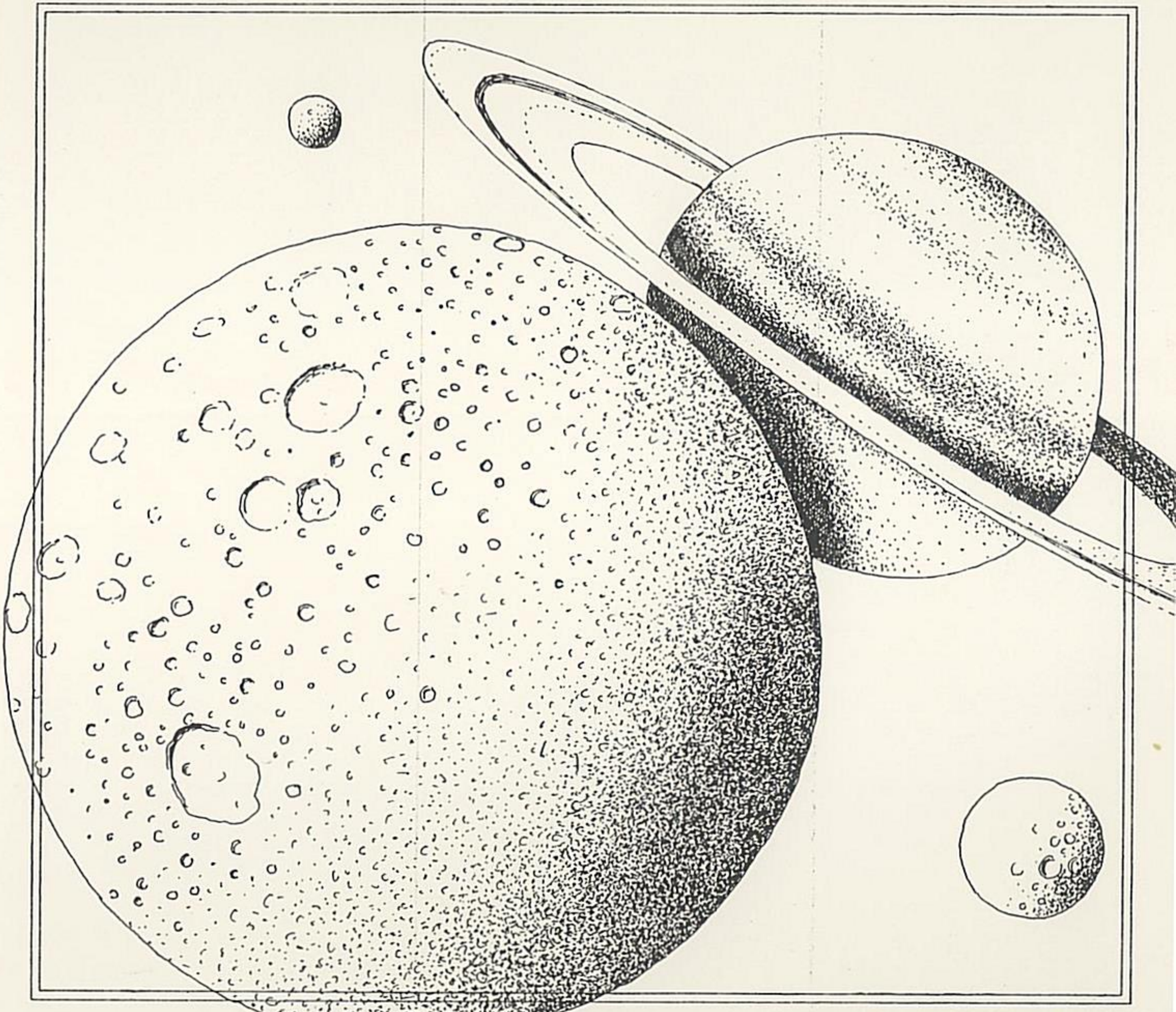
SKY TRAVEL™

An All Encompassing Astronomy Program



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SKY TRAVEL™

An All Encompassing Astronomy Program

Macintosh™ Version

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MACINTOSH VERSION
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IMPORTANT NOTE
FOR MACINTOSH II USERS

Sky Travel is shipped on 400K format disks, as opposed to the newer, 800K format. This was done for compatibility with all Macintosh models from the Macintosh 512K up. Because of restricted disk space, however, an older version of the System Folder is included on the disk and the MiniFinder is used instead of the Finder. This should not cause problems with the majority of Macintosh users, but the disk may fail to boot on Macintosh II systems. If this happens, we suggest either booting your system from another disk (with the latest version of the System Folder on it), or making an 800K **Sky Travel** work disk that includes the latest version of the System Folder (instructions for doing this are in the **Sky Travel** manual).

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GETTING STARTED

If you are unfamiliar with standard Macintosh procedures and terminology such as turning the computer on, starting up application programs, "double-clicking," "dragging," copying files and disks, etc., it would be a good idea to read the manuals that came with your Macintosh before trying to run **Sky Travel**.

You can start up **Sky Travel** by either turning on (or restarting) your Macintosh with the **Sky Travel** disk in the drive, or by opening (double-clicking) the **Sky Travel** icon from the Finder.

> **Note:** Make a backup! As a convenience to you, **Sky Travel** is not copy-protected, and you are free to make backup copies for your use *only*.

Sky Travel is distributed on 400K format disks, and needs about 60K of free space on the disk for the `Print Chart` command to work. Because of this, there is little room left over for desk accessories, fonts (which aren't needed by **Sky Travel** anyway), or the Finder.™ Quitting **Sky Travel** will take you to the MiniFinder. If you have disk drives that can read 800K format disks, you may wish to create an 800K **Sky Travel** work disk. To do this, format and prepare an 800K disk, and make sure it has a recent version of the System Folder on it. Copy the **Sky Travel** icon and all other icons whose names begin with "STData" into it. If there is not enough room on the disk you are trying to copy to, try using the Font/DA Mover utility that came with your Macintosh to remove unnecessary fonts and desk accessories, and use the Finder to remove any unnecessary files from the System Folder. All that should be necessary are the files "System," "Finder," and the files pertaining to the printer you are using.

If you have a hard disk, you may want to install **Sky Travel** on it. To do this, create a new folder and copy the **Sky Travel** icon and all other icons whose names begin with "STData" into it.

> **Note:** In order for **Sky Travel** to function properly, all files beginning with "STData" must reside in the same folder as the **Sky Travel** icon.

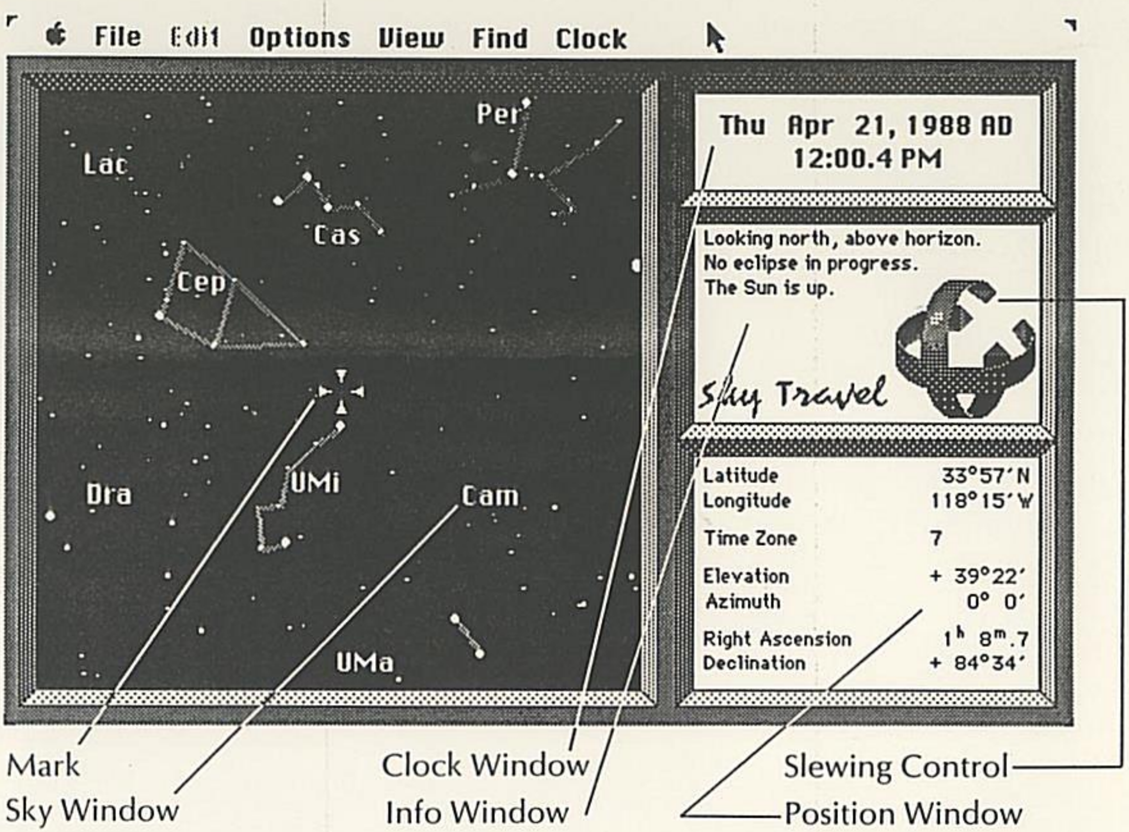
SKY TRAVEL QUICK REFERENCE

This section is a brief summary of the features of **Sky Travel**. Subsequent chapters will describe the operations of the various elements in greater detail.

When **Sky Travel** starts up there will be a pause as it computes the planetary positions for the current time, as indicated by the Macintosh internal clock. The cursor changes to indicate which planets are being computed. The sky display will then appear, and **Sky Travel** will be ready.

The Primary Windows

Sky Travel has four Primary Windows: Sky, Clock, Info, and Position.



Note: For users of large screens and application-switching programs such as MultiFinder,™ **Sky Travel**'s Primary Windows may be dragged from one location to another by their window frames, as you would drag any other Macintosh windows. All may be returned to their starting point by double-clicking any of their window frames.

The Sky Window displays the heavens as they appear from the particular time and place you have chosen. It contains a crosshair which is called the Mark. The Mark is used to point at various objects in the Sky Window. You move the Mark by clicking or dragging within the Sky Window. As you drag the Mark around you will notice that several of the values in the Position Window change along with the position of the Mark.

Note: The World Map Dialog (accessed from the `World Map...` command in the `Options` menu) also contains a Mark that functions almost exactly as the Mark in the Sky Window.

The Clock Window displays and allows you to set the current date and time. This is accomplished by clicking on the various values you want to change, using the up/down arrow control that appears to change them, then clicking outside the window. **Sky Travel** then computes the new display.

The Info Window displays various information in english sentences, and also holds a control which allows you to rotate and incline your telescope (this is called "slewing"). When the `Information...` command from the `Options` menu is invoked, the database entry for the selected object also appears in this window.

The Position Window displays various information relating to where you are on Earth, where you are looking, and what point in the sky you are looking at. `Latitude` and `Longitude` pinpoint the position of your "observatory" on Earth. `Time Zone` determines how your local time is calculated. `Elevation` and `Azimuth` are the inclination and rotation of your telescope (*where* you are looking). `Right Ascension` and `Declination` pinpoint the position on the "celestial globe" your telescope is pointed at (*what* you are looking at).

The Menu Bar

The **Sky Travel** menu bar contains seven menus: `Apple`, `File`, `Edit`, `Options`, `View`, `Find` and `Clock`. Below is a brief description of what each menu command does. More detailed descriptions of these functions will appear later in the manual.

The `Apple` Menu

The `Apple` menu (the one that appears as the Apple® logo) contains whatever desk accessories you currently have installed in your System file and the `About Sky Travel...` command which displays **Sky Travel**'s credits, copyright messages, and version number.

The `File` Menu

`Save Chart to MacPaint™ File...` allows you to save a full-page chart to disk that you can edit using many Macintosh graphics programs.

`Print Chart` prints a full-page chart to whatever printer your system is currently set up for.

`Quit` causes **Sky Travel** to shut down and return control to the Finder (or MiniFinder if you are using 400K format disks).

The `Edit` Menu

The standard functions in this menu, `Cut`, `Copy`, `Paste`, `Clear`, and `Undo` are only included for compatibility with the desk accessories in the `Apple` menu. You will not be able to select any of the options in this menu when a desk accessory's window is in front of any of **Sky Travel's** windows.

The `Options` Menu

The `Options` menu allows you to change your location with the World Map, get information on any object in the sky, center your view on any point visible, and change many parameters that control what you see in the Sky Window and how you see it.

`World Map...` lets you reposition your observatory almost anywhere on Earth and also set your current local time zone. One position and time zone may be saved to disk as your "home," making it easy to return there after roaming anywhere else on the globe. **Sky Travel** always goes to your home position when it starts up.

`Information...` tells you about the object in the Sky Window that is nearest the Mark.

`Center View on Mark` repositions your view so the point the Mark is at is centered. This is a fast way to get around the sky.

`Track Object` keeps the last moving object found using the `Find` menu (Sun, Moon, etc.) centered in the view.

`Track Sky Position` keeps the last position the Mark was pointed at centered in the view.

`Constellation Lines` controls the display of the lines of the principal constellations.

`Constellation Names` controls the display of the three-letter abbreviations next to the constellations.

`Planet Symbols` controls the display of the symbols used to identify the planets, in place of dots representing the brightness of the planets.

`Ecliptic Symbols` controls the display of the ecliptic, and the zodiacal symbols along the ecliptic.

`Deep Sky Objects` controls the displays of normally invisible objects such as galaxies and nebulae.

`Celestial Globe Lines` controls the display of celestial coordinate lines for right ascension and declination.

`Chart Orientation` allows you to display the sky viewed either as an observer would view it through a telescope or in a standard format for printed charts.

`Horizon` allows you to display the Earth either as translucent or completely transparent.

`Fast Slewing` makes it possible to slew the view faster by temporarily not calculating the positions of dim stars or the Celetial Globe.

The View Menu

`72° - 4.5°` let you choose the "lens" through which you observe the sky.

`North, South, East, West, and Opposite` let you turn to look a particular direction without having to slew your view there manually.

The Find Menu

The `Find` menu lets you instantly locate the Moon, Sun, planets, Halley's Comet, and the constellations. Selecting `Venus`, for example, causes **Sky Travel** to redraw the Sky Window with Venus and the Mark directly in the center.

The Clock Menu

`Reverse Clock` lets you watch events both in forward and reverse.

`Sync to Internal Clock` causes **Sky Travel** to keep it's clock in sync with the battery-operated clock built into the Macintosh.

`0x - 64x` lets you run **Sky Travel's** clock at a variety of speeds to watch events in "time-lapse."

`Display Greenwich Mean Time/Local Time` lets you display the clock in your local time zone or Greenwich Mean Time (time zone 0).

`Display 24/12 Hour Clock` allows you to choose between the "civilian" and "military" methods of telling time.

`Clock +1 Week` and `Clock -1 Week` provide a shorthand method to watch celestial events (such as planetary retrogression) in "time-lapse" over a period of weeks.

A GUIDED TOUR OF SKY TRAVEL

A great deal of flexibility has been built into **Sky Travel** to make it both versatile and easy to use. This section explains how to operate the program and how to choose from among the many options to get the best results for your particular purpose.

If you're a novice, don't get discouraged by the astronomical drawings and explanations. All that's required to operate the program is following directions and using the mouse. You may bypass the descriptions of the various coordinate systems at a first reading and still be well rewarded by the uses you'll find for **Sky Travel.**

If you're an expert, you'll appreciate the convenience of having **Sky Travel** do preliminary calculations for you.

Starting Up

When you first start up **Sky Travel** you will be looking at the four Primary Windows. When using the program, you will alternate between the Primary Windows and the World Map Dialog. The World Map Dialog is invoked by selecting the `World Map...` command from the `Options` menu. During the course of this guided tour you will use the World Map Dialog to reset the location of your "observatory" on Earth and then return to the Primary Windows to adjust the date and time of your observance in the Clock Window. After setting the clock, **Sky Travel** will recalculate the proper location of the objects in the sky using the new data from the World Map Dialog and the Clock Window.

Understanding the Examples

Throughout the manual, the examples given follow the same general pattern:

1. Set the location from the World Map Dialog.
2. Set the date and time in the Clock Window.
3. Observe the Sky Window.

Look at the following example step by step:

Imagine you're looking out the window early in the morning on January 1, 1985, in Washington, D.C. You're looking straight south and, with the help of the line diagrams and names magically painted in the sky, you immediately recognize the constellation Leo (the Lion).

The first thing you must do is place your location in Washington, D.C. Go to the World Map Dialog by selecting `World Map...` from the `Options` menu, and set your location:

```
38°54'N Latitude
 77°0'W Longitude
Time Zone 5
```

To do this, drag the Mark to the vicinity of Washington, D.C. on the World Map, observing the latitude and longitude settings until they roughly match the settings above. Now use fine-adjustment control near the bottom-center of the map. Click the mouse button on the four arrows to fine-tune your location (up/north, down/south, right/east and left/west). Once the location values are correct, click on the OK button to return to the Primary Windows. The Sky display will now show the sky as seen from Washington, D.C., but the date and time still need to be changed.

When **Sky Travel** starts up it synchronizes it's clock to the Macintosh internal clock and sets it running forward. This is fine if you want to observe what's happening in real-time, but for this example we want to freeze the action. To do this, select the `0x` command from the `Clock` menu.

Remember that it is "early morning," so change the date and time settings to the following:

```
Tue Jan 1, 1985 AD
    4:55.0 AM
```

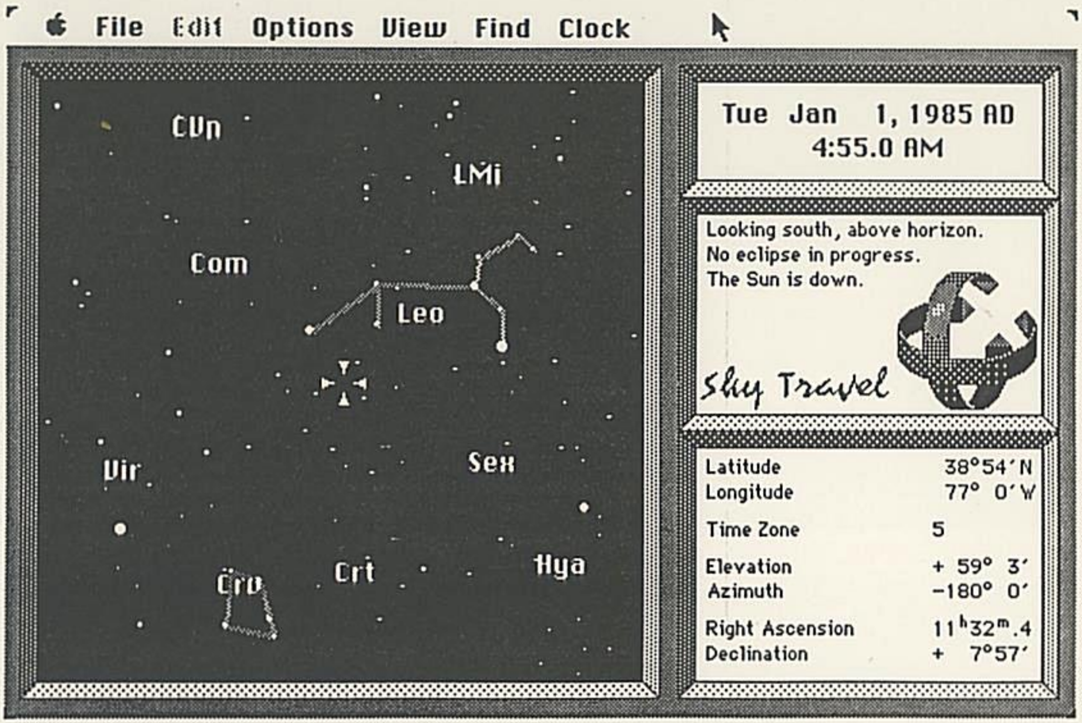
To do this, click on the value you wish to change in the Clock Window. Then click on the up-arrow to move forward in time and the down-arrow to move backward. For example, if the date reads "Nov 12, 1987," first click on "Nov" then on the up-arrow until it becomes "Jan" for January. Next, click on the twelve; now click on the down-arrow until it reads "1," and so on. Make sure the time is AM. When you are done setting values, click anywhere outside the Clock Window. **Sky Travel** will then update the display to show the sky as it appeared from Washington, D.C., on January first, 1985, at 4:55 in the morning.

> **Note:** In the Clock Window, the only indicators that cannot be directly set are the day-of-week, AD/BC, and AM/PM. You set these by manipulating the other values in the window. Before exiting the set-clock function, always check all your values. If, for example, you have moved the time forward from 11:55 PM to 12:05 AM, the day field will have increased by one. Also check to make sure that you have not accidentally changed the year from AD to BC.

Most examples in this manual will involve the manipulation of your point-of-view so that you may observe the objects described. The above example states: "You are looking straight south." To accomplish this, select the `South` command from the `View` menu. The messages in the Info Window will read, "Looking south, above horizon. No eclipse in progress. The Sun is down."

> **Note:** "No eclipse in progress" may seem like a strange choice of words, since 99.99% of the time there is no eclipse of any kind happening. This was chosen for two reasons. First, "No eclipse in progress" is a placeholder showing that this space is for telling you about eclipses when they *do* happen. Second, only one word needs to be changed when an eclipse occurs; "No" changes to "Solar" or "Lunar."

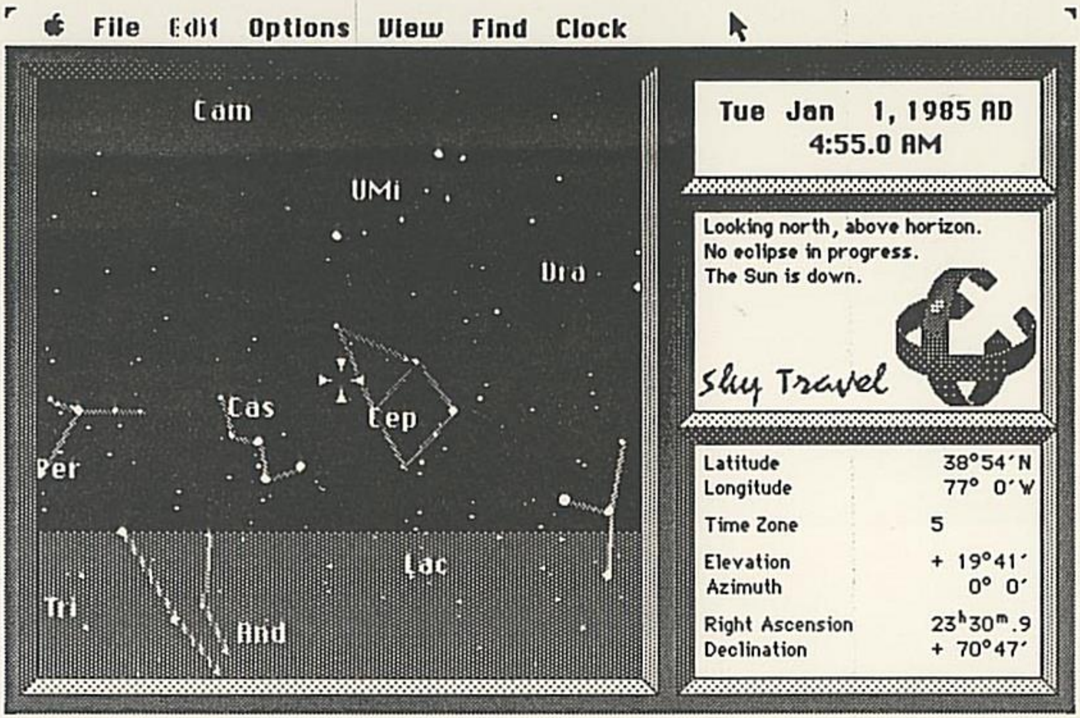
The above example also mentions "line diagrams and names magically painted in the sky." These may or may not be shown depending on the current settings in the `Options` menu. When **Sky Travel** starts up, these options are on by default (they have a check-mark if they're on), but if you have changed them you will need to select the proper commands from the `Options` menu to turn them back on. Now you are looking south at the early morning Washington, D.C., sky, but the constellation of Leo may or may not be visible depending on two things: elevation and viewing angle. Your view angle of the sky may range from a wide angle of 72° to a narrow angle of 4.5°. When searching for a particular object, use the widest viewing angle to place the maximum number of objects in the Sky Window. You select your viewing angle from the `View` menu. If Leo still is not visible, try adjusting your elevation by pressing on the up- and down-pointing arrows on the Slewing Control in the Info Window. The screen should now look something like this:



Now you can scan the sky for other objects. Press and hold on the right-pointing arrow of the Slewing Control in the Info Window until the message reads "Looking west" then stop. You can now see the constellation Gemini (the Twins).

Note: The "right-pointing arrow" is the left-most arrow on the Slewing Control. This is because it was designed to suggest the axes that your "telescope" can turn on. From now on the "right-pointing arrow" will simply be called the "right-arrow," etc.

Again press on the right-arrow of the Slewing Control until the message reads "Looking north," and then stop: you now set the Big Dipper and the Little Dipper. Near the center of the screen is Polaris, the polestar. Now press on the down-arrow of the Slewing Control to move your view down until you see the horizon (a dark-gray band) come up. Stop when the horizon is about a third of the way up the screen. You can now see the open "W" shape of Cassiopeia just above the horizon in the early morning hours.



Sky Travel's Earth is translucent, which means that objects that have already set or that may be about to rise can actually be seen through the Earth. You can also see the Sun and the Moon when they are just below the horizon. Press on the down arrow of the Slewing Control to move your view farther down. When you can look no farther down, you will simply turn in a counter-clockwise circle, looking at where your feet would be. The message in the Info Window will read "Looking north, at nadir."

