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If you still have questions or want help please call or write me:

John Watkins
CELESTICOMP, INC
8903 SW BAYVIEW DRIVE
VASHON WA 98070
(206) 463 9626

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HOW TO USE YOUR CELESTICOMP V

CELESTICOMP V uses the "run only" Sharp PC1270 pocket computer. Its programs are in a ROM cartridge that fits in the back. The cartridge can be removed and replaced with other cartridges, either ROM or RAM. By installing another cartridge with another program you can easily convert to an entirely different purpose. With no cartridge installed it will not operate at all, not even as a simple calculator.

The ROM cartridge furnished by Celesticomp will not lose its programs even if the battery fails or the cartridge is removed. The Celesticomp cartridge has 32K ROM for the programs and 8K RAM to hold the data you input and the results of computations. The data in RAM will be lost on battery failure or if you remove the cartridge. That would be merely inconvenient since it is easy to re-enter the data and recompute. Batteries are reliable and durable and there is seldom a need to remove the cartridge so this may never happen to you.

The keys on the right side look just like those of a simple calculator, and can be used for simple computations when you are not running a program. A wheel on the right controls the display contrast.

Look at the left side of your CELESTICOMP V. The YES and NO keys are used to answer prompts that end in "?Y/N." If there is no "?Y/N" on the screen they have no effect. The ENTER key does two things: It steps the program forward when the program has stopped to display information, and it enters the numbers you key in response to a prompt that ends with a question mark. (Note that you do not key ENTER after the YES and NO keys. They enter themselves automatically.)

Further left you find a bank of eight keys in two lines of four. These are the Program Start keys. Above each is a very abbreviated clue to its program.

If you don't fully understand the above don't worry. Learn by doing is the motto here. Soon you'll learn by running a program. But first a few rules:

1. EAST IS LEAST. Because it rhymes it's easy to remember that you must always precede East Longitude, East Magnetic Variation, and East Compass Deviation with a minus sign.
2. South is down. South latitude must be preceded by the minus sign.
3. Answers are displayed in the same way. South latitude, east longitude, variation, and deviation are preceded by the minus sign.
4. Latitude and longitude are entered and displayed in degrees, minutes, and tenths of minutes. For example latitude south 23 degrees, 4 and 3/10ths minute is entered and displayed as -23.043. The same applies to sextant altitude. (It's always positive.)

5. Time is always entered in the 24 hour clock with minutes and seconds to the right of the decimal: 1:06:02 PM enters as 13.0602.
6. Erase mistakes with the C-CE key and correct them before you key ENTER.
7. Prompts have question marks and must be answered YES, NO, ENTER, or by entering a number.
9. Body numbers for the planets, moon, Aries, unknown star, starlist, and sun's upper limb are preceded by a minus sign.
10. Always enter a FIX TIME. (See page 4.)
11. If you enter a FIX TIME or SHOTTIME greater than 24 Celesticomp returns to the prompt until you enter a value less than 24.

Now try a simple program. What is the shortest distance and course between Tokyo at 35.323N/139.48E and San Francisco at 37.425N/ 123.006W? To find out you'll run the great circle course planning program. The left column called "KEY" tells which keys to press. The center column "SEE" shows what you will see on the screen. The right column, "COMMENT", is for explanation.

With power on:

KEY	SEE	COMMENT
PLAN	GR CIR?Y/N	*YES starts the great circle program.*
YES	DP LAT0.00?	

The prompt shows the current departure latitude To approve ENTER. To change key in the new value. As you do the old marches off stage.

35.323	LAT0.000?35.323	
ENTER	DP LON0.000?	

When you ENTERed the program accepted the new value and brought up the next prompt.

-139.48	0.000?-139.48	
ENTER	DS LAT0.000?	
37.425	0.000?37.425	
ENTER	DS LON0.000?	
123.006	LON0.0000?123.006	
ENTER	REVIEW DATA?Y/N	

YES takes you back to the first data input and runs you through the input routine again. But this time it shows the numbers you just keyed in.

YES	DP LAT?35.323	

If the values are OK key ENTER. To change you key in the correct number and ENTER that. Usually it's just a matter of ENTER ENTER ENTER ENTER until REVIEW DATA?Y/N comes up. If data is OK say NO to REVIEW DATA and the computation begins.

	REVIEW DATA?Y/N (NO starts computation.)	
NO	BUSY	

BUSY says wait. When computation is done BUSY is replaced by a result announcement.

	GR CIR D 4442.4	Always nautical miles.
ENTER	1ST TC 54.7	

Angles for direction are in degrees and tenths of a degree. A great circle course curves with respect to the chart meridians so the first great circle course is steered only at the departure point.

Now abandon the great circle program and do a rhumbline (Mercator) course and distance. On these you steer the same true course from start to finish. They are never shorter than great circle paths. In high latitudes they are much longer.

KEY	SEE	COMMENT
PLAN	GR C?Y/N	Just say NO.
NO	RHUMB LINE?Y/N	YES starts the program.
YES	DP LAT35.323?	Tokyo again? Yes.
ENTER	DP LON-139.480?	Ditto!
ENTER	DS LAT 37.425?	" for San Francisco.
ENTER	DS LON 123.006?	" "
ENTER	REVIEW DATA?Y/N	
NO	BUSY	
ENTER	RL DIS 4701.8	In nautical miles.
ENTER	RL TR CS 88.4	
ENTER	+/-VAR/DEV00.0?	Here variation is 9E, deviation 2W.
-9+2	+/-VAR/DEV00.0?-9+2	
ENTER	MAG CS 81.4	Course to steer.
ENTER	DP LAT 37.425?	

The last ENTER puts destination lat/lon in the departure spots so you can do another leg. No need to re-enter waypoint coordinates.

Only the start keys on the bottom deck have more than one program under them. However the LOP key branches 181 ways for named bodies, one for UNKNOWN STAR, for STARLIST, and for LHA of Aries.. That makes 200 programs in all.

You bought CELESTICOMP V to make it easy to turn celestial sights into a useful mark on your chart so get on with that. The procedure is to first compute LOPs (lines of position) for each sight. They are then converted to lat/lon values by the FIX program. To get a fix you need two or more LOPs that cross each other at a good angle--30 degrees or more if possible. The LOP program tells you the bearings of each sight and the LOPs will make the same angle with each other as the bearings. (There is a warning "USE GOOD CUTS!" in the FIX program to remind you of

this.) If you plot the LOPs their crossing angles will be obvious.

Unless the sight reductions are advanced or retired to a common time they will be slightly, even grossly, inaccurate depending on how far your craft moved between sights. To avoid this CELESTICOMP V asks you to name a fix time. Using this and your inputs of course and speed it then advances/retires the LOPs to be valid for that time. **(If you input 0 for speed--as when at anchor or on land-- the LOPs will not be adjusted.)** If you name a time later than the time of your last sight you will have a fix that shows where you will be instead of one that shows where were some time ago. As long as the time spread from sight time to fix time is less than 12 hours Celesticomp can cope. If your fix GMT date/time differs from the date/time of a sight (within 12 hours) the sight date will be adjusted.

The LOP program input section is divided into two parts: Part one is on the "Paperless Printer" and is easy to review. Part one inputs usually stay the same throughout the fix. You may want to change course, speed, eye height or IC. **BUT IF YOU CHANGE DAY, DATE, YEAR, A LAT, A LON OR FIX TIME YOU MUST REDO ALL SIGHTS FROM START AS A NEW FIX.**

Part two calls for SHOT TIME, SXT ALT, and BODY#. These often change with every sight. The prompt for SHOT TIME is the only data prompt in the LOP program that doesn't show the value from the last program run. (No room).

Here is a problem to work with the LOP program: You are cruising in the Pacific off the coast of Japan. Your DR position for 21.00 GMT, 1 Jan. 1982 is 29deg45.2min north latitude and 142deg18min east longitude. (A LAT 29.452, A LON -142.18) Speed is 8.5 knots on a course of 230 degrees true. Eye height is 7 feet, Index Correction is -2.5 minutes of arc. You shoot three stars with the following result:

STAR NAME/#	SHOT TIME	SEXTANT READING	
Kochab/#40	20.4616	43deg	25.0min
Antares/#42	20.4831	15 "	30.0 "
Regulus/#26	20.5026	45 "	29.0 "

Key LOP to start. Here are the prompts and replies:

PROMPT	REPLY	COMMENT
COMPUTE CEL LOPS	ENTER	Program title.
NEW FIX?Y/N	YES	Erases LOPs saved from last fix.
OLD FIX ERASED		(Statement flashes.)
REVIEW DATA?Y/N	YES	
DAY 0?	1 ENTER	Date of month.
MONTH 0?	1 ENTER	For January.
YEAR 0?	1982 ENTER	All four digits.
A LAT 0.000?	29.452 ENTER	Assumed lat.
A LON 0.000?	-142.18 ENTER	" lon.

