Random Numbers

RANDOM VS PSEUDO RANDOM

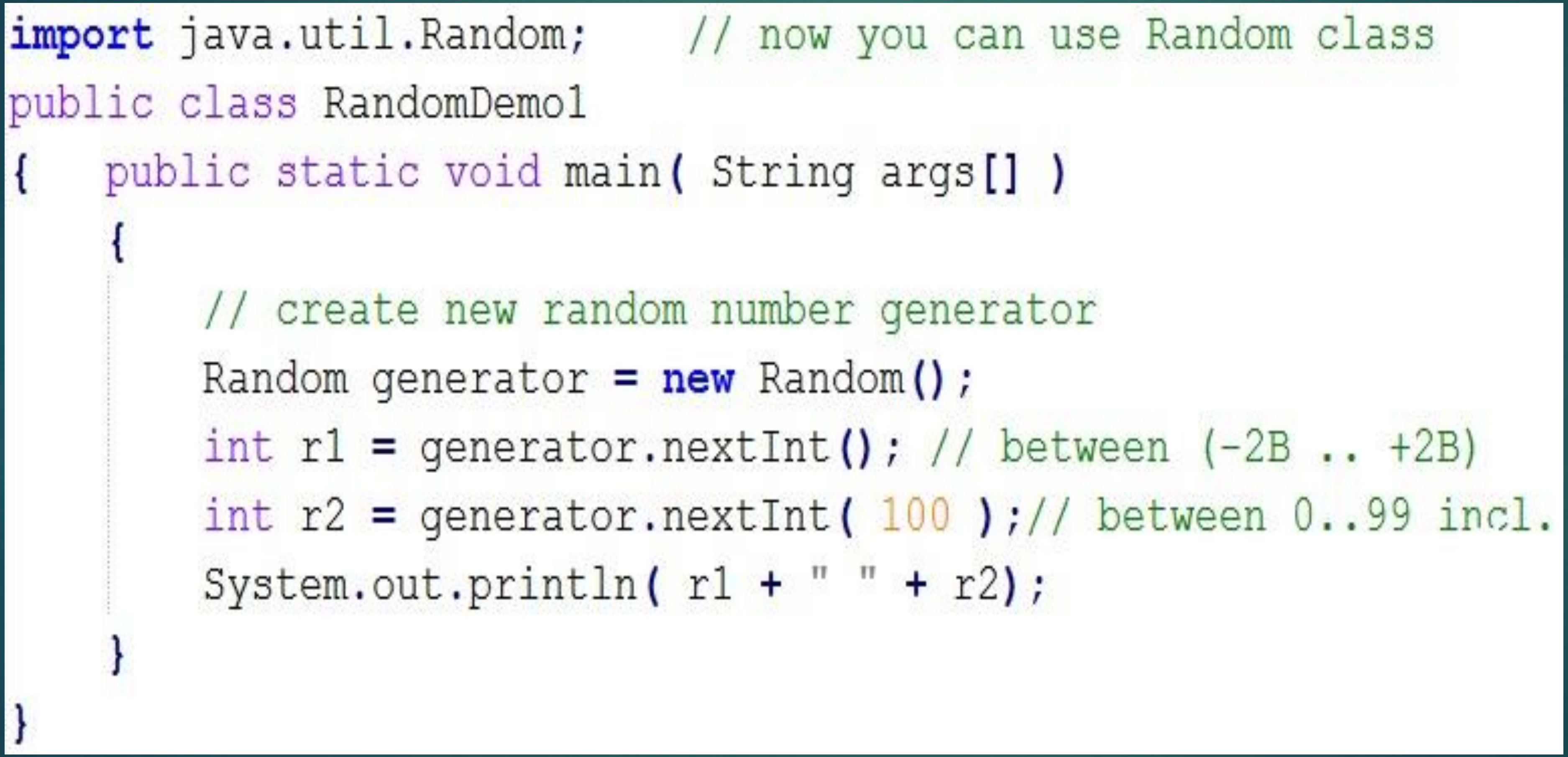
Truly Random numbers

- From Wolfram: “A *random number* is a *number* chosen as if by chance from some specified distribution such that selection of a large set of these *numbers* reproduces the underlying distribution. Almost always, such *numbers* are also required to be independent, so that there are no correlations between successive *numbers*”
- Another word that characterizes true randomness is unpredictability. Natural phenomenon is our best known source of random values.
- Examples of natural phenomena producing truly random values are radioactive decay, atmospheric noise, background radiation, and turbulence.

