



## **Sampling With Graphics Calculators**

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### **LEVEL**

Senior high schools and first year of university after students have been introduced to Statistics.

### **OBJECTIVES**

To discuss data collection and random sampling with a graphics calculator.

### **CORRESPONDING eActivity**

RANDOM.g1e

### **OVERVIEW**

Application of statistics in some scientific study or quality control of production at a factory normally begins after the important process of data collection, or sampling. We shall look at using graphics calculator to help us perform random sampling, random selection and simple surveying activities.

### **EXPLORATORY ACTIVITIES**

[Note]

- We shall use small letter  $x$  instead of capital  $X$  as shown on the calculator throughout the paper.
- The Ran# of the calculator generates pseudo-random numbers.

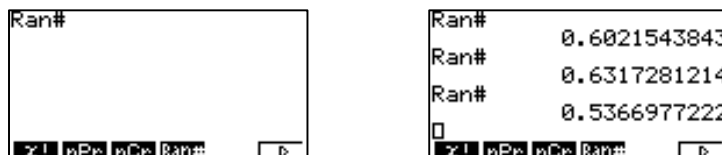
Random sampling helps avoid bias-ness during data collection. A good way to choose a random sample is by drawing lots but this is not really feasible when the population size is very large. Here we look at some ways of generating "random number" in the graphics calculator, where we can use them to select a random sample.

**Exploration 1:** Suppose a chocolate factory produces 5,000 pieces of chocolate daily. The quality control division decided to randomly select 50 pieces (or 1%) of chocolates produced for its daily quality inspection (before analyzing the data statistically.)

## Sampling With Graphics Calculators

As usual, today the quality inspector numbered the pieces of chocolates according to their production order, so the first piece of chocolate produced for the day is numbered as 1, the second piece is numbered as 2 and so on. Using his graphics calculator, he can randomly select 50 pieces out of these 5000 using the [Ran#] for inspection.

Open the Run strip "**Exp-1**". Now tap  $\boxed{\text{OPTN}}$   $\boxed{\text{F6}}$   $\boxed{\text{F3}}$   $\boxed{\text{F4}}$  to enter [Ran#] then tap  $\boxed{\text{EXE}}$ . Follow this by tapping  $\boxed{\text{EXE}}$  a few more times.



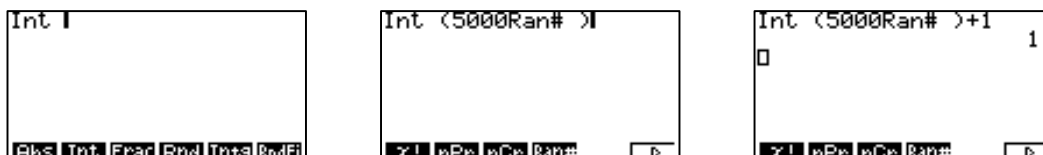
Note that each tap of [Ran#] produced different ten-digit decimals and [Ran#] output actually observes the following inequality:

$$0 < \text{Ran\#} < 1$$

We can help the inspector to adapt this to suit his random sampling needs. If we multiply [Ran#] with 5000 we ensure that each output falls between 0 and 5000 as follow.

$$0 < 5000 \times \text{Ran\#} < 5000$$

We could further adjust the [Ran#] to help him selects his random sample. While still in "**Exp-1**" strip tap  $\boxed{\text{OPTN}}$   $\boxed{\text{F6}}$   $\boxed{\text{F4}}$   $\boxed{\text{F2}}$  to call out the function of [Int], followed by the expression  $5000 \times \text{Ran\#}$ , then add 1.



While the inspector can now generate 50 different numbers randomly out of 1 to 5000 at the [Run] window by pressing  $\boxed{\text{EXE}}$  50 times, it is much more advantageous and efficient for him to use a spreadsheet to handle the sampling, recording the quality test results of the chocolate and even for statistical analysis.