Use DR LAT/LON at FIX time or a convenient point nearby. LOPs, if you plot them, are measured from this point.

EYE HT 0.0FT?	7 ENTER	Height in feet of eye above water.
I.C. 0.0MIN?	-2.5 ENTER	

Correction in minutes of arc for known sextant error.

SP 0.0?KTS	8.5 ENTER	Speed made good.
TR CS 0.0?	230 ENTER	True course.
FIX TIME 0.0000?	21.00 ENTER	All LOPs adjusted to this GMT.
REVIEW DATA?Y/N	YES	

YES sends you back through the inputs. If you find an error, correct it. If value is OK key ENTER. If you say NO to REVIEW DATA?Y/N you get:

SHOTTIME?	20.4616 ENTER	Input GMT exact time of sight.
SXT ALT0.000?	43.25 ENTER	

Input raw sextant reading. Celesticomp will correct for refraction, parallax, semi-diameter, and your input of I.C .

BODY# 0?	40 ENTER	From list inside computer's cover.
HC 43.234	ENTER	Information.
AWAY -4.5	ENTER	Record distance.
ZN 9.9	ENTER	Record.

True direction from AP to body.

ACCEPT LOP?Y/N	YES	

Yes will cause the LOP to be used to compute the fix. NO will cause it to be it to be omitted. Very useful. Very important.

NEXT LOP		Flashes.
REVIEW DATA?Y/N	NO	

Sends you to the SHOTTIME prompt. Say YES if you want to review all the inputs. (You may want to change EYE HT, IC, TR CS, or SP MG. **But remeber this: If you change DAY, MONTH, YEAR, FIX TIME, A LAT, or A LON you must re-do the fix from start.)**

SHOTTIME?	20.4831 ENTER	

SXT ALT43.250?	15.30 ENTER	
BODY# 40?	42 ENTER	
BUSY		
HC 15.183	ENTER	
TO 3.0	ENTER	Record.
ZN 133.4	ENTER	Record
ACCEPT LOP?Y/N	YES	

(If you say NO "LOP REJECTED" will flash.)

REVIEW DATA?Y/N	NO	
SHOTTIME?	20.5026 ENTER	
SXT ALT15.300?	45.29 ENTER	
BODY# 42?	26 ENTER	
BUSY		
HC 45.227	ENTER	
TO 0.2	ENTER	LOP runs right through DR pos!
ZN 256.2	ENTER	
ACCEPT LOP?Y/N	YES	

Once you have set up the basic data the following LOPs compute quickly. If the TO or AWAY value is more than a few miles it is probably bad. Reject it. Review data and recompute.

As soon as you have two or more LOPs that cross at good angles you can get your fix on the map by plotting them or you can use the FIX program to compute their intersection in latitude and longitude. (If there are more than two LOPs there will be several intersections and FIX will compute the graphic average of all the intersections.) If you don't know what an LOP is or how to plot it read the section on theory of the LOP. The LOPs are averaged by the "least squares fit" method. It's an excellent and accurate system as long as the fix-to-AP distance is less than 30 miles or so. If this distance is large it's best to recompute using the fix lat/lon as the new A LAT/A LON. This won't happen often if you do careful DR.

(NOTE: If you try to compute a fix from only one LOP you will get a worthless answer.)

You can use TO/AWAY and ZN to plot the LOPs on a chart and fix your position. You will see how this is done in the next problem so you will skip that for now and use the FIX program to compute the latitude and longitude of the fix. To start key FIX.

PROMPT	REPLY	COMMENT
LAT-LON FIX	ENTER	
LOPS COMP?Y/N	YES	

NO will send you to the LOP program. LOPs must be computed first.

USE GOOD CUTS!	ENTER	
CANCEL LOP?Y/N	NO	

YES lets you remove an LOP you wish you hadn't accepted. (CATCH 22: The program thinks zero is an LOP running east-west through your AP. So take care.) NO computes the fix.

FIX LAT 29.408	ENTER	Record.
FIX LON -142.186	ENTER	Record.
FIX TIME 21.00	ENTER	

Now Celesticomp computes the distance and direction from the AP/DR position to the FIX position. If this distance is more than 30 miles the fix computation may be slightly off. To refine it recompute the LOPs using the FIX LAT/LON as the A LAT/A LON. Then recompute the fix.

DR TO FIX 4NM	ENTER	(4 Nautical miles.)
173 DEG		

Some people call this "current", but it is just as likely to be caused by compass error, speed log error or sloppy DR. (The program goes on. See page 30.)

(NOTE: To CANCEL you answer prompts for the TO/AWAY--with proper sign--and ZN of the LOP you want to cancel. It's easier to reject them in the LOP program. Use CANCEL LOP only if you have accepted an LOP you wish you hadn't.) If you were quick you got your 21.00 fix on the chart before 21.00. You could have given yourself more time by getting a DR position for 21.30 and using its coordinates for AP and 21.30 for fix time.

UNKNOWN STAR. If you know how to compute an LOP from one body you know how to do them all. It's just a matter of putting in a different body number. Body #-8 starts the UNKNOWN STAR program after you have told all the usual things including shot time and sextant altitude. When you ENTER BODY#-8 the program will flash UNKNOWN STAR. Then it begins to search through its almanac of 173 stars for any star that would appear at about the height and time you shot. If a star comes within 2 degrees of your sextant alt. it stops, tells you the star number, and computes an LOP for that star. You accept or reject the LOP. If the first nomination looks doubtful you continue the search by keying the SRCH program start key. Another star will be nominated for you to accept or reject. It is not unusual to see a dozen stars nominated if you run the program all the way through. Usually you can accept with reasonable certainty by the third star, sometimes on the first. If you know the bearing of the unidentified star to within ten degrees it will be easy to

choose. The nominated star whose TO/AWAY is reasonably small and whose ZN agrees closely with your bearing is certain to be the one you shot. Keep track of the sextant alt and bearing. Tomorrow night the star will be there again, at nearly the same place and time. So can easily find it again.

To learn the **UNKNOWN STAR** program use the star sights from page 5. This time, however, you will assume that you didn't know the stars you shot--only that they were bright stars bearing at about 15, 140, and 260 degrees. (You used a hand bearing compass or sighted over the binnacle compass to determine the bearings.) Use exactly the same inputs as on page 5 until the prompt for **BODY#**. There you will reply: -8. You pick up the program here with the first shot time.

TIME	SXT ALT	APPROXIMATE TRUE BEARING
20.4616	43.25	15 deg
20.4831	15.30	140
20.5026	45.29	260

PROMPT	REPLY/COMMENT	
SHOTTIME O.0000?	20.4616 ENTER	
SXT ALT 00.000?	43.25 ENTER	
BODY# 000?	-8 ENTER	
UNKNOWN STAR		Flashes.
BUSY		
STAR # 29	ENTER	
HC 41.32	ENTER	
TO 106.8	ENTER	
ZN 194.5	ENTER	
ACCEPT LOP?Y/N	NO	Wrong direction.
SIGHT REJECTED!		Flashes.
NEXT LOP		Flashes.
REVIEW DATA?Y/N		

At this point you are back in the LOP program, but want to continue searching for the unknown star. The SRCH key will do that.

	SRCH	
SEARCH ON?Y/N	YES	
STAR # 40	ENTER	
HC 43.234	ENTER	
AWAY -4.5	ENTER	Record.
ZN 9.9	ENTER	Record.

This must be our star. The TO/AWAY is reasonable and the direction agrees well with the 15 you measured with the sighting compass. (It is hard to get an accurate bearing sight on something high in the sky.) You accept the LOP and go on to the *next sight.*

NEXT LOP		
REVIEW DATA?Y/N	NO	
SHOTTIME?	20.4831 ENTER	
SXT ALT 00.000	15.30 ENTER	
BODY# 40?	-8 ENTER	
UNKNOWN STAR		Flashes.
BUSY		
STAR # 42	ENTER	
HC 15.183	ENTER	
TO 3.0	ENTER	Record.
ZN 133.4	ENTER	Record.
ACCEPT LOP?Y/N	YES	

You were lucky. On the very first star TO/AWAY was reasonable and ZN and bearing were close. #42 (Antares) is certainly our star.

REVIEW DATA?Y/N	NO	
SHOTTIME?	20.5026 ENTER	
SXT ALT 15.30?	45.29 ENTER	
BODY# 42?	-8 ENTER	
BUSY		
STAR # 26	ENTER	
HC 45.227	ENTER	
TO 0.2	ENTER	Record.
ZN 256.2	ENTER	Record.

Lucky again! #26 with a small intercept and a ZN that agrees well with the azimuth is certainly our star. You accept it and compute the fix. But before you do let's have some fun. Continue the search over and over again until you have examined all of the 173 stars for a match. You'll get a lot of nominees, but probably none that can't be eliminated with the ZN-bearing test. You'll see that if you don't have an approximate bearing it's not so easy to be sure when you have the right star. The program examines about one star per second and stops when it finds a nominee.