Pseudo Random Numbers

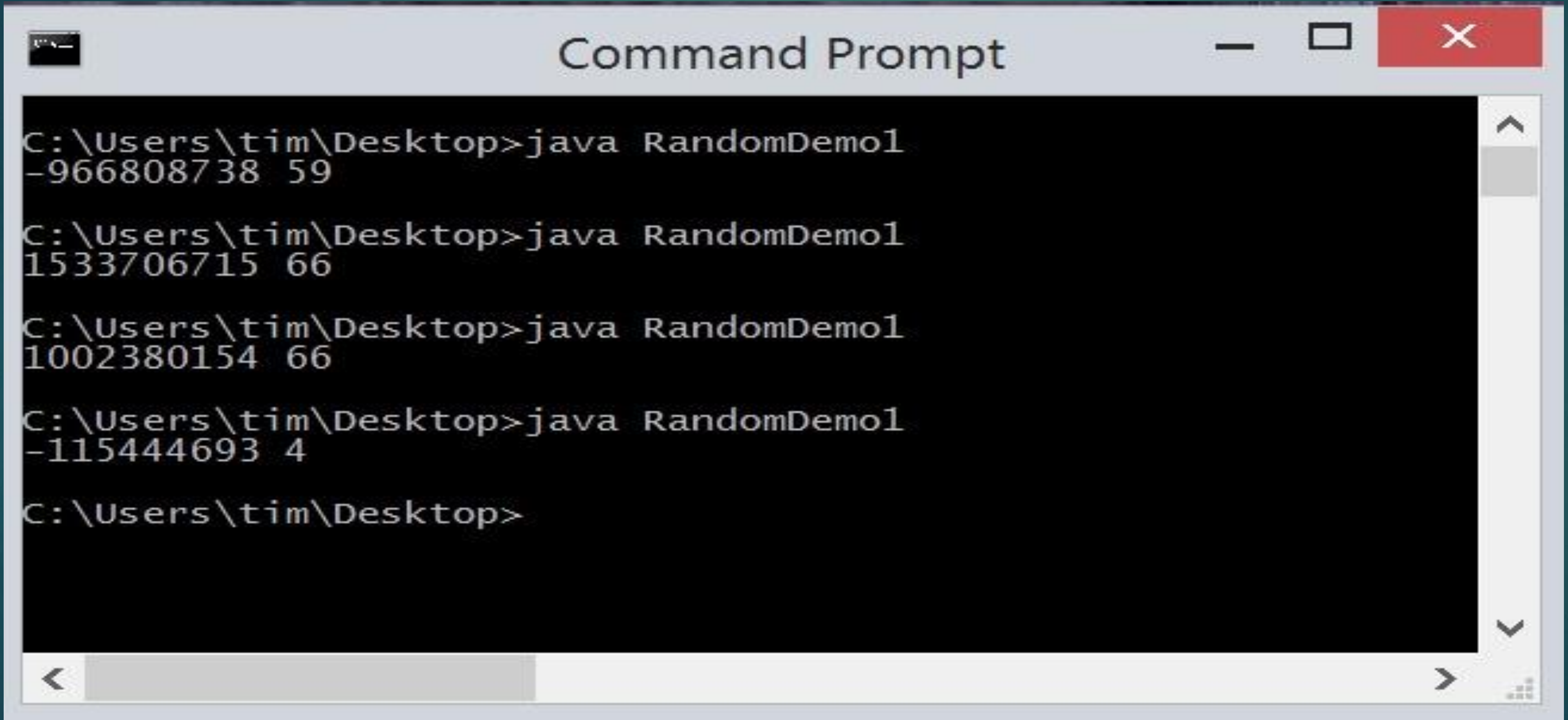
- Pseudo random numbers are number produced by an algorithm that appear unpredictable, uncorrelated and when produced in sequence form a distribution that is representative of the underlying distribution.
- Computers generate pseudo random numbers very easily and efficiently. To humans a well implemented algorithm will produce a sequence of pseudo random numbers that look unpredictable, uncorrelated and distributed fairly evenly from among the set of all possible integers that the computer can represent, for example in Java, -2 billion to +2 billion.
- Pseudo random numbers are extremely useful in all fields of science where “realistic” sequences of random values are needed.

Java’s Random generates pseudo random numbers.