**Activity 1:** Use the spreadsheet mode of the graphics calculator to help the inspector randomly selects 50 chocolates to be tested today.

### **Solution:**

**(A)** Open the Spreadsheet strip "**Act1A**". We shall use the A column for random number generation and named it as "Random". We also record the sample in the B column and named B column as "Sample". Then, scroll to the first empty cell of the "Random" column.

## Sampling With Graphics Calculators

ACT1	A	B	C	D
1	Random			
2				
3				
4				
5				

Sample  
GRAB \$ : If CEL REL

ACT1	A	B	C	D
1	Random	Sample		
2				
3				
4				
5				

FILE EDIT DEL INS CLR D

Enter the formula of "Int(5000Ran#)+1" to the selected cell of A2. It is similar to how we entered it before. As we tap **EXE** we will have generated a random number.

ACT1	A	B	C	D
1	Random	Sample		
2				
3				
4				
5				

=Int (5000Ran# )+1  
x! nPr nCr Ran# D

ACT1	A	B	C	D
1	Random	Sample		
2	1528			
3				
4				
5				

FILE EDIT DEL INS CLR D

**(B)** For this activity we want to generate 49 more random numbers, and there is a quick way to do so. While still in the spreadsheet and cell A3 is highlighted, tap **F2** (EDIT) followed by **F6** **F1** (FILL). Enter the formula of "=Int(5000Ran#)+1" (enter only between the quotation marks) to [Formula] and set [Cell Range] to A3:A51 to generate the other 49 random numbers.

ACT1	A	B	C	D
1	Random	Sample		
2	1528			
3				
4				
5				

CUT COPY CELL JUMP SEQ D

ACT1	A	B	C	D
Fill				
Formula :=Int (5000				
Cell Range:A2:A51				

EXE

ACT1	A	B	C	D
7	2108			
8	3488			
9	4376			
10	443			
11	4130			
	=Int (5000Ran# )+1			

FILL SRTA SRTD D

**(C)** Next we save the numbers in "Random" column to a list before recalling the same set of numbers to the "Sample" column. Scroll to the first number cell, or A2, of "Random" and tap **SHIFT** **B** (CLIP). With A2 highlighted, scroll down till the last of the number cell of A51. The cell reference displayed at the bottom left of the screen means we have highlighted the cell A2 till A51.

ACT1	A	B	C	D
1	Random	Sample		
2	4026			
3	805			
4	1215			
5	3522			

=Int (5000Ran# )+1  
FILE EDIT DEL INS CLR D

ACT1	A	B	C	D
1	Random	Sample		
2	4026			
3	805			
4	1215			
5	3522			

A2:A51  
FILE EDIT DEL INS CLR D

ACT1	A	B	C	D
48	1745			
49	3925			
50	4925			
51	1235			
52				

A2:A51  
FILE EDIT DEL INS CLR D

To store these numbers into a list, tap **F6** **F3** (STO) and followed by **F2** and set to store these numbers into [List1].

ACT1	A	B	C	D
48	1745			
49	3925			
50	4925			
51	1235			
52				

A2:A51  
VAR LIST FILE MAT

ACT1	A	B	C	D
Store In List Memory				
Cell Range:A2:A51				
List1(126)F1				

EXE

## Sampling With Graphics Calculators

Go to the first empty cell of the "Sample" column and tap **EXIT** until we see the screenshot below left. Tap **F4** **F1** to recall entries of [List1] and put them in "Sample" column beginning at B2.

ACT1	A	B	C	D
1	Random	Sample		
2		4026		
3		805		
4		1215		
5		3522		

GRAPH CALC STO RCL

Recall From List Mem	
List[[1~26]:1	
1st Cell	:B2

EXE

ACT1	A	B	C	D
1	Random	Sample		
2		2760	4026	
3		4544	805	
4		4768	1215	
5		4303	3522	1215

LIST FILE MAT

**(D)** Finally we sort the numbers at "Sample" column in ascending order and check for possible repeating numbers. Go to the first cell of "Sample" column, tap **SHIFT** **8** and scroll to the last non-empty cell of B51. To sort the column tap **EXIT** **F6** **F2** **F6** **F2** (SRT.A), then explore the column and check to see if there is any repeating number.