Nominees are: #40 (Kochab, TO 110.6, ZN 9.6), #104 (AWAY -1.9, ZN 274.7. The AWAY is very reasonable the ZN not quite reasonable.), #132 (TO 79.6, ZN 14--not close.), #134 (AWAY -36.8, ZN 113.8), #140 (T0 41.4, ZN 30.7), #144 (TO 84.5, ZN 73.2). Seven stars were nominated. When all 173 stars have been examined you get the message: SEARCH ENDED.

Testing with both TO/AWAY and ZN it was easy to choose one. But tested only by TO/AWAY three were equally reasonable choices.

<u>SUNRISE/SET</u> gives you the best time to shoot morning or evening stars, and some

other useful information as well. How would you have planned for the star fix above? You run the SSET program using the date and DR position from the star LOP program above.

PROMPT	**REPLY/COMMENT**	
0	SSET	
SUNRISE/SET?Y/N	YES	
ALL TIMES GMT!		Flashes.
DAY 0?	1 ENTER	
MONTH 0?	1 ENTER	
YEAR0?	1982 ENTER	
LAT0?	29.45 ENTER	
LON0?	-142.18 ENTER	
REVIEW DATA?Y/N	NO	
LAN: 2.3420	ENTER	(GMT of local app. noon.)
SUNRISE: 21.2613	ENTER	(21:26:13 GMT)
SUNSET: 7.4227	ENTER	
AM TWI: 21.004	ENTER	
PM TWI: 8.0837	ENTER	
BEST STAR TIMES		Flashes.
AM STARS 20.45		

(GMT of mid-time of twilight. The star fix above was taken in morning twilight.)

	ENTER	
PM STARS 8.23	ENTER	
AM LHA ARIES 193	ENTER	(Use in a starfinder.)
PM LHA ARIES 8	ENTER	" " "
0		(Program end.)

<u>THE STARLIST</u> program helps you plan ahead for your star shots and makes it easy to find the stars you plan to shoot. You tell it the approximate DR position for the GMT that you plan to take your sights. (You can get the time by running the SUNRISE/SET program.) STARLIST will give you about a dozen stars to choose from and tell you how to find them.

STARLIST chooses your stars from the short list of the 57 "best" navigational stars. To make the list the star must be higher than 30 degrees (to avoid clouds) and lower than 70 degrees (very high stars are harder to shoot accurately). It tells you the star number, its approximate sextant altitude, and bearing. To find your star you just preset the altitude on the sextant and "sweep" the sky around the bearing. Your star will be the brightest one close to the horizon line in the sextant field of view. Fine-tune it to the horizon with the sextant's tangent screw, take the time, and you have your sight.

Use the data from the UNKNOWN STAR problem you just worked since most of it is already in the basic data section. (If you've changed it you can easily go back to the first star fix problem and re-enter it.)

PROMPT	REPLY/COMMENT
0	LOP
COMPUTE CEL LOP	YES ENTER
NEW FIX?Y/N	NO (or YES, it doesn't matter.)
REVIEW DATA?Y/N	YES (To confirm it's OK.)
DAY 1?	ENTER
MONTH 1?	ENTER
YEAR 1982?	ENTER
A LAT 29.452?	ENTER
A LON-142.18?	ENTER
EYE HT 7?	ENTER
IC -2.5MIN	ENTER
SP 8.5KTS?	ENTER
TRUE CSE 230?	ENTER
FIX TIME 21.00?	ENTER (A time within 8 hours of twilight.)
REVIEW DATA?Y/N NO	
SHOTTIME?	20.45 (This time should be in mid-twilight.)
SXT ALT 45.29?	ENTER (Any angle less than 90.)
BODY# 144?	-9 ENTER (Starts STARLIST.)
STARLIST	Flashes.
STAR# 26	ENTER Record.
STAR HT: 46.35	ENTER "
STAR BRG 255	ENTER "
STAR# 27	ENTER "
STAR HT: 52.47	ENTER "
STAR BRG 337	ENTER "
STAR# 28	ENTER "
STAR HT: 67.48	ENTER "
STAR BRG 230	ENTER "
STAR# 29	ENTER "
STAR HT: 41.34	ENTER "
STAR BRG 193	ENTER "
STAR# 32	ENTER "
STAR HT: 63.44	ENTER "
STAR BRG 358	ENTER "
STAR# 33	ENTER "
STAR HT: 48.38	ENTER "
STAR BRG 170	ENTER "

STAR# 34	ENTER "
STAR HT: 68.23	ENTER "
STAR BRG 21	ENTER "
STAR# 37	ENTER "
STAR HT: 69.45	ENTER "
STAR BRG 117	ENTER "
STAR# 39	ENTER "
STAR HT: 36.55	ENTER "
STAR BRG 145	ENTER "
STAR# 40	ENTER "
STAR HT: 43.22	ENTER "
STAR BRG 10	ENTER "
STAR# 41	ENTER "
STAR HT: 55.49	ENTER "
STAR BRG 85	ENTER "
STAR# 47	ENTER "
STAR HT: 32.18	ENTER "
STAR BRG 45	ENTER "
*LIST COMPLETE!	

The list shows twelve stars in good position. I would choose a set of three that gave good cuts. (My ideal would be 120 degree cuts. That gives a third star to check on the others. With 120 spacing a constant shooting error is neutralized. There are many opinions on this.) If I expected lots of clouds I would select a back-up set of three with bearing spaced at approximate 120 degrees. You will soon form your own opinion and act accordingly. My choices? 26 (Regulus), 39 (Zuben'ubi), 40 (Kochab).

PLANETS are not listed by STARLIST. They look like stars, but are brighter and don't twinkle. They make good twilight LOPs. Which are up and how do you find them? At last you will learn what that bothersome HC that reads out for every LOP is for. It tells you approximately how high in the sky the body computed will be. You use it to precompute a body's position. HC is the height (Height Computed) and ZN is the bearing.

Use the basic data from the STARLIST PROGRAM you just ran. Say NO to REVIEW DATA, use 20.45 for SHOTTIME, and the planet number for BODY#.

PROMPT	REPLY/COMMENT	
REVIEW DATA?Y/N	NO	
SHOTTIME?	20.45	
SXT ALT 0.000?	ENTER	Any value is OK here.
BODY# O.O?	-4 ENTER	For Venus.

SXT ALT 0.000?	ENTER	Any value is OK here.
BODY# O.O?	-4 ENTER	For Venus.
VENUS		Flashes.
HC -30.246	ENTER	Minus means Venus is not up yet.
TO 000.0	ENTER	Ignore.
ZN 92.3	ENTER	Ignore.
ACCEPT LOP?Y/N	NO	
REVIEW DATA?Y/N	NO	
SHOTTIME?	ENTER	It hasn't changed.
SXT ALT 0.000?	ENTER	Any value is OK.
BODY# -4?	-5 ENTER	For Mars.
HC 58.430	ENTER Record.	Mars is up.
TO 0.000	ENTER	Ignore this value.
ZN 193.5	ENTER	Record.
At GMT 20.45 Mars is about 58 degrees above the horizon at about 193 deg.		
ACCEPT LOP?Y/N	NO	
REVIEW DATA?Y/N	NO	
SHOTTIME	ENTER	
SXT ALT?O.000?	ENTER	
BODY# -5?	-6 ENTER	Jupiter.
HC 43.445	ENTER	Record.
TO 000.0	ENTER	Ignore.
ZN 153.1	ENTER	Record.
ACCEPT LOP?Y/N	NO	
REVIEW DATA?Y/N	NO	
SHOTTIME	ENTER	
SXT ALT 0.000?	ENTER	
BODY# -6?	-7 ENTER	Saturn.
HC 53.380	ENTER	Record.
TO 0000.0	ENTER	Ignore.
ZN 169.8	ENTER	Record.

That is all of the planets. A minus HC tells you it is below the horizon, positive tells how high above the horizon. ZN tells you the planet's bearing. Now planets are easy to find as stars. I grant that this computation is a long one, but planets change their position in the sky very slowly so you need not do it daily.

Navigators who use the old graphic starfinders need the LHA of Aries to set them up. To get that you run the LOP program and select body #-10. The only inputs that must be correct are: Day, month, year, longitude, speed, fix time, shot time, and body number. The others can be whatever is left from an earlier computation.

