00511 PROGRAM DESCRIPTION I

Program Title: NAVIGATION PACKAGE

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Program Description, Equations, Variables: "NAV" solves for lines of position from observations of any celestial body. An almanac for the sun and stars is included in the program. A Nautical Almanac is required for the moon and planets, and input required is GHA and Declination for the whole hours immediately preceeding and following the observation, plus S.D. of the moon. Hc and Zn can be computed in advance for star sight planning. A Dead Reckoning routine will provide and store an up-dated Latitude and Longitude. The Great Circle course and distance between two points can be determined in order to set a new course after obtaining a fix. The program is designed for ease of operation by including the YEAR, MONTH, and HE in the programmed steps, by the use of PROMPT for inputs, and by automatic execution. NAV works equally well with or without a Printer.

Necessary Accessories: Two Memory Modules. (Optional: Printer and Card Reader)

Operating Limits and Warnings: YEAR, MONTH, and HE are fixed. Several program steps must be updated as necessary if this feature is retained. (Fixed YEAR and MONTH can be bypassed by entering at prompt.) Dead Reckoning will not work across equator or date line, and is not accurate above 50° latitude. Maximum error of intercept should not exceed 1 mile.

Reference(s): Bowditch: "The American Practical Navigator"

Smart: "A Textbook on Spherical Astronomy"

Dutton: "Navigation and Nautical Astronomy"

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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PROGRAM DESCRIPTION I

The several programs presented in the HP-67/97 Navigation PAC I were used as guides. The following formulae were presented in that instruction manual.

Sextant Corrections for Refraction and Height of Eye

$$H_0 = h_s + 0'97 \left\{ \tan \left[h_s - \tan^{-1} 12 (h_s + 3) \right] - \sqrt{HE} \right\}$$

Sight Reduction

$$Z_n = 180 + \tan^{-1} \frac{\sin t}{\cos t \sin L - \cos L \tan d}$$

$$H_c = \sin^{-1} \left[\sin d \sin L + \cos L \cos t \cos d \right]$$

$$a = H_c - H_0$$

Sun Almanac

The Sun Almanac equations are based on formulas found in Smart, *A Textbook on Spherical Trigonometry*.

From the date (Y, M, D) the day of year DOY is computed, then the longitude of the Moon's ascending mode Ω is computed:

$$\Omega = 20 \left(Y - 1969.1 + \frac{DOY}{365} \right)$$

Then a quantity $\odot$ related to the Greenwich Hour Angle of Aries is computed:

$$\odot = DOY + 101.18 + \text{Frac} \left\{ \frac{2000 - Y}{4} \right\} + \frac{Y \cdot y - 1969}{128} + .004 \sin \Omega$$

GHA Υ maybe computed from $\odot$ and the time of day t by:

$$\text{GHA } \Upsilon = .9856 \left(\odot + \frac{t}{24} \right) + 15\, t$$

The Earth's mean anomaly M and longitude of perigee ω are computed together:

$$M + \bar{\omega} = .9856 \left(\odot + \frac{t}{24} \right)$$

Then an approximation to Kepler's equation is used to compute the true anomaly ν:

where $\theta = \nu + \bar{\omega} = M + \bar{\omega} + 1.92 \sin M + .02 \sin 2M$

The longitude of perigee ω is given by:

$$\bar{\omega} = .01717\,(Y - 1969) - 77.56$$

The obliquity of the ecliptic is:

$$\epsilon = 23.4433 - 1.3 \times 10^{-4}\,(Y - 1969) + .0028 \cos \Omega$$

Using the above values we now compute the Greenwich Hour Angle GHA $\odot$ and declination δ of the Sun.

$$\text{GHA} \odot = M + \bar{\omega} - \tan^{-1}(\tan \theta \cos \epsilon) + 180 + 15\,t$$
$$\delta = \sin^{-1}(\sin \theta \sin \epsilon)$$

Star Almanac

For stars, Ω and $\odot$ from the above equations are used in the following formulas to compute star positions to approximately 0.1 accuracy.

$$\begin{aligned} \text{SHA}_\star = \alpha = \alpha_0 &+ (Y - 1969)(20'' \sin \alpha_0 \tan \delta_0 - 46'') && \text{precession} \\ &+ 8'' \cos(\Omega - \alpha_0) \tan \delta_0 - 15''.8 \sin \Omega && \text{nutation} \\ &- 21'' \frac{\cos(\alpha_0 - \odot)}{\cos \delta_0} && \text{aberration} \end{aligned}$$

$$\begin{aligned} \text{DEC}_\star = \delta = \delta_0 &+ (Y - 1969)\,20'' \cos \alpha_0 && \text{precession} \\ &+ 8'' \sin(\Omega - \alpha_0) && \text{nutation} \\ &+ 21'' \sin \delta_0 \sin(\alpha_0 - \odot) + 8'' \odot \cos \delta_0 && \text{aberration} \end{aligned}$$

where (α_0, δ_0) is the star's 1969 mean place (see the table in appendix 1).

The star data also contains an encoded correction to both α and δ to account for proper motion for the fastest-moving star.

