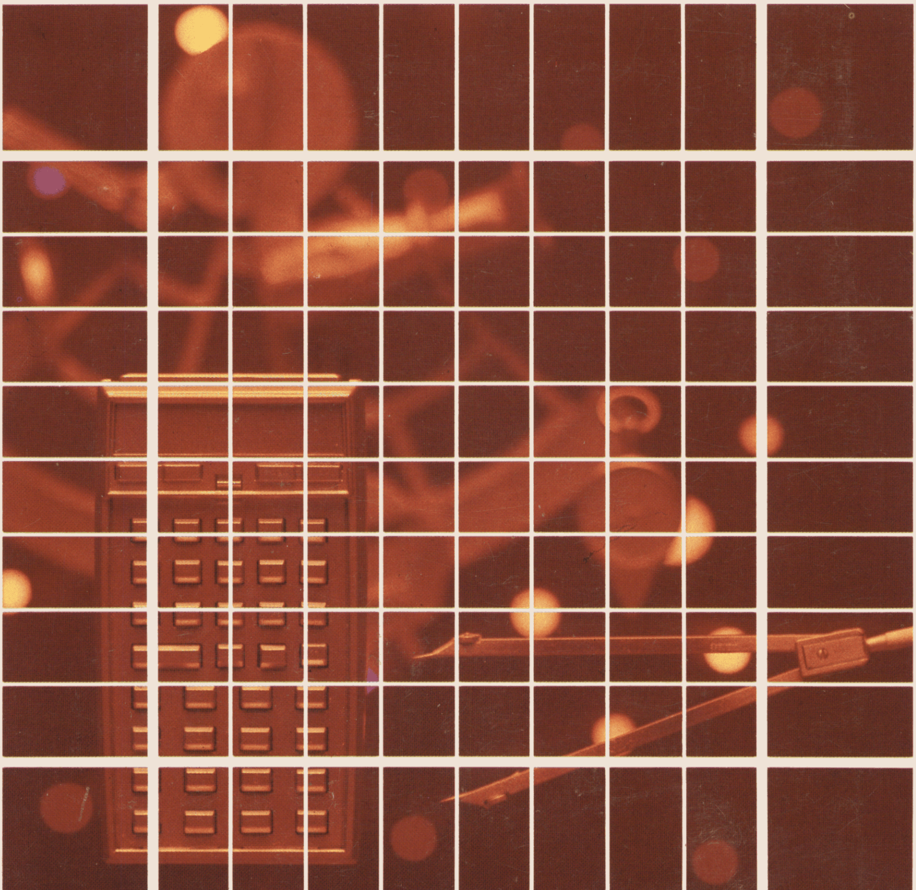
HEWLETT-PACKARD

HP-41C

NAVIGATION PAC



NOTICE

HEWLETT PACKARD

HEWLETT-PACKARD LISTENS

To provide better calculator support for you, the Application Engineering group needs your help. Your timely inputs enable us to provide higher quality software and improve the existing application pacs for your calculator. Your reply will be extremely helpful in this effort.

1. Pac name ______________________________

2. How important was the availability of this pac in making your decision to buy a Hewlett-Packard calculator?

   ☐ Would not buy without it. ☐ Important ☐ Not important

3. What is the major application area for which you purchased the pac?

____

4. In the list below, please rate the usefulness of the programs in this pac.

PROGRAM NUMBER	ESSENTIAL	IMPORTANT BUT NOT REQUIRED	INFREQUENTLY USED	NEVER USED
1				
2				
3				
4				
5				
6				
7				
8				

PROGRAM NUMBER	ESSENTIAL	IMPORTANT BUT NOT REQUIRED	INFREQUENTLY USED	NEVER USED
9				
10				
11				
12				
13				
14				
15				
16				

5. Did you purchase a printer? ☐ YES ☐ NO

   If you did, is the printing format in this pac useful? ☐ YES ☐ NO

6. What programs would you add to this pac?

____

7. What additional application pacs would you like to see developed?

____

THANK YOU FOR YOUR TIME AND COOPERATION.

____
Name Position

____
Company

____
Address

____
City State

____
Zip Phone

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INTRODUCTION

The programs in the Navigation Pac were selected to solve the problems that are common to all marine navigators.

Each program in this pac is represented by one program in the Application Module and a section in this manual. The manual provides a description of the program, a set of instructions for using the program, and one or more example problems each of which includes a list of the keystrokes required for its solution.

Before plugging in your Application Module, **turn your calculator off,** and be sure you understand the section "Inserting and Removing Application Modules." Before using a particular program, take a few minutes to read "Format of User Instructions" and "A Word About Program Usage."

You should first familiarize yourself with a program by running it once or twice while following the complete User Instructions in the manual. Thereafter, the program's prompting should provide the necessary instructions, including which variables are to be input, which keys are to be pressed and which values will be output.

We hope that Navigation Pac I will assist in your course planning and celestial navigation. We would appreciate knowing your reactions to the programs in this pac, and to this end we have provided a questionnaire inside the front cover of this manual. Would you please take a few minutes to give us your comments on these programs? It is from your comments that we learn how to increase the usefulness of our programs.

CONTENTS

INSERTING AND REMOVING APPLICATION MODULES

Before you insert an Application Module for the first time, familiarize yourself with the following information.

Up to four Application Modules can be plugged into the ports on the HP-41C. While plugged in, the names of all programs contained in the Module can be displayed by pressing ■ [CATALOG] 2.

CAUTION

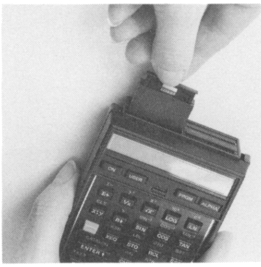
Always turn the HP-41C off before inserting or removing any plug-in extension or accessories. Failure to turn the HP-41C off could damage both the calculator and the accessory.

To insert Application Modules:

1. Turn the HP-41C off! Failure to turn the calculator off could damage both the Module and the calculator.

2. Remove the port covers. Remember to save the port covers; they should be inserted into the empty ports when no extensions are inserted.

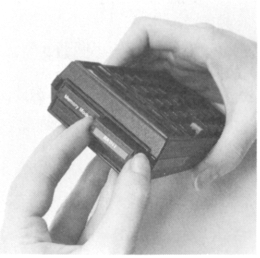
3. Insert the Application Module with the label facing downward as shown, into any port **after** the last Memory Module. For example, if you have a Memory Module inserted in port 1, you can insert an Application Module in any of ports 2, 3, or 4. (The port numbers are shown on the back of the calculator.) **Never insert an Application Module into a lower numbered port than a Memory Module.**



4. If you have additional Application Modules to insert, plug them into any port afte the last Memory Module. Be sure to place port covers over unused ports.
5. Turn the calculator on and follow the instructions given in this book for the desired application functions.

To remove Application Modules:

1. Turn the HP-41C off! Failure to do so could damage both the calculator and the Module.
2. Grasp the desired Module handle and pull it out as shown.



3. Place a port cap into the empty ports.

Mixing Memory Modules and Application Modules

Any optional accessories (such as the HP 82104A Printer) should be treated in the same manner as Application Modules. That is, they can be plugged into any port after the last Memory Module. Also, the HP-41C should be turned off prior to insertion or removal of these extensions.

The HP-41C allows you to leave gaps in the port sequence when mixing Memory and Application Modules. For example, you can plug a Memory Module into port 1 and an Application Module into port 4, leaving ports 2 and 3 empty.

FORMAT OF USER INSTRUCTIONS

The User Instruction Form—which accompanies each program—is your guide to operating the programs in this Pac.

The form is composed of five labeled columns. Reading from left to right, the first column, labeled STEP, gives the instruction step number.

The INSTRUCTIONS column gives instructions and comments concerning the operations to be performed.

The INPUT column specifies the input data, the units of data if applicable, or the appropriate alpha response to a prompted question. Data input keys consist of 0 to 9 and the decimal point (the numeric keys), [EEX] (enter exponent), and [CHS] (change sign).

The FUNCTION column specifies the keys to be pressed after keying in the corresponding input data.

The DISPLAY column specifies prompts, intermediate and final answers, and their units, where applicable.

Above the DISPLAY column is a box which specifies the minimum number of data storage registers necessary to execute the program. Refer to the Owner's Handbook for information on how the SIZE function affects storage configuration.

The following illustrates the User Instruction Form.

SIZE: 054

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Initialize program.		[XEQ] SIGHT	DRL=0:00:00?
2	Key in DR latitude.	DRL, d.ms	[R/S]	DRLO=0:00:00?
3	Key in DR longitude.	DRLo, d.ms	[R/S]	DATE= 0.000000?
4	Key in date.	mm.ddyyyy	[R/S]	TIME=0:00:00?
5	Key in Greenwich Mean Time.	GMT, h.ms	[R/S]	HE=0.0?
6	Key in height of eye in ft. or —HE in m.	HE, ft. HE, m	[R/S] [CHS] [R/S]	 HS=?
7	Key in sextant height.	HS, d.ms	[R/S]	WHICH BODY?
8	Select which body. a) Key in name. or b) Take HP-41C out of alpha and key in star number.	 NAME* star #	 [R/S] [ALPHA] [R/S]	
9	HP-41C will display intercept and azimuth. * Note (NAME) is any member of the list of objects shown in the appendix.		 [R/S]	Name a=0.0 A or T ZN=0.0

A WORD ABOUT PROGRAM USAGE

Catalog

When an Application Module is plugged into a port of the HP-41C, the contents of the Module can be reviewed by pressing ■ [CATALOG] 2 (the Extension Catalog). Executing the [CATALOG] function lists the name of each program or function in the Module, as well as functions of any other extensions which might be plugged in.

ALPHA and USER Mode Notation

This manual uses a special notation to signify ALPHA mode. Whenever a statement on the User Instruction Form is printed in gold, the [ALPHA] key must be pressed before the statement can be keyed in. After the statement is input, press [ALPHA] again to return the calculator to its normal operating mode, or to begin program execution. For example, [XEQ] SIGHT means press the following keys: [XEQ] [ALPHA] SIGHT [ALPHA].

When the calculator is in USER mode, this manual will use the symbols [A] – [J] and ■ [A] – ■ [E] to refer to the reassigned keys in the top two rows. These key designations will appear on the User Instruction Form and in the keystroke solutions to sample problems.

Optional HP 82143A Printer

When the optional printer is plugged into the HP-41C along with the Navigation Application Module, all results will be printed automatically. You may also want to keep a permanent record of the values input to a certain program. A convenient way to do this is to set the Print Mode switch to NORMAL before running the program. In this mode, all input values and the corresponding keystrokes will be listed on the printer, thus providing a record of the entire operation of the program.

Downloading Module Programs

If you wish to trace execution, to modify, or to record on magnetic cards a program in this Application Module, it must first be copied into the HP-41C's program memory. For information concerning the HP-41C's COPY function, see the Owner's Handbook. It is not necessary to copy a program in order to run it.

Program Interruption

These programs have been designed to operate properly when run from beginning to end, without turning the calculator off (remember, the calculator might turn itself off). If the HP-41C is turned off, it may be necessary to set flag 21 (SF 21) to continue proper execution.

Size

Size 054 is sufficient for programs in this pac. A smaller size is accepted where indicated.

Use of Labels

You should generally avoid writing programs into the calculator memory that use program labels identical to those in your Application Module. In case of a label conflict, the label within program memory has priority over the label within the Application Module.

Assigning Program Names

Key assignments to keys [A] – [J] and ■ [A] – ■ [E] take priority over the automatic assignments of local labels in the Application Module. Be sure to clear previously assigned functions before executing a Module program.

NOTATION USED IN THIS PAC

This pac is written to recognize angles expressed as degrees, minutes, and tenths of minutes as well as angles expressed as degrees, minutes, and seconds. Flag 0 is used to distinguish the two. Those who prefer the former notation should be sure that flag 0 is set (■ [SF] 00). Although time is also an angular measurement, it is always expressed as hours, minutes, and seconds.

