

SUPPLEMENT TO:

A CALCULATOR-ASSISTED METHOD OF RANDOM SAMPLING\*

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\* Program instructions and listings for Texas Instrument (TI) and Hewlett-Packard (HP) calculators.

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I. METHOD I FOR TI AND HP CALCULATORS. (A) GENERAL DESCRIPTION.

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- (1) This program generates a list of  $n$  random integers in a range between 1 and  $p$ , where  $n$  = the desired sample size and  $p$  = the estimated population size.
- (2) The random integers are ranked from smallest to largest, and stored in registers 10 through  $[10 + (n-1)]$ .
- (3) When the calculator is used in sampling, part of the program acts as a counter. The current count is compared with the list of ranked random numbers. If a match is detected, the display indicates that a sample should be taken.
- (4) With TI-58 models, the maximum sample size is 29. With TI-59 models it is 89. Maximum sample size with HP calculators will depend on the model and the amount of memory (e.g. with the HP-41C and one memory module, the maximum sample size is 20).
- (5) User instructions for TI and HP models follow, together with program listings.

METHOD I. (B) USER INSTRUCTIONS FOR TI CALCULATORS.

Step	Procedure	Enter	Press	Display
1.	Partition memory to:			
	159.39 (TI-58)		4, 2nd Op, 17	159.39
	159.99 (TI-59)		10, 2nd Op, 17	159.99
2.	Enter program (see listing)			
3.	Clear memories and initialize the random number generator		A	0.
4.	Enter seed number (i.e. a number between 1 and 199017)	seed	B	0.
5.	Enter population size	population size	C	0.
6.	Enter sample size. Begin routine for generating and ranking random numbers. Calculating time will depend on size of sample.	sample size	D	0.
7.	The calculator is now ready to be used in sampling. The counter will increment from 0 up to p as "E" is pressed. If a given individual should be sampled, the current count will flash on and off in the display. When all sample members have been taken, the display will show 9's.		E E E . . . E	1 (may flash) 2 " 3 " . . . 999999999
8.	Reset counter to 0 for another round of sampling using the same list of ranked random numbers. Skip steps 1-6.		E'	0.

## METHOD I. (C) PROGRAM LISTING FOR TI CALCULATORS.

<u>LOC</u>	<u>CODE</u>	<u>KEY</u>	<u>LOC</u>	<u>CODE</u>	<u>KEY</u>	<u>LOC</u>	<u>CODE</u>	<u>KEY</u>
000	76	LBL	051	36	PGM	102	22	INV
001	15	E	052	15	15	103	44	SUM
002	25	CLR	053	10	E'	104	03	03
003	67	EQ	054	91	R/S	105	01	1
004	00	00	055	76	LBL	106	00	0
005	29	29	056	12	B	107	12	STO
006	01	1	057	36	PGM	108	05	05
007	44	SUM	058	15	15	109	42	STO
008	02	02	059	15	E	110	08	08
009	43	RCL	060	25	CLR	111	85	+
010	02	02	061	91	R/S	112	01	1
011	77	GE	062	76	LBL	113	95	=
012	00	00	063	13	C	114	42	STO
013	15	15	064	42	STO	115	06	06
014	91	R/S	065	00	00	116	73	RC*
015	01	1	066	01	1	117	08	08
016	44	SUM	067	00	0	118	32	X $\nabla$ T
017	03	03	068	42	STO	119	73	RC*
018	73	RC*	069	04	04	120	06	06
019	03	03	070	25	CLR	121	77	GE
020	67	EQ	071	91	R/S	122	01	01
021	00	00	072	76	LBL	123	28	28
022	15	15	073	14	D	124	43	RCL
023	32	X $\nabla$ T	074	42	STC	125	06	06
024	43	RCL	075	01	01	126	42	STO
025	02	02	076	42	STO	127	08	08
026	61	GTO	077	02	02	128	01	1
027	09	09	078	42	STO	129	44	SUM
028	99	99	079	03	03	130	06	06
029	00	0	080	36	PGM	131	00	0
030	23	LN $\nabla$ X	081	15	15	132	32	X $\nabla$ T
031	91	R/S	082	71	SBR	133	73	RC*
032	76	LBL	083	88	DMS	134	06	06
033	10	E'	084	65	X	135	22	INV
034	00	0	085	43	RCL	136	67	EQ
035	42	STO	086	00	00	137	01	01
036	02	02	087	85	+	138	16	16
037	01	1	088	01	1	139	73	RC*
038	00	0	089	95	=	140	05	05
039	42	STO	090	59	INT	141	32	X $\nabla$ T
040	03	03	091	72	ST*	142	73	RC*
041	25	CLR	092	04	04	143	08	08
042	32	X $\nabla$ T	093	01	1	144	75	ST*
043	73	RC*	094	44	SUM	145	05	05
044	03	03	095	04	04	146	32	X $\nabla$ T
045	32	X $\nabla$ T	096	97	DSZ	147	72	ST*
046	91	R/S	097	02	02	148	08	08
047	68	NOP	098	00	00	149	01	1
048	76	LBL	099	80	80	150	44	SUM
049	11	A	100	68	NOP	151	05	05
050	47	CMS	101	01	1	152	43	RCL
						153	05	05
						154	97	DSZ
						155	03	03
						156	01	01
						157	09	09
						158	71	SBR
						159	10	E'

METHOD I. (D) NOTES ON PROGRAM LISTING FOR TI CALCULATORS.

