"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
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

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

int x = 4;
int y = 5;
x = mystery(x, y);
System.out.print(x + " " + y);
y = mystery(x, x);
System.out.print(" " + 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><code>Math.abs(value)double</code></td>
<td>absolute value</td>
</tr>
<tr>
<td><code>Math.ceil(value)double</code></td>
<td>rounds up</td>
</tr>
<tr>
<td><code>Math.floor(value)double</code></td>
<td>rounds down</td>
</tr>
<tr>
<td><code>Math.log10(value)</code></td>
<td>logarithm, base 10</td>
</tr>
<tr>
<td><code>Math.max(value1, value2)</code></td>
<td>larger of two values</td>
</tr>
<tr>
<td><code>Math.min(value1, value2)</code></td>
<td>smaller of two values</td>
</tr>
<tr>
<td><code>Math.pow(base, exp)</code></td>
<td>base to the exp power</td>
</tr>
<tr>
<td><code>Math.random()</code></td>
<td>random double between 0 and 1</td>
</tr>
<tr>
<td><code>Math.round(value)int</code></td>
<td>nearest whole number</td>
</tr>
<tr>
<td><code>Math.sqrt(value)</code></td>
<td>square root</td>
</tr>
<tr>
<td><code>Math.sin(value)</code></td>
<td>sine/cosine/tangent of an angle in radians</td>
</tr>
<tr>
<td><code>Math.cos(value)</code></td>
<td></td>
</tr>
<tr>
<td><code>Math.tan(value)</code></td>
<td></td>
</tr>
<tr>
<td><code>Math.toDegrees(value)</code></td>
<td>convert degrees to radians and back</td>
</tr>
<tr>
<td><code>Math.toRadians(value)</code></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>
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, -11.0
B: -10, -11, -11.0, -11.0, -10.0, -10.0
C: -10, -11, -10.0, -10.0, -11.0, -11.0
D: -10, -10, -10.0, -11.0, -11.0, -11.0
E: Something else
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! ");
}
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/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/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
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
}

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

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

- This version of \texttt{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 {
        return b;
    }
}
```

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

... 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

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 algorithms

reading: 4.2
Adding many numbers

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

// 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.
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.
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?
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
// 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: $%6.2f\n", subtotal);
    System.out.printf("Tax:      $%6.2f\n", tax);
    System.out.printf("Tip:      $%6.2f\n", tip);
    System.out.printf("Total:    $%6.2f\n", total);
}