Building Java Programs

Chapter 5
Lecture 5-2: Random Numbers

reading: 5.1, 5.6
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
  - 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.*;
```

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

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

- **Common usage:** to get a random number from 1 to N

  ```java
  int n = rand.nextInt(20) + 1;  // 1-20 inclusive
  ```

- **To get a number in arbitrary range** \([min, max]\) **inclusive:**

  ```java
  name.nextInt(size of range) + min
  ```

  - Where **size of range** is \((max - min + 1)\)

- **Example:** A random integer between 4 and 10 inclusive:

  ```java
  int n = rand.nextInt(7) + 4;
  ```
Random questions

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

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

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

  • A random even number between 4 and 12 inclusive?
    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 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!
// Rolls two dice until a sum of 7 is reached.
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!");
    }
}
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) { // play one game
                wrong++;
            } else {
                points++;
            }
        }

        System.out.println("You earned " + points + " total points.");
    }
}
public static int play(Scanner console, Random rand) {  
    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(" = ");  
    int guess = console.nextInt();  
    if (guess == sum) {  
        return 1;  
    } else {  
        System.out.println("Wrong! The answer was "+ total);  
        return 0;  
    }
}