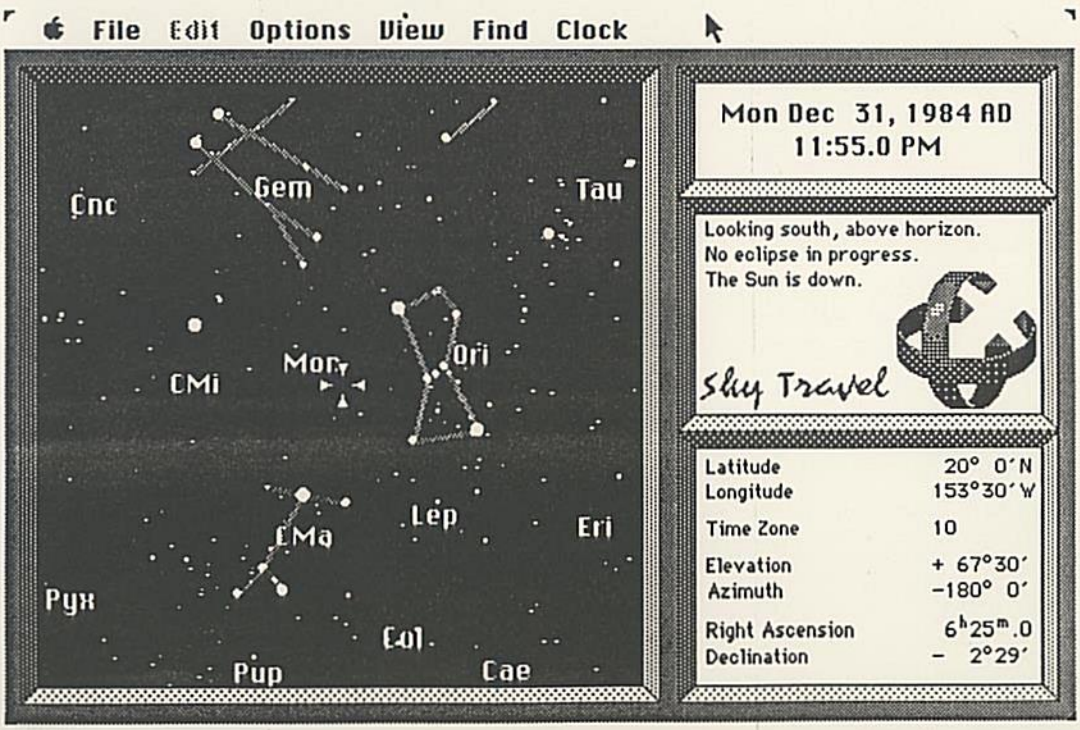
Now. pressing on the up-arrow, move your view upward as far as it will go. When you are finally looking straight up you will once again start turning in a counter-clockwise circle. The message in the Info Window will read "Looking north, at zenith." As you turn, looking straight up, the constellations Leo and Ursa Major rotate above you.

The above example illustrates most of the actions needed to follow any of the examples in the manual. Any additional operations will be covered in more detail under the description of the various commands.

Note that the "astronomical time" may differ from the "official time" in a given place because actual time-zone boundaries are based on political decisions. The official time may also vary during the year due to Daylight Savings Time. Imagine this example: while you are looking out the window early New Year's morning in Washington, D.C., your friends are flying back from a vacation in Hawaii. If you haven't changed the settings from the last example, you can now easily move to your friends' location. Select `World Map...` from the `Options` menu and set your location as follows:

```
   20°0'N Latitude
153°30'W Longitude
Time Zone 10
```

Flying over the eastern Pacific (time zone 10), your friends are five hours behind Washington,



D.C. (time zone 5), and are just getting ready to welcome the New Year. Click the `OK` button to dismiss the World Map, and you can see that the Clock Window shows that their local time is 11:55 PM on December 31, 1984.

If you wish to see their view of the southern sky, select `South` from the `View` menu. You should now be able to recognize both the familiar constellation Orion and the brightest of all stars, Sirius, just to the lower left of Orion in the constellation Canis Major. This is your friends' view as they celebrate New Year's Eve.

View from Hawaii

If you are in an area affected by Daylight Savings Time, **Sky Travel** may display the sky in your area "offset" by one hour. To correct for this, you may manually change the time zone from the `World Map...` function in the `Options` menu. When you are in the World Map, you can see the Time Zone Control near the Time Zone indicator. By pressing on this control, you can select any time zone regardless of your actual longitude. For example, the normal time zone for Los Angeles is 8, but during Daylight Savings Time it is 7. Clicking on the down-arrow of the Time Zone Control once after setting the proper location and before clicking the OK button will correct for this. This technique can also be used to compensate when you are in a time zone mandated by political boundaries, instead of longitude.

Now let's go on to learn more about the many useful features of **Sky Travel.**

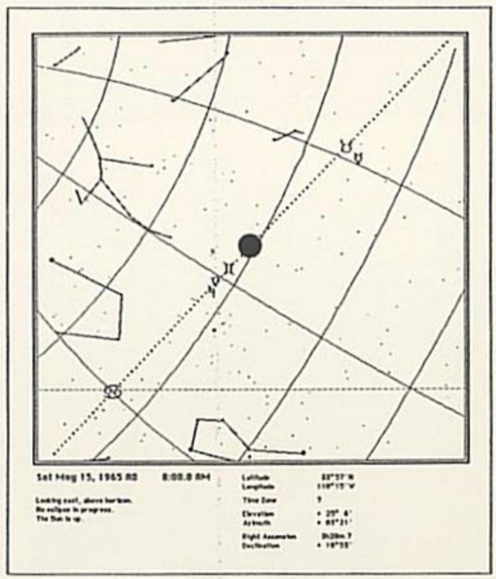
File

Save Chart to MacPaint File...	⌘/
Print Chart	⌘;
Quit	⌘Q

Save Chart to MacPaint File...

This command generates a full-page chart from the current display and places it in a MacPaint™ file. The chart contains all the information you see in the Primary Windows, but is scaled to fill an entire page. This allows you to use any paint program (all of them read MacPaint files) to embellish **Sky Travel** charts in any way you please.

Note: You may, of course, select any of **Sky Travel's** menu commands with the mouse, or you may use the command key ⌘ shortcuts shown in the menu (for example "⌘H" selects `Horizon` from the `Options` menu and "⌘;" selects `Print Chart` from the `File` menu).

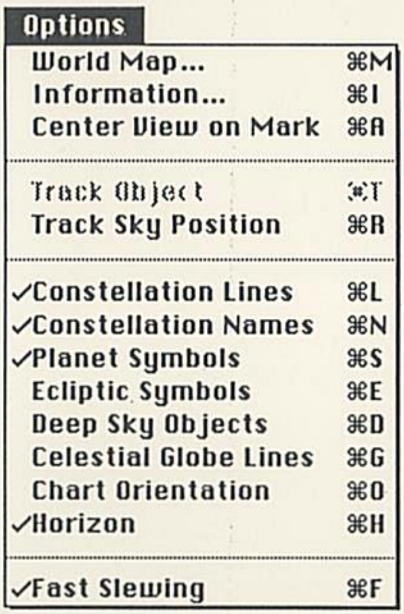


Print Chart

This command generates the same full-page chart as the `Save Chart to MacPaint File...` command (above), but sends it directly to whatever printer you have your system configured for.

Quit

This command does what you have probably come to expect a `Quit` command to do: **Sky Travel** shuts down and gives control to the program that started it (usually the Finder or the MiniFinder).



The `Options` menu contains many choices that affect how **Sky Travel** displays the sky.

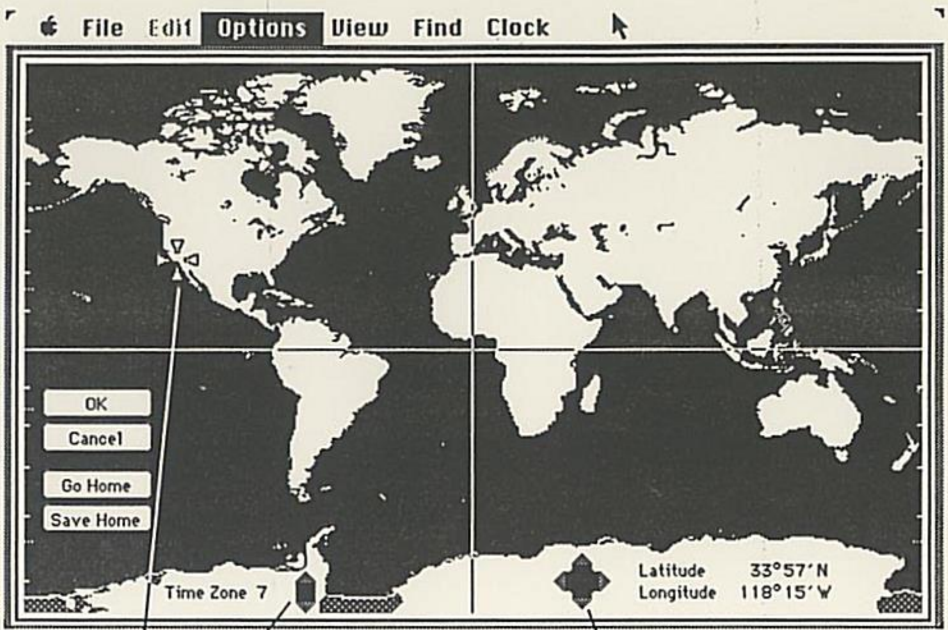
World Map...

The World Map is a Mercator Projection of Earth's surface: Earth's sphere is "projected" onto a cylinder, which then is unrolled into a flat map. Each location on Earth is defined by two coordinates: latitude and longitude.

Latitude, measured in degrees from the equator, goes from 0° at the equator to 90°N at the North Pole. Note that on a Mercator map, you cannot reach the poles. Also, the map reproduces actual distances and areas faithfully only near the equator but stretches everything more and more as you go near the poles. On the other hand, a Mercator Projection is ideal for mapping time zones because lines of constant longitude are parallel lines on the map.

Longitude is measured in degrees (or hours) from the Greenwich meridian near London, England, and is counted positive eastward and negative westward. Each 15° corresponds to an hour of time difference (360°/24 hours = 15°/hour). In a Mercator Projection, each hour zone is therefore a band 15° wide, parallel to the Greenwich meridian, which goes through the middle of the Greenwich, or "Zero Time Zone." At 180°E and 180°W, the eastern and western longitudes superimpose as the date line.

Selecting `World Map...` brings up the World Map Dialog, which contains a Mark similar to the one in the Sky Window. As you drag this Mark around the map, you will see the Latitude, Longitude, and Time Zone indicators track the Mark's location. Once you have adjusted your position in this coarse fashion, you can fine-tune your position by using the controls provided. The four-direction arrow cluster allows you to adjust



Mark **Time Zone Control** **Fine Position Control**

your latitude and longitude, and the up/down arrows allow you to adjust your time zone. Once you have these values as you want them, clicking the `OK` button will return you to the Primary Windows and **Sky Travel** will recalculate the view from your new position. Clicking the `Cancel` button returns you to the primary windows without changing your position.

The two other buttons, `Go Home` and `Save Home` allow you to define one spot on the map and one time zone as your home. When you click `Save Home` the current location of the Mark and the current value of the Time Zone Indicator are saved on disk. From then on, whenever you click the `Go Home` button these values are restored and the Mark will jump to the point you previously selected. Most people will probably use this to save the location that the Macintosh is at, to be able to get a reading of the sky in their area.

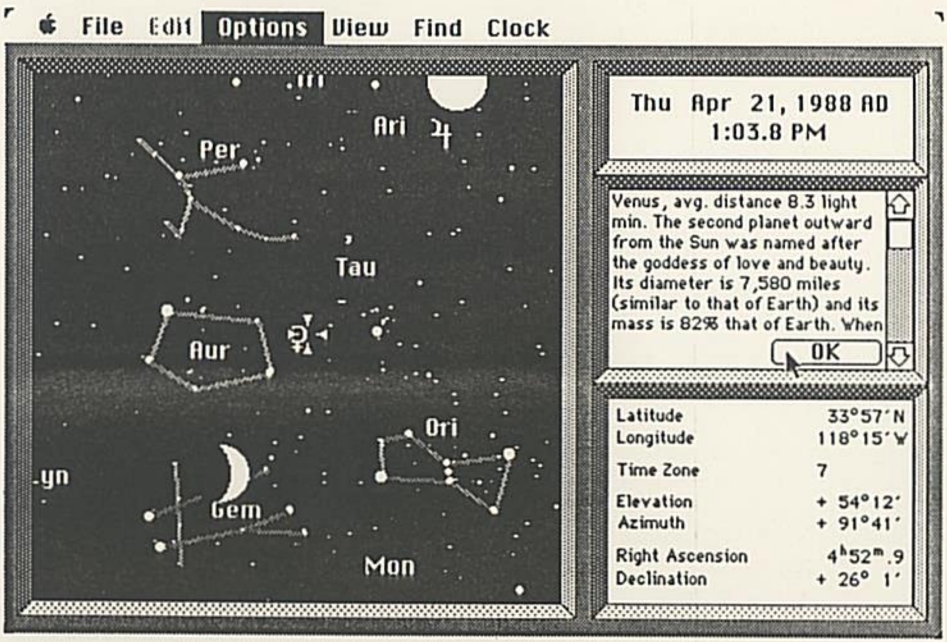
> **Note:** The `Save Home` button will not work if the **Sky Travel** disk is write-protected. `Go Home` will still restore the location previously saved.

Information...

To reduce the need to look things up, **Sky Travel** contains descriptions of the 88 constellations, more than 1200 stars, and more than 300 deep-sky objects in it's built-in database. You can access these by placing the Mark over a particular object in the Sky Window and selecting `Information...` from the `Options` menu. As a short cut, you may also double-click the mouse at the position of the object you want information on. This has the effect of bringing the Mark to the point double-clicked on and then asking for information.

Note: To ask for information on constellations, place the Mark near the center of the three-letter abbreviated name. Remember, the `Information...` command always gets information on the closest object to the Mark. You do not have to position the Mark exactly on the center of the object.

The information is displayed in the Info Window. If it is too long for the Info Window you may use the scroll bar to move through it. When you are done with the information, dismiss it by clicking the OK button, pressing the Return or Enter key, or simply clicking anywhere outside the Info Window.



The database identifies each star by its HD number and each deep-sky object by its NGC number. The HD numbers refer to the Henry Draper Catalog; the NGC numbers refer to the New General Catalog. In addition, the M numbers are given for deep-sky objects if they are included in Charles Messier's catalog dating from 1781 AD. These ID numbers will help you search astronomical literature for additional information, should you wish to do so. The text also gives you pertinent astronomical data, including mass and/or dimensions, and distance in light years.

Track Object

When **Sky Travel** first starts up, this command is "grayed," meaning it cannot be selected. This is because you must first select an object to track from the `Find` menu. Once you have done so, you will see that the words "Track Object" will have changed to denote the object you have selected. For example, if you select `Sun` froom the `Find` menu, `Track Object` will change to `Track Sun`. When you select this command, the Sun will always be brought to the center of the Sky Window when **Sky Travel**'s clock changes enough to cause the sky to be recalculated. This means the view will remain "locked-on" to the particular object you select, no matter how it moves. If you select another object from the `Find` menu while tracking is still on, you will then be tracking the new object.

Note: In the `Find` menu, the only type of object that cannot be tracked by the `Track Object` command are the constellations. This is because constellations represent fixed points in the sky, rather than moving objects. To track a constellation or other fixed point, use `Track Sky Position`.

Track Sky Position

By selecting `Track Sky Position`, you lock the center of your view on the point that the Mark is currently at. This means that as the clock changes, your elevation and azimuth *where* your telescope is pointing) will change while your right ascension and declination *what* your telescope is pointed at) will remain frozen. This is the opposite of the case when all tracking is off: your telescope remains pointed in the same direction, but due to the Earth's rotation it will point at different places in the sky over time.

If you use the Slewing Control or the `Center View on Mark` command to change your direction of view, the new point will be the one `Track Sky Position` follows.

Note: Although both `Track Object` and `Track Sky Position` can be individually toggled on and off, only one of them may be on at a time.

Constellation Lines

This command controls the display of simplified line diagrams, which are available to help locate principal constellations, especially those that are useful for orienting yourself in the sky. Selecting `Constellation Lines` toggles this feature on and off. By default, it is on.

Constellation Names

When `Constellation Names` is on (checked), three-letter abbreviations are displayed near their respective constellations. Selecting `Constellation Names` toggles this feature on and off. By default, it is on. As with `Constellation Lines` (above), `Constellation Names` is helpful for general orientation but may get in the way if you're trying to identify tightly clustered individual objects.

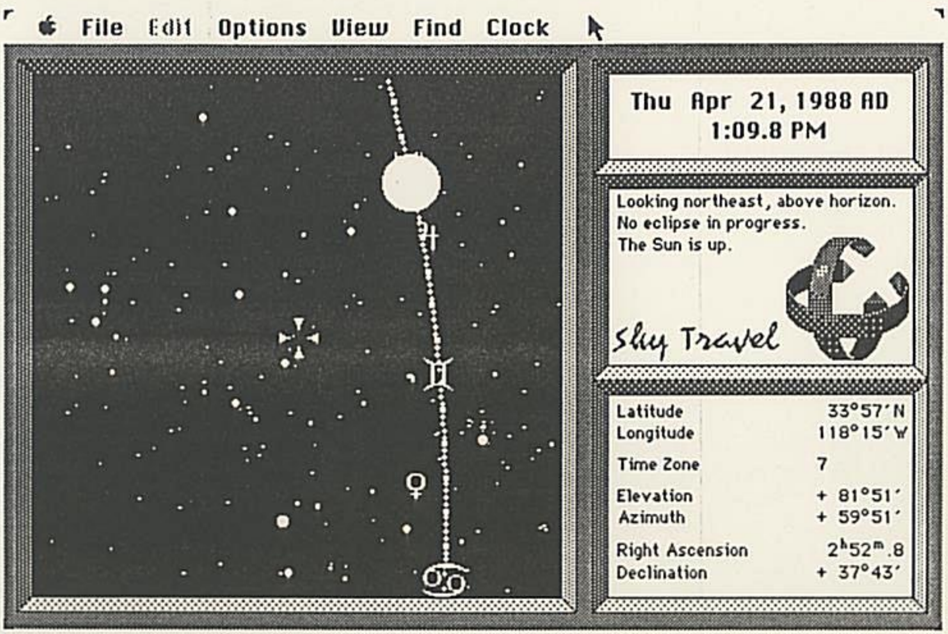
Planet Symbols

When Planet Symbols is on (checked), planets are displayed as their historical symbols to make them easy to identify. When off, they are displayed as dots whose size represents the planets' relative magnitudes (brightness). Selecting Planet Symbols toggles this feature on and off. By default, it is on.

Note: To make planet-identification still easier, small planetary symbols appear next to the names of the planets in the Find menu. You can simply pull this menu down without selecting anything and use it as a legend.

Ecliptic Symbols

When Ecliptic Symbols is turned on (checked) the twelve zodiacal symbols (Aries, Pisces, Taurus, etc.) will appear along the ecliptic, as well as small marks representing single degrees of ecliptic longitude. The ecliptic is the path that the Sun follows through the sky over the course of a year. The zodiac symbols are useful for marking the change of seasons (vernal and autumnal equinoxes, and summer and winter solstices) and for demonstrating precession. Selecting this feature toggles it on and off. By default, it is off.



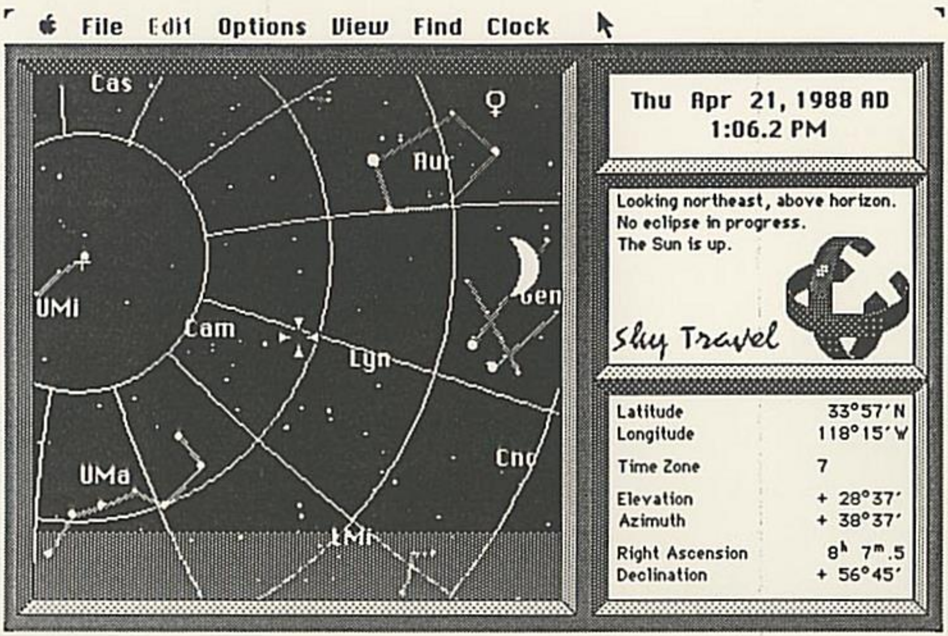
Note: You may use the `Information . . .` command to find out more about any of the twelve zodiacal symbols, but the small marks representing individual degrees are only for visual purposes, and do not have entries in the database.

Deep Sky Objects

The `Deep Sky Objects` command controls the display of several hundred interesting nebulae and galaxies, and is essential when you want to study the distant universe. Since these objects do clutter up the more familiar star patterns and make it more difficult to orient yourself, `Deep Sky Objects` is off (unchecked) by default. Selecting it will toggle it on and off.

Celestial Globe Lines

When `Celestial Globe Lines` is turned on (checked), coordinate lines representing right ascension and declination (corresponding to longitude and latitude on Earth) appear superimposed over the display. Small crosses representing the exact north and south celestial poles also appear. Selecting `Celestial Globe Lines` toggles them on and off. Because they take a while to draw, they are off by default.

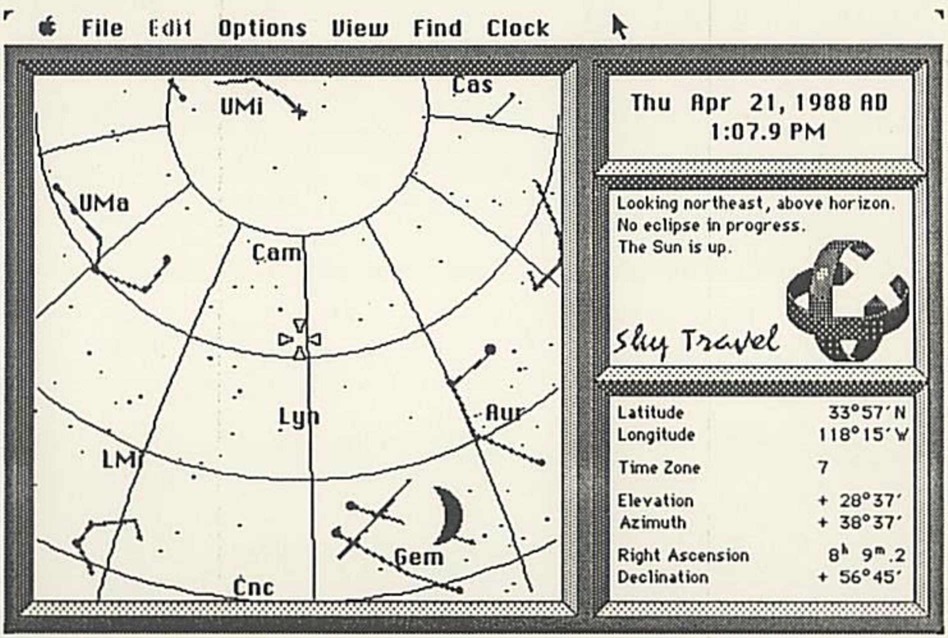


Note: When the `Fast Slewing` option is on (see below), `Celestial Globe Lines` are temporarily turned off while slewing.

Chart Orientation

Normally **Sky Travel** displays the sky as an observer standing somewhere on Earth would see it. When the `Chart Orientation` feature is on (checked) **Sky Travel** does three things. First, it "tilts" your view so the north celestial pole is always up. Second, it completely removes the horizon. Thirdly, it "inverts" the display so black symbols are displayed on a white background. These changes put the display in a standard format for star charts. Selecting `Chart Orientation` toggles it on and off. By default it is off.

Note: The `Print Chart` and `Save Chart to MacPaint File...` commands always output the view as black symbols on a white background, whether or not `Chart Orientation` is on.



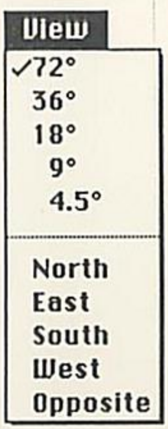
Horizon

When `Horizon` is on (the default), everything below the observer's horizon appears shaded. This produces the effect of a translucent Earth. If you would rather not have this, turning `Horizon` off will replace the shading with a single horizon line. The message in the Info Window will still tell you whether you are looking above or below the horizon, even if you can't see the horizon line.

Note: When the `Chart Orientation` command is on, no horizon of any kind will be displayed, printed or saved. Also, the `Print Chart` and `Save Chart to MacPaint File...` commands always display the horizon as a dashed line (as if the `Horizon` command is off).

Fast Slewing

When `Fast Slewing` is on (the default), **Sky Travel** will minimize the amount of calculation it has to do while the view is being slewed. It does this by not calculating the position of the many dim stars in its database until slewing is discontinued. It also temporarily shuts off the `Celestial Globe Lines` command (if it is on to begin with) until you stop slewing.



The `View` menu allows you to change two things: your viewing angle and your viewing direction.

72°, 36°, 18°, 9°, and 4.5°

These commands let you select the "lens" to use on your "telescope." To display objects approximately the same size as they would appear to the naked eye, use the `36°` setting. `72°` is the equivalent of a wide angle lens, and `4.5°` the equivalent of a telephoto lens.

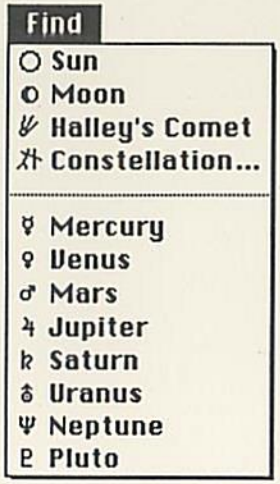
Note: It's always a good idea to start out with the widest angle, making sure that the objects you're interested in are well centered in the Sky Window before you reduce the angle; otherwise, you may lose your object outside the view and not find it easy to reorient yourself. For the same reason, it's easiest to decrease the angle in steps, rather than jumping from a very wide angle down to a narrow angle.

North, East, South, West

These commands provide quick ways to look any of the four major directions. `North`, for example, causes the view azimuth to be set to 0°, and `West` sets it to -90°.

Opposite

Selecting this commands points the view in a direction exactly opposite from the direction in which you were looking. For example, if you are looking due north (0° azimuth), and diagonally upward (+45° elevation), selecting `Opposite` will flip you to looking due south (-180° azimuth) and looking diagonally down (-45° elevation). One use of this command is to find out whether any planets are in direct opposition to the Sun. To do this, first select `Sun` from the `Find` menu to center the Sun in the Sky Window, then select `Opposite`.



The `Find` menu enables you to bring the Sun, Moon, planets, constellations, and Halley's Comet (during its 1985-86 appearance) to the center of the Sky Window. Instead of looking around the sky for a specific object, you can just select the object from the `Find` menu.

