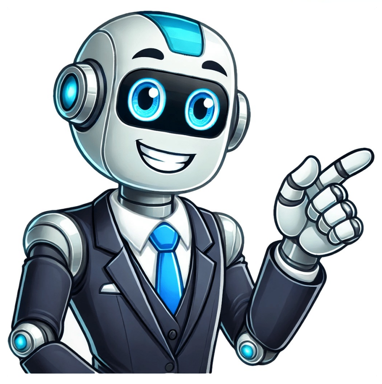

Twilight is the light received from the sun, when the sun is below the horizon, i.e. before the sunrise and after the sunset. Twilight completely ceases in the evening, when the sun is 18° vertically below the horizon. After that, there is total darkness. In the mornings, twilight commences when the sun is 18° vertically below the horizon and ceases at sunrise. The entire period of twilight has 3 stages, Civil, Nautical and Astronomical. Astronomical commences when the sun is 18° below the horizon. Nautical – 12° below the horizon. Civil – 6° below the horizon. Each twilight lasts until visible sunrise. In the evening, they all commence at visible sunset and Civil continues till the – sun is 6° below the horizon, Nautical continues till – the sun is 12° below the horizon and Astronomical continues till – the sun is 18° below the horizon.Tables of the timings are provided in the Nautical almanac for commencement and end of Civil, Nautical and Astronomical twilight before sunrise and after sunset for different latitudes. Periods of TwilightTwilight last longer in higher latitudes as compared to lower latitudes As is evident from the below fig. when the observer is in low latitude, the sun rises and sets almost perpendicular to the horizon covering the 18° twilight belt in a rather short arc and therefore in a rather short period of time. When the observer is higher latitude however the sun rises and sets at a more oblique angle to the horizon, thus covering the 18° twilight belt over a much larger arc and therefore over a much larger period of time. Lower latitude Higher LatitudeConditions necessary for twilight all night For an observer to have twilight, the sun must set, therefore, he must have some night. An observer would have some night for some part of the 24 hours, either – 1. If the observer's latitude and the sun's declination are of opposite name. 2. If, they are of the same name and the sum of the latitude and declination is less than 90°. For continuous twilight, throughout the night, the observer's latitude and sun's declination should be of the same name and the limiting latitudes are obtained as: 1. lat + dec /= 90° (so that the sun will not go below the astronomical twilight belt and will have astronomical twilight throughout the night). Or ii. lat + dec + 12° >/= 90° (so that the sun will not go below the nautical twilight belt and will have nautical twilight throughout the night). Or iii. lat + dec + 6° >/= 90° (so that the sun will not go below the civil twilight belt and will have civil twilight throughout the night). Conditions are necessary for continuous Daylight (Midnight Sun) For continuous DAYLIGHT (Midnight Sun), the observer's latitude and sun's declination should be of the same name and the limiting latitudes are obtained as: lat + dec >/= 90° (so that the sun will NOT set) Conditions are necessary for continuous Night For continuous Night, the observer's latitude and sun's declination should be of the different name and the limiting latitudes are obtained as: lat + dec >/= 90° (so that the sun will NOT RISE) Theoretical and Visible Sunrise and Sunset Occurs when the True sun's centre is on the observer's rational horizon. Then the true altitude of the Sun is 0° and the true zenith distance 90°. The times of theoretical sunrise or sunset can be obtained by solving the PZX triangle in which ZX is 90°. Visible sunrise and sunset are not 0, because of corrections for refraction, semi-diameter, dip, etc. Assuming the Sun to be at the sea level, the true altitude of the Sun at visible sunrise and sunset is about 0 50′, the true zenith distance then is therefore 90 50′. Because of this visible sunrise occurs before theoretical sunrise and visible sunset after theoretical sunset. The nautical twilight lists the times for visible sunrise and sunset for various latitudes. Interpolation is required for intermediate latitudes. How to identify a star which you have sighted during evening twilight, if you do not have any kind of a star constellation charts? By referring to the Nautical Almanac Take a bearing & altitude of the star The correct GMT to be calculated. Then the LHA Aries is calculated. Using the PZX spherical triangle, lat, azimuth, altitude we first calculate the declination of the star and then the LHA star by calculating the angle P. LHA star – LHA Aries = SHA star Therefore using the declination and SHA of the star we can find the star by referring to the day page of the Nautical almanac. Or By referring to the Sight, Reduction tables. First we have to calculate the correct GMT. Then find out the LHA Aries. Take a visual bearing of the star and also, take the approx. altitude of the star. Using the LHA Aries, bearing and altitude of the star enter the Sight Reduction Tables for the present Latitude of the vessel. We can then identify the star having the closest values of LHA Aries, Azimuth and Altitude. Conditions required for a body to rise bearing east Irrespective of the observer's latitude, the body will rise bearing east and set bearing west, when the body's declination is 0º. Under this condition, the