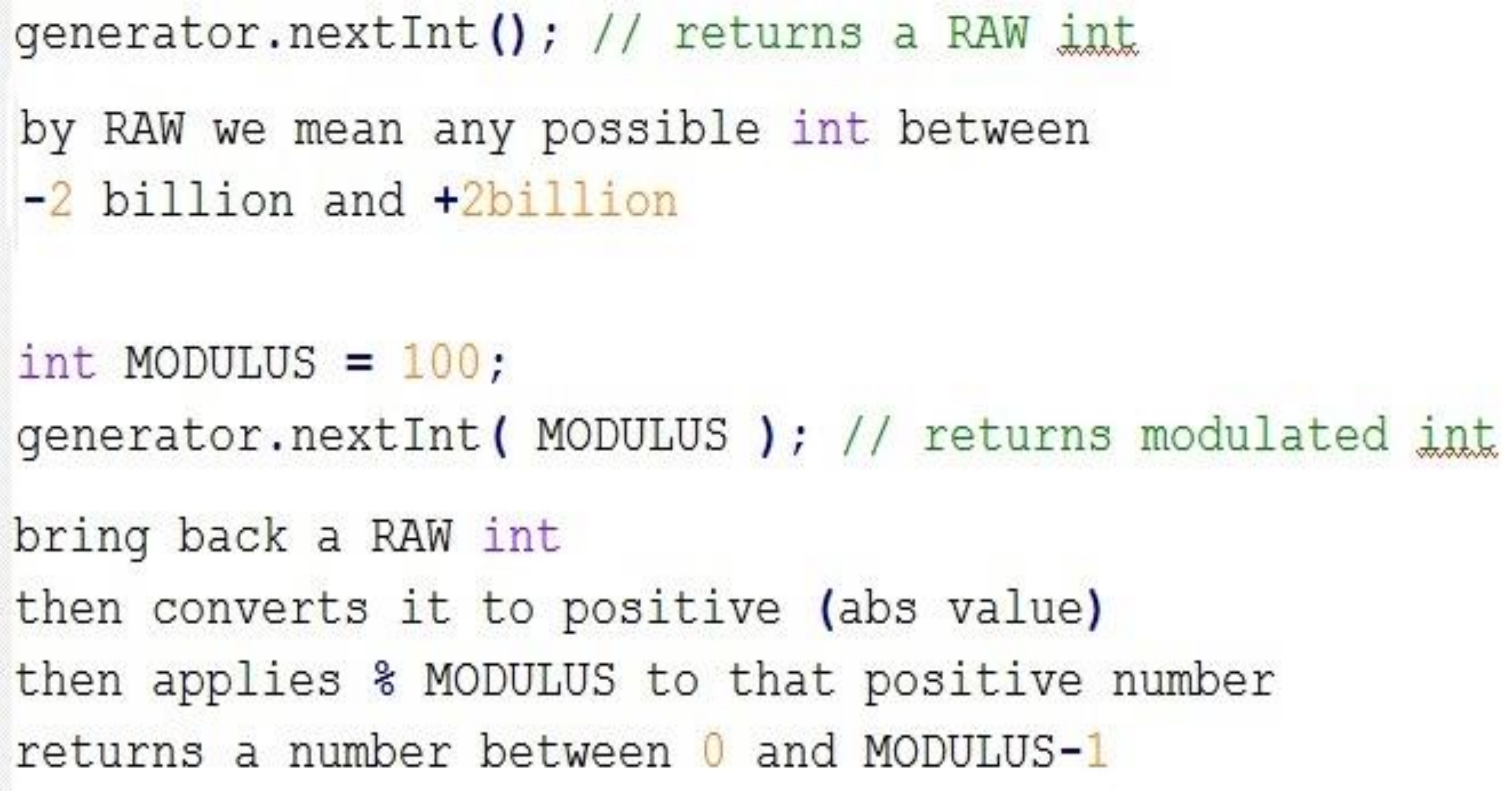
```
import java.util.Random;    // now you can use Random class
public class RandomDemo1
{   public static void main( String args[] )
    {
        // create new random number generator
        Random generator = new Random();
        int r1 = generator.nextInt(); // between (-2B .. +2B)
        int r2 = generator.nextInt( 100 );// between 0..99 incl.
        System.out.println( r1 + " " + r2);
    }
}
```

