Building Java Programs

Chapter 5
Lecture 5-2: Random Numbers

reading: 5.1, 5.6
int getRandomNumber()
{
    return 4;  // chosen by fair dice roll.
    // guaranteed to be random.
}
Randomness

- Lack of predictability: don't know what's coming next

- Random process: outcomes do not follow a deterministic pattern (math, statistics, probability)

- Lack of bias or correlation (statistics)

- Relevant in lots of fields
  - Genetic mutations (biology)
  - Quantum processes (physics)
  - Random walk hypothesis (finance)
  - Cryptography (computer science)
  - Game theory (mathematics)
  - Determinism (religion)
Pseudo-Randomness

- Computers generate numbers in a predictable way using a mathematical formula

- Parameters may include current time, mouse position
  - In practice, hard to predict or replicate

- True randomness uses natural processes
  - Atmospheric noise (http://www.random.org/)
  - Lava lamps (patent #5732138)
  - Radioactive decay
The Random class

- A Random object generates pseudo-random numbers.
- Class Random is found in the java.util package.

```java
import java.util.*;

Random rand = new Random();
int randomNumber = rand.nextInt(10); // 0-9
```

<table>
<thead>
<tr>
<th>Method name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>nextInt()</code></td>
<td>returns a random integer</td>
</tr>
<tr>
<td><code>nextInt(max)</code></td>
<td>returns a random integer in the range [0, max) in other words, 0 to max-1 inclusive</td>
</tr>
<tr>
<td><code>nextDouble()</code></td>
<td>returns a random real number in the range [0.0, 1.0)</td>
</tr>
</tbody>
</table>
Generating random numbers

- Common usage: to get a random number from 1 to $N$
  \[
  \text{int } n = \text{rand.nextInt(20)} + 1; \quad \text{// 1-20 inclusive}
  \]

- To get a number in arbitrary range $[min, max]$ inclusive:
  \[
  \text{name.nextInt(size of range)} + \text{min}
  \]
  - Where \text{size of range} is $(\text{max} - \text{min} + 1)$

- Example: A random integer between 4 and 10 inclusive:
  \[
  \text{int } n = \text{rand.nextInt(7)} + 4;
  \]
Random questions

- Given the following declaration, how would you get:
  ```java
  Random rand = new Random();
  ```

- A random number between 1 and 47 inclusive?
  ```java
  int random1 = rand.nextInt(47) + 1;
  ```

- A random number between 23 and 30 inclusive?
  ```java
  int random2 = rand.nextInt(8) + 23;
  ```

- A random even number between 4 and 12 inclusive?
  ```java
  int random3 = rand.nextInt(5) * 2 + 4;
  ```
Random and other types

• `nextDouble` method returns a `double` between 0.0 - 1.0
  
  • Example: Get a random GPA value between 1.5 and 4.0:
    ```java
double randomGpa = rand.nextDouble() * 2.5 + 1.5;
```

• Any set of possible values can be mapped to integers
  
  • code to randomly play Rock-Paper-Scissors:
    ```java
    int r = rand.nextInt(3);
    if (r == 0) {
      System.out.println("Rock");
    } else if (r == 1) {
      System.out.println("Paper");
    } else { // r == 2
      System.out.println("Scissors");
    }
    ```
Random question

- Write a program that simulates rolling of two 6-sided dice until their combined result comes up as 7.

  2 + 4 = 6
  3 + 5 = 8
  5 + 6 = 11
  1 + 1 = 2
  4 + 3 = 7

  You won after 5 tries!
import java.util.*;

public class Dice {
    public static void main(String[] args) {
        Random rand = new Random();
        int tries = 0;

        int sum = 0;
        while (sum != 7) {
            // roll the dice once
            int roll1 = rand.nextInt(6) + 1;
            int roll2 = rand.nextInt(6) + 1;
            sum = roll1 + roll2;
            System.out.println(roll1 + " + " + roll2 + " = " + sum);
            tries++;
        }

        System.out.println("You won after " + tries + " tries!");
    }
}
Point objects

• Java has a class of objects named Point.
  • They store two values, an (x, y) pair, in a single variable.
  • They have useful methods we can call in our programs.
  • To use Point, you must write:
    import java.awt.*;

• Two ways to construct a Point object:

    Point name = new Point(x, y);
    Point name = new Point();  // the origin (0, 0)

• Examples:
    Point p1 = new Point(5, -2);
    Point p2 = new Point();
Point data and methods

- **Data stored in each** Point object:

<table>
<thead>
<tr>
<th>Field name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>the point's x-coordinate</td>
</tr>
<tr>
<td>y</td>
<td>the point's y-coordinate</td>
</tr>
</tbody>
</table>

- **Methods of each** Point object:

<table>
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<tbody>
<tr>
<td>distance(p)</td>
<td>how far away the point is from point p</td>
</tr>
<tr>
<td>setLocation(x, y)</td>
<td>sets the point's x and y to the given values</td>
</tr>
<tr>
<td>translate(dx, dy)</td>
<td>adjusts the point's x and y by the given amounts</td>
</tr>
</tbody>
</table>
Random drawing question

- Write a program that draws 100x100 rectangles at random (x, y) positions within a 500x500 DrawingPanel.

- The rectangles' color should be randomly chosen between red, green, and blue.

- Print how far away the upper left corner of the rectangle is from the middle of the screen
Random drawing question

- Modify the rectangle program to draw randomly placed/colored 10x10 rectangles until it draws 20 red ones.
  - Break up your program using static methods.
  - Print a line of output each time a red rectangle is drawn:
    - Drew red #1 at (120, 312)
    - Drew red #2 at (285, 337)
    - Drew red #3 at (410, 251)
    - Drew red #4 at (15, 372)
    - Drew red #5 at (61, 248)

- Make the `DrawingPanel` animate by calling its `sleep` method between each rectangle drawn.
Random question

- Write a program that plays an adding game.
  - Ask user to solve random adding problems with 2-5 numbers.
  - The user gets 1 point for a correct answer, 0 for incorrect.
  - The program stops after 3 incorrect answers.

4 + 10 + 3 + 10 = 27
9 + 2 = 11
8 + 6 + 7 + 9 = 25
Wrong! The answer was 30
5 + 9 = 13
Wrong! The answer was 14
4 + 9 + 9 = 22
3 + 1 + 7 + 2 = 13
4 + 2 + 10 + 9 + 7 = 42
Wrong! The answer was 32
You earned 4 total points.
// Asks the user to do adding problems and scores them.
import java.util.*;

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

        // play until user gets 3 wrong
        int points = 0;
        int wrong = 0;
        while (wrong < 3) {
            int result = play(console, rand); // play one game
            if (result == 0) {
                wrong++;
            } else {
                points++;
            }
        }

        System.out.println("You earned " + points + " total points.");
    }
}
public static int play(Scanner console, Random rand) {
    // print the operands being added, and sum them
    int operands = rand.nextInt(4) + 2;
    int sum = rand.nextInt(10) + 1;
    System.out.print(sum);
    for (int i = 2; i <= operands; i++) {
        int n = rand.nextInt(10) + 1;
        sum += n;
        System.out.print(" + " + n);
    }
    System.out.print(" = ");
    // read user's guess and report whether it was correct
    int guess = console.nextInt();
    if (guess == sum) {
        return 1;
    } else {
        System.out.println("Wrong! The answer was " + total);
        return 0;
    }
}