IGNITECS KICKOFF MEETING

MONDAY, SEPTEMBER 18
5:30 PM
CIT ROOM 368

Passionate about computer science education? Join us for our kickoff meeting to learn more!

PIZZA WILL BE PROVIDED!
Lecture 3
Introduction to Parameters / Math
Review of Inter-Object Communication

- A class provides a blueprint for instances of that class
- Instances send each other messages
- Instances respond to a message via a method
- Format of messages is `<instance>..<method>()`
  - e.g., `samBot.moveForward(3)`;
- Sometimes an instance want to send a message to itself, using a method defined in its own class: `this.<method>()`
- `this` means “me, myself” AND the method is defined in this class
  - Choreographer tells dancer: `dancer3.pirouette(2)`;
  - Dancer tells themself: `this.pirouette(2)`;
  - Note: we’ve not yet learned how to create new instances of any class

Note: Object is used loosely for both class and instance. We try to minimize our use of this overloaded term.
This Lecture:

- Mathematical functions in Java
- Defining more complicated methods with inputs and outputs
- The constructor
- Creating instances of a class
- Understanding Java flow of control
Defining Methods

- We know how to define simple methods
- Today, we will define more complicated methods that have both inputs and outputs
- Along the way, we will learn the basics of manipulating numbers in Java
BookstoreAccountant

- We will define a `BookstoreAccountant` class that models an employee in a bookstore, calculating certain costs:
  - finding the price of a purchase, calculating change needed, etc.

- Each of the accountant’s methods will have inputs (numbers) and a single output (number)
Basic Math in Java

- First, we’ll talk about numbers and mathematical expressions in Java

\[ V = l \times w \times h \]
Integers

- An integer is a whole number, positive or negative, including 0

- Depending on size (number of digits) of the integer, you can use one of four numerical base types (primitive Java data types): byte, short, int, and long, in increasing order of number of bits of precision

- Bit: binary digit, 0 or 1
## Integers

<table>
<thead>
<tr>
<th>Base Type</th>
<th>Size</th>
<th>Minimum Value</th>
<th>Maximum Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte</td>
<td>8 bits</td>
<td>-128 (-2^7)</td>
<td>127 (2^7 - 1)</td>
</tr>
<tr>
<td>short</td>
<td>16 bits</td>
<td>-32,768 (-2^{15})</td>
<td>32,767 (2^{15} - 1)</td>
</tr>
<tr>
<td>int</td>
<td>32 bits</td>
<td>-2,147,483,648 (-2^{31})</td>
<td>2,147,483,647 (2^{31} - 1)</td>
</tr>
<tr>
<td>long</td>
<td>64 bits</td>
<td>-9,223,372,...,808 (-2^{63})</td>
<td>9,223,372,...,807 (2^{63} - 1)</td>
</tr>
</tbody>
</table>

In CS15, almost always use `int` – good range and we’re not as memory-starved as we used to be so don’t need `byte`
Floating Point Numbers

- Sometimes, need rational and irrational numbers, i.e., numbers with decimal points
- How to represent \( \pi = 3.14159... \)?
- **Floating point numbers**
  - called “floating point” because decimal point can “float” – no fixed number of digits before and after it – historical nomenclature
  - used for representing numbers in “scientific notation,” with decimal point and exponent, e.g., \( 4.3 \times 10^{-5} \)
- Two numerical base types in Java represent floating point numbers: `float` and `double`
Floating Point Numbers

<table>
<thead>
<tr>
<th>Base Type</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>float</td>
<td>32 bits</td>
</tr>
<tr>
<td>double</td>
<td>64 bits</td>
</tr>
</tbody>
</table>

Feel free to use both in CS15. Use of `double` is more common in modern Java code.
Operators and Math Expressions (1/2)

- **Example expressions:**
  - $4 + 5$
  - $3.33 \times 3$
  - $11 \% 4$
  - $3.0 / 2.0$
  - $3 / 2$

<table>
<thead>
<tr>
<th>Operator</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>addition</td>
</tr>
<tr>
<td>-</td>
<td>subtraction</td>
</tr>
<tr>
<td>*</td>
<td>multiplication</td>
</tr>
<tr>
<td>/</td>
<td>division</td>
</tr>
<tr>
<td>%</td>
<td>remainder</td>
</tr>
</tbody>
</table>
Operators and Math Expressions (2/2)

- Example expressions:
  - $4 + 5 \rightarrow 9$
  - $3.33 \times 3 \rightarrow 9.99$
  - $11 \% 4 \rightarrow 3$
  - $3.0 \div 2.0 \rightarrow 1.50$
  - $3 \div 2 \rightarrow 1$

- What does each of these expressions evaluate to?
Be careful with integer division!