PROMPT	REPLY/COMMENT	
0	LOP	
COMPUTE CEL LOPS	ENTER	
NEW FIX?Y/N	YES	(or NO, either is OK)
REVIEW DATA?Y/N	YES	
DAY 0.0?	12 ENTER	
MONTH 0.O?	12 ENTER	
YEAR 0.0?	1991 ENTER	
A LAT 0.0?	0 ENTER	
A LON 0.0?	50.32 ENTER	
EYE HT 0.0?	ENTER	
IC 0.0?	ENTER	
SP 0.0?	0 ENTER	(Be sure to enter a zero here.)
TRUE CS 0.0?	ENTER	
FIX TIME 0.0?	12.00 ENTER	
(Entering 12 insures the date will not be changed.)		
REVIEW DATA?Y/N	NO	
SHOTTIME?	8.00 ENTER	
SEXT ALT 0.0	ENTER	
BODY# 0.0?	-10 ENTER	
LHA ARIES 150.00	ENTER	(Record if needed.)
REVIEW DATA?Y/N	NO	
SHOTTIME?	18.35 ENTER	
SXT ALT 0.0?	ENTER	
BODY# -10?	ENTER	
LHA ARIES 309.11	ENTER	(Record if needed.)

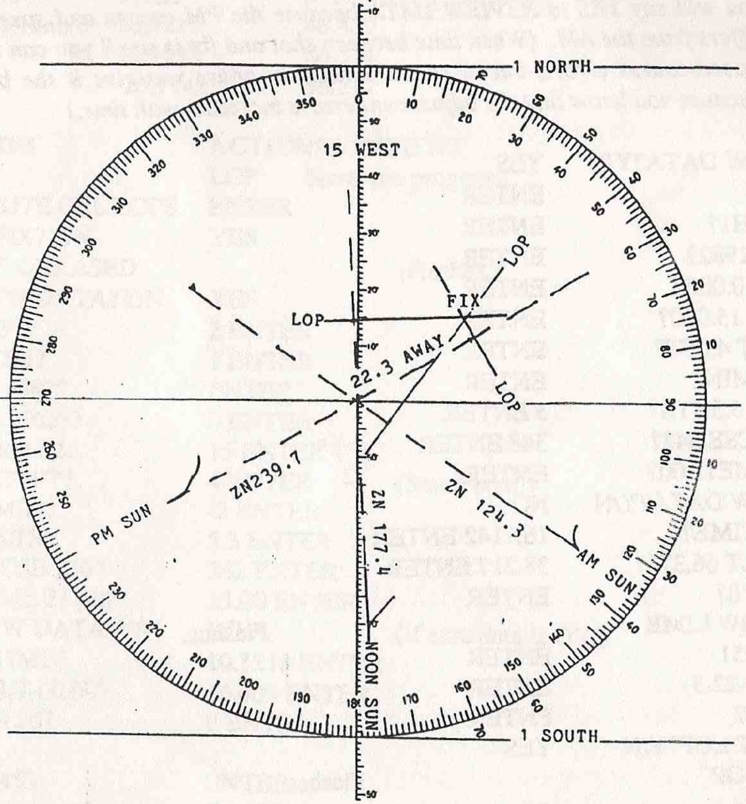
You can shoot the stars only at twilight in good weather, but you can shoot the sun any time you see it, and you can see it through thin clouds. Because its bearing changes throughout the day you can get LOPs from it that will cross at good angles. Besides that you will never shoot the wrong sun. Some very good navigators use no other body. Of course the LOPs must be advanced retired to a common fix time or their intersection will be wrong. Time difference between sights will be several hours so small errors in speed and course will be magnified.

In this example you will get a position for noon, Local Zone Time (13.00GMT). DR for 13.00GMT is N 0.13, W 14.40, but you plan to plot the LOPs on your plotting sheet so you make you A LAT/LON N 0.00, W 15.00. That puts your plotting base squarely in the center of the plotting sheet so you won't even need a protractor. You have a sunshot for mid-morning, mid-day, and mid-afternoon. Average speed/true course between morning and noon differs slightly from that between noon and afternoon so you will need to make that change by using REVIEW DATA/Y/N.

are not part of the fix. They are just to help you plot the LOP.

If you practice plotting LOPs you will find it almost as easy as plotting lat/lon coordinates. It also tells you a lot more about which LOPs are good and helps you improve your shooting.

You can plot the LOPs right on your navigation chart or on a plotting sheet. The cover of your instruction booklet is a copy of a plotting sheet. You can copy that for your own use. Use the plotting sheet for this example.



1. Locate the AP (assumed position) on the sheet. It is the intersection of the A LAT and A LON you used to compute the LOPs. Label the horizontal line through the center 0 for 0 latitude, and the central vertical line 15 for W 15 longitude.
2. Use a straight edge to draw a straight, dashed line through the center bearing 124.3 degrees. (The first ZN). Put an arrowhead on the end pointing to 124.3 degrees.

3. The "intercept" was TO 6.9 nm (nautical miles) so you measure 6.9 miles from the AP toward the arrowhead and mark the point. (The vertical scale is in nm.)
4. Draw a solid line through the marked point on the dashed line at right-angles to the dashed line. That is your LOP. Your position is somewhere on the LOP but you don't know where until you cross it with another LOP.
5. Next draw a dashed ZN line at 177.4 deg with an arrowhead on the south end. The intercept is AWAY -14.2 so you measure from the AP away from the arrowhead 14.2 nm (northerly in this case), mark and draw your LOP as a solid line. It should intersect the first LOP at about 20 miles northeast of the AP
6. You now have a fix valid for 13.00GMT. Good navigators try to have a third LOP that will cross both the first two at a good angle. (Making a good cut.) So you plot the third line in the same way as you did the others with a ZN line whose arrow points to 239.7 with an LOP crossing it at 22.3 miles away from the AP. In this made-up problem they make a very small triangle. You hope that all your real-world fix triangles are that small. If you get a large triangle you know it's time to recheck your work, perhaps to ignore one of the LOPs. The computed FIX is an accurate way to find the 0graphic average of the LOPs, but it doesn't give you warning you get from a large triangle.

Minutes of latitude and longitude are of a different scale except **at the equator where they are the same.** In this case you can use the vertical scale for both when you determine the lat/lon of the fix. When you compute with FIX you will find that it should be: (North) 0.145, (West) 14.421. For the reasons given above I hope you will decide to plot the LOPs. If they agree reasonably well with the computed FIX I suggest that its lat/lon will plot with slightly more accuracy than the LOP plot.

Because you get to name the fix time, and because you can use any sight within 12 hours of fix time in a fix you can almost always find a way to combine enough LOPs in your fix to provide a good check. For example if you got only two stars at PM twilight you could include the afternoon sun sight in the evening star fix.

N LAT actually computes the lat/lon of the "near point" on the last LOP computed. If the ZN for that LOP is 360 (0)+/- 5 degrees or 180 +/- 5 degrees the latitude of that point is also your latitude for fix time but the point's longitude is not to be trusted.

Why shoot for noon latitude? It's a way to get your latitude when you don't know what time it is--not common in this day of the cheap reliable quartz watch and WWV time broadcasts. The custom dates from the 18th and 19th centuries when a good chronometer was too dear for most sea captains, and the tradition has stuck like a Puget Sound barnacle.

The sun shot for 12.5938, 2 Jan 1982 (see page 14) you computed from an AP of 0 lat, west 15 lon would do very nicely for noon latitude, but this time you use our best DR: N 0.13, W 14.40

First you compute the LOP:

PROMPT	REPLY	
0	LOP	
COMPUTE CEL LOPS	ENTER	
NEW FIX?Y/N	YES	
OLD FIX ERASED		Flashes.
REVIEW DATA?Y/N	YES	
DAY 0?	2 ENTER	
MONTH 0?	1 ENTER	
YEAR 0000?	1982 ENTER	
A LAT 000.000?	0.13 ENTER	
A LON 000.000?	14.40 ENTER	
EYE HT 0.0	4 ENTER	
IC 00.0?	-2 ENTER	
SP 00.0KTS?	5.3 ENTER	
TRUE CSE 000.0?	342 ENTER	
FIX TIME 00.00?	13.00 ENTER	
REVIEW DATA?Y/N	NO	
SHOTTIME?	12.5938 ENTER	
SXT ALT 00.000?	66.374 ENTER	
BODY# 000?	0 ENTER	
SUN LOW LIMB		Flashes.
HC 66.513	ENTER	
AWAY -2.0	ENTER	Close to our DR!
ZN 178.2	ENTER	

As soon as TO/AWAY and ZN are computed you can activate N LAT. (If you plan to use the sight in a fix wait until you have accepted the LOP.)

0	N LAT	
NEAR POSITION	ENTER	
OR NOON LAT		Flashes.
FROM LAST COMP	"	
LOP COMP?Y/N	YES	(NO sends you to LOP.)
NP LAT 0.150	ENTER	Record.
NP LON 14.400	ENTER	

(Only as good as your DR longitude.)

DR-NP DIST 2	ENTER

NP LON 14.400	ENTER

(Only as good as your DR longitude.)

DR-NP DIST 2	ENTER
DR-NP DIR 358	ENTER

This puts you back into the LOP program to compute more LOPs.