MIDDLE LATITUDE SAILING

$l = d \cos C$ $\quad L_2 = L_1 \pm l \quad L_m = L_1 + L_2 / 2 \quad DLo = p \sec L_m$

$p = d \sin C$ $\quad Lo_2 = Lo_1 \pm DLo$

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APPENDIX I

Following is a list of the 57 selected stars plus Polaris, listed in numerical order, and giving the sidereal hour angle and declination. In program operation steps 386, 387, and 388 will store SHA in Register 07 and declination in Register 06. When programming a new list for sub-routine "LST" use the following short format for each star:

1/ Lable nn (where nn is the star's number)
2/ Declination
3/ Name of star
4/ SHA
5/ RTN

Star Number	Star Name	1969 POSITION Declination	Sidereal Hour Angle
0	Polaris	89.1214	329.3708
1	Alpheratz	28.9194	358.3050
2	Ankaa	-42.4744	353.8113
3	Schedar	56.3678	350.3163
4	Diphda	-18.1564	349.4917
5	Achernar	-57.3959	335.8596
6	Hamal	23.3167	328.6450
7	Acamar	-40.4281	315.7288
8	Menkar	3.9692	314.8358
9	Mirfak	49.7522	309.4750
10	Aldebaran	16.4483	291.4650
11	Rigel	-8.2361	281.7383
12	Capella	45.9683	281.4008
13	Bellatrix	6.3231	279.1333
14	Elnath	28.5828	278.9175
15	Alnilam	-1.2203	276.3400
16	Betelgeuse	7.4028	271.6267
17	Canopus	-52.6783	264.1854
18	Sirius	2663.3278	1339.0542
19	Adhara	-28.9289	255.6483
20	Procyon	1805.3056	1325.5800
21	Pollux	28.1025	1324.1446
22	Avior	-59.4094	234.5300
23	Suhail	-43.3069	223.2863
24	Miaplacidus	-69.5894	221.7829
25	Alphard	-8.5233	218.4842
26	Regulus	12.1194	208.3142
27	Dubhe	61.9186	194.5429
28	Denebola	14.7453	1263.1300
29	Gienah	-17.3700	176.4479
30	Acrux	-62.9275	173.7850
31	Gacrux	-56.9400	172.6413
32	Alioth	56.1278	166.8325
33	Spica	-11.0000	159.1108
34	Alkaid	49.4675	153.4200
35	Hadar	-60.2244	149.5950
36	Menkent	683.7817	1228.7875
37	Arcturus	3619.3431	2666.4383
38	Rigil Kentaurus	-1500.7086	13460.6300
39	Zubenelgenubi	-15.9142	137.7100
40	Kochab	74.2822	137.3058
41	Alphecca	26.8181	126.6567
42	Antares	-26.3647	113.1242
43	Alna	-68.9733	109.6588
44	Sabik	-15.6881	102.8508
45	Shaula	-37.0831	97.1246
46	Rasalhague	12.5811	96.6267
47	Eltanin	51.4919	91.0287
48	Kaus Australis	-34.4011	84.4717
49	Vega	38.7539	81.0279
50	Nunki	-26.3969	76.6642
51	Altair	-711.2147	-1017.3175
52	Peacock	-56.8361	54.1988
53	Deneb	45.1689	49.9067
54	Enif	9.7322	34.3346
55	Al Na'ir	-47.1119	26.4283
56	Fomalaut	-29.7869	16.0150
57	Markab	15.0381	14.1967

PROGRAM DESCRIPTION II

Sample Problem (Sketch if Desired) A vessel is enroute between New Zealand and Fiji. On April 3, 1980, SIRIUS is observed at 06:21:14. The Hs (corrected for index error) was 84° 10'. The D.R. position was 21°05' S, 178°14' E.

2. A vessel is enroute from Honolulu to Cape Flattery, Wash. On June 6, 1980, the upper limb of the moon was observed. Hs was 63°08' corrected. GMT was 17:21:17. The D.R. position was 21°51'N, 157°02'W. The Nautical Almanac gives the GHA and Dec for 17 hours and 18 hours as: 154° 51.1', 169° 19.9'; S 4° 51.9', S 4° 40.3'. The S.D. is 16.1'.

3. On the same occasion the navigator observed the sun: GMT 17:23:14; Hs 20°28'.

4. The vessel then sails under light breezes for 11½ hours and logs the following legs: (compass courses corrected mentally for deviation only)

025°	21 miles	Fix from previous sights:
030°	18 miles	21°46'N 157°00'W
020°	26 miles	Variation 12°E

Using the Dead Reckoning routine of the program, the navigator computes the D.R. position and retains the Latitude and Longitude in the storage registers for the next celestial observation.

(cont'd)

SOLUTION:

	Input	Function	Display	Comments
		User mode		
		XEQ Size 008		
		I	BODY ?	Initialize and Prompt
1)		C	STAR NO.?	Prompt
	18	R/S	SIRIUS	
			LA↗ LO	Prompt
	21.05	CHS	-21.05	
		ENTER↗	-21.0500	
	178.14	CHS	-178.14_	
		R/S	DATE?	
	1980	ENTER↗	1980	
	4	ENTER↗	4	
	3	R/S	4/ 3/ 1980	
			GMT =	Prompt
	6.2114	R/S	GMT = 6.2114	
			HC = 84.0423	
			HS =	Prompt
	84.1	R/S	HS = 84.1000	
			AZ = 317.1	
		R/S	TO 2.8	
2)		R/S or I	BODY ?	Prompt
		B	MOON	
			LA↗ LO	Prompt
	21.51	ENTER↗	21.5100	
	157.02	R/S	21.5100	
			157.0200	
			GMT =	Prompt
	17.2117	R/S	GMT = 17.2117	
			GHA↗ GHA	Prompt
	154.5106	ENTER↗	154.5106	Mentally convert tenths of minut
	169.1954	R/S	154.5106	
			169.1954	
			DEC↗ DEC	

Sample Problem (Sketch if Desired) (Cont'd)