- When dividing two integer types, result is “rounded down” to an \textit{int} after remainder is dropped
- 3 / 2 evaluates to 1
- If either number involved is floating point, result is floating point: allows greater “precision,” i.e., fractional portion.
  - $10 / 3 \rightarrow 3$
  - $10 / 3.0 \rightarrow 3.3333...$ (more precise)
  - called \texttt{mixed-mode arithmetic}

\[
\begin{align*}
3 / 2 & \rightarrow 1 \\
3.0 / 2 & \rightarrow 1.50 \\
3 / 2.0 & \rightarrow 1.50 \\
3.0 / 2.0 & \rightarrow 1.50
\end{align*}
\]
Evaluating Math Expressions

- Java follows the same evaluation rules that you learned in math class years ago – PEMDAS (Parentheses, Exponents, Multiplication/Division, Addition/Subtraction)

- Evaluation takes place left to right, except:
  - expressions in parentheses evaluated first, starting at the innermost level
  - operators evaluated in order of precedence/priority (* has priority over +)

\[
\begin{align*}
2 + 4 \times 3 - 7 & \rightarrow 7 \\
(2 + 3) + (11 / 12) & \rightarrow 5 \\
3 + (2 - (6 / 3)) & \rightarrow 3
\end{align*}
\]
TopHat Question

What does x evaluate to?

int x = (((5 / 2) * 3) + 5);

A. 12.5
B. 11
C. 13
D. 10
E. 12
BookstoreAccountant

- BookstoreAccountants should be able to find the price of a set of books

- When we tell a BookstoreAccountant to calculate a price, we want it to perform the calculation and then tell us the answer

- To do this, we need to learn how to write a method that returns a value – in this case, a number
Return Type (1/2)

- The **return type** of a method is the kind of data it gives back to whomever called it.

- So far, we have only seen return type **void**.

- A method with a return type of **void** doesn’t give back anything when it’s done executing.

- **void** just means “this method does not return anything.”
Return Type (2/2)

- If we want a method to return something, replace `void` with the type of thing we want to return.
- If method should return an integer, specify `int` return type.
- When return type is not `void`, we have promised to end the method with a `return` statement.
  - Any code following the `return` statement will not be executed.

A silly example:

```java
public int giveMeTwo() {
    return 2;
}
```

Return statements always take the form:

```java
return <something of specified return type>;
```
Accountant (1/6)

- Let’s write a silly method for `BookstoreAccountant` called `priceTenDollarBook()` that finds the cost of a $10 book
- It will return the value “10” to whoever called it
- We will generalize this example soon...

```java
public class BookstoreAccountant {
    /* Some code elided */

    public int priceTenDollarBook() {
        return 10;
    }
}
```

“10” is an integer – it matches the return type, int!
Accountant (2/6)

- What does it mean for a method to “return a value to whomever calls it”?

- Another object can call `priceTenDollarBook()` on a `BookstoreAccountant` from somewhere else in our program and use the result.

- For example, consider a `Bookstore` class that has an accountant named `myAccountant`.

- We will demonstrate how the `Bookstore` can call the method and use the result.
Accountant (3/6)

/*
 * Assume a Bookstore instance has created an
 * instance of BookstoreAccount named myAccountant
 */

myAccountant.priceTenDollarBook();

- We started by just calling priceTenDollarBook()

- This is fine, it will return 10, but we are not doing anything with that result!

- Let’s use the returned value by printing it to the terminal

```java
public class BookstoreAccountant {

    /* Some code elided */

    public int priceTenDollarBook() {
        return 10;
    }

}
```
Aside: `System.out.println`  

- `System.out.println()` is an awesome tool for testing and debugging your code – learn to use it!  

- Helps the user see what is happening in your code by printing out values to the terminal as it executes  

- NOT equivalent to `return`, meaning other methods cannot see/use what is printed  

- If Bookstore program is not behaving properly, can test whether `priceTenDollarBook()` is the problem by printing its return value to verify that it is “10” (yes, obvious in this trivial case, but not in general!)
Accountant (4/6)

- In a new method, `manageBooks()`, print result

- “Printing” in this case means displaying a value to the user of the program

- To print to terminal, we use `System.out.println(<expression to print>)`

- `println()` method prints out value of expression you provide within the parentheses

```java
public class BookstoreAccountant {
    /* Some code elided */

    public int priceTenDollarBook() {
        return 10;
    }

    public void manageBooks() {
        System.out.println(this.priceTenDollarBook());
    }
}
```
Accountant (5/6)

- We have provided the expression `this.priceTenDollarBook()` to be printed to the console.

- This information given to the `println()` method is called an argument; more on this in a few slides.