When the User Instructions indicate the units of an angle which is to be input, d.ms will be used. Usually the display will prompt with old values and the form of the number to be input will be immediately recognized. Negative values must be used for southerly latitudes and declinations and for easterly longitudes and hour angles. On output, the signs are removed and the letters N, S, E, and W are used instead.

When a program prompts for data, it recalls the value used previously and affixes a question mark. If there is no change in the data, simply press [R/S] to skip to the next prompt. Prompts shown in the examples usually have the value zero. Values in actual applications will be non-zero and will depend on the order in which the programs are run. Sometimes much of the data the examples require will be in place already and no further action beyond pressing [R/S] will be required to solve the problem.

SYMBOLS USED IN THIS PAC

SYMBOL	MEANING
β	celestial latitude
δ	declination
$\delta\lambda$	precession of equinox
$\delta\odot$	Sun's declination
ϵ	obliquity of the ecliptic
λ	longitude
Π	longitude of perihelion
ρ	radius vector
Ω	longitude of Moon's ascending node
a	altitude intercept
C	course
dec	declination
D	day of month, distance
DLo	difference in longitude

DRL	dead-reckoning latitude
DRLo	dead-reckoning longitude
d.ms	degrees, minutes and seconds
d.mt	degrees, minutes and tenth-minutes
e	eccentricity of the spheroid
F	latitude argument
G	mean anomaly
GC	great circle
GHA	Greenwich hour angle
GHA♈	Greenwich hour angle of the Vernal Equinox
GMT	Greenwich mean time
GST	Greenwich sidereal time
HA	hour angle
Hc	computed height
HE	height of eye
Hi	initial heading
Ho	corrected sextant height
HP	horizontal parallax
hs	uncorrected sextant height
h.ms	hours, minutes and seconds
JD	Julian date
L	latitude, celestial longitude
Lx	mean longitude of object x
LHA	local hour angle
Lo	longitude
M	month
mm.ddyyyy	month, day and year
S	speed
SD	semidiameter
SHA	sidereal hour angle
T	centuries from 1900.0
t	Julian days from 2000.0, meridian angle
Y	year

GREAT-CIRCLE COURSE AND DISTANCE

This program calculates the great-circle distance and initial heading between any two points. A subroutine entry point is provided.

				SIZE: 011
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Initialize program.		[XEQ] GC	L1=0:00:00N?
2	Key in source latitude.	L1,d.ms	[R/S]	LO1=0:00:00W?
3	Key in source longitude.	LO1,d.ms	[R/S]	L2=0:00:00N?
4	Key in destination latitude.	L2, d.ms	[R/S]	LO2=0:00:00W?
5	Key in destination longitude and compute distance and initial heading.	Lo2,d.ms Lo2,d.ms	[R/S] [R/S] *	D=0.0NMI HI=0.0
	*Press [R/S] if you are not using a printer.			

To use this program as a subroutine, store L1, Lo1, L2, and Lo2 in decimal form in registers 7 through 10 respectively. Then execute the function *GC. The outputs D and Hi will be in the X- and Y-registers, respectively.

Example:

Determine the great-circle distance and initial heading from (33°31′07″N, 118°38′32″W) to (21°16′N, 157°44′42″W).

Keystroke	Display
[XEQ] [ALPHA] GC [ALPHA]	*L1=0:00:00N?*
33.3107 [R/S]	*LO1=0:00:00W?*
118.3832 [R/S]	*L2=0:00:00N?*
21.16 [R/S]	*LO2=0:00:00W?*
157.4442 [R/S]	*D=2,193.8 NMI*
[R/S]	*HI=260.6*

GREAT-CIRCLE POSITION

This program calculates a point on a great circle at a specified distance and initial heading. A subroutine entry point is provided.

				SIZE: 011
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Initialize program.		[XEQ] GCPOS	L1=0:00:00N?
2	Key in source latitude.	L1,d.ms	[R/S]	LO1=0:00:00W?
3	Key in source longitude.	Lo1,d.ms	[R/S]	D=?
4	Key in distance.	D, n.mi.	[R/S]	HI=?
5	Key in initial heading and compute new position.	Hi, d.ms	[R/S] [R/S]*	L2= LO2=
	*Press [R/S] if you are not using a printer.			

To use this program as a subroutine, store L1 and Lo1 in decimal form in registers 7 and 8 and store distance and course in registers 1 and 6. Then execute the function *GCPOS. The values L2 and Lo2 will be stored in decimal form in registers 9 and 10, respectively.

Example:

We depart from (33°31′07″N, 118°38′32″W) at 0845 in the direction 260.6. If we could follow a great circle, where would we be at noon assuming a speed of 16 knots?

Keystroke	Display	Comments
[XEQ] [ALPHA] GCPOS [ALPHA]	*L1=0:00:00N?*	Displayed values assume cleared registers. Actual displays will show previous values of the variable.
33.3107 [R/S]	*LO1=0:00:00W?*	
118.3832 [R/S]	*D=?*	
3.15 [XEQ] [ALPHA] HR [ALPHA]	*3.2500*	
16 [×] [R/S]	*HI=?*	
260.6 [R/S]	*L2=33:22:22N*	
[R/S]	*LO2=119:39:57W*	

RHUMB-LINE COURSE AND DISTANCE

This program calculates the rhumb-line distance and course between any two points. A subroutine entry point is provided.

For those who wish to be more precise, this program will compute rhumb lines on aspherical surfaces. The following table shows eccentricity values for some spheroids.

Spheriods in Common Use

Spheroid	Eccentricity
Sphere	0.0
Clarke Spheroid of 1866	0.08227185422
Clarke Spheroid of 1880	0.08248340005
International Spheroid	0.08199188998

				SIZE: 052
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Initialize program.		[XEQ] RL	e=0.00000E0?
2	Key in eccentricity.	e	[R/S]	L1=0:00:00N
3	Key in source latitude.	L1,d.ms	[R/S]	LO1=0:00:00W?
4	Key in source longitude.	Lo1,d.ms	[R/S]	L2=0:00:00N?
5	Key in destination latitude.	L2, d.ms	[R/S]	LO2=0:00:00W?
6	Key in destination longitude and compute distance and course.	Lo2,d.ms	[R/S]	D=0.0NMI
			[R/S]*	C=0.0
	*Press [R/S] if you are not using a printer.			

To use this program as a subroutine, store L1, Lo1, L2, and Lo2 in decimal form in registers 7 through 10 respectively. Be sure the desired eccentricity is stored in R11, then execute the function *RL.

The outputs D and C will be in the X- and Y-registers, respectively.

Example:

Determine the rhumb-line distance and course on a sphere from (33°31′07″N, 118°38′32″W) to (21°16′N, 157°44′42″W).

Keystroke	Display
[XEQ] [ALPHA] RL [ALPHA]	*e=0.00000E0?*
[R/S]	*L1=0:00:00N?*
33.3107 [R/S]	*LO1=0:00:00W?*
118.3832 [R/S]	*L2=0:00:00N?*
21.16 [R/S]	*LO2=0:00:00W?*
157.4442 [R/S]	*D=2,203.2 NMI*
[R/S]	*C=250.5*

RHUMB-LINE POSITION

This program calculates a point on a rhumb line at a specified distance and initial course. An appropriate value for the Earth's eccentricity should be selected from the table accompanying the Rhumb-Line Course and Distance program.

				SIZE: 052
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Initialize program.		[XEQ] RLPOS	e=0.00000E0?
2	Key in eccentricity.	e	[R/S]	L1=0:00:00N?
3	Key in source latitude.	L1,d.ms	[R/S]	LO1=0:00:00W?
4	Key in source longitude.	Lo1,d.ms	[R/S]	D=?
5	Key in distance.	D, n.mi.	[R/S]	C=?
6	Key in course and compute new position.	C, d.d	[R/S] [R/S] *	L2= LO2=
	*Press [R/S] if you are not using a printer.			

To use this program as a subroutine, store L1 and Lo1 in decimal form in registers 7 and 8 and store distance and course in registers 1 and 6. Then execute the function *RLPOS. The values L2 and Lo2 will be stored in decimal form in registers 9 and 10.

Example:

We depart from (33°31′07″N, 118°38′32″W) at 0845 in the direction 250.5. Where will we be at noon if we are able to make good a speed of 16 knots? Assume that the Earth is a sphere.

Keystroke	**Display**	**Comments**
[XEQ] [ALPHA] RLPOS [ALPHA]	*e=0.00000E0?*	Displayed
[R/S]	*L1=0:00:00N?*	values assume
33.3107 [R/S]	*LO1=0:00:00W?*	cleared regis-
118.3832 [R/S]	*D=?*	ters. Actual
3.15 [XEQ] [ALPHA] HR [ALPHA]	*3.25*	displays will
16 [×] [R/S]	*C=?*	show previous
250.5 [R/S]	*L2=33:13:45N*	values of the
[R/S]	*LO2=119:37:13W*	variable.

GREAT-CIRCLE PLOTTING AND VOYAGE PLANNING

These programs allow you to plot a great-circle track in two ways. You can specify a longitude increment to obtain a list of points on the great circle spaced by that interval, or you can specify a distance to obtain equally-spaced points. The former technique is useful for plotting on a chart, and the latter is useful for predicting daily positions. Both programs provide the rhumb-line course and distance between successive great-circle points. A subroutine entry point is provided.

SIZE: 054

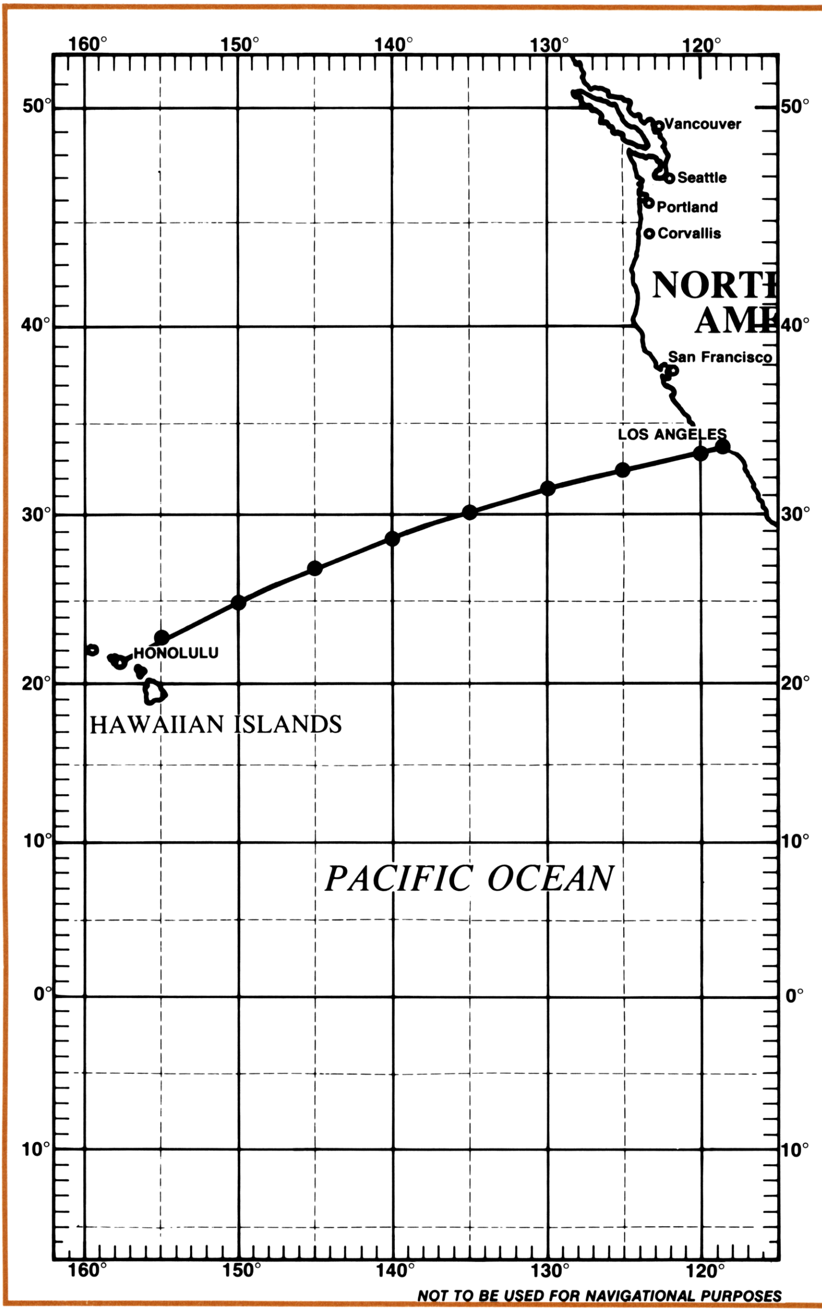
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
	To Plot a Great-Circle Track (constant longitude increment)			
1	Initialize program.		[XEQ] GCPLOT	L1=0:00:00N?
2	Key in source latitude.	L1,d.ms	[R/S]	LO1=0:00:00W?
3	Key in source longitude.	Lo1,d.ms	[R/S]	L2=0:00:00N?
4	Key in destination latitude.	L2, d.ms	[R/S]	LO2=0:00:00W?
5	Key in destination longitude.	Lo2, d.ms	[R/S]	DLO=0:00:00W?
6	Key in the longitude increment and the calculator will produce a list of great-circle points with rhumb line course and distance between them. *Press [R/S] if you are not using a printer.	DLo, d.ms	[R/S] *	

Example 1:

Produce a plot of the great circle from (33°31′07″N, 118°38′32″W), off Catalina, to (21°16′N, 157°44′42″W), east of Diamond Head, using a longitude increment of 5 degrees.