5. Jupiter was observed that evening at sunset, at GMT 04:55:47. The corrected (for index error) Hs was 69°30'. The navigator used the Latitude and Longitude already in the storage registers from the previous problem. (22-38-12N & 156-18-28W). The Nautical Almanac gives the GHA and Dec for 04 hours and 05 hours as:

160-34-48	N 11-32-54	Date: June 7, 1980 Greenwich
175-37-00	11-32-48	

6. Using the plotted position of 22° 34'N and 156° 22'W, the navigator determines the new heading (true) and distance to Cape Flattery, using the Great Circle solution. Cape Flattery is 48° 25' N and 124° 45' W

SOLUTION:

	Input	Function	Display	Comments
	4.5154	CHS	- 4.5154_	
		ENTER↑	-4.5154	
	4.4018	CHS	- 4.4018	
		R/S	- 4.5154	
			- 4.4018	
			HS =	Prompt
	63.08	R/S	HS = 63.0800	
			S.D. =	Prompt
	.1606	CHS	- .1606_	Note decimal point;and CHS for U.L
		R/S	S.D.= -0.1606	
			AZ = 186.5	Zn true of body
		R/S	TO 3.5	Intercept miles, toward body.
3)		I (or R/S)	BODY ?	Prompt
		A	SUN	
			LA↑LO	Prompt
	21.51	ENTER↑	21.5100	
	157.02	R/S	21.5100	
			157.0200	
			DATE ?	Prompt
	6	R/S	6/ 6/ 1980	
			GMT =	Prompt
	17.2314	R/S	GMT = 17.2314	
			HC = 20.3749	
			HS =	Prompt
	20.28	R/S	HS = 20.2800	
			AZ = 72.9	Zn true of body
		R/S	TO 0.7	Intercept 0.7 miles toward body
4)		I (or R/S)	BODY ?	Initialize
		F	DED REC	
			LA↑LO	Prompt
	21.46	ENTER↑	21.4600	
	157	R/S	21.4600	
			157.0000	

PROGRAM DESCRIPTION II

Sample Problem (Sketch if Desired)

SOLUTION:

Input	Function	Display	Comments
		VAR E+ W-	Prompt
12	R/S	CC ↗ DIST	Prompt
25	ENTER↗	25.0000	
21	R/S	CC ↗ DIST	
30	ENTER↗	30.0000	
18	R/S	CC ↗ DIST	
20	ENTER↗	20.0000	
26	R/S	CC ↗ DIST	
	R/S		R/S with no entry will take
			operation out of closed loop.
		LAT= 22.3812	
	R/S	LONG= 156.1828	Lat & Long retained in memory
			for next observation, if desired
5)	I (or R/S)	BODY ?	Prompt
	D	PLANET	
		LA↗ LO	Prompt
	R/S	22.3812	Lat & Long from memory from
		156.1828	Dead Reckoning problem
		GMT =	Prompt
4.5547	R/S	GMT = 4.5547	
		GHA↗ GHA	Prompt
160.3448	ENTER↗	160.3448	
175.37	R/S	160.3448	
		175.3700	
		DEC↗ DEC	Prompt
11.3254	ENTER↗	11.3254	
11.3245	R/S	11.3254	
		11.3245	
		HS =	
69.3	R/S	HS = 69.3000	
		AZ = 240.5	Zn of body
	R/S	TO 5.2	Intercept is toward 5.2 miles

Sample Problem (Sketch if Desired)

SOLUTION:

Input	Function	Display	Comments
	I (or R/S)	BODY ?	Prompt
	E (STEP 995)	GREAT CIRCLE	
		LA↗LO	Prompt
22.34	ENTER↗	22.3400	
156.22	R/S	22.3400	
		156.2200	
		LA↗LO	Prompt
48.25	ENTER↗	48.2500	
124.45	R/S	124.4500	
		AZ = 36.3	True course to destination.
	R/S	D = 2160.3	Great Circle distance

005110 To aid in checking —
PRINT OUT OF EXAMPLES ON PAGES 5, 6, 7, + 8

SIRIUS

LAT↑LO
-21.0500
-178.1400

4/3/1980
GMT= 6.2114
HC= 84.0423
HS= 84.1000

AZ= 317.1
TO 2.8

MOON

LAT↑LO
21.5100
157.0200

GMT= 17.2117

GHA↑GHA
154.5106
169.1954

DEC↑DEC
-4.5154
-4.4018

HS= 63.0800
S.D.= -0.1606

AZ= 186.5
TO 3.5

SUN

LAT↑LO
21.5100
157.0200

6/6/1980
GMT= 17.2314
HC= 20.3749
HS= 20.2800

AZ= 72.9
TO 0.7

DED REC

LAT↑LO
21.4600
157.0000

LAT= 22.3812
LONG= 156.1028

PLANET

LAT↑LO
22.3812
156.1028

GMT= 4.5547

GHA↑GHA
160.3448
175.3700

DEC↑DEC
11.3254
11.3245

HS= 69.3000

AZ= 240.5
TO 5.2

GREAT CIRCLE

LAT↑LO
22.3400
156.2200

LAT↑LO
48.2500
124.4500

AZ= 36.3
D= 2160.3

42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE
NATIONAL

USER INSTRUCTIONS

SIZE: 008

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	USER MODE			
2	SIZE 008			
3	Enter Program "NAV" Adjust date.(Note1)			
4	Enter Program "LST". Star list is divided			
	into "LST" I, II, and III. Use only one			
	at a time. (If Card Reader is used:		J	CARD)
5	Initialize It may be necessary to press		I	BODY ?
	Catalog 1 and R/S to position pointer.			(
	S U N			
1	Initialize SUN routine.		A	SUN
				LA↗ LO
	- or - if upper limb observation		a	SUN U.L.
				LA↗ LO
2	Enter latitude and longitude	D.MMSS latitude	ENTER↗	latitude
		longitude	R/S	longitude
				DATE ?
3	Enter day of month	day		Mo/Day/Year
	- or - Enter year (e.g. 1980),	year	ENTER↗	Year
	month, and day.	month	ENTER↗	Month
		day	R/S	Mo/Day/Year
				GMT =
4	Enter Greenwich Mean Time	H.MMSS	R/S	H.MMSS
				HC= D.mmss
	(Note 1: Year is step 46, month is step			
	48, and HE is step 210. To adjust,			
	delete step and enter new number.			