- Putting one method call inside another is called nesting of method calls; more examples later.

```java
public class BookstoreAccountant {
    /* Some code elided */

    public int priceTenDollarBook() {
        return 10;
    }

    public void manageBooks() {
        System.out.println(this.priceTenDollarBook());
    }
}
```
When this line of code is evaluated:

- `println()` is called with argument of `this.priceTenDollarBook()`
- `priceTenDollarBook()` is called on this instance of the `BookstoreAccountant`, returning 10
- `Println()` gets 10 as an argument, 10 is printed to terminal
Accountant: A More Generic Price Calculator (1/4)

- Now your accountant can get the price of a ten-dollar book – but that’s completely obvious.
- For a functional bookstore, we’d need a separate method for each possible book price!
- Instead, how about a generic method that finds the price of any number of copies of a book, given its price?
  - useful when the bookstore needs to order new books

```java
public class BookstoreAccountant {
    public int priceTenDollarBook() {
        return 10;
    }

    public int priceBooks(int numCps, int price) {
        // let's fill this in!
    }
}
```
Accountant: A More Generic Price Calculator (2/4)

- Method answers the question: given a number of copies and a price per copy, how much do all of the copies cost together?

- To put this in algebraic terms, we want a method that will correspond to the function:
  \[ f(x, y) = x \times y \]

- “x” represents the number of copies; “y” is the price per copy

```java
public class BookstoreAccountant {
    public int priceTenDollarBook() {
        return 10;
    }

    public int priceBooks(int numCps, int price) {
        // let’s fill this in!
    }
}
```

Mathematical function:

\[ f(x, y) = x \times y \]

Equivalent Java method:

```java
public int priceBooks(int numCps, int price) {
    return (numCps * price);
}
```
Method takes in two integers from caller and gives appropriate answers depending on those integers

When defining a method, extra pieces of information that the method needs to take in (specified inside the parentheses of the declaration) are called **parameters**

**priceBooks()** is declared to take in two parameters, "**numCps**" and "**price**" – these, like variable names, are arbitrary, i.e., your choice

```java
public class BookstoreAccountant {
    /* Some code elided */

    public int priceBooks(int numCps, int price) {
        return (numCps * price);
    }
}
```
Outline

- Mathematical functions in Java
- Defining more complicated methods with inputs and outputs
- The constructor
- Creating instances of a class
- Understanding Java flow of control
Parameters (1/3)

- General form of method you are defining that takes in parameters:

  ```java
  <visibility> <returnType> <methodName>(<type1> <name1>, <type2> <name2>...) {
    <body of method>
  }
  ```

- Parameters are specified as comma-separated lists of type-name pairs
  - for each parameter, specify **type** (for example, `int` or `double`), and then **name** ("x", "y", "banana"... whatever you want!)

- In basic algebra, we only deal with numbers and freely mix their types. In programming, we use many different types, not just numbers, but also class names, and must tell Java explicitly what we intend
  - Java is a "strictly typed" language, i.e., it makes sure the user of a method passes the right number of parameters of the specified type, in the right order – if not, compiler error! In short, the compiler checks for a strict **one-to-one correspondence**
Parameters (2/3)

- Dummy name of each parameter is completely up to you, but...
  - Java naming restriction: needs to start with a letter
  - refer to CS15 style guide for naming conventions
- It is the name by which you will refer to the parameter throughout method
- Note again that each parameter is a pair: type and name

The following methods are completely equivalent:

```java
public int priceBooks(int numCps, int price) {
    return (numCps * price);
}

public int priceBooks(int bookNum, int pr) {
    return (bookNum * pr);
}

public int priceBooks(int a, int b) {
    return (a * b);
}
```
Parameters (3/3)

- Remember **Robot** class from last lecture?
- Its `moveForward` method took in one parameter – an **int** named `numberOfSteps`
- Follows same parameter format: **type**, then **name**
We Want Human-readable Code

- Try to come up with descriptive names for parameters that make their purpose clear to anyone reading your code

- Robot’s moveForward method calls its parameter “numberOfSteps”, not “x” or “thingy”

- We used “numCps” and “price”

- Try to avoid single-letter names for anything that is not strictly mathematical; be more descriptive
Accountant (1/2)

- Give `BookstoreAccountant` class more functionality by defining more methods!
- Methods to calculate change needed or how many books a customer can afford
- Each method will take in parameters, perform operations on them, and return an answer
- We choose arbitrary but helpful parameter names

```java
public class BookstoreAccountant {

    public int priceBooks(int numCps, int price) {
        return (numCps * price);
    }

    // calculate a customer's change
    public int calcChange(int amtPaid, int price) {
        return (amtPaid - price);
    }

    // calculate max # of books (same price) u can buy
    public int calcMaxBks(int price, int myMoney) {
        return (myMoney / price);
    }
}
```
calcMaxBks takes in price of a book (price) and an amount of money you have to spend (myMoney), tells you how many books you can buy.

calcMaxBks works because when we divide 2 ints, Java rounds the result down to an int!