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- (1) Steps 000-031 are the counter and matching sequence.
- (2) Steps 032-047 reset the counter to 0 and the indirect recall register to the first member in the list of ranked random numbers.
- (3) Steps 048-054 initialize the random number generator (Program 15 in the library module).
- (4) Steps 055-061 are for entry of the seed number for the random number generator.
- (5) Steps 062-071 store the population size and initialize the register for indirect storage of the random numbers.
- (6) Steps 072-100 are for entry of the sample size and storage of the generated random numbers in registers 10 to  $[10 + (\underline{n}-1)]$ . Register  $(10 + \underline{n})$  must be empty.
- (7) Steps 101-159 sort the random numbers from smallest to largest in registers 10 to  $[10 + (\underline{n}-1)]$ .

METHOD I. (E) USER INSTRUCTIONS FOR HP CALCULATORS.

Step	Procedure	Enter	Press	Display
1.	Partition memory (e.g. with the HP-41 and one memory module leave 20 data registers for storing the random numbers)		Xeq, Size, 031	0.
2.	Enter program (see listing)			
3.	Assign program LO to key A		Asn, Alpha, LO, X+ (A)	0.
	Assign program FS to key B		Asn, Alpha, PS 1/x (B)	0.
	Assign program CT to key E		Asn, Alpha, CT ln (E)	0.
	Assign program RS to key Y		Asn, Alpha, RS, x (Y)	0.
4.	Enter seed number (i.e. a number between 1 and 199017). Load random number generator sequence. Calculator will prompt for seed.	Seed	A R/S	SEED? 99,991
5.	Enter population and sample sizes. Calculator will prompt for data. Begin routine for generating and ranking random numbers. Calculating time will depend upon sample size.	Population size Sample size	B R/S R/S	POP? SMP? 0.
6.	The calculator is now ready to be used in sampling. The counter will increment from 0 up to p as "E" is pressed. If a given individual should be sampled, the word SAMPLE will appear in the display and a high tone will sound. When all sample members have been taken, 4 tones (beep) will sound, and 0 will appear in the display.		E E . . . E	1 or SAMPLE 2 " . . . 0 (beep)
7.	Reset counter to 0 for another round of sampling using the same list of ranked random numbers. Skip steps 1-5.		Y	0

METHOD I. (F) PROGRAM LISTING FOR HP CALCULATORS.

<u>step no.</u>	<u>display</u>	<u>step no.</u>	<u>display</u>	<u>step no.</u>	<u>display</u>
01	LBL <sup>T</sup> LO	41	0	04	GTO 13
02	CLRG	42	X ≠ Y?	05	1
03	<sup>T</sup> SEED?	43	GTO 02	06	ST+ 00
04	PROMPT	44	RCL IND 05	07	RCL 00
05	STO 00	45	STO 00	08	RCL IND 03
06	24298	46	RCL IND 08	09	X = Y?
07	STO 07	47	STO IND 05	10	GTO 12
08	199017	48	RCL 00	11	RCL 00
09	STO 08	49	STO IND 08	12	STOP
10	99991	50	1	13	LBL 12
11	STO 09	51	ST+ 05	14	1
12	END	52	RCL 05	15	ST+ 03
		53	DSE 03	16	<sup>T</sup> SAMPLE
01	LBL <sup>T</sup> PS	54	GTO 03	17	AVIEW
02	<sup>T</sup> POP?	55	LBL <sup>T</sup> RS	18	TONE 9
03	PROMPT	56	TONE 0	19	STOP
04	STO 01	57	10	20	LBL 13
05	<sup>T</sup> SMP?	58	STO 03	21	BEEP
06	PROMPT	59	0	22	END
07	STO 02	60	STO 00		
08	10	61	END		
09	STO 03				
10	LSL 01	01	LBL <sup>T</sup> GE		
11	NEQ <sup>T</sup> GE	02	RCL 07		
12	RCL 04	03	RCL 00		
13	1	04	*		
14	+	05	RCL 09		
15	STO IND 03	06	+		
16	1	07	RCL 08		
17	ST+ 03	08	/		
18	DSE 02	09	INT		
19	GTO 01	10	RCL 08		
20	LBL <sup>T</sup> OR	11	*		
21	11	12	CHS		
22	ST- 03	13	RCL 09		
23	10	14	+		
24	STO 05	15	RCL 07		
25	LBL 03	16	ENTER <sup>^</sup>		
26	STO 08	17	RCL 00		
27	1	18	*		
28	+	19	+		
29	STO 06	20	STO 00		
30	LBL 02	21	RCL 08		
31	RCL IND 08	22	/		
32	RCL IND 06	23	RCL 01		
33	X > Y?	24	*		
34	GTO 11	25	INT		
35	RCL 06	26	STO 04		
36	STO 08	27	END		
37	LBL 11				
38	1	01	LBL <sup>T</sup> CT		
39	ST+ 06	02	RCL IND 03		
40	RCL IND 06	03	X = 0?		



