + " " + room);
         }
      } catch (IOException e) {
         System.err.println(e.getMessage());
      } finally {
         if (input != null)
            input.close();
      }
   }
}
```

same try…catch…finally structure

use Scanner class

use a while loop to check if file still has lines

.next() is space separated (if you want the whole line, call .nextLine())

close the file

https://liveexample.pearsoncmg.com/html/ReadData.html

Worksheet time!

- Fill in lines of code in the Java class called FileIOExample
- It will contain a main method that will prompt the user for a String corresponding to a text file in their directory and a number for how many lines of text they want to read from that file.
- It should use these 2 pieces of information to open the file, read the specified number of lines, and write them into a new file called output.txt.
- You can add whatever checks for exceptions you think are appropriate.
- Don’t forget to close the input and output streams!

Worksheet answers

- https://github.com/pomonacs622025sp/code/blob/main/Lecture3/FileIOExample.java

Lecture 3 wrap-up

- Data and methods can be declare public, private, default, or protected
- File I/O classes: Scanner, FileWriter
- TODO: HW1 due TONIGHT! (Kellie's mentor hours 8-10pm)
- Lab (and HW2) have been released on Canvas, please come to lab tomorrow having **already forked Lab 1 to your own computer and read the README file.**
- Your first quiz will be in lab (on all the material we've seen before). 5 min. It's not too hard! Bring a red or differently colored pen; self graded.

Resources

- I/O: https://docs.oracle.com/javase/tutorial/essential/io
- See the appendix for more practice problems

Appendix: More review

The simple assignment operator

- One of the most common operators that we’ve already encountered is the simple assignment operator “="; it assigns the value on its right to the operand on its left. For example:
    - int age = 19;
    - int year = 2024;

Arithmetic operators

- Java arithmetic operators support addition, subtraction, multiplication, division, and remainder/modulo.

Operator	Description
+	Additive operator (also used for String concatenation)
–	Subtraction operator
*	Multiplication operator
/	Division operator
%	Remainder operator

Practice problems

Assume you are given the following Java code. What would be printed on your screen?

```
int result = 1 + 2;
System.out.println("1 + 2 = " + result);
int original_result = result;

result = result − 1;
System.out.println(original_result + " − 1 = " + result);
original_result = result;

result = result ∗ 2;
System.out.println(original_result + " ∗ 2 = " + result);
original_result = result;

result = result / 2;
System.out.println(original_result + " / 2 = " + result);
original_result = result;
```

Answer

1 + 2 = 3

3 - 1 = 2

2 * 2 = 4

4 / 2 = 2

2 + 8 = 10

10 % 7 = 3

Other assignment operators

- The assignment operators +=, -=, *=, /=, and %= are a compound of arithmetic and assignment operators.
- They operate by adding/subtracting/multiplying/dividing/taking the remainder of the current value of the variable on the left to the value on the right and then assigning the result to the operand on the left. E.g.,
- `num1 += num2;` means `num1 = num1 + num2;`

Equality and relational operators

- Determine if one operand is greater than, less than, equal to, or not equal to another operand

Operator	Description
==	equal to
!=	not equal to
>	greater than
>=	greater than or equal to
<	less than
<=	less than or equal to