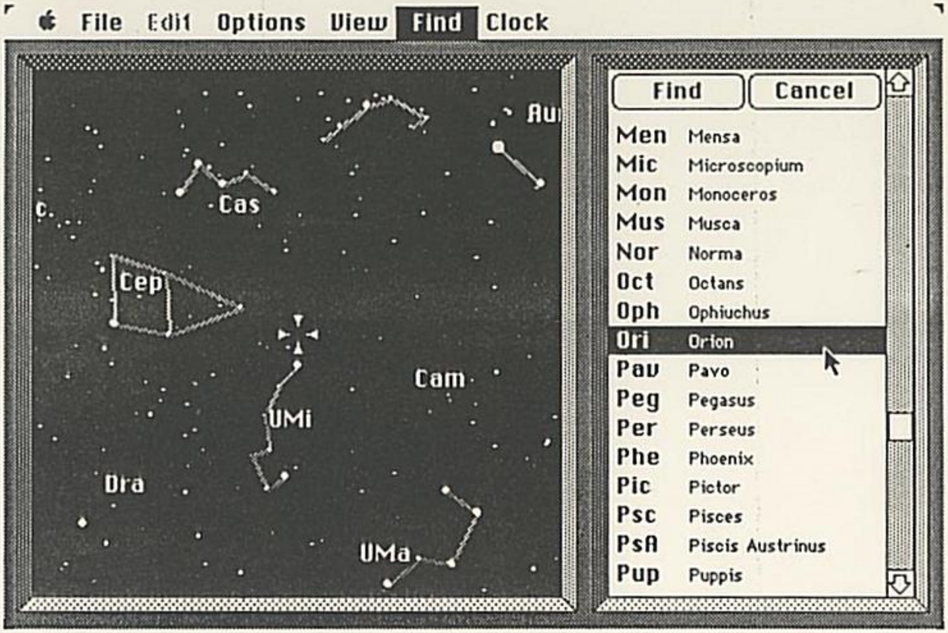
Sun, Moon, Halley's Comet, and Planets

These commands change your view so the selected object is centered in the Sky Window, and sets the `Track Object` command in the `Options` menu to the name of the selected object. For example, if you select `Mercury` from the `Find` menu, the Sky Window will be redisplayed with Mercury at it's center, and the `Track Object` command in the `Options` menu will then read `Track Mercury`. If `Track Object` is currently on, the newly selected object will begin to be tracked.

Note: If you want to track a constellation or any other fixed point in the sky you must use the `Track Sky Position` command in the `Options` menu.

Constellation...

Selecting this command causes the Constellation Dialog to appear containing a list of the 88 constellations and their three-letter abbreviations. You may use the scroll bar to move through the list. Alternately, typing the first letter of the constellation you wish to find will cause the list to jump to the first constellation beginning with that letter. Clicking on a name will cause it to be highlighted, and clicking on the `Find` button will bring that constellation to the center of the Sky Window. Clicking on the `Cancel` button dismisses the Find Constellation Dialog without changing anything.



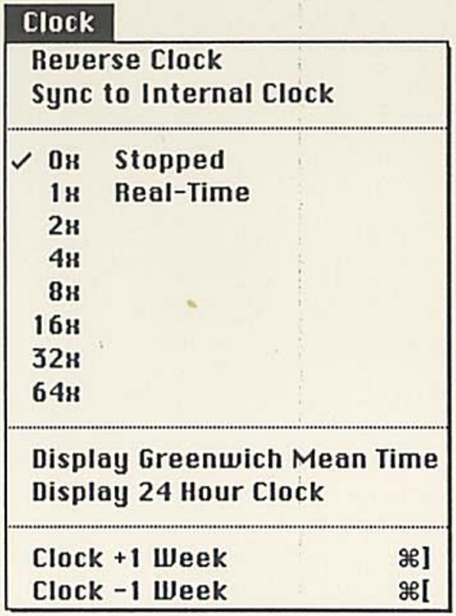
Note: Simply double-clicking the name of the constellation you wish to find has the same effect as clicking the Find button.

Reverse Clock

When **Sky Travel**'s clock is running it normally runs forward, but my selecting `Reverse Clock` you can watch events such as eclipses much as one would watch a film; being able to run the projector in both forward and reverse. Selecting this command toggles it on and off. It is off by default.

Sync to Internal Clock

When `Sync to Internal Clock` is on (the default), **Sky Travel** constantly monitors the very accurate clock built into the Macintosh and sets its own clock by it. This means you can lock the events on **Sky Travel**'s screen to events in the real world as they happen. When you turn on `Sync to Internal Clock`, **Sky Travel** shuts off the `Reverse Clock` command (if it is on) and sets the clock speed to `1x`. Assuming your location and time zone are set for your actual location (from the `World Map...` command in the `Options` menu), and the Macintosh internal clock is set correctly (from the `Alarm Clock` or `Control Panel` desk accessories in the `Apple` menu), what **Sky Travel** displays will be a true representation of the sky in your area at that particular moment.



Note: Changing the clock's forward/reverse direction or speed will shut off the `Sync to Internal Clock` command. It may also be toggled on and off manually by selecting it.

0x Stopped

When this speed is selected, the clock will be totally stopped and you will essentially be looking at a "snapshot" of time.

1x Real-Time

This is the default clock speed, along with `Sync to Internal Clock`, which is on by default. When this speed is selected, events in the Sky Window will proceed at the same pace as real life.

Note: Setting the clock for the current time and date and selecting `1x` is **not** the same as selecting `Sync to Internal Clock`. There are slight differences between the speed of the `1x` command and the speed of the Macintosh internal clock which would eventually become noticable after several hours as a "drift" away from the actual time.

2x, 4x, 8x, 16x, 32x, and 64x

These accelerated clock speeds allow you to view celestial events in a fraction of their normal time. `2x` is twice the speed of actual time, and when set for `64x`, events that would normally take an hour take about a minute to observe.

Display Greenwich Mean Time/Local Time

This command provides an easy way to use the standard method of telling time that astronomers use, called Greenwich Mean Time. Normally **Sky Travel**'s clock shows your local time for whatever time zone you have set for your location from the World Map. Selecting `Display Greenwich Mean Time` temporarily sets your time zone to 0, and reflects this change in the Clock Window by displaying the abbreviation `GMT` by the time. Selecting this command again changes the clock back to local time.

Display 24/12 Hour Clock

Military forces usually use a 24 hour clock instead of the usual 12 hour AM/PM clock. Selecting this command causes the `AM/PM` indicator in the Clock Window to disappear, and the hours of 1:00 PM - 12:00 AM to be displayed as 13:00 - 24:00. Selecting this command again restores the clock to 12 hour format.

Sky Travel Operating Hints

Once you become familiar with **Sky Travel** and begin using it on your own, you'll appreciate the many options it provides. However, for practice purposes, use the following settings:

- Clock Rate (from the `Clock` menu): `0x Stop`
- View Angle (from the `View` menu): `72°`
- Display options (from the `Options` menu): `Constellation Names`, `Constellation Lines`, `Planet Symbols`, `Horizon`, and `Fast Slewing` on (these are the defaults) and all others off.

For the following purposes, these changes are useful:

- Sunrise/Sunset studies: Set the clock rate to either `16x` or `32x`.
- Studies of galaxies: Turn `Deep Sky Objects` on and reduce the view angle in steps.
- Plotting trajectories on charts: Use `Track Object` and `Chart Orientation`.

Note: For special purposes, consult the examples in this manual and the technical notes at the end of the manual.

A GUIDED TOUR OF THE UNIVERSE

In this section, you'll take a tour of the universe by way of **Sky Travel**. Knowledge about the universe has affected human life through the ages, from religion and philosophy to such mundane tasks as being able to get from one place to another! Understanding of the world we live in has increased perhaps as much in this generation as in all the generations that preceded us. And the more we learn, the more amazing the universe becomes!

Geography

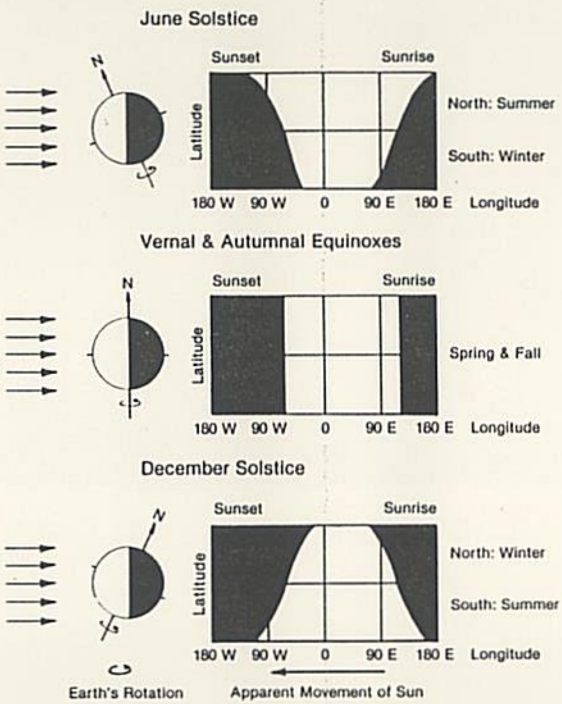
The first civilizations emerged in the valleys of the great rivers: the Nile (Egypt), the Euphrates and the Tigris (Babylonia and Assyria), the Indus and the Ganges (India), and the Yangtze and the Yellow (China). The fertility of these regions provided a necessary condition for the creation of cities: since some people could be freed from laboring solely to provide food, they were free to do other things. On the other hand, as farming and the raising of animals developed, the new societies became more vulnerable to such vagaries of nature as flooding and droughts. It became essential to know when to plant, when to irrigate, and when to harvest. In short, it became necessary to understand the seasons.

Days, Years, and Seasons

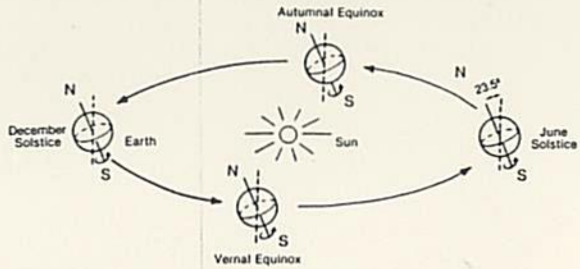
Time is the dimension that prevents everything from occurring simultaneously.

Anonymous

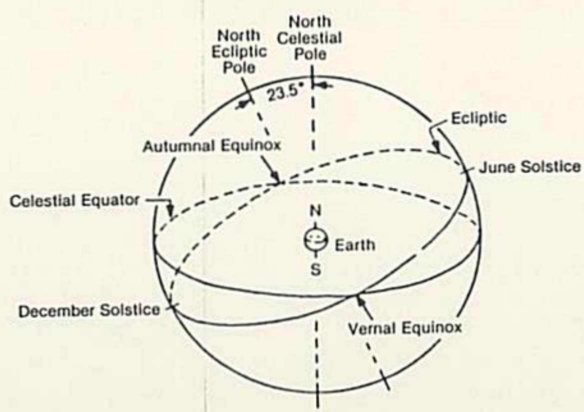
A solar day is the time it takes Earth to make one complete turn around its own axis. When a given location is facing the Sun, it's daytime there; when that location is no longer facing the Sun, it's night. Earth's axis of rotation is tilted 23.5° with respect to the plane of Earth's orbit. One result of this is that days and nights are not of equal length except at the equator (all year) and at other locations twice a year (the vernal, or spring, and autumnal, or fall, equinoxes). The following illustrations show Earth's shadow during its rotation and varying orbital positions around the Sun and mercator maps of Earth showing Earth's shadow during the solstices and equinoxes.



It takes Earth 365.2422 solar days to complete an orbit around the Sun. This is the solar year on which our calendar is based. After the solar year is completed, the cyclic changes in daylight and in seasons are repeated. Like the variations in the length of the day during the year, the seasons are the result of the inclination of Earth's axis of rotation with respect to the plane of Earth's orbit. When the North pole is tilted toward the Sun, it's summer in the Northern Hemisphere. When the North Pole points away from the Sun, it's winter. The seasons in the Southern Hemisphere are the opposite of those in the Northern Hemisphere.

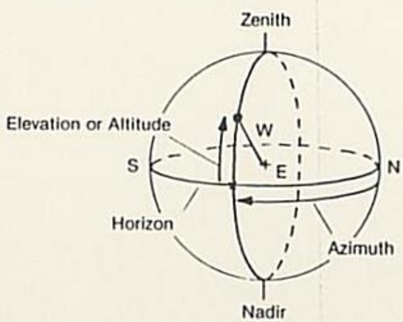


When these motions are translated into the apparent movement of the Sun on the celestial sphere, that is the way things actually appear to an observer on Earth.

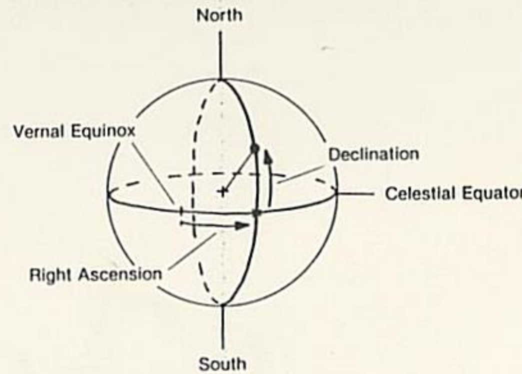


The Sun appears to travel in a great circle, called the ecliptic, which is tilted 23.5° with respect to the celestial equator. This is the angle Earth's axis of rotation makes the Earth's orbit. Ancient astronomers knew the celestial sphere extremely well, including the precise location of the ecliptic. However, they also believed that Earth was stationary (after all, you can't feel the rotation) and that it was the center of the universe. Nevertheless, even though we now know much more about the spatial geometry of the universe, the sky still appears to be the same way it did to ancient peoples. Therefore, it's still useful to use this representation of the sky, and, in fact, it's the way it's displayed in a planetarium!

Before you look at some specific demonstrations, you'll want to learn the meaning of some of the numbers that appear in the Position Window. The four numbers at the bottom of the window are the coordinates of the Mark in the Sky Window. By moving the Mark over any visible object, you can directly read its coordinates. `Elevation` and `Azimuth` are the direction coordinates for a point in the sky as seen by the observer with reference to the horizon and a meridian (great circle) through the zenith (the point directly overhead). These numbers are convenient for measuring, but they change constantly as Earth rotates.

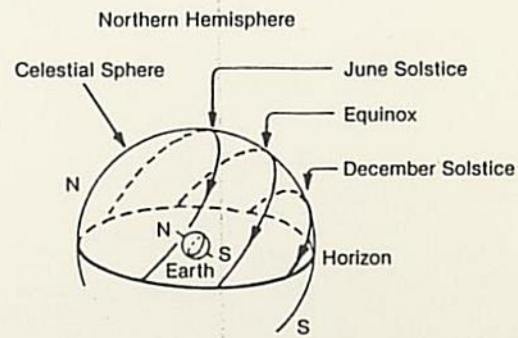


The other numbers, `Right Ascension` and `Declination`, are the position coordinates on the celestial sphere corresponding to the longitude and latitude on Earth. Maps for locating stars in the sky are often Mercator-style maps corresponding to the maps of Earth discussed earlier.



Sunrise and Sunset at Washington, D.C.

Sky Travel lets you observe and study the movements of the Sun at different latitudes and times of year. The illustration below shows how Earth's tilted axis affects the elevation of the Sun in the Northern Hemisphere during the year. This is quite familiar to people living in North America and Europe.



Now you're ready to use **Sky Travel** to simulate a familiar sunrise.

Go to the World Map Dialog by selecting `World Map...` from the `Options` menu. Set your location to Washington, D.C.

`38°54'N Latitide`
`77° 0'W Longitude`
`Time Zone 5`

Click on the `OK` button to dismiss the World Map Dialog and then set the date and time to the following (but make sure the clock is at `0x Stopped` first):

`Fri Jul 4, 1986 AD`
`2:45.0 AM`

Now make sure that the `Constellation Lines` and `Planet Symbols` commands are on, and that the view angle is set to `72°`. Locate the Moon by selecting `Moon` from the `Find` menu. You now see that it's night in Washington, with a new Moon just above the horizon. Now start the clock moving by selecting `32x` from the `Clock` menu. (If you're in a hurry, select `64x`.) Watch the sky as the Sun rises in the constellation Gemini. Mercury and Venus on this day rise after the Sun; therefore, they won't be visible until shortly after sunset.

To confirm this, set the time to 5:00 PM, select `Moon` again from the `Find` menu, and watch the setting Sun.

> **Note:** You don't have to stop the clock. It will pause while you are changing its settings, and then continue when you finish.

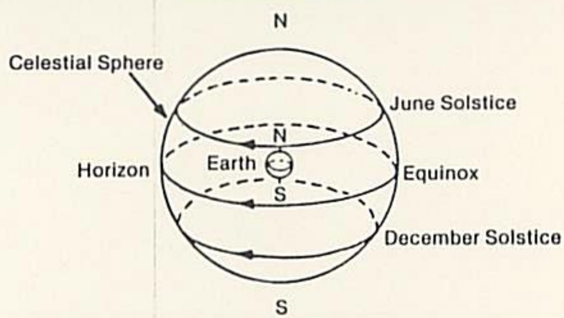
At about 6:00 PM, the new Moon is setting, and at about 7:30 PM the Sun sets. You can see the symbols of Mercury and Venus. Now that you know where they are, turn off `Planet Symbols` from the `Options` menu so you can see the planets as bright star shapes.

Around 8:50 PM, Mercury is setting below the horizon. Venus shines brightly in the constellation Leo before setting below the north-western horizon.

The Sun At Equinox Near the Poles

Near the poles, the Sun moves parallel to the horizon. The Sun is above the horizon all summer and below it all winter. At the equinox, it moves along the horizon. In the Northern Hemisphere, it moves to the right; in the Southern Hemisphere, it moves to the left.

North and South Poles



Equinox Near the North Pole

Sky Travel can demonstrate the equinox near the North Pole, where the Sun moves to the right. Make sure the clock is stopped, then go to the world map, and drag the Mark to the vertical center line (the Greenwich meridian), and as far north as it will go.

> **Note:** Since this is a mercator-style map, you cannot quite get to the exact North Pole, and so your setting will be approximate, but sufficient for our purposes.

`83°40'N Latitude`
`0° 0'W Longitude`
`Time Zone 0`

Set the date and time:

```
Mon Mar 19, 1984 AD
    12:00.0 PM
```

Locate the Sun using the `Find` menu, then move it to the left side of the Sky Window by pressing on the right-arrow (remember, this is the one that *points to the right,* not the right-most one) in the Slewing Control. Set the clock rate to `32x`, and observe that the Sun now moves to the right along the horizon, neither setting nor rising.

Equinox Near the South Pole

Follow the steps below to see the same phenomenon near the South Pole. Notice that here the Sun moves to the left.

Stop the clock, and return to the World Map. Leave the Mark at longitude 0°, but drag it as far as it will go toward the South Pole. Set the date and time to the following:

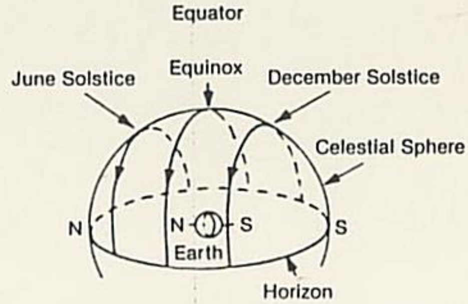

```
Thu Mar 22, 1984 AD
    12:00.0 PM
```

Find the Sun again, and move it to the right of the Sky Window by pressing on the left-arrow in the slewing gadget. When you start the clock, the Sun will now move to the left along the horizon, again neither rising nor setting.

> **Note:** Repeating these examples with the `Ecliptic Symbols`, `Celestial Globe Lines`, and `Chart Orientation` commands activated is particularly instructive. The Sun crosses the ecliptic at the first point of the zodiac sign Aries, whose symbol is the ram's head.

Sunrise and Sunset at the Equator

At the equator, the celestial North and South Poles lie at the horizon. Both the Sun and the stars rise straight up on the east side and set straight down on the west side of the horizon.



Follow the following instructions to see both a sunrise and a sunset at the equator.

Stop the clock and return to the World Map. Set both the latitude and longitude to 0° (the equator at the Greenwich meridian). Set the date and time as follows:

```
Wed Dec 21, 1983 AD
    5:00.0 AM
```

Find the Sun so that it is at the center of the Sky Winow, then turn on the clock. The Sun now rises straight up from the horizon, as do the stars. To watch the Sun set, change the time to 5:00 PM and watch the Sun go straight down, followed by the same motion of the stars.

> **Note:** If you repeat this example with `Ecliptic Symbols`, `Celestial Globe Lines`, and `Chart Orientation` on, the movement of the Sun through the first point of Capricorn on the ecliptic marks and the exact time of the winter solstice.

Astronomy

Each location on Earth is defined by two coordinates, latitude and longitude. Similarly, each location on the celestial sphere is defined by a similar pair of coordinates, declination and right ascension. Declination, measured in degrees from the celestial equator, goes from 0° at the equator to +90° at the celestial North Pole and -90° at the celestial South Pole.

> **Note:** Three sky orientation maps are shown on page 28. You'll use them later to help you find your way around the sky.

Note that on a Mercator map, you cannot reach the poles; also, the map faithfully reproduces stellar distances and shapes of constellations only near the equator, but it stretches everything more and more as you move closer to the poles. On the other hand, a Mercator projection has the advantage that the circles of constant declination and right ascension, which intersect each other at right angles on the sphere, become sets of parallel lines, which still intersect each other at right angles on the Mercator projection.

Right ascension is measured in degrees (or hours) from the vernal equinox, marked by the ram's head symbol of the first point of Aries (the location of the Sun on the first day of spring, when day and night are of equal length). As is the case for longitudes on Earth, each 15° esponds to an hour of time difference (360°/24 hours = 15°/hour). The Mercator map displays line diagrams of prominent constellations; these are particularly useful when you're trying to orient yourself in the sky. A few geometrical star patterns commonly used by navigators are also shown. Since the polar regions cannot be shown on a Mercator map, yet are important regions of the sky, special projections of both the north and south polar regions are also shown. All of these maps are discussed in more detail in following sections.

The Position Window displays the right ascension and declination of the Mark location. Therefore, if you know these coordinates for any given sky object, you can readily locate it on the map and on your screen. The right ascensions and declinations of the bright stars used in navigation, as well as those of some other prominent stars, are listed in a table in the back of this manual.

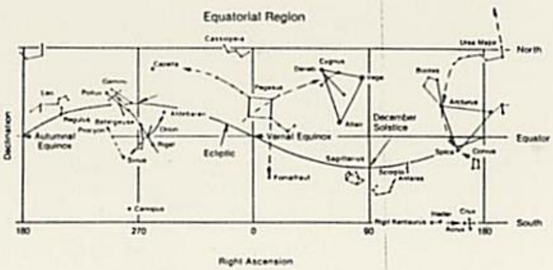
Star Recognition/Constellations

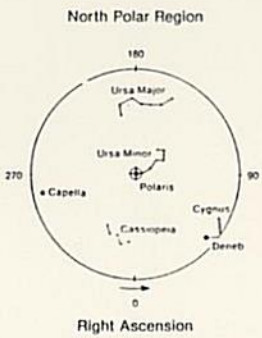
The Ram, the Bull, the Heavenly Twins,
Next the Crab, and the Lion shines,
The Virgin and the Scales,
The Scorpion, Archer, and Seagoat,
The Man that pours the water out,
And the Fish with the glittering scales.

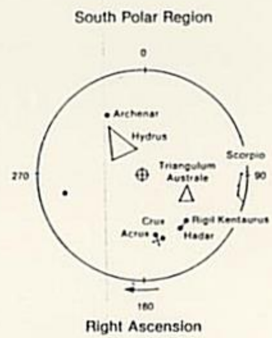
from an old English nursery rhyme

During the last two millennia BC, astrologer-priests in the ancient Assyrian and Babylonian civilizations named particular star patterns after their gods, heroes, and animals. The Greeks later changed the names to those of their own gods and heroes, and the Romans, when they adopted the basic Greek mythology, gave most of the constellations the Latin names we still use today.

Although the grouping of stars into constellations has no scientific meaning, some constellations are still useful as signposts when you want to orient yourself in the sky. **Sky Travel** displays simplified line diagrams of some of the more conspicuous constellations and gives an abbreviated name next to every constellation. When you no longer need these aids, or if you're already an expert star-finder, you may prefer to turn these options off. However, if you're a beginner, you may find these features helpful.



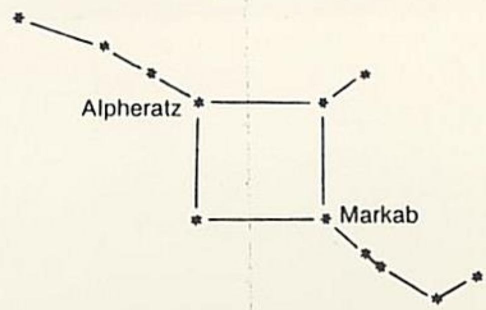




Look at the sky orientation maps above. Note that certain stars are "pointer stars". By drawing imaginary lines through them, you can more easily locate other stars. The most useful instances are marked on the maps.

A well-known example of using pointer stars is that of finding Polaris by means of the Big Dipper (Ursa Major), perhaps the most familiar constellation in the northern sky (see the North Polar Region Map). A line extended through the stars Merak and Dubhe in the Big Dipper leads directly to Polaris, the North Star. Polaris, in turn, is the last star in the handle of the constellation the Little Dipper (Ursa Minor). Note also that a curved line extended through the handle of the Big Dipper leads to Arcturus, the bright star at the point of the kite-shaped constellation Bootes, and farther down to the bright star Spica in the rather inconspicuous constellation Virgo (see the Equatorial Region map).

If you go through Polaris, almost directly opposite the Little Dipper you'll find the constellation Cassiopeia, easily recognized by its open-W shape. Farther away from Polaris in the same direction is the readily recognizable "Great Square" of Pegasus, with the bright stars Alpheratz and Markab in opposite corners. A line from Markab through Alpheratz leads directly to Marfak in Perseus and to Capella in Auriga. A line through the opposite corners of the square leads to the constellation Cygnus (also called the Northern Cross because of its shape) and farther on to the bright star Vega.



Orion, one of the most beautiful constellations of the northern sky in winter, is another good starting point because of its prominence. A line through the corner stars Rigel and Betelgeuse leads directly to Castor and Pollux, the twin head stars in Gemini.

Another line through the stars in Orion's belt leads on one side to Aldebaran in Taurus, and on the other side to Sirius, the brightest star in the sky, in the otherwise inconspicuous constellation Canis Major.