	Display
[XEQ] [ALPHA] GCPLOT [ALPHA]	*L1=0:00:00N?*
33.3107 [R/S]	*LO1=0:00:00W?*
118.3832 [R/S]	*L2=0:00:00N?*
21.16 [R/S]	*LO2=0:00:00W?*
157.4442 [R/S]	*DLO=0:00:00W?*
5 [R/S]	

```
L1=33:31:07N
LO1=118:38:32W

C=260.3
D=68.99 NMI

L2=33:19:26N
LO2=120:00:00W

C=258.5
D=257.03 NMI

L3=32:28:17N
LO3=125:00:00W

C=255.8
D=262.57 NMI

L4=31:24:02N
LO4=130:00:00W

C=253.2
D=269.25 NMI

L5=30:06:22N
LO5=135:00:00W

C=250.7
D=277.02 NMI

L6=28:34:55N
LO6=140:00:00W

C=248.3
D=285.78 NMI

L7=26:49:25N
LO7=145:00:00W

C=246.1
D=295.38 NMI

L8=24:49:39N
LO8=150:00:00W

C=244.0
D=305.62 NMI

L9=22:35:36N
LO9=155:00:00W

C=242.5
D=172.30 NMI

L10=21:16:00N
LO10=157:44:42W
```


160°
150°
140°
130°
120°
50°
40°
30°
20°
10°
0°
10°
Vancouver
Seattle
Portland
Corvallis
NORTH
AMI
San Francisco
LOS ANGELES
HONOLULU
HAWAIIAN ISLANDS
PACIFIC OCEAN
NOT TO BE USED FOR NAVIGATIONAL PURPOSES

				SIZE: 011
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
	To Plan a Voyage (equally spaced points)			
1	Initialize program.		[XEQ] GCPLAN	L1=0:00:00N
2	Key in source latitude	L1,d.ms	[R/S]	LO1=0:00:00W
3	Key in source longitude	Lo1,d.ms	[R/S]	L2=0:00:00N?
4	Key in destination latitude	L2, d.ms	[R/S]	LO2=0:00:00W
5	Key in destination longitude	Lo2, d.ms	[R/S]	D=0.0?
6	Key in the distance increment and the calculator will produce a list of great-circle points with rhumb-line course and distance between them. *Press [R/S] if you are not using a printer.	D,n.mi.	[R/S]*	

To use these programs as subroutines, store L1, Lo1, L2, and Lo2 in decimal form in registers 12, 13, 14, and 15. Store the distance in register 1 and execute *GCPLOT or store the longitude increment in register 5 and execute *GCPLAN. The programs will proceed as if you had performed step 6 of either set of instructions.

Example 2:

Produce a list of daily positions from (33°13′45″N, 119°37′13″W) to (21°16′N, 157°44′42″W), assuming a vessel speed of 16 knots.

Keystroke	Display
[XEQ] [ALPHA] GCPLAN [ALPHA]	*L1=0:00:00N?*
33.1345 [R/S]	*LO1=0:00:00W?*
119.3713 [R/S]	*L2=0:00:00N?*
21.16 [R/S]	*LO2=0:00:00W?*
157.4442 [R/S]	*D=0.0?*
16 [ENTER↑] 24 [×]	*384.*
[R/S]	

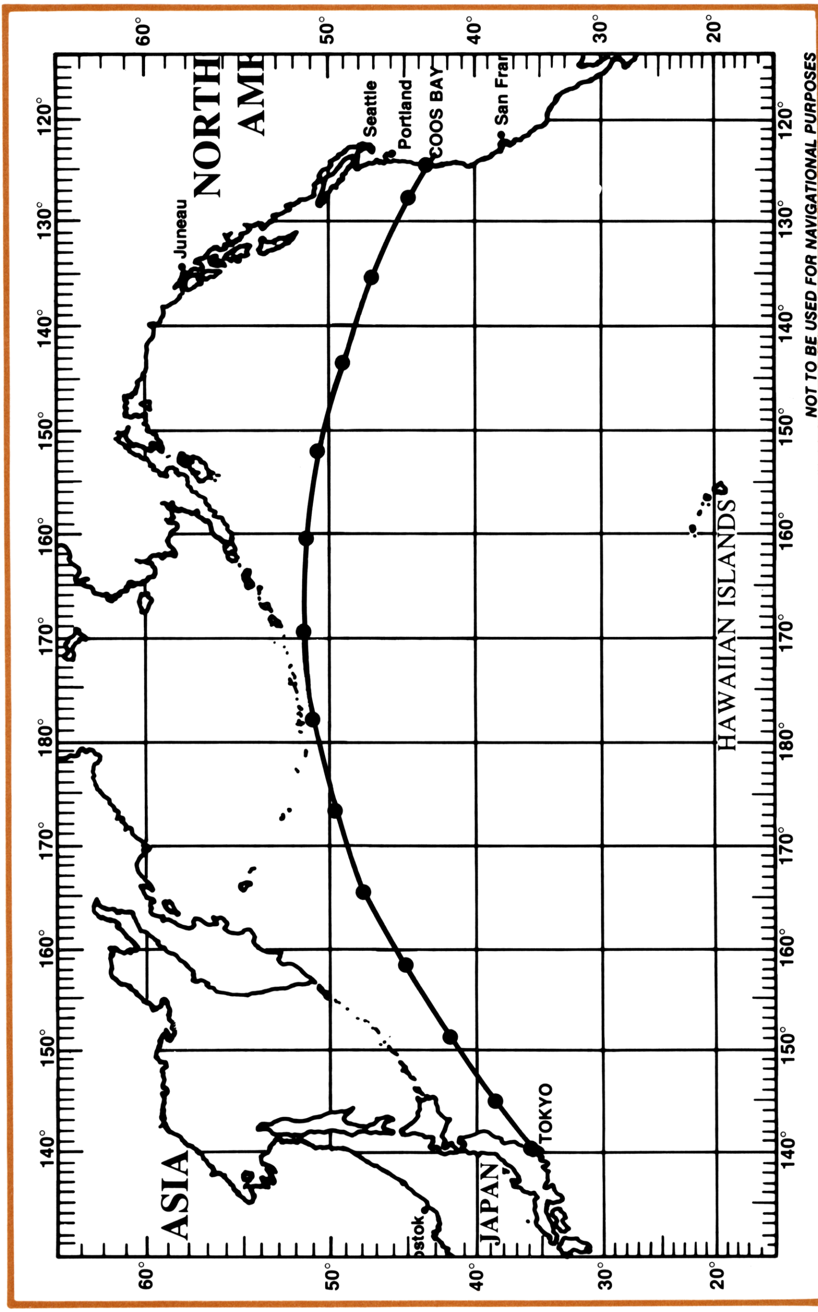
```
L1=33:13:45N
LO1=119:37:13W

C=258.3
D=384.08 NMI

L2=31:55:43N
LO2=127:03:31W

C=254.4
D=384.07 NMI

L3=30:12:31N
LO3=134:15:27W

C=250.9
D=384.06 NMI

L4=28:06:35N
LO4=141:10:58W

C=247.7
D=384.04 NMI

L5=25:40:39N
LO5=147:49:19W

C=244.8
D=384.03 NMI

L6=22:57:26N
LO6=154:10:50W

C=242.9
D=222.57 NMI

L7=21:16:00N
LO7=157:44:42W
```

Example 3:

A ship leaves Tokyo (35°40′N, 139°45′E) bound for Coos Bay, Oregon, (43°22′N, 124°13′W). Plot her position every 336 miles.

	Display
[XEQ] [ALPHA] GCPLAN [ALPHA]	*L1=0:00:00N?*
35.40 [R/S]	*LO1=0:00:00W?*
139.45 [CHS] [R/S]	*L2=0:00:00N?*
43.22 [R/S]	*LO2=0:00:00W?*
124.13 [R/S]	*D=0.0?*
336 [R/S]	

```
L1=35:40:00N
LO1=139:45:00E

C=51.8
D=336.05 NMI

L2=39:07:35N
LO2=145:17:44E

C=55.5
D=336.07 NMI

L3=42:17:51N
LO3=151:23:19E

C=59.8
D=336.09 NMI

L4=45:06:47N
LO4=158:05:21E

C=64.8
D=336.12 NMI

L5=47:29:54N
LO5=165:25:42E

C=70.4
D=336.15 NMI

L6=49:22:28N
LO6=173:23:12E

C=76.7
D=336.18 NMI

L7=50:39:55N
LO7=178:07:36W

C=83.4
D=336.20 NMI

L8=51:18:39N
LO8=169:17:03W

C=90.3
D=336.21 NMI

L9=51:16:42N
LO9=160:19:24W

C=97.3
D=336.20 NMI

L10=50:34:08N
LO10=151:30:19W

C=103.9
D=336.18 NMI

L11=49:13:08N
LO11=143:03:48W

C=110.1
D=336.15 NMI

L12=47:17:27N
LO12=135:09:41W

C=115.7
D=336.12 NMI

L13=44:51:39N
LO13=127:53:01W

C=119.6
D=181.63 NMI

L14=43:22:00N
LO14=124:13:00W
```


NORTH
AM
ASIA
JAPAN
HAWAIIAN ISLANDS
Juneau
Seattle
Portland
COOS BAY
San Fra
TOKYO
stok
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
120°
130°
140°
150°
160°
170°
180°
170°
160°
150°
140°
60°
50°
40°
30°
20°

DEAD RECKONING

This program calculates a point on a rhumb line at a specified distance and initial course and stores that point as your new position. Thus it can be used to determine a position from a vessel's sailing history, or to update a DR position using the data reduced from a celestial sight.