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT	FUNCTION	SIZE: DISPLAY
				HS =
5	Enter HS corrected for index error	D.mmss	R/S	HS = D.mmss
				AZ = D.
6	Intercept given in miles To or Away.		R/S	Intercept
	S T A R Initialize		I	BODY ?
1	Initialize STAR routine		C	STAR NO. ?
2	Enter list number of star	nn	R/S	"NAME"
				LA/ LO
	Steps 3, 4, 5, and 6 are same as for SUN			
3a	If different star list is required,			
	select cards for LST I, II, or III		J	CARD
	enter selected cards. Follow prompts.			
	MOON and PLANETS Initialize		I	BODY ?
1	Initialize MOON routine		B	MOON
	or PLANET routine		D	PLANET
				LA/ LO
2	Enter latitude and longitude	D.mmss	ENTER/	latitude
		D.mmss	R/S	longitude
				GMT =
3	Enter Greenwich Mean Time	H.mmss	R/S	GMT = H.mmss
				GHA GHA
4	From Nautical Almanac, enter GHA for	D.mmss	Enter/	D.mmss
	whole hour preceeding and following sight	D.mmss	R/s	D.mmss
				DEC DEC
5	From Nautical Almanac, enter declination	D.mmss	ENTER/	D.mmss

USER INSTRUCTIONS

STEP	INSTRUCTIONS	INPUT	FUNCTION	SIZE: DISPLAY
	for hours as above. If South, change sign	D.mmss	R/S	D.mmss
				HS =
6	Enter sextant angle corrected for			
	index error.	D.mmss	R/S	HS = D.mmss
(7)	Prompt for semi-diameter appears only in			S.D. =
	Moon routine. Enter S.D. CHS if upper			
	limb. Observe decimal point.	0.mmss	R/S	S.D.= .mmss
				AZ= D. (
				Intercept
	DEAD RECKONING Initialize		I	BODY ?
1	Initialize D.R. routine		F	DED REC
				LA ↗ LO
2	Enter latitude and longitude of	D.mmss	ENTER↗	D.mmss
	initial point	D.mmss	R/S	D.mmss
				VAR E + W-
3	Enter variation. Change sign if WEST	degrees	R/S	CC ↗ DIST
4	Enter compass course corrected for	degrees	ENTER↗	
	deviation only, and distance of leg	miles	R/S	CC ↗ DIST
	After all legs are entered, leave routine			
	by making no entry and pressing R/S		R/S	latitude$_2$
			R/S	longitude$_2$
	GREAT CIRCLE Initialize	(495)	I	BODY ?
1	Initialize Great Circle routine		E	LAT↗ LO
2	Enter Lat. & long. CHS if East or South	D.mmss	Enter↗	
		D.mmss	R/S	LA ↗ LO
3	Enter Lat.& long. of destination	D.mmss D.mmss	Enter R/S	AZ degrees Distance

PROGRAM LISTING

☐ 67 ☐ 97 ☒ 41C

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
01	♦LBL "NAV"		
02	♦LBL I		Initialize
03	CF 00		
04	CF 01		
05	CF 02		
06	CF 03		
07	CF 04		
08	CF 05		
09	CF 29		
10	SF 12		
11	"BODY ?"		
12	PROMPT		
13	♦LBL a		
14	SF 01		SUN Upper Limb
15	♦LBL A		
16	SF 00		
17	"SUN"		
18	FS? 01		
19	"⊢ U.L."		
20	♦LBL 00		
21	ADV		
22	AVIEW		
23	PSE		
24	ADV		
25	CF 12		
26	♦LBL 01		View entries
27	FIX 4		
28	ADV		
29	"LA↑LO"		
30	♦LBL 02		
31	AVIEW		
32	STOP		
33	CLA		
34	X<>Y		
35	XEQ 08		
36	ADV		
37	FS? 04		
38	RTN		
39	STO 01		Store longitude
40	X<>Y		
41	STO 03		Store latitude
42	FC? 00		
43	RTN		
44	♦LBL 03		
45	FIX 0		
46	1980		
47	ENTER↑		
48	6		
49	"DATE ?"		
50	PROMPT		
51	CLA		
52	ARCL Y		
53	"⊢/"		
54	ARCL X		
55	"⊢/"		
56	ARCL Z		
57	AVIEW		
58	STO 00		
59	X<>Y		
60	STO 02		
61	3056		
62	%		
63	INT		
64	ST+ 00		Store month
65	R↑		
66	STO 05		Store day
67	FC? 00		
68	GTO 04		
69	1900		
70	−		
71	♦LBL 04		
72	RCL 02		
73	3		
74	X>Y?		
75	1		
76	RCL 05		
77	4		
78	/		
79	FRC		
80	+		
81	1		
82	X<>Y		
83	X=Y?		
84	2		
85	FC? 00		
86	RTN		
87	RCL 05		
88	7		
89	−		
90	RCL 00		
91	365.25		
92	STO 04		
93	/		
94	+		
95	STO 02		
96	20		
97	*		
98	STO 05		
99	SIN		
100	4		

Note: Refer to "HP-41C OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for specific information on keystrokes. Function index begins on page 262. Refer to Appendix E in 67 or 97 "OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for exact keystrokes.