Other useful examples are the line that can be drawn through two of the stars in the sail-shaped constellation Corvus, leading to Spica, and the line from the Southern Cross (Crux) to the bright stars Hadar and Rigil Kentaurus.

Three conspicuous triangles, which are not constellations, are used by navigators because the triangles contain very bright stars and are easy to locate. They are Procyon-Betelgeuse-Sirius, Deneb-Vega-Altair, and Arcturus-Denebola-Spica, where Denebola is the star at the tail of the constellation Leo.

Signposts like these will help you locate many less conspicuous but nevertheless very interesting objects in the sky. By pointing and clicking the mouse button, you can identify any visible object with **Sky Travel**. As an exercise, use the `Constellation...` command in the `Find` menu to locate the Big Dipper (UMa). Then identify the individual star in the constellation.

Telescope Stars and Galaxies

Many stars that appear as single stars to the naked eye are actually double stars visible even at relatively low magnification. **Sky Travel** can be used as a low-power telescope so that you can see this phenomenon. One example is Epsilon Lyrae.

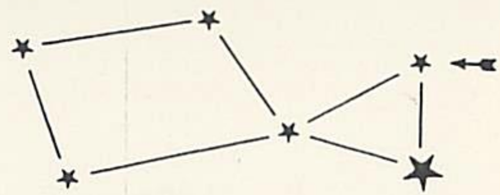
Set your location on the World Map to Kansas City:

```
 39° 7'N Latitude
94°39'W Longitude
Time Zone 6
```

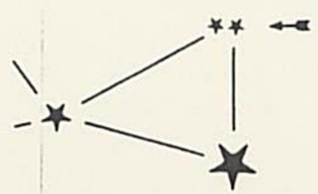
Make sure the clock is stopped, then set the date and time to the following:

```
Wed Aug 28, 1985 AD
    11:00.0 PM
```

Set the view angle to `72°`. From the `Options` menu, make sure `Constellation Names` and `Constellation Lines` commands are turned on. Select `Constellation...` from the `Find` menu, and select the constellation Lyra (`Lyr`). The characteristic connected diamond/triangle pattern with the bright star Vega is now in the center of the screen. Look at the rather faint star above and to the right of Vega.



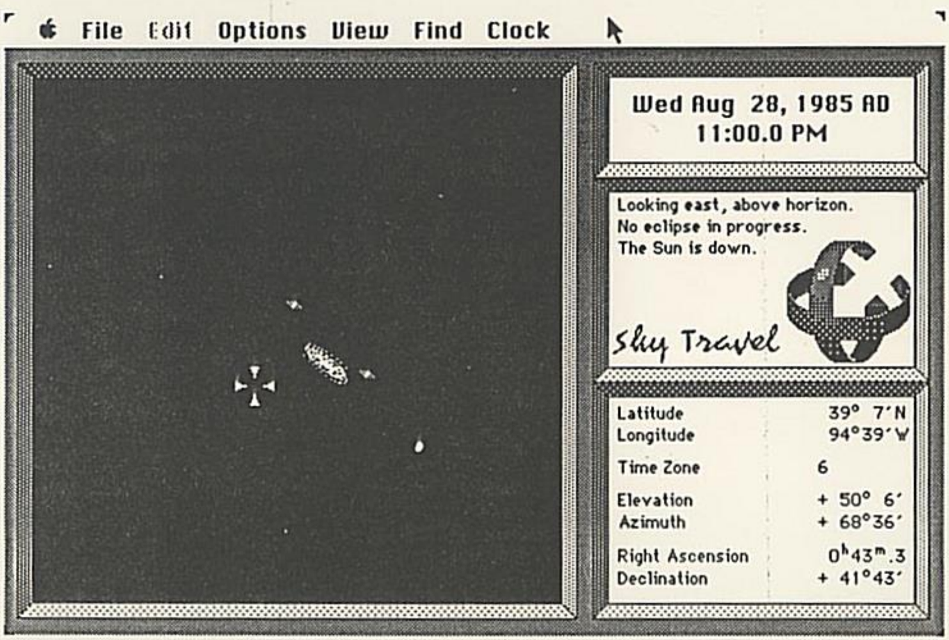
At this magnification it looks perfectly normal. Now lower the view angle to `36°` using the `View` menu. Place the cursor on the faint star, and select `Center View on Mark` from the `Options` menu to center the object in the Sky Window. Gradually lower the view angle, recentering the object each time. When you reach `4.5°`, turn off `Constellation Lines`, and you will see the faint star has resolved into two stars.



Place the Mark in turn over each individual star, and select `Information...` from the `Options` menu (or just double click the mouse button on the star). The stars are Epsilon-1 and Epsilon-2 Lyrae.

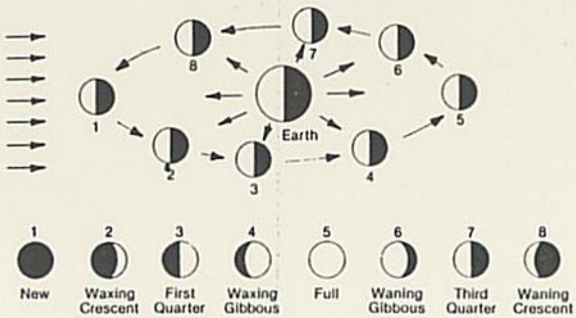
Here's how to resolve the great galaxy in Andromeda into three separate galaxies:

Stay in Kansas City, the same day and same time. Increase the view angle back to 72°; then select Andromeda (`And`) from the `Constellation` command in the `Find` menu. Now turn on `Deep Sky Objects` from the `Options` menu. Place the cursor on the conspicuous oval galaxy just to the left of Andromeda. Select Center Cursor from the `Options` menu to center the galaxy on the screen. Gradually lower the view angle as before. You now see two small satellite galaxies near the Andromeda Galaxy. Use the `Information...` command from the `Options` menu to identify all three.



Phases of the Moon

The phases of the Moon are caused by the position of the Moon, in relation to the Sun, as seen from Earth. According to a Latin saying, the Moon fools you ("Luna fallit"): when it looks like a C ("crescit" means "it increases"), it's actually decreasing; and when it looks like a D ("decrescit" means "it decreases"), it's actually increasing. The illustration shows why that's so.



Sky Travel calculates the Moon's phases during regular updates of the Moon's position in the sky. This is illustrated in the following example of the Moon phases as seen from New York City during the month of December 1983:

Day	NY Time	Moon Phase
Dec 4	8:47.0 AM	New
Dec 11	4:00.0 PM	1st Quarter
Dec 19	7:00.0 PM	Full
Dec 26	11:55.0 PM	3rd Quarter

Set the World Map to New York City:

40°43'N Latitude
74° 1'W Longitude
Time Zone 5

Set the date and time:

Sun Dec 4, 1983 AD
8:47.0 AM

The Moon is now new. In order to see it, set the view angle to 4.5°, and locate the Moon using the Find menu.

Reset the date and time:

Sun Dec 11, 1983 AD
4:00.0 PM

Find the Moon, which is now in its first quarter.

Change the date and time to the following:

Mon Dec 19, 1983 AD
9:00.0 PM

On this date, the Moon is full.

Finally, set the date and time to the following:

Mon Dec 26, 1983 AD
11:55.0 PM

Now the Moon is in its third quarter.

Solar Eclipses

WARNING! *Never* look directly at the Sun, even during a *total* eclipse!

A solar eclipse occurs when the Moon blocks the Sun's light at some location on Earth. Although the Moon is much smaller than the Sun, the Moon is closer to Earth, so the apparent sizes are quite similar as seen from Earth. When the Moon almost completely covers the solar disk, we call the eclipse ***total***.

One of the first reliable records of a solar eclipse dates from the Greek historian Thucydides. He reported an eclipse that occurred in the afternoon on August 3 in the year 431 BC. The eclipse was not total, but enough of the Sun was darkened to make some bright stars appear. The location of the observation was not mentioned, but since Thucydides was an Athenian, it's assumed to have been Athens.

Now you can look at that eclipse with **Sky Travel**.

Take a journey to Athens on the World Map:

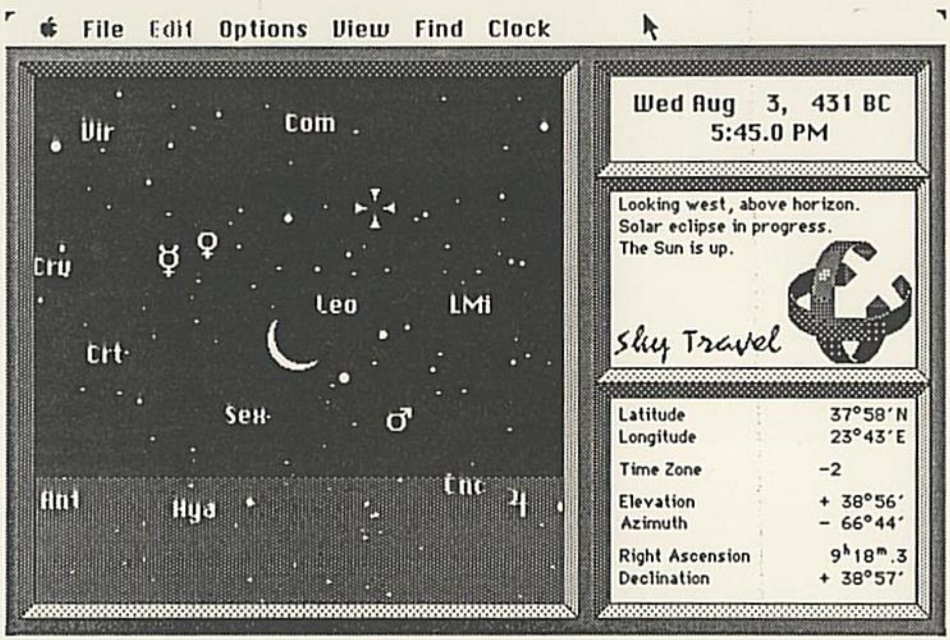
37°58'N Latitude
23°43'E Longitude
Time Zone -2

Set the date and time:

Wed Aug 3, 431 BC
4:30.0 PM

Note: Remember to set the year to BC. Because of the large change in time, when you finish setting the clock, the mouse pointer will change to the Precessing symbol for a few moments while **Sky Travel** calculates the Earth's precession.

Set the view angle to `72°`. Make sure the `Planet Symbols` option is on, and find the Sun. Next, use the Slewing Control to move the Sun to the upper-left part of the screen. Now set the clock rate to `32x`. The eclipse starts before 5:00 PM and is over by 6:45 PM. The illustration below shows the screen at 5:45 PM, local Athens time. Note the crescent Sun and the planets Mercury, Venus, and Mars against a sky which was about as bright as twilight at that time, confirming Thucydides's report!



Next, you can try to confirm an eclipse predicted to occur in the future — for example, the one predicted for June 30, 1992:

You have decided that the island of Tristan da Cunha might be a favorable place to observe and photograph this eclipse. So go to the World Map and set your location:

`37°15'S Latitude`
`12°30'W Longitude`
`Time Zone 1`

Set the date and time:

`Tue Jun 30, 1992 AD`
`9:35.0 AM`

Set your view angle to `36°`, and center the Sun on your screen; then use the Slewing Control to move the Sun to the right side of the screen. Next, set the clock rate to `16x`, and you'll see an eclipse take place.

Now, before you pack your bags for Tristan da

Cunha, you realize that total solar eclipses are extremely location-dependent because of the small diameter of the Moon's shadow; and under even the best conditions, totality last only about five minutes. The eclipse is not total at Tristan da Cunha. Nor is it total at the island of St. Helena. But you could schedule your trip so that you'd be sailing from one island to the other and be at 24°56' latitude and at the longitude of Tristan da Cunha at around 9:30 AM local time. That way (weather permitting) you'd see a total eclipse by 11:00 AM!

Note: For observations requiring pinpoint accuracy, such as determining the precise path of totality of a solar eclipse, you'll need specialized computer programs. Nevertheless, **Sky Travel** gives a quick and rather accurate account of the main features of a wide range of celestial phenomena over very large time spans. A more detailed discussion of the structure and precision of the program appears in Technical Notes in the back of this manual.

Lunar Eclipses

A lunar eclipse occurs when Earth blocks the line of sight between the Sun and some location on the Moon. If the shadow of Earth completely covers the Moon's surface, the lunar eclipse is total. Therefore, though solar eclipses can occur only when the Moon is approximately new, lunar eclipses can occur only when the Moon is full. Total lunar eclipses are less frequent than solar eclipses, but they're much more common from any given location; lunar eclipses are always visible from about half the surface of Earth, while solar eclipses are visible only from within the narrow path traced on Earth by the Moon's small shadow. Examples of famous historical lunar eclipses appear on page 49.

Planetary Transits

The inferior planets, Mercury and Venus, are closer to the Sun than Earth is. Therefore, when they block the line of sight between the Sun and some position on Earth, a planetary transit occurs.

A planetary transit is similar to a solar eclipse, which is caused by the Moon blocking the line of sign between the Sun and some location on Earth. However, planetary transits are much more difficult to observe, in the case of Mercury because of the small apparent size of the planet and in the case of Venus because of the infrequency of the transits.

Early attempts to observe transits of Mercury, the smallest and innermost of the two planets, were unreliable due to confusion with Sun spots. The first recorded Mercury transit was one predicted by Johannes Kepler to occur on November 7, 1631 AD. Kepler himself died the year before, but an astronomer in Paris, Pierre Gassendi, observed and recorded the path of the planet across the surface of the Sun. A second Mercury transit predicted to occur on May 3, 1661 AD, was observed independently by the Polish astronomer Johann Hevelius from Gdansk, Poland, and by the Dutch scientist Christiaan Huygens from London (Gingerich: 1983).

Here's how you can verify these early recorded transits of Mercury. To see the Mercury transit observed by Gassendi, set your location to Paris on the World Map:

```
48°52'N Latitude
  2°20'E Longitude
Time Zone 0
```

Set the date and time:

`Fri Nov 7, 1631 AD`
`7:00.0 AM`

In the `Options` menu, turn off everything except `Horizon` and `Fast Slewing`. Set the view angle to `4.5°`, then select `Sun` from the `Find` menu so the Sun is centered in the Sky Window. Now select `Mercury` from the `Find` menu and `Track Object` from the `Options` menu (which will read `Track Mercury` at that time). Set the clock rate to `64x`. You will see the Mark move slowly across the face of the Sun during the day, emerging as a tiny dot in the center of the Mark at 10:16 AM.

Now stop the clock, and adjust the World Map location for London, and date and time values to the following:

`51°30'N Latitude`
`0°10'W Longitude`
`Time Zone 0`

`Tue May 03, 1661 AD`
`12:01.0 PM`

Again, center the Sun in the sky; then center Mercury. Set the clock rate to `64x`, and observe the result. This is the Mercury transit observed by Huygens.

The first predicted transit of Venus was calculated from kepler's laws to occur on December 7, 1631 AD, but unfortunately the Sun was below the horizon from Europe at the time of the transit, so no observation of the transit could be made from there. The next transit was predicted to occur on December 4, 1639 AD, and was observed and recorded by the English astronomer and clergyman Jeremiah Horrocks. No Venus transits have occurred during the past 100 years. The next transits will occur on June 8, 2004, and on June 5-6, 2012 (Janiczek and Houchins: 1974).

To check both a past and a future Venus transit, first stop the clock. If you're continuing from the previous example, stay in London; otherwise, go back to the World Map and set the location for London:

`51°30'N Latitude`
`0°10'W Longitude`
`Time Zone 0`

Set the date and time:

`Sun Dec 4, 1639 AD`
`3:00.0 PM`

Find the Sun. Set the clock rate to `64x`. This is the Venus transit observed by Horrocks.

Stop the clock again and go to New York. Set the place and date:

`41°43'N Latitude`
`74°01'W Longitude`
`Time Zone 5`

`Tue Jun 8, 2004 AD`
`4:00.0 AM`

Find the Sun. Set the clock rate to `64x`. This is one of the Venus transits yet to come.

Planetary Occultations

Planetary occultations are eclipses of one planet by another planet or by the Moon, as seen from Earth.

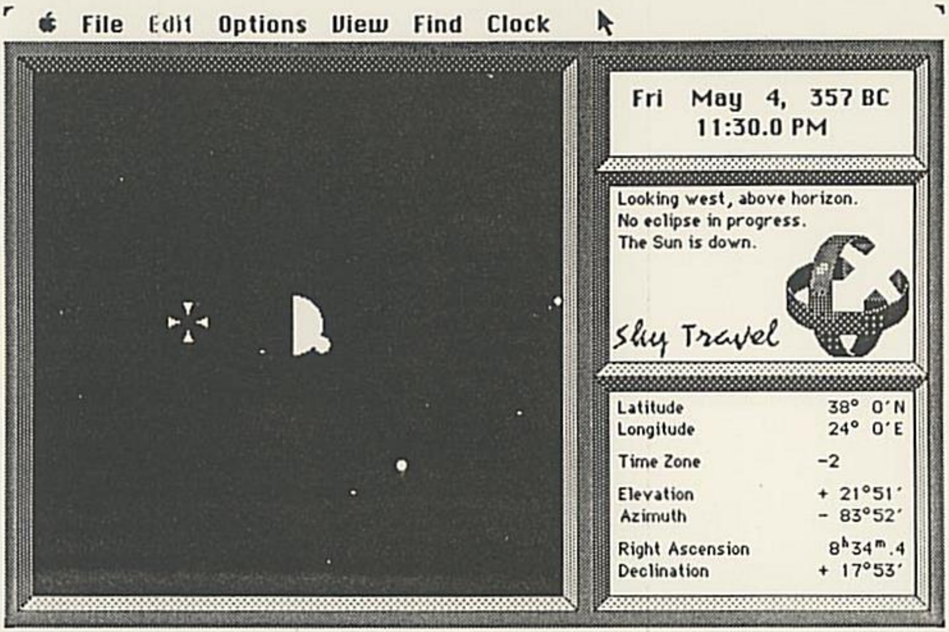
The Greek philosopher Aristotle observed and recorded an occultation of Mars by the half-Moon on May 4, 357 BC. He described how Mars disappeared behind the dark side of the Moon and then reappeared on the bright side. Aristotle used this observation as conclusive proof that the Moon is closer to Earth than Mars is and commented that similar, earlier observations by the Egyptians and Babylonians had proven this to be the case also for the other then-known planets (Richardson and Clark: 1978).

Here's how you can re-create this personal observation by Aristotle. Set your location to Athens and your date and time as follows:

38°00'N Latitude
24°00'E Longitude
Time Zone -2
Fri May 4, 357 BC
6:00.0 PM

Find Mars, turn on `Track Object` (which will read `Track Mars`), set the view angle to `4.5°`, and make sure the `Planet Symbols` option is off.

Then set the clock rate to `16x`. Watch from 6:00 PM to about 10:00 PM. Mars passes behind the dark side of the Moon and reappears on the bright side, just as Aristotle observed.



As a young man in Tubingen, Germany, Johannes Kepler observed and recorded a rare occultation of Jupiter by Mars on January 19, 1591 AD. Because of the distinct red color of Mars, Kepler was able to see that Mars covered Jupiter rather than the other way around. He therefore concluded —based on the Artistotelian argument previously explained — that Mars is closer to Earth than Jupiter is. You can observe this event from Tubingen, near Stuttgart, West Germany.

48° 5'N Latitude
7° 4'E Longitude
Time Zone 0
Sat Jan 19, 1591 AD
7:00.0 AM

Find Jupiter, then Mars; note their proximity. Set your view angle at 36° and the clock rate to 32x. Then watch the motion of the two planets.

An occultation of Venus by the Moon on July 17, 1974 AD, is an example from recent times. The occultation took place in the early morning hours, and observations in the United States were particularly favorable from Florida. Using the method described above, set **Sky Travel** to the correct time and place and see this event for yourself.

Planetary Alignments and the *Jupiter Effect*

One of the most striking astronomical spectacles occurs when several planets are visible within a narrow field of view. In ancient and medieval times, such spectacles were regarded as portents of great catastrophes. Even quite recently, predictions of natural disasters have been widely reported. Present-day fears are based on concerns that the combined gravitational pull of several planets might trigger major Earthquakes and tidal waves on Earth. On September 15, 1186 AD, Mercury, Venus, Mars, Jupiter, Saturn, and the Moon were all close to the Sun and within a narrow view angle of 12°. This rare configuration of planets had been predicted several years before by the astrologer John of Toledo. It was taken as an omen of great calamities and Earthquakes. Near panic ensued, and the location of the planetary clustering in the Libra sign of the zodiac was taken as a particularly ill omen for high winds. People sought refuge in cellars and caves. The windows of the Imperial Palace in Byzantium were boarded up, and the Archbishop of Canterbury ordered fasting. Finally, the month of September came, and the predicted planetary configuration occurred without any of the feared consequences on Earth.

The illustration on the opposite page represents this planetary alignment:

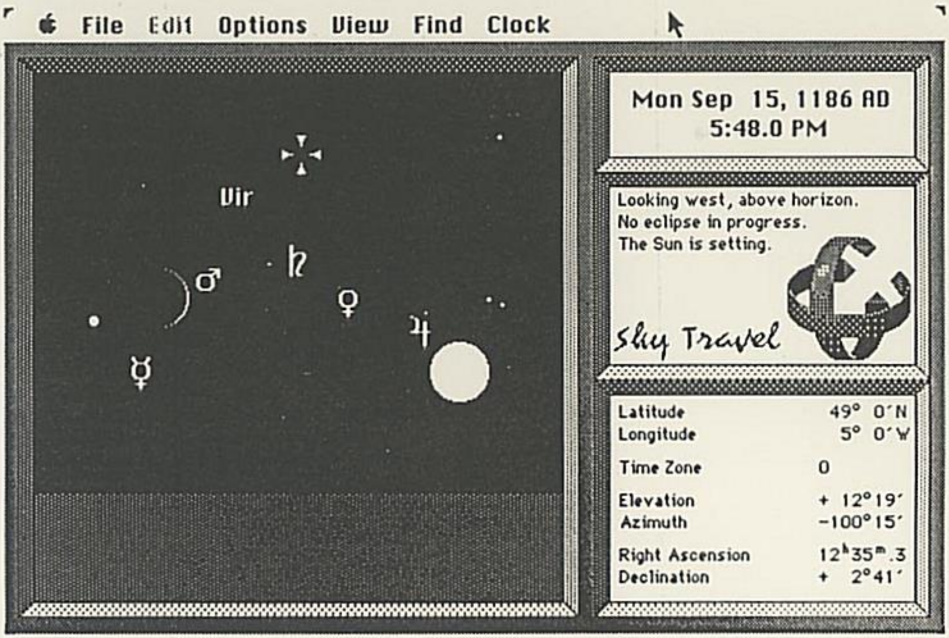
You can re-create this view by journeying to western Europe:

49° 0'N Latitude
5° 0'W Longitude
Time Zone 0
Mon Sep 15, 1186 AD
5:00.0 PM

Make sure the clock is stopped. From the Options menu, turn off the tracking commands and turn on Planet Symbols. Set the view angle to 18°. Now find Saturn, and you will get a display similar to the illustration on the opposite page.

On February 5, 1524 AD, another close planetary clustering was predicted, this time in the Aquarius sign of the zodiac. Another deluge was predicted, serious flooding was feared, and many people took refuge in boats. The year turned out to be an unusually dry one (Ashbrook: 1973).

On March 10, 1982 AD, the eight planets (excluding Earth) were within about one quadrant of the sky. The event, which scarcely qualified as an "alignment," was nevertheless forecast (by highly unscientific sources) to trigger a major Earthquake in California and to result in enhanced solar activity. A "Jupiter effect" was widely discussed in the news media. For the record, California did *not* break off at the San Andreas Fault and slide into the Pacific Ocean in 1982 (Thompson: 1981).



On February 26, 1953 BC, the five planets Mercury, Venus, Mars, Jupiter, and Saturn were within a view angle of less than 4°. No historical record exists of this ancient planetary clustering. You have an opportunity to practice with **Sky Travel** by demonstrating the planetary alignments described above. For each example, your location can be anywhere on Earth.

Planetary Retrogression

Since ancient times, the planets have been recognized as being different from the stars because they move relative to the background of fixed stars. This is reflected in the word "planet," which means "wanderer." The superior, or outer, planets, which are more distant from the Sun than Earth is, at times show a peculiar motion: they temporarily appear to move backward. The astronomer-geographer Ptolemy of Alexandria in the 2nd century AD rationalized this observation by suggesting that a planet moves in a circle about a center, which itself orbits the Sun.

The laws of planetary motion discovered by Johannes Kepler provided the true explanation for this phenomenon, which is now called "retrogression." Actually, planets don't move backward when seen from the location of the Sun. The reason that they appear to do so is that we observe the planets from Earth, which is itself a moving planet. The closer a planet is to the Sun, the greater its orbital speed. Therefore, when a planet is near "opposition" — that is, when it's located in the opposite direction of the Sun as seen from Earth — the line of sight from Earth to the planet changes direction relative to the celestial sphere background as Earth catches up with and then overtakes the outer planet. Because the Earth and the planets are not in exactly the same orbital planes, a retrogression usually appears as a shallow loop.

The retrograde motion of Mars may best be seen by finding Mars at the time of opposition and then watching its motion relative to a fixed point in the sky. With the clock stopped, set the following date (time of day doesn't matter for this demonstration):

Wed Apr 6, 1986 AD

Set your view angle to `36°`, turn on the `Constellation Lines`, `Constellation Names`, and `Chart Orientation` options, then find Mars. You will see that to its lower-left is the bright star Nunki in the constellation Sagittarius. Place the Mark on Nunki and turn on `Track Sky Position`. This will keep Nunki centered in the Sky Window and provide us with a point of reference.

Now, repeatedly using the `Clock +1 Week` command in the `Clock` menu (which can be conveniently accessed from the keyboard with ⌘]), observe the motion of mars until September 30. Mars moves to the left, away from Sagittarius. Then it slows, stops, reverses direction and makes a loop inside the constellation before once again moving away to the left.

Mars Retrogression

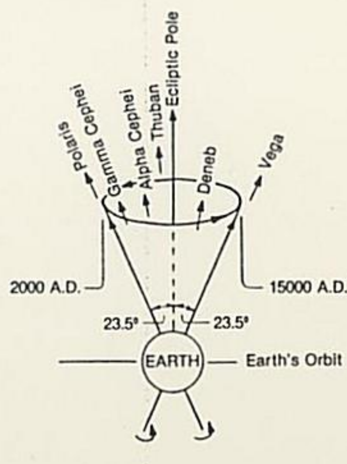
Precession, Polestars, and the Zodiac

This is the dawning of the age of Aquarius.

from the Broadway musical Hair

Observers of the northern sky are familiar with the polestar (Polaris), also called the North Star. This star makes it particularly easy to determine the cardinal directions in the Northern Hemisphere at night. (There is no similarly easy method in the Southern Hemisphere because of the lack of a "South Star.") As mentioned earlier, you can easily locate the North Star by extending a line through two pointer stars in the constellation the Big Dipper (Ursa Major). The North Star is formally known as Alpha Ursae Minoris, which means "the first star of Little Bear." Little Bear is another name for the Little Dipper. However, Alpha Ursae Minoris has not always been the North Star, nor will it always continue to be.