body will rise in the east, appear to move along the equinoctial and will set bearing west. Refer to below fig. Also, when the observer is at the equator, a body with 0° declination will rise bearing east and continue to bear east till the body is at the observer's zenith and thereafter will be bearing west till it sets. Refer to below fig. Twilight is the time of day where the sky is lighter than the nighttime sky, but the Sun is below the horizon. When the Sun is just below the horizon, some of its light is scattered by atmospheric gases and tiny suspended particles, which lightens our sky and allows us to see. There are three stages of twilight based on what we can see when there are clear skies: Civil Twilight: the Sun is within 6º below the horizon, and there is enough light to carry out ordinary outdoor activities. Nautical Twilight: the Sun is between 6º and 12º below the horizon, but both the horizon and brightest stars are visible, so navigation is possible. Astronomical Twilight: the Sun is between 12º and 18º below the horizon, and there is only a faint sky glow at this time. When the Sun is below 18º, astronomical observations are possible in the dark sky, unless light pollution is created by nearby human artificial lighting. Dawn refers to the twilights associated with sunrise, and dusk are those that follow sunset. The Sun's path for 42ºN on January 1 (black line), with the zones of twilight shown relative to the horizon (green line). The hourly positions of the Sun are shown as orange circles). See Interpreting Time on Declination Circles if these concepts are unfamiliar to you. The first rule of romantic sunsets is that the romance should last well after sunset, especially when on a honeymoon. When my wife and I honeymooned on a tropical island, we walked down to a remote beach to watch the sunset. Since the sun sets so quickly in the tropics, and dusk is unexpectedly brief, we found ourselves trying to avoid the hundreds of awakening (and aggressive!) hermit crabs as we tried to find our way back along the densely vegetated path in our sandals. The memory of that romantic sunset was very short-lived! My advice if you want to enjoy a tropical romantic sunset: bring a flashlight! Better yet, use the following web apps to know how much time you have before it gets too dark to see where you are heading and what critters you may be walking on… Not interested in romantic sunsets? The seasonal variability of how long twilights take affects our outdoor activities. Sports, walking the dog in the woods or park, hiking, jogging, etc. Any location poleward of 40ºN or S has times when twilight is considerably shorter than the rest of the year. Sunsets may be romantic due to their dramatic colors, but be prepared for how quickly twilight passes (especially civil twilight) to maintain its romantic glow. Calculate how long the skylight contains yellows, oranges, and reds just before and after the sun sets (this period is referred to as the golden hour) using the app below, Times and Durations of Sun Angles. Since the Earth rotates at 15º per hour, the shortest time the Sun can move through one of the 6º bands of sun angle is 24 minutes, but this only happens at the Equator during an equinox. The twilight's duration depends on the angle of the declination circle to the horizon and what time of day it occurred. Lower latitudes have steeper angles of the declination circle to the horizon, so they tend to have shorter twilights, and higher latitudes have longer twilights. For any given latitude, twilights will be the shortest when occurring near 6 AM/PM. Run Calculating Twilights Click the button to run the web app for desktops, laptops, tablets, and smartphones. Acknowledgments: Matti Horne's suggestions improved this web app's functionality and aesthetics significantly. Animation of declination circles by 10° increments of latitude for January 1. Included are the 3 bands of twilight. Notice that the polar latitudes do not have twilight: they either experience 24 hours of sunlight or darkness at this time of year! Animation of declination circles for 40°N on the 21st of each month. Included are the 3 bands of twilight. Use the Calculating Twilights web app to calculate and visualize twilight at any latitude during any day of the year. Note: The times calculated in the app are displayed in sun time or solar time, not clock time. Sun time is defined by local noon and midnight when the Sun is at the highest and lowest points to the horizon, respectively. Sunrise is defined as when the sun first appears on the horizon, not when its geometric center crosses the horizon. Sunset occurs the moment the sun disappears below the horizon. The sunrise and sunset duration is the time it takes for the sun to transit across the horizon, and the size of the Sun in the sky is 0.5º. To make it easier to compare to the 6º sun angle bands used for the three twilights, we defined low-angle sun as the time it takes for the sun's geometric center to transit from 0º to 6º above the horizon. The Calculate Twilight web app above lets you calculate the timing and duration of twilights for a given day