Unit 3: Boolean Expressions, if statements

if-else if-else statements

Adapted from:

1) Building Java Programs: A Back to Basics Approach

by Stuart Reges and Marty Stepp

2) Runestone CSAwesome Curriculum

Textbook Reference

Online Textbook Think Java - 2nd Edition by Allen Downey and Chris Mayfield

For this lecture use Chapter 5

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 = 22;
boolean minor = age < 21; // false
boolean lovesAPCS = true;
boolean is1049Prime = isPrime(1049);
```

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. We'll cover this in the next lecture. (A and B) is true if and only if both are true.

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`

Relational Expressions

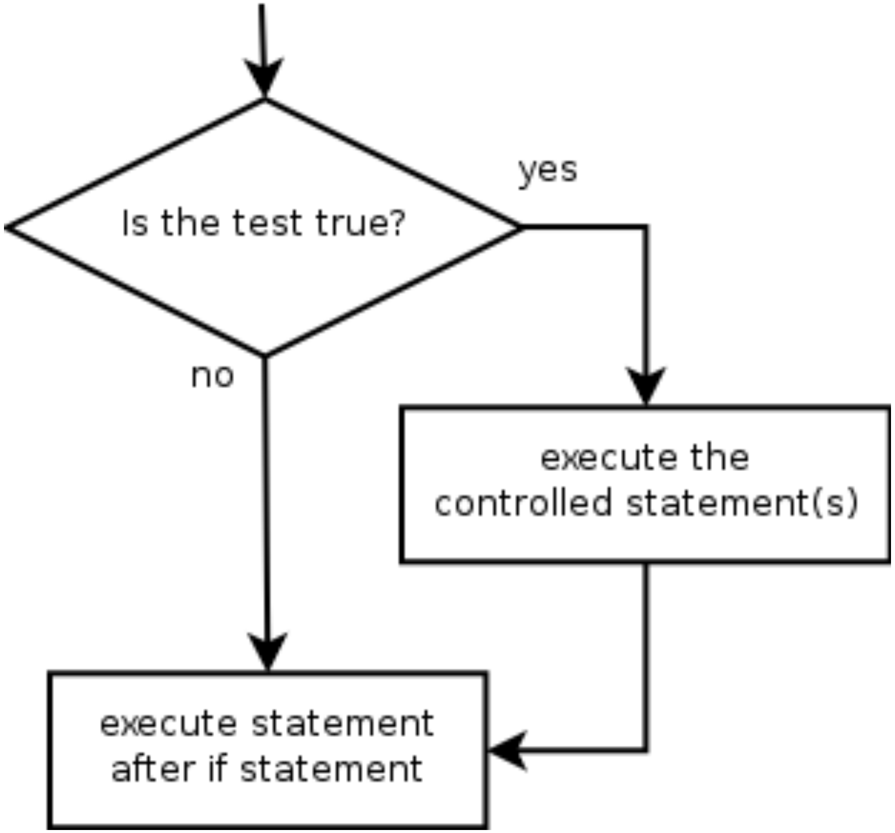
```
public class Boolean_Class{
   public static void main(String[] args){
      int x = 2, y = 3;
      System.out.println(x == y); // false
      System.out.println(x != y); // true
      System.out.println(2 + 4 * 3 <= 15); // true
      System.out.println(x > 5); // false
      System.out.println(y >= 3); // true

   }
}
```

The `if` statement

Executes a block of statements only if a test is true

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


Is the test true?
yes
no
execute the controlled statement(s)
execute statement after if statement

The `if` statement