ACT1	A	B	C	D
1	Random	Sample		
2		2760	4026	
3		4544	805	
4		4768	1215	
5		4303	3522	4026

GRAPH CALC STO RCL

ACT1	A	B	C	D
48		302	1745	
49		2568	3925	
50		3738	4925	
51		10	1235	
52				
52	B51			

GRAPH CALC STO RCL

ACT1	A	B	C	D
18		4794	1341	
19		3983	1447	
20		3152	1481	
21		4341	1488	
22		3755	1593	1488

FILL SRTA SRTD

The random numbers we have in this discussion contains no repeating number (the random numbers you generate should be different from the above,) but if we do see repeating numbers, we just begin once again at section (C).

Therefore according to the random numbers we helped generate, the quality inspector will be inspecting the chocolates produced according to the order displayed in the "Sample" column in the Spreadsheet strip of "Act1A" today. □

The quality inspector could always use this same spreadsheet to select a random sample for his work everyday and even to record the quality check. Furthermore, the spreadsheet could be improvised to do more and be more flexible.

**Activity 2:** The factory sometimes produces between 4000 and 4500 pieces of chocolate daily, apart from the usual 5000. The sample size required for quality testing is always 1% of the daily production amount. In the test, each piece of chocolate either passes (given 1 point), or fails (given 0 point.) Not more than 8% of the sample should fail the daily quality test or further control action will be taken. The following is the planned daily production for the next 5 days.

Day	1	2	3	4	5
Chocolate Production	5000	4000	4500	5000	5000

Improvise the spreadsheet to help the inspector perform the above on a daily basis.

### Solution:

In summary here are the daily sample size needed and the 8% of sample size.

## Sampling With Graphics Calculators

	Day1	Day2	Day3	Day4	Day5
Chocolate Production	5000	4000	4500	5000	5000
Sample size	50	40	45	50	50
8% of sample size	4	3.2	3.6	4	4

(A) Open the Spreadsheet strip "Act2A". Here we set the daily production as parameter in the random number generation. Cell A2 is used to record the daily production. We also use the B column as an indexing column for easy reference to the amount produced and the random numbers. We begin with the daily production of 5000 for Day1.

SHEE	A	B	C	D
1	Prod	Index		
2	5000			
3				
4				
5				

Sequence	:	X
Expr	:	X
Var	:	X
Start	:	1
End	:	50
Incre	:	1
1st Cell	:	B2

SHEE	A	B	C	D
1	Prod	Index		
2	5000	1		
3		2		
4		3		
5		4		

(B) The "Random" column and "Sample" column are put in C and D columns respectively. To set up the spreadsheet to generate 50 random numbers, tap **F2** (EDIT) followed by **F6** **F1** (FILL). This time we enter the formula of " $=Int(\$A\$2Ran\#)+1$ " to [Formula] and set [Cell Range] to C2:C51.

SHEE	A	B	C	D
1	Prod	Index	Random	Sample
2	5000	1		
3		2		
4		3		
5		4		

Fill	:	
Formula	:	$=Int(\$A\$2Ran\#)+1$
Cell Range	:	C2:C51

SHEE	A	B	C	D
1	Prod	Index	Random	Sample
2	5000	1	793	
3		2	3992	
4		3	648	
5		4	4909	

(C) Here we have generated 50 random numbers for Day1. Again we want to save the numbers in the "Random" column to [List1] before recalling the same set of numbers to the column "Sample", sort these numbers and check for repeating number. First let's return to the main spreadsheet menu by tapping **EXIT** (see below.)

