

## 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:

```
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:

Operation	Result	
	Low Value	High Value
(a) Call the <code>Math.random</code> method to generate a random value $x$ , where $0 \leq x < 1$	0.000000	0.999999
(b) Multiply this value by 6 (since there are six possible sides on the die) to get the interval $0 \leq x < 6$ .	0.000000	5.999999
(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.	0	5
(d) Adding 1 will give us the desired range of values, from 1 to 6.	1	6

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

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

                  ↑          ↑          ↑          ↑  
                 (c)     (b)     (a)     (d)

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.

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### Exercises

1. Write a statement that will make the int variable result take on a random value from the given set.
  - (a)  $\{1, 2, 3, \dots, 10\}$
  - (b)  $\{1, 2, 3, \dots, 52\}$  which simulates a 52-card deck.
  - (c)  $\{5, 10, 15, \dots, 100\}$  (Hint: How many possible values are there, and how do we create the correct number of values when generating a random number?)
  - (d)  $\{-5, -4, -3, \dots, 5\}$
  - (e)  $\{100, 110, 120, \dots, 300\}$
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  $\{1.00, 1.25, 1.50, \dots, 4.00\}$ .

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### 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,...,10}

```
(int) (10 * Math.random()) + 1
```

(b) {1,2,3,...,52} which simulates a 52-card deck.

```
(int) (52 * Math.random()) + 1
```

(c) {5,10,15,...,100} (Hint: How many possible values are there, and how do we create the correct number of values when generating a random number?)

```
(int) (20 * Math.random()) + 1 // gives 1 to 20
```

```
5 * ((int) (20 * Math.random()) + 1) // gives 5 to 100, by 5's
```

(d) {-5,-4,-3,...,5}

```
(int) (11 * Math.random()) - 5
```

(e) {100,110,120,...,300}

```
(int) (21 * Math.random()) // gives 0 to 20
```

```
(int) (21 * Math.random()) + 10 // gives 10 to 30
```

```
(int) (21 * Math.random()) + 10 // 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','B','C','D','E'}.

```
(int) (5 * Math.random()) // 0 to 4
```

```
(int) (5 * Math.random()) + (int)'A' // 65 to 69
```

```
(char)((int) (5 * Math.random()) + (int)'A') // convert to chars
```

Therefore, the assignment statement should be:

```
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,...,4.00}.

```
(int) (13 * Math.random()) // 0 to 12 is 13 choices
```

```
(int) (13 * Math.random()) + 4 // 4 to 16 is 13 choices
```

```
0.25 * ((int) (13 * Math.random()) + 4) // 1.00 to 4.00 by 0.25
```

or

```
25 * (int) (13 * Math.random()) // 0 to 300, by 25's
```

```
25 * (int) (13 * Math.random()) + 100 // 100 to 400, by 25's
```

```
(25 * (int) (13 * Math.random()) + 100)/100.0 // 1.00 to 4.00 by 0.25
```

```
double randVal = 0.25 * ((int) (13 * Math.random()) + 4);
```