Sunsetwheel Instructions

The sunsetwheel is a circular slide-rule sunrise/sunset calculator. It can determine the time of sunrise or sunset at any location on Earth on any day of the year in any time zone.

First let's become familiar with the four main parts of the sunsetwheel. The sunsetwheel has an outer band (showing the days of the year), a middle band (showing the hours of the day), an inner band (showing the time zones of the world), and a map window (showing coastlines, political boundaries, lines of latitude and longitude, cities, and sunrise and sunset terminators (boundaries between day and night)).

Now, let's do an example calculation together. Let's calculate the time of sunset in Chicago, Illinois on March 15. First, while holding the outer band in place, turn the middle band so that the large black diamond (on the middle band) aligns with the middle of March 15 on the outer band. Next, find Chicago, Illinois in the map window. Now, find in the red area of the map window (used for sunset), the markings for March 15. (The long marks designate the 10th, 20th, and 30th of each month; the medium length marks designate the 5th, 15th, and 25th.) Now, while holding the outer and middle bands in place, turn the inner band so that Chicago, Illinois aligns with the middle of March 15 in the markings in the red area. Finally, while holding all of the bands in place, look on the inner band (on the same side of the sunsetwheel) to find the time-zone indicator labeled "CST" (Central Standard Time, the time used in Chicago, Illinois in March) and at its tip, read off the time of sunset. You should conclude that on March 15, the sun sets in Chicago, Illinois at 5:57PM CST.

As the above example has illustrated, the procedure for calculating sunrise or sunset times is as follows. **STEP ONE:** While holding the outer band in place, turn the middle band so that the large black diamond (on the middle band) aligns with the middle of the appropriate date on the outer band. (The marks on the outer band divide one day from the next and every fifth day in each month is represented by a rectangle.) **STEP TWO:** While holding the outer and middle bands in place, turn the inner band so that the appropriate location on the map of the world aligns with the middle of the appropriate date in the markings in the colored area of the map window. (Use the blue area for sunrise and the red area for sunset.) **STEP THREE:** Read the calculated time on the middle band at the tip of the indicator on the inner band that has the appropriate time zone designation.

Practice Exercises: 1) March 15, sunset, Chicago, Illinois -- 5:57PM CST. 2) December 25, sunrise, Tokyo, Japan -- 6:49AM JST. 3) August 11, sunset, Calcutta, India -- 6:12PM IST. 4) February 2, sunrise, Los Angles, California -- 6:50AM PST. 5) September 11, sunrise, New York, New York -- 6:33AM EDT.

The accuracy of the results obtained using the instructions above is such that the apparent upper limb of the sun will be within one degree of the horizon at the computed time (as viewed from sea level under standard meteorological conditions (explained below-left)). (Accuracy claim not valid before 1750 or after 2250 due to drift of perihelion (explained at left)). To improve accuracy, one can employ the methods of "recursion" and "date correction" (explained at right).

http://www.sunsetwheel.com/

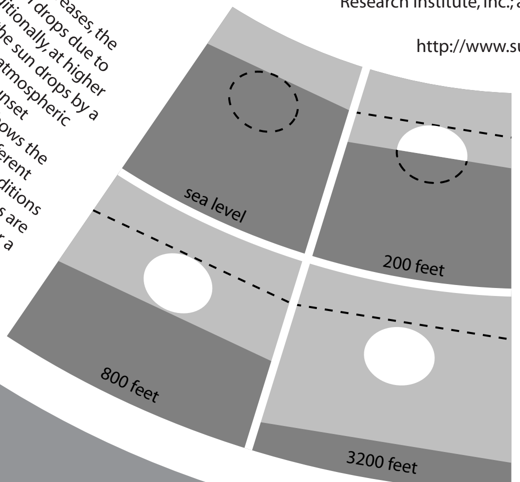
Drift of Perihelion

The orbit of the Earth is not perfectly circular and because planets move faster through their orbits when they are closer to the Sun, the Earth moves at different speeds in different parts of its orbit. In the year 2000, the Earth was closest to the Sun (perihelion) on January 4. And because the seasonal position of perihelion is later by an average 25 minutes every year, the timing of the seasonal Earth/Sun relationship slowly changes over many years and repeats every 21,000 years.

The seasonal positions of the sunrise and sunset terminators shown in the map window of the sunsetwheel are based on the timing of the seasonal Earth/Sun relationship as it was around the year 2000. Moving 250 years into the past or future will result in the before mentioned error of less than 0.15 degree. When using the sunsetwheel between the years 1990 and 2010 (employing both recursion and date correction), theoretical accuracy is better than 0.01 degree and thus the limiting factor becomes the accuracy with which the sunsetwheel was constructed. Errors associated with the drift of perihelion will peak at less than 4 degrees in years that are an odd multiple of 10500 years after or before the year 2000 (e.g. 12500AD and 8500BC).

Effect of Altitude and Meteorological Conditions on the Appearance of Sunset

As the altitude of an observer increases, the apparent position of the horizon drops due to the curvature of the Earth. Additionally, at higher altitude, the apparent position of the sun drops by a lesser amount due to slightly reduced atmospheric refraction. As a result, the appearance of sunset depends on altitude. The following diagram shows the typical appearance of a sea-level sunset at four different altitudes. Furthermore, changes in meteorological conditions can also effect atmospheric refraction. Standard conditions are 760 millibars and 0ºC. An increase in pressure of 10 millibars or a temperature drop of 5ºC will additionally lower the image of the sun by about 0.01 degree. Furthermore, at a boundary between air masses, additional highly irregular refraction can occur.



