Topic 12
more if/else, cumulative algorithms, printf

"We flew down weekly to meet with IBM, but they thought the way to measure software was the amount of code we wrote, when really the better the software, the fewer lines of code."

-Bill Gates

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Based on slides by Marty Stepp and Stuart Reges
from http://www.buildingjavaprograms.com/

Clicker Question 1

```
int a = 6;
if (a < 6)
    a = a + 1;
System.out.println("a incremented.");
else if (a > 6) {
    System.out.println("a is too high.");
} else {
    System.out.println("a is correctly set.");
}
```

What is output by the code above when it is run?
A. a incremented. B. a is too high. C. a is correctly set. D. syntax error E. runtime error

Clicker Question 2

```
int x = 4;
int y = 5;
x = mystery(x, y);
System.out.print(x + " " + y);
y = mystery(x, x);
System.out.print(" " + x + " " + y);
```

```
public static int mystery(int x, int y) {
    x *= 3;
y = x / y;
    return x + y;
}
```

What is output by the code above when it is run?
A. 4 5 4 5
B. 14 5 14 45
C. 14 5 14 5
D. 14 5 50 5
E. 14 5 14 50

Java's Math class

<table>
<thead>
<tr>
<th>Method name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math.abs(value)</td>
<td>absolute value</td>
</tr>
<tr>
<td>Math.ceil(value)</td>
<td>rounds up</td>
</tr>
<tr>
<td>Math.floor(value)</td>
<td>rounds down</td>
</tr>
<tr>
<td>Math.log10(value)</td>
<td>logarithm, base 10</td>
</tr>
<tr>
<td>Math.max(value1, value2)</td>
<td>larger of two values</td>
</tr>
<tr>
<td>Math.min(value1, value2)</td>
<td>smaller of two values</td>
</tr>
<tr>
<td>Math.pow(base, exp)</td>
<td>base to the exp power</td>
</tr>
<tr>
<td>Math.random()</td>
<td>random double between 0 and 1</td>
</tr>
<tr>
<td>Math.round(value)</td>
<td>nearest whole number</td>
</tr>
<tr>
<td>Math.sqrt(value)</td>
<td>square root</td>
</tr>
<tr>
<td>Math.sin(value)</td>
<td>sine/cosine/tangent of an angle in radians</td>
</tr>
<tr>
<td>Math.cos(value)</td>
<td>sine/cosine/tangent of an angle in radians</td>
</tr>
<tr>
<td>Math.tan(value)</td>
<td>sine/cosine/tangent of an angle in radians</td>
</tr>
<tr>
<td>Math.toDegrees(value)</td>
<td>convert degrees to radians and back</td>
</tr>
<tr>
<td>Math.toRadians(value)</td>
<td>convert degrees to radians and back</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constant</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math.E</td>
<td>2.7182818...</td>
</tr>
<tr>
<td>Math.PI</td>
<td>3.1415926...</td>
</tr>
</tbody>
</table>
Clicker Question 3

What values do the following statements return?

- Math.round(-10.2)
- Math.round(-10.8)
- Math.ceil(-10.2)
- Math.ceil(-10.8)
- Math.floor(-10.2)
- Math.floor(-10.8)

A: -10, -11, -10.0, -11.0, -11.0
B: -10, -11, -11.0, -10.0, -10.0
C: -10, -11, -11.0, -11.0, -11.0
D: -10, -10, -10.0, -11.0, -11.0
E: Something else

Misuse of if

What's wrong with the following code?

```java
Scanner console = new Scanner(System.in);
int percent = console.nextInt();
if (percent >= 90) {
    System.out.println("You got an A!");}
if (percent >= 80) {
    System.out.println("You got a B!");}
if (percent >= 70) {
    System.out.println("You got a C!");}
if (percent >= 60) {
    System.out.println("You got a D!");}
if (percent < 60) {
    System.out.println("You got an F!");}
...
```

Nested if/else

Chooses between outcomes using many tests

```java
if (test) {
    statement(s);
} else if (test) {
    statement(s);
} else {
    statement(s);
}
```

Example:

```java
if (x > 0) {
    System.out.println("Positive");
} else if (x < 0) {
    System.out.println("Negative");
} else {
    System.out.println("Zero");
}
```

Nested if/else/else if

- If it ends with else, exactly one path must be taken.
- If it ends with if, the code might not execute any path.

```java
if (test1) {
    statement(s);
} else if (test 2) {
    statement(s);
} else if (test 3) {
    statement(s);
}
```

Example:

```java
if (place == 1) {
    System.out.println("Gold medal!");
} else if (place == 2) {
    System.out.println("Silver medal!");
} else if (place == 3) {
    System.out.println("Bronze medal.");
}
```
### Nested if structures

- **exactly 1 path** (mutually exclusive)
  ```java
  if (test) {
    statement(s);
  } else if (test) {
    statement(s);
  } else {
    statement(s);
  }
  ```

- **0 or 1 path** (mutually exclusive)
  ```java
  if (test) {
    statement(s);
  } else if (test) {
    statement(s);
  } else if (test) {
    statement(s);
  } else if (test) {
    statement(s);
  } else if (test) {
    statement(s);
  }
  ```

- **0, 1, or many paths** (independent tests; not exclusive)
  ```java
  if (test) {
    statement(s);
  } else if (test) {
    statement(s);
  } else if (test) {
    statement(s);
  } else if (test) {
    statement(s);
  } else if (test) {
    statement(s);
  }
  ```

### Which nested if/else?

- **(1) if/if/if**
  - Whether a user is lower, middle, or upper-class based on income.
    - (2) nested if/else if/else

- **(2) nested if/else**
  - Whether you made the dean’s list (GPA ≥ 3.8) or honor roll (3.5-3.8).
    - (3) nested if/else if

- **(3) nested if/else/if**
  - Whether a number is divisible by 2, 3, and/or 5.
    - (1) sequential if/else if
  - Computing a grade of A, B, C, D, or F based on a percentage.
    - (2) nested if/else if/else if/else if/else

### if/else with return

- The following two versions of a `max` method don't compile:
  ```java
  public static int max(int a, int b) {
    if (a > b) {
      return a;
    } // Error: not all paths return a value
  }
  ```

- The compiler thinks `if/else/if` code might skip all paths, even though mathematically it must choose one or the other.

