Building Java Programs

Chapter 3
Lecture 3-3: Interactive Programs w/ Scanner

reading: 3.3 - 3.4
self-check: #16-19
exercises: #11
videos: Ch. 3 #4

Interactive programs

- We have written programs that print console output, but it is also possible to read *input* from the console.
  - The user types input into the console. We capture the input and use it in our program.
  - Such a program is called an *interactive program*.

- Interactive programs can be challenging.
  - Computers and users think in very different ways.
  - Users misbehave.

Input and `System.in`

- `System.out`
  - An object with methods named `println` and `print`
- `System.in`
  - not intended to be used directly
  - We use a second object, from a class `Scanner`, to help us.

- Constructing a `Scanner` object to read console input:

```
Scanner name = new Scanner(System.in);
```

  - Example:

```
Scanner console = new Scanner(System.in);
```

Java class libraries, import

- **Java class libraries**: Classes included with Java's JDK.
  - organized into groups named *packages*
  - To use a package, put an *import declaration* in your program.

- Syntax:

```
// put this at the very top of your program
import packageName.*;
```

- `Scanner` is in a package named `java.util`

```
import java.util.*;
```

  - To use `Scanner`, you must place the above line at the top of your program (before the `public class` header).

`Scanner` methods

Method	Description
`nextInt()`	reads a token of user input as an `int`
`nextDouble()`	reads a token of user input as a `double`
`next()`	reads a token of user input as a `String`
`nextLine()`	reads a *line* of user input as a `String`

- Each method waits until the user presses Enter.
  - The value typed is returned.

```
System.out.print("How old are you? ");     // prompt
int age = console.nextInt();
System.out.println("You'll be 40 in " +
        (40 - age) + " years.");
```

  - **prompt**: A message telling the user what input to type.

Example `Scanner` usage

```
import java.util.*;   // so that I can use Scanner

public class ReadSomeInput {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);

        System.out.print("How old are you? ");
        int age = console.nextInt();

        System.out.println(age + "... That's quite old!");
    }
}
```

- Output (user input underlined):

```
How old are you? 14
14... That's quite old!
```

Another `Scanner` example

```
import java.util.*;   // so that I can use Scanner

public class ScannerSum {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);

        System.out.print("Please type three numbers: ");
        int num1 = console.nextInt();
        int num2 = console.nextInt();
        int num3 = console.nextInt();

        int sum = num1 + num2 + num3;
        System.out.println("The sum is " + sum);
    }
}
```

- Output (user input underlined):

```
Please type three numbers: 8 6 13
The sum is 27
```

  - The `Scanner` can read multiple values from one line.

Input tokens

- **token**: A unit of user input, as read by the `Scanner`.
  - Tokens are separated by *whitespace* (spaces, tabs, newlines).
  - How many tokens appear on the following line of input?

```
23  John Smith   42.0 "Hello world"   $2.50   " 19"
```

- When a token is not the type you ask for, it crashes.

```
System.out.print("What is your age? ");
int age = console.nextInt();
```

Output:

```
What is your age? Timmy
java.util.InputMismatchException
        at java.util.Scanner.next(Unknown Source)
        at java.util.Scanner.nextInt(Unknown Source)
        ...
```

Scanners as parameters

- If many methods read input, declare a `Scanner` in `main` and pass it to the others as a parameter.

```
public static void main(String[] args) {
    Scanner console = new Scanner(System.in);
    int sum = readSum3(console);
    System.out.println("The sum is " + sum);
}

// Prompts for 3 numbers and returns their sum.
public static int readSum3(Scanner console) {
    System.out.print("Type 3 numbers: ");
    int num1 = console.nextInt();
    int num2 = console.nextInt();
    int num3 = console.nextInt();
    return num1 + num2 + num3;
}
```

Cumulative sum

reading: 4.1

self-check: Ch. 4 #1-3

exercises: Ch. 4 #1-6

Adding many numbers

- How would you find the sum of all integers from 1-1000?

```
int sum = 1 + 2 + 3 + 4 + ... ;
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?

- We could write a method that accepts the max value as a parameter and prints the sum.
  - How can we generalize code like the above?

A failed attempt

- An incorrect solution for summing 1-1000:

```
for (int i = 1; i <= 1000; i++) {
    int sum = 0;
    sum = sum + i;
}

// 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` in the above code is an attempt at a cumulative sum.

Fixed cumulative sum loop

- A corrected version of the sum loop code:

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

Key idea:

- Cumulative sum variables must be declared *outside* the loops that update them, so that they will 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?

