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

```
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.");
}
```

The result of executing the above code is:
A. a incremented. C. a is correctly set.
B. a is too high. D. Compile error.

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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></td>
</tr>
<tr>
<td>Math.tan(value)</td>
<td></td>
</tr>
<tr>
<td>Math.toDegrees(value)</td>
<td>convert degrees to radians and back</td>
</tr>
<tr>
<td>Math.toRadians(value)</td>
<td></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>

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Clicker Question

- 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, -11, -11, -11
B: -10, -11, -11, -11, -10, -10
C: -10, -11, -10, -11, -11, -11
D: -10, -10, -10, -11, -11, -11
Misuse of if

What's wrong with the following code?

```java
Scanner console = new Scanner(System.in);
System.out.print("What percentage did you earn? ");
int percent = console.nextInt();
if (percent >= 90) {
    System.out.println("You got an A!");
} else if (percent >= 80) {
    System.out.println("You got a B!");
} else if (percent >= 70) {
    System.out.println("You got a C!");
} else if (percent >= 60) {
    System.out.println("You got a D!");
} else 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/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 (test 1) {
    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);
  }
  ```

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

- (1) if/if/ (2) nested if/else
- (3) nested if/else/if
  - Whether a user is lower, middle, or upper-class based on income.
    - (2) nested if / else if / else
  - Whether you made the dean’s list (GPA ≥ 3.8) or honor roll (3.5-3.8).
    - (3) nested if / else if
  - Whether a number is divisible by 2, 3, and/or 5.
    - (1) sequential if / if / 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

All paths must return

- This version of max does compile and works:

  // Returns the larger of the two given integers.
  public static int max(int a, int b) {
      if (a > b) {
          return a;
      } else {
          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.

if/else with return

- The following two versions of a max method don't compile:

  public static int max(int a, int b) {
      if (a > b) {
          return a;
      }
      // Error: not all paths return a value
  }

  public static int max(int a, int b) {
      if (a > b) {
          return a;
      } else if (b >= a) {
          return b;
      }
  }

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

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? 10.00

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

Formatting text with printf

```java
System.out.printf("format string", parameters);
```

- A format string can contain *placeholders* to insert parameters:
  - `%d` integer
  - `%f` real number
  - `%s` string
  - these placeholders are used instead of + concatenation

- Example:

  ```java
  int x = 3;
  int y = -17;
  System.out.printf("x is %d and y is %d!\n", x, y);
  // x is 3 and y is -17!
  
  ```

  - **printf** does not insert a newline unless you add `\n`

Printf width

- `%Wd` integer, `W` characters wide, right-aligned
- `%Wd` integer, `W` characters wide, left-aligned
- `%Wf` real number, `W` characters wide, right-aligned

```java
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` real number, rounded to `D` digits after decimal
- `%W.Df` real number, `W` chars wide, `D` digits after decimal
- `%W.Df` real number, `W` wide (left-align), `D` after decimal

```java
double gpa = 3.253764;
System.out.printf("your GPA is \%.1f\n", gpa);
System.out.printf("more precisely: \%.8.3f\n", gpa);
```

Output:

```
your GPA is 3.3
more precisely: 3.254
```
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;
    }
    ...
}
```

printf answer (partial)

```java
...  
// 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);
    }
...  
```