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

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

Clicker 1

```
int a = 6;
if (a < 6)
    a = a + 1;
    System.out.println("a incremented.");
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. Something other than the answers listed here

Clicker 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

Method name	Description
`Math.abs(`*value*`)double`	absolute value
`Math.ceil(`*value*`)double`	rounds up
`Math.floor(`*value*`) double`	rounds down
`Math.log10(`*value*`)`	logarithm, base 10
`Math.max(`*value1*`, `*value2*`)`	larger of two values
`Math.min(`*value1*`, `*value2*`)`	smaller of two values
`Math.pow(`*base*`, `*exp*`)`	*base* to the *exp* power
`Math.random()`	random `double` between 0 and 1
`Math.round(`*value*`)int`	nearest whole number
`Math.sqrt(`*value*`)`	square root

`Math.sin(`*value*`)`
`Math.cos(`*value*`)`
`Math.tan(`*value*`)`
	sine/cosine/tangent of an angle in radians

`Math.toDegrees(`*value*`)` `Math.toRadians(`*value*`)`	convert degrees to radians and back

Constant	Description
`Math.E`	2.7182818...
`Math.PI`	3.1415926...

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

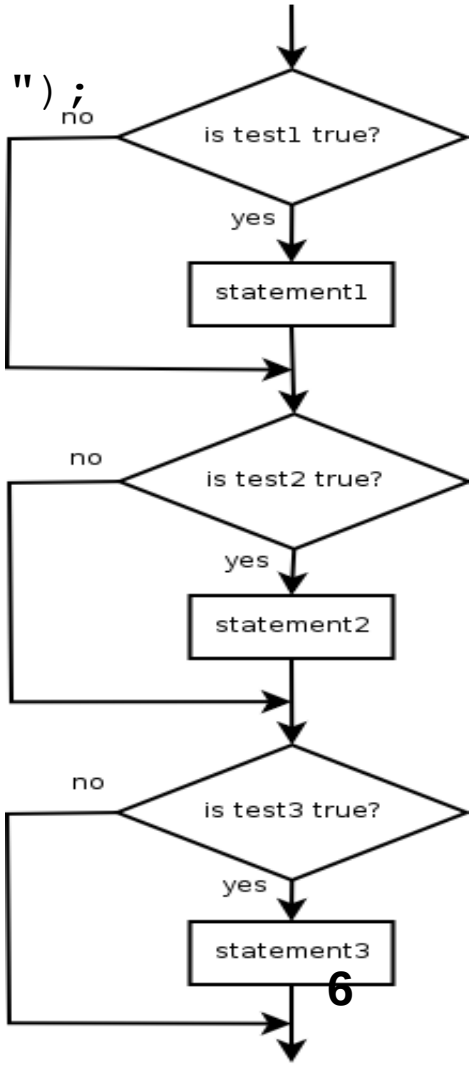
D: -10, -10, -10.0, -11.0, -11.0, -11.0

E: Something else

Misuse of `if`

- What's wrong with the following code?

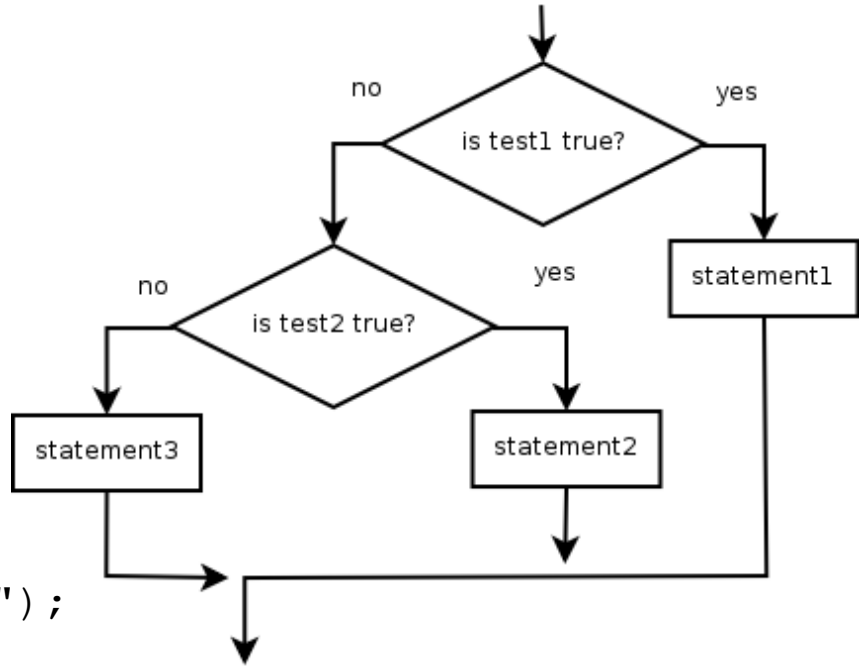
```
Scanner console = new Scanner(System.in);
System.out.print("What percentage did you earn? ");
int percent = console.nextInt();
if (percent >= 90) {
    System.out.println("You got an A!");
}
if (percent >= 80) {
    System.out.println("You got a B!");
}
if (percent >= 70) {
    System.out.println("You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

