Building Java Programs

Chapter 4

Lecture 4-1: `if` and `if/else` Statements

reading: 4.2

self-check: #4-5, 7, 10, 11

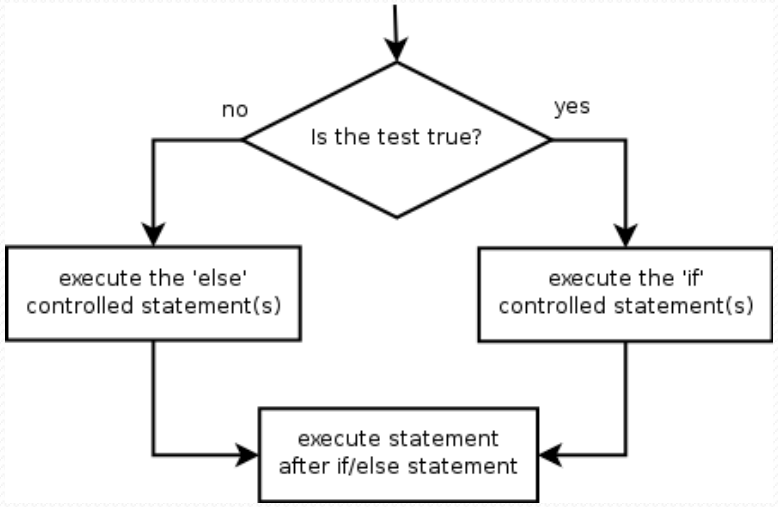
exercises: #7

videos: Ch. 4 #2-4

The `if/else` statement

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

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



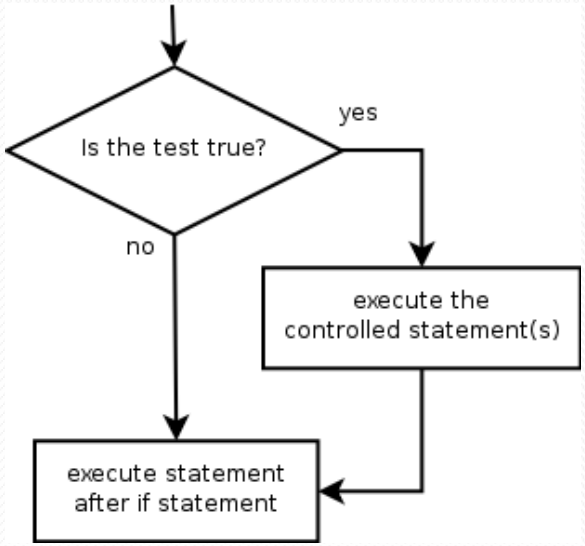
- Example:

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

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.");
}
```

What do we *need*?

- The if/else statement is a *really* key programming tool
  - Every programming language has it; we use it everywhere
  - What a program does depends on the data

- Variations are a matter of style
  - Good style lets other programmers quickly see what you mean
  - We *could* make do with just if/else
  - Example (more in a minute):

Good style

```
if(test) {
  …
}
```

Bad style but it works

```
if(test) {
   …
} else { // nothing
}
```

Relational expressions

- A **test** in an `if` is the same as in a `for` loop.

```
for (int i = 1; i <= 10; i++) { ...
if (i <= 10) { ...
```

  - These are `boolean` expressions, seen in Ch. 5.

- 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`

Multiple part tests

Something else that works but is bad style

```
if(x > -10) {
   if(x < 10) {
      System.out.println("x is 1 digit long");
   }
}
```

We can combine tests with &&

```
if(x > -10 && x < 10) {
   System.out.println("x is 1 digit long");
}
```

Aside: could also just test `x % 10 == x`

Logical operators: &&, ||, !

- Conditions 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

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.

```
-10 <= x <= 10          (assume x is 15)
true    <= 10
   error!
```

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

```
-10 <= x && x <= 10          (assume x is 15)
true    && false
   false
```

Logical mini-exercises

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

```
int x = 10;
int y = 5;
int z = 12;
```

  - `x <= y`
    - Answer: false
  - `y < x && y <= z`
    - Answer: true
  - `x/y+x == z && z > 20`
    - Answer: false
  - `x <= 2*y && x >= 2*y && z > 4`
    - Answer: true
  - `!(x < y && x < z)`
    - Answer: true

Loops with `if/else`

- `if/else` statements can be used with loops or methods:

```
int evenSum = 0;
int oddSum = 0;

for (int i = 1; i <= 5; i++) {
    if (i % 2 == 0) {
        evenSum = evenSum + i;
    } else {
        oddSum = oddSum + i;
    }
}

System.out.println("Even sum: " + evenSum);
System.out.println("Odd sum: " + oddSum);
```

Another Example

```
// compute how many feet taller first thing is
// Note: assumes first thing *is* taller
int feetTaller(int feet1, int inches1,
               int feet2, int inches2) {
  int answer = feet1 - feet2;
  if(inches1 < inches2) {
    --answer;
  }
  return answer;
}
```

Note: Many other ways to write this function

Nested `if/else`

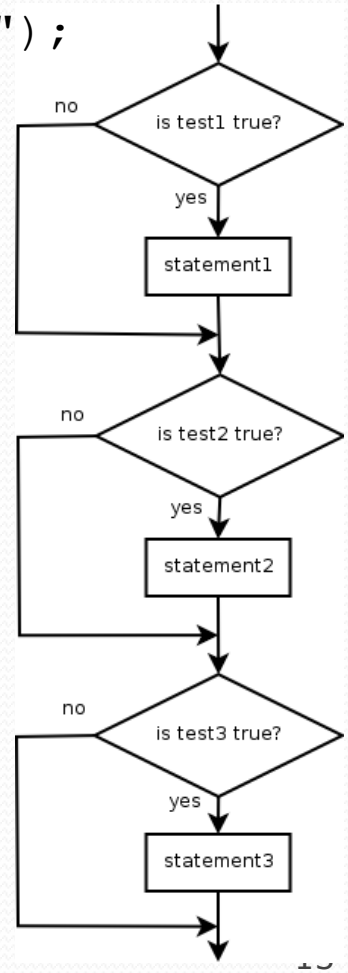
reading: 4.2, 4.5

self-check: #6, 8, 9, 24-27
exercises: #10-14
videos: Ch. 4 #4

Sequential `if` bug

- 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!");
} else {
    System.out.println("You got an F!");
}
...
```



Fixed but bad style

- With what we know so far, we would write this:

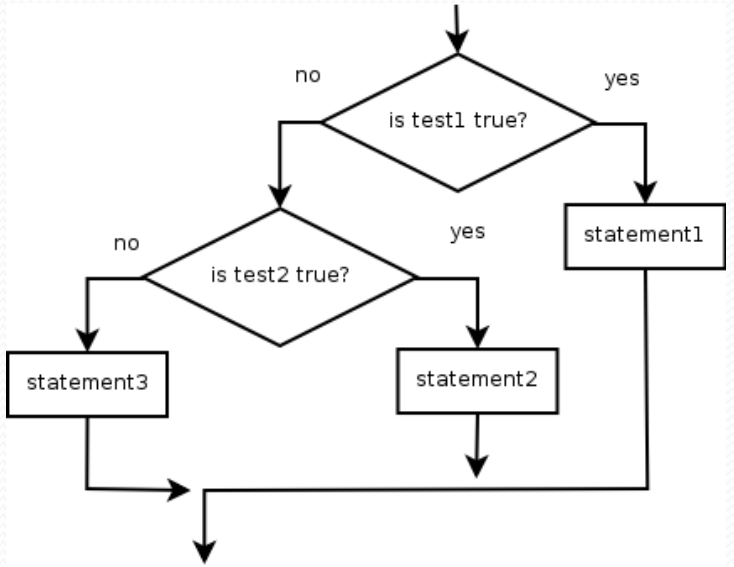
```
if (percent >= 90) {
    System.out.println("You got an A!");
} else {
   if (percent >= 80) {
    System.out.println("You got a B!");
   } else {
      if (percent >= 70) {
        System.out.println("You got a C!");
      } else {
       if (percent >= 60) {
        System.out.println("You got a D!");
       } else {
          System.out.println("You got an F!");
       }
      }
   }
 }
```