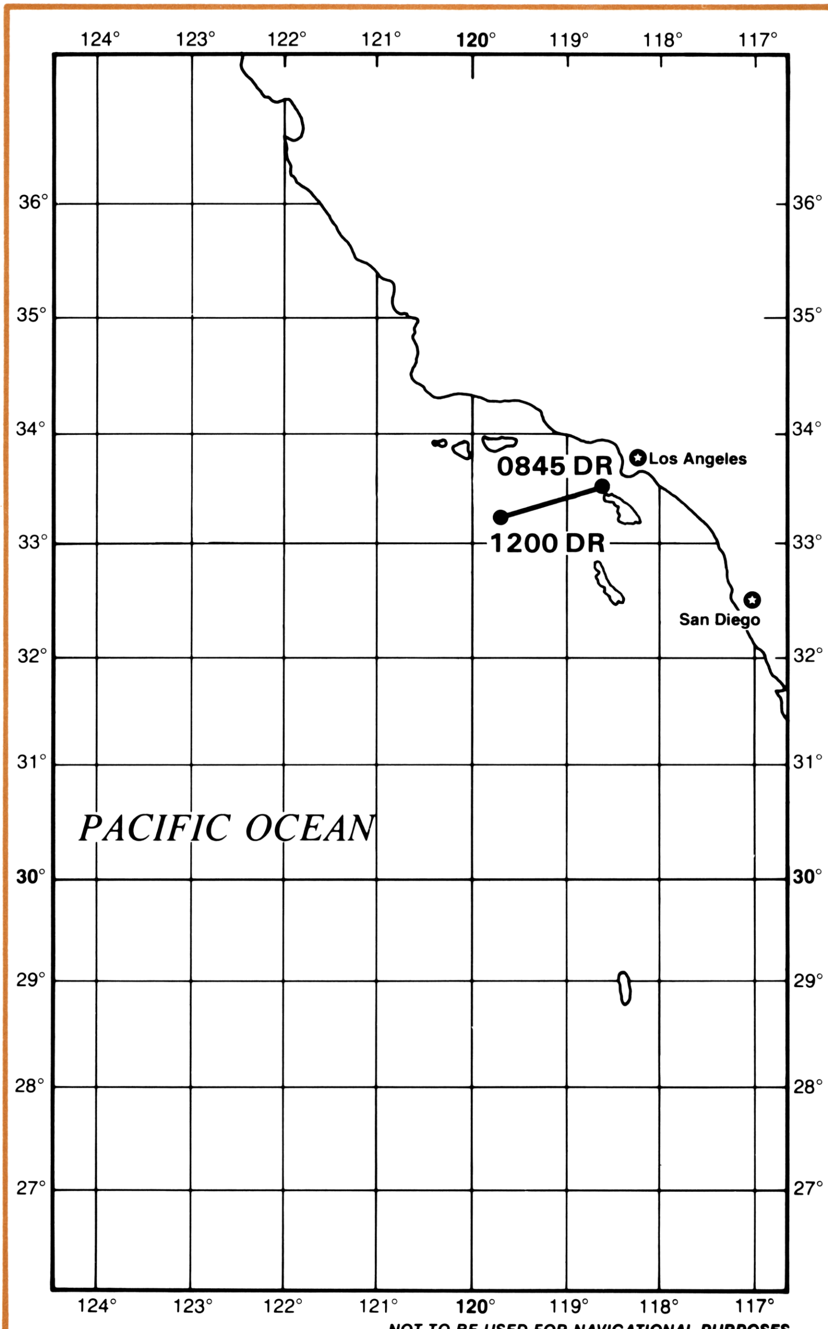
				SIZE: 012
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Initialize program.		[XEQ] DR	L1=0:00:00N?
2	Key in source latitude.	L1,d.ms	[R/S]	LO1=0:00:00W?
3	Key in source longitude.	LO1,d.ms	[R/S]	D=?
4	Key in distance.	D, n.mi.	[R/S]	HI=?
5	Key in course and compute new position.	C, d.d	[R/S] [R/S]*	DRL= DRLO=
	*Press [R/S] if you are not using a printer.			

To use this program as a subroutine, store L1 and Lo1 in decimal form in registers 7 and 8 and store distance and course in registers 1 and 6. Then execute the function *DR. The values DRL and DRLo will be stored in decimal form in registers 9 and 10 and also in registers 7 and 8.

Example:

We depart from (33°31′07″N, 118°38′32″W) at 0845 in the direction 250.0. What is our position at noon if we are able to make good a speed of 16 knots?

Keystroke	**Display**	**Comments**
[XEQ] [ALPHA] DR [ALPHA]	*L1=0:00:00N?*	Displayed
33.3107 [R/S]	*LO1=0:00:00W?*	values assume
118.3832 [R/S]	*D=0.0000?*	cleared regis-
3.15 [XEQ] [ALPHA] HR [ALPHA]	*3.2500*	ters. Actual dis-
16 [×] [R/S]	*C=0.0000?*	plays will show
250.5 [R/S]	*DRL=33:13:45N*	previous values
[R/S]	*DRLO=119:37:13W*	of the variable.


124°
123°
122°
121°
120°
119°
118°
117°
36°
35°
34°
33°
32°
31°
30°
29°
28°
27°
Los Angeles
0845 DR
1200 DR
San Diego
PACIFIC OCEAN
NOT TO BE USED FOR NAVIGATIONAL PURPOSES

SIGHT REDUCTION

This program calculates an altitude intercept for any of the objects listed in *The Nautical Almanac:* 58 stars, including Polaris, the Sun, Venus, Mars, Jupiter, Saturn, and the Moon. The inputs required are date, time, height of eye, sextant height (angle), and which body sighted. The suffixes U and L are used with SUN and MOON to indicate upper or lower limb.

Mean refraction and dip corrections are applied to the sextant height for all bodies. For the Sun and Moon, semidiameter corrections are made for upper- or lower-limb sights. For the Moon, horizontal parallax is computed and included in the corrections.

SIZE: 054

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Initialize program.		[XEQ] SIGHT	DRL=0:00:00?
2	Key in DR latitude.	DRL, d.ms	[R/S]	DRLO=0:00:00?
3	Key in DR longitude.	DRLo, d.ms	[R/S]	DATE= 0.000000?
4	Key in date.	mm.ddyyyy	[R/S]	TIME=0:00:00?
5	Key in Greenwich Mean Time.	GMT, h.ms	[R/S]	HE=0.0?
6	Key in height of eye in ft. or −HE in m.	HE, ft. HE, m	[R/S] [CHS] [R/S]	 HS=?
7	Key in sextant height.	HS, d.ms	[R/S]	WHICH BODY?
8	Select which body. a) Key in name. or b) Take HP-41C out of alpha and key in star number.	 NAME* star #	 [R/S] [ALPHA] [R/S]	
9	HP-41C will display intercept and azimuth. * Note (NAME) is any member of the list of objects shown in the appendix.		 [R/S]	Name a=0.0 A or T ZN=0.0

Example:

At 19:45:20 GMT on May 12, 1980, a navigator shoots the lower limb of the noon Sun. His height of eye is 10 feet and the sextant reading is 73°50′. His DR is (33°13′45″N, 119°67′13″W). What is the intercept resulting from this sight.

If the dead reckoning example has just been run, the DR position will be correctly stored. If other values are stored, key in the proper ones when prompted.

	Display
[XEQ] [ALPHA] SIGHT [ALPHA]	*DRL=33:13:45N?*
[R/S]	*DRLO=119:37:13W?*
[R/S]	*DATE=0.000000?*
5.121980 [R/S]	*TIME=0.0000?*
19.4520 [R/S]	*HE=0. FT?*
10 [R/S]	*HS=?*
74.40 [R/S]	*WHICH BODY?*
SUNL [R/S]	*SUN a=4.1 A*
[R/S]	*ZN=171.4*

PERPETUAL ALMANAC

This program is based on equations developed at the United States Naval Observatory†. It calculates the Greenwich hour angle and declination for the celestial bodies most commonly used by navigators: 57 navigational stars, Polaris, the Sun, Venus, Mars, Jupiter, Saturn, and the Moon.

Star positions are corrected for the effects of precession, nutation, aberration, and proper motion.

For the stars and the Sun, accuracy is much better than one minute of arc. For the inner planets, Venus and Mars, it is better than two minutes of arc, and for the outer plants, Jupiter and Saturn, it is approximately three minutes of arc. The Moon, always more difficult to predict, may be in error by as much as five minutes of arc.

The inputs required are date, time, and the name of the body observed. If the index number of a particular star is known, it can be used instead of spelling out the name. The stars Al Na'ir and Zubenelgenubi are spelled using commas instead of apostrophes: "AL NA,IR" and "ZUBEN, UBI".

				SIZE: 054
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Initialize program.		[XEQ] BODY	DATE= 0.000000?
2	Set or clear flag 21 as desired.			
3	Key in date.	mm.ddyyyy	[R/S]	TIME=0.0000?
4	Key in GMT.	GMT, h.ms	[R/S]	WHICH BODY?
5	Select which body. a) Key in name. or b) Take HP-41C out of alpha and key in star number.	 NAME * star #	 [R/S] [ALPHA] [R/S]	
6	HP-41C will display GHA and and declination.		 [R/S]	NAME GHA= DEC=
	*Note NAME is any member of the list of objects shown in the appendix.			

†Van Flandern and Pulkkinen. "Low-Precision Formulae for Planetary Positions", *Astrophysical Journal Supplement Series*, 41:391-411, November, 1979.

Example:

On March 8, 1980, Regulus, Mars, and Jupiter formed a small triangle. What were the coordinates of these bodies at 0600 GMT?

Keystroke	Display	Comments
■ [SF] 21		If a printer is attached, flag 21 may be ignored.
[XEQ] [ALPHA] BODY [ALPHA]	*DATE=0.00000?*	
3.081980 [R/S]	*TIME=0.0000?*	
6.0000 [R/S]	*WHICH BODY?*	
REGULUS [R/S]	*REGULUS GHA=*	
	104:16:33	
[R/S]	*DEC=12:03:51N*	
[XEQ] [ALPHA] BODY [ALPHA]	*DATE=3.081980?*	
[R/S]	*TIME=6.0000?*	
[R/S]	*WHICH BODY?*	
MARS [R/S]	*MARS GHA=*	
	101:19:49	
[R/S]	*DEC=14:55:26N*	
[XEQ] [ALPHA] BODY [ALPHA]	*DATE=3.081980?*	
[R/S]	*TIME=6.0000?*	
[R/S]	*WHICH BODY?*	
JUPITER [R/S]	*JUPITER GHA=*	
	100:00:11	
[R/S]	*DEC=11:23:25N*	

ALMANAC INTERPOLATER

This program provides the SIGHT program with a method of obtaining positions of celestial bodies using *The Nautical Almanac*. It is ordinarily run by first executing SIGHT. You will be prompted for date, time, height of eye, and sextant height as with any other sight. When the prompt WHICH BODY? appears, key in NA (Nautical Almanac). The program determines what kind of sight (star, planet, Sun, or Moon) you desire by inspecting your answer to the question SD OR HP? A semidiameter of zero is used for stars; one near zero (say .01), for planets; and one of about 16′ for the Sun. If a value near 60′ is used, the program interprets it as the Moon's horizontal parallax. For upper limb sights, SD or HP must be entered as a negative quantity (i.e. press [CHS]).

				SIZE: 054
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Initialize program.		[XEQ] SIGHT	DRL=0:00:00N?
2	Key in latitude of DR.	L, d.ms	[R/S]	DRLO= 0:00:00W?
3	Key in longitude of DR.	Lo, d.ms	[R/S]	DATE= 0.000000?
4	Key in the date.	mm.ddyyyy	[R/S]	TIME=0.0000?
5	Key in GMT.	GMT, h.ms	[R/S]	HE=0. FT.?
6	Key in HE in ft. or −HE in m.	HE, ft. HE, m	[R/S] [CHS] [R/S]	 HS=?
7	Key in sextant height.	HS, d.ms	[R/S]	WHICH BODY?
8	Now select the almanac.	NA	[R/S]	SD OR HP?
For star sights:				
9	Use 0 for SD.	0	[R/S]	GHAY<hh>= 0:00:00?
10	Key in GHA Aries at previous whole hour.	GHAY, d.ms	[R/S]	GHAY<hh>= 0:00:00?
11	Key in GHA Aries at next whole hour.	GHAY, d.ms	[R/S]	SHA=0:00:00?
12	Key in SHA.	SHA, d.ms	[R/S]	DEC=0:00:00N?
13	Key in DEC and compute	DEC, d.ms	[R/S]	STAR a=<a> A or T
14	Compute azimuth.		[R/S]*	ZN=

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
For Sun Sights:				
9	Use Sun's semidiameter. ([CHS] for upper limb)	SD, m.m	[R/S]	GHA<h>= 0:00:00?
10	Key in GHA at previous whole hour.	GHA(h)	[R/S]	GHA<h+1>= 0:00:00?
11	Key in GHA at next hour.	GHA(h+1)	[R/S]	DEC<h>= 0:00:00N?
12	Key in DEC at previous whole	DEC(h)	[R/S]	DEC<h+1)= 0:00:00N?
13	Key in DEC at next hour and compute intercept.	DEC(h+1)	[R/S]	SUN a=<a> A or T
14	Compute azimuth		[R/S]*	ZN=
For Moon Sights:				
9	Use Moon's horizontal parallax. ([CHS] for upper limb)	HP, m.m	[R/S]	GHA<h> = 0:00:00?
10	Continue with step 10 under Sun Sights.			
	* Press [R/S] if you are not using a printer.			