Ancient astronomers and navigators did not use Polaris as the North Star. In fact, the "North Star" at the time the Great Pyramids were built was the star Thuban in the constellation Draco. The North Star today is about 1° from the true pole, and by the year 2102 AD it will reach its closest proximity to the true north of about 1/2°. The next polestar will be the star Gamma Cephei in the year 4145 AD, and the one after that will be the star Alpha Cephei in the year 7530 AD. Both stars are in the constellation Cepheus.



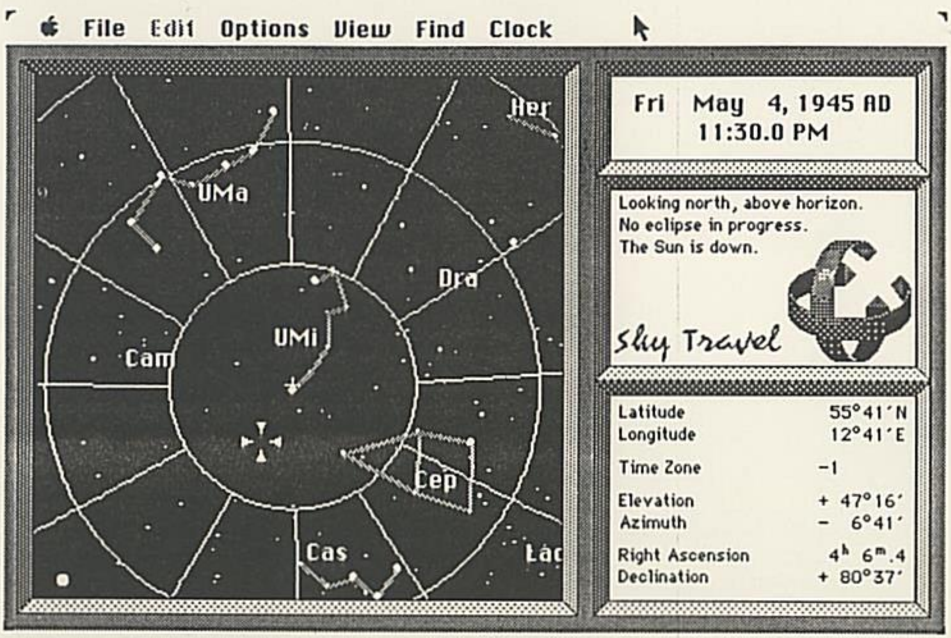
The reason for the changing polestars is that Earth's axis wobbles like that of a spinning top. The wobbling, or precession, has a time cycle of 26,000 years, after which the sequence of polestars will repeat itself.

Sky Travel takes Earth's precession into account, so you can demonstrate for yourself the past and future polestars mentioned above. The polestar in the distant past will be shown in a later example. Here you can see the appearance of the northern polar region far into the future.

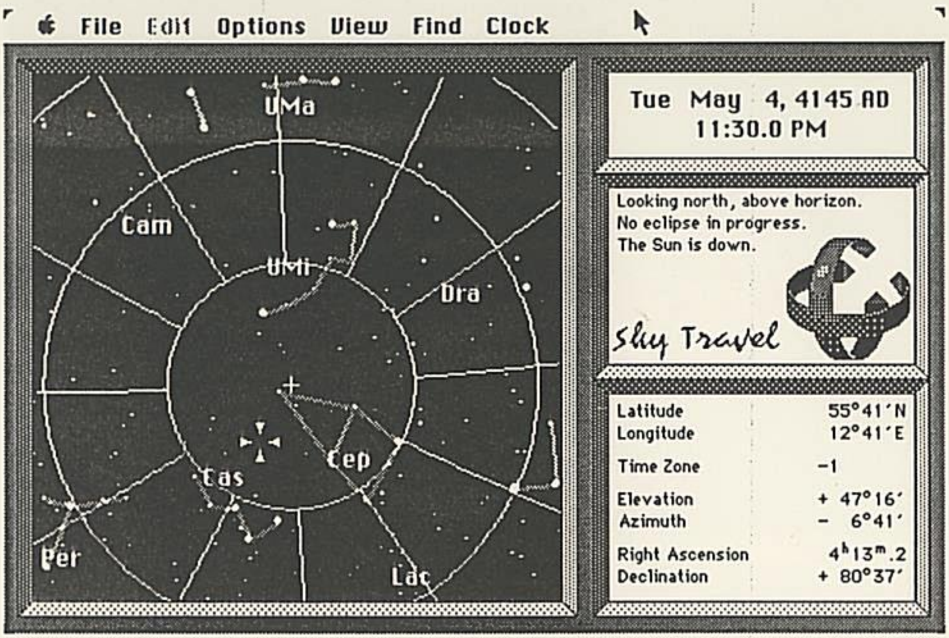
Observe the following example from Copenhagen just after sunset:

55°41'N Latitude
12°41'E Longitude
Time Zone -1
Fri May 4, 1945 AD
11:30.0 PM

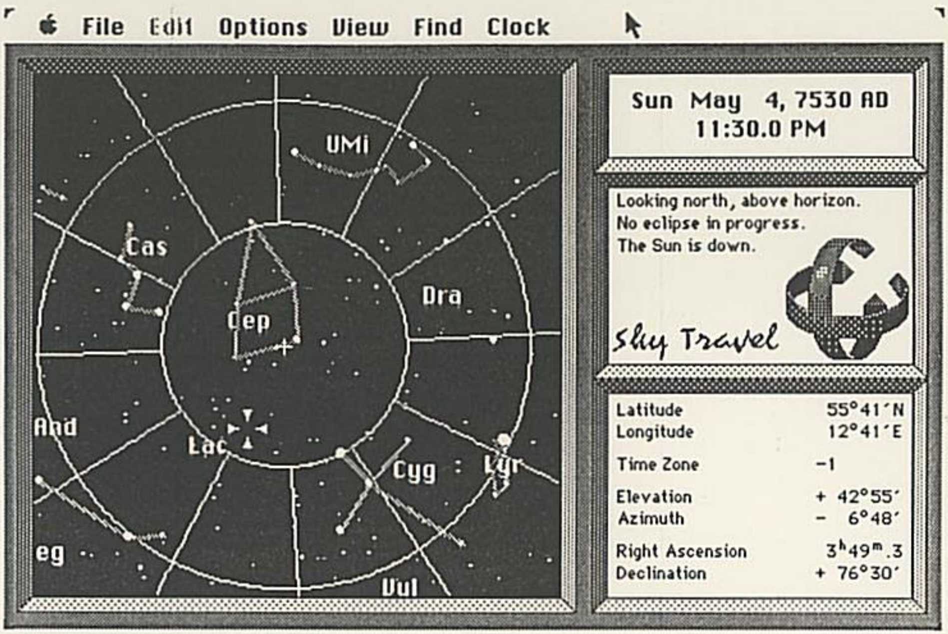
Set your viewing angle to 72°, select Constellation . . . from the Find menu, and choose Ursa Minor (UMi) from the constellation list. You now see the current polestar, Polaris, in the center of the screen. Now turn on the Celestial Globe Lines option. You will see a small cross where the true north celstial pole is.



Next, change the year to 4145 AD. Corrections for precession require recalculation of all star coordinates on the celestial sphere. While this is happening, the cursor changes to a small sphere. When the calculations are done, notice the shift in positions of the stars near the North Pole. Specifically, the polestar is no longer Polaris but instead is Gamma Cephei. To confirm this, use the `Information ...` command on the new polestar.



Now repeat the procedure for the year 7530 AD.



Another effect of precession is that the vernal equinox, the autumnal equinox, and both solstices change slowly during the same period of 26,000 years. You can see this by comparing the illustration on page 40 , which shows the wobbling of Earth's axis, with the illustration of the celestial sphere and ecliptic above.

The celestial equator will turn in relation to the ecliptic when Earth's axis of rotation precesses. This is because the celestial equator and Earth's equator are in the same plane.

One effect of this is that the star coordinates on the celestial sphere are not constant over long periods of time. It may seem strange at first that astronomers would choose a moving origin for measuring right ascension. Nevertheless, the advantage is that this method keeps the Sun's position independent of precession, and for all inhabitants of Earth —including astronomers — the Sun and the seasons are more important for everyday life than the stars.

The star background changes slowly with respect to the position of the Sun. This is more obvious in relation to the zodiac constellations, located in a narrow band along the ecliptic. This is also the region in which all the planets move, because their orbital planes are tilted only moderately relative to Earth's orbit. This ecliptic band is thus the region of the sky where all the action is, and it is the region that captured the attention of the astrologer-priests in the Babylonian and Assyrian civilizations. They divided the ecliptic into twelve 30° intervals, or signs, and named them after the principal constellations located in those sections at the time. The Greeks later coined the name "Zodiac" (meaning "the circle of animals") for the ecliptic constellations. In the 2nd century AD, greek astronomer-geographer Ptolemy of Alexandria described and published illustrations of most of the constellations. Those illustrations are still in use today: you can see them by turning on the `Ecliptic Symbols` option.

When the Babylonians made their observations around 2000 BC, the vernal equinox was in the constellation Aries. Two thousand years later, the vernal equinox was moving into Pisces; today, it's approaching the constellation Aquarius. In a sense, precession makes the ecliptic into a gigantic clock with a 26,000-year period for a single turn of the "hand," the vernal equinox. The circular motion of the celestial poles, causing changes in the star that happens to be closest to the North Pole, is just another look at the same clock from a different direction. The Sun is at the symbol for Aries on the first day of spring (vernal equinox) and at the symbol for Libra on the first day of fall (autumnal equinox). The summer solstice occurs when the Sun is at the symbol for cancer, and the winter solstice occurs when the Sun is at the symbol for Capricorn. The 23.5° northern and southern parallels on Earth are named the tropics of Cancer and Capricorn, respectively, because of the location of the Sun on these signs at the solstices.

Precession causes the signs of the zodiac to move relative to the constellations of the zodiac. For example, at the time of the construction of the Stone Lion of Nimrud Dagh (see page 52), the head and shoulders of the constellation Leo were several degrees into the sign of Cancer, and the western part of the constellation Virgo overlapped the eastern part of the sign of Leo. Today the zodiac signs are nowhere near the constellations for which they were named.

Halley's Comet

Of all the comets in the sky,
There's none like comet Halley.
We see it with the naked eye
And periodically.

Harold Spencer Jones

Comets are relatively small, frozen bodies that revolve around the Sun. When a comet passes close to a large body, such as a large planet, the comet's orbit is perturbed. For this reason, the trajeectories of comets are changeable. Comet "tails" are vapor and dust clouds formed when the frozen "head" of the comet passes close to the Sun and is heated. This process eventually depletes the comet. Since the tails of comets can be extremely large and spectacular, appearances of comets have been recorded since ancient times.

Halley's Comet was first observed and recorded in 240 BC. Subsequent returns have been extensively recorded around the world. A particularly famous appearance is shown on the Bayeux tapestry, a 2-foot-high, 239 foot-long crewel embroidery made in medieval times in Normandy, which depicts the Norman conquest of England. The comet appeared as William the Conqueror set sail for England and was taken as an omen presaging the fate of King Harold, who later was defeated and slain at the Battle of Hastings in 1066 AD.

Courtesy: William the Conqueror Center, Bayeux, France

The Latin inscription on the tapestry means "men marvelling at the star." Note the messenger bringing the bad news to King Harold and the invasion ships below the king (Setton: 1966).

The comet is named after the British astronomer Edmund Halley, who personally observed the "Great Comet" of 1682 AD. Halley was a close friend of Isaac Newton and, in fact, was instrumental in getting Newton's theory of gravitation published. Working from Newton's ideas, Halley compared the appearance of the 1682 comet with the records of earlier ones and concluded that this was a periodic comet. He determined its orbit and correctly predicted subsequent appearances. In recognition of this accomplishment, the comet was later named for him. The comet appears about every 75 years; the last appearance before the 1985-86 one was in 1910 AD (Bortle: 1985).

Several space probes were sent toward the comet to carry out scientific studies and to transmit closeup pictures back to Earth, making this visit a particularly spectacular and exciting event (Berry: 1987).

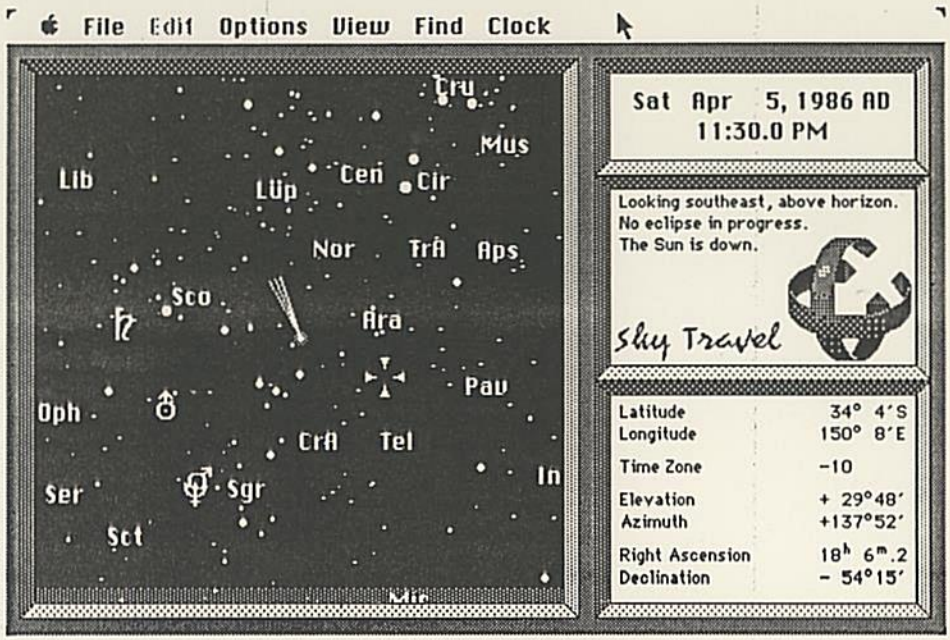
Sky Travel can demonstrate the trajectory for the 1985-86 passage of Halley's Comet. The closest approach to the Sun (the perihelion) was early February 1986. The best time for observation was from September through December 1985 (especially in the Northern Hemisphere) and from March through July 1986 (especially in the Southern Hemisphere). Since the comet's tail is formed by evaporation as its head passes close to the Sun, a periodic comet is more spectacular on its return trip. You can watch the 1986 spring trajectory of Halley's Comet across the sky. To observe the comet as it appeared from Wollongong, New South Wales, set your location:

```
 34° 4'S Latitude
150° 8'E Longitude
Time Zone -10
```

Set your date and time to the following:

```
Sat Apr 5, 1986 AD
   11:30.0 PM
```

Now that you're in the active comet-watching period, you can select `Halley's Comet` from the `Find` menu to bring it to the center of the Sky Window. From the `Options` menu turn on `Track Object` (which will read `Track Halley's Comet`), `Constellation Names`, and `Constellation Lines`. Use a view angle of `72°` or `36°`. Now go forward one day (from April 5th to April 6th), and watch the display. Notice as the Comet moves away from the constellation Scorpius. Continue to advance by days and observe the comet's path.



Until the middle of March, the comet remained below the horizon in Wollongong, but it was rather inconspicuous anyway. However, from the end of March to Early April, the comet was well above the horizon, and a large tail was visible. By mid-April, the comet show was about over for observers without telescopes.

Southern Constellations

If you live in the Northern Hemisphere, you may be curious about the less familiar southern constellations. To learn more about them, move the Mark over the center of a desired constellation abbreviation or celestial object and select `Information...` from the `Options` menu (or simply double-click the mouse button on the name or object). The information appears in the Information window, and you can use the scroll bar to move through it if it is longer than the window. Click the `OK` button to dismiss the information.

Chronology

Calenders and Astronomical Dates

Beware the Ides of March.

from Shakespeare's Julius Caesar

Sky Travel allows you to go backward or forward in time about 10,000 years. However, in checking astronomical events in the past, you'll need to be sure that the proper calendar date is used — often no easy task.

The calendar of western civilization dates back to 753 BC, the mythical date for the founding of Rome. For many centuries, the Romans dated events by counting from this date and designated the years ab urbe condita (AUC), which means "since the founding of city." The Roman year originally had only ten months and began in the spring with the month of March. We still have a reminder of this in the names of the months September, October, November, and December, meaning the seventh, eighth, ninth, and tenth months, respectively. Later on, the Romans added two more months, January and February, at the beginning of the year.

When the early calendar got too much out of step with the seasons, the Romans occasionally added an extra month. These adjustments, made under the jurisdiction of the priests, were often arbitrary and weren't always co-ordinated within different parts of the Roman Empire. Understandably, this became increasingly intolerable to the historians, scribes, and tax collectors, not to mention the taxpayers.

Julius Caesar introduced the Julian calendar, which was a major improvement, based on a solar year of 365 1/4 days as determined by the Egyptians (a year is actually 365.2422 days long). This calendar has three years of 365 days and a fourth year (or leap year) of 366 days. Leap years then, as now, were those evenly divisible by four. The Julian calendar was put into effect on January 1, 45 BC. In order to offset errors accumulated beforehand, corrections were made all at once in the year 46 BC, which was made 445 days long and is generally referred to as the "Year of Confusion"!

The Gregorian calendar, the one currently in use, was formally introduced by Pope Gregory XIII, in 1582 AD. His main interest in an improved calendar was to ensure the proper timing of the holy days of Easter. The Julian calendar year was slightly too long. The Gregorian calendar corrected the error by requiring that only those years ending in hundreds that were evenly divisible by 400 (such as 1600) and all other years evenly divisible by four be leap years (366 days). Other years ending in hundreds (such as 1700) would remain normal years (365 days). Errors which had accumulated since the establishment of the Julian calendar were again adjusted all at once by eliminating ten days in the year 1582: October 4 was followed immediately by October 15.

The Gregorian calendar was not universally adopted at the time. For example, England and the American colonies didn't adopt the calendar until 1752 AD, at which time 11 days had to be eliminated: September 2 was immediately followed that year by September 14. One well-known historical consequence is the discrepancy in George Washington's birthday. According to the Gregorian calendar in use today, he was born on February 22, 1732 AD, but the calendar in use at his birth showed February 11. Russia didn't change to the Gregorian calendar until the Bolshevik Revolution (1917 AD), at which time 13 days had to be eliminated.

After the French Revolution, France's National Convention in 1795 AD legislated a "new" calendar, based in part on the decimal system. The year started in the fall at the autumnal equinox and consisted of 12 months, each with 30 days. A month was divided into three ten-day weeks, each day having 10 hours, each hour 100 minutes, and each minute 100 seconds. To correct for the fact that a year is longer than 360 days, five or six specially named extra days were added at the end of each year. Actually, this revolutionary calendar was not new at all, but a rediscovery of an ancient calendar used in Egypt as early as 3000 BC. However, no one liked the ten-day week, the attempt failed, and the law was repealed in 1805 AD.

Astronomical calculations are based on "Julian day numbers," which have nothing to do with the Julian calendar. The system was created in 1583 AD by the French chronologist and mathematician J.J. Scaliger, who named his invention after his father. The Julian day number system begins at Greenwich noon (GMT) on January 1, 4713 BC; a Julian number is simply the number of the day in a continuous count since that date. Dates before 4713 BC are counted as negative numbers. The Julian day number system has three simple advantages: first, differences in days can be determined by simple subtraction; second, the week can be determined by dividing the Julian day number by seven, and then using the remainder to define the day of the week (0 = Monday, 1 = Tuesday, and so on); and third, it provides an unambiguous reference standard for synchronizing dates among the multitude of ancient calendars.

For example, set the date to:
`Wed Feb 29, 1984 AD`

Because 1984 is evenly divisible by four, it's a leap year and February 29 exists. Now change the year to 1985; the date changes to February 28, since there is no February 29 in a non-leap year. Now change the year to 1900 AD and try to set the date to February 29; **Sky Travel** won't let you. Although 1900 is evenly divisible by four, it ends in hundreds and is not evenly divisible by 400; by the Gregorian calendar convention, such years are not leap years. In contrast, the year 2000 AD is evenly divisible by 400; hence, it's a leap year and February 29 exists.

An example of how **Sky Travel** can be used to determine historical dates with certainty is the rare planetary occultation of Jupiter by Mars presented earlier. The German astronomer Johannes Kepler reported that the event occurred on January 9, 1591 AD; yet, if you try to repeat the example on that date, you'll see that no occultation occurred. However, on January 19, 1591 AD, the date given in the example, there was indeed an occultation. The explanation is unquestionably that in 1591 — only nine years after Pope Gregory had introduced his calendar reform — Johannes Kepler in Germany was still using the Julian calendar.

The Star of Bethlehem

Now, when Jesus was born in Bethlehem of Judaea in the days of Herod the King, behold, there came wise men from the east to Jerusalem, ... and, lo, the star, which they saw in the east, went before them, till it came and stood over where the young child was.

Matthew 2: 1, 9

The Julian calendar was used for many centuries with the year count beginning at the founding of Rome (AUC). However, in the 6th century AD (by our present calendar), the monk and scholar Exiguus suggested that the count start instead at the birth of Christ, which he calculated to have occurred in the year 754 AUC. The proposal was accepted only gradually. In the 9th century, Charlemagne ordered this change in the calendar within his empire. Even so, the custom of counting the years from the birth of Christ did not become common practice in Europe until the 11th century AD.

There is considerable uncertainty as to the accuracy of Exiguus's calculations. Although Christmas is celebrated on December 25 by convention, both the day and year of Christ's birth are uncertain. For example, based on what are believed to be reliable historical sources, Herod the Great died in 4 BC; both the accounts in Matthew and Luke state that Christ was born during Herod's reign.

Because astronomical events have often proven to be a means of accurately dating historical events, the brief description of the "star of Bethlehem" in Matthew might provide a valuable clue. Many attempts were made for centuries to identify the nature of the "star" that brought the three Magi to Bethlehem. It has been suggested, for example, that the "star" might have been a supernova, but such an event would most likely have been observed and recorded elsewhere; besides, no supernova remnant from that time has ever been found.

Another suggestion was that it might have been a comet. For example, the early Renaissance painter Giotto depicted the star as a comet in a well-known 1300 AD fresco of the nativity scene in the Arena Chapel in Padua, Italy. Indeed, later studies have shown that Halley's Comet did appear during October in the year 12 BC.

However, according to the account in Luke 2:1-7, Joseph and Mary traveled to Bethlehem because Caesar Augustus had issued a census order, since dated at 8 BC. The apparition of the comet in 12 BC, therefore, is too early to be the plausible explanation.

It is considered more likely that the "star" was an unusual planetary alignment. A very close conjunction of the planets Venus and Jupiter occurred on June 17.2 BC (Sinnot: 1986). However, conjunctions of these two planets are frequent, and they are of very short duration. Therefore, it's doubtful that this even would have been unusual enough for the magi to undertake the long and arduous journey to Jerusalem (Burton: 1977).

A triple conjunction of Jupiter and Saturn occurred in 7 BC, with the two planets being close from May all through December. Johannes Kepler suggested in the seventeenth century that this might have been the "star" of Bethlehem.

The alignment took place in the constellation Pisces (the Fish) at the time when the vernal equinox was moving from the sign of Aries into the sign of Pisces. This may well have had a special meaning to magi from the Mesopotamian region who were well-versed in Babylonian astrology. Assuming that these conjectures are correct, September 15 has been suggested as the most probable date for the birth of Christ (Hughes: 1979).

Sky Travel allows you to observe the alignment of Jupiter and Saturn on that night nearly 2000 years ago.

Select `World Map...` from the `Options` menu, and go to Bethlehem:

`32°29'N Latitude`
`34° 1'E Longitude`
`Time Zone -3`

Set the date and time:

`Tue Sep 15, 7 BC`
`11:55.0 PM`

Set the view angle to `72°`. Now find Saturn. You are now looking at the midnight sky over Bethlehem; Saturn and Jupiter are very close to each other. Now, turn off the `Constellation Names` and `Planet Symbols` options.

Sky Travel has now re-created the suggested "star of Bethlehem" as it may have appeared to the Magi and the shepherds on the night Christ was born.

History and Archaeology

Solar Eclipses In Antiquity

WARNING! *Never* look directly at the Sun, even during a *total* eclipse!

In ancient times, total solar eclipses, which turned day into night, were believed to be frightening signs of the displeasure of the gods. In many instances, primitive responses to eclipses influenced human history.

Eclipses are important to historians for another reason. Because they were widely considered to be warnings of great misfortunes and calamities, they were often recorded if they had preceded major historical events. Since present-day calculations can determine the precise date of an eclipse for a given location, such records have proven extremely valuable for synchronizing early calendars and correlating the histories of ancient societies.

The Roman statesman Cicero has written about a solar eclipse that occurred on June 21, 400 BC. This eclipse attracted special attention since it occurred near Rome a few minutes after sunset and was very nearly total. The sudden, complete darkening of the twilight sky followed by the reappearance of twilight was described by the poet Ennius as "on the nones of June, the Sun was covered by the Moon and night." This particular event is an example of an eclipse that has helped histories solve some problems with the very cumbersome early Roman calendar.

With **Sky Travel,** you can re-create this famous solar eclipse from an observation point near Rome:

```
42° 0'N Latitude
 14° 0'E Longitude
Time Zone -1
Sat Jun 21, 400 BC
    6:30.0 PM
```

Note: When adjusting the date in BC, the arrows appear to work backward. Actually, the up-arrow still adjusts the values forward in time, but since the period is set for BC, the years count down toward the birth of Christ, rather than up away from it.

Find the Sun, set the clock rate to `16x`, and watch the sunset until about 8:00 PM.