- Java always rounds down

$25 / $10 per book = 2 books

```java
public class BookstoreAccountant {

    public int priceBooks(int numCps, int price) {
        return (numCps * price);
    }

    // calculates a customer’s change
    public int calcChange(int amtPaid, int price) {
        return (amtPaid - price);
    }

    // calculates max # of books customer can buy
    public int calcMaxBks(int price, int myMoney) {
        return (myMoney / price);
    }

```
TopHat Question: Declaring Methods

We want a new method *getSalePrice* that returns an integer and takes in two parameters, one integer that represents the original price of a purchase and one integer that represents the percent discount offered. Which method declaration is correct?

A. `public void getSalePrice() {
    // code elided
}

B. `public int getSalePrice(int price, int discount) {
    // code elided
}

C. `public int getSalePrice(price, discount) {
    // code elided
}

D. `public void getSalePrice(int price, int discount) {
    // code elided
    // code elided
    // code elided
}
Calling (i.e., using) Methods with Parameters (1/3)

- Now that we defined `priceBooks()`, `calcChange()`, and `calcMaxBks()` methods, we can call them on any `BookstoreAccountant` instance.

- When we call `calcChange()` method, we must tell it the amount paid for the books and how much the books cost.

- How do we call a method that takes in parameters?
Calling Methods with Parameters (2/3)

- You already know how to call a method that takes in one parameter!
- Remember `moveForward()`?

```java
//within Robot class definition
public void moveForward(int numberOfSteps) {
    // code that moves the robot
    // forward goes here!
}
```
Calling Methods with Parameters (3/3)

- When we *call* a method, we pass it any extra piece of information it needs as an argument within parentheses.

- When we call `moveForward` we **must** supply one `int` as argument:
  - `samBot.moveForward();` is NOT correct.

- Do **NOT** specify type of argument when calling a method:
  - `samBot.moveForward(int 4);` is NOT correct.

```java
public class RobotMover {
    /* additional code elided */

    public void moveRobot(Robot samBot) {
        samBot.moveForward(4);
        samBot.turnRight();
        samBot.moveForward(1);
        samBot.turnRight();
        samBot.moveForward(3);
    }
}
```
Arguments vs. Parameters

// within the Robot class
public void moveForward(int numberOfSteps) {
    // code that moves the robot
    // forward goes here!
}

// within the RobotMover class
public void moveRobot(Robot samBot) {
    samBot.moveForward(4);
    samBot.turnRight();
    samBot.moveForward(1);
    samBot.turnRight();
    samBot.moveForward(3);
}

● In defining a method, the parameter is a dummy name picked by the author used by a method to refer to a piece of information passed into it, e.g. “x” and “y” in the function f(x, y) = x + y

● In calling a method, an argument is the actual value passed in, e.g. 2 and 3 in f(2, 3) -> 5
Calling Methods That Have Parameters (1/9)

- When we call `samBot.moveForward(3)`, we are passing 3 as an argument.

- When `moveForward()` executes, its parameter is assigned the value of argument that was passed in.

- Thus `moveForward()` here executes with `numberOfSteps=3`.

```java
// in some other class...
samBot.moveForward(3);

public void moveForward(int numberOfSteps) {
    // code that moves the robot
    // forward goes here!
}
```
Calling Methods That Have Parameters (2/9)

- When calling a method that takes in parameters, must provide a valid argument for each parameter
  - analogy: When each district selects 2 tributes to compete in the Hunger Games, they must be one male and one female, and from that district.
- Means that number and type of arguments must match number and type of parameters
- One-to-one correspondence: same number of arguments, given in the same order, of the same matching type
Each of our accountant’s methods takes in two \texttt{ints}, which it refers to by different names (also called \texttt{identifiers}). Whenever we call these methods, must provide two \texttt{ints} – first, desired value for first parameter, then desired value for second.

```java
public class BookstoreAccountant {

    public int priceBooks(int numCps, int price) {
        return numCps * price;
    }

    // calculates a customer’s change
    public int calcChange(int amtPaid, int price) {
        return amtPaid - price;
    }

    // calculates max # of books you can buy
    public int calcMaxBks(int bookPr, int myMoney) {
        return myMoney / bookPr;
    }
}
```
Calling Methods That Have Parameters (4/9)

- Let’s go back to our instance of `BookstoreAccountant` named `myAccountant`
- When we call a method on `myAccountant`, we provide a comma-separated list of arguments (in this case, `ints`) in parentheses
- These **arguments** are values we want the method to use for the first and second parameters when it runs

```java
myAccountant.priceBooks(2, 16);
myAccountant.calcChange(18, 12);
myAccountant.calcMaxBks(6, 33);
```
Note: \textit{calcChange}(8, 4) isn’t \textit{calcChange}(4, 8) – order matters!