METHOD I. (G) NOTES ON PROGRAM LISTING FOR HP CALCULATORS.

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- (1) Program LO clears all registers and stores the numbers used in the random number generator subroutine GE.
- (2) Program PS (steps 01-09) store the population and sample sizes.  
  
Steps 10-19 of PS and the subroutine GE are for generating random numbers and storing them (unranked) in registers 10 to  $[10 + (\underline{n}-1)]$ . Register  $(10 + \underline{n})$  must be empty.  
  
Steps 20-54 of PS order the random numbers from smallest to largest and store them in registers 10 to  $[10 + (\underline{n}-1)]$ .  
  
Steps 55-61 of PS reset the counter to 0 and the indirect recall register to the first number in the list of ranked random numbers.
- (3) Program CT is the counter, and compares the current count to the list of ranked random numbers.

II. METHOD II FOR TI AND HP CALCULATORS. (A) GENERAL DESCRIPTION.

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- (1) This program acts as a counter, and with each count of the population, the program calculates the probability that the current count is selected on a random basis as part of the sample. This probability is equal to:

$$Pr = (\underline{n-s}) / (\underline{p-c}),$$

where  $\underline{n}$  = the sample size,  $\underline{s}$  = the number of previously selected sample members,  $\underline{p}$  = the population size, and  $\underline{c}$  = the current count.

- (2) Each time the counter is incremented, a random number is generated from a uniform distribution between 0 and 1. If  $Pr$  is greater than the generated random number, the display will indicate that a sample should be taken.
- (3) There is no practical limit to the size of the sample using this method.
- (4) User instructions for TI and HP calculators follow, together with program listings.

METHOD II. (B) USER INSTRUCTIONS FOR TI CALCULATORS.

Step	Procedure	Enter	Press	Display
1	Partition memory to 159.39 (TI-58).		4, 2nd Op, 17	159.39
	159.99 (TI-59).		10, 2nd Op, 17	159.99
2.	Enter program (see listing).			
3.	Load random number generator sequence.		A	99991
4.	Enter seed number for the random number generator (i.e. a number between 1 and 199017).	seed	B	0.
5.	Enter population size.	population size	C	0.
6.	Enter sample size.	sample size	D	0.
7.	The calculator is now ready to be used in sampling. The counter will increment from 0 up to <u>p</u> as "E" is pressed. If a given individual should be sampled, the current count will appear in exponential notation. When all sample members have been taken, the display returns to 0.		E E . . . . . E	1. (may show up with exponent) 2. " . . . . . 0.

METHOD II. (C) PROGRAM LISTING FOR TI CALCULATORS.