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



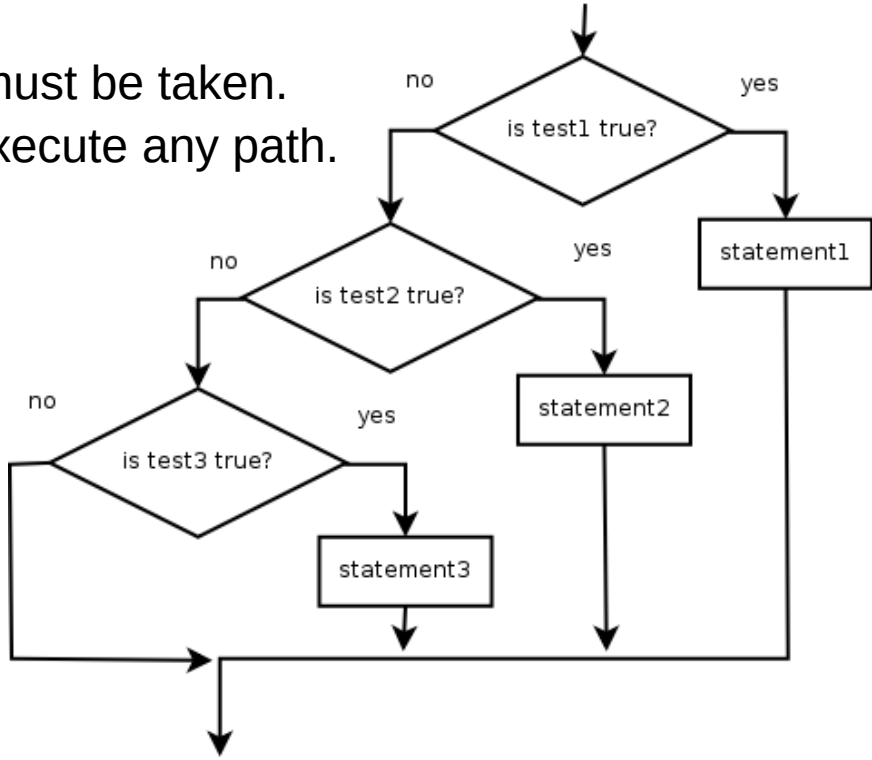
- Example:

```
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.

```
if (test 1) {
    statement(s);
} else if (test 2) {
    statement(s);
} else if (test 3) {
    statement(s);
}
```



- Example:

```
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)*

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

- 0 or 1 path *(mutually exclusive)*

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

- 0, 1, or many paths *(independent tests; not exclusive)*

```
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`

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.

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.

FORMATTING WITH PRINTF

Formatting text with `printf`

```
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:

```
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

`%`**W**`d` integer, **W** characters wide, right-aligned

`%-`**W**`d` integer, **W** characters wide, *left*-aligned

`%`**W**`f` 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
```

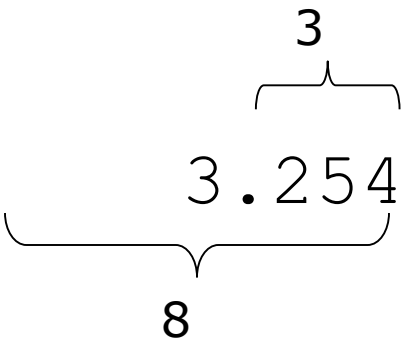
`printf` precision

`%.`**`D`**`f`	real number, rounded to **D** digits after decimal
`%`**`W`**`.`**`D`**`f`	real number, **W** chars wide, **D** digits after decimal
`%-`**`W`**`.`**`D`**`f`	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:

```
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

```
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:

```
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
```

Cumulative sum answer

```
// 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)

```
    ...

    // 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);
    }
}
```

Case Study

- Write program that prompts for exam and homework grades and prints out the letter grade for the student.
- Each exam has a weight
- Homeworks, as a whole, have a weight.
- The sum of the weights shall equal 100.
- Calculates numeric grade and prints out letter grade: A, B, C, D, F
- Program does not perform any error checking

Sample Output

```
Enter grades to calculate letter grade.

Number of midterms? 2

Midterm 1:
Weight (1 - 100)? 15
Score? 82
Scores bumped? (1=yes, 2=no)? 1
Bump amount? 5
Raw points: 87 / 100
Weighted points: 13.1 / 15
```

```
Midterm 2:
Weight (1 - 100)? 20
Score? 93
Scores bumped? (1=yes, 2=no)? 2
Raw points: 93 / 100
Weighted points: 18.6 / 20

Final Exam:
Weight (1 - 100)? 30
Score? 97
Scores bumped? (1=yes, 2=no)? 1
Bump amount? 10
Raw points: 100 / 100
Weighted points: 30.0 / 30
```

```
Homeworks:
Weight is 35
Number of homeworks? 4
Homework 1 score? 13
Homework 2 score? 19
Homework 3 score? 18
Homework 4 score? 17
Raw points: 68 / 80
Weighted points: 29.3 / 35


Total weighted points: 91.4 / 100
Final grade: A
```