- \textit{calcChange}(8, 4) → 4
- \textit{calcChange}(4, 8) → -4

/* in the BookstoreAccountant class... */

```java
public int calcChange(int amtPaid, int price) {
    return amtPaid - price;
}
```
Calling Methods That Have Parameters (6/9)

/* somewhere else in our code (e.g., the Bookstore class) */

myAccountant.priceBooks(2, 16);

- Java does “parameter passing” by:
  - first checking that one-to-one correspondence is honored (this includes type checking!),
  - then substituting arguments for parameters,
  - and finally executing the method body using the arguments

/* in the BookstoreAccountant class... */

public int priceBooks(int numCps, int price) {
    return (numCps * price);
}
**Calling Methods That Have Parameters (7/9)**

/* somewhere else in our code
(e.g., the Bookstore class) */

myAccountant.priceBooks(2, 16);

- Java does “parameter passing” by:
  - first checking that one-to-one correspondence is honored (this includes type checking!),
  - then substituting arguments for parameters,
  - and finally executing the method body using the arguments

```java
public int priceBooks(int numCps, int price) {
    return (numCps * price);
}
```
Calling Methods That Have Parameters (8/9)

/* somewhere else in our code (e.g., the Bookstore class) */

myAccountant.priceBooks(2, 16);

- Java does “parameter passing” by:
  - first checking that one-to-one correspondence is honored (this includes type checking!),
  - then substituting arguments for parameters,
  - and finally executing the method body using the arguments

/* in the BookstoreAccountant class... */

public int priceBooks(2, 16) {
    return (2 * 16);
}

32 is returned
Calling Methods That Have Parameters (9/9)

/* somewhere else in our code  
(e.g., the Bookstore class) */

System.out.println(myAccountant.priceBooks(2, 16));

/* in the BookstoreAccountant class… */

public int priceBooks(int numCps, int price) {
    return (numCps * price);
}

- If we want to check the result returned from our method call, use System.out.println to print it to the console
- We’ll see the number 32 printed out!
TopHat Question

Which of the following contains arguments that satisfy the parameters of the method `calcChange()` below in the `BookstoreAccountant` class?

A. `myAccountant.calcChange(20, 14.50)`
B. `myAccountant.calcChange(10)`
C. `myAccountant.calcChange(20, 10)`
D. None of the above

```java
// calculates a customer’s change
public int calcChange(int amtPaid, int price) {
    return amtPaid - price;
}
```
But where did myAccountant come from?!?

- We know how to send messages to an instance of a class by calling methods.
- So far, we have called methods on samBot, an instance of Robot, and myAccountant, an instance of BookstoreAccountant...
- Where did we get these objects from? How did we make an instance of BookstoreAccountant?
- Next: how to use a class as a blueprint to actually build instances!
Outline

• Mathematical functions in Java
• Defining more complicated methods with inputs and outputs
• The constructor
• Creating instances of a class
• Understanding Java flow of control
Constructors (1/3)

- Bookstore Accountants can `priceBooks()`, `calcChange()`, and `calcMaxBks()`
- Can call any of these methods on any instance of `BookstoreAccountant`
- But how did these instances get created in the first place?
- Define a special kind of method in the `BookstoreAccountant` class: a constructor
- Note: every class must have a constructor

```java
public class BookstoreAccountant {

    public int priceBooks(int numCps, int price) {
        return (numCps * price);
    }

    public int calcChange(int amtPaid, int price) {
        return (amtPaid - price);
    }

    public int calcMaxBks(int price, int myMoney) {
        return (myMoney / price);
    }
}
```
Constructors (2/3)

- A constructor is a special kind of method that is called whenever an instance is to be “born,” i.e., created – see shortly how it is called.
- Constructor's name is always same as name of class.
- If class is called “BookstoreAccountant,” its constructor must be called “BookstoreAccountant.” If class is called “Dog,” its constructor had better be called “Dog.”

```java
public class BookstoreAccountant {

    public BookstoreAccountant() {
        // this is the constructor!
    }

    public int priceBooks(int numCps, int price) {
        return (numCps * price);
    }

    public int calcChange(int amtPaid, int price) {
        return (amtPaid - price);
    }

    public int calcMaxBks(int price, int myMoney) {
        return (myMoney / price);
    }
}
```
Constructors (3/3)

- Constructors are special methods: used to create an instance stored in an assigned memory location.
- When we create an instance with the constructor (example in a few slides!), it provides a reference to the location in memory, which is “returned”.
- We never specify a return value in its declaration.
- Constructor for BookstoreAccountant does not take in any parameters (notice empty parentheses), constructors can, and often do, take in parameters – stay tuned for next lecture.

```java
public class BookstoreAccountant {

    public BookstoreAccountant() {
        // this is the constructor!
        // constructor code elided
    }

    public int priceBooks(int numCps, int price) {
        return (numCps * price);
    }

    public int calcChange(int amtPaid, int price) {
        return (amtPaid - price);
    }

    public int calcMaxBks(int price, int myMoney) {
        return (myMoney / price);
    }
}
```
TopHat Question

Which of the following is not true of constructors?

