# Building Java Programs

Chapter 4
Lecture 4-2: Advanced `if/else`; Cumulative sum

**reading: 4.2, 4.4 - 4.5**

# Advanced `if/else`

**reading: 4.4 - 4.5**

# Logical operators

- Tests can be combined using *logical operators*:

| Operator | Description | Example | Result |
|---|---|---|---|
| `&&` | and | `(2 == 3) && (-1 < 5)` | `false` |
| `\|\|` | or | `(2 == 3) \|\| (-1 < 5)` | `true` |
| `!` | not | `!(2 == 3)` | `true` |

- "Truth tables" for each, used with logical values *p* and *q*:

| p | q | p && q | p \|\| q |
|---|---|---|---|
| true | true | true | true |
| true | false | false | true |
| false | true | false | true |
| false | false | false | false |

| p | !p |
|---|---|
| true | false |
| false | true |

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# Evaluating logical expressions

- Relational operators have lower precedence than math operators; logical operators have lower precedence than relational operators

```
5 * 7 >= 3 + 5 * (7 - 1) && 7 <= 11
5 * 7 >= 3 + 5 * 6 && 7 <= 11
35    >= 3 + 30 && 7 <= 11
35    >= 33 && 7 <= 11
true && true
true
```

- Relational operators cannot be "chained" as in algebra

```
2 <= x <= 10
true   <= 10
Error!
```

(assume that `x` is `15`)

  - Instead, combine multiple tests with `&&` or `||`

```
2 <= x && x <= 10
true   && false
false
```

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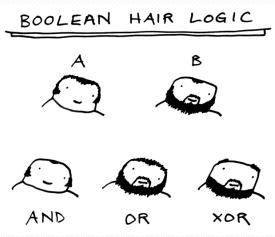
# Logical questions

- What is the result of each of the following expressions?

```
int x = 42;
int y = 17;
int z = 25;
```

  - `y < x && y <= z`
  - `x % 2 == y % 2 || x % 2 == z % 2`
  - `x <= y + z && x >= y + z`
  - `!(x < y && x < z)`
  - `(x + y) % 2 == 0 || !((z - y) % 2 == 0)`




    - Answers: `true`, `false`, `true`, `true`, `false`

- Exercise: Write a program that prompts for information about an apartment and uses it to decide whether to rent it.



# Factoring `if/else` code

- **factoring**: Extracting common/redundant code.
  - Can reduce or eliminate redundancy from `if/else` code.
- Example:

```
if (a == 1) {
    System.out.println(a);
    x = 3;
    b = b + x;
} else if (a == 2) {
    System.out.println(a);
    x = 6;
    y = y + 10;
    b = b + x;
} else {  // a == 3
    System.out.println(a);
    x = 9;
    b = b + x;
}
```

```
System.out.println(a);
x = 3 * a;
if (a == 2) {
    y = y + 10;
}
b = b + x;
```

# The "dangling if" problem

- What can be improved about the following code?

```
if (x < 0) {
    System.out.println("x is negative");
} else if (x >= 0) {
    System.out.println("x is non-negative");
}
```

- The second if test is unnecessary and can be removed:

```
if (x < 0) {
    System.out.println("x is negative");
} else {
    System.out.println("x is non-negative");
}
```

  - This is also relevant in methods that use `if` with `return`.

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# `if/else` with `return`

```
// 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`
  - Returning a value causes a method to immediately exit.
  - All paths through the code must reach a `return` statement.

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# All paths must return

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

- The following also does not compile:

```
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.
    - Solution here is to change `else if` to just `else`.

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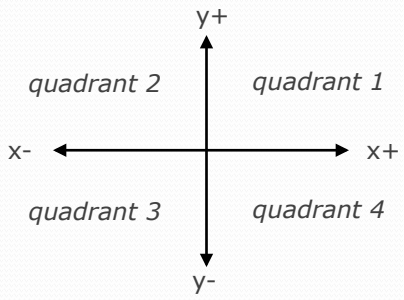
# `if/else`, `return` question

- Write a method `quadrant` that accepts a pair of real numbers *x* and *y* and returns the quadrant for that point:




  - Example: `quadrant(-4.2, 17.3)` returns `2`
    - If the point falls directly on either axis, return `0`.

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## if/else, return answer

```
public static int quadrant(double x, double y) {
    if (x > 0 && y > 0) {
        return 1;
    } else if (x < 0 && y > 0) {
        return 2;
    } else if (x < 0 && y < 0) {
        return 3;
    } else if (x > 0 && y < 0) {
        return 4;
    } else {      // at least one coordinate equals 0
        return 0;
    }
}
```



## Cumulative algorithms

**reading: 4.2**

# Adding many numbers

- How would you find the sum of all integers from 1-5?

```
int sum = 1 + 2 + 3 + 4 + 5;
System.out.println("The sum is " + sum);
```

- What if we want the sum from 1 - 1,000?

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# Attempt at cumulative sum

- What is wrong with the following code?

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

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# Cumulative sum loop

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

- **cumulative sum**: A variable that keeps a sum in progress and is updated repeatedly until summing is finished.
  - The `sum` in the above code represents a cumulative sum.
  - Cumulative sum variables must be declared *outside* the loops that update them, so that they will still exist after the loop.

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# 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?

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# `Scanner` and cumulative sum

- We can do a cumulative sum of user input:

```
Scanner console = new Scanner(System.in);
int sum = 0;
for (int i = 1; i <= 100; i++) {
    System.out.print("Type a number: ");
    sum = sum + console.nextInt();
}
System.out.println("The sum is " + sum);
```

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# Cumulative sum question

- Modify the `Receipt` program from Ch. 2.
  - 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: $75.0
Tax: $6.0
Tip: $11.25
Total: $92.25
```


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# 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;
    }
    ...
```



# Cumulative answer, cont'd.

```
    ...

    // 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.println("Subtotal: $" + subtotal);
        System.out.println("Tax: $" + tax);
        System.out.println("Tip: $" + tip);
        System.out.println("Total: $" + total);
    }
}
```