Each call to nextInt() returns the next number from the sequence



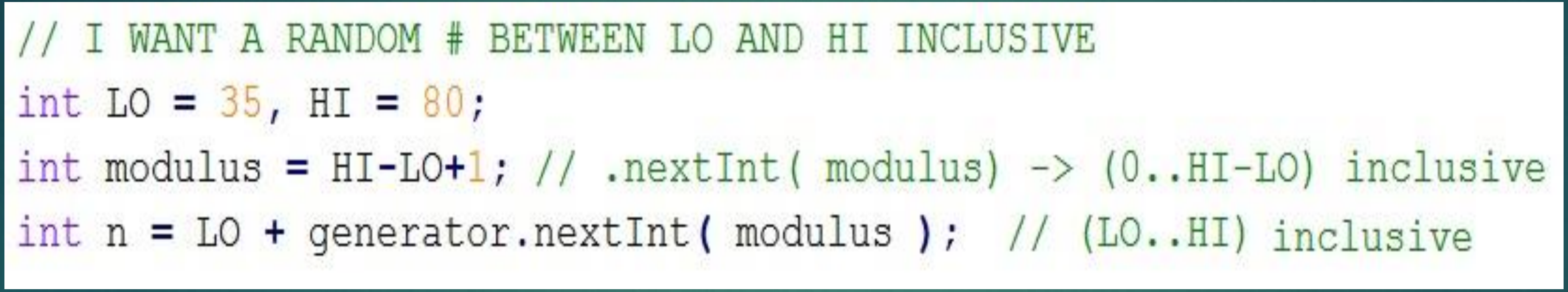
```
C:\Users\tim\Desktop>java RandomDemo1
-966808738 59

C:\Users\tim\Desktop>java RandomDemo1
1533706715 66

C:\Users\tim\Desktop>java RandomDemo1
1002380154 66

C:\Users\tim\Desktop>java RandomDemo1
-115444693 4

C:\Users\tim\Desktop>
```

.nextInt() vs .nextInt(modulus)



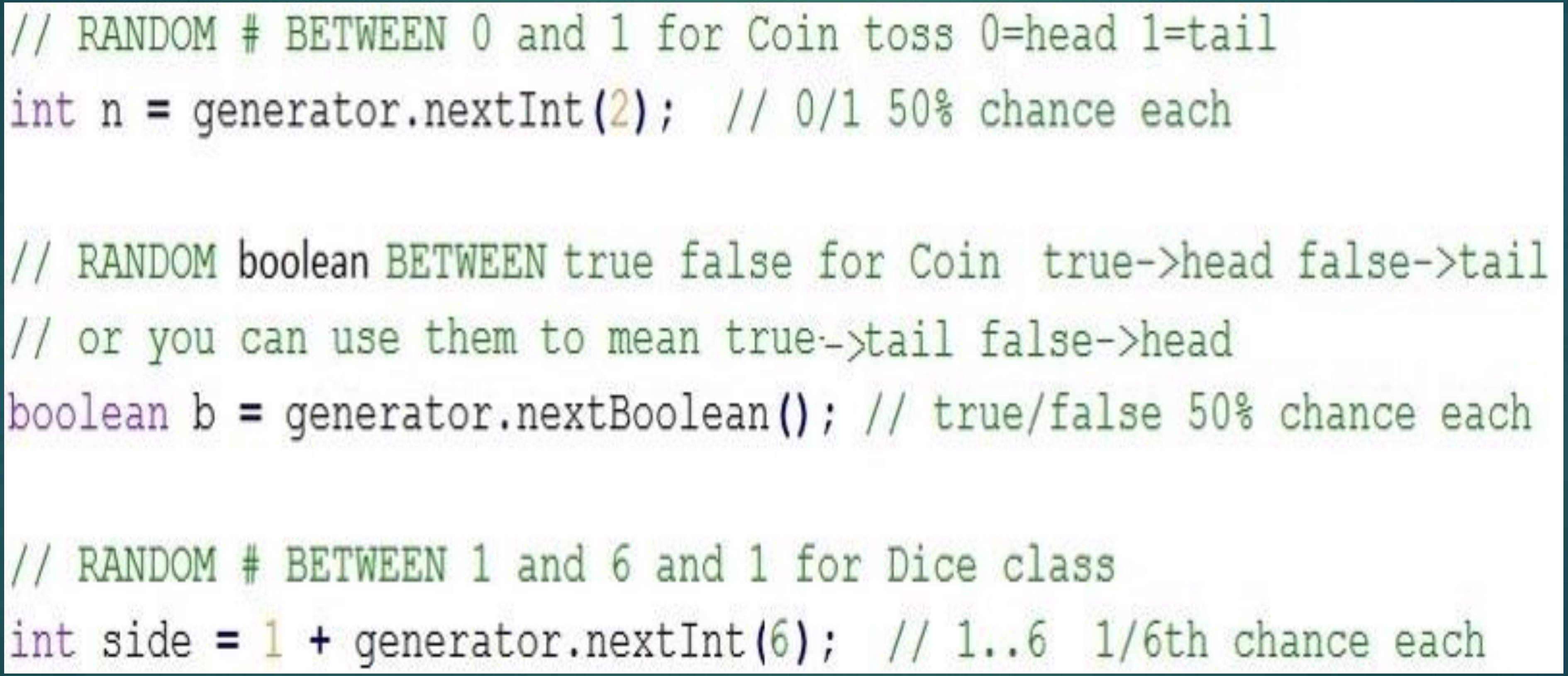
```
generator.nextInt(); // returns a RAW int

by RAW we mean any possible int between
-2 billion and +2billion


int MODULUS = 100;
generator.nextInt( MODULUS ); // returns modulated int

bring back a RAW int
then converts it to positive (abs value)
then applies % MODULUS to that positive number
returns a number between 0 and MODULUS-1
```