To use this program as a subroutine, store the date, time, and semidiameter and then press [XEQ] NA. The GHA and declination will be stored in registers 45 and 46.

Note that you can also use this program with BODY to compute and display a body's GHA and DEC.

Example:

Use the extract from *The Nautical Almanac* shown here to reduce a Venus sight from June 19, 1975 at 1625 GMT. The navigator's height of eye was 4 m and the sextant height was 66°55.3′. His DR was (38°N, 32°W).

Keystroke	Display	Comment
■ [SF] 00		Select D.MT mode.
[XEQ] [ALPHA] SIGHT [ALPHA]	*DRL=0:00.0N?*	
38 [R/S]	*DRLO=0:00.0W?*	
32 [R/S]	*DATE=0.000000?*	
6.191975 [R/S]	*TIME=0.0000?*	
16.25 [R/S]	*HE=0. FT?*	
4 [CHS] [R/S]	*HS=?*	
66.553 [R/S]	*WHICH BODY?*	
NA [R/S]	*SD OR HP?*	
.01 [R/S]	*GHA<16>=0:00.0?*	
11.066 [R/S]	*GHA<17>=0:00.0?*	
26.067 [R/S]	*DEC<16>= 0:00.0N?*	
18.402 [R/S]	*DEC<17>= 0:00.0N?*	
18.394 [R/S]	*PLANET a=1.4 A*	
[R/S]	*ZN=142.5*	

1975 JUNE 18, 19, 20 (WED., THURS., FRI.)

G.M.T.	ARIES	VENUS −3.9		MARS +0.8		JUPITER −1.9		SATURN +0.4		STARS		
	G.H.A.	G.H.A.	Dec.	G.H.A.	Dec.	G.H.A.	Dec.	G.H.A.	Dec.	Name	S.H.A.	Dec.
d h	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		° ′	° ′
18 00	265 36.8	131 03.1	N19 12.9	246 02.2	N 6 27.7	246 57.2	N 6 34.5	155 04.6	N22 01.2	Acamar	315 40.3	S40 24.0
01	280 39.3	146 03.1	12.1	261 02.9	28.4	261 59.3	34.6	170 06.7	01.1	Achernar	335 48.2	S57 21.4
02	295 41.8	161 03.2	11.3	276 03.7	29.1	277 01.4	34.7	185 08.9	01.1	Acrux	173 41.1	S62 58.2
03	310 44.2	176 03.3	·· 10.5	291 04.5	·· 29.8	292 03.4	·· 34.9	200 11.0	·· 01.1	Adhara	255 35.3	S28 56.4
04	325 46.7	191 03.3	09.7	306 05.2	30.5	307 05.5	35.0	215 13.1	01.0	Aldebaran	291 22.4	N16 27.6
05	340 49.2	206 03.4	08.9	321 06.0	31.2	322 07.6	35.2	230 15.3	01.0			
06	355 51.6	221 03.5	N19 08.1	336 06.8	N 6 31.8	337 09.7	N 6 35.3	245 17.4	N22 00.9	Alioth	166 45.5	N56 05.8
W 07	10 54.1	236 03.5	07.2	351 07.5	32.5	352 11.8	35.5	260 19.5	00.9	Alkaid	153 21.0	N49 26.3
E 08	25 56.6	251 03.6	06.4	6 08.3	33.2	7 13.9	35.6	275 21.7	00.9	Al Na'ir	28 19.2	S47 04.5
D 09	40 59.0	266 03.7	·· 05.6	21 09.1	·· 33.9	22 16.0	·· 35.7	290 23.8	·· 00.8	Alnilam	276 15.6	S 1 13.1
N 10	56 01.5	281 03.8	04.8	36 09.8	34.6	37 18.1	35.9	305 25.9	00.8	Alphard	218 24.3	S 8 33.3
E 11	71 03.9	296 03.8	04.0	51 10.6	35.3	52 20.2	36.0	320 28.1	00.7			
S 12	86 06.4	311 03.9	N19 03.2	66 11.4	N 6 35.9	67 22.3	N 6 36.2	335 30.2	N22 00.7	Alphecca	126 34.8	N26 47.9
D 13	101 08.9	326 04.0	02.4	81 12.1	36.6	82 24.4	36.3	350 32.4	00.7	Alpheratz	358 13.0	N28 57.2
A 14	116 11.3	341 04.1	01.6	96 12.9	37.3	97 26.5	36.4	5 34.5	00.6	Altair	62 35.7	N 8 48.2
Y 15	131 13.8	356 04.1	19 00.8	111 13.7	·· 38.0	112 28.6	·· 36.6	20 36.6	·· 00.6	Ankaa	353 43.8	S42 26.0
16	146 16.3	11 04.2	18 59.9	126 14.4	38.7	127 30.6	36.7	35 38.8	00.5	Antares	113 00.9	S26 22.7
17	161 18.7	26 04.3	59.1	141 15.2	39.3	142 32.7	36.9	50 40.9	00.5			
18	176 21.2	41 04.4	N18 58.3	156 16.0	N 6 40.0	157 34.8	N 6 37.0	65 43.0	N22 00.5	Arcturus	146 21.5	N19 18.6
19	191 23.7	56 04.5	57.5	171 16.7	40.7	172 36.9	37.1	80 45.2	00.4	Atria	108 27.8	S68 59.1
20	206 26.1	71 04.6	56.7	186 17.5	41.4	187 39.0	37.3	95 47.3	00.4	Avior	234 30.2	S59 26.1
21	221 28.6	86 04.7	·· 55.9	201 18.3	·· 42.1	202 41.1	·· 37.4	110 49.4	·· 00.3	Bellatrix	279 02.9	N 6 19.6
22	236 31.1	101 04.8	55.0	216 19.0	42.8	217 43.2	37.6	125 51.6	00.3	Betelgeuse	271 32.5	N 7 24.1
23	251 33.5	116 04.8	54.2	231 19.8	43.4	232 45.3	37.7	140 53.7	00.3			
19 00	266 36.0	131 04.9	N18 53.4	246 20.6	N 6 44.1	247 47.4	N 6 37.8	155 55.8	N22 00.2	Canopus	264 09.3	S52 41.0
01	281 38.4	146 05.0	52.6	261 21.3	44.8	262 49.5	38.0	170 58.0	00.2	Capella	281 17.0	N45 58.4
02	296 40.9	161 05.1	51.8	276 22.1	45.5	277 51.6	38.1	186 00.1	00.1	Deneb	49 50.5	N45 11.5
03	311 43.4	176 05.2	·· 50.9	291 22.9	·· 46.2	292 53.7	·· 38.3	201 02.2	·· 00.1	Denebola	183 02.7	N14 42.5
04	326 45.8	191 05.3	50.1	306 23.6	46.8	307 55.8	38.4	216 04.4	00.1	Diphda	349 24.5	S18 07.1
05	341 48.3	206 05.4	49.3	321 24.4	47.5	322 57.9	38.5	231 06.5	00.0			
06	356 50.8	221 05.5	N18 48.5	336 25.2	N 6 48.2	338 00.0	N 6 38.7	246 08.6	N22 00.0	Dubhe	194 26.6	N61 53.2
07	11 53.2	236 05.6	47.7	351 25.9	48.9	353 02.1	38.8	261 10.8	21 59.9	Elnath	278 49.0	N28 35.2
T 08	26 55.7	251 05.7	46.8	6 26.7	49.5	8 04.2	39.0	276 12.9	59.9	Eltanin	90 58.8	N51 29.6
H 09	41 58.2	266 05.8	·· 46.0	21 27.5	·· 50.2	23 06.3	·· 39.1	291 15.0	·· 59.9	Enif	34 14.9	N 9 45.8
U 10	57 00.6	281 05.9	45.2	36 28.2	50.9	38 08.4	39.2	306 17.2	59.8	Fomalhaut	15 55.2	S29 44.9
R 11	72 03.1	296 06.0	44.4	51 29.0	51.6	53 10.5	39.4	321 19.3	59.8			
S 12	87 05.5	311 06.1	N18 43.5	66 29.8	N 6 52.3	68 12.6	N 6 39.5	336 21.4	N21 59.7	Gacrux	172 32.6	S56 58.9
D 13	102 08.0	326 06.3	42.7	81 30.5	52.9	83 14.7	39.7	351 23.6	59.7	Gienah	176 21.6	S17 24.5
A 14	117 10.5	341 06.4	41.9	96 31.3	53.6	98 16.7	39.8	6 25.7	59.7	Hadar	149 28.0	S60 15.6
Y 15	132 12.9	356 06.5	·· 41.1	111 32.1	·· 54.3	113 18.8	·· 39.9	21 27.8	·· 59.6	Hamal	328 33.1	N23 20.7
16	147 15.4	11 06.6	40.2	126 32.8	55.0	128 20.9	40.1	36 30.0	59.6	Kaus Aust.	84 21.2	S34 23.7
17	162 17.9	26 06.7	39.4	141 33.6	55.7	143 23.0	40.2	51 32.1	59.5			
18	177 20.3	41 06.8	N18 38.6	156 34.4	N 6 56.3	158 25.1	N 6 40.4	66 34.2	N21 59.5	Kochab	137 18.0	N74 15.6
19	192 22.8	56 06.9	37.8	171 35.1	57.0	173 27.2	40.5	81 36.4	59.5	Markab	14 06.6	N15 04.4
20	207 25.3	71 07.1	36.9	186 35.9	57.7	188 29.3	40.6	96 38.5	59.4	Menkar	314 45.1	N 3 59.6
21	222 27.7	86 07.2	·· 36.1	201 36.7	·· 58.4	203 31.4	·· 40.8	111 40.6	·· 59.4	Menkent	148 41.0	S36 15.2
22	237 30.2	101 07.3	35.3	216 37.4	59.0	218 33.5	40.9	126 42.7	59.3	Miaplacidus	221 46.3	S69 37.3
23	252 32.7	116 07.4	34.4	231 38.2	6 59.7	233 35.6	41.0	141 44.9	59.3			
20 00	267 35.1	131 07.5	N18 33.6	246 39.0	N 7 00.4	248 37.7	N 6 41.2	156 47.0	N21 59.3	Mirfak	309 21.6	N49 46.3
01	282 37.6	146 07.7	32.8	261 39.7	01.1	263 39.8	41.3	171 49.1	59.2	Nunki	76 33.2	S26 19.6
02	297 40.0	161 07.8	31.9	276 40.5	01.7	278 41.9	41.5	186 51.3	59.2	Peacock	54 03.5	S56 48.6
03	312 42.5	176 07.9	·· 31.1	291 41.3	·· 02.4	293 44.0	·· 41.6	201 53.4	·· 59.1	Pollux	244 02.9	N28 05.2
04	327 45.0	191 08.0	30.3	306 42.0	03.1	308 46.1	41.7	216 55.5	59.1	Procyon	245 29.8	N 5 17.2
05	342 47.4	206 08.2	29.4	321 42.8	03.8	323 48.2	41.9	231 57.7	59.1			
06	357 49.9	221 08.3	N18 28.6	336 43.6	N 7 04.5	338 50.3	N 6 42.0	246 59.8	N21 59.0	Rasalhague	96 32.5	N12 34.7
07	12 52.4	236 08.4	27.8	351 44.3	05.1	353 52.4	42.1	262 01.9	59.0	Regulus	208 13.9	N12 05.2
08	27 54.8	251 08.6	26.9	6 45.1	05.8	8 54.5	42.3	277 04.1	58.9	Rigel	281 39.8	S 8 13.8
F 09	42 57.3	266 08.7	·· 26.1	21 45.9	·· 06.5	23 56.6	·· 42.4	292 06.2	·· 58.9	Rigil Kent.	140 30.2	S60 44.3
R 10	57 59.8	281 08.8	25.3	36 46.6	07.2	38 58.7	42.6	307 08.3	58.9	Sabik	102 44.9	S15 41.7
I 11	73 02.2	296 09.0	24.4	51 47.4	07.8	54 00.8	42.7	322 10.5	58.8			
D 12	88 04.7	311 09.1	N18 23.6	66 48.2	N 7 08.5	69 02.9	N 6 42.8	337 12.6	N21 58.8	Schedar	350 13.2	N56 24.0
A 13	103 07.2	326 09.2	22.8	81 48.9	09.2	84 05.0	43.0	352 14.7	58.7	Shaula	97 00.2	S37 05.2
Y 14	118 09.6	341 09.4	21.9	96 49.7	09.9	99 07.2	43.1	7 16.9	58.7	Sirius	258 59.2	S16 41.1
15	133 12.1	356 09.5	·· 21.1	111 50.5	·· 10.5	114 09.3	·· 43.2	22 19.0	·· 58.7	Spica	159 01.2	S11 02.1
16	148 14.5	11 09.7	20.2	126 51.2	11.2	129 11.4	43.4	37 21.1	58.6	Suhail	223 13.7	S43 20.3
17	163 17.0	26 09.8	19.4	141 52.0	11.9	144 13.5	43.5	52 23.3	58.6			
18	178 19.5	41 10.0	N18 18.6	156 52.8	N 7 12.6	159 15.6	N 6 43.6	67 25.4	N21 58.5	Vega	80 57.8	N38 45.7
19	193 21.9	56 10.1	17.7	171 53.5	13.2	174 17.7	43.8	82 27.5	58.5	Zuben'ubi	137 36.7	S15 56.5
20	208 24.4	71 10.3	16.9	186 54.3	13.9	189 19.8	43.9	97 29.6	58.5		S.H.A. ° ′	Mer. Pass. h m
21	223 26.9	86 10.4	·· 16.1	201 55.1	·· 14.6	204 21.9	·· 44.1	112 31.8	·· 58.4			
22	238 29.3	101 10.6	15.2	216 55.8	15.2	219 24.0	44.2	127 33.9	58.4	Venus	224 29.0	15 16
23	253 31.8	116 10.7	14.4	231 56.6	15.9	234 26.1	44.3	142 36.0	58.3	Mars	339 44.6	7 34
Mer. Pass.	h m 6 12.6	v 0.1	d 0.8	v 0.8	d 0.7	v 2.1	d 0.1	v 2.1	d 0.0	Jupiter	341 11.4	7 28
										Saturn	249 19.8	13 34

