Lecture 4: Conditionals

Building Java Programs: A Back to Basics Approach
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Type `boolean`

Type `boolean`

- **`boolean`**: A logical type whose values are `true` and `false`.
  - It is legal to:
    - create a `boolean` variable
    - pass a `boolean` value as a parameter
    - return a `boolean` value from methods
    - call a method that returns a `boolean` and use it as a test

```
int age = 18;
String name = "Mr. Smith";
boolean minor    = (age < 21);
boolean lovesAPCS = true;
```

Using `boolean`

- Why is type `boolean` useful?
  - Can capture a complex logical test result and use it later
  - Can write a method that does a complex test and returns it
  - Makes code more readable
  - Can pass around the result of a logical test (as param/return)

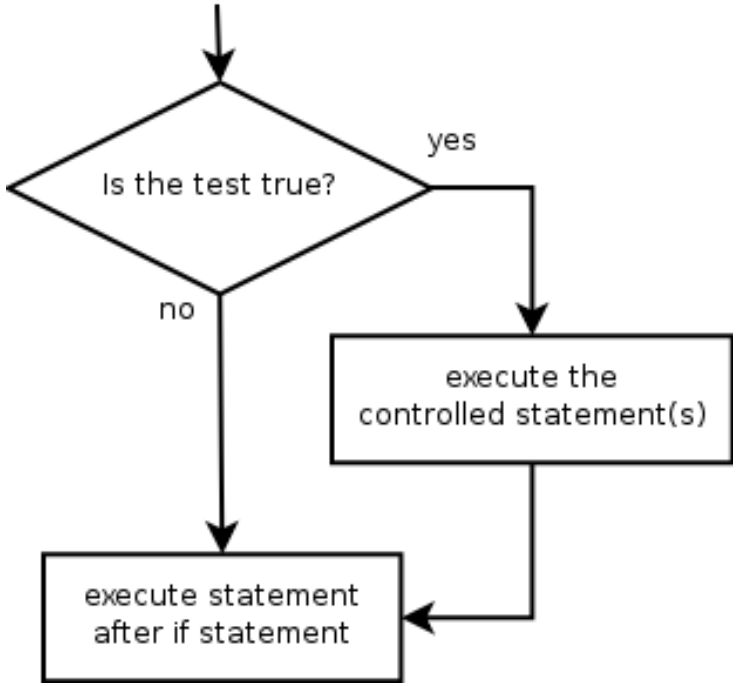
```
int age = 21, height = 88;
double salary = 100000;

boolean goodAge    = age >= 12 && age < 29;//true
boolean goodHeight = height >= 78 && height < 84;//false
boolean rich       = salary >= 100000.0;//true
```

NOTE: && is the "and" operator. See slide 13.

The `if` statement

Executes a block of statements only if a test is true

```
if (test) {
    statement;
    ...
    statement;
}
```



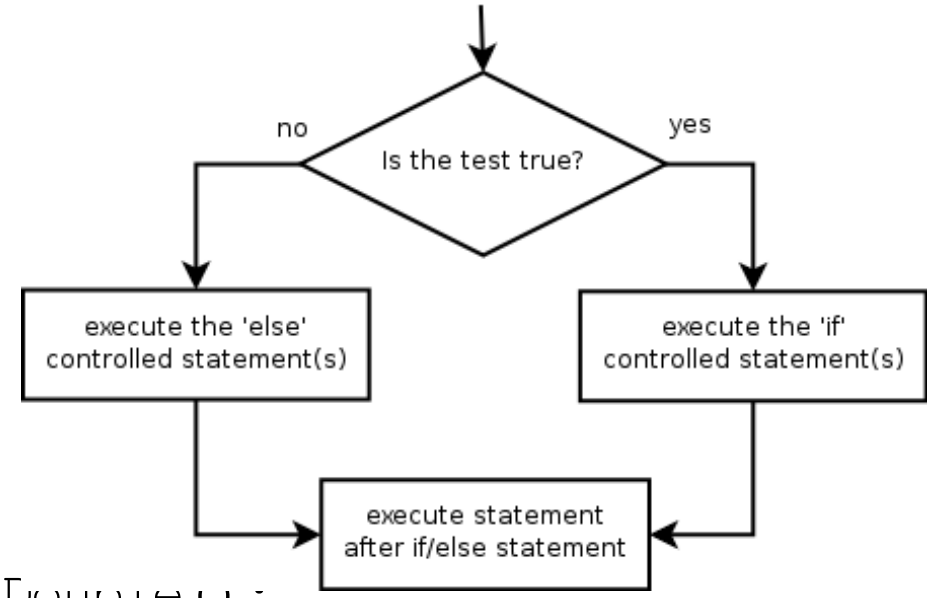
- Example:

```
double gpa = console.nextDouble();
if (gpa >= 2.0) {
    System.out.println("Application accepted.");
}
```

The `if/else` statement

Executes one block if a test is true, another if false

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



- Example:

```
double gpa = console.nextDouble();
if (gpa >= 2.0) {
    System.out.println("Welcome to Mars University!");
} else {
    System.out.println("Application denied.");
}
```