☐ 67 ☐ 97 ☒ 41C

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
101	*		
102	50941		
103	+		
104	RCL 02		
105	7		
106	*		
107	+		
108	896		
109	/		
110	-		
111	ST- 00		
112	360		
113	ST* 00		
114	♦LBL 05		
115	FIX 4		
116	"GMT= "		
117	PROMPT		
118	XEQ 09		
119	FC?C 00		
120	RTN		
121	15		
122	*		
123	STO 02		
124	RCL 00		
125	+		
126	RCL 04		
127	/		
128	118.1		
129	RCL 05		
130	968		
131	/		
132	-		
133	+		
134	.2		
135	P-R		
136	9.58		
137	-		Semi diameter
138	STO 00		
139	*		
140	+		
141	RCL 05		
142	427		
143	/		
144	RCL 05		
145	COS		
146	-		
147	8531.5		
148	-		
149	360		
150	/		
151	CHS		
152	X<>Y		
153	-1		
154	P-R		
155	RDN		
156	P-R		
157	R↑		
158	R-P		
159	RDN		
160	X<>Y		
161	STO 05		
162	ASIN		
163	STO 04		Declination
164	RDN		
165	-		
166	ST+ 02		GHA
167	RCL 02		
168	RCL 01		
169	-		
170	RCL 04		LHA
171	COS		
172	P-R		
173	RCL 03		
174	X<>Y		
175	P-R		
176	X<> 03		
177	RCL 05		
178	♦LBL 07		
179	P-R		
180	X<> 03		
181	+		
182	ASIN		
183	X<> 03		
184	-		
185	R-P		
186	RDN		
187	180		
188	+		
189	STO 01		
190	RCL 03		
191	HMS		
192	"HC= "		
193	XEQ 09		
194	FS? 04		
195	RTN		
196	"HS= "		
197	PROMPT		
198	XEQ 09		
199	♦LBL 11		
200	ENTER↑		

Note: Refer to "HP-41C OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for specific information on keystrokes. Function index begins on page 262. Refer to Appendix E in 67 or 97 "OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for exact keystrokes.

PROGRAM LISTING

☐ 67 ☐ 97 ☒ 41C

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
201	ENTER↑		
202	ENTER↑		
203	3		
204	+		
205	12		
206	*		
207	ATAN		
208	−		
209	TAN		
210	8		HE
211	SQRT		
212	−		
213	62		Mean refraction
214	/		Dip correction
215	FS? 04		
216	RTN		
217	+		
218	RCL 03		
219	−		
220	CHS		
221	60		
222	*		
223	FS?C 03		
224	RTN		
225	RCL 00		
226	36		
227	%		
228	+		
229	3		
230	−		
231	FS?C 01		
232	CHS		Change sign if U.L.
233	+		
234	STO 00		
235	◆LBL 12		Viewing routine
236	FIX 1		
237	ADV		
238	"AZ= "		
239	ARCL 01		
240	AVIEW		
241	STOP		
242	CLA		
243	FS?C 04		
244	RTN		
245	RCL 00		
246	X>0?		
247	"AWAY "		
248	X<0?		
249	"TO "		
250	ABS		
251	ARCL X		
252	AVIEW		
253	SF 11		
254	STOP		
255	GTO I		
256	◆LBL 08		Viewing routine
257	ARCL X		
258	AVIEW		
259	PSE		
260	HR		
261	CLA		
262	X<>Y		
263	◆LBL 09		Viewing routine
264	ARCL X		
265	AVIEW		
266	PSE		
267	HR		
268	CLA		
269	RTN		
270	◆LBL B		MOON routine
271	"MOON"		
272	SF 02		
273	◆LBL D		PLANET routine
274	FC? 02		
275	"PLANET"		Both essentially same.
276	XEQ 00		
277	XEQ 05		
278	STO 06		
279	INT		
280	STO 00		Store GHA
281	ADV		
282	"GHA↑GHA "		
283	SF 04		
284	XEQ 02		
285	X<>Y		
286	STO 02		
287	−		
288	SIN		
289	ASIN		
290	STO 05		
291	"DEC↑DEC "		
292	XEQ 02		Store Dec
293	X<>Y		
294	STO 04		
295	−		
296	STO 07		
297	"HS= "		
298	PROMPT		
299	XEQ 09		
300	X<> 05		

Note: Refer to "HP-41C OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for specific information on keystrokes. Function index begins on page 262. Refer to Appendix E in 67 or 97 "OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for exact keystrokes.

PROGRAM LISTING

☐ 67 ☐ 97 ☒ 41C

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
301	*LBL	14	
302	RCL	06	
303	RCL	00	
304	−		
305	*		
306	RCL	02	
307	+		
308	STO	02	
309	RCL	07	
310	RCL	06	
311	RCL	00	
312	−		
313	*		Compute proportional GHA
314	RCL	04	
315	+		
316	STO	04	
317	RCL	05	
318	XEQ	11	
319	+		
320	STO	06	
321	RCL	03	
322	1		
323	P−R		
324	STO	05	
325	RCL	02	
326	RCL	01	
327	−		
328	RCL	04	
329	COS		
330	P−R		
331	ST*	05	
332	R↑		
333	STO	03	
334	*		
335	R↑		
336	RCL	04	
337	SIN		
338	ST*	03	
339	*		
340	−		
341	R−P		
342	RDN		
343	180		
344	+		
345	FS?C	05	
346	RTN		
347	STO	01	
348	RCL	05	
349	RCL	03	
350	+		