SUBROUTINES

This module contains many subroutines that are valuable to anyone concerned with navigational astronomy. Most programs documented elsewhere in this book can be used as subroutines with or without their associated prompts. In addition there are a number of subroutines which are not of interest to most navigators but might very well be useful to people writing their own programs.

The programs are listed here and documented more fully in the following pages.

	Subroutine Name	Meaning
	*SRT	Sight Reduction Table
	JD	Julian Date
Astronomy	D+T	Date & Time
	GST	Greenwich Sidereal Time
Routines	STAR	Star Almanac
	FA	Fundamental Arguments
	LBRYZX	Convert LBR to YZX
	ZYXdHA	Convert ZYX to dHA
	LOTOL	LOngitude TO Latitude
	DSPHAd	Display HA and dec
Input/	*IN1	INput 1 point
	*IN	INput points
Output	*DMT	Degrees, Minutes, and Tenths
	*DMS	Degrees, Minutes, and Seconds
Routines	*HR	HouRs
	*T	Time
	DSPP2	DiSPlay Point
	DSPL	DiSPlay Latitude
	DSPLO	DiSPlay LOngitude

SIGHT REDUCTION TABLE

This program evaluates the sight reduction table equation

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

$$H_c = \sin^{-1} (\sin d \sin L + \cos d \cos L \cos t)$$

where t = meridian angle (negative if east)
L = latitude (negative if south)
d = declination (negative if east)
Hc = computed altitude
Zn = azimuth from north

In addition to the altitude and azimuth problem, the sight reduction table can also be employed to solve star identification, great-circle heading and distance, and great-circle position problems. The trick is to call the program with altered inputs as shown.

Star identification
Use Zn instead of t
Use Ho instead of d
Get t instead of Zn
Get d instead of Ho

Great Circle Heading and Distance
Use DLo instead of t
Use L2 instead of Hc
Get Hi instead of Zn
Get (90–D/60) instead of Hc

Great Circle Position
Use Hi instead of t
Use (90–D/60) instead of d
Get DLo instead of Zn
Get L2 instead of Hc

SIZE: 054

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Initialize program.		[XEQ] SRT	T=?
2	Set or clear flag 21 as desired.			
3	Key in meridian angle.	t, deg	[R/S]	L=?
4	Key in latitude.	L, deg	[R/S]	d=?
5	Key in declination and compute altitude.	d, deg	[R/S]	Hc=
6	Display azimuth.		[R/S]	ZN=
	*Press [R/S] if you are not using a printer.			

To use this program as a subroutine, first set up the stack with t, L, and d in Z, Y, and X respectively. Then press [XEQ] *SRT and the computed altitude and azimuth wil be returned in X and Y.

Example 1:

What is the altitude of the Sun on the date of the Vernal Equinox observed from 45°N when its LHA is 30°?

Keystroke	Display
■ [FIX] 2	*0.00*
[XEQ] [ALPHA] SRT [ALPHA]	*T=?*
30 [R/S]	*L=?*
45 [R/S]	*D=?*
0 [R/S]	*Hc=37.76*
[X≷Y]	*ZN=219.23*

Example 2:

What is the distance from (0°N,150°W) to (45°N, 120°W)?

Keystroke	Display	
120 [ENTER↑] 150 [-]	*−30.00*	
0 [ENTER↑]	*0.00*	
45 [XEQ] [ALPHA] *SRT [ALPHA]	*37.76*	
90 [-] 60 [CHS] [*]	*3,134.33*	D in nautical
[X≷Y]	*26.57*	miles in degrees

Example 3:

A star is observed through the clouds in the approximate direction 115°. Our latitude is approximately 33.5°N, and the star's direction is 57°35′. Which star did we observe?

Keystroke	Display	
115 [ENTER↑]	*115.00*	
33.5 [ENTER↑]	*33.50*	
57.35 [XEQ] [ALPHA] HR [ALPHA]	*57.58*	
[XEQ] [ALPHA] * SRT [ALPHA]	*16.08*	This is the star's declination, so it must be Aldebaran.
[X≷Y]	*329.63*	This is the star's local hour angle.

CALENDAR FUNCTIONS

These routines consist of a date and time input routine, D+T, and a Julian date calculator, JD. The routine D+T prompts you for date and time and stores them in registers 30 and 34. The JD routine converts a date of the form mm.ddyyyy in the X-register and a time in register 34 to a Julian date which it leaves in the X-register. It also stores t, the number of Julian centuries from 1900.0, and T, the number of Julian days until 2000.0. The calendar routine works correctly from October 15, 1582, onwards.

				SIZE: 037
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
To input date and time.				
1	Initialize program.		[XEQ] D+T	DATE= 0.000000?
2	Key in date.	mm.ddyyyy	[R/S]	TIME=0.0000?
3	Key in GMT.	GMT, h.ms	[R/S]	GMT, hours
To compute Julian date.				
1	Be sure time is stored by running D+T or by storing it directly in R34.			
2	Key in date or recall it from R30.		[RCL] 30	Date
3	Compute Julian date. *Press [R/S] if you are not using a printer.	DATE	[XEQ] JD	JD

These programs use storage registers as follows:

29 Year	34 GMT
30 Date	35 T (Centuries from 1900.0)
31 Month	36 t (JD from 2000.0)
32 Day	

Example:

What is the Julian date corresponding to Greenwich mean noon on September 26, 1980?

Keystroke	**Display**
■ FIX 3	
0 [STO] 34	
9.261980 [XEQ] [ALPHA] JD	
[ALPHA]	*2,444,508.500*

GREENWICH SIDEREAL TIME

This program calculates Greenwich sidereal time from the Greenwich mean time stored in R34 and the value of T, the centuries from 1900.0, stored in R35. The value for GST is stored in the X-register.

				SIZE: 011
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Store date and time directly or by using D+T.			
2	Compute T using JD. (Date must be in X.)		[RCL] 30 [XEQ] JD	Date
3	Compute GST.		[XEQ] GST	GST

Example:

What is the Greenwich Sidereal Time at 1500 GMT on October 27, 1980?

Keystroke	Display
[XEQ] [ALPHA] D+T [ALPHA]	*DATE=0.000000?*
10.271980 [R/S]	*TIME=0.0000?*
15 [R/S] [RCL] 30	*10.2720*
[XEQ] [ALPHA] JD [ALPHA]	*2,444,540.125*
[XEQ] [ALPHA] GST [ALPHA]	*261.1238*

STAR ALMANAC

This program is a subroutine of the BODY program documented earlier, but it is interesting in its own right. The routine is used to determine a star's Greenwich hour angle and declination.

				SIZE: 011
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Initialize program.		[XEQ] STAR	DATE=0.000000?
2	Key in date.	mm.ddyyyy	[R/S]	TIME=0.0000?
3	Key in time.	GMT, h.ms	[R/S]	STAR NO.=?
4	Key in star number.	star no.	[R/S]	0.0000
5	The results are now stored as follows: NAME in ALPHA GST in R44 GHA☆ in R45 dec☆ in R46			

Example 1:

What is the declination of POLARIS on 1 JAN 1980? What will it be on 1 JAN 2080?

Keystroke	Display	
[XEQ] [ALPHA] STAR [ALPHA]	*DATE=0.000000?*	
1.011980 [R/S]	*TIME=0.0000?*	
[R/S]	*STAR NO.=?*	
0 [R/S]	*0.0000*	
[RCL] 46	*89.1721*	Declination 1 JAN 1980
[XEQ] [ALPHA] STAR [ALPHA]	*DATE=1.011980?*	
1.012080 [R/S]	*TIME=0.0000?*	
[R/S]	*STAR NO.=?*	
0 [R/S]	*0.0000*	
[RCL] 46	*89.6531*	Declination 1 JAN 2080

A useful feature of this routine is that it can be called without prompts with the name *STAR. The routine expects the fundamental arguments subroutine, FA, to have been run already. You can skip some of the computation by setting flag 6 if all you want are approximate answers.

An example will clarify the reasons for some of these features.

Example 2:

Construct a routine which searches the star list for stars having nearly the same declination as you specify.

There are many ways to do this job, some nicer than others, but the following routine is a reasonable place to start.

```
01♦LBL "WHICH?"
02 STO 05
03 1.057
04 STO 47
05♦LBL 47
06 SF 06
07 XROM "*STAR"
08 X<>Y
09 FIX 0
10 RND
11 RCL 05
12 RND
13 X=Y?
14 GTO 00
15 ISG 47
16 GTO 47
17 STOP
18♦LBL 00
19 AVIEW
20 ISG 47
21 GTO 47
22 .END.
```

This little program is used by keying in the declination of the unknown star and then executing WHICH?. All stars having the specified declination will be listed.