```
double gpa = 2.1;
if (gpa >= 2.0) {
   System.out.println("Application accepted.");
}
```

Output:

Application accepted.

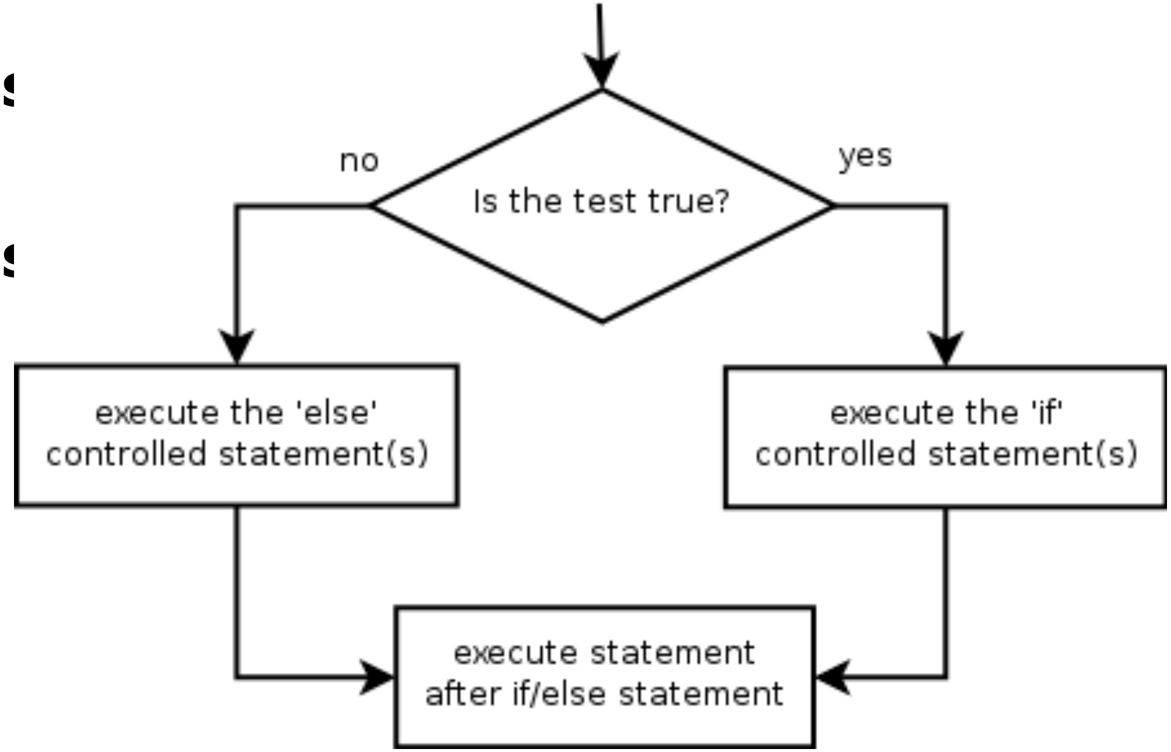
```
double gpa = 1.9;
if (gpa >= 2.0) {
   System.out.println("Application accepted.");
}
```

Output: (No output)

The if/else statement

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

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


no
Is the test true?
yes
execute the 'else' controlled statement(s)
execute the 'if' controlled statement(s)
execute statement after if/else statement

The if/else statement

```
double gpa = 3.0;
if (gpa >= 2.0){
   System.out.println("Welcome to Mars University!");
}
else{
   System.out.println("Application denied.");
}
```

```
Output:
Welcome to Mars University.
```

The if/else statement

```
double gpa = 1.0;
if (gpa >= 2.0){
   System.out.println("Welcome to Mars University!");
}
else{
   System.out.println("Application denied.");
}
```

Output:

```
Application denied.
```

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!");
}
...
```

Misuse of `if`

- What's wrong with the following code?

```
int percent = 90;

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!");
}
...
```