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
351	ASIN		
352	STO	03	
353	RCL	06	
354	−		
355	RCL	03	
356	COS		
357	FC?	02	
358	GTO	10	If planet, skip steps
359	"S.D.= "		
360	PROMPT		
361	XEQ	09	If moon, enter S.D.
362	*LBL	10	
363	FC?C	02	
364	1 E−5		Minimal number to remove zero for test
365	STO	00	
366	ABS		
367	TAN		
368	3.67		
369	*		
370	ASIN		
371	*		
372	−		
373	RCL	00	
374	−		
375	60		
376	*		
377	STO	00	
378	CF	04	
379	GTO	12	
380	*LBL	C	
381	SF	03	
382	FIX	0	STAR routine
383	"STAR NO.?"		
384	PROMPT		
385	XEQ	"LST"	
386	STO	07	
387	X<>Y		
388	STO	06	
389	XEQ	00	
390	XEQ	03	
391	ST−	00	
392	1969.1		
393	ST−	05	Whole years from 1969.1
394	RCL	00	
395	365.25		
396	/		
397	ST+	05	
398	360		
399	ST*	00	
400	25986		

Note: Refer to "HP-41C OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for specific information on keystrokes. Function index begins on page 262. Refer to Appendix E in 67 or 97 "OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for exact keystrokes.

PROGRAM LISTING

☐ 67 ☐ 97 ☒ 41C

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
401	ST+	00	Add fractional year
402	365.25		
403	ST/	00	
404	19		
405	RCL	05	
406	*		
407	RCL	07	
408	-		
409	.8		
410	P-R		
411	STO	04	
412	RDN		
413	STO	02	
414	RCL	07	
415	2		
416	RCL	05	
417	*		
418	P-R		
419	ST+	02	
420	RDN		
421	RCL	06	
422	TAN		
423	ST*	04	
424	*		
425	93		
426	RCL	07	Mean anomaly
427	♦LBL	06	
428	360		
429	/		
430	INT		
431	-		
432	50		
433	/		
434	RCL	05	
435	*		
436	FC?C	03	
437	RTN		
438	-		
439	ST+	04	
440	RCL	00	
441	RCL	07	
442	+		
443	2		
444	P-R		
445	RCL	06	
446	1		
447	P-R		
448	X<>Y		
449	R↑		
450	*		
451	ST+	02	
452	RDN		
453	/		
454	ST-	04	
455	RCL	00	
456	LASTX		
457	P-R		
458	.8		
459	*		
460	ST+	02	
461	0		
462	RCL	06	
463	XEQ	06	
464	SF	03	
465	ST+	02	
466	360		
467	ST/	04	
468	ST/	02	
469	RCL	06	
470	ST+	02	
471	RCL	07	
472	ST+	04	
473	XEQ	05	
474	15.04107		
475	*		
476	RCL	00	
477	+		
478	RCL	04	
479	+		
480	RCL	01	
481	-		
482	RCL	02	
483	COS		
484	P-R		Decode proper motion corr'n.
485	RCL	03	
486	X<>Y		
487	P-R		
488	X<>	03	
489	RCL	02	
490	SIN		
491	XEQ	07	
492	STO	00	
493	GTO	12	
494	♦LBL	E	
495	"GREAT C		GREAT CIRCLE ROUTINE
IRCLE"			
496	XEQ	00	
497	SF	04	
498	SF	05	
499	XEQ	01	
500	STO	02	

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PROGRAM LISTING

☐ 67 ☐ 97 ☐ 41C

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
501	X<>Y		
502	STO 04		
503	0		
504	STO 05		Use sub routines from celestial sights for solving great circle
505	STO 07		
506	XEQ 14		
507	STO 01		
508	XEQ 12		
509	RCL 05		
510	RCL 03		
511	+		
512	ASIN		
513	90		
514	X<>Y		Less zenith angle
515	-		
516	60		
517	*		
518	"D= "		
519	ARCL X		
520	AVIEW		
521	SF 11		
522	STOP		
523	GTO I		
524	*LBL J		RSUB for cards for "LST" or other routines
525	RSUB		
526	GTO I		
527	*LBL F		DEAD RECKONING ROUTINE
528	SF 11		
529	CLRG		
530	"DED REC "		
531	XEQ 00		
532	"VAR E+ W-"		
533	PROMPT		
534	STO 00		
535	*LBL 15		Loop for entering legs
536	"CC↑DIST "		
537	PROMPT		
538	X=0?		Test to get out of loop
539	GTO 16		
540	X<>Y		
541	RCL 00		
542	+		
543	X<>Y		
544	P-R		
545	ST+ 04		
546	X<>Y		
547	CHS		
548	ST+ 02		
549	CLX		
550	GTO 15		
551	*LBL 16		
552	RCL 03		
553	RCL 04		
554	60		
555	/		
556	ST+ 03		
557	2		
558	/		
559	+		
560	COS		
561	1/X		Secant L_m
562	ST* 02		
563	RCL 03		
564	HMS		
565	"LAT= "		
566	ARCL X		
567	AVIEW		
568	STOP		
569	RCL 02		
570	60		
571	/		
572	ST+ 01		
573	RCL 01		
574	HMS		
575	RDN		
576	X<>Y		Hold lat & long in X and Y
577	R↑		
578	"LONG= "		
579	ARCL X		
580	AVIEW		
581	STOP		
582	GTO I		
583	END		
		90	
		00	