REVIEW DATA?Y/N

If you really need this program it will be because your watch has stopped. Then you'll have to find port by "running down you latitude" just as the old timers did. Here's the drill:

1. Change course to get on destination latitude well short of destination. As time goes by you will be less and less sure of your longitude.
2. Start shooting the sun when you are sure it is still east of your longitude. As it passes due south (or north) of you it will rise ever more slowly. Finally it will "hang", then start to sink. You want the sextant reading at its highest point. You don't take the time because you don't know the time.
3. Use the SSET program with your best guess of longitude to find LAN. (GMT of local apparent noon.) Use this as the SHOTTIME and compute with the LOP program in the usual way. When ZN and TO/AWAY are computed and accepted use the NLAT program to find an accurate latitude. (Pay no attention to the longitude. It is no better than the DR longitude you gave the LOP program.)

If you use the NLAT program on a sight where the body's ZN is not due north or south you get a "near position." That is the point on the LOP closest to your DR position. As for the Near Position lat/lon: think long and hard about it before you trust it for anything important. If your DR position was good you may justify calling it an EP (Estimated Position). Which is to say it might be better than the DR but you aren't really sure.

MOON AND PLANET LOPS are easy to compute with CELESTICOMP V--just as easy as the sun and stars. (You'll find the older navigation books are full of excuses for not using the moon. It's less accurate, has a poor horizon, etc. The real reason was that it was difficult to reduce a moon sight. A properly reduced moon LOP is as accurate as any other, and the moon is a lot easier to shoot accurately in bad weather.) It does take CELESTICOMP V longer--as much as 30 seconds--to reduce a moon or planet sight because there are literally hundreds more corrections for the internal almanac to make for them. But for the navigator they are just as easy.

Here is a Venus-moon fix to try: You are cruising in the South Atlantic off the coast of Africa. Your DR position for 8 Jan 1982, 19.30GMT is South 19.05 and East 2.05. You choose 19.30 for fix time, use you DR for AP. Eye height is 7 ft, IC is +3 min, course is 342 and speed 9 kts.

BODY/#	DATE/TIME	SXT ALT
MOON LL/-2	1/8/1982/19.0316	18.56
VENUS/-4	" 19.0643	6.57

You start the LOP program, say YES to NEW FIX? and to REVIEW DATA?, put in the new values and find:

Moon LOP is	TO 7.3, ZN 57.1
Venus LOP is	AWAY -8.1, ZN 256.4

You accept the LOPs. After plotting them you work the FIX program and get FIX LAT -19.041, FIX LON -2.136. (South latitude and east longitude, of course.) DR TO FIX is 8NM at 83 degrees. When you plot the LOPs you note that they cross at a shallow angle of about 20 degrees. A shooting error of one minute of sextant angle--easy to make--would move the LOP by one mile. That would change the intersection by three miles. If the LOPs crossed at 90 degrees the same error would only change the fix point by one mile. Good cuts are important!

If you say NO to SUNRISE/SET you get

COMPASS CHECK BY		
SUN BEARING?Y/N	YES	
ALL TIMES GMT!		Flashes
DAY 1?	ENTER	
MONTH 1?	ENTER	
YEAR 1982?	ENTER	
LAT 29.45?	ENTER	
LON-142.18	ENTER	
REVIEW DATA?Y/N	NO	
OBS TIME?	22.04 ENTER	It's AM here.)
SUN TR AZ 121	ENTER	
+/-(E/W)VAR?	-12.5 ENTER (East Variation.)	
MAG AZ 108.5	ENTER	
SHADOW BEARING	ENTER	
BY COMPASS?	290 ENTER	

(You read this bearing from the pin shadow on the binnacle compass.)

DEV COR 1.4	ENTER	

(It is positive so the compass has west deviation on this heading. If you are using a pelorus ignore some of the above prompts and readouts.)

NEXT OBS		Flashes.
OBS TIME?	22.11 ENTER	
SUN TR AZ 122.0		

(Program re-runs exactly as above, but with answers for the later time.)

The program makes it easy to take a series of observations on a series of headings to make a deviation card for your compass. No need to re-enter everything since only the observation time will change.

PLAN. The rest of the story. Figuring great circle or Mercator distance with the two programs under the PLAN button is pretty easy. That is why you used them to introduce the Celesticomp system. However you broke off before using all the features. Now do a great circle all the way through.

From Land's End, England (N 50.04, W 5.45) to St. John's, Newfoundland (N 47.34, W 52.40):

PROMPT	REPLY/COMMENT	
0	PLAN	
GR CIR?Y/N	YES	
DP LAT 00.000?	50.04 ENTER	
DP LON 000.000?	5.45 ENTER	
DS LAT 00.000?	47.34 ENTER	
DS LON 000.000?	52.40 ENTER	
REVIEW DATA?Y/N	NO	
GR CIR D 1828.9	ENTER	
1ST TC 283.7	ENTER	(It's ever-changing.)

To plot a great circle course on your Mercator chart you need to draw an arc--very hard to do. You settle for drawing a series of straight lines (rhumb lines, actually) between points on the course. Call them WP (waypoints). At the WP PT LON? prompt key in any longitude between departure and destination. Celesticomp will tell you its latitude. This is also a quick way to make sure your great circle course clears all hazards.

WAY PT LON?	20 ENTER	
WP LAT 51.223	ENTER	(Way point is at N51.223, W20.)
NEXT WP?Y/N	YES	
WAY PT LON?	30 ENTER	
WP LAT 51.142	ENTER	
NEXT WP?Y/N	NO	(When you've enough WPs.)
VERT LAT 51.253	ENTER	
VERT LON 23.250	ENTER	

The vertex is the point on the extended great circle closest to the north or south pole. I put it in for students in maritime academies. The computer has made it obsolete for the rest of us. Now do a rhumb line (Mercator) problem. Use the same two points, then go from St John's back to Land's End.

GR CIR?Y/N	NO	(Yes, to do another one.)
RHUMB LINE?Y/N	YES	(To find Mercator course.)
DP LAT 50.04?	ENTER	(Saved from GC program.)
DP LON 5.45?	ENTER	"
DS LAT 47.340?	ENTER	"
DS LON 52.40?	ENTER	"
REVIEW DATA?Y/N	NO	
RL DIS 1864.5	ENTER	(Slightly longer.)
RL TR CS 265.4	ENTER	
+/-VAR&DEV?	-9+2 ENTER	(East is least.)

Celesticomp applies magnetic variation and compass deviation to find a course to steer. The rhumb line true course stays the same.

MAG CS 258.4	ENTER	Compass course to steer.
NEXT POINT		Flashes.

Now Celesticomp puts the old destination lat/lon into the departure prompt--a great convenience when your course has many doglegs.

DP LAT 47.34?	ENTER	
DP LON 52.40?	ENTER	
DS LAT 00.00?	50.04 ENTER	Land's End lat.
DS LON 00.00?	5.45 ENTER	"" lon.

(You can use any destination you wish here.)

REVIEW DATA?Y/N	NO	
RL DIS 1864.5	ENTER	
RL TR CS 85.4	ENTER	
+/-VAR&DEV?	20-1	

Variation at St. Johns and compass deviation for the new course.

MAG CS 104.4	ENTER	
NEXT POINT		Flashes.

You can go point to point as often as you wish.

The DR key has only one program. When you start from a known position and travel at a known speed and course for a known time you can compute a DR (dead reckoning) position. If you keep careful track of your speed and compass readings a DR position can be very accurate indeed. As time passes DR becomes less precise because small errors get big over time. I would use this program as a check on my chart DR because I find that charting a course and distance keeps me in touch with the progress of the ship. That "feel" helps me make better navigational decisions.

Set up another imaginary, but lifelike situation: You had a good fix at 12.00 and were sailing a compass course of 205 at 8 knots. At 15.15 you tacked to 273. Your well-trained crew faithfully kept track of compass and speed log reading. You find

the following in your nav log:

12.00 Fix at N 42.31, W 132.18. Steering 205.
15.15 Tacked to 273.
For 12.00-15.15 average course/speed was: 205/6.5.
Variation: East 25, Deviation: East 2.
18.30 Tacked to 192.
Average course/speed:273/5.5. Var/Dev: E25/W1.
21.00 Average course/speed was: 192/4.5. Var/Dev: E25/E1.
(Note that magnetic variation is steady, but deviation changes with every course change.) Find your DR position at 21.00.