Lunar Eclipses in Antiquity

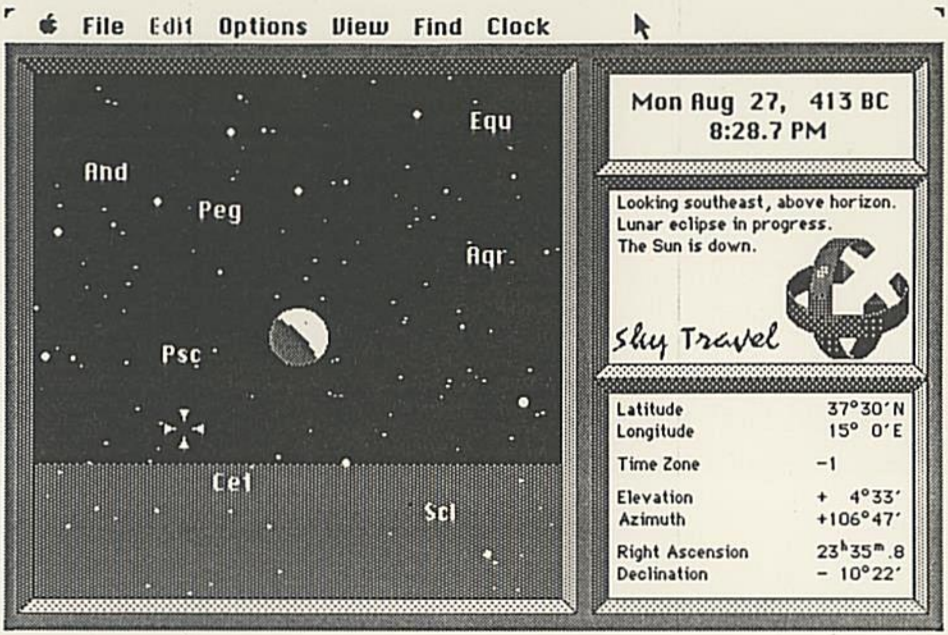
Although the loss of the Moon's light was less frightening to people in antiquity than the loss of the Sun's light, a lunar eclipse was nevertheless considered an important omen.

The Greek historian Thucydides reported on a famous lunar eclipse during the Peloponnesian war. The eclipse occurred on August 27, 413 BC, the day the Athenian commanders had planned to leave Syracuse. The Eclipse so frightened the Athenian soldiers and sailors that, on the advice of the astrologer-priests, the departure was delayed 27 days. This delay gave the people of Syracuse the opportunity to regroup, and they destroyed or captured everyone in the Athenian force.

Cicero and the Roman historian Livy have both written about a lunar eclipse that occurred on June 21, 168 BC, during a war between Rome and Macedonia. The Roman soothsayers astutely construed the eclipse as a sign that the reign of the Macedonian king was nearing its end. The eclipse — and the priests — were thus given credit for having contributed to the Roman victory at the famous battle of Pydna, which marked the end of the Macedonian Empire founded by Alexander the Great (Banks: 1973).

To see these historical lunar eclipses for yourself, begin by journeying to Syracuse, Sicily:

37°30'N Latitude
15°00'E Longitude
Time Zone -1
Mon Aug 27, 413 BC
7:45.0 PM
Stop the clock, find the Moon, and then turn the Track Object command on. Adjust your view angle to 36°, and then set the clock rate to 32x. The gray disk of Earth's shadow will become visible as the Moon enters into it. The eclipse becomes total just before 9:00 PM and is over by about 11:25 PM.



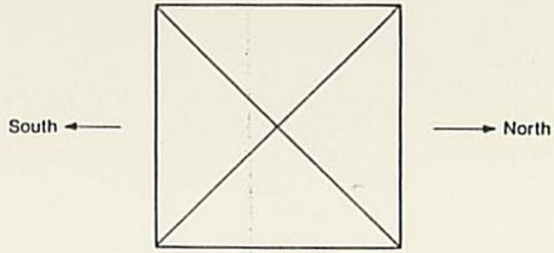
For the second example, stop the clock, and then go to the ancient city of Pydna near Mt. Olympus in Greece:
40° 3'N Latitude
22° 6'E Longitude
Time Zone -1
Tue Jun 21, 168 BC
7:00.0 PM
Leave the Track Object (which will read Track Moon) command on. Set the clock rate to 32x, and watch the Moon rise, totally eclipsed. By about 9:40 PM the eclipse is over.

The Great Pyramid at Giza

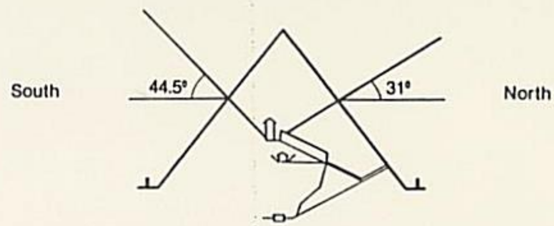
The Great Pyramid at Giza, near Cairo, was built during the reign of Cheops (Khufu), a pharaoh of the 4th dynasty. The dimensions of this, the greatest of the pyramids, are truly impressive: the base is a square measuring 756 feet on each side and covers more than 13 acres; the original height was 482 feet. Even more impressive is the precision of this large monument: the maximum deviation from a true square is less than eight inches, and the base is aligned in the four cardinal directions, north, south, east, and west, with a maximum deviation of less than 1/10 . This is testimony to the skill of the early Egyptians as master builders and surveyors.

The pyramid is a solid building containing more than two million limestone blocks, each weighing an average of two and one-half tons. Originally faced with smooth, well-fitted white limestone, the pyramid was capped with gold. The Greek historian Herodotus, who visited Giza in the 5th century BC, reported that Cheops, during his 50-year reign, exchanged 100,000 men every three months to toil at the construction site.

The interior of the pyramid is accessible through a single entrance, originally covered, on the north face about 55 feet above ground level. From here, a narrow corridor descends at a 26° angle for 355 feet to an unfinished subterranean chamber. About 100 feet from the entrance, another corridor, originally blocked off, ascends at a 26° slope from the ceiling of the descending corridor. The ascending corridor ends in a long, tall, narrow chamber called the Great Gallery. The gallery is connected to an upper burial chamber, the King's Chamber, and through a separate corridor (also originally blocked off) to a lower burial chamber, the Queen's Chamber. The purpose of the complicated network of corridors was no doubt to mislead potential grave robbers.



Top View



Cross Section

Of special interest are two narrow (nine-inch square), precisely aligned shafts, one leading from the upper end of the gallery and ending on the northern face of the pyramid, the other leading from the King's Chamber and ending on the southern face. The purpose of these shafts have been the subject of speculation for centuries. An early suggestion that they were intended for ventilation is implausible: the construction of these shafts at precise angles through many courses of limestone blocks must have been such an arduous task that a much more commanding reason must be sought. Considering the importance of celestial mythology to the ancient Egyptians, it's much more likely that the astrologer-priests oriented the shafts toward carefully selected regions of the sky.

Early estimates placed the 4th dynasty, the period of the "Great Pyramid Kings," at about 4000-3000 BC. However, at that time, the northern shaft would have pointed toward a segment of the sky without any bright stars. In contrast, from 3000-2500 BC, the bright star Thuban in the constellation Draco was perfectly aligned with the northern shaft. Based on this and other evidence, the time of the building of Cheops' pyramid is now believed to have been about 2800-2600 BC. The question then is what did the southern shaft point toward at that time? Recent studies show that only three bright stars qualify — the three stars in what we now call Orion's belt (Trimble: 1964).

It's not likely that the shafts were intended for astronomical observation. First, the shafts were originally covered by the facing stones on the pyramid. Second, a slight bend at both ends of the shafts, presumably designed to prevent accumulation of sand and debris, would have prevented direct sighting. It's therefore more likely that the purpose was a religious one.

In ancient Egypt, the circumpolar stars, which neither set nor rose, were called "imperishable" stars and represented immortal gods. The pharaoh's soul was believed to ascend to these eternal stars to take its place among the gods in the sky. Thuban, then the polestar, would have been the ultimate eternal star. The stars of Orion, in turn, were representative of Osiris, the Egyptian god of transformation and resurrection. The shafts in the pyramid were therefore most likely intended as passageways for Cheops' soul toward its ultimate destination in the sky. The Pyramid Kings of the 4th dynasty left no written records and no pictorial descriptions on the walls of their tombs. Yet, in the precise alignment of their pyramids, they revealed insights into astronomy that have allowed later generations to determine the age of these pyramids.

With **Sky Travel**, you can re-create the ancient sky over Giza as it appeared at the time of the construction of Cheops' pyramid. By setting the elevation and azimuth of the cursor to correspond to those of the northern and southern shafts, you can see the transits of Thuban and the belt stars of Orion, respectively, as the pharaoh's astrologer-priests planned it more than 4500 years ago. Stop the clock, and begin at Giza:

`29°59'N Latitude`
`31°00'E Longitude`
`Time Zone -2`

`Fri Jan 1, 2700 BC`
`8:00.0 PM`

Turn off all tracking options, and make sure that the `Constellation Names`, `Constellation Lines`, and `Celestial Globe Lines` options are activated. Set the view angle to `72°`. Select `North` from the `View` menu. Now use the `Constellation` command in the `Find` menu to locate the constellation Ursa Minor (`UMi`). Because of Earth's precession, Polaris is no longer the polestar. The view in the center of the sky display now corresponds to the view through the northern shaft of the pyramid at the time of its construction. Place the cursor over the star in the center of the screen and verify that the star is Thuban. Now set the clock rate to `64x`, and watch the stars rotate around Thuban as they did at the time of Cheops.

Now change the setting to show the original view through the southern shaft. Stop the clock; select `South` from the `View` menu. Drag the cursor as close as possible to an elevation of 44°30', watching the display in the position window. Next, set the clock rate to

`64x`, and watch the belt stars in Orion pass through the Mark (at about 8:25 PM).

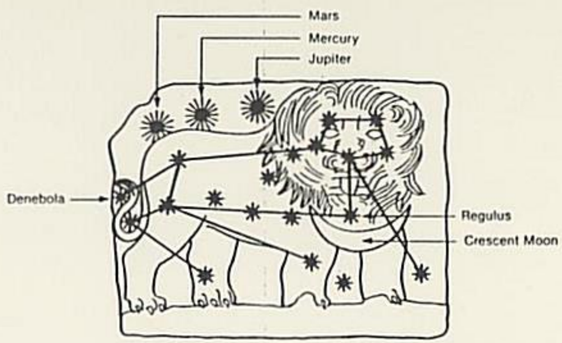
Cheops' pyramid was admired even in antiquity as one of the seven wonders of the world; in fact, it's the only one still standing. However, in terms of the its principal function, namely to guarantee the pharaoh a peaceful resting place surrounded by his vestiges of power and wealth and protected from grave robbers, it was a monumental failure. Today, none of the pharaoh's treasures remain, and even the mummy of Cheops himself vanished long ago.

The Stone Lion of Numrud Dagh

In the 1st century BC, Antioch I of Commagene (Kummuhu) was as concerned with preserving his bodily remains and worldly goods as Cheops had been. He may have been more successful, however, since it appears that to this day, nobody has uncovered his burial chamber. Commagene, now desolate and barren, in ancient times was a fertile land between the Greek and Roman empires to the west and the Mesopotamian and Parthian empires to the east.

A century ago, German and Turkish archaeologists investigated an open-air pantheon of colossal statutes on top of the Nimrud Dagh (Mt. Nimrod), a 7000-foot mountain south of the Anti-Taurus mountain chain in Turkey and just north of present-day Syria. The statues were between 25 and 29 feet tall and stood on 20-foot-high platforms on two terraces, one facing east and the other west. The eastern terrace also contained a fire alter for religious ceremonies. The stone statues were magnificently carved and represented an intriguing blend of Greek and Persian gods, as well as the king himself. Between the terraces was a 150-foot-high stone mound believed to contain the remains of King Antioch (Goell: 1961).

Of particular interest was a large stone relief of a lion showing 3 planets, a crescent Moon, and 19 stars on and around the lion's body. A sketch of the stone lion is shown below:



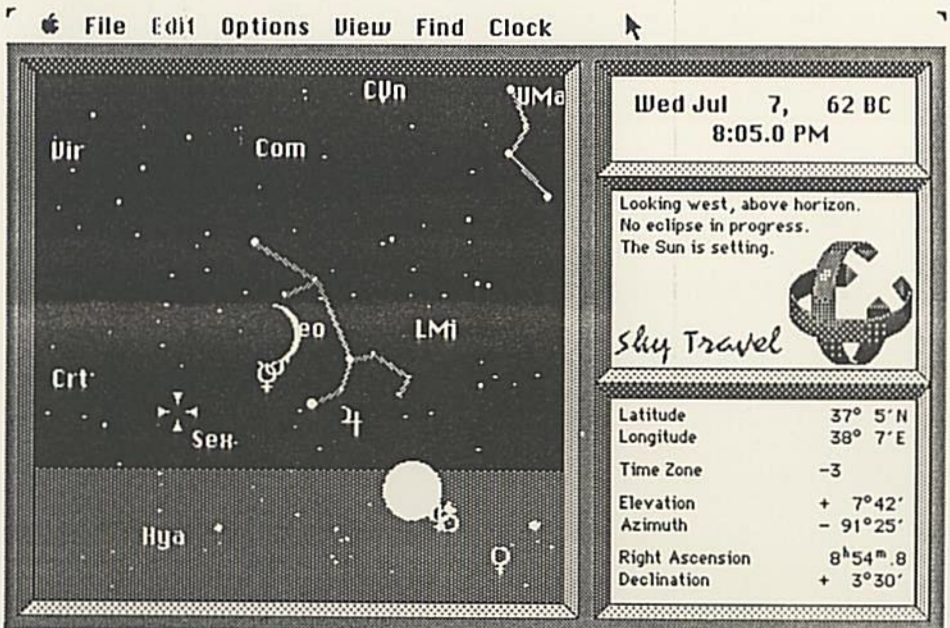
Greek inscriptions identify the three large stars above the lion as the planets Mars, Mercury, and Jupiter. The star pattern is recognizable as the constellation Leo. The prominent star on the lion's chest is no doubt Regulus, also known as Cor Leonis, or the heart of the lion. The star nearest the tail must be Denebola, which means "tail of the lion." The angles in the constellation are a bit distorted, but this may be ascribed to artistic license on the part of the unknown sculptor.

This stone lion is the first known Greek horoscope, and the unusual configuration of the Moon, planets and stars has been extensively studied in an attempt to determine the exact date represented by the horoscope. These studies show that the only dates on which a crescent Moon and three planets were observable in the sign of leo during the life of King Antioch were July 6-7, 62 BC. These dates are in agreement with the arrival in the region of the Roman consul Pompeius after he had defeated Mithradates VI, finally consolidating the Roman protectorates in Asia Minor. The kingdom of Commagene was a buffer state between the Roman and Parthian empires, and it has been suggested that King Antioch may have shown his gratitude for the defeat of the treacherous Mithradates by erecting this temple and perhaps even by counting his own reign from this date (Neugebauer and Van Hoesen: 1959).

With **Sky Travel**, you can compare the appearance of the sky over Commagene on the above dates with the planetary configuration and crescent Moon depicted on the stone lion. First, a quick trip to Samosata, ancient capital of Commagene:

37° 5'N Latitude
38° 7'E Longitude
Time Zone -3
Wed Jul 7, 62 BC
8:05.0 PM

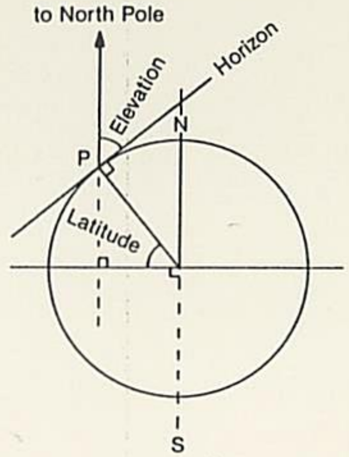
Turn off the Celestial Globe Lines option, and set the view angle to 36°. Next, select Leo from the Constellation... command in the Find menu. Note that the three planets and the crescent Moon are indeed clustered in the constellation Leo. Actually, the only time they were all visible was shortly after sunset, and then only for a brief period. If you check the previous day, you'll see that the Moon, although within the constellation Leo, had not actually crossed into the sign (or house) of Leo, the beginning of which is marked by its symbol. Of the two days, July 7 appears to be the better fit for the horoscope.



Navigation

The art of navigating by the Sun and stars was developed by mariners in ancient times. The earliest primitive form of navigation consisted merely of determining the "bearing," or the direction in which you were sailing.

In order to know your position, it's necessary to determine both your latitude and longitude. Latitude can be determined solely from celestial observations; longitude requires knowledge of both local time and the time at some reference longitude, i.e., the time difference from a known longitude. Although it's always possible to determine local time, it wasn't until the invention of a reliable portable chronometer by the British clock maker John Harrison in 1735 AD that it became possible to know a reference time aboard ships. The standard reference time and longitude was and still is that of Greenwich.



Latitude from Polaris

At any point P on the Northern Hemisphere, the latitude equals the elevation above the horizon of the North Pole (see the illustration above). Since stars are so far away that sightings are parallel no matter where on Earth they are made, the north-south line of Earth and the sighting line from P are parallel. It follows that the angle of P's latitude equals the angle of elevation of the North Pole as sighted from P: (see the illustration above).

Since Polaris is within 1° of the North Pole, you can get an immediate, approximate reading of your latitude simply by measuring the elevation of the polestar, as long as you're in the Northern Hemisphere.

Imagine you're a merit-badge counselor in astronomy for the Boy Scouts. Your young scouts want to know whether astronomy "can be used for anything," so you give them a problem to figure out. You tell them they're on a small boat in the Caribbean. There has been a storm, their two-way radio doesn't work, and they're lost. However, they have a small sextant, a wristwatch, a small transistor radio, and a map. The sea is now calm, and the boat is dead in the water with no current. Just before dawn, a break in the clouds allows them to read the elevation of Polaris as 15.5°. Around noon, they sight the Sun at its highest elevation and find that their watch shows 12:15 PM. Shortly afterward, they hear a radio broadcast from Miami stating that it's 12:30 PM (EST). When they check their wristwatch, it shows 12:37 PM. Where are they?

First, their latitude is approximately the same as the elevation of Polaris, (15.5°N). Second the broadcast tells them that their watch is seven minutes fast, meaning that the Sun was at its zenith at their location at 12:08 PM (EST).

Third, since eastern standard time is zone 5, the Sun would be at its zenith at 12:00 noon (EST) in the middle of time zone 5, which is five times 15° or 75° west of Greenwich (5 for the number of time zones away from time zone 0 and 15° per time zone). Thus the boys conclude that they are eight minutes or 2° (8 x 15 / 60° = 2°) farther west than the middle of time zone 5. Accordingly, their longitude must be 75° + 2° or 77°W. Looking at their map, the boys see that they're about 2.5 (150 nautical miles) directly south of Kingston, Jamaica. By setting a course due north, they cannot miss this large island, where they'll be able to get their equipment repaired.

Using **Sky Travel**, you can go to the World Map, position the Mark at the boys' latitude and longitude, return to the Primary Windows, and show the boys that the elevation of polaris and the local time of noon were as they reported!

Positional Navigation

You can determine your position on Earth in terms of both degrees and distance. Since the circumference of Earth is 40,000 kilometers along any great circle (the equator, for example), 1° of arc corresponds to 111 km (69 miles or 60 nautical miles; 40,000 km/360° 111 km/1°). One minute of arc is 1.9 km (1.2 miles or 1 nautical mile) and one second of arc is 31 meters (116 feet). If, for instance, you want to know your location to within 200 meters or 1/10 of a mile, your position in terms of degrees must be determined to within 1/10 of a minute of arc. For this reason, a number of corrections are required to ensure that observations of celestial objects are sufficiently accurate.

Consider also the accuracy needed in a chronometer for determining longitude. In 1714, the British Government posted an award of 20,000 pounds for anyone who could design a clock that could be used to determine a ship's longitude within 30 miless after a six-week voyage. This translates into an accuracy of better than three seconds per day — much better than even a pendulum clock on land was able to do at that time. John Harrison won the award, and by the end of the 18th century, chronometers were in common use aboard ships.

After the invention of the radio by Marconi in 1920, it became very easy to know the Greenwich time anywhere on Earth, so longitude became as simple to determine as latitude. Today, pulsed radio and radar signals from Earth stations and satellites, combined with on-boat computers ,have speeded up navigation computations to match the needs of jet airplanes and spacecraft. Still, in case of equipment or power failures, the chronometer method is a stand-by technique, especially on small ocean-going craft. Navigation by the stars is, of course, a special subject in the case of space exploration.

Sky Travel cannot cover the actual techniques used in nautical and air navigation. Due to the accuracy of measurement required, a number of corrections must be made to the direct readings (for example, for altitude over the horizon or for refraction by air). Nevertheless, **Sky Travel** can replace a Nautical Almanac for instructional purposes, since the program can calculate the position of the Sun, the Moon, and the navigational stars at any time from any location on Earth. This means you can use the program as a self-contained system for training, without the need for sextants, astronomical tables, or even clear weather!

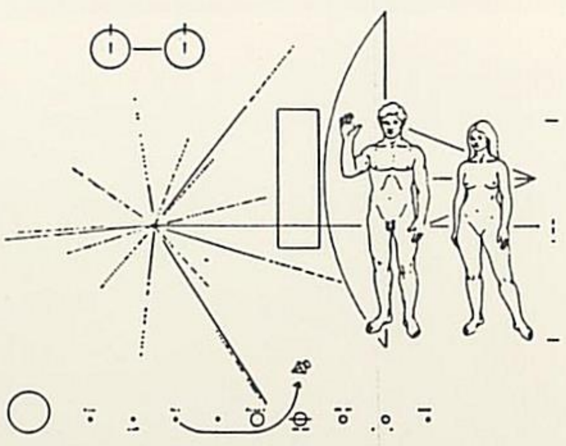
Space Exploration

. . . it would be surprising if life were not abundant in the galaxy. Our problem is to find it.

George O. Abell

In July 1969 AD, American astronauts landed on the Moon. They were the first human beings ever to set foot on a celestial body other than Earth. The astronauts left a plaque with a message in English, with the reasonable expectation that other human expeditions to the Moon will occur before English — and perhaps humankind — becomes extinct.

Toward the end of 1973 AD, the spacecraft Pioneer 10 passed Jupiter on its way toward the constellations Taurus and Orion, the first human-made object to leave our solar system. This mission also carried a plaque, but since other intelligent beings in the universe would be unfamiliar with any human language, the message was written in the language of science:



In order to introduce ourselves to extraterrestrials who may have developed very differently from the way we have, male and female humans are shown to the same scale as a drawing of the spacecraft. The symbol at the top of the plaque refers to hydrogen, the most abundant element in the universe. To identify the launch site, Pioneer 10 is shown leaving Earth and passing out of our Solar System between Saturn and Jupiter. In order to allow a decoding of the time of the launching, a diagram shows the directions to 14 pulsars as presently seen from our solar system. In a sense, this plaque is a 20th century counterpart of the stone lion of Nimrud Dagh.

This space experiment has been compared to throwing a bottle with a note into the sea. However, such a comparison is charitable: the ocean of the universe is vast, and even though Pioneer 10 travels at seven miles per second, it will not reach a potential planetary system for ten billion years (Sagan: 1980)!

The space program has encouraged laypersons, scientists, and science fiction writers alike to speculate on future human exploration in space and on the possibility of finding intelligent life-forms somewhere else in the universe. **Sky Travel**, through its `Information . . .` command, provides general information about all the celestial bodies and galaxies visible on your screen, as well as their distances if known. With this information, you can appreciate both the possibilities and the limitations of interplanetary and interstellar exploration and make your own judgments regarding reports you will see or hear in the news media in the future.

Astronautics

The space program has resulted in a general realization of just how unique Earth really is, and how inhospitable the rest of even our own solar system is. This doesn't mean that colonization of space is impossible, but it does mean that it will be difficult — and probably quite some time in coming. Aside from artificial space stations, the most likely bases for space colonies in our solar system are the Moon and perhaps the asteroids between Mars and Jupiter. These asteroids are relatively small, solid bodies ranging from about 1 to 500 miles in diameter; their advantage is that they are already in orbit. Some day such space stations might well serve as bases for deeper space probes.

The following procedure details the nature (size, temperature, and composition) of the Moon and the planets and lists the distances within our solar system.

Use the commands in the `Find` menu to locate each planet and the Moon. As you do, use the `Information...` command on each one. Since the fastest existing spacecraft travels at a speed of no more than about 1/10,000 the speed of light, you can calculate present travel times from the distances given. For example, to calculate travel time to a planet, multiply the number of light-minutes by 10,000 and convert the minutes to days, months, and years. For human space travel outside the solar system, the problems are literally astronomical. The distance to the nearest bright star (Rigil Kentaurus) is 4.3 light-years, which corresponds to a travel time of 43,000 years!

Of course, it's possible that the speed of future spacecraft may be increased dramatically. It's also possible that astronauts could be brought to a state of hibernation to increase their life spans or that later generations born and raised on board might eventually make it to distant places in the universe. Nevertheless, even if they do, this is not exploration in the sense that Earth was explored, nor the type of exploration that may be possible within our solar system itself: there would be no return tickets for the astronauts! Should they or their descendants ever return to Earth, it would be to a different place. If humankind were still to exist, the difference might be even greater than that between the Stone Age and our own age.

To develop an appreciation of the enormity of the universe and the distances even to the closest stars and galaxies outside our solar system, use the star and constellation tables in the back of this manual. For example, compare the distance from Earth to Sirius in Canis Major to the distance from Earth to Deneb in Cygnus. To locate the selected stars and deep-sky objects, use the `Constellation...` command from the `Find` menu and select the star's corresponding constellation. Once the constellation is centered in the Sky Window, use the `Information...` command on the star. If you don't recognize the star, rather than resorting to trial and error, use the declination/right ascension values in the star table and the same values in the Position Window to place the Mark directly on the star.

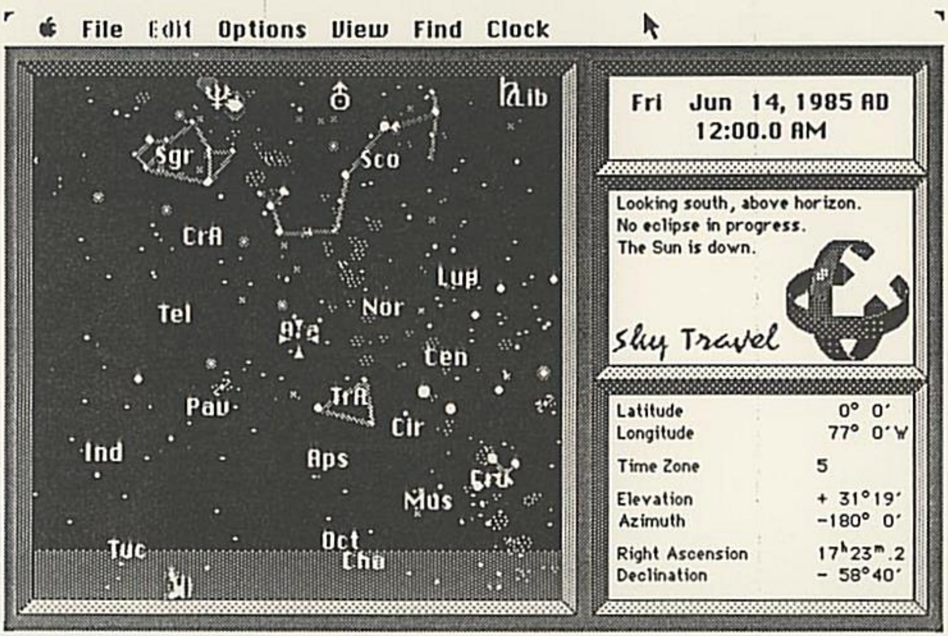
Sky Travel's `Deep Sky Objects` command lets you study the distant universe on your Macintosh. Here are a few examples:

Our galaxy, the Milky Way, is 100,000 light-years across. Our Sun is about 30,000 light-years from the center of the galaxy. If you look toward Sagittarius, you're looking in the direction of the center of the Milky Way.