and location while also showing why the variations in time and duration occur. If you would like to see a year's worth of twilight times and durations for a given latitude, use this Google Sheets document: Times and Durations of Twilight. Below are examples of data and graphs you may create using the app. The file will open in Google Sheets, then use the "Make a Copy" in the File Menu so you may change the latitude to calculate and graph a year of times and durations of twilights. Tip: the name of your file should include what experiment(s) you are trying. Animation of the yearly timing of twilight associated with dawn and dusk for every 10º of latitude. Animation of the yearly duration of twilights for every 10º of latitude. Notice that the duration scale on the vertical axis changes for each latitude. Use the Times and Durations of Twilight app to calculate and visualize the timing and duration of twilights at any latitude for an entire year. There are two sheets in the document: Input and Output: Change the latitude on this sheet and automatically see the graphs update. Calculations: See the data used to create the graphs in table form on this sheet, and explore the formulas used to calculate the times and durations of twilights. They don't take into account that a year is 365.25 days long (which creates our leap year), convert to clock time (use longitude and time zone), account for daylight savings time/standard time, or deal with Earth's eccentric orbit (Equation of Time). They don't account for atmospheric refraction. Most of the assumptions and limitations above deal with calculating the times of twilight and low-angle sun; the errors cancel each other out (except for atmospheric refraction and eccentricity of our orbit) when calculating the duration of the sun traversing the sun angles, so the duration values are rather reasonable. Using the links in the Assumptions and Limitations section, modify the Times and Durations of Twilight spreadsheet with the following improvements: Add your longitude and time zone to convert sun time to clock time. Add daylight savings time if appropriate. Add that a year is ~ 365.25 days and that Earth's orbit is slightly eccentric. Account for atmospheric refraction. Account for the size of the Sun (this is if calculating sunrise/sunset). Compare your results to these advanced models available online: University of Toronto and StarGazing.net. Photographers have two favorite times when natural lighting conditions create dramatic art: golden hour and blue hour. The sky colors tend to range from reds, oranges to yellows during the golden hour, which is defined when the Sun is between 4º below and 6º above the horizon. During the blue hour, the Sun is between 4 and 6º below the horizon, and the sky tends to have deep blue shades. Use the Times and Durations of Sun Angles app to calculate the time it takes for the Sun to transit two sun angles at a latitude you select. The interface is similar to the Google Sheets document above, Times and Durations of Twilight. An example of the graphical output from the Times and Durations of Sun Angles app. Even though the sun was below the horizon when this photo was taken, the golden hour can produce amazing tones of yellows, oranges, and reds! Observed trends in the durations of twilights: Higher latitudes have a larger seasonal change in the duration of twilights (and sunrises/sunsets) than tropical latitudes, The longest twilights occur near the summer solstice (the summer solstice for the Northern Hemisphere is June 21 and December 21 for the Southern Hemisphere), and The shortest twilights occur closest to 6 AM/PM, which happens near the equinoxes. Click on the following toggles to view descriptions and links of the web pages on each topic of the Sun-Earth Connection. An overview of how the Sun's energy is generated and how its thermal radiation illuminates and heats Earth. Overview: The Sun illuminates the spherical, rotating planets orbiting it. Obliquity and Earth's Illumination: Obliquity is the angle between the planes of the Earth's equator and its orbit around the Sun. Declination, Latitude, & Earth Illumination: Solar declination is the angle between the Sun's rays and the plane of the Earth's Equator. Its value depends on where Earth is in its orbit around the Sun. Astronomical Seasons & Illumination: Astronomical seasons are based on the orientation of Earth's axis of rotation to the Sun, which determines the amount of illumination between the Northern and Southern Hemispheres. Overview: Even though an area is illuminated by sunlight, there can be quite a range of energy interacting with the surface. Sun Angle and Beam Concentration: If every beam of sunlight reaching Earth has the same amount of energy, why do some areas warm up more than others? Diurnal Heating: Diurnal heating is the temperature change over 24 hours. When sunlight shines on the ground, it warms. Two critical factors that determine the amount of heating deal with the Sun's illumination. Seasons: Earth experiences astronomical seasons due to its obliquity. Climate Regimes: Climate regimes are an extension of diurnal