PROMPT	REPLY/COMMENT	
0	DR	(The program start key.)
DR FR CS&DS	ENTER	
DP LAT 0.00?	42.31 ENTER	
DP LON 0.00	132.18 ENTER	
STEERED 0.0?	205 ENTER	
SPEED 0.0KTS?	6.5 ENTER	
+-VAR&DEV 0.0?	-25-2 ENTER	
DP TIME 0.00?	12.00 ENTER	
TP TIME 0.00?	15.15 ENTER	(Turn point time.)
REVIEW DATA?Y/N	NO	
DR LAT 42.179?	ENTER	
DR LON 132.404?	ENTER	
NEXT TP?Y/N	YES	
DP LAT 42.179?	ENTER	*Gives you a departure from*
DP LON 132.404?	ENTER	*the turning point.*
STEERED 205.O?	273 ENTER	
SPEED 6.5KTS?	5.5 ENTER	
+-VAR&DEV-27?	-25+1 ENTER	
DP TIME 15.15?	ENTER	(Departing the turn point.)
TP TIME 00.00?	18.30 ENTER	(Time of 2d tack.)
REVIEW DATA?Y/N	NO	
DR LAT 42.261	ENTER	(Lat/lon at 18.30)
DR LON 133.019	ENTER	
NEXT TP?Y/N	YES	
DR LAT 42.261?	ENTER	
DR LON 133.019	ENTER	
STEERED 273?	192 ENTER	
SPEED 5.5KTS?	4.5 ENTER	
+-VAR&DEV-24.0?	-25-1 ENTER	
DP TIME 18.30?	ENTER	

TP TIME 00.00?	21.00 ENTER	
REVIEW DATA?Y/N	NO	
DR LAT 42.172	ENTER	
DR LON 133.112	ENTER	
NEXT TP?Y/N	NO	

MAKE AP=DR?Y/N	YES	

YES puts the DR lat/lon into the ALAT and ALON of the LOP program..

AP=DR		Flashes
TO FIN DEST?Y/N	YES	
FD LAT 00.00	41.30 ENTER	
FD LON 00.00?	135.30 ENTER	
SP 00.0 KTS?	4.5 ENTER	
-+VAR&DEV 0.0?	-25-1 ENTER	
REVIEW DATA?Y/N	NO	
STEER 219.5	ENTER	(Compass course to destination.)
DIST113.9	ENTER	(Distance to destination.)
ETA 22.18 DAY 2		(Day 1 is today.)

Under the UTIL key are ten programs:

1. TRUE&APWIND computes true wind from apparent wind, and vice versa.
2. ADD TIMES makes it easy to add and subtract hours, minutes, and seconds.
3. COMP ETR/A figures estimated time of arrival/enroute from inputs of departure time, speed, and distance.
4. COMP SPEED computes speed from distance/time.
5. COMP DIS computes distance from speed times time.
6. STEER/CUR tells you the compass course to steer to offset the effects of a current.
7. CS MG/CUR find the course and speed made good in a current.
8. TIDE, HEIGHTS AND TIMES will find the tide height at any time or the time of any height.
9. GHA&DEC computes the GHA and declination of the last body for which an LOP was computed. But only if done immediately after the LHA computation. Just call it up and follow the prompts.
10. CLEAR ERROR#7 is a quick way to clear the most bothersome error. See Trouble Shooting.

You start by pressing the Key marked **UTIL**. This puts you at the top of the list of utility programs.

TRUE AND APPARENT WIND comes first.:This program computes the true wind (wind sensed by a stationary observer) from the apparent wind (wind sensed by an

observer on a moving vessel). It will also compute "opposite tack"--the course on which the apparent wind will be at the same angle from the opposite side--and the apparent wind on other courses at other speeds. If you know the true wind you can also predict the apparent wind for any course and speed. These features are particularly useful to racing sailors. Here is a problem:

You are sailing as close-hauled as you can on the starboard tack. Your course is 275, speed 6.5 knots. Your next course will be 135 degrees and you estimate that you can make good 8 knots since it will give you a fair wind for setting the spinnaker. Your wind meter shows the wind at 26 degrees off your starboard bow at 17 knots. What is the true wind? What course will you sail if you tack to close hauled on the port tack? What is the layline course on the port tack? What will the apparent wind be on the next course?

NOTE: If your craft's wind direction indicator is marked 0 through 360 degrees an apparent wind at 30 degrees off the port bow would be 330 degrees. If the port side of the meter reads anti-clockwise 0 through 180then the apparent wind would be a minus 30 degrees (-30). The program accepts either entry but reads back apparent winds measured clockwise through 360 so if the apparent wind computed to be 30 degrees off the port bow it would say: 330. Doing problems ashore is sometimes confusing because apparent winds are measured relative to the ship's head while true winds are referenced to north. Don't worry. What seems strange in the arm chair seems perfectly natural aboard ship.

PROMPT	RESPONSE/COMMENT	
0	UTIL	
TR&AP WIND?Y/N	YES	
TR FROM AP?Y/N	YES	
STEERED?	275 ENTER	
LOG SPEED?	6.5 ENTER	
A WIND DIR?	26 ENTER	
A WIND SP?	17 ENTER	
TR WV 315D 12K	ENTER	(Record if needed.)
OP TACK 356D	ENTER	(356 degrees.)

(Record if needed. This is your layline for the port tack.)

A WV ON NEW CS	ENTER	
NEW CS?	135 ENTER	
NEW LOG SP?	8 ENTER	
A WV 181D 4K	ENTER	(The wind is dead aft.)
NEW CS?		

(You can find the apparent wind for as many combinations of course and speed as you wish.)

If you say NO to TR FROM AP?Y/N you get AP FROM TR?Y/N. YES to this lets you compute apparent wind from true for any course and speed.

PROMPT	RESPONSE/COMMENT	
0	UTIL	
TR&AP WIND?Y/N	YES	
TR FROM AP?Y/N	NO	
AP FROM TR?Y/N	YES	
WIND:AP FROM TR	ENTER	
TR WIND DIR?	175 ENTER	
TR WIND SP?	7 ENTER	
NEW CS?	320 ENTER	
NEW LOG SP?	5 ENTER	
A WV 260D 4K	ENTER	
NEW CS?	110	
NEW LOG SP?	6 ENTER	
A WV 35D 11K	ENTER	
NEW CS?		

And so on for as may combinations as you wish.

TRUE&AP WIND?Y/N	NO	
ADD TIMES?Y/N	YES	

You will add 10h 45m to 2h 18m and subtract 4h 9m 8s.

TIME?	10.45 ENTER	
+-TIME?	2.18 ENTER	
SUM 13.0300	ENTER	
+-TIME?	-4.0908 ENTER	
SUM 8.5352		

This program is endless. You must press a program start key to end it.

ADD TIMES?Y/N	NO	
COMP ETR/A	YES	
REVIEW DATA?Y/N	YES	

In this problem you departed a point at 13.51. Speed is 12.4 knots. When will you reach a point 43.5 miles on course?

DEP TIME 0.00?	13.51 ENTER	
LEG DIS 0.00?	43.5 ENTER	
SP MG 0.0?	12.4 ENTER	
REVIEW DATA?Y/N	NO	
ETA 17.21DAY 1	ENTER	(Day one is today.)
COMP ETA/R?Y/N	NO	Steps to next program.

You depart a point at 23.51 and arrive at a point 32.3 miles away at 3.11. Our speed?

COMP SPEED?Y/N	YES	
REVIEW DATA?Y/N	YES	
DEP TIME 0.00?	23.51 ENTER	
WP TIME 0.00?	3.11 ENTER	(WP=waypoint.)
DIS RUN 0.0?	32.3 ENTER	
REVIEW DATA?Y/N	NO	
SP MG 9.6	ENTER	
COMP SPEED?Y/N	NO	Go to next program.

You left a point at 23.30, ran at 12 knots until 2.50. How far had you gone?

COMP DIS?Y/N	YES	
REVIEW DATA?Y/N	YES	
DEP TIME 00.00?	23.30 ENTER	
WP TIME 0.00?	2.50 ENTER	
SP MG 0.0?	12 ENTER	
REVIEW DATA?Y/N	NO	
DIS RUN 39.9	ENTER	
COMP DIS?Y/N	NO	Go to next program.

Desired course is 89 true through a current flowing 2 knots toward 140 degrees, cruising 10 knots through the water. Variation is 22.5 east, deviation 2.5 east. What course shall you steer?

STEER /CUR?Y/N	YES	
REVIEW DATA?Y/N	YES	
DES CS 0.0?	89 ENTER	
+-VAR&DEV 0.0?	-22.5-2.5 ENTER	
LOG SP 0.0?	10 ENTER	
CUR DIR 0.0?	140 ENTER	
CUR VEL 0.0?	2 ENTER	(Current velocity in knots.)
REVIEW DATA?Y/N	NO	
STEER: 55.0	ENTER	

Corrected for drift, variation, and deviation.

SP MG 11.1	ENTER	
STEER/CUR?Y/N	NO	

Now let us find what course you made good in the above current had you steered 55 and cruised 10.

winds, several days out. You do all your navigation in GMT time/date to avoid confusion. Your last fix from the evening stars valid 7/4/89 at 5.00 was 29.46N, 130.11W. Your average compass course and speed through the night was 235 degrees/7.5 knots.