Example:

A star's declination is determined to be 16°. Which star is it?

Keystroke	Display
16 [XEQ] WHICH?	*ALDEBARAN*

FUNDAMENTAL ARGUMENTS

This subroutine is basic to the entire long-term almanac. It computes mean longitude L, mean anomaly G, and latitude argument F for the navigational planets, the Sun and the Moon. All 33 arguments used by Van Flandern and Pulkkinen* are not calculated by this program, because the series for the various objects are truncated. The truncation is such that the maximum error due to missing terms should not exceed 1 minute of arc. The routine requires the time stored in R34 (decimal hours) and the date (mm.ddyyyy) in the X-register. Its outputs are located from R12 to R36 as shown.

R12	Lm	R25	G6
R13	Gm	R26	L2
R14	Fm	R27	L4
R15	D = Lm−Ls	R28	Ω m = Lm−Fm
R16	Ls	R29	ϵ
R17	Gs	R30	Date
R18	G2	R31	$-\delta\lambda$
R19	F2	R32	Day of month
R20	G4	R33	(not used)
R21	F4	R34	GMT
R22	L5	R35	T (Centuries from 1900.0)
R23	G5	R36	t(JD from 2000.0)
R24	L6		

*op. cit

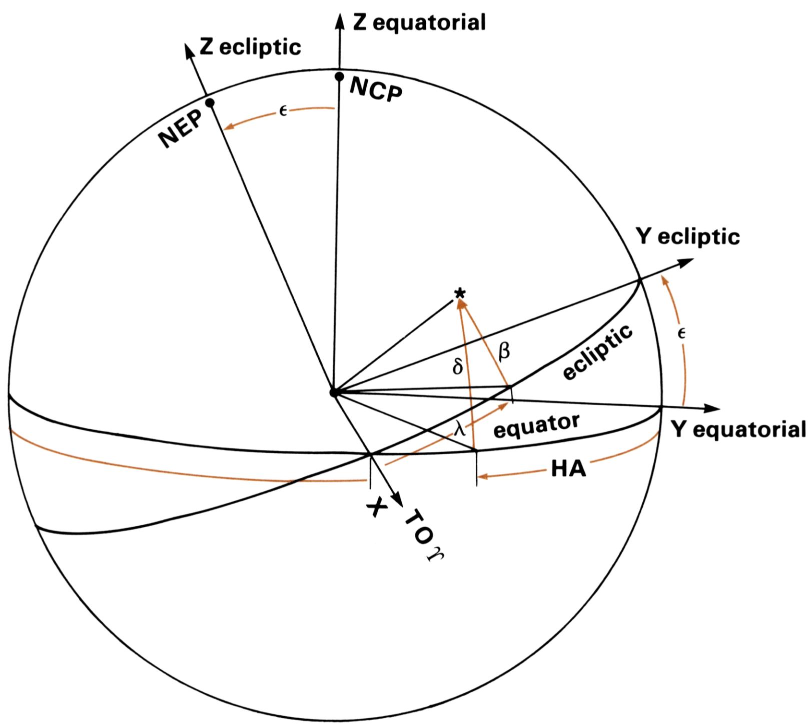
ASTRONOMICAL COORDINATE CONVERSION

These programs interconvert spherical and rectangular coordinates in equatorial and ecliptic coordinate systems. They are used as subroutines by the perpetual almanac program.

Ecliptic spherical coordinates are longitude, latitude, and radius vector. Equatorial rectangular coordinates are X, the direction of the Vernal equinox; Y, the direction of 90° longitude on the equator; and Z, the direction of the north celestial pole. Equatorial spherical coordinates are hour angle, declination, and radius vector (which is ignored, because it is not needed).

When converting from spherical coordinates to rectangular coordinates, the value in R29 is used for the obliquity of the ecliptic. An obliquity of zero results in conversion from equatorial coordinates rather than from ecliptic coordinates. The fundamental arguments routine, FA, can be used to calculate the obliquity of the ecliptic when it is needed.

The names of these two functions are intended to indicate the stack contents on entry and exit. Thus, LBRYZX expects Longitude, Beta, and Radius vector and produces Y, Z, and X. ZYXdHA converts Z, Y, and X to declination and Hour Angle.



				SIZE: 030
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
To convert equatorial spherical to equatorial rectangular coordinates				
1	Store zero for the obliquity.	0	[STO] 29	
2	Key in negative longitude.	−LO, d.ms	[ENTER↑]	
3	Key in latitude.	L, d.ms	[ENTER↑]	
4	Key in radius vector (usu. 1).	r	[XEQ] LBRYZX	X
5	Inspect other coordinates.		[RDN] [X≷Y]	Z Y
To convert ecliptic spherical to equatorial rectangular coordinates				
1	Store obliquity of ecliptic. (Use FA to compute obliquity if desired)	ϵ	[STO] 29	
2	Key in celestial longitude.	Lo	[ENTER↑]	
3	Key in celestial latitude.	β	[ENTER↑]	
4	Key in radius vector.	ρ	[XEQ] LBRYZX	X
5	Inspect other coordinates.		[RDN] [X≷Y]	Z Y
To convert equatorial rectangular to equatorial spherical coordinates				
1	Key in Z-coordinate.	Z	[ENTER↑]	
2	Key in Y-coordinate.	Y	[ENTER↑]	
3	Key in X-coordinate and compute hour angle.	X	[XEQ] ZYXdHA	HA
4	Inspect declination.		[X≷Y]	d

Example 1:

An ephemeris lists the coordinates of the Sun as X = 0.1487897, Y = −0.8917501, and Z = −0.3866720. What are its hour angle and declination?

Keystroke	Display	
■ [FIX] 8		
.3866720 [CHS] [ENTER↑]		
.8917501 [CHS] [ENTER↑]		
.1487897 [XEQ] [ALPHA] ZYXdHA		
[ALPHA]	440.527383	
360 [XEQ] [ALPHA] MOD [ALPHA]	80.527383	HA
[X≷Y]	−23.15628516	dec

Example 2:

The ephemeris also lists the coordinates of the Sun in terms of ecliptic longitude, 278°42′11.61″, ecliptic latitude, −0.58″, and radius vector, 0.9832965. For an obliquity of 23.441884°, compute the equatorial rectangular coordinates of the Sun.

Keystroke	Display	
■ [FIX] 8		
23.44184 [STO] 29	23.44188400	
278.421161 [XEQ] [ALPHA] HR		
[ALPHA]	278.7032250	
.000058 [CHS] [XEQ] [ALPHA] HR		
[ALPHA]	−.00016111	
.9832965 [XEQ] [ALPHA] LBRYZX		
[ALPHA]	0.14878894	X
[RDN]	−0.38667203	Z
[X<>Y]	−0.89175030	Y

LONGITUDE TO LATITUDE

This program calculates the latitude at which a specified longitude is reached on a great circle defined by two points.

				SIZE: 011
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Initialize program.		[XEQ] LOTOL	L1=0:00:00N?
2	Key in source latitude	L1, d.ms	[R/S]	L01=0:00:00W?
3	Key in source longitude	L01, d.ms	[R/S]	L2=0:00:00N?
4	Key in destination latitude	L2, d.ms	[R/S]	L02=0:00:00W?
5	Key in destination longitude	Lo2, d.ms	[R/S]	LOI=?
6	Key in intermediate longitude	Loi, d.ms	[R/S]	LI=

To use this program as a subroutine, store L1, Lo1, L2, and Lo2 in decimal form in registers 7, 8, 14, and 15. Store the intermediate longitude in register 10, and execute *LOTOL. The corresponding intermediate latitude will be in the X-register.

Example:

At what latitude does the great circle from (33°31′07″N, 118°38′32″W) to (21°16′N, 157°44′42″W) cross longitude 135°W?

Keystroke	Display
[XEQ] [ALPHA] LOTOL [ALPHA]	*L1=0:00:00?*
33.3107 [R/S]	*LO1=0:00:00?*
118.3832 [R/S]	*L2=0:00:00?*
21.16 [R/S]	*LO2=0:00:00?*
157.4442 [R/S]	*LOI=?*
135 [R/S]	*LI=30:06:22N*

INPUT/OUTPUT ROUTINES

The Navigation ROM contains several subroutines which are useful to people writing their own programs. The essential details of these routines are outlined here. Angles are stored in decimal form, and are input and displayed in degrees, minutes and seconds or degrees minutes and tenths of minutes depending on the status of flag 00.

Subroutine	Label	Initial Registers	Initial Stack	Final Registers	Final Stack	Alpha	Remarks
Date and Time	D+T			30 Date 34 Time			
Julian Day	JD		X Date	29 Year 30 Date 31 Month 32 Day 34 GMT 35 T 36 t	X JD		Centuries from 1900.0 JD from 2000.0
Display Hour Angle and declination	DSPHAd	44 GST 45 GHA 46 DEC				GHA= DEC=	

Subroutine	Label	Initial Registers	Initial Stack	Final Registers	Final Stack	Alpha	Remarks
Input P1	*IN1			7 L1 8 Lo1			Prompts for L1 and Lo1
Input P1 and P2	*IN			7 L1 8 Lo1 9 L2 10 Lo2			Calls *IN1 and then prompts for L2 and Lo2
Degrees minutes and tenths	*DMT		X d.d		X D.MT	D:M.t	Converts and adds angle to display
Degrees minutes and seconds	*DMS		X d.d		X DMS	D:M:S	If flag 0 is set then *DMT is done instead
Hours	*HR		X d.ms or d.mt		X D.d		Depends on flag 00

Subroutine	Label	Initial Registers	Initial Stack	Final Registers	Final Stack	Alpha	Remarks
Time	*T		X h.h		Z H Y M X S	TIME= H:M:S	
Display Point	DSPP2	9 L 10 Lo 48 index		same		Li= LOi=	Displays GC point
Display Latitude	DSPL		X L			=<L> N or S	Flag 5 is set if L is south
Display Longitude	DSPLO		X Lo			=<Lo> W or E	Flag 5 is clear if Lo is east

Notes

Appendix A

ALMANAC OBJECTS

The objects listed below are in the perpetual almanac programmed in this ROM. There are 57 navigational stars, Polaris, the Sun, Venus, Mars, Jupiter, Saturn, and the Moon. The stars are listed both alphabetically and numerically for your convenience on the back of the fold-out star chart.