- We want this meaning, but nicer looking…

Nested `if/else`

Chooses between outcomes using many tests

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



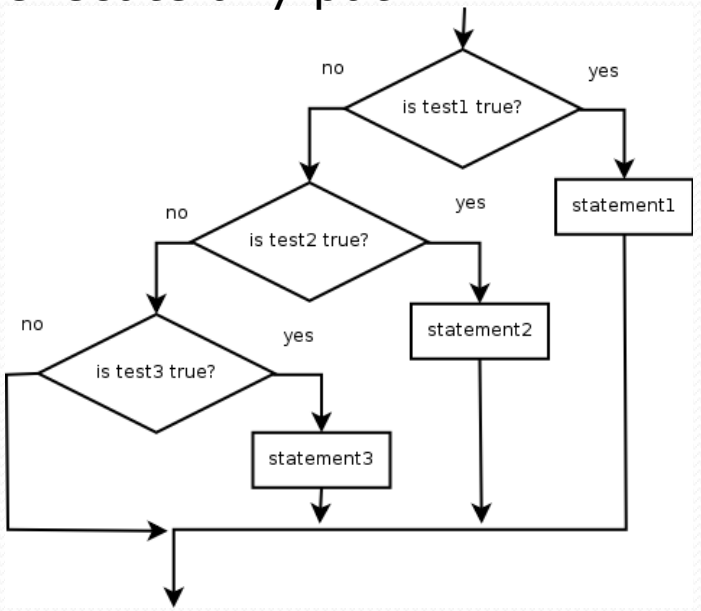
- Example:

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

Nested `if/else/if`

- If it ends with `else`, one code path must be taken.
- If it ends with `if`, the program might not execute any path.

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



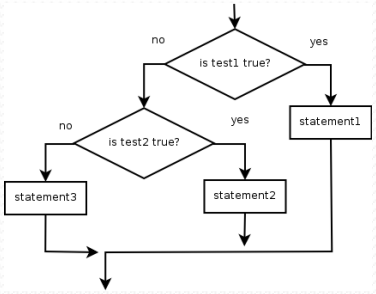
- Example:

```
if (place == 1) {
    System.out.println("You win the gold medal!");
} else if (place == 2) {
    System.out.println("You win a silver medal!");
} else if (place == 3) {
    System.out.println("You earned a bronze medal.");
}
```

Structures

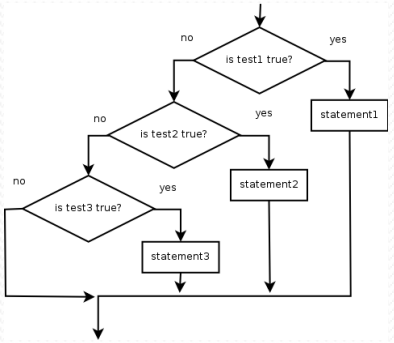
- Exactly 1 path: (mutually exclusive)

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



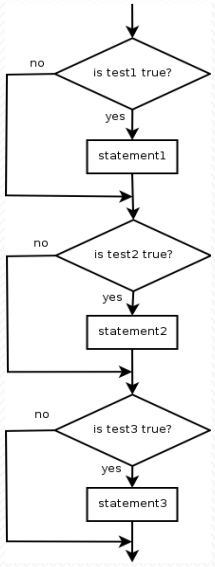
- 0 or 1 path:

```
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`?

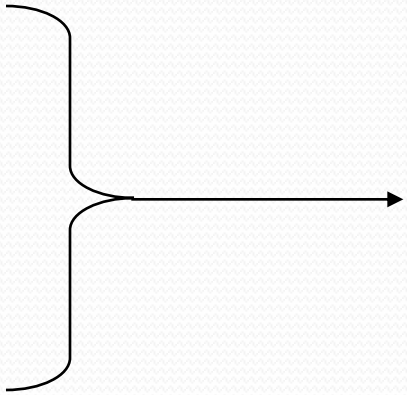
- **(1) if/if/if (2) nested if/else (3) nested if/else/if**
  - Reading the user's GPA and printing whether the student is on the dean's list (3.8 to 4.0) or honor roll (3.5 to 3.8).
    - **(3)** nested `if / else if`
  - Printing whether a number is even or odd.
    - **(N/A)** simple `if / else`
  - Printing whether a user is lower-class, middle-class, or upper-class based on their income.
    - **(2)** nested `if / else if / else`
  - Reading a number from the user and printing whether it is divisible by 2, 3, and/or 5.
    - **(1)** sequential `if / if / if`
  - Printing a grade of A, B, C, D, or F based on a percentage.
    - **(2)** nested `if / else if / else if / else if / else`

Factoring `if/else` code

- **factoring**: extracting common/redundant code
  - Factoring `if/else` code can reduce the size of `if/else` statements or eliminate the need for `if/else` altogether.

- Example:

```
if (a == 1) {
    x = 3;
} else if (a == 2) {
    x = 6;
    y++;
} else {  // a == 3
    x = 9;
}
```



```
x = 3 * a;
if (a == 2) {
    y++;
}
```

Code in need of factoring

```
if (money < 500) {
    System.out.println("You have, $" + money + " left.");
    System.out.print("Caution!  Bet carefully.");
    System.out.print("How much do you want to bet? ");
    bet = console.nextInt();
} else if (money < 1000) {
    System.out.println("You have, $" + money + " left.");
    System.out.print("Consider betting moderately.");
    System.out.print("How much do you want to bet? ");
    bet = console.nextInt();
} else {
    System.out.println("You have, $" + money + " left.");
    System.out.print("You may bet liberally.");
    System.out.print("How much do you want to bet? ");
    bet = console.nextInt();
}
```

Code after factoring

```
System.out.println("You have, $" + money + " left.");

if (money < 500) {
    System.out.print("Caution!  Bet carefully.");
} else if (money < 1000) {
    System.out.print("Consider betting moderately.");
} else {
    System.out.print("You may bet liberally.");
}

System.out.print("How much do you want to bet? ");
bet = console.nextInt();
```

- If the start of each branch is the same, move it *before* the `if/else`.
- If the end of each branch is the same, move it *after* the `if/else`.
- If similar but code exists in each branch, look for patterns.

Factoring mini-exercise

Improve the following code:

```
if (x < 10) {
    System.out.println("x = " + x);
    y = x+20;
    System.out.println("y = " + y);
} else {
    System.out.println("x = " + x);
    y = x+5;
    System.out.println("y = " + y);
}
```

Factoring mini-exercise - solution

```
if (x < 10) {
    y = x+20;
} else {
    y = x+5;
}
System.out.println("x = " + x);
System.out.println("y = " + y);
```

(or the first println could be before the 'if')

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`...

if/else with return

- Methods can return different values using `if/else`:

```
// Returns the phone-row of an int (assumed to be 0-9)
public static String phoneRow(int x) {
    if (x % 3 == 1) {
        return "left";
    } else if (x % 3 == 2 || x == 0) {
        return "middle";
    } else {
        return "right";
    }
}
```

  - Whichever path the code enters, it will return the appropriate value.
  - Returning a value causes a method to immediately exit.
  - All code paths must reach a `return` statement.
    - All paths must also return a value of the same type.

All paths must return

```
public static String phoneRow(int x) {
    if (x % 3 == 1) {
        return "left";
    } else if (x % 3 == 2 || x == 0) {
        return "middle";
    }
    // Error: not all paths return a value
}
```

- The following also does not compile:

```
public static String phoneRow(int x) {
    if (x % 3 == 1) {
        return "left";
    } else if (x % 3 == 2 || x == 0) {
        return "middle";
    } else if (x % 3 == 0) {
        return "right";
    }
}
```

  - The compiler thinks `if/else/if` code might skip all paths.

`if/else`, `return` question

- Write a method `countFactors` that returns the number of factors of an integer.
  - `countFactors(24)` returns `8` because 1, 2, 3, 4, 6, 8, 12, and 24 are factors of 24.

- Write a program that prompts the user for a maximum integer and prints all prime numbers up to that max.

```
Maximum number? 52
2 3 5 7 11 13 17 19 23 29 31 37 41 43 47
15 primes (28.84%)
```

if/else, return answer 1

```
// Prompts for a maximum number and prints each prime up to that maximum.
import java.util.*;

public class Primes {
    public static void main(String[] args) {
        // read max from user
        Scanner console = new Scanner(System.in);
        System.out.print("Maximum number? ");
        int max = console.nextInt();
        printPrimes(max);
    }

    // Prints all prime numbers up to the given maximum.
    public static void printPrimes(int max) {
        int primes = 0;
        for (int i = 2; i <= max; i++) {
            if (countFactors(i) == 2) {       // i is prime
                System.out.print(i + " ");
                primes++;
            }
        }
        System.out.println();

        double percent = 100.0 * primes / max;
        System.out.printf("%d primes (%.2f%%)\n", primes, percent);
    }
```

if/else, return answer 2

```
    ...

    // Returns how many factors the given number has.
    public static int countFactors(int number) {
        int count = 0;
        for (int i = 1; i <= number; i++) {
            if (number % i == 0) {
                count++;  // i is a factor of number
            }
        }
        return count;
    }
}
```