- This version of `max` does compile and works:
  ```java
  // Returns the larger of the two given integers.
  public static int max(int a, int b) {
    if (a > b) {
      return a;
    } else if (b >= a) {
      return b;
    } else if (a > b) {
      return a;
    } else if (b >= a) {
      return b;
    }
  }
  ```

- Methods can return different values using `if/else`
  - Whichever path the code enters, it will return that value.
  - Returning a value causes a method to immediately exit.
  - All paths through the code must reach a `return` statement.
FORMATTING WITH PRINTF

printf width

\%Wd \hspace{0.5cm} \text{integer, } W \text{ characters wide, right-aligned}
\%-Wd \hspace{0.5cm} \text{integer, } W \text{ characters wide, left-aligned}
\%Wf \hspace{0.5cm} \text{real number, } W \text{ characters wide, right-aligned}

... for (int i = 1; i <= 3; i++) {
  for (int j = 1; j <= 10; j++) {
    System.out.printf("%4d", (i * j));
  }
} System.out.println(); // to end the line

Output:

1 2 3 4 5 6 7 8 9 10
2 4 6 8 10 12 14 16 18 20
3 6 9 12 15 18 21 24 27 30

printf precision

\%.Df \hspace{0.5cm} \text{real number, rounded to } D \text{ digits after decimal}
\%W.Df \hspace{0.5cm} \text{real number, } W \text{ chars wide, } D \text{ digits after decimal}
\%-W.Df \hspace{0.5cm} \text{real number, } W \text{ wide (left-align), } D \text{ after decimal}

double gpa = 3.253764;
System.out.printf("your GPA is %.1f\n", gpa);
System.out.printf("more precisely: %.8f\n", gpa);

Output:
your GPA is 3.3
more precisely: 3.254
Cumulative algorithms

Reading: 4.2

Adding many numbers

- How would you find the sum of all integers from 1-1000?

```java
// This may require a lot of typing
int sum = 1 + 2 + 3 + 4 + ... + 999 + 1000;
System.out.println("The sum is " + sum);
```

- What if we want the sum from 1 - 1,000,000? Or the sum up to any maximum?
  - How can we generalize the above code?

A failed attempt

- An incorrect solution for summing 1-1000:

```java
for (int i = 1; i <= 1000; i++) {
    int sum = 0;
    sum = sum + i;
} // error: sum is undefined here
System.out.println("The sum is " + sum);
```

  - sum's scope is in the for loop, so the code does not compile.

- cumulative sum: A variable that keeps a sum in progress and is updated repeatedly until summing is finished.
  - The sum above is an incorrect attempt at a cumulative sum.

Corrected cumulative sum

```java
int sum = 0;
for (int i = 1; i <= 1000; i++) {
    sum = sum + i;
} System.out.println("The sum is " + sum);
```

- Cumulative sum variables must be declared outside the loops that update them, so that they will still exist after the loop.
Cumulative product

- This cumulative idea can be used with other operators:

```java
int product = 1;
for (int i = 1; i <= 20; i++) {
    product = product * 2;
}
System.out.println("2 ^ 20 = " + product);
```

- How would we make the base and exponent adjustable?

Cumulative sum question

- Modify the Receipt program from Ch 2 (tax 8%, tip 15%).
  - Prompt for how many people, and each person's dinner cost.
  - Use static methods to structure the solution.

Example log of execution:

```
How many people ate? 4
Person #1: How much did your dinner cost? 20.00
Person #2: How much did your dinner cost? 15
Person #3: How much did your dinner cost? 30.0
Person #4: How much did your dinner cost? 10.0
```

```
Subtotal: $ 75.00
Tax: $ 6.00
Tip: $ 11.25
Total: $ 92.25
```

Cumulative sum answer

```java
// This program enhances our Receipt program using a cumulative sum.
import java.util.*;
public class Receipt2 {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        double subtotal = meals(console);
        results(subtotal);
    }
    // Prompts for number of people and returns total meal subtotal.
    public static double meals(Scanner console) {
        System.out.print("How many people ate? ");
        int people = console.nextInt();
        double subtotal = 0.0; // cumulative sum
        for (int i = 1; i <= people; i++) {
            System.out.print("Person #" + i + ": How much did your dinner cost? ");
            double personCost = console.nextDouble();
            subtotal = subtotal + personCost; // add to sum
        }
        return subtotal;
    }
    // Calculates total owed, assuming 8% tax and 15% tip
    public static void results(double subtotal) {
        double tax = subtotal * .08;
        double tip = subtotal * .15;
        double total = subtotal + tax + tip;
        System.out.printf("Subtotal: $%.2f\n", subtotal);
        System.out.printf("Tax: $%.2f\n", tax);
        System.out.printf("Tip: $%.2f\n", tip);
        System.out.printf("Total: $%.2f\n", total);
    }
}
```