ALMANAC OBJECTS

Solar system objects

The Sun	The Moon	The Navigational Planets
SUN	MOON	VENUS
SUNL	MOONL	MARS
SUNU	MOONU	JUPITER
		SATURN

Stars

ACAMAR	ARCTURUS	GACRUX	RASALHAGUE
ACHERNAR	ATRIA	GIENAH	REGULUS
ACRUX	AVIOR	HADAR	RIGEL
ADHARA	BELLATRIX	HAMAL	RIGIL KENTAURUS
ALDEBARAN	BETELGEUSE	KAUS AUSTRALIS	SABIK
ALIOTH	CANOPUS	KOCHAB	SCHEDAR
ALKAID	CAPELLA	MARKAB	SHAULA
AL NA,IR	DENEB	MENKAR	SIRIUS
ALNILAM	DENEBOLA	MENKENT	SPICA
ALPHARD	DIPHDA	MIAPLACIDUS	SUHAIL
ALPHECCA	DUBHE	MIRFAK	VEGA
ALPHERATZ	ELNATH	NUNKI	ZUBEN,UBI
ALTAIR	ELTANIN	PEACOCK	
ANKAA	ENIF	POLLUX	
ANTARES	FOMALHAUT	PROCYON	

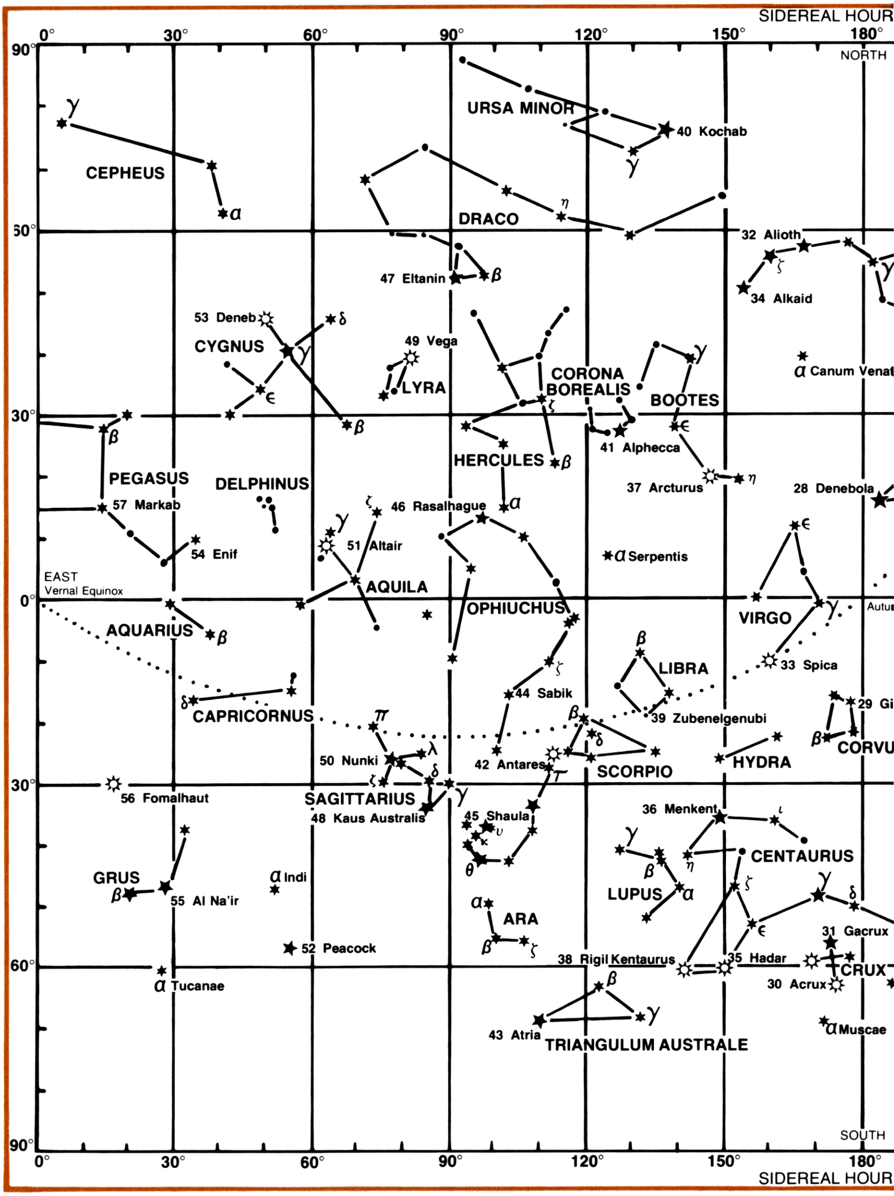
All Nautical Almanac Objects

NA (This mnemonic calls up the almanac interpolator program.)

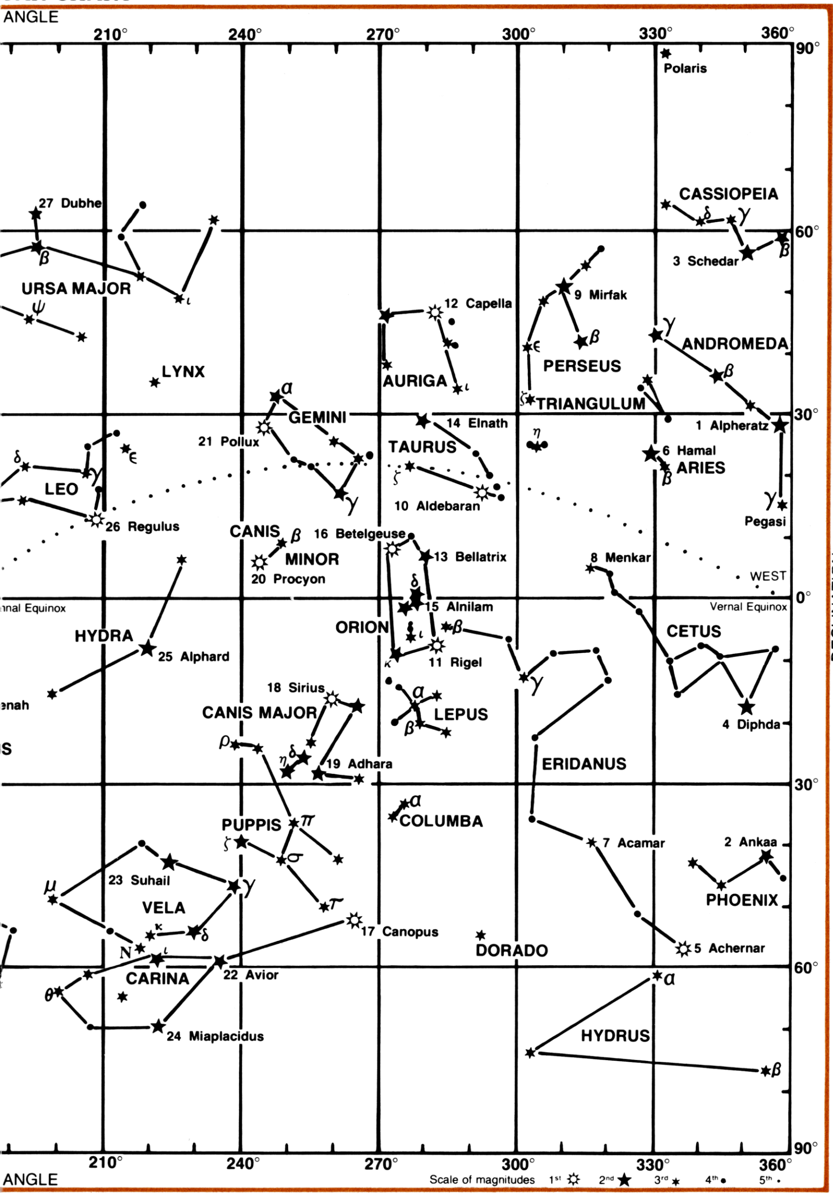
INDEX TO SELECTED STARS

Name	No.	No.	Name
Acamar	**7**	**1**	*Alpheratz*
Achernar	**5**	**2**	*Ankaa*
Acrux	**30**	**3**	*Schedar*
Adhara	**19**	**4**	*Diphda*
Aldebaran	**10**	**5**	*Achernar*
Alioth	**32**	**6**	*Hamal*
Alkaid	**34**	**7**	*Acamar*
Al Na'ir	**55**	**8**	*Menkar*
Alnilam	**15**	**9**	*Mirfak*
Alphard	**25**	**10**	*Aldebaran*
Alphecca	**41**	**11**	*Rigel*
Alpheratz	**1**	**12**	*Capella*
Altair	**51**	**13**	*Bellatrix*
Ankaa	**2**	**14**	*Elnath*
Antares	**42**	**15**	*Alnilam*
Arcturus	**37**	**16**	*Betelgeuse*
Atria	**43**	**17**	*Canopus*
Avior	**22**	**18**	*Sirius*
Bellatrix	**13**	**19**	*Adhara*
Betelgeuse	**16**	**20**	*Procyon*
Canopus	**17**	**21**	*Pollux*
Capella	**12**	**22**	*Avior*
Deneb	**53**	**23**	*Suhail*
Denebola	**28**	**24**	*Miaplacidus*
Diphda	**4**	**25**	*Alphard*
Dubhe	**27**	**26**	*Regulus*
Elnath	**14**	**27**	*Dubhe*
Eltanin	**47**	**28**	*Denebola*
Enif	**54**	**29**	*Gienah*
Fomalhaut	**56**	**30**	*Acrux*

NAVIGATIONAL S



TAR CHART


ANGLE
210° 240° 270° 300° 330° 360°
90°
Polaris
CASSIOPEIA
3 Schedar
27 Dubhe
URSA MAJOR
12 Capella
9 Mirfak
ANDROMEDA
LYNX
AURIGA
PERSEUS
TRIANGULUM
GEMINI
14 Elnath
1 Alpheratz
30°
21 Pollux
TAURUS
6 Hamal
ARIES
LEO
10 Aldebaran
26 Regulus
CANIS
16 Betelgeuse
Pegasi
MINOR
13 Bellatrix
8 Menkar
20 Procyon
WEST
Vernal Equinox
15 Alnilam
0°
HYDRA
ORION
CETUS
25 Alphard
11 Rigel
18 Sirius
CANIS MAJOR
LEPUS
4 Diphda
ERIDANUS
19 Adhara
30°
COLUMBA
PUPPIS
7 Acamar
2 Ankaa
23 Suhail
VELA
PHOENIX
17 Canopus
DORADO
5 Achernar
CARINA
22 Avior
60°
24 Miaplacidus
HYDRUS
90°
DECLINATION
ANGLE
Scale of magnitudes 1st 2nd 3rd 4th 5th

Gacrux	**31**	**31**	*Gacrux*
Gienah	**29**	**32**	*Alioth*
Hadar	**35**	**33**	*Spica*
Hamal	**6**	**34**	*Alkaid*
Kaus Australis	**48**	**35**	*Hadar*
Kochab	**40**	**36**	*Menkent*
Markab	**57**	**37**	*Arcturus*
Menkar	**8**	**38**	*Rigil Kentaurus*
Menkent	**36**	**39**	*Zubenelgenubi*
Miaplacidus	**24**	**40**	*Kochab*
Mirfak	**9**	**41**	*Alphecca*
Nunki	**50**	**42**	*Antares*
Peacock	**52**	**43**	*Atria*
Pollux	**21**	**44**	*Sabik*
Procyon	**20**	**45**	*Shaula*
Rasalhague	**46**	**46**	*Rasalhague*
Regulus	**26**	**47**	*Eltanin*
Rigel	**11**	**48**	*Kaus Australis*
Rigil Kentaurus	**38**	**49**	*Vega*
Sabik	**44**	**50**	*Nunki*
Schedar	**3**	**51**	*Altair*
Shaula	**45**	**52**	*Peacock*
Sirius	**18**	**53**	*Deneb*
Spica	**33**	**54**	*Enif*
Suhail	**23**	**55**	*Al Na'ir*
Vega	**49**	**56**	*Fomalhaut*
Zubenelgenubi	**39**	**57**	*Markab*

Appendix B

DATA STRUCTURE

00 Scratch	R18 G2	R36 t (JD from 2000.0)
01 D or S	R19 F2	R37 GHA ☉
02 ΔT	R20 G4	R38 $\lambda+\delta\lambda$, Xs
03 not used	R21 F4	R39 β, Ys
04 not used	R22 L5	R40 RP, Zs
05 $\Delta\lambda$	R23 G5	R41 λ, Xp
06 Hi or C	R24 L6	R42 β, Yp
07 Li	R25 G6	R43 R, Zp
08 Loi	R26 L2	R44 GST
09 Li+1	R27 L4	R45 SHA ☆, GHA planet
10 Loi+1	R28 Ωm=Lm−Fm	R46 declination
11 e	R29 Y, ϵ	R47 Star #
12 Lm L1	R30 Date	R48 Star Name, temp.
13 Gm Lo1 GCPLOT	R31 M, $-\delta\lambda$	R49 HE
14 Fm L2	R32 D, SD	R50 ☉
15 D=Lm−Ls Lo2	R33 δ ☉	R51 Ho=hs−Rm−Dip
16 Ls	R34 GMT	R52
17 Gs	R35 T (Centuries from 1900.0)	R53 HP, # rhumb lines

Flag	Meaning when set
00	Angles displayed as d.mt
05	*DMS is negative, HE is negative
06	Don't repeat FA
07	Moon
09	used by GCPLOT

HEWLETT PACKARD

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