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PROGRAM LISTING

☐ 67 ☐ 97 ☐ 41C

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
01	✱LBL "LST"		SUB-ROUTINE
02	GTO IND X		LST I
03	✱LBL 01		STAR LIST
04	28.9194		
05	"ALPHERATZ"		List of stars
06	358.3050		SHA
07	RTN		DEC
08	✱LBL 12		NAME
09	45.9683		
10	"CAPELLA"		
11	281.4008		
12	RTN		
13	✱LBL 18		
14	2863.3278		
15	"SIRIUS"		
16	1339.0542		
17	RTN		
18	✱LBL 27		
19	61.9186		
20	"DUBHE"		
21	194.5429		
22	RTN		
23	✱LBL 33		
24	-11		
25	"SPICA"		
26	159.1108		
27	RTN		
28	✱LBL 37		
29	3619.3431		
30	"ARCTURUS"		
31	2666.4383		
32	RTN		
33	✱LBL 49		
34	38.7539		
35	"VEGA"		
36	81.0279		
37	RTN		
50			

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
38	✱LBL 51		
39	-711.2147		
40	"ALTAIR"		
41	-1017.3175		
42	RTN		
43	✱LBL 53		
44	45.1689		
45	"DENEB"		
46	49.9067		
47	RTN		
48	✱LBL 56		
49	-29.7869		
50	"FOMALHAUT"		
51	16.0150		
52	RTN		
53	END		
70			

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
01	✱LBL "LST"		LST II
02	GTO IND X		
03	✱LBL 00		
04	89.1214		
05	"POLARIS"		
06	329.3708		
07	RTN		
08	✱LBL 05		
09	-57.3959		
10	"ACHERNAR"		
11	335.8596		
12	RTN		
13	✱LBL 09		
14	49.7522		
15	"MIRFAK"		
16	309.4750		
17	RTN		
18	✱LBL 10		
19	16.4483		
20	"ALDEBARAN"		
21	291.4650		
22	RTN		

Note: Refer to "HP-41C OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for specific information on keystrokes. Function index begins on page 262. Refer to Appendix E in 67 or 97 "OWNER'S HANDBOOK AND PROGRAMMING GUIDE" for exact keystrokes.

PROGRAM LISTING

☐ 67 ☐ 97 ☐ 41C

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
23	✱LBL 11		LIST OF STARS CONTINUED
24	-8.2361		
25	"RIGEL"		
26	281.7383		
27	RTN		
28	✱LBL 13		
29	6.3231		
30	"BELLATRIX"		
31	279.1333		
32	RTN		
33	✱LBL 16		
34	7.4028		
35	"BETELGEUSE"		
36	271.6267		
37	RTN		
38	✱LBL 17		
39	-52.6783		
40	"CANOPUS"		
41	264.1854		
42	RTN		
43	✱LBL 20		
44	1805.3056		
45	"PROCYON"		
46	1325.5800		
47	RTN		
48	✱LBL 21		
49	28.1025		
50	"POLLUX"		
51	1324.1446		
52	RTN		
53	END		

STEP/ LINE	KEY ENTRY	KEY CODE (67/97 only)	COMMENTS
01	✱LBL "LST"		LST III
02	GTO IND X		
03	✱LBL 26		
04	12.1194		
05	"REGULUS"		
06	208.3142		
07	RTN		
08	✱LBL 28		
09	14.7453		
10	"DENEBOLA"		
11	1263.1300		
12	RTN		
13	✱LBL 30		
14	-62.9275		
15	"ACRUX"		
16	173.7850		
17	RTN		
18	✱LBL 35		
19	-60.2244		
20	"HADAR"		
21	149.5950		
22	RTN		
23	✱LBL 38		
24	-1500.7086		
25	"RIGIL K"		
26	13460.6300		
27	RTN		
28	✱LBL 40		
29	74.2822		
30	"KOCHAB"		
31	137.3058		
32	RTN		
33	✱LBL 42		
34	-26.3647		
35	"ANTARES"		
36	113.1242		
37	RTN		
38	.END.		

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REGISTERS, STATUS, FLAGS, ASSIGNMENTS

005 I 1C

DATA REGISTERS

00	Multiple uses	50	
	"		
	"		
	"		
	"		
05	"	55	
	"		
07	"		
10		60	
15		65	
20		70	
25		75	
30		80	
35		85	
40		90	
45		95	

STATUS

SIZE 008 TOT. REG. 188 * USER MODE

ENG ____ FIX X SCI ____ ON X OFF ____

DEG ____ RAD ____ GRAD ____

* with LST I entered.

