

[Return to List of Lessons](#)

## Calculator Lesson 23

### Random Numbers and Custom Menus

In this lesson we will learn to generate random numbers. It will require using commands from two different directories. In such cases it is easier to create a custom menu that contains all of the commands we need so we do not have to keep switching between directories. Before starting this lesson, create a directory (see Lesson 1) called RanNo. We will be creating several variables to be stored in this directory to make our work with the Monte Carlo method easier. After creating the directory RanNo get into it and continue with the lesson.

The random number generator can be found by keying LS MTH NXT F1-PROB. The F4 button is now RAND, which is the random number generator. Each press of F4-RAND will put a random number between 0 and 1 on the stack. Actually, these are pseudo-random numbers. No computer algorithm can produce truly random numbers. We can see this by using the F5-RDZ command. Pick your favorite number and press F5-RDZ. This sets a “seed”, a starting value, for the random number generator. Press F4-RAND three times and leave the values on the stack. Now enter the same seed again and press F5-RDZ, then F4-RAND three times. You will see the same three “random” numbers showing up again.

In most cases we want random numbers in some given interval  $(a, b)$ . If  $x$  is a random number between 0 and 1, then  $y = a + x(b - a)$  is a random number in  $(a, b)$ . Enter and define the function  $RN(x) = A + x(B - A)$ . Now save values for A and B. Press RAND followed by RN and you will see a random number between A and B.

The above procedure requires switching back and forth between the VAR menu and the PROB menu, which is not very convenient. To solve this problem, we will create a custom menu that has all the commands we need. From our RanNo directory and with the PROB menu open, we create a list as shown below. To enter RAND in the list, we simply press F4-RAND.

{ RAND A B RN F FRN }

We now save the list with the name CST. If we now press LF CUSTOM, the commands in the list will show above the menu buttons. We can now generate a random number between A and B by pressing F1-RAND then F4-RN. We can change the value of A or B by entering the new value then LS F2-A or LS F3-B.

#### Application 1.

The definite integral  $\int_a^b f(x)dx$  can be approximated by a method called the Monte Carlo method. We must evaluate  $f(x)$  at a large number of random values  $x$  between  $a$  and  $b$ , find the average of these values, then multiply by  $b - a$ . This method is based on the mean value theorem for integrals. The last step to get our directory ready to do this is to enter and define the function  $FRN(X) = F(RN(X))$ , that is, FRN is the composite of F and RN. We are now read for a sample problem.

**Example:** Use the Monte Carlo method to approximate  $\int_1^3 x^3 dx$  with 20 random values of  $x^3$  between  $x=1$  and  $x=3$ .

**Solution:** Save 1 in A, 3 in B and define the function  $F(X) = X^3$ . To make sure we all get the same result, get back to the PROB menu and set the seed for the random number generator to 10. Now get back into the custom menu and press the combination F1-RAND F6-FRN 20 times. This will put twenty values of  $x^3$ , with  $x$  between 1 and 3, on the stack. Pres + 19 times to add them together then divide by 20. Finally multiply by  $3 - 1 = 2$  to get the approximation  $\int_1^3 x^3 dx \approx 21.266$ . The exact solution is 20, so this is not a particularly good approximation. If we set the seed to 1 and try again with 50 random values, the approximation is 20.526, which is a bit better. To get a highly accurate approximation requires several hundred random values, and that requires a great deal of patience or a program. Those who are interested in programming can go to *An Introduction to Programming HP Graphics Calculators*.

## Application 2

There are times when we want the random numbers to be integers. For example, suppose we want to simulate the roll of a die. We want the integers 1, 2, 3, 4, 5, and 6 to come up in random order. Set the number format to FIX 0, store .5 in A and store 6.5 in B. Now, to get the same solution as this example, set the seed to 15 and press the combination F1-RAND F4-RN 6 times. You see the six simulated die rolls 1, 5, 3, 6, 1, 3 on the stack. We have not yet seen a 2 or a 4. If you keep pressing the above combination 8 more times will have all six possible numbers at least once.

[Return to List of Lessons](#)