I want a random number between LO and HI inclusive



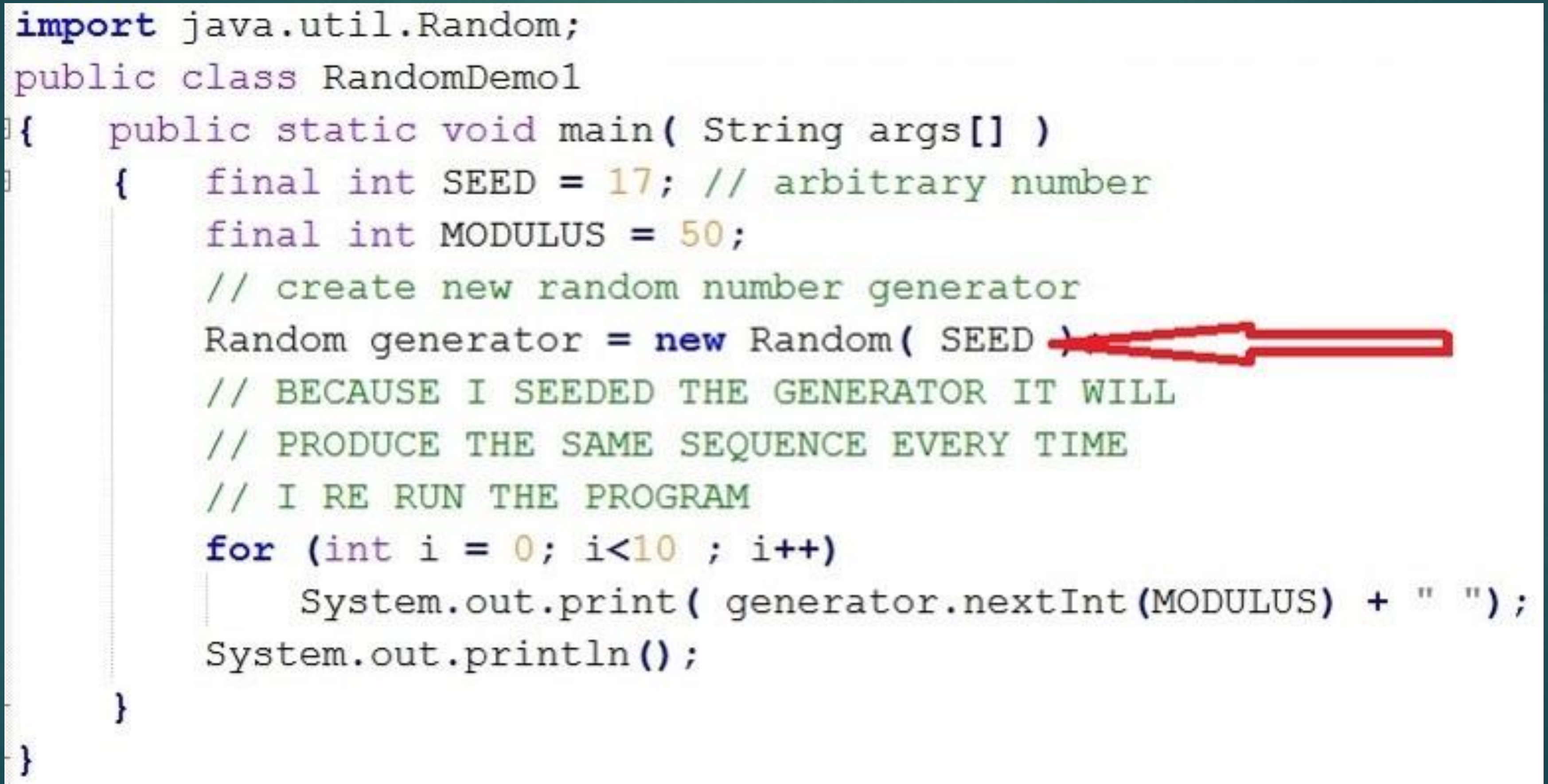
```
// I WANT A RANDOM # BETWEEN LO AND HI INCLUSIVE
int LO = 35, HI = 80;
int modulus = HI-LO+1; // .nextInt( modulus) -> (0..HI-LO) inclusive
int n = LO + generator.nextInt( modulus );  // (LO..HI) inclusive
```