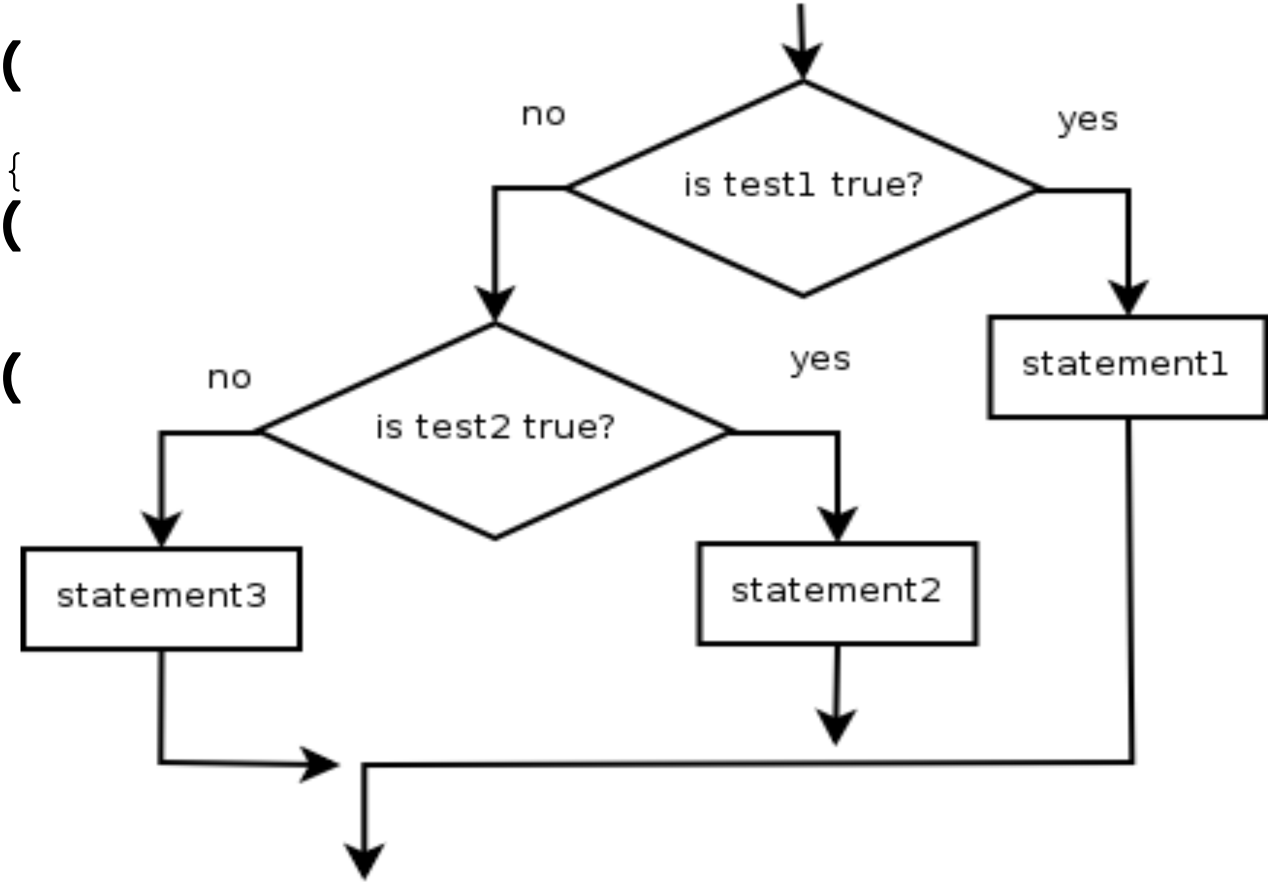
Output:

```
You got an A!
You got a B!
You got a C!
You got a D!
```

Nested `if/else`

Chooses between outcomes using many tests

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



Nested if/else

```
int x = 10;
if (x > 0) {
    System.out.println("Positive");
}
else if (x < 0) {
    System.out.println("Negative");
}
else {
    System.out.println("Zero");
}
```

```
Output:
Positive
```

Nested if/else

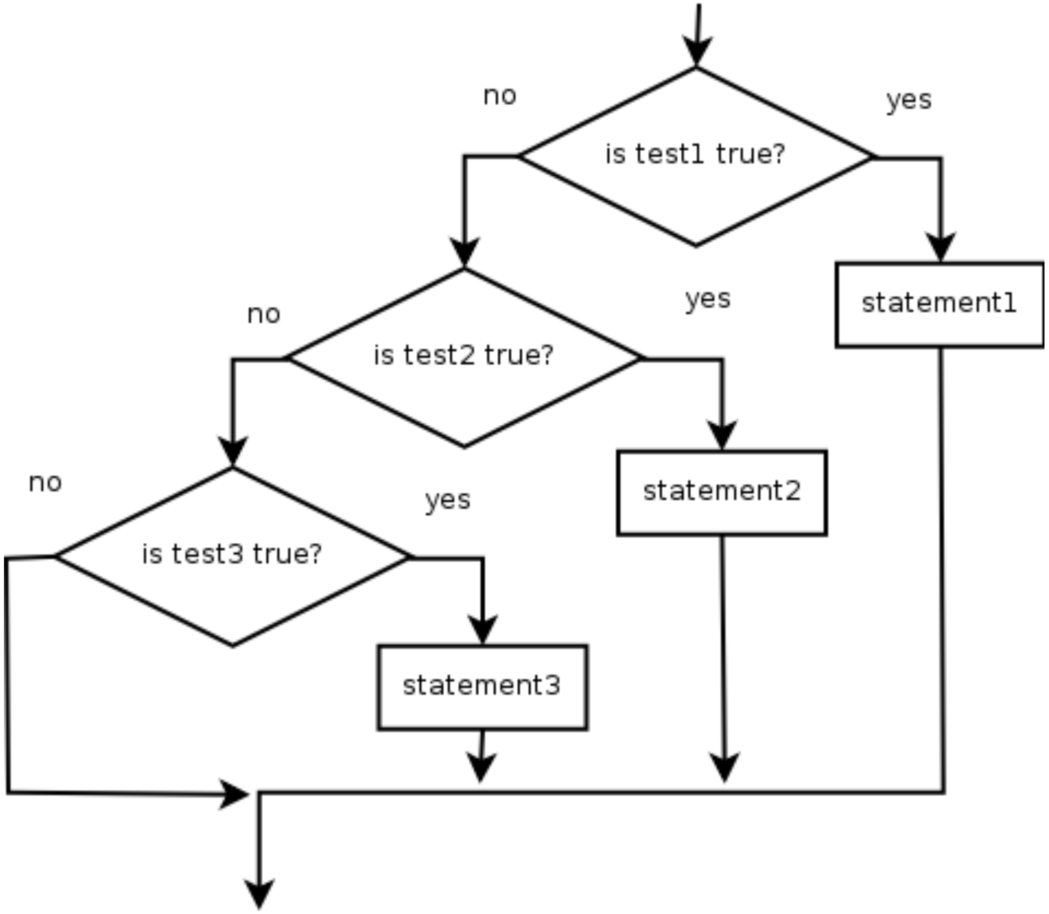
```
int x = 0;
if (x > 0) {
    System.out.println("Positive");
}
else if (x < 0) {
    System.out.println("Negative");
}
else {
    System.out.println("Zero");
}
```

```
Output:
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);
  }
```



