Mathematical Operations in Java – Random Numbers

Most programming languages, including Java, have some sort of random number generator. Some languages provide multiple options for generating random numbers, but most provide a single option that must be manipulated by the programmer to produce the desired result.

In Java, the random number generation is part of the Math class, and it is invoked using the Math.random method, which has the following signature:

```java
public double random()
```

This method returns a double value \( x \) where \( 0 \leq x < 1 \) (i.e., the numbers from 0.00000 to 0.99999, but does not include 1).

Example 1 – One common use of random numbers in programming is to simulate the throwing of a fair die, which is a six-sided die with an equal probability of getting a 1, 2, 3, 4, 5, or 6. We can do so by performing the following operations:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Call the Math.random method to generate a random value ( x ), where ( 0 \leq x &lt; 1 )</td>
<td>Low Value: 0.000000, High Value: 0.999999</td>
</tr>
<tr>
<td>(b) Multiply this value by 6 (since there are six possible sides on the die) to get the interval ( 0 \leq x &lt; 6 ).</td>
<td>Low Value: 0.000000, High Value: 5.999999</td>
</tr>
<tr>
<td>(c) Cast this result as an integer, which chops off any fractional (decimal) part. Our value is now 0, 1, 2, 3, 4, or 5.</td>
<td>Low Value: 0, High Value: 5</td>
</tr>
<tr>
<td>(d) Adding 1 will give us the desired range of values, from 1 to 6.</td>
<td>Low Value: 1, High Value: 6</td>
</tr>
</tbody>
</table>

All of these operations can be performed in one step with the statement

```java
int dieRoll = (int)( 6 * Math.random() ) + 1;
```

All random number generation follows these basic steps, where we:

(a) generate a random number between 0.00000 and 0.99999,
(b) multiply by the number of possible results we desire,
(c) optional: cast the result as an integer (if we want integer values),
(d) add (or subtract) some number to shift our random numbers to the desired range.
Exercises

1. Write a statement that will make the int variable result take on a random value from the given set.
   (a) \{1, 2, 3, \ldots, 10\}
   (b) \{1, 2, 3, \ldots, 52\} which simulates a 52-card deck.
   (c) \{5, 10, 15, \ldots, 100\} (Hint: How many possible values are there, and how do we create the correct number of values when generating a random number?)
   (d) \{-5, -4, -3, \ldots, 5\}
   (e) \{100, 110, 120, \ldots, 300\}

2. Write a statement that will assign the char variable randChoice a random value from the set \{‘A’, ‘B’, ‘C’, ‘D’, ‘E’\}.

3. Write a statement that will assign the double variable randVal a random value from the set \{1.00, 1.25, 1.50, \ldots, 4.00\}.
Solutions

1. Write a statement that will make the int variable result take on a random value from the given set.

   (a) \{1,2,3,\ldots,10\}
   
   \[\text{(int) } (10 \times \text{Math.random()} + 1)\]

   (b) \{1,2,3,\ldots,52\} which simulates a 52-card deck.
   
   \[\text{(int) } (52 \times \text{Math.random()} + 1)\]

   (c) \{5,10,15,\ldots,100\} (Hint: How many possible values are there, and how do we create the correct number of values when generating a random number?)
   
   \[\text{(int) } (20 \times \text{Math.random()} + 1) \quad \text{// gives 1 to 20}\]
   
   \[5 \times ((\text{int}) (20 \times \text{Math.random()} + 1)) \quad \text{// gives 5 to 100, by 5's}\]

   (d) \{-5,-4,-3,\ldots,5\}
   
   \[\text{(int) } (11 \times \text{Math.random()} - 5)\]

   (e) \{100,110,120,\ldots,300\}
   
   \[\text{(int) } (21 \times \text{Math.random()}) \quad \text{// gives 0 to 20}\]
   
   \[\text{(int) } (21 \times \text{Math.random()}) + 10 \quad \text{// gives 10 to 30}\]
   
   \[\text{(int) } (21 \times \text{Math.random()}) + 10 \quad \text{// gives 100 to 300, by 10's}\]

2. Write a statement that will assign the char variable randChoice a random value from the set \{'A'..'E'\}.

   \[\text{(int) } (5 \times \text{Math.random()}) \quad \text{// 0 to 4}\]

   \[\text{(int) } (5 \times \text{Math.random()}) + (\text{int})'A' \quad \text{// 65 to 69}\]

   \[\text{(char)}((\text{int}) (5 \times \text{Math.random()}) + (\text{int})'A') \quad \text{// convert to chars}\]

   Therefore, the assignment statement should be:

   \[
   \text{char randChoice = (char)((int) (5 * Math.random()) + (int)'A');}
   \]

3. Write a statement that will assign the double variable randVal a random value from the set \{1.00,1.25,1.50,\ldots,4.00\}.

   \[\text{(int) } (13 \times \text{Math.random()}) \quad \text{// 0 to 12 is 13 choices}\]

   \[\text{(int) } (13 \times \text{Math.random()}) + 4 \quad \text{// 4 to 16 is 13 choices}\]

   \[0.25 \times ((\text{int}) (13 \times \text{Math.random()}) + 4) \quad \text{// 1.00 to 4.00 by 0.25}\]

   or

   \[25 \times (\text{int}) (13 \times \text{Math.random()}) \quad \text{// 0 to 300, by 25's}\]

   \[25 \times (\text{int}) (13 \times \text{Math.random()}) + 100 \quad \text{// 100 to 400, by 25's}\]

   \[
   (25 \times (\text{int}) (13 \times \text{Math.random()}) + 100)/100.0 \quad \text{// 1.00 to 4.00 by 0.25}\]

   \[
   \text{double randVal = 0.25 * ((int) (13 * Math.random() + 4));}
   \]