Notes on Using the Sunsetwheel in the "Land of the Midnight Sun"

Sometimes, to achieve the desired alignment in step two of the instructions above, one must follow the markings in a colored area of the map window beyond the edge of the colored area. In this situation, please note the following. 1) The markings in the blue area of the map window appear red when viewed outside their colored area. 2) The markings in the red area of the map window appear blue when viewed outside their colored area. 3) If you reach the point where all marks converge and still have not achieved alignment, try using the marks of the other color from the other colored area. 4) If still no alignment is possible, then the event (sunrise or sunset) does not occur on the date in question.

Practice Exercises: 1) March 20, sunset, Barrow, Alaska -- 7:44PM AKST (7:47PM after recursion (explained at right)). 2) July 1, sunrise, Reykjavik, Iceland -- 3:07AM GMT (3:06AM after recursion (explained at right)). 3) September 20, sunset, Nord, Greenland -- ~4:50PM UTZ. 4) December 10, sunrise, Wainwright, Alaska -- does not occur.

Recursion

In the instructions above, one uses the "middle of the appropriate date" when making the alignments in steps one and two. This sets the seasonal Earth/Sun relationship as it would be at midday Greenwich Mean Time (GMT) on the date in question. By instead using the part of the day that reflects the actual time in the GMT time zone that the event occurs (sunrise or sunset), more accurate results can be obtained. Let's do an example together.

In a previous example, we concluded that in Chicago, Illinois on March 15, sunset occurs at 5:57PM CST. Redo this example calculation on the sunsetwheel. Now, without changing anything, see what time of day it is in the GMT time zone. Given that the international date line passes through the Pacific Ocean, you should conclude that it is 11:57PM on the night of March 15/16 in the GMT time zone. So now redo the calculation using the night of March 15/16 (the boundary between March 15 and 16) instead of the middle of March 15 in steps one and two. You should now conclude that sunset occurs at 5:58PM. (The use of recursion reduces the before mentioned one-degree margin of error to six tenths of a degree.)

Date Correction (Converting Calendar Date to Seasonal Date)

Thus far, no consideration has been given to the particular year for which calculations are being performed. Because the relationship between the days of the year to the seasons can vary from one year to another by more than 2 days, the year must be specified and taken into account for improved accuracy. On the outer band of the sunsetwheel, the calendar dates are shown in their seasonal positions for an average year. The seasonal positions of the dates in any particular year will vary slightly from this. The table at right will allow you to determine the correction that must be added to the calendar date of a particular year to arrive at the mean seasonal date for an average year.

So, for example, the table indicates that in March through December of 1903, the correction is -1.13 days. Thus the seasonal characteristics on the night of March 15/16, 1903 are the same as those on the evening of March 14 in an average year. Thus, during 1903 (except January and February) the season can most accurately be set on the sunsetwheel by using a date that is 1.13 days earlier than the actual date in steps one and two. Returning to the previous example for sunset in Chicago, Illinois on March 15 and computing for the particular year of 1903, one would use (instead of the night of March 15/16) the evening of March 14 in steps one and two. You should now conclude that on March 15, 1903, the sun sets in Chicago, Illinois at 5:57PM (as reckoned from 90°W longitude). (Before the use of the Gregorian Calendar (first introduced in 1582), further corrections are required (at right).) (The use of date correction along with recursion reduces the before mentioned one-degree margin of error to only fifteen hundredths of a degree.)

Gregorian Calendar Date to Seasonal Date Correction

Add the column and row corrections for both the century and the year. For January and February, use the correction for the previous year.

-.50	000's	100's	200's	300's	400's	500's	600's	700's
-.25	800's	900's	1000's	1100's	1200's	1300's	1400's	1500's
±00	1600's	1700's	1800's	1900's	2000's	2100's	2200's	2300's
+.25	2400's	2500's	2600's	2700's	2800's	2900's	3000's	3100's
+.50	3200's	3300's	3400's	3500's	3600's	3700's	3800's	3900's
	+.27	+.05	-.17	-.39	+.39	+.17	-.05	-.27

-.31	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	-.31
-.16	'20	'21	'22	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	-.16
±00	'40	'41	'42	'43	'44	'45	'46	'47	'48	'49	'50	'51	'52	'53	'54	'55	'56	'57	'58	'59	±00
+.16	'60	'61	'62	'63	'64	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	+.16
+.31	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	+.31
	+.30	+.06	-.18	-.43	+.33	+.09	-.15	-.39	+.36	+.12	-.12	-.36	+.39	+.15	-.09	-.33	+.43	+.18	-.06	-.30	

Using Julian Calendar Dates with the Sunsetwheel

Before the Gregorian Calendar, the Julian Calendar was in common use. Dates and date correction on the sunsetwheel are calibrated for the Gregorian Calendar. If Julian Calendar dates are used, they must first be converted to Gregorian Calendar dates. To make the conversion, use the following formula.

date + year/100 - year/400 - 2
(Discard all remainders and include January and February with the previous year.)

Example: 1900-01-09 -- 1900-01-17