I want a random number between 0 and 1 or 1 and 6



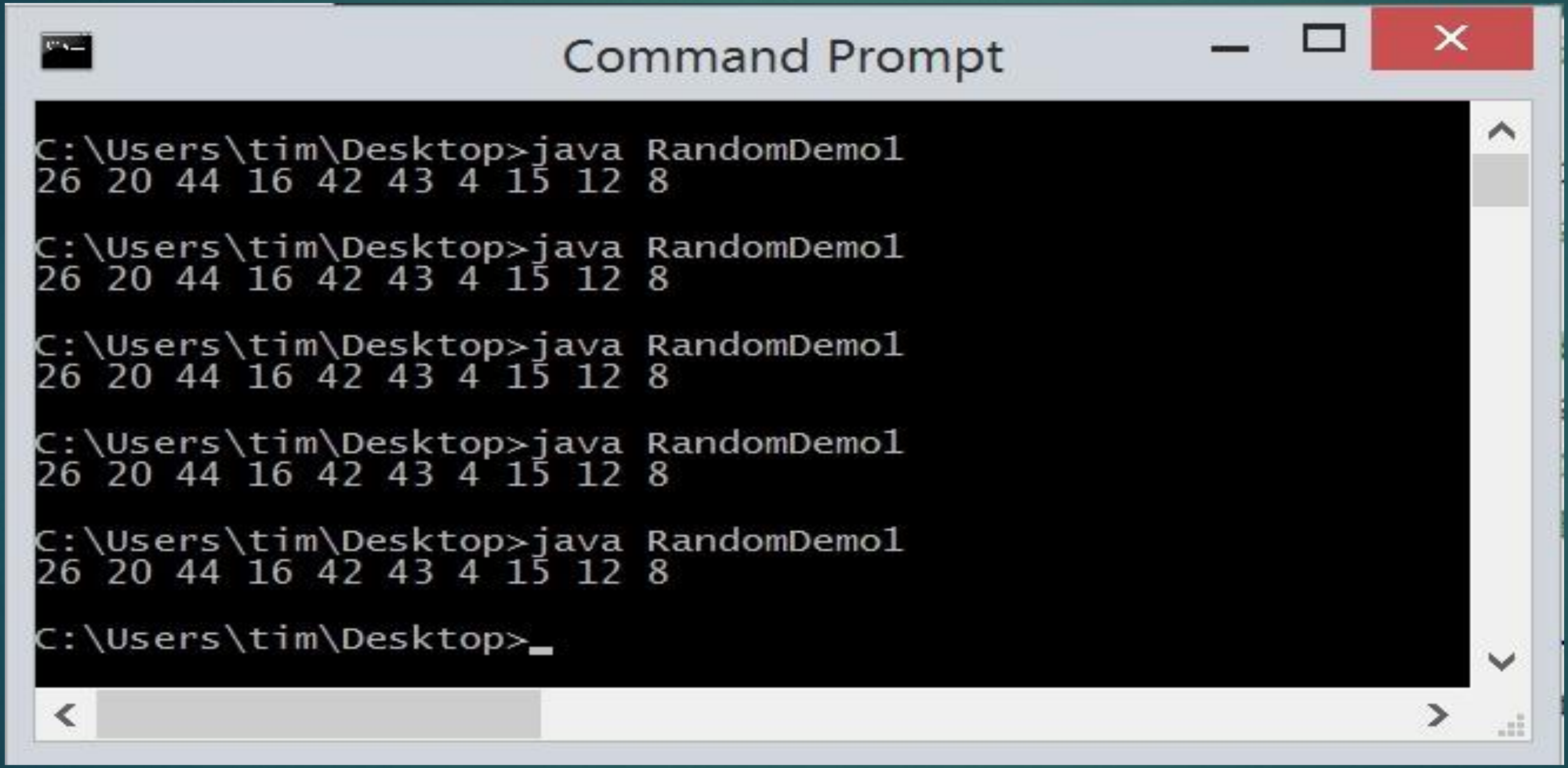
```
// RANDOM # BETWEEN 0 and 1 for Coin toss 0=head 1=tail
int n = generator.nextInt(2);  // 0/1 50% chance each

// RANDOM boolean BETWEEN true false for Coin  true->head false->tail
// or you can use them to mean true->tail false->head
boolean b = generator.nextBoolean(); // true/false 50% chance each

// RANDOM # BETWEEN 1 and 6 and 1 for Dice class
int side = 1 + generator.nextInt(6);  // 1..6  1/6th chance each
```