Looking at yesterday's morning star fix you see that the best time for stars was about 13.00. It won't change much day to day so you get a DR position for 13.00/7/4/89. Variation here is 15E and your compass deviation for 235 degrees heading is 2W so true course was 248. (13.00 DR: 29.235N, 131.146W from the DR program.)

You could, at this point run the SSET program to get the BEST TIME AM STARS (13.06) but using yesterday's time is close enough. Tomorrow you can use the mid-time of today's actual shots for best star time. What stars shall you shoot and where will you find them? Use the LOP program, the DR lat/lon, time/date, and body #-9 to list potential stars. Eye height: 8, IC:0, course/speed from DR (248/7.5) and a fix time and shottime of 13.00. (#3 Schedar, #4 Diphda, and #51 Altair will give you the approximate 120 deg cuts you want so you choose them.) From the STARLIST program you know their approximate heights and bearings making it easy to find them. (#3: 58.10/24, #4: 37.00/150, #51: 40.03/255)

You ask for a call at first light (a navigator's life is not an easy one) and take your sights with the following results:

BODY	TIME	SEXTANT READING
#3	12.5143	57.285
#4	12.5401	36.20
#51	12.5734	40.392

LOPs compute as follows:

#3 TO O.4/ZN 26.4
#4 AWAY -4.8/ZN 148.8
#51 TO 0.8/ZN 255.5

You plot the LOPs and find they make a tight triangle a few miles northwest of your DR. Then you run the FIX program to get the exact coordinates: 29.265N, 131.176W. These check with your plotted LOPs so you use the coordinates to mark the fix (with time and date) on your navigation chart. The DR to fix distance is only 4nm/318 degrees. Why doesn't the fix agree exactly with the DR? Could be a current sweeping you to the NW or it could be small errors in the speed and compass readings. You decide.

When you run the FIX program say YES to MAKE DR=FIX? and Celesticomp will put an accurate departure point for the next DR leg into your FIX program.

DR REPLACED		Flashes.
TO FIN DEST?Y/N	YES	
FD LAT 0.000?	21.16 ENTER	(Diamond Head.)
FD LON 0.000?	157.49 ENTER	
SP?0.0	7.5 ENTER	Estimated speed.
-+DEV0.0?	-15+2 ENTER	
REVIEW DATA?Y/N	NO	
STEER 238.2	*Compass course to Diamond Head.*	
DIST 1525.2	*Rhumbline distance to Diamond Head.*	
ETA 0.22 DAY 10		

(If today is the fourth you will arrive on the 13th.

At about 18.00GMT (That's about 10.00 local zone daylight savings time if anyone cares.) you decide to shoot the sun so you get a DR position for 18.30. Average speed and compass course for the period 13.00-18.30 was 8.0kts/237 degrees. Variation deviation, eye height, and IC remain the same, true course is 250. You choose 18.30 for fix time and the 18.30 DR lat/lon you worked out with the DR program (29.115N, 132.048W) as AP. You make several shots on the sun well before fix time knowing that the LOP program will automatically average them for you. Here are the results (all shots on the sun's lower limb):

TIME	SEXTANT ALTITUDE	TO-AWAY/ZN
18.1256	53.345	TO 1.8/90.6
18.1342	53.452	TO 2.5/90.7
18.1415	53.519	TO 2.1/90.7
18.1502	54.152	TO 15.3/90.8

You accept the first three LOPs but reject the fourth. Why? When you make a series of shots on the same body in a period of five minutes or less they are all at close to the same azimuth (ZN). Their LOPs will therefore be parallel. Your Celesticomp used your DR course and speed to make them valid for the fix time. If your shooting and your inputs were perfect they should all have the same TO-AWAY value. Nothing is perfect, but #4 shot disagrees with the others by about 13 miles. Something is wrong with it so you reject it.

Now you have three sights averaged into the LOP program, but you can't make a fix from them because being virtually parallel they don't make good cuts. So no fix, right? What about the morning star shots? #3 and #4 have LOPs that would cut your sun LOP at about 60 degrees. Can they be advanced to be valid for 18.30?

Yes, they can as long as you know your course and speed between 13.00 and 18.30. After reducing the sun shots your computer is still set up to advance/retire any LOP within 12 hours of fix time. So the morning stars can make a fix out of your mid-morning sun line. You have only to enter their shottimes, sextant altitudes, and body numbers. Use #3 and #4.

#3 AWAY -1.2/26.5
#4 AWAY -1.0/148.8

Again the plotted LOPs make a tight triangle. The FIX program yields: 29.113N, 132.030W. Since it agrees well with your plot you plot the fix lat/lon on your navigation chart with time and date. The fix is close to your DR (1nm/94deg). Is there really a current here?.

NOTE: On a sailing vessel in Mid-Pacific it is not really necessary to get five fixes a day as you will do in this made-up problem. You do it here to illustrate how it can be done. You may want to do it at sea just to build your skills with practice.

You estimate the sun will reach zenith (its highest point) at about 20.54 and decide on a fix at 21.00. As the sun warms the sea the trade winds pick up and the ship's speed and motion increase. Average speed/compass heading for the period is 9.5kts/234 degrees. IC, Eye height, variation and deviation stay the same giving you a true course of 247. Starting from your 18.30 fix you compute a DR for 21.00: 29.022N, 132.277W.

Your shots on the sun's lower limb are:

TIME	SXT ALT	INTERCEPT
20.5213	83.303	AWAY -2.5/175.8
20.5342	83.309	AWAY -2.8/178.9
20.5421	83.310	AWAY -2.8/180.2

This is good shooting indeed! There is no reason to reject any shot. However there is no "good cut" here so you go back to the mid-morning sun and choose the median shot.

18.1415	53.519	AWAY -0.0/90.7

It makes an almost perfect 90 degree cut with the noon sun so you can hope for an excellent fix.

Note that because the fix time and DR are now different for the 18.14 sight the intercept is also different. The FIX program gives you: 29.049N 132.277W which agrees well with your plot. This time, however, the fix fell 2nm/3 deg or north of the DR. If the difference was due to current there has been a change.

Ever the busy navigator you decide to get a fix by crossing the LOP of the 20.5421 sight with the mid-afternoon sun shooting at about 23.45. The 21.00-23.45 speed/compass course is 9kts/232 deg with no change in eye height, IC variation or deviation making true course 245 deg. You start your 23.45 DR vector from the 21.00 fix and get: 28.544N 132.532W.

You note that the moon is up. It's just a sliver, not ideally separated from the sun but worth a shot. (To estimate the cut angle two bodies will make point an arm at each body, then look at the angle made by your arms. Here it looks to be 20 or 30 degrees.) You record the following sights, both on the lower limb, in your navigation log:

BODY	TIME	SXT ALT	INTERCEPT/ZN
#-2 moon/LL	23.4458	70.51	AWAY -2.3/248.5
# 0 sun /LL	23.4617	51.11	AWAY -1.6/271.0
# 0 " "	20.5421	83.31	AWAY -0.1/180.3

It's afternoon in the trade winds and there are squall clouds all round. There is no chance for multiple shots to average out errors and the LOP cut of 24 deg is not ideal. You compute with these and hope for the best. The computed fix is 28.546N 132.509W is 2nm/84 deg from the DR. Is this caused by current? Probably not. Shooting in rough seas with no chance to average, and with a mediocre LOP cut I'd bet the fix is a bit off.

You decide on an evening fix to be valid for 5.00, July 5, 1989. You start your DR vector from 23.45 fix on the 4th to 5.00, the 5th. Eye ht. and IC are unchanged. Average speed/compass course for the period is 9kts/230. Variation: -15.5, deviation: +2.5, making true course 243 deg. Computed DR position for 5.00: 28.321N 133.386W.

At 4.30GMT, about half an hour after sunset, you have a good horizon and some stars overhead. But, as often happens, there are clouds on the horizon in almost every direction. Only the moon is bright enough to shine through them. So you shoot the moon' lower limb and one star high overhead bearing about 330. With no pointers visible you can't identify the star. The moon was in the clear long enough to get three quick sights as was the star, but clouds obscure almost everything else. The sights were:

BODY	TIME	SEXT ALT	TO-AWAY/ZN
Moon LL	4.3426	10.150	TO 0.2/286.7
" "	4.3505	10.059	AWAY -1.0/286.8
" "	4.3623	9.511	AWAY -0.1/286.9

To identify Your star you run the UNKNOWN STAR program by selecting Body #-8 for the first star sight. #34 is the first star nominated and checks so well both by TO/AWAY distance and ZN that you accept it immediately. The next two sights you work using Body #34--it's much faster. Here are the results:

Unknown Star	4.4327	66.506	TO 2.9/337.1
#34	4.4435	66.435	TO 1.7/336.7
"	4.4643	66.325	TO 1.9/336.0

Computed FIX: 28.361N 133.372W

NOTE: If you had used SRCH to continue the UNKNOWN STAR program to the bitter end you would find that only one more star is nominated: #118 (HC=65.174, TO 71.8, ZN= 300.5). Star #34 is far more logical.