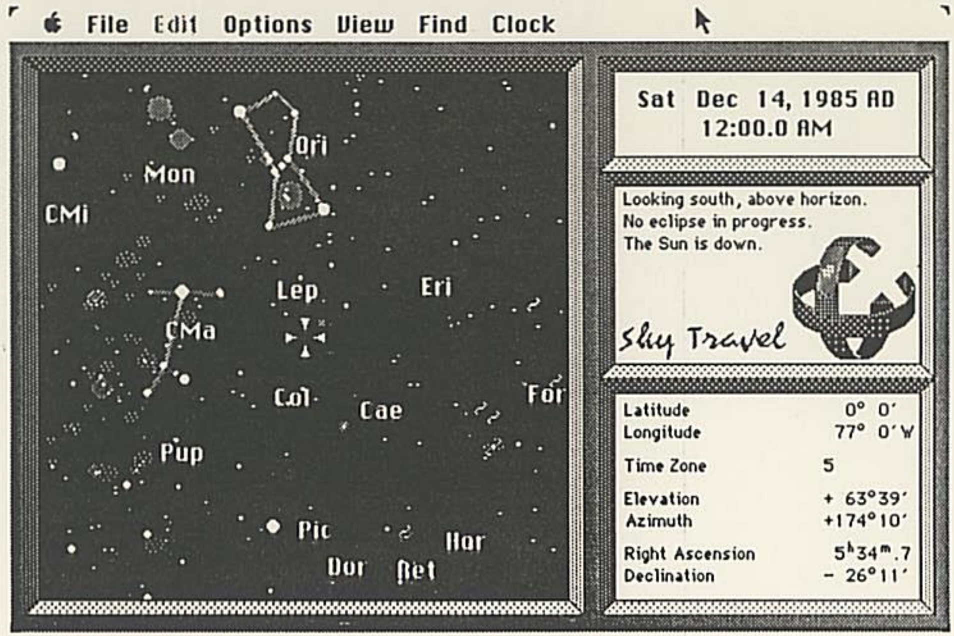
Set the World Map and the date and time as follows:

0° 0'N Latitude
77° 0'W Longitude
Time Zone 5
Fri Jun 14, 1985 AD
12:00.0 AM

From the Options menu turn on Constellation Names, Constellation Lines, and Deep Sky Objects. Set the view angle to 72°, and select South from the View menu for a southern view. You now have a typical summer night's view with a section of the Milky Way stretching diagonally across the screen. Note the many star clusters in this section.



Take a look now at the Milky Way in the direction of Orion and Canis Major. For a good view, you must go to the winter season. Keep the above settings, but change the month to December. Again look south with a view angle of 72°. Here you see a section of the Milky Way that covers the whole left half of your screen. Note particularly M42, the Great Nebula below the belt stars in Orion.

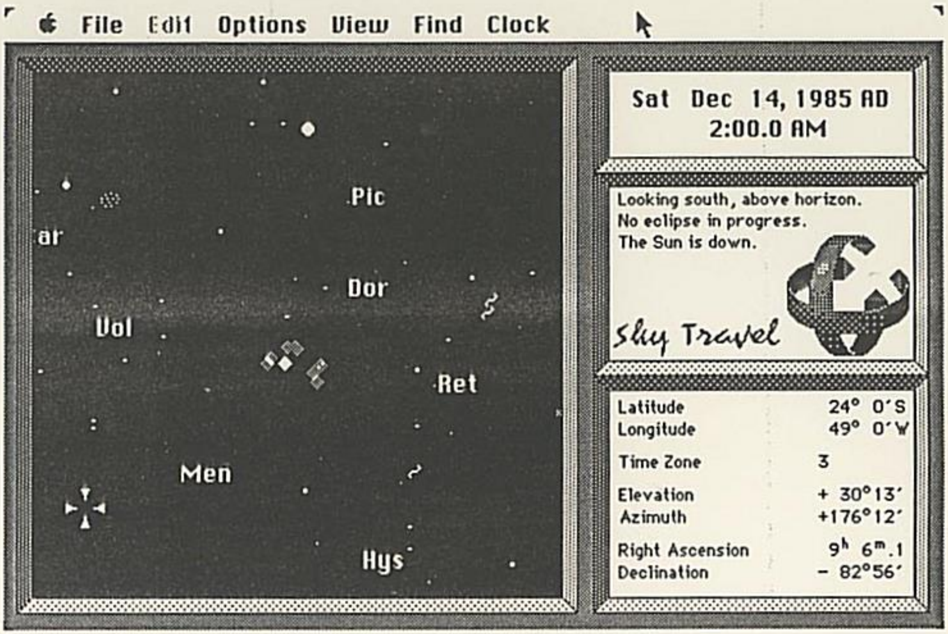


The closest galaxies to the Milky Way are the Small and the Large Magellanic Clouds, named after Ferdinand Magellan, the Portuguese explorer and discoverer of the Magellan Strait, who observed these "clouds" in the southern Sky. Satellite galaxies of the Milky Way, the Magellanic Clouds are 160,000 to 180,000 light years away. In order to observe them, you'll need to go to the Southern Hemisphere.

Leave the date and time (Dec 14, 1985, 12:00.0 AM) from the previous example, but change the World Map settings to the following:

24° 0'S Latitude
49° 0'W Longitude
Time Zone 3

Set your view angle to 72°, then select Constellation... from the Find menu. The easiest way to locate the Large Magellanic Cloud is to find the constellation Dorado (Dor). The Large Magellanic Cloud is indicated by the outline and several star clusters within the nebulosity. The Small Magellanic Cloud is nearby in the constellation Hydrus (Hys).



Earlier, you observed the Andromeda Galaxy, the most distant object in the sky that can still be seen with the naked eye. This galaxy is 2.2 million light-years away. The known universe is 40 billion light-years across (Gore: 1983).

Extraterrestrial Life

No signs of intelligent life, Scotty. Beam us up. Kirk out!

Captain James Kirk, from the television series Star Trek

The question of the possible existence of life beyond Earth is really a question on two levels. First, is there any form of life? Second, are there any intelligent life-forms? As to the first question, the Viking spacecraft's trip to Mars tried to determine whether the Martian soil contained any form of living organisms with which the addition of water and nutrients would show a typical biological reaction. Unfortunately, the results were inconclusive: the soil did respond, but in such a manner that chemical reactions alone might explain the observations. Thus, there is still no proof of life, even in a primitive form, beyond Earth.

The conditions that enable life, especially higher life-forms, to exist appear to occur very rarely in the universe. On the other hand, the universe is incredibly huge. In trying to estimate the probability that intelligent life-forms exist somewhere in the universe, we have to multiply a very small number by a very large one, both of which we have little basis for estimating. The result of such a calculation is basically a guess.

If we ask whether any advanced extraterrestrial beings might exist close enough to make possible some form of contact, such as the reception of radio signals, the answer is a definite "maybe." But the contact would hardly be a traditional conversation: by the time the answer got back, the "civilization" might well have ceased to exist! Certainly, the civilization on Earth, assuming that one still existed, would be very different from the one that sent the signals.

When a source of extremely regular radio pulses from deep space was observed for the first time in 1967 AD, the discoverers initially referred to the deep-sky object as LGM1 (LGM standing for "little green men"). Similar objects have since been detected and are now called pulsars. The types of radio signals emitted have been shown to be those expected from a rapidly rotating neutron star.

We may not be alone, but do not seem to have any close neighbors!

TECHNICAL NOTES

The technical details that follow are of particular interest to astronomers and advanced students.

Stellar Positions

A 2000 AD-epoch star catalog is used as the basis for all stellar positions. Calculations for other epochs take into account Earth's precession but not the proper motion of the stars. With the exception of a few of the closest stars which have large proper motions, stellar positions are accurate to within one minute of arc over the time span from 9999 BC to 9999 AD.

Planetary Positions

The planetary ephemerides used in the program are based on the method of T. Van Flandern and K.F. Pulkkinen *The Astrophysical Journal,* Supplement Series, Vol. 41, Nov. 1979: 391-411). Planetary perturbation effects are included. For the period 1700 AD-2300 AD, planetary position calculations are accurate to within a few minutes of arc. An exception is Pluto, whose orbit is not known accurately enough for position calculations better than about 15 minutes of arc. The utility of the planetary ephemerides has been considerably extended into the past by correcting for the difference between universal time (related to Earth's rotation) and ephemeris time (related to an absolute atomic clock standard). Calculations for the distant future are less reliable due to the lack of an accurate physical model for the long-term variations in the rate of rotation of Earth.

Solar and Lunar Positions

In addition to the planetary perturbations, this program allows for the long-term decelerations of the orbital motions of Earth and the Moon (due to tidal effects). For modern times (1900-2000 AD), the solar and lunar positions are accurate to within one minute of arc. For dates earlier than 1000 AD, time differences of 30 minutes to two hours may be expected due to uncertainties in the difference between ephemeris time and universal time. These differences are the result of changes in the distribution of mass on Earth (such as formation and melting of ice caps, continental drifts, and convection in the mantle) and may cause corresponding errors in lunar positions ranging from 15 minutes of arc to 1°. In cases where there's suitable historical data to verify events, the accuracy has been well within these limits.

Display Updates

When the Sky display is driven by the clock, the positions of all celestial bodies are updated automatically according to the following schedule:

Update Intervals in minutes and seconds

Clock Rate	Clock Time	Real-Time
1x	0:48	0:48
2x	1:24	0:41
4x	2:18	0:34
8x	3:48	0:28
16x	5:36	0:21
32x	7:48	0:14
64x	8:24	0:08

Precession updates occur automatically whenever the interval between a new date/time setting and the previous one exceeds 50 years. To calculate precession for a given year, set the clock to a date at least fifty years different from the one it is currently on, then set it for the date you wish.

Graphic Display

In order to achieve a pleasing display, the size of the tokens used to represent the Sun and the Moon is greatly exaggerated. Since the token size is constant, the size exaggeration factor for both the Sun and the Moon varies with the view angle, as shown in the table below:

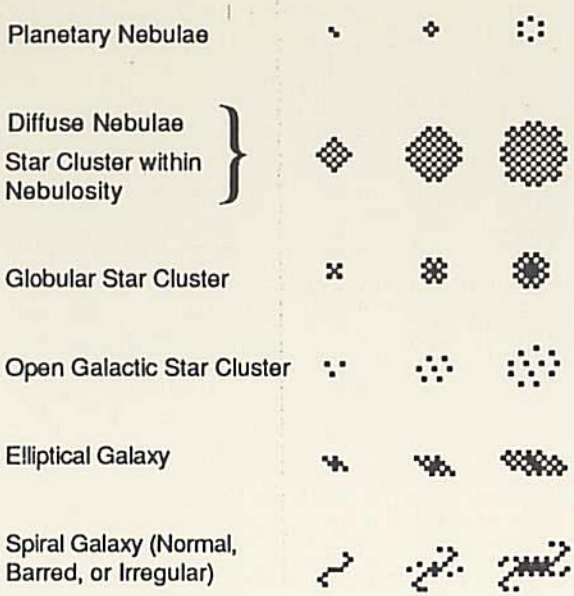
View Angle	Size Factor
72°	16x
36°	8x
18°	4x
9°	2x
4.5°	1x

The 4.5° view angle shows the Sun and Moon to scale. Use this setting for eclipses, transits, and occultations.

Enlarged tokens are also used for the stars and planets to give an impression of their brightness. The pixel patterns are shown in the following table:

<-2
-2 to -1
-1 to 0
0 to 1
1 to 2
2 to 3
3 to 4
4 to 5

The deep-sky objects are also represented by enlarged tokens with pixel patterns as shown on the opposite page.



The Andromeda Galaxy (M31) has its own token.

In addition to aesthetic considerations, oversized tokens were chosen to help the user easily differentiate between the various celestial objects shown on the monitor. Actual angular sizes are greatly exaggerated by the displays, so the tokens do not portray the actual apparent sizes of the objects they represent. Nor were they intended to; they're meant solely as schematic aids for displaying the various celestial objects and for showing their positions.

Eclipses, Transits, and Occultations

Oversized tokens and finite intervals of position updating can lead to misinterpretation of certain displays unless the 4.5° view angle is selected. When wider fields are used, overlap of tokens doesn't necessarily mean that an event is in progress. In the special cases of solar eclipses, the program overcomes the difficulty by calculating eclipse graphics based on actual angular sizes rather than on the displayed token sizes. When an eclipse actually occurs, the program plots a token for the partially eclipsed solar disk that has the correct relative size of the obscuring dark disk of the Moon. This allows the various phases of a solar eclipse, from first contact through totality to last contact, to be displayed as they would appear in the sky.

TABLES

Latitudes and Longitudes

I: North American Cities

Name	Latitude Deg	Min	NS	Longitude Deg	Min	EW	State/Country
Albuquerque	35	05	N	106	38	W	New Mexico, USA
Anchorage	61	10	N	149	53	W	Alaska, USA
Atlanta	33	45	N	84	23	W	Georgia, USA
Baltimore	39	17	N	76	37	W	Maryland, USA
Bangor	44	49	N	68	47	W	Maine, USA
Boise	43	37	N	116	13	W	Idaho, USA
Boston	42	20	N	71	05	W	Massachusetts, USA
Calgary	51	03	N	114	05	W	Alberta, Canada
Chicago	41	59	N	87	38	W	Illinois, USA
Cincinnati	39	06	N	84	31	W	Ohio, USA
Cleveland	41	30	N	81	41	W	Ohio, USA
Dallas	32	47	N	96	48	W	Texas, USA
Denver	39	45	N	105	00	W	Colorado, USA
Des Moines	45	35	N	93	35	W	Iowa, USA
Detroit	42	20	N	83	03	W	Michigan, USA
Edmonton	53	34	N	113	25	W	Alberta, Canada
El Paso	31	45	N	106	29	W	Texas, USA
Fairbanks	64	51	N	147	43	W	Alaska, USA
Halifax	44	38	N	63	35	W	Nova Scotia, Canada
Honolulu	21	19	N	157	52	W	Hawaii, USA
Houston	29	46	N	95	22	W	Texas, USA
Indianapolis	39	46	N	86	09	W	Indiana, USA
Jacksonville	30	20	N	81	40	W	Florida, USA
Kansas City	39	05	N	94	37	W	Kansas/Missouri, USA
Las Vegas	36	11	N	115	08	W	Nevada, USA
Los Angeles	34	00	N	118	15	W	California, USA
Madison	43	04	N	89	22	W	Wisconsin, USA
Mexico City	19	25	N	99	10	W	Mexico; Capital
Miami	25	45	N	80	15	W	Florida, USA
Milwaukee	43	02	N	87	55	W	Wisconsin, USA
Minneapolis	45	00	N	93	15	W	Minnesota, USA
Montreal	45	31	N	73	34	W	Quebec, Canada
New Orleans	30	00	N	90	03	W	Louisiana, USA
New York	40	43	N	74	01	W	New York, USA
Nome	64	30	N	165	30	W	Alaska, USA
Oklahoma City	35	28	N	97	32	W	Oklahoma, USA
Omaha	41	15	N	96	00	W	Nebraska, USA
Ottawa	45	25	N	75	42	W	Ontario, Canada; Capital
Philadelphia	40	00	N	75	10	W	Pennsylvania, USA
Phoenix	33	30	N	112	03	W	Arizona, USA
Pittsburgh	40	26	N	80	00	W	Pennsylvania, USA
Quebec	46	50	N	71	15	W	Quebec, Canada
Salt Lake City	40	45	N	111	55	W	Utah, USA
San Francisco	37	45	N	122	27	W	California, USA
San Juan	18	29	N	66	08	W	Puerto Rico, USA
Seattle	47	36	N	122	20	W	Washington, USA
St. John's	47	34	N	52	41	W	Newfoundland, Canada
St. Louis	38	40	N	90	15	W	Missouri, USA
Toronto	43	39	N	79	23	W	Ontario, Canada
Vancouver	49	13	N	123	06	W	British Columbia, Canada
Washington D.C.	38	55	N	77	00	W	USA; Capital
Winnipeg	49	53	N	97	10	W	Manitoba, Canada

II: Cities Outside NA Continent

Name	Latitude Deg	Min	NS	Longitude Deg	Min	EW	Country/Continent
Accra	5	33	N	0	15	W	Ghana, Africa; Capital
Addis Ababa	9	03	N	38	42	E	Ethiopia, Africa; Capital
Algiers	36	50	N	3	00	E	Algeria, Africa; Capital
Amsterdam	52	21	N	4	54	E	Holland, Europe; Capital
Anadyr	64	55	N	176	05	E	USSR, Asia
Ankara	39	55	N	32	50	E	Turkey, Asia Minor; Capital
Asuncion	25	15	S	57	40	W	Paraguay, S. America; Capital
Athens	38	00	N	23	44	E	Greece, Europe; Capital
Baghdad	33	20	N	44	26	E	Iraq, Middle East; Capital
Bangkok	13	44	N	100	30	E	Thailand, Asia; Capital
Beirut	33	52	N	35	30	E	Lebanon, Middle East; Capital
Belgrade	44	50	N	20	30	E	Yugoslavia, Europe; Capital
Benghazi	32	07	N	20	05	E	Libya, Africa
Berlin	52	32	N	13	25	E	West Germany, Europe
Bern	46	57	N	7	26	E	Switzerland, Europe; Capital
Bogota	4	38	N	74	05	W	Columbia, S. America; Capital
Bombay	18	56	N	72	51	E	India, Asia
Bonn	50	44	N	7	06	E	West Germany, Europe; Capital
Brasilia	15	45	S	47	57	W	Brazil, S. America; Capital
Brussels	50	50	N	4	21	E	Belgium, Europe; Capital
Bucharest	44	25	N	26	07	E	Romania, Europe; Capital
Budapest	47	30	N	19	03	E	Hungary, Europe; Capital
Buenos Aires	34	40	S	58	30	W	Argentina, S. America; Capital
Cairo	30	03	N	31	15	E	Egypt, Africa; Capital
Calcutta	22	30	N	88	20	E	India, Asia
Cape Town	33	56	S	18	28	E	South Africa, Africa
Caracas	10	35	N	66	56	W	Venezuela, S. America; Capital
Casablanca	33	39	N	7	35	W	Morocco, Africa
Colombo	6	55	N	79	52	E	Ceylon-Sri Lanka, Asia; Capital
Copenhagen	55	43	N	12	34	E	Denmark, Europe; Capital
Dacca	23	42	N	90	22	E	Bangladesh, Asia; Capital
Dakar	14	38	N	17	27	W	Senegal, Africa; Capital
Dublin	53	20	N	6	15	W	Ireland, Europe; Capital
Godthaab	64	15	N	51	35	W	Greenland
Hanoi	21	01	N	105	52	E	N. Vietnam, Asia; Capital
Havana	23	07	N	82	25	W	Cuba, Caribbean; Capital
Helsinki	60	08	N	25	00	E	Finland, Europe; Capital
Hiroshima	34	23	N	132	27	E	Japan, Asia
Hong Kong	22	15	N	114	11	E	China, Asia
Istanbul	41	02	N	28	57	E	Turkey, Asia Minor
Jakarta	6	08	S	106	45	E	Indonesia, Asia; Capital

Name	Latitude			Longitude			Country/Continent
	Deg	Min	NS	Deg	Min	EW	
Jerusalem	31	47	N	35	13	E	Israel, Middle East
Johannesburg	26	10	N	28	02	E	South Africa, Africa
Kabul	34	30	N	69	10	E	Afghanistan, Asia; Capital
Karachi	24	51	N	67	02	E	Pakistan, Asia
Khartoum	15	33	N	32	32	E	Sudan, Africa; Capital
Kiev	50	26	N	30	31	E	USSR, Europe
Kinshasa	4	18	S	15	18	E	Zaire, Africa; Capital
Kyoto	35	02	N	135	45	E	Japan, Asia
Lagos	6	27	N	3	28	E	Nigeria, Africa; Capital
La Paz	16	30	S	68	10	W	Bolivia, S. America; Capital
Leningrad	59	55	N	30	25	E	USSR, Europe
Lima	12	06	S	77	03	W	Peru, S. America; Capital
Lisbon	38	44	N	9	08	W	Portugal, Europe; Capital
London	51	30	N	0	10	W	England, Europe; Capital
Longyearbyen	78	12	N	15	40	E	Svalbard, Norway, Europe
Madrid	40	25	N	3	43	W	Spain, Europe; Capital
Magadan	59	38	N	150	50	E	USSR, Asia
Manila	14	37	N	120	58	E	Phillipines; Capital
Marrakech	31	49	N	8	00	W	Morocco, Africa
Mecca	21	26	N	39	49	E	Saudi Arabia, Middle East
Melbourne	37	45	S	144	58	E	Victoria, Australia
Montevideo	34	55	S	56	10	W	Uruguay, S. America; Capital
Moscow	55	45	N	37	42	E	USSR, Europe; Capital
Murmansk	68	59	N	33	08	E	USSR, Europe
Nagasaki	32	45	N	129	52	E	Japan, Asia
Nairobi	1	17	S	36	50	E	Kenya, Africa; Capital
New Delhi	28	37	N	77	13	E	India, Asia; Capital
Novosibirsk	55	04	N	83	05	E	USSR, Asia
Omsk	55	00	N	73	22	E	USSR, Asia
Oslo	59	56	N	10	45	E	Norway, Europe; Capital
Paris	48	52	N	2	20	E	France, Europe; Capital
Peking	39	55	N	116	26	E	China, Asia; Capital
Perth	31	58	S	115	49	E	West Australia
Prague	50	06	N	14	26	E	Czechoslovakia, Europe; Capital
Quito	0	14	S	78	30	W	Ecuador, S. America; Capital
Rangoon	16	47	N	96	10	E	Burma, Asia; Capital
Reykjavik	64	09	N	21	58	W	Iceland; Capital
Rio de Janeiro	22	53	S	43	17	W	Brazil, S. America
Riyadh	24	39	N	46	46	E	Saudi Arabia, Mdl. East; Capital
Rome	41	53	N	12	30	E	Italy, Europe; Capital
Saigon	10	46	N	106	43	E	S. Vietnam, Asia; Capital
Santiago	33	30	S	70	40	W	Chile, S. America; Capital
Sao Paulo	23	33	S	46	39	W	Brazil, S. America
Seoul	37	30	N	127	00	E	Korea, Asia; Capital
Shanghai	31	13	N	121	25	E	China, Asia
Singapore	1	17	N	103	51	E	Malacca, Asia
Sofia	42	40	N	23	18	E	Bulgaria, Europe; Capital
Stockholm	59	20	N	18	05	E	Sweden, Europe; Capital
Sydney	33	55	S	151	10	E	New South Wales, Australia
Taipei	25	05	N	121	32	E	Taiwan, Asia; Capital
Tananarive	18	52	S	47	30	E	Madagascar; Capital
Tashkent	41	16	N	69	13	E	USSR, Asia
Teheran	35	40	N	51	26	E	Iran, Middle East; Capital
Tel Aviv	32	05	N	34	46	E	Israel, Middle East
Thule	77	30	N	69	29	W	Greenland
Timbuktu	16	49	N	2	59	E	Mali, Africa
Tokyo	35	40	N	139	45	E	Japan, Asia; Capital
Tomsk	56	30	N	85	05	E	USSR, Asia
Tripoli	32	58	N	13	12	E	Libya, Africa
Tunis	36	50	N	10	13	E	Tunisia, Africa; Capital
Vienna	48	13	N	16	20	E	Austria, Europe; Capital
Vladivostok	43	09	N	131	53	E	USSR, Asia
Warsaw	52	15	N	21	00	E	Poland, Europe; Capital
Wellington	41	17	S	174	47	E	New Zealand; Capital
Yakutsk	62	10	N	129	50	E	USSR, Asia
Zanzibar	6	10	S	39	11	E	Tanzania, Africa

III: Islands

Name	Latitude			Longitude			Ocean
	Deg	Min	NS	Deg	Min	EW	
Ascension	7	57	S	14	22	W	Atlantic
Azores	38	30	N	28	00	W	Atlantic
Bermuda	32	20	N	64	45	W	Atlantic
Bouvet	54	26	S	3	24	E	Atlantic
Canary	28	30	N	14	10	W	Atlantic
Cape Verde	16	00	N	24	00	W	Atlantic
Christmas	2	00	N	157	30	W	Pacific
Christmas	10	30	S	105	40	E	Indian
Coco	13	14	N	144	39	E	Pacific
Cocos/Keeling	12	10	S	96	55	E	Indian
Cook	20	00	S	158	00	W	Pacific
Easter	27	07	S	109	22	W	Pacific
Falkland	51	45	S	59	00	W	Atlantic
Fiji	18	00	S	175	00	E	Pacific
Galapagos	0	30	S	90	30	W	Pacific
Gilbert	0	30	S	174	00	E	Pacific
Gough	40	20	S	10	00	W	Atlantic
Guam	13	50	N	144	75	E	Pacific
Jan Mayen	71	00	N	8	20	W	Arctic
Kerguelen	49	15	S	69	10	E	Antarctic
Marquesas	9	00	S	139	30	W	Pacific
Marshall	9	00	N	168	00	E	Pacific
Palmyra	5	52	N	162	05	W	Pacific
Pitcairn	25	04	S	130	06	W	Pacific
Samoa	14	00	S	171	00	W	Pacific
Seychelles	4	35	S	55	40	E	Indian
South Georgia	54	15	S	36	45	W	Antarctic
South Orkney	60	35	S	45	30	W	Antarctic
St. Helena	15	57	S	5	42	W	Atlantic
Tahiti	17	70	S	150	00	W	Pacific
Tonga	20	00	S	175	00	W	Pacific
Tristan da Cunha	37	15	S	12	30	W	Atlantic
Wake	19	17	N	166	36	E	Pacific

Names Stars & Navigational Stars

Name	Declination Deg	Min	NS	Rt. Asc. Hrs.	Min.	Constellation	Comments
Acamar	40	18	S	2	58.3	Eridanus	
Achernar	57	14	S	1	37.7	Eridanus	
Acrux	63	6	S	12	26.6	Crux	
Adhara	28	58	S	6	58.6	Canis Major	
Albireo*)	27	58	N	19	30.7	Cygnus	Blue/yellow double star
Aldebaran	16	31	N	4	35.9	Taurus	
Algenib	15	11	N	0	13.2	Pegasus	
Algol	40	57	N	3	8.2	Perseus	3 day cycle double star
Alioth	56	58	N	12	54.0	Ursa Major	
Alkaid	49	18	N	13	47.5	Ursa Major	
Alnilam	1	12	S	5	36.2	Orion	
Alphard	8	40	S	9	27.6	Hydra	
Alphecca	26	43	N	15	34.7	Corona Borealis	
Alpheratz	29	5	N	0	8.4	Andromeda	
Altair	8	52	N	19	50.8	Aqila	
Ankaa	42	18	S	0	26.3	Phoenix	
Antares	26	26	S	16	29.4	Scorpio	
Arcturus	19	11	N	14	15.7	Bootes	
Atria	69	2	S	16	48.7	Triangulum Australe	
Avior	59	31	S	8	22.5	Carina	
Bellatrix	6	21	N	5	25.1	Orion	
Betelgeuse	7	24	N	5	55.2	Orion	
Canopus	52	42	S	6	24.0	Carina	Second brightest star
Capella	45	60	N	5	16.7	Auriga	
Caph	59	9	N	0	9.2	Cassiopeia	
Castor	31	53	N	7	34.6	Gemini	
Deneb	45	17	N	20	41.4	Cygnus	
Deneb Kaitos	17	59	S	0	43.6	Cetus	
Denebola	14	34	N	11	49.0	Leo	
Dubhe	61	45	N	11	3.7	Ursa Major	
Elnath	28	36	N	5	26.3	Taurus	
Eltanin	51	29	N	17	56.6	Draco	
Enif	9	52	N	21	44.2	Pegasus	
Fomalhaut	29	37	S	22	57.6	Pisces Austrinus	
Gacrux	57	7	S	12	31.2	Crux	
Gienah	17	32	S	12	15.8	Corvus	
Hadar	60	22	S	14	3.8	Centaurus	
Hamal	23	28	N	2	7.2	Aries	
Kaus Australis	34	23	S	18	24.2	Sagittarius	
Kochab	74	9	N	14	50.7	Ursa Minor	
Markab	15	12	N	23	4.8	Pegasus	
Menkar	4	5	N	3	2.3	Cetus	
Menkent	36	22	S	14	6.7	Centaurus	
Merope	23	57	N	3	46.3	Taurus	
Miaplacidus	69	43	S	9	13.2	Carina	
Mira	2	59	S	2	19.3	Cetus	"Disappearing" star, varies during year from very bright to invisible to naked eye
Mirfak	49	52	N	3	24.3	Perseus	
Mizar**)	54	56	N	13	23.9	Ursa Major	Double star, observable w/naked eye
Nunki	26	18	S	18	55.3	Sagittarius	
Peacock	56	44	S	20	25.6	Pavo	
Polaris	89	16	N	2	31.8	Ursa Minor	Pole Star = North Star
Polluxz	28	2	N	7	45.3	Gemini	
Procyon	5	14	N	7	39.3	Canis Minor	
Ras Elhague	12	34	N	17	34.9	Ophiuchus	
Regulus	11	58	N	10	8.4	Leo	
Rigel	8	12	S	5	14.5	Orion	
Rigil Kentaurus	60	50	S	14	39.6	Centaurus	Third brightest star: closest star to Sun (4.3 light years)
Sabik	15	44	S	17	10.4	Ophiuchus	
Saiph	9	40	S	5	47.8	Orion	
Schedar	56	32	N	0	40.5	Cassiopeia	
Shaula	37	06	S	17	33.6	Scorpio	
Sirius	16	43	S	6	45.1	Canis Major	Brightest star
Spica	11	10	S	13	25.3	Virgo	
Vega	38	47	N	18	36.9	Lyra	Orbiting infra-red observatory recently discovered solar system in formative state
Zuben Elgenubi	16	02	S	14	50.9	Libra	

*) 30-40 X telescope needed

**) In ancient times, the Arabs used the star Mizar in the Big Dipper for testing vision. If you could see two stars, your eyesight was perfect! Mizar's companion star is Alcor.