Seeding the Random number generator



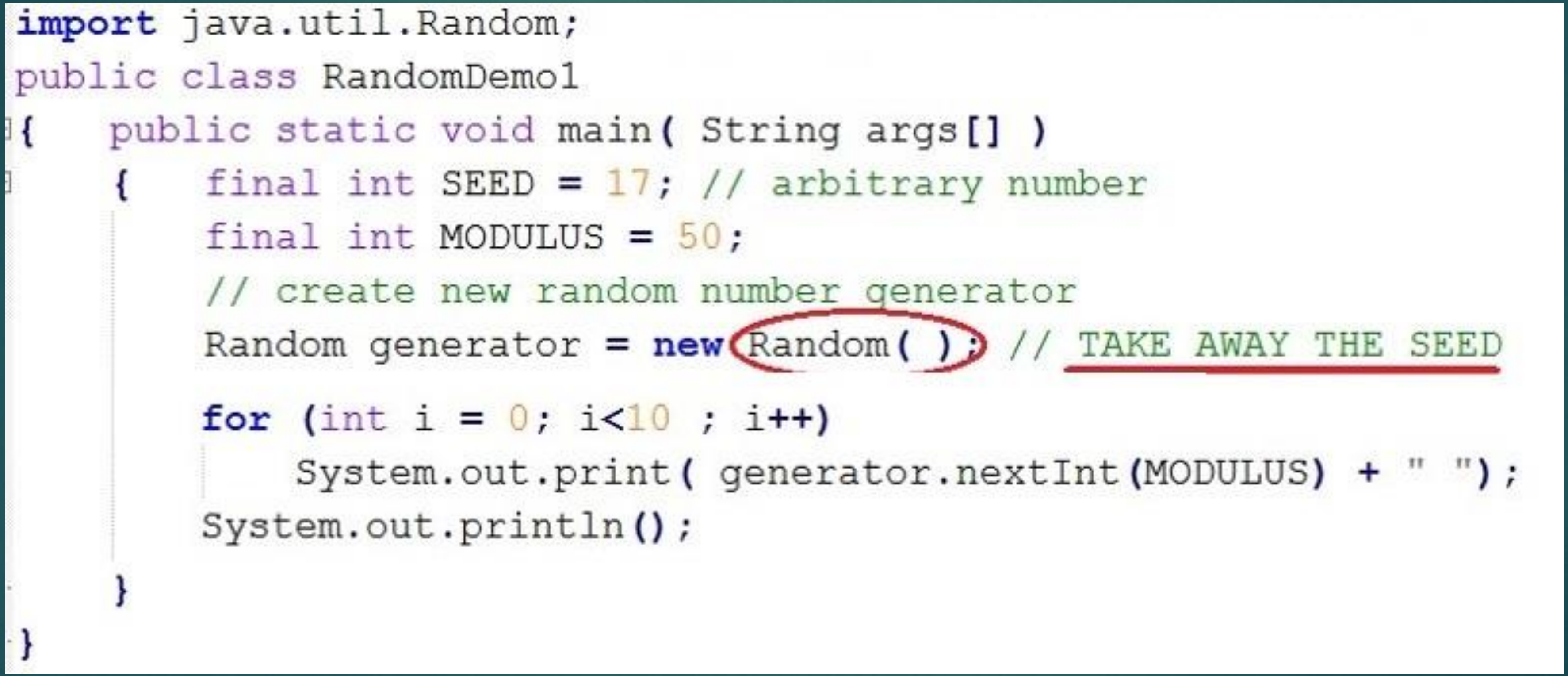
```
import java.util.Random;
public class RandomDemo1
{   public static void main( String args[] )
    {   final int SEED = 17; // arbitrary number
        final int MODULUS = 50;
        // create new random number generator
        Random generator = new Random( SEED );
        // BECAUSE I SEEDED THE GENERATOR IT WILL
        // PRODUCE THE SAME SEQUENCE EVERY TIME
        // I RE RUN THE PROGRAM
        for (int i = 0; i<10 ; i++)
            System.out.print( generator.nextInt(MODULUS) + " ");
        System.out.println();
    }
}
```