By accepting all six sights you have automatically averaged them into your fix. But you have only two LOPs. (The average moon makes one, the average star the other.) The mid-afternoon moon shot with a ZN of 248.5 would make a good cut with your evening sights. You can use it as your checker.

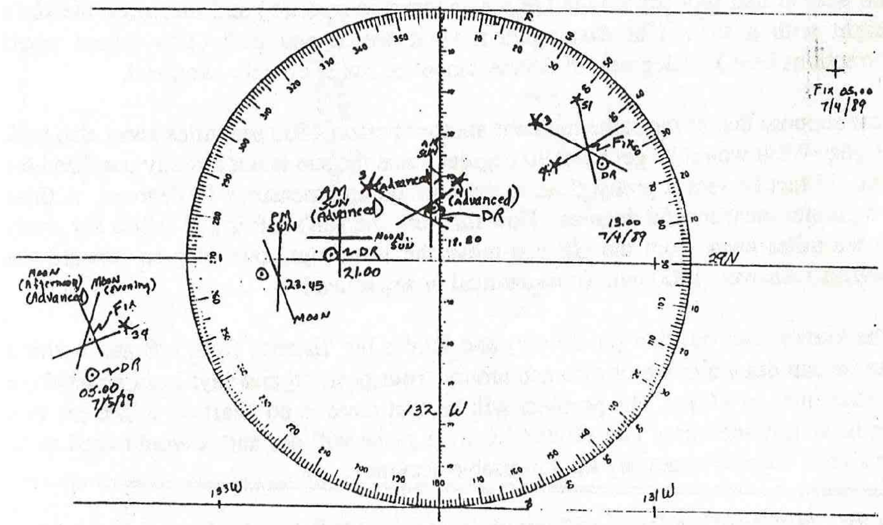
#-2/moon/LL	23.4458	70.51	AWAY -0.1/248.6

With this LOP computed and accepted you recompute the fix and find that is now: 28.354N 133.381W. That's within a mile of the fix computed without the checker, a good indication that there aren't any gross errors in either fix.

That completes a hypothetical day's navigation. You hope it's not typical. The navigator worked very hard and it didn't follow the pattern the standard texts suggest. Clouds, unexpected course changes, etc. often produce untypical days. Here is a sequence suggested for a "typical" day of navigation:

1. Up before sunrise. Figure DR position for a time near sunrise. Shoot three stars bearing--you hope--at intervals of 120 deg. Plot and compute fix valid at the time selected for the DR position.
2. Mid-morning: Shoot sun when it bears southeast (or northeast if the sun will pass north of you at noon). Of course for each shot you record the exact GMT and sextant angle. Compute a DR position for a GMT close to local noon.
3. Local noon: At a time near local noon take another sun sight. (You can make this a sight for latitude if you wish, but that means tracking the sun in your sextant until

it reaches its zenith--not worth the bother if you know the time.) Compute LOPs from the mid-morning and noon sights. Plot them for a fix. Check your plotting by computing a lat/lon fix from them.
4. Mid-afternoon: shoot the sun when it is southwest (or northwest). Compute a DR position for a convenient time in mid-afternoon and combine the noon and mid-afternoon sights into a fix valid for mid-afternoon.
5. Evening twilight: Shoot three stars as you did in morning twilight (different stars, of course), and combine them into a fix valid at a convenient time during or just after twilight. Of course you compute a DR position for every fix time.
That gives you four fixes for the day, or one about every 20 or 30 miles. It's good practice, but a lot more fixing than you really need in the middle of the ocean on a sailing vessel.



Some experienced navigators simply combine the three sun sights into a single mid-day fix and let it go at that. The main reason for doing more is to sharpen your skills against the time that you will need to use the other bodies. I suggest that you practice fixes from all bodies, some stars, the sun, moon, available planets so that, when the need arises, you will feel comfortable with using them. If you have Loran C or GPS aboard use it to check on your celestial. Nothing speeds learning like comparing your celestial fixes to a known position. Keep in mind that while the electronic fixing systems are easier and more accurate they have a way of packing in when you most need them--usually caused by power surges in the ship's generating system.

2. He chooses a chart position near his best known position (You call this his assumed position or AP.) and works out the sextant height (HC or computed height) he would actually read if he were at that position. He also computes the direction from the AP to the sun's GP at shot time.

3. He now has two sextant angles: The one he measured with the sextant, and the one he computed for the AP. Suppose they are the same. Can he say to himself: "Aha! the two angles agree. Therefore I am actually at the AP."? No, it's not quite that simple. Any observer at the same distance from the GP would measure his angle. So the AP is just one point on a circle of distance.

To show all possible positions he would need to draw a circle completely around the sun's GP. Fortunately that isn't necessary because he knows he is near the AP. He needs only to draw that part of the circle nearby. Moreover it is such a big circle that he can show his small part of it as a straight line without error.

The computed direction of the sun (called ZN) is like the spoke of a wheel pointing from his spot on the rim toward the GP.

4. He draws a dashed line (the ZN) pointing through his AP toward the sun's GP. That's the spoke.

5. Next he draws a solid line at right angles to the ZN. That is his LOP. In this case because the difference between his computed height and measured height was zero the LOP also passes through his AP. Now he can say: "Aha! I am somewhere on that LOP." Why not: "Aha! I am at the AP."? Remember he *measured the height of the sun, but not it's bearing.* (There is no practical way to measure such a bearing at sea with the needed accuracy.)

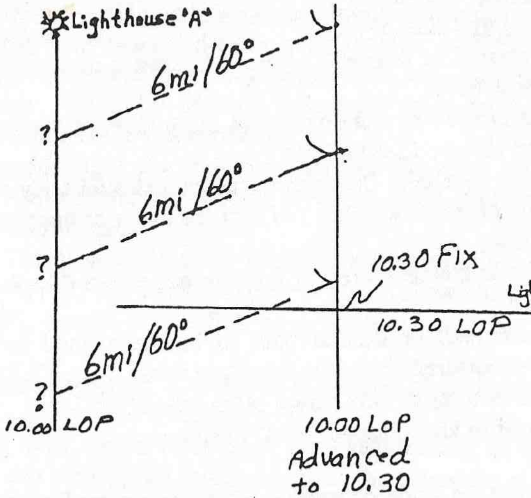
6. What does he do if the sextant angle doesn't match the computed angle (the usual case)? He reasons like this: If my actual position is closer to the GP than the AP the sun will appear to be higher and my sextant angle will be greater. For each minute the actual angle is greater than the computed I am one sea mile closer and for each minute the measured angle is less I am one mile farther from the GP. So I can measure TO or AWAY from the GP using the AP as the zero point. There I will draw my LOP at right angles to the ZN, and that will be my true LOP. Fine, that'sone LOP. But it takes two LOPs crossing to make a fix. For the fix to be perfect both LOPs would have to measured at exactly the same time if the ship is moving. That's a practical impossibility so I must adjust for the ship's travel between sights..

To illustrate the problem let's suppose that you are powering at 12 knots in a fog on a course of 60 degrees. At 10.00 the fog breaks and you sight a known light house due north, distance unknown. The fog closes in and you continue on course. At 10.30 the fog breaks again and you sight another known lighthouse due east, distance unknown again. How can you fix your position?

ADJUSTING LOPs FOR SHIP'S TRAVEL

The 10.00 sighting told you that you were somewhere on a line due south of lighthouse A. But at 10.30, when you sighted lighthouse B, you were about 6 miles east-northeast of your 10.00 position, whatever that was. Crossing the two lines makes no sense at all. What to do?

Why not take three of the possible points on line A and draw your distance and course--6nm/60deg-- from each of the three points. If you connect the points you will find that they make a straight line parallel to the north-south line from lighthouse A. Are you somewhere on that line at 10.30? If you are right about your speed and course you must be. And now you have two lines of position valid at 10.30. Where they cross you are--a fix.



LOPs can be advanced, as you just did, or retired. You could have advanced line A 15 minutes to 10.15 and retired line B by measuring back 15 minutes worth of ship's travel and made a fix for 10.15. When Celesticomp computes LOPs it does this for you automatically making all LOPs valid for the fix time you chose. A little thought will tell you that it would be impossible to get a daytime fix from the sun only without doing this.

This phenomenon, sometimes called "motion of the observer" is generally ignored in star fixes since the LOPs are close in time and the ship's movement small. But when the ship has moved a mile or more between the first and last LOP ignoring the motion of the observer can cause a significant error. 15 minutes between star sights is not uncommon. A tanker traveling 24 knots moves 6 miles in that time. He doesn't need a 6 miles motion error. Happily, with Celesticomp, he doesn't get one.

For a daytime running fix on the sun the time between LOPs is often several hours.