FLAGS

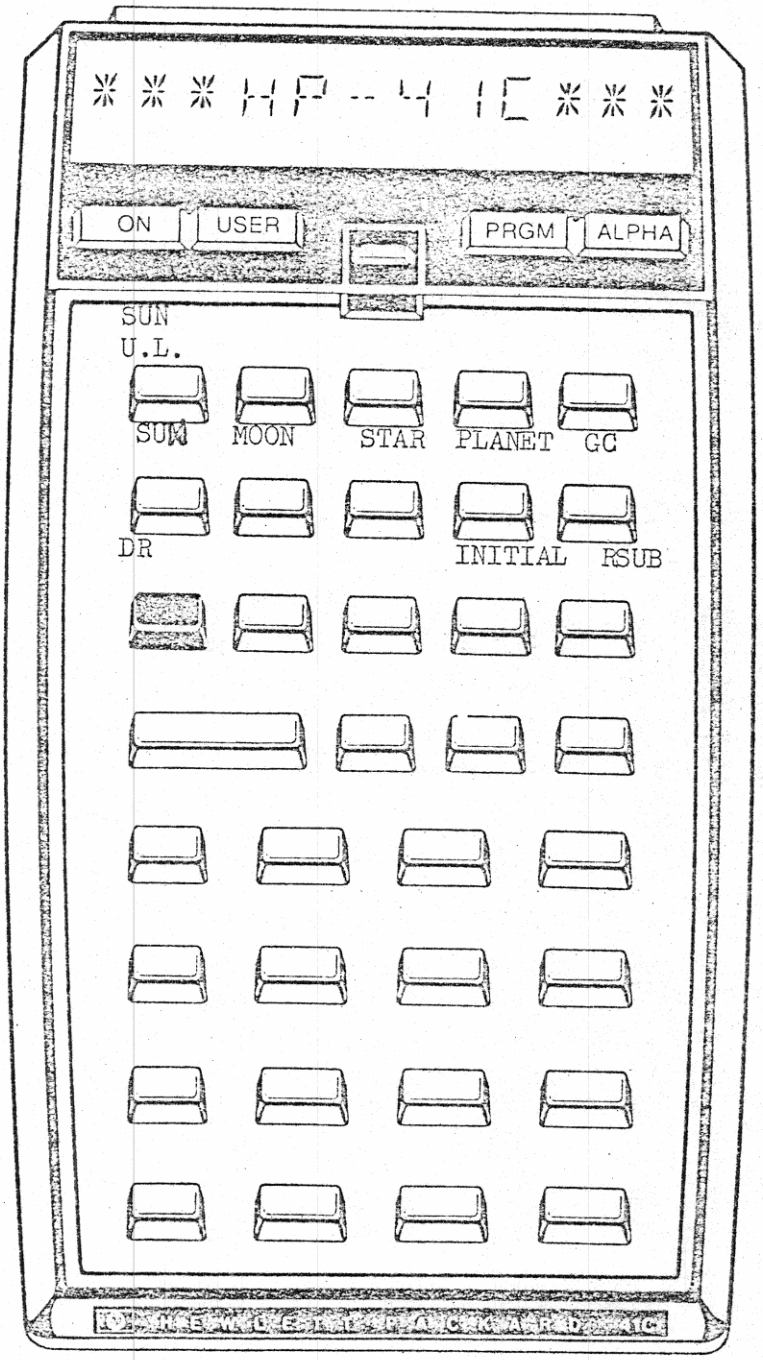
#	INIT S/C	SET INDICATES	CLEAR INDICATES
00	c	Sun routine	
01	c	Sun U.L.	
02	c	Moon routine	Planet routine
03	c	Star routine	
04	c	GC routine	
05	c	GC routine	
29	c		No digit grouping
12	s	Double-size print	

ASSIGNMENTS

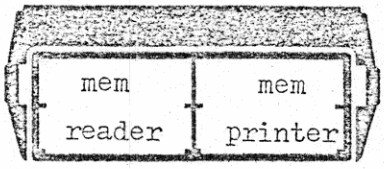
FUNCTION	KEY	FUNCTION	KEY

KEYBOARD CARD LABELING

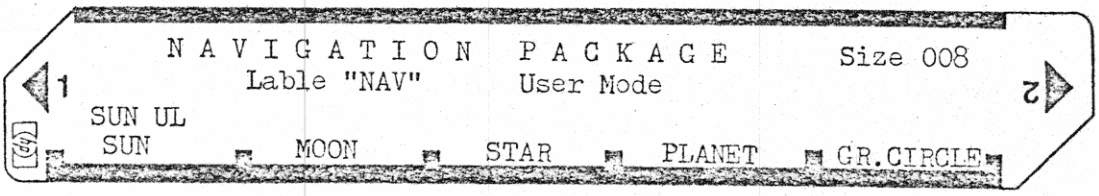
KEYBOARD



SYSTEM CONFIGURATION



CARD



005110

21A

USERS' GUIDE

STAR NAME & NUMBER

Attachment
Navigation Package
Star Lists

Subroutine LST I		Subroutine LST II		Subroutine LST III	
Alpheratz	1	Achernar	5	Acrux	30
Altair	51	Aldebaran	10	Antares	42
Arcturus	37	Bellatrix	13	Denebola	28
Capella	12	Betelgeuse	16	Hadar	35
Deneb	53	Canopus	17	Kochab	40
Dubhe	27	Mirfak	9	Regulus	26
Fomalhaut	56	Polaris	00	Rigil K.	38
Sirius	18	Pollux	21		
Spica	33	Procyon	20		
Vega	49	Rigel	11		

Numerical	
0	Polaris
1	Alpheratz
5	Achernar
9	Mirfak
10	Aldebaran
11	Rigel
12	Capella
13	Bellatrix
16	Betelgeuse
17	Canopus
18	Sirius
20	Procyon
21	Pollux
26	Regulus
27	Dubhe
28	Denebola
30	Acrux
33	Spica
35	Hadar
37	Arcturus
38	Rigil Kent.
40	Kochab
42	Antares
49	Vega
51	Altair
53	Deneb
56	Fomalhaut

Alphebetical	
Achernar	5
Acrux	30
Aldebaran	10
Alpheratz	1
Altair	51
Antares	42
Arcturus	37
Bellatrix	13
Betelgeuse	16
Canopus	17
Capella	12
Deneb	53
Denebola	28
Dubhe	27
Fomalhaut	56
Hadar	35
Kochab	40
Mirfak	9
Polaris	0
Pollux	21
Procyon	20
Regulus	26
Rigel	11
Rigil Kent.	38
Sirius	18
Spica	33
Vega	49