A. Constructors are methods
B. Constructors always have the same name as their class
C. Constructors should specify a return value
D. Constructors can take in parameters
Outline

• Mathematical functions in Java
• Defining more complicated methods with inputs and outputs
• The constructor
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Creating Instances of Classes (1/2)

- Now that the `BookstoreAccountant` class has a constructor, we can create instances of it!
- Here is how we create a `BookstoreAccountant` in Java:
  ```java
  new BookstoreAccountant();
  ```
- This means “use the `BookstoreAccountant` class as a blueprint to create a new `BookstoreAccountant` instance”
- `BookstoreAccountant()` is a call to `BookstoreAccountant`’s constructor, so any code in constructor will be executed as soon as you create a `BookstoreAccountant`
Creating Instances of Classes (2/2)

- We refer to “creating” an instance as **instantiating** it.
- When we say:

  ```java
  new BookstoreAccountant();
  ```

  … We’re **creating an instance** of the `BookstoreAccountant` class, a.k.a. **instantiating** a new `BookstoreAccountant`.

- Where exactly does this code get executed?
- Stay tuned for the next lecture to see how this constructor is used by another instance to create a new `BookstoreAccountant`!
Aside: Another Example of Nesting (1/2)

- Our `calcChange()` method takes in two `ints` – the amount the customer paid, and price of the purchase

- Our `priceBooks()` method finds the price of the purchase

- What if we want to use result of `priceBooks()` as an argument to `calcChange()`?

- Say we have got 3 copies of an $11 book. We also have $40 in cash to pay with. `priceBooks()` will tell us that purchase costs $33. We want to use this as “price” parameter for `calcChange()`

- How do we do this? **Nesting!**
Aside: Another Example of Nesting (2/2)

- `myAccountant.priceBooks(3, 11)` returns “33”
  - we want to pass this number into `calcChange()`
- We can nest `myAccountant's priceBooks()` method within `myAccountant's calcChange()` method:

  ```java
  myAccountant.calcChange(40, myAccountant.priceBooks(3, 11));
  ```

  Returns 33

  ```java
  myAccountant.calcChange(40, 33);
  ```

  And `calcChange()` returns 7! Always, evaluate inner parentheses first.
TopHat Question

You have an instance of BookstoreAccountant, accountant, with the methods given from before.

What is the proper way to calculate the change you will have if you pay with a $50 bill for 5 books at a cost of $8 each?

A. accountant.priceBooks(5, 8);
B. accountant.priceBooks(8, 5);
C. accountant.calcChange(50, accountant.priceBooks(5, 8));
D. accountant.calcChange(accountant.priceBooks(5, 8));
Important Techniques Covered So Far

- Defining methods that take in **parameters** as input
- Defining methods that **return** something as an output
- Defining a **constructor** for a class
- Creating an **instance** of a class with the **new** keyword
- Up next: Flow of Control
Outline

• Mathematical functions in Java
• Defining more complicated methods with inputs and outputs
• The constructor
• Creating instances of a class
• Understanding Java flow of control
What Is Flow of Control?

- We've already seen lots of examples of Java code in lecture.
- But how does all of this code actually get executed, and in what order?

- **Flow of control** or **control flow** is the order in which individual statements in a program (lines of code) are executed.
- Understanding flow of control is essential for hand simulation and debugging.
Overview: How Programs Are Executed

- Code in Java is executed sequentially, line by line
- Think of an arrow “pointing” to the current line of code
- Where does execution start?
  - in Java, first line of code executed is in a special method called the `main` method
The Main Method

- Every Java program begins at first line of code in `main` method and ends after last line of code in `main` is executed – you will see this shortly!

- You will see this method in every project or lab stencil, typically in `App.java` (the `App` class)
  - by CS15 convention, we start our programs in `App`

- Program starts when you run file that contains `main` method

- Every other part of application is invoked from `main`
Method Calls and Constructors

- When a method is called, execution steps into the method
  - next line to execute will be first line of method definition

- Entire method is executed sequentially
  - when end is reached (when method returns), execution *returns* to line following the method call

```java
public static void main(String[] args) {
    System.out.println("first line");
    System.out.println("last line");
}
```

Ignore this parameter for now, we’ll discuss it later this semester
Example: Baking Cookies

- Some of your TAs are trying to bake cookies for a grading meeting
  - they’ve decided to make mystery flavored cookies, to surprise the HTAs
- Let’s write a program that will have a baker make a batch of cookies!
The makeCookies() Method

- First, let’s define a method to make cookies, in the Baker class
  - public void makeCookies()