Output created by a SEEDED random number generator



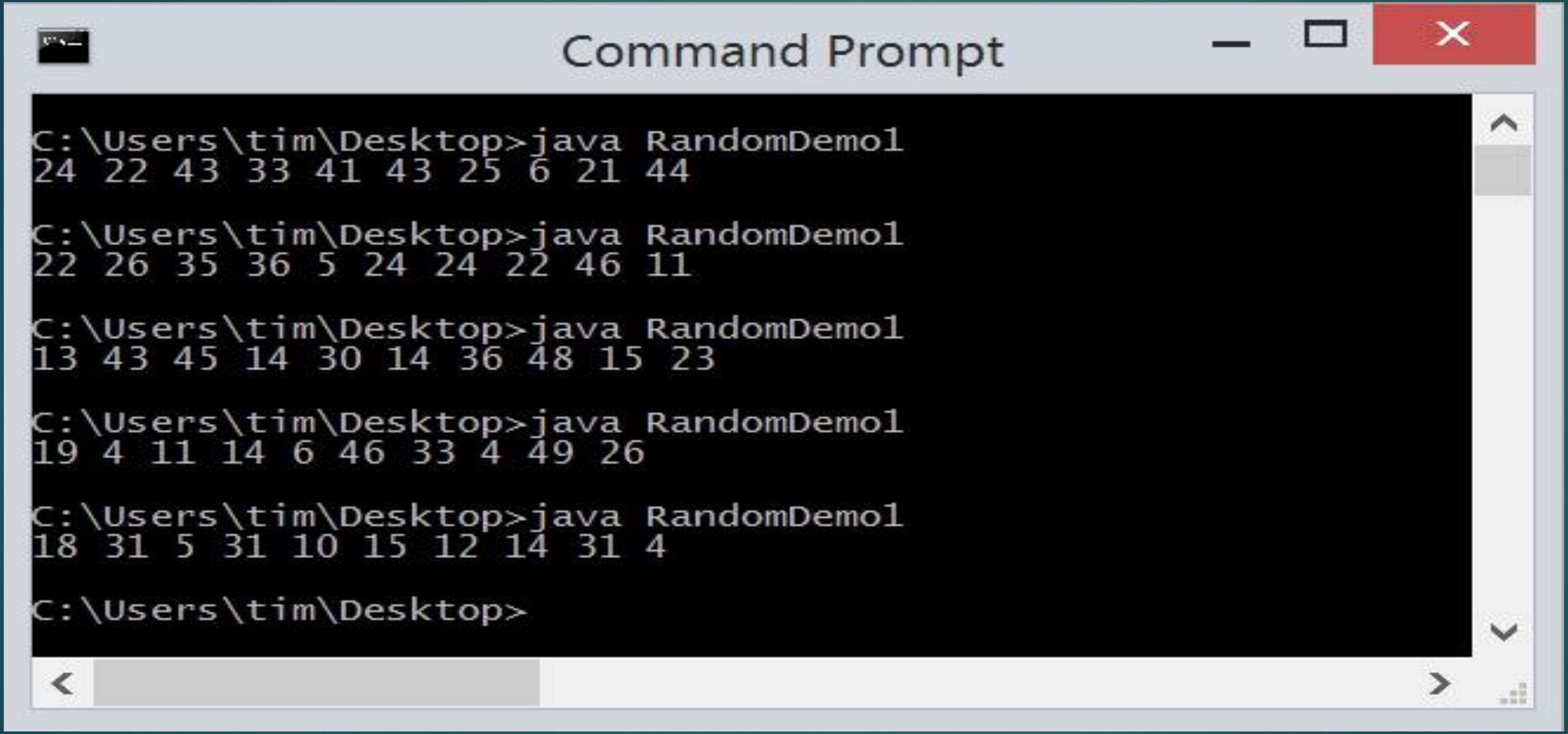
```
C:\Users\tim\Desktop>java RandomDemo1
26 20 44 16 42 43 4 15 12 8

C:\Users\tim\Desktop>java RandomDemo1
26 20 44 16 42 43 4 15 12 8

C:\Users\tim\Desktop>java RandomDemo1
26 20 44 16 42 43 4 15 12 8

C:\Users\tim\Desktop>java RandomDemo1
26 20 44 16 42 43 4 15 12 8

C:\Users\tim\Desktop>java RandomDemo1
26 20 44 16 42 43 4 15 12 8

C:\Users\tim\Desktop>_
```

Same code BUT with NO SEED in the initialization of generator



```
import java.util.Random;
public class RandomDemo1
{   public static void main( String args[] )
    {   final int SEED = 17; // arbitrary number
        final int MODULUS = 50;
        // create new random number generator
        Random generator = new Random( ); // TAKE AWAY THE SEED
        for (int i = 0; i<10 ; i++)
            System.out.print( generator.nextInt(MODULUS) + " ");
        System.out.println();
    }
}
```

Now the sequence is different every time you run the program



```
C:\Users\tim\Desktop>java RandomDemo1
24 22 43 33 41 43 25 6 21 44

C:\Users\tim\Desktop>java RandomDemo1
22 26 35 36 5 24 24 22 46 11

C:\Users\tim\Desktop>java RandomDemo1
13 43 45 14 30 14 36 48 15 23

C:\Users\tim\Desktop>java RandomDemo1
19 4 11 14 6 46 33 4 49 26

C:\Users\tim\Desktop>java RandomDemo1
18 31 5 31 10 15 12 14 31 4

C:\Users\tim\Desktop>
```