Constellations

* Constellations Belong to Zodiac

**Constellations Have Line Diagrams in Planetarium

† Marked Constellations Are Post-Ptolemy (c. 150 A.D.)

Abr.	Latin Name	English Name	Comments
And	Andromeda	Andromeda	Great Spiral Galaxy (M31), most distant naked eye object (2 million light years)
Ant	†Antilia	Air Pump	
Aps	†Apus	Bird of Paradise	
Aql	**Aquila	Eagle	
Aqr	*Aquarius	Water Carrier	
Ara	Ara	Altar	
Ari	*Aries	Ram	
Aur	**Auriga	Charioteer	
Boo	**Bootes	Herdsman	
Cae	†Caelum	Graving Tool	
Cam	†Camelopardus	Giraffe	
Cap	***Capricorn	Sea Goat	
Car	†Carina	Keel	
Cas	**Cassiopeia	Cassiopeia	
Cen	Centaurus	Centaur	Rigil Kentaurus = a-Centauri, this is the closest star (4.3 light years)
Cep	**Cepheus	Cepheus	
Cet	Cetus	Whale	
Cha	†Chamaeleon	Chamaeleon	
Cir	†Circinus	Compass	
CMa	Canis Major	Big Dog	
CMi	Canis Minor	Little Dog	
Cnc	*Cancer	Crab	Beehive Cluster = Praesepe Cluster (M44)
Col	†Columba	Dove	
Com	†Coma Berenices	Berenice's Hair	
CrA	Corona Australis	Southern Crown	
CrB	**Corona Borealis	Northern Crown	
Crt	Crater	Cup	
Cru	†Crux	Southern Cross	
Crv	Corvus	Crow	Cutter's Mainsail
CVn	†Canis Venaciti	Hunting Dogs	
Cyg	**Cygnus	Swan	Northern Cross, CygX-1 may be "Black Hole"
Del	**Delphinus	Dolphin	
Dor	†Dorado	Goldfish	
Dra	Draco	Dragon	
Equ	Equuleus	Little Horse	
Eri	Eridanus	River	
For	†Fornax	Furnace	
Gem	***Gemini	Twins	
Gru	†Grus	Crane	
Her	**Hercules	Hercules	Great Cluster (M13)
Hor	†Horologium	Clock	
Hya	Hydra	Sea Serpent	
Hys	**†Hydrus	Water Monster	
Ind	†Indus	Indian	
Lac	†Lacerta	Lizard	
Leo	***Leo	Lion	
Lep	Lepus	Hare	
Lib	***Libra	Scales	
LMi	†Leo Minor	Little Lion	
Lup	Lupus	Wolf	
Lyn	†Lynx	Lynx	
Lyr	**Lyra	Lyre	Vega (see star table), Ring Nebula (M57)
Men	†Mensa	Table Mountain	
Mic	†Microscopium	Microscope	
Mon	†Monoceros	Unicorn	
Mus	†Musca	Fly	
Nor	†Norma	Level	
Oct	†Octans	Octant	
Oph	Ophiuchus	Serpent Holder	
Ori	**Orion	Orion	Great Nebula (M42)
Pav	†Pavo	Peacock	
Peg	**Pegasus	Pegasus	
Per	**Perseus	Perseus	
Phe	†Phoenix	Phoenix	
Pic	†Pictor	Easel	
PsA	Piscis Austrinus	Southern fish	
Psc	*Pisces	Fishes	
Pup	†Puppis	Stern	
Pyx	†Pyxis	Mariner's Compass	
Ret	†Reticulum	Net	
Scl	†Sculptor	Sculptor	
Sco	**†Scorpius	Scorpion	
Sct	†Scutum	Shield	
Ser	Serpens Caput	Serpent	
Ser	Serpens Cauda	Serpent	
Sex	†Sextans	Sextant	
Sge	Sagitta	Arrow	
Sgr	***Sagittarius	Archer	Tea Pot, Center of our galaxy (Milky Way)
Tau	*Taurus	Bull	Crab Nebula (M1) w/pulsar is remnant of 1054 A.D. supernova, Hyades and Pleiades Clusters
Tel	†Telescopium	Telescope	
TrA	**†Triangulum Australe	Southern Triangle	
Tri	Triangulum	Triangle	
Tuc	†Tucana	Toucan	
UMa	**Ursa Major	Big Bear	Big Dipper, Exploding galaxy (M82)
UMi	**Ursa Minor	Little Bear	Little Dipper, Polaris
Vel	†Vela	Sail	
Vir	*Virgo	Virgin	
Vol	†Volans	Flying Fish	
Vul	†Vulpecula	Little Fox	

FUTURE ASTRONOMICAL EVENTS

Total Solar Eclipse

(WARNING — Never look directly at the SUN, even during a total eclipse)

Year	Date	Duration (Min)	Location
1984	Nov. 22	2.1	Indonesia, S. America, Pacific Ocean
1987	Mar. 29	0.3	Equatorial Africa, Atlantic Ocean
1988	Mar. 18	4.0	Phillipines, Indonesia, Indian and Pacific Oceans
1990	July 22	2.6	Finland, North Atlantic
1991	July 11	7.1	Hawaii, Brazil, Central America, Pacific Ocean
1992	June 30	5.4	South Atlantic
1994	Nov. 3	4.6	S. America, Pacific Ocean
1995	Oct. 24	2.4	S. Asia, Pacific and Indian Oceans
1997	Mar. 9	2.8	Siberia, Arctic
1998	Feb. 26	4.4	Central America, Pacific and Atlantic Oceans
1999	Aug. 11	2.6	Central and Southern Europe, Central Asia

Transits by Venus

2004 June 8
2012 June 5-6

Transits by Mercury*)

1986 Nov. 13
1993 Nov. 6
1999 Nov. 15

*) Telescope needed

Halley's Comet

Best time of observation, Northern Hemisphere:	1985, Sept.-Dec.
Perihelion:	1986, early February
Best time of observation, Southern Hemisphere:	1986, March-July

CONVERSIONS

Distance

$$\text{velocity} = \frac{\text{distance}}{\text{time}}$$

e.g. velocity of light $= \frac{186{,}282 \text{ miles}}{1 \text{ second}} = \frac{299{,}793 \text{ km}}{1 \text{ second}}$

$$\text{distance} = \text{velocity} * \text{time}$$

e.g. light second
= 186,282 miles/sec * 1 sec = 186,282 miles
= 299,793 km/sec * 1 sec = 299,793 km

e.g. light minute
= 186,282 miles/sec * 1 min * 60 sec/min
= 11,176,945 miles
= 299,793 km/sec * 1 min * 60 sec/min
= 17,987,550 km

e.g. light hour
= 186,282 miles/sec * 1 hr * 60 min/hr * 60 sec/min
= 670,616,721 miles
= 299,793 km/sec * 1 hr * 60 min/hr * 60 sec/min
= 1,079,253,000 km

e.g. light year
= 186,000 miles/sec * 1 * 365.25 * 24 * 60 * 60
= 5,878,626,175,000 miles
= 299,793 km/sec * 1 * 365.25 * 24 * 60 * 60
= 9,460,731,798,000 km

Another unit of distance is the parsec. It is defined to be the distance at which the orbit of the earth has an apparent radius of 1 sec. of arc. Since the average radius of the earth's orbit is 149,500,000 km, this enormous distance is:

$$\frac{149{,}500{,}000 \text{ km}}{1 \text{ sec} / 3600 \text{ sec/deg} / 180 \text{ deg/pi} \cdot \text{radians}} = 3.083659 * 10^{13} \text{ km} = 3.25943 \text{ light years}$$

One light year is therefore 0.306802 parsecs.

Hours and Degrees

Hours ⟷ Degrees

24 hrs = 360 degrees

Hours ⟶ Degrees

e.g. Convert 7 hrs 12 min 27 sec to degrees

7 hrs * 360 deg/24 hrs	=	105.0000 deg
12 min * 1 hr/60 min * 360 deg/24 hrs	=	3.0000 deg
27 sec * 1 hr/3600 sec * 360 deg/24 hrs	=	0.1125 deg
		108.1125 deg

i.e.

108.1125 degrees

Degrees ⟶ Hours

e.g. Convert 108.1125 deg to hrs:min:sec
108.1125 deg * 24 hr/360 deg = 7.2075 hrs
0.2075 hrs * 60 min/hr = 12.450 min
0.450 min * 60 sec/min = 27.00 sec

or

7 hrs 12 min 27 sec

GLOSSARY

Asteroid: A rocky object, smaller than a planet, that orbits the sun.

Astronomy: The branch of science that studies the universe beyond the Earth's atmosphere.

Autumnal Equinox: The equinox that takes place around September 23.

Azimuth: The position of an object above the Earth. The number of degrees east from due north to the object's vertical circle.

Cardinal Directions: North, south, east, or west.

Celestial Equator: An imaginary circle on the celestial sphere directly above the Earth's equator.

Celestial Pole: Either of the two imaginary points on the celestial sphere directly above the Earth's North and South Poles.

Celestial Sphere: An imaginary sphere surrounding the Earth and representing the entire sky. The stars, planets, and other heavenly bodies appear to be located on the surface of the celestial sphere.

Chronologist: A person who studies time and records human history. Orders the time and place of events in the order in which they occurred.

Chronometer: Instrument used to keep time with great accuracy.

Circumpolar: Surrounding or found in the vicinity of the Earth's or the sky's poles.

Cluster: Groups of thousands to millions of stars that appear to be close together.

Comet: A bright heavenly body made up of ice, frozen gases, and dust particles that orbits the sun. It has a long tail that points away from the sun.

Configuration: The arrangement of several things.

Conjunction: The apparent meeting or passing of two or more celestial bodies in the same degree of the zodiac.

Constellation: A group of stars forming a pattern that suggests an object, animal, or mythological character. The constellations divide the sky into 88 areas.

Declination: The angular distance of a celestial body north or south of the celestial equator.

Double Star: Two stars that appear as one because they are nearly in line with each other, or are close together.

Eclipse: Total or partial blocking of light from a celestial body caused by its passing into the shadow of another body. Also the hiding of on a celestial body by another.

Ecliptic: The circular path that the sun seems to travel in a year around the sky.

Elevation: The angular distance of a celestial body above the horizon.

Equatorial Sky Orientation Map: Mercator projection of the celestial sphere.

Equinox: Either of the two times a year when day and night are of equal length all over the Earth. During these two times, the sun is directly above the equator.

Extraterrestrial: Originating or existing outside the Earth or its atmosphere.

Galaxy: Any of the huge grouping of stars, dust, and gases scattered throughout the universe. Billions of stars held together by gravitational attraction.

Greenwich Mean Time: The time at the prime meridian in Greenwich, England. Used as the prime basis of standard time by which the time zones of the world are established.

Horizon: The line where the sky and the Earth, or sea, meet.

Latitude: The angular distance north or south of the equator. All points of a given latitude form a circle running east and west. These circles are parallel to the equator.

Light Year: The distance travelled by light in one solar year. About 5,880,000,000,000 miles.

Longitude: The angular distance east or west of the prime meridian. All points of a given longitude form a circle running north and south through the North and South Poles.

Lunar Eclipse: A partial or total darkening of the moon when the Earth moves between the moon and the sun.

Mathematician: An expert in mathematics.

Meridian: Imaginary great circles on the Earth's surface passing through the North and South Poles. Also known as longitude.

Messier Number: Charles Messier was a French astronomer and comet hunter who prepared the first catalog of non-stellar sky objects. He assigned a number to these objects as he encountered them in his comet hunting.

Meteor: The streak of light caused by a meteoroid that passes through Earth's atmosphere. The burning meteoroid is often called a "shooting star."

Meteorite: A meteoroid that survives passage through the Earth's atmosphere and arrives on the Earth's surface without completely burning up.

Meteoroid: A solid body, smaller than an asteroid, that orbits the sun. Both meteors and meteorites were meteoroids.

Millennial: Of or relating to a thousand years.

Moon: A natural satellite orbiting a planet.

Nebula: A bright, cloudlike mass composed of stars, or dust, and gases. Visible in the night sky.

Opposition: A position that is opposite to another.

Orbital (positions): Of or relating to the path of a heavenly body as it revolves in a closed curve around another body.

Parallel: Going in the same direction and always being the same distance apart at every point, so as never to meet.

Phases: The varying shape of the lighted position of a planet or moon, such as full, half, crescent, etc.

Planet: A rotating body held in orbit by the gravitational attraction of a star. A planet is not self-luminous; it reflects starlight. Its own gravity pulls the planet into its most stable shape, a slightly flattened sphere.

Planetary Occultations: The hiding of a star or one planet by another planet.

Planetary Transit: The passage of a planet directly between the earth and the sun so that it can be seen as a black dot moving across the disk of the sun.

Precession: A slow change in the direction of the tilt of the Earth's axis. This results in an apparent change in the position of the stars. Precession is a wobble in the rotation of the Earth, like a top when it slows down.

Prime Meridian: O° longitude which runs through Greenwich, England. The point from which longitude east and west is measured.

Pulsars: A neutron star that rotates rapidly and emits a beam of radiation. Any number of astronomical objects that send out intense pulses of radiation at short, regular intervals.

Refraction:	The change in the apparent position of a celestial body due to the bending of the light rays which come from the celestial body.
Right Ascension:	The east/west coordinate by which the position of a celestial body is measured.
Rotation:	The act or process of turning around an axis. The rotation of the Earth takes 24 hours.
Sextant:	An instrument for determining the angle between the horizon and a celestial body. Used in navigation of ships and planes to determine latitude.
Slew:	To turn about a fixed point.
Solar Day:	The time interval between 2 successive transits by the sun of the meridian directly opposite that of the observer. The 24 hour interval from one midnight to the following.
Solar Eclipse:	The partial or total blocking of the sun's light by the moon as it passes between the sun and the Earth.
Solar Year:	The time interval between one vernal equinox and the next. 365 days, 5 hours, 48 minutes, and 46 seconds.
Stellar:	Resembling a star or stars.
Synchronize:	To happen at the same time.
Trajectory:	The path followed by a meteor, or the like, moving through space.
Universe:	All that exists including the Earth, heavens, and all of space. The entire physical world.
Vernal Equinox:	The equinox that takes place around March 21.
Zenith:	The point in the heavens directly above the place where a person stands.
Zodiac:	An imaginary belt in the heavens approximately 18° wide that the sun, the moon, and all the planets except Pluto appear to follow. The zodiac is divided into 12 parts, called signs, with each part named after a constellation.

SUPPLEMENTARY READING

Books & Articles

Code: E = Elementary
P = Popular
A = Advanced
* = Multi-Authored
Anon = Anonymous Author

Reference	Geography	Astronomy/Star Finding	Astronomy/General	Astronomy/Deep Sky Objects	Chronology/Calendars	History/Archaeology	Navigation	Astronautics/Xtraterr. Life	CODE
*, "Scientific Reports on Viking Missions (Mars)," *Science*, Vol. 193, No. 4255, August 1976, pp. 759-815; Vol. 194, No. 4260, October 1976, pp. 57-110; Vol. 194, No. 4271, December 1976, pp. 1274-1353.								✓	A
*, "Scientific Reports on Voyager Missions (Jupiter)," *Science*, Vol. 204, No. 4396, June 1979, pp. 945-1008; Vol. 206, No. 4421, November 1979, pp. 925-996.								✓	A
Abell, George O., *Exploration of the Universe*, New York, Holt, Rinehart and Winston, 3rd Ed. 1975.			✓	✓	✓				P
Abell, George O., *The Search for Life Beyond Earth: A Scientific Update, in James L. Christian: The First Encounter*, Buffalo, N.Y., Prometheus Books, 1976								✓	P
Albers, Steven C., "Mutual Occultations Of Planets: 1557 to 2230," *Sky and Telescope*, March 1979, pp. 220-222.			✓						P
Anon., Astronomy (Merit Badge Library #3303), Boy Scouts of America, Scout Equipment Center, 289 Park Avenue South, New York City.		✓							E
Anon., *The Earth and Man*, New York, Rand McNally & Company, 1972.	✓					✓			P
Anon., *Space Exploration* (Merit Badge Library #3354), Boys Scouts of America, Scout Equipment Center, 289 Park Avenue South, New York City.								✓	E
Anon., *The Times Atlas of the World*, Comprehensive Edition, New York, Quadrangle/The New York Times Book Co., 5th Ed., 1975.	✓								P
Ashbrook, Joseph, "Astronomical Scrapbook: Some Bunchings of Planets," *Sky and Telescope*, November 1973, pp. 300 & 305.			✓			✓			P
Asimov, Isaac, *Asimov on Astronomy*, New York, Doubleday, 1975.			✓		✓			✓	P

Reference	Geography	Astronomy/Star Finding	Astronomy/General	Astronomy/Deep Sky Objects	Chronology/Calendars	History/Archaeology	Navigation	Astronautics/Xtraterr. Life	CODE
Asimov, Isaac, *Exploring the Earth and the Cosmos*, New York, Crown Publishers, 1982.	✓		✓			✓		✓	P
Banks, Arthur, *A World Atlas of Military History*, New York, Hippocrene Books Inc., 1973.						✓			P
Barraclough, G. (Ed.), *The Times Atlas of World History*, Maplewood, N.J., Hammond Inc., 1979.	✓					✓			P
Beatty, J. Kelly, Brian O'Leary, Andrew Chaikin (Ed.), *The New Solar System*, 2nd Ed., Cambridge, Massachusetts, Cambridge Univ. Press.			✓						P
Bergamini, David et al, *The Universe*, New York/Chicago, Time Inc., 1962. (Life Nature Library)			✓	✓					P
Breed, Joseph B. III, *Stars for the Space Age*, New York, World Publishing/Times Mirror, 1971.		✓							P
Calder, Nigel, *The Comet is Coming*, New York, Viking Press, 1980.			✓						P
Clarke, Arthur C., *The Exploration of Space*, Revised Ed., 1979.								✓	P
Ernst, Br., TJ. E. De Vries, *Atlas of the Universe*, London/New York, Thomas Nelson and Sons Ltd., 1961.		✓	✓	✓					P
Friedman, H., *The Amazing Universe*, Washington D.C., National Geographic Society, 1975.		✓	✓	✓					P
Gardner, Martin, *The Relativity Exploration: A Lucid Account of Why Quasars, Pulsars, Black Holes & the New Atomic Clocks Are Vindicating Einstein's Revolutionary Theory*, Random, 1976.			✓	✓					P
Gingerich, Owen, "Astronomical Scrapbook: How Astronomers Finally Captured Mercury," *Sky and Telescope*, September 1983, pp. 203-205.			✓			✓			P
Goell, Theresa, "Throne Above the Euphrates," *National Geographic*, March 1961, pp. 381-405.					✓	✓			P
Gore, Rick, "The Once and Future Universe," *National Geographic*, June 1983, pp. 704-749.			✓	✓					P

	Geography	Astronomy/Star Finding	Astronomy/General	Astronomy/Deep Sky Objects	Chronology/Calendars	History/Archaeology	Navigation	Astronautics/Xtraterr. Life	CODE
Hart, M.R., *How to Navigate Today,* Cambridge, Maryland, Cornell Maritime Press, 1970.							✓		P
Hirschfeld, Alan, Roger Sinnott (Ed.), *Catalogue 2000.0, Vol. 1: Stars to Magnitude 8.0,* Cambridge, Mass., Cambridge Univ. Press, 1982.			✓						A
Hughes, David, *The Star of Bethlehem: An Astronomer's Confirmation,* Walker & Co., 1979.					✓	✓			P
Janiczek, P.M., L. Houchins, "Transits of Venus and the American Expedition of 1874," *Sky and Telescope,* December 1974, pp. 366-371.			✓						P
Krupp, E.C., *Echoes of the Ancient Skies,* New York, Harper & Row, 1983.	✓					✓			P
Lindsay, Jack, *Origins of Astrology,* New York, Barnes & Noble, 1971.	✓				✓	✓			A
Michener, James, *Space (A Novel),* New York, Fawcett, 1983.								✓	P
Moyer, G., *"The Origin of the Julian Day System," Sky and Telescope,* April 1981, pp. 311-313.					✓				A
Neugebauer, Otto, *A History of Ancient Mathematical Astronomy,"* Berlin, Springer, 1975. (3 Volumes)					✓	✓			A
Neugebauer, Otto, H.B. Van Hoesen, "Greek Horoscopes," *Memoirs of the American Philosophical Society,* Vol. 48, Philadelphia, 1959.					✓	✓			A
Newton, Robert R., *Ancient Astronomical Observations and the Accelerations of the Earth and Moon,* Baltimore/London, Johns Hopkins Press, 1970.			✓		✓	✓			A
Norville, Warren, *Celestial Navigations Step by Step,* New York, Association Press, 1973.							✓		P
Pournelle, Jerry (Ed.), *Black Holes,* New York, Fawcett, 1979.				✓					P
Rey, H.A., *The Stars — A New Way to See Them,* Boston, Houghton Mifflin Co., 1967.		✓							P

Reference	Geography	Astronomy/Star Finding	Astronomy/General	Astronomy/Deep Sky Objects	Chronology/Calendars	History/Archaeology	Navigation	Astronautics/Xtraterr. Life	CODE
Sagan, Carl, *The Cosmic Connection: An Extraterrestrial Perspective*, New York, Doubleday, 1980.			✓					✓	P
Sagan, Carl, *Cosmos*, New York, Random House, 1980.	✓		✓	✓		✓		✓	P
Stephenson, F. Richard, David H. Clark, "Ancient Astronomical Records from the Orient," *Sky and Telescope*, February 1977, pp. 84-91.					✓	✓			A
Stephenson, F. Richard, David H. Clark, *Application of Early Historical Records*, New York, Oxford Univ. Press, 1978.					✓	✓			A
Thompson, L.G., "On the Trail of the 'Jupiter Effect'," *Sky and Telescope*, September 1981, pp. 220-221.			✓						P
Trimble, V., "Astronomical Investigation Concerning the So-Called Air-Shafts of Cheops' Pyramid," *Mitteilungen des Instituts fuer Orientforschung*, Vol. 10, 1964, pp. 183-187. (Deutsche Akademie der Wissenschaften, Berlin)					✓	✓			A
Vehrenberg, Hans, *Atlas of Deep-Sky Wonders*, 4th Ed., Cambridge Massachusetts, Cambridge Univ. Press.				✓					P
Warner, L., *Astronomy for the Southern Hemisphere*, Wellington New Zealand, A.H. & A.W. Reed, 1975.		✓	✓						P

Periodicals:

"Archaeoastronomy," Center for Archaeoastronomy, University of Maryland, College Park, Maryland.

"Astronomy," Astro Media Corporation, Milwaukee, Wisconsin.

"Mercury," Astronomical Society of the Pacific, San Francisco, California.

"Scientific American," Scientific American, New York, N.Y.

"Sky and Telescope," Sky Publishing Corporation, Harvard College Observatory, Cambridge, Massachusetts.