- What are the steps of making cookies?
  - combine wet ingredients (and sugars) in one bowl
    - mix this
  - combine dry ingredients in another bowl, and mix
  - combine wet and dry ingredient bowls
  - form balls of dough
  - bake for 10 minutes
  - sometime before baking, preheat oven to 400°

- Order is not fixed, but some steps must be done before others
- Let’s write methods for these steps and call them in order in makeCookies()
Defining the Baker Class

- First, here are more methods of the *Baker* class – method definitions are elided. Method definitions can occur in any order in the class.

```java
public class Baker {
    public Baker() {
        // constructor code elided for now
    }

    public void makeCookies() {
        // code on next slide
    }

    public void combineWetIngredients() {
        // code to mix eggs, sugar, butter, vanilla
    }

    public void combineDryIngredients() {
        // code to mix flour, salt, baking soda
    }

    public void combineAllIngredients() {
        // code to combine wet and dry ingredients
    }

    public void formDoughBalls(int numBalls) {
        // code to form balls of dough
    }

    public void bake(int cookTime) {
        // code to bake cookies and remove from oven
    }

    public void preheatOven(int temp) {
        // code to preheat oven to a temp
    }
}

// end of Baker class
```
The `makeCookies()` Method

```java
public void makeCookies() {
    this.preheatOven(400);
    this.combineWetIngredients();
    this.combineDryIngredients();
    this.combineAllIngredients();
    this.formDoughBalls(24);
    this.bake(10);
}
```
TopHat Question

Using the `Baker` class from before, is the following method correct for creating cookie dough? Why or why not?

```java
public class Baker {
    //constructor elided
    public void createDough() {
        this.combineWetIngredients();
        this.combineAllIngredients();
        this.combineDryIngredients();
    }
    //other methods elided
}
```

A. Yes, it has all the necessary methods in proper order
B. No, it uses `this` instead of `Baker`
C. No, it has the methods in the wrong order
D. No, it is inefficient
Flow of Control Illustrated

- Each of the methods we call in `makeCookies()` has various sub-steps involved
  - `combineWetIngredients()` involves adding sugar, butter, vanilla, eggs, and mixing them together
  - `bake(int cookTime)` involves putting cookies in oven, waiting, taking them out

- In current code, every sub-step of `combineWetIngredients()` is completed before `combineDryIngredients()` is called
  - execution steps into a called method, executes everything within method
  - both sets of baking steps must be complete before combining bowls, so these methods are both called before `combineAllIngredients()`
  - could easily switch order in which those two methods are called
Putting it Together (1/2)

- Now that **Bakers** have a method to bake cookies, let’s put an app together to make them do so

- Java launches our app **App** in its **main** method

- Generally, use **App** class to start our program and have it do nothing else

```java
public class App {
    public static void main(String[] args) {
    }
}
```
Putting it Together (2/2)

- First, we need a **Baker**
- Calling **new Baker()** will execute **Baker**’s constructor
- How do we get our **Baker** to bake cookies?
  - call the **makeCookies()** method from its constructor!
  - this is not the only way – stay tuned for next lecture

```java
public class App {
    public static void main(String[] args) {
        new Baker();
    }
}
```

```
// in Baker class
public Baker() {
    this.makeCookies();
}
```
Following Flow of Control

```java
public class App {
    public static void main(String[] args) {
        new Baker();
    }
}

public class Baker {
    public Baker() {
        this.makeCookies();
    }
    public void makeCookies() {
        this.preheatOven(400);
        this.combineWetIngredients();
        this.combineDryIngredients();
        this.combineAllIngredients();
        this.formDoughBalls(24);
        this.bake(10);
    }
    public void preheatOven(int temp) {
        // code to preheat oven to a temp
    }
    public void combineWetIngredients() {
        // code to mix eggs, sugar, butter, vanilla
    }
    public void combineDryIngredients() {
        // code to mix flour, salt, baking soda
    }
    public void combineAllIngredients() {
        // code to combine wet and dry ingredients
    }
    public void formDoughBalls(int numBalls) {
        // code to form balls of dough
    }
    public void bake(int cookTime) {
        // code to bake cookies and remove from oven
    }
} // end of Baker class
```
Modifying Flow of Control

- In Java, various control flow statements modify sequence of execution
  - these cause some lines of code to be executed multiple times, or skipped over entirely

- We’ll learn more about these statements in Making Decisions and Loops lectures later on
Important Concepts Covered

● Numbers represented as integers (e.g., `int` type) or floating-point (e.g., `double` type)
● Defining methods that take in `parameters` as input
● Defining methods that `return` something as an output
● Using `System.out.println` to test and debug code
● Defining a `constructor` for a class
● Creating an `instance` of a class with the `new` keyword
● Following Java’s sequential `flow of control`
Announcements (1/2)

• Get lab0 checked off by Saturday
  o if you’re having issues with IntelliJ setup or running code or want to get lab checked off come to Conceptual Hours!