<u>LOC</u>	<u>CODE</u>	<u>KEY</u>	<u>LOC</u>	<u>CODE</u>	<u>KEY</u>	<u>LOC</u>	<u>CODE</u>	<u>KEY</u>
000	76	LBL	051	43	RCL	104	54	)
001	11	A	052	02	02	105	95	=
002	02	2	053	32	X $\frac{1}{T}$	106	69	OP
003	04	4	054	43	RCL	107	23	23
004	02	2	055	04	04	108	32	X $\frac{1}{T}$
005	09	9	056	67	EQ	109	43	RCL
006	08	8	057	18	C'	110	00	00
007	42	STO	058	53	(	111	55	:
008	07	07	059	43	RCL	112	43	RCL
009	01	1	060	07	07	113	08	08
010	09	9	061	65	X	114	95	=
011	09	9	062	43	RCL	115	77	GE
012	09	9	063	00	00	116	16	A'
013	01	1	064	85	+	117	69	OP
014	07	7	065	43	RCL	118	24	24
015	42	STO	066	09	09	119	43	RCL
016	08	08	067	54	)	120	03	03
017	09	9	068	55	:	121	52	EE
018	09	9	069	43	RCL	122	91	R/S
019	09	9	070	08	08	123	76	LBL
020	09	9	071	95	=	124	16	A'
021	01	1	072	59	INT	125	43	RCL
022	42	STC	073	65	X	126	02	02
023	09	09	074	43	RCL	127	75	-
024	91	R/S	075	08	08	128	43	RCL
025	76	LBL	076	95	=	129	04	04
026	12	B	077	94	+/-	130	95	=
027	42	STC	078	85	+	131	32	X $\frac{1}{T}$
028	00	00	079	43	RCL	132	43	RCL
029	25	CLR	080	09	09	133	01	01
030	91	R/S	081	85	+	134	75	-
031	76	LBL	082	43	RCL	135	43	RCL
032	13	C	083	07	07	136	03	03
033	42	STO	084	65	X	137	85	+
034	01	01	085	43	RCL	138	01	1
035	25	CLR	086	00	00	139	95	=
036	91	R/S	087	95	=	140	67	EQ
037	76	LBL	088	42	STC	141	17	B'
038	14	D	089	00	00	142	43	RCL
039	42	STO	090	53	(	143	03	03
040	02	02	091	43	RCL	144	91	R/S
041	25	CLR	092	02	02	145	76	LBL
042	42	STC	093	75	-	146	17	B'
043	03	03	094	43	RCL	147	69	OP
044	42	STC	095	04	04	148	24	24
045	04	04	096	54	)	149	43	RCL
046	91	R/S	097	55	:	150	03	03
047	76	LBL	098	53	(	151	52	EE
048	15	E	099	43	RCL	152	91	R/S
049	22	INV	100	01	01	153	76	LBL
050	52	EE	101	75	-	154	18	C'
			102	43	RCL	155	25	CLR
			103	03	03	156	91	R/S

METHOD II. (D) NOTES ON PROGRAM LISTING FOR TI CALCULATORS.

- (1) Steps 000-024 load the random number generator sequence  
(Note: Program 15 of the library module is not used here).
- (2) Steps 025-30 store the seed for the random number  
generator sequence.
- (3) Steps 031-036 store the population size (p).
- (4) Steps 037-046 store the sample size (n), and set c and s  
equal to 0.
- (5) Steps 047-156 calculate  $Pr$ , generate a random number  
between 0 and 1, compare the random number to  $Pr$  (and display  
p in exponential notation if  $Pr >$  random number). This  
sequence also contains the counter.



METHOD II. (F) PROGRAM LISTING FOR HP CALCULATORS.

<u>step no.</u>	<u>display</u>	<u>step no.</u>	<u>display</u>
01	LBL <sup>↑</sup> LO	25	STO 00
02	<sup>↑</sup> SEED?	26	RCL 02
03	PROMPT	27	RCL 04
04	STO 00	28	-
05	24298	29	RCL 01
06	STO 07	30	RCL 03
07	199017	31	-
08	STO 08	32	/
09	99991	33	X<>Y
10	STO 09	34	CLX
11	END	35	RCL 03
		36	1
01	LBL <sup>↑</sup> PS	37	+
02	<sup>↑</sup> POP?	38	STO 03
03	PROMPT	39	CLX
04	STO 01	40	RCL 00
05	<sup>↑</sup> SMP?	41	RCL 08
06	PROMPT	42	/
07	STO 02	43	X >Y?
08	0	44	GTO 01
09	STO 03	45	1
10	STO 04	46	ST+ 04
11	END	47	TONE 9
		48	<sup>↑</sup> SAMPLE
01	LBL <sup>↑</sup> CT	49	AVIEW
02	RCL 02	50	STOP
03	X<>Y	51	LBL 01
04	CLX	52	RCL 02
05	RCL 04	53	RCL 04
06	X = Y?	54	-
07	GTO 03	55	X<>Y
08	RCL 07	56	CLX
09	RCL 00	57	RCL 01
10	*	58	RCL 03
11	RCL 09	59	-
12	+	60	1
13	RCL 08	61	+
14	/	62	X = Y?
15	INT	63	GTO 02
16	RCL 08	64	RCL 03
17	*	65	STOP
18	CHS	66	LBL 02
19	RCL 09	67	1
20	+	68	ST+ 04
21	RCL 07	69	TONE 9
22	RCL 00	70	<sup>↑</sup> SAMPLE
23	*	71	AVIEW
24	+	72	STOP
		73	LBL 03
		74	BEEP
		75	END

METHOD II. (G) NOTES ON PROGRAM LISTING FOR HP CALCULATORS.

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- (1) Program LO stores the numbers to be used in the random number generating sequence (see program CT).
- (2) Program PS stores the population and sample sizes and sets c and s equal to 0.
- (3) Program CT calculates  $Pr$ , generates a random number between 0 and 1, compares the random number to  $Pr$  (and displays the word SAMPLE if  $Pr >$  random number). This sequence also contains the counter.