Nested if/else/if

int place = 2;

```
  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.");
  }
```

```
Output:
Silver medal!
```

Nested if/else/if

```
int place = 6;
   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.");
   }
```

```
Output:
No output.
```

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`

"Boolean Zen", part 1

- Students new to `boolean` often test if a result is `true`:

```
if (isPrime(57) == true) {     // bad
    ...
}
```

- But this is unnecessary and redundant. Preferred:

```
if (isPrime(57)) {             // good
    ...
}
```

"Boolean Zen", part 1

- A similar pattern can be used for a `false` test:

```
if (isPrime(57) == false) {    // bad
…
}

if (!isPrime(57)) {            // good
…
}
```

Note: ! is the "not" operator, which flips the boolean value from true to false and false to true.

"Boolean Zen", part 2

- Methods that return `boolean` often have an `if/else` that returns `true` or `false`:

```
public static boolean bothOdd(int n1, int n2) {
    if (n1 % 2 != 0 && n2 % 2 != 0) {
        return true;
    } else {
        return false;
    }
}
```

  - But the code above is unnecessarily verbose.

"Boolean Zen", part 3

- We could store the result of the logical test.

```
public static boolean bothOdd(int n1, int n2) {
    boolean test = (n1 % 2 != 0 && n2 % 2 != 0);
    if (test) {   // test == true
        return true;
    }
  else {      // test == false
        return false;
    }
}
```

  - Notice: Whatever `test` is, we want to return that.
    - If `test` is `true` , we want to return `true`.
    - If `test` is `false`, we want to return `false`.

Final "Boolean Zen"

- Observation: The `if/else` is unnecessary.
  - The variable `test` stores a `boolean` value;

    its value is exactly what you want to return. So return that!

```
public static boolean bothOdd(int n1, int n2) {
    boolean test = (n1 % 2 != 0 && n2 % 2 != 0);
    return test;
}
```

- An even shorter version:
  - We don't even need the variable `test`.

    We can just perform the test and return its result in one step.

```
public static boolean bothOdd(int n1, int n2) {
    return (n1 % 2 != 0 && n2 % 2 != 0);
}
```

"Boolean Zen" template

- Replace

```
public static boolean name(parameters) {
    if (test) {
        return true;
    }
    else {
        return false;
    }
}
```

- with

```
public static boolean name(parameters) {
    return test;
}
```

Lab 1: Day Of the Week

Create a new repl on replit. Write a program that outputs the day of the week for a given date! You program has just the main method and the dayOfWeek method below.

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 String dayOfWeek(int m, int d, int y){
  // fill in code
}
```

Lab 1: Day Of the Week

Write the main method so that the output is similar to the following: (Use scanner)

Output:

```
Enter month: 10
Enter day: 15
Enter year: 2019
Day of the week: Tuesday
```

Use conditionals! And try entering your birthday and test your parents!

Lab 2: repl.it Problems

Do the 4 Conditional Statement Problems(# 015-018) on repl.it classroom.

References

1) CPJava Website
2) CPJava Google Classroom
3) CPJava trinket.io Classroom
4) Runestone CSAwesome BUSHSCHOOL_CPJAVA Course
5) Online Textbook Think Java - 2nd Edition by Allen Downey and Chris Mayfield
6) Building Java Programs: A Back to Basics Approach by Stuart Reges and Marty Stepp