Relational expressions

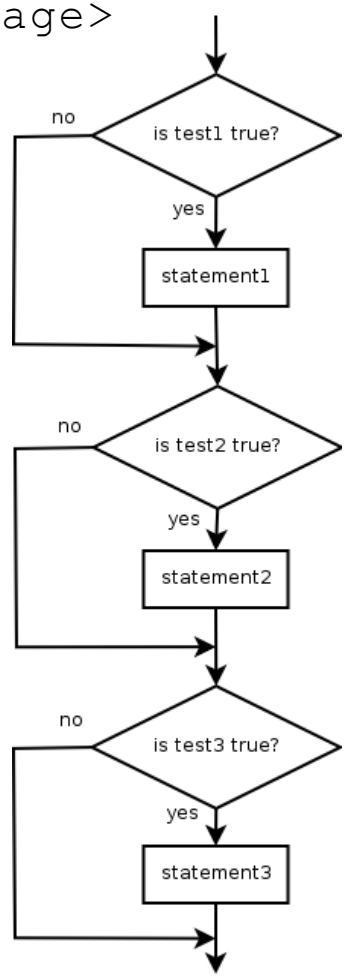
- Tests use *relational operators*:

Operator	Meaning	Example	Value
`==`	equals	`1 + 1 == 2`	`true`
`!=`	does not equal	`3.2 != 2.5`	`true`
`<`	less than	`10 < 5`	`false`
`>`	greater than	`10 > 5`	`true`
`<=`	less than or equal to	`126 <= 100`	`false`
`>=`	greater than or equal to	`5.0 >= 5.0`	`true`

Misuse of `if`

- What's wrong with the following code?

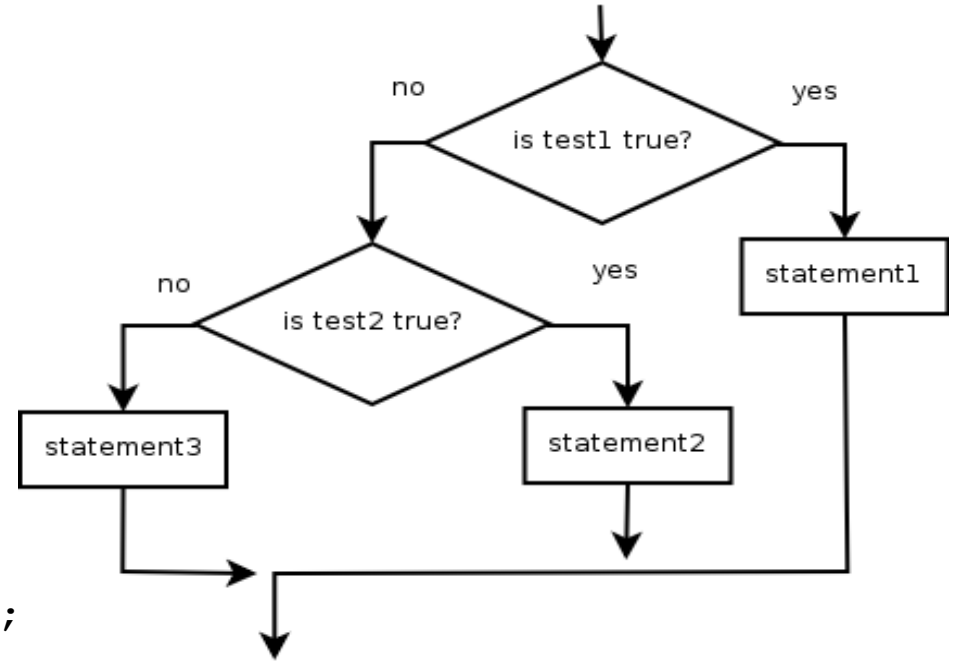
```
int percent = <Code to ask user to enter a percentage>

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);
}
```



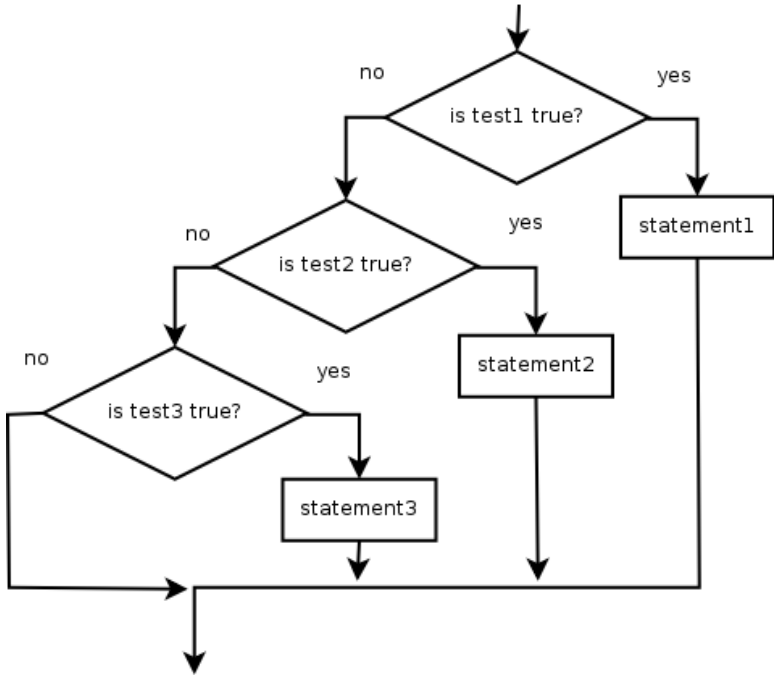
- Example:

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

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`

Using `boolean`

```
boolean goodAge    = age >= 12 && age < 29;
boolean goodHeight = height >= 78 && height < 84;
boolean rich       = salary >= 100000.0;

if ((goodAge && goodHeight) || rich) {
    System.out.println("Okay, let's go out!");
} else {
    System.out.println("It's not you, it's me...");
}
```

Using boolean

```
boolean minor    = (age < 21);
boolean isProf   = name.contains("Prof");
boolean lovesAPCS = true;

// allow only APCS-loving students over 21
if (minor || isProf || !lovesAPCS) {
      System.out.println("Can't enter the club!");
}
```

Evaluating logic expressions

- Relational operators have lower precedence than math.

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

Evaluating logic expressions

- AND is evaluated before OR.

```
int x = 2;
int y = 4;
int z = 5;

z > 2 || x > 3 && y < 3 ;
// true if evaluate && before ||
// false if evaluate || before &&
// the correct answer is true: &&
// must be evaluated before ||
```

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`

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`
  - 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.

All paths must return

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

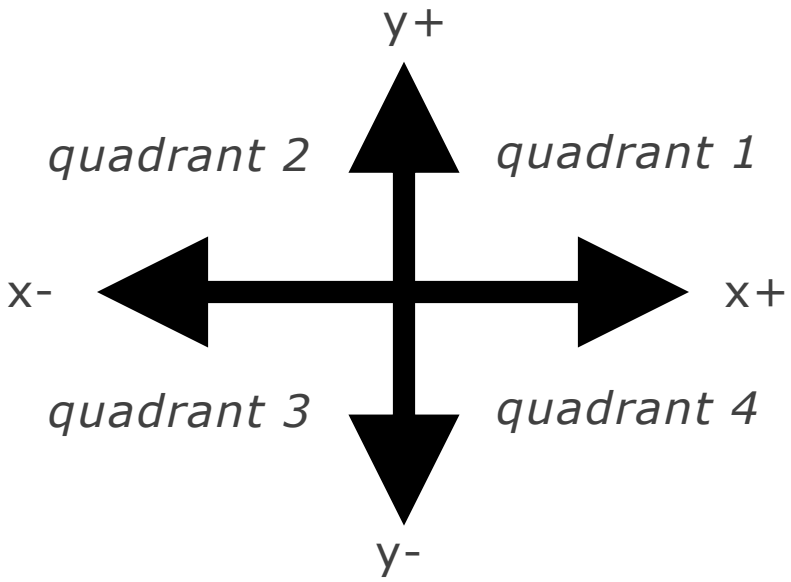
- The following also does not compile:

```
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.

`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`.

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;
    }
}
```

Lab 1: BMI

Create a folder called BMI for these labs.

BMI	Weight class
below 18.5	underweight
[18.5 – 25)	normal
[25.0 – 30)	overweight
30.0 and up	obese

Formula for body mass index (BMI):

$$BMI = \frac{weight}{height^2} \times 703$$

- Write a program that produces output like the following:

```
Height (in inches) 70.0
Weight (in pounds) 194.25
BMI = 27.868928571428572
Overweight
```

BMI

Your program must include two methods:1) the method `bmi` which takes two double parameters height and weight and returns the bmi and 2) the method `weightClass` which takes two double parameters height and weight and returns a string classifying the weight class. **The weightClass method must call the bm**

$$
\begin{aligned}
y_0 &= y - (14 - m)/12 \\
x_0 &= y_0 + y_0/4 - y_0/100 + y_0/400 \\
m_0 &= m + 12 \times ((14 - m)/12) - 2 \\
\mathcal{D} &= (d + x_0 + 31 \times m_0/12) \bmod 7
\end{aligned}
$$

```
public stat                                    double
  weight)
{…}

public static String weightClass(double height,
  double weight)
{…}
```

Lab 2: Day Of the Week

Write a program that outputs the day of the week for a given date.

Create a new folder in CS50 called DayOfWeek.

Given the month, m, day, d and year y, the day of the week(Sunday = 0, Monday = 1, …, Saturday = 6) D is given by:

$$
\begin{aligned}
y_0 &= y - (14 - m)/12 \\
x_0 &= y_0 + y_0/4 - y_0/100 + y_0/400 \\
m_0 &= m + 12 \times ((14 - m)/12) - 2 \\
\mathcal{D} &= (d + x_0 + 31 \times m_0/12) \bmod 7
\end{aligned}
$$

Your program needs one method:

```
public static int dayOfWeek(int m, int d, int y){
}
```

Day Of the Week

Write the main method so that the output is similar to the following:

Output:

Date: 9-25-2018
Day of the week: Tuesday

Use conditionals!