• Rattytouille due Saturday, 9/16 @ 11:59pm

• Code-Alongs to cover Java syntax
  o hands-on opportunity to code along with a TA in a group
  o Tomorrow and Sunday at 7pm in Macmillan 117!
  o check Ed post / email for all the specific dates and times
Announcements (2/2)

• Fill out Mentorship form by tonight at 11:59: mandatory for all freshmen, fill out during lab/section (or using the link on Ed)
• Permanent Lab/Section Swap form up on Ed.
• Temporary Swaps will be dealt with by emailing your lab/section TAs and the TAs of the lab/section you are switching into, at least the Monday of the week.
Socially Responsible Computing: Intro to AI

CS15 Fall 2023
Artificial Intelligence

ChatGPT

DALL-E
What is Artificial Intelligence? (approximately!)

Artificial Intelligence
The ability of a machine to perform ‘intelligent’ tasks (predicting outcomes, classifying inputs, learning, planning, perception, robotics...)

Machine Learning
The ability of a machine to “learn”/ gain takeaways from data using statistical/mathematical methods (pattern recognition, image discrimination, query analysis)

Deep Learning
a subset of ML based on a simplified model of the human brain (artificial neural networks)
Current Final Project: Othello, uses mini-max algorithm!
History of AI

• 1997: Deep Blue beats Gary Kasparov
• 2006: University of Toronto develops Deep Learning
• 2011: IBM's Watson wins Jeopardy
• 2016: Go software based on Deep Learning beats world’s champions

Increased explosive growth due to GAI

Image source: actuaries.digital, DeepMind, Forbes
Language and image recognition capabilities of AI systems have improved rapidly.

Test scores of the AI relative to human performance
+20
0 → Human performance, as the benchmark, is set to zero.

The capability of each AI system is normalized to an initial performance of -100.

Data source: Kíla et al. (2021) – Dynabench: Rethinking Benchmarking in NLP
OurWorldinData.org – Research and data to make progress against the world’s largest problems.

Licensed under CC-BY by the author Max Roser
Prompt: Write a funny limerick about a Brown CS TA who dies in the Hunger Games

In Brown’s CS class, a TA so witty,  
Tackled bugs and code with a spirit so gritty,  
But off to the Games, he ventured one day,  
With algorithms and syntax in play,  
Sadly, he met his demise, not quite pretty.
A text-to-image generator developed by OpenAI recognizes concepts, attributes, and styles. More on this in the lab next week!
Projected Generative AI Revenue Growth

Source: Bloomberg Intelligence, IDC
AI Startups in Different Market Sectors

Cross-industry applications

- Synthetic voice: CleverLabs
- Image & text generation: Jasper
- Privacy & security: Project AI
- Code generation: MII
- Sales & customer support: Adept
- AI assistants & HMs: Anthropic
- Design tools: Galaxy AI
- Productivity tools: mem
- Warehouse & logistics: Covenant
- Content moderation: Logically
- Smell tech: Osmo
- Translation: DeepL
- Climate tech: Multai
- Quantum AI software: D Wave

General-purpose humanoid: FIGURE
Image processing: VISIONAI
Search: Twelve Labs

Industry-specific

- Materials & manufacturing: Cradle, Mankmantels
- Gaming: conval, MOOSILATE
- Fashion & retail: Refiberd, Seel
- Energy: phoebra, WhaveGrid
- Healthcare: OQEMUS, Atomic AI
- Defense: VARNEYAR Labs
- Finance: Arteria, DocadoAI
- Agriculture: BLSI
- Physical infrastructure: exaigo
- Education: Ello
- Media & entertainment: Character.ai, descript
- Legal: Harvey
- Auto & mobility: Helmi.
- Construction: Augmenta

Note: Companies are private as of 6/20/23.
Positive Use Cases of AI

Researchers speed up analysis of Arctic ice and snow data through artificial intelligence

AI technique enables researchers to study data trends more quickly, improving prediction ability
Concerning Use Cases

Racial Bias Found in a Major Health Care Risk Algorithm

How China’s Police Used Phones and Faces to Track Protesters

BuzzFeed Is Quietly Publishing Whole AI-Generated Articles, Not Just Quizzes

Educators Battle Plagiarism As 89% Of Students Admit To Using OpenAI’s ChatGPT For Homework
Courses at Brown:

- CSCI 1410: Artificial Intelligence
- CSCI 1420: Machine Learning
- CSCI 1430: Computer Vision
- CSCI 1460: Computational Linguistics
- CSCI 1470: Deep Learning
- CSCI 1951R: Intro to Robotics

How can I get involved?

Quadcopter from CSCI 1951R: Intro to Robotics

Next Generation Robotics Education

Learn about the DuckieSky curriculum under development by Dr. Tellez