SHEE	A	B	C	D
1	Prod	Index	Random	Sample
2	5000	1	793	
3		2	3992	
4		3	648	
5		4	4909	

Go to cell C2 tap **SHIFT** **8** (CLIP) then scroll down till cell C51. With cell C2:C51 selected, tap **F6** **F3** (STO) and followed by **F2** and store these numbers into [List1].

SHEE	A	B	C	D
47		46	3814	
48		47	4084	
49		48	1248	
50		49	4739	
51		50	2493	

Store In List Memory	:	
Cell Range	:	C2:C51
List	:	1(26)F1

## Sampling With Graphics Calculators

Press **EXIT** to return to the main spreadsheet menu (see screenshot below left.) Go to the first empty cell of the "Sample" column, tap **F4** **F1** to recall entries of [List1].

SHEET	A	B	C	D
1	Prod	Index	Randor	Sampl
2	5000	1	793	
3		2	3992	
4		3	648	
5		4	4909	

Recall From List Mem	
List[1~26]:1	
1st Cell :D2	

SHEET	B	C	D	E
1	Index	Randor	Sample	
2	1	2975	793	
3	2	1231	3992	
4	3	3980	648	
5	4	4191	4909	4909

**(D)** Now we sort the numbers at the "Sample" column in ascending order and check for possible repeating number. Again use **SHIFT** **8** to highlight cell D2 till cell D51 and sort the column with **F6** **F2** **F6** **F2** (SRT.A), then explore and check for repeating number.

SHEET	B	C	D	E
48	47	1732	4084	
49	48	2527	1248	
50	49	978	4739	
51	50	4648	2493	
52				

SHEET	B	C	D	E
1	Index	Randor	Sample	
2	1	4976	39	
3	2	4472	58	
4	3	3386	113	
5	4	2408	157	113

**(E)** We add two other columns called "Test" to record the result of the quality test, and another called "#of 0" to calculate the number of 0 (fail quality test.) The "#of 0" column actually consists of just the cell F2 which tells the number of fail cases with the formula  $\frac{\$A\$2}{100} - \text{CellSum}(E2:E51)$ . Now the inspector can use this spreadsheet for his daily work.

SHEET	C	D	E	F
1	Randor	Sample	Test	#of 0
2	4864	39		
3	4396	58		
4	4827	113		
5	515	157		

SHEET	C	D	E	F
1	Randor	Sample	Test	#of 0
2	386	39		50
3	2681	58		
4	1259	113		
5	3691	157		

### Day1

For the discussion of this activity, we use the random numbers generated above for Day1 quality test and the test results, shown partially, is supposed to be as follow.

SHEET	C	D	E	F
7	4193	348	1	
8	1559	648	0	
9	2023	765	1	
10	2207	793	1	
11	2240	832	1	

SHEET	C	D	E	F
39	442	3814	0	
40	4028	3992	1	
41	575	4052	1	
42	2329	4084	1	
43	3169	4103	1	

SHEET	C	D	E	F
1	Randor	Sample	Test	#of 0
2	838	39	1	3
3	965	58	1	
4	3100	113	1	
5	2574	157	1	

The results mean that the chocolates produced on Day1 passed the quality inspection and no further control action is needed. We can save the random numbers and test results in [List1] and [List2] as record using **SHIFT** **8** (CLIP) and [STO].

Store In List Memory	
Cell Range:D2:D51	
List[1~26]:1	

SHEET	C	D	E	F
49	1897	4754	1	
50	1705	4902	1	
51	3218	4909	1	
52				
53				

Store In List Memory	
Cell Range:E2:E51	
List[1~26]:2	

## Sampling With Graphics Calculators

So the Day1 random sample and test result are stored in [List1] and [List2].