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);
```

User-guided cumulative sum

```
Scanner console = new Scanner(System.in);
System.out.print("How many numbers to add? ");
int count = console.nextInt();

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

- Output:

```
How many numbers to add? 3
Type a number: 2
Type a number: 6
Type a number: 3
The sum is 11
```

Cumulative sum question

- Write a program that reads two employees' hours and displays each employee's total and the overall total hours.
  - The company doesn't pay overtime; cap each day at 8 hours.
- Example log of execution:

```
Employee 1: How many days? 3
Hours? 6
Hours? 12
Hours? 5
Employee 1's total hours = 19 (6.3 / day)

Employee 2: How many days? 2
Hours? 11
Hours? 6
Employee 2's total hours = 14 (7.0 / day)

Total hours for both = 33
```

Cumulative sum answer

```
// Computes the total paid hours worked by two employees.
// The company does not pay for more than 8 hours per day.
// Uses a "cumulative sum" loop to compute the total hours.

import java.util.*;

public class Hours {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);

        int hours1 = processEmployee(console, 1);
        int hours2 = processEmployee(console, 2);

        int total = hours1 + hours2;
        System.out.println("Total hours for both = " + total);
    }

    ...
```

Cumulative sum answer 2

```
    ...

    // Reads hours information about an employee with the given number.
    // Returns total hours worked by the employee.
    public static int processEmployee(Scanner console, int number) {
        System.out.print("Employee " + number + ": How many days? ");
        int days = console.nextInt();

        // totalHours is a cumulative sum of all days' hours worked.
        int totalHours = 0;
        for (int i = 1; i <= days; i++) {
            System.out.print("Hours? ");
            int hours = console.nextInt();
            totalHours = totalHours + Math.min(hours, 8);
        }

        double hoursPerDay = (double) totalHours / days;
        System.out.printf("Employee %d's total hours = %d (%.1f / day)\n",
                          number, totalHours, hoursPerDay);
        System.out.println();
        return totalHours;
    }
}
```

Cumulative sum question

- Write a modified version of the `Receipt` program from Ch.2 that prompts the user for how many people ate and how much each person's dinner cost.
  - Display results in format below, with `$` and 2 digits after the `.`
- 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? 25.0
Person #4: How much did your dinner cost? 10.00

Subtotal: $70.00
Tax: $5.60
Tip: $10.50
Total: $86.10
```

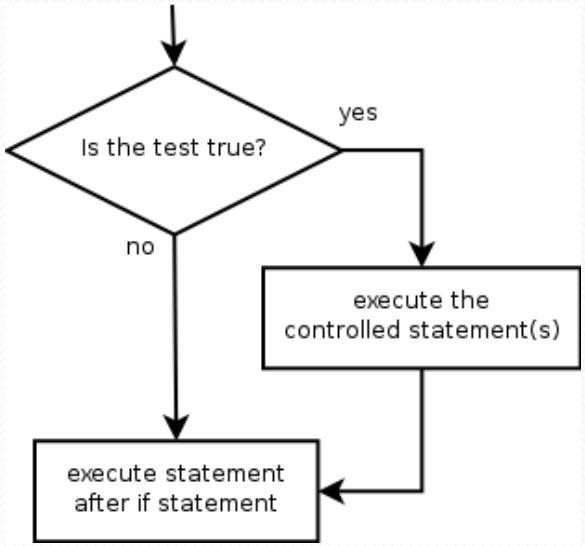
Cumulative sum answer

```
// 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);
        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
        }
        results(subtotal);
    }

    // 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: $%.2f\n", subtotal);
        System.out.printf("Tax: $%.2f\n", tax);
        System.out.printf("Tip: $%.2f\n", tip);
        System.out.printf("Total: $%.2f\n", total);
    }
}
```

The `if` statement

Executes a block of statements only if a test is true

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



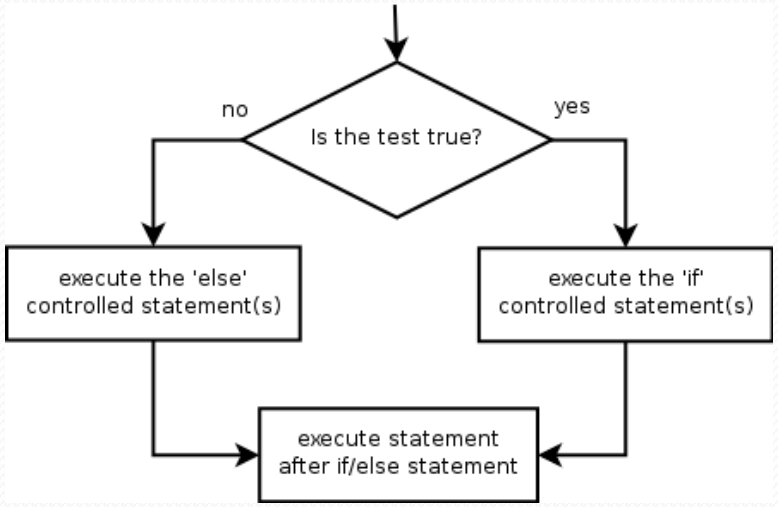
- Example:

```
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

- 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

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.

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

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

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

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`