### Day2

Change the daily production at cell A2 to 4000. Repeat process in section (C) and (D), but consider only the first 40 numbers in the "Random" column. The random sampling is not affected in this case although we generate 50 random numbers at the "Random number". Also, use [List3] as the temporary storing list instead.

SHEET	A	B	C	D
38		37	B	3789
39		38	2445	3814
40		39	3593	3992
41		40	944	4052
42		41	1857	4084
D2:C41				

Store In List Memory	
Cell Range:	C2:C41
List:	[1~26]:3

Recall From List Mem	
List:	[1~26]:3
1st Cell:	D2

When pasting entries of [List3] to the "Sample" column, contents of cell D2 till D41 are replaced with the new set of random numbers. We can use the "Index" column as guide in selecting the newly generated 40 random numbers for sorting, and avoid selecting cell D42 till D51 (see below left.)

SHEET	B	C	D	E
39	38	1680	2445	0
40	39	3748	3593	1
41	40	314	944	1
42	41	3091	4084	1
43	42	1214	4103	1
D2:D41				

SHEET	B	C	D	E
1	Index	Random	Sample	Test
2	1	1133	B	1
3	2	2577	338	1
4	3	1124	576	1
5	4	3480	583	0
1				

SHEET	B	C	D	E
39	38	106	3905	0
40	39	1485	3972	1
41	40	426	3978	1
42	41	14	4084	
43	42	1827	4103	
1				

We assume that the test results, shown partially above, as the actual results. Contents in the cell of E42 till E51 must be deleted to ensure the correct number of 0 is displayed.

SHEET	C	D	E	F
1	Random	Sample	Test	# of 0
2	1133	B	1	4
3	2577	338	1	
4	1124	576	1	
5	3480	583	0	
=(\$A\$2,100)-CellSum(E				

Store In List Memory	
Cell Range:	D2:D41
List:	[1~26]:3

Store In List Memory	
Cell Range:	E2:E41
List:	[1~26]:4

The number of 0 recorded is 4, which means that the chocolates produced on Day2 do not pass the quality inspection and appropriate control action is needed. We now save the random numbers and test record in [List3] and [List4] as record.

With similar approach the quality inspector selects the appropriate random sample for his Day3, Day4 and Day5 tests, then stores the corresponding random numbers and their corresponding results to [List5] and [List6] for Day3, [List7] and [List8] for Day4, and [List9] and [List10] for Day5.

SHEET		
1	Conics Editor	↑
2	Stat Graph	
3	List Editor	
4	Solver	
5	Recur Editor	↓
6		

SHEET	List 3	List 4	List 5	List 6
1	Day2		Day3	
2	B	1	151	1
3	338	1	155	1
4	576	1	237	1
5	583	0	459	0
338				

## Sampling With Graphics Calculators

You can view the full records in the [List] mode by tapping  $\boxed{\text{SHIFT}}$   $\boxed{\text{V}}$  in the "Act2A" spreadsheet strip and select to view [List Editor]. The numbers you will be working with should be different from the numbers recorded there. □

The sampling method we have used above is called simple random sampling. One other method of random sampling is stratified sampling which based on identifiable strata. Useful strata might be 'males' and 'female', or 'obese' and 'non-obese'. A stratified sampling is made up of separate simple random samples for each of the strata. If we know the proportions of the population falling into these different categories, we should ensure that the proportions are reproduced by the sample.

**Activity 3:** Suppose your school student population can be described as follow:

Male students	Female students
45%	55%

Use stratified sampling to choose a random sample of 40 students.

### **Solution:**

In this case, we would choose a simple random sample of  $40 \times 45\% = 18$  male students and another simple random sample of  $40 \times 55\% = 22$  female students. □

## **EXERCISE**

### **Exercise 1**

Suppose the student population of a school is 1750 and the male-female composition is as described below.

Male students	Female students
38%	62%

Use the spreadsheet to select a stratified sample of 50 students for a survey on students' preference between almond and milk chocolate. Design the spreadsheet to record the responses to the survey if possible.

## **SOLUTIONS to EXERCISE**

### **Exercise 1**

First we select the stratified sample then use the technique of Activity 2 on the sample. In summary here is the information about the two categories.

	Male students	Female students
% of population	38%	62%
Of 1750 population ( $\% \times 1750$ )	665	1085
Stratified sample size ( $\% \times 50$ )	19	31



## Sampling With Graphics Calculators

You can use Run strip "Ex1A" to calculate the relevant information shown above.

38	→M	
100		
		19
		50
62	→F	
100		
JUMP DEL ▶ MAT MATH		

1750	×M	50
1750	×F	665
50	×M	1085
		19
JUMP DEL ▶ MAT MATH		

One possible ways to design the spreadsheet is as follow:

- Open the Spreadsheet strip "Ex1A". Use columns A and B to record the population and the sample size of each stratum, so you would have more control of the parameters.

SHEE	A	B	C	D
1	POP.	1750		
2	MALE	665		
3	FEMALE	1085		
4	SAMPLE	50		
5	M. Sam	19		
				MALE
FILE EDIT DEL INS CLR ▾				

SHEE	A	B	C	D
3	FEMALE	1085		
4	SAMPLE	50		
5	M. Sam	19		
6	F. Sam	31		
7				31
FILE EDIT DEL INS CLR ▾				

- Set up the 3<sup>rd</sup> column for indexing and 4<sup>th</sup> column for random number generation. Firstly select the random sample of male students with formula of " $=Int(\$B\$2Ran\#)+1$ " for D2 till D20 (sample size of 19.)

SHEE	A	B	C	D
1	POP.	1750	Index	Random
2	MALE	665		
3	FEMALE	1085		
4	SAMPLE	50		
5	M. Sam	19		
FILE EDIT DEL INS CLR ▾				

Fill
Formula :=Int(\$B\$2
Cell Range:D2:D20
EXE

SHEE	B	C	D	E
1	1750	Index	Random	
2	665	1	310	
3	1085	2	149	
4	50	3	540	
5	19	4	311	
				$=Int(\$B\$2Ran\#)+1$
FILE EDIT DEL INS CLR ▾				

- Create two more columns called 'Male' and 'Female'. Copy, paste and sort the numbers at the 'Male' column with methods used in Activity 2. Then select the random sample of female students with the formula " $=Int(\$B\$3Ran\#)+1$ " for D2 till D32 (sample size of 31) at the "Random" column and copy-sort the numbers to the 'Female' column.

SHEE	D	E	F	G
1	Random	Male		Female
2	305	59		
3	345	100		
4	651	149		
5	983	180		
				180
FILE EDIT DEL INS CLR ▾				

SHEE	D	E	F	G
1	Random	Male		Female
2	496	59		6
3	444	100		7
4	583	149		10
5	840	180		19
				10
LIST FILE MAT				

- Use the F column to record the responses of male students for the survey and the H column for female students' responses. Below are screenshots of possible responses where 1 is for students who prefer almond chocolate and 2 for students who milk chocolate. □

SHEE	E	F	G	H
1	Male	M. Pref	Female	F. Pref
2	59	1	6	1
3	100	2	7	1
4	149	1	10	1
5	180	1	19	2
FILE EDIT DEL INS CLR ▾				

SHEE	E	F	G	H
6	221	1	50	2
7	233	2	76	1
8	310	2	169	2
9	317	1	234	1
10	322	1	247	1
FILE EDIT DEL INS CLR ▾				

## ***Sampling With Graphics Calculators***

### **REFERENCE**

[1] G. Upton and I. Cook, *Introducing Statistics 2<sup>nd</sup> Edition*, Oxford University Press, 2001. ISBN: 0 19 914 801 5.

[2] S. Dobbs and J. Miller, *Statistics 2*, Cambridge University Press, 2001. ISBN: 0 521 78604 5.