heating and seasons, but the time frame is now years. Overview: Drawings of declination circles contain the visual and numerical information to understand and predict the Sun's motion across the sky. Declination Circles 101: Draw a declination circle with just a ruler and protractor/compass to quickly and accurately know the Sun's position in the sky at any day and time of the year for any location on Earth. Drawing Declination Circles: Declination circles are quite easy to draw by hand. Interpreting Time on Declination Circles: Accurately estimate the time of day using the Sun's location in the sky. Sunrise, Sunset, & Twilight: Calculate the timing and duration when the Sun is at or near the horizon. Solar Time, Angle, & Position: The sun's angle and direction to the local horizon define the Sun's position in the local sky. Explore how to use declination circles to calculate the Sun's position at any solar time anywhere in the world on any day of the year. Changing Views of Declination Circles: Use the web app View Declination Circles to explore three common views of declination circles to identify their strengths, limitations, and applications. Then learn how to go from one view to another. Using Declination Circles: Humans have been using the apparent motion of the Sun as a compass, clock, and calendar for millennia. Using Sundials: Humans have been using the Sun's position to navigate and tell the time, day, and season for millennia. Sundials create shadows that make it easier to do these tasks. Sunrise is defined as the instant in the morning under ideal meteorological conditions, with standard refraction of the Sun's rays, when the upper edge of the sun's disk is coincident with an ideal horizon.SunsetSunset is defined as the instant in the evening under ideal meteorological conditions, with standard refraction of the Sun's rays, when the upper edge of the sun's disk is coincident with an ideal horizon.Civil twilightBeginning of morning civil twilightDefined as the instant in the morning, when the centre of the Sun is at a depression angle of six degrees (6°) below an ideal horizon. At this time in the absence of moonlight, artificial lighting or adverse atmospheric conditions, the illumination is such that large objects may be seen but no detail is discernible. The brightest stars and planets can be seen and for navigation purposes at sea, the sea horizon is clearly defined.Ending of evening civil twilightDefined as the instant in the evening, when the centre of the Sun is at a depression angle of six degrees (6°) below an ideal horizon. At this time in the absence of moonlight, artificial lighting or adverse atmospheric conditions, the illumination is such that large objects may be seen but no detail is discernible. The brightest stars and planets can be seen and for navigation purposes at sea, the sea horizon is clearly defined.Nautical twilightBeginning of morning nautical twilightIs defined as the instant in the morning, when the centre of the Sun is at a depression angle of twelve degrees (12°) below an ideal horizon. At this time in the absence of moonlight, artificial lighting or adverse atmospheric conditions, it is dark for normal practical purposes. For navigation purposes at sea, the sea horizon is not normally visible.Ending of evening nautical twilightIs defined as the instant in the evening, when the centre of the Sun is at a depression angle of twelve degrees (12°) below an ideal horizon. At this time in the absence of moonlight, artificial lighting or adverse atmospheric conditions, it is dark for normal practical purposes. For navigation purposes at sea, the sea horizon is not normally visible.Astronomical twilightBeginning of morning astronomical twilightIs defined as the instant in the morning, when the centre of the Sun is at a depression angle of eighteen degrees (18°) below an ideal horizon. At this time the illumination due to scattered light from the Sun is less than that from starlight and other natural light sources in the sky.Ending of evening astronomical twilightIs defined as the instant in the evening, when the centre of the Sun is at a depression angle of eighteen degrees (18°) below an ideal horizon. At this time the illumination due to scattered light from the Sun is less than that from starlight and other natural light sources in the sky.Sun transit timeThe transit timeThe transit time of a celestial body refers to the instant that its center crosses an imaginary line in the sky - the observer's meridian - running from north to south. For observers in low to middle latitudes, transit is approximately midway between rise and set, and represents the time at which the body is highest in the sky on any given day. At high latitudes, neither of these statements may be true - for example, there may be several transits between rise and set. The transit of the Sun is local solar (sundial) noon.Moonrise and moonsetMoonriseMoonrise is defined as the instant when, in the eastern sky, under ideal meteorological conditions, with standard refraction of the Moon's rays, the upper edge of the Moon's disk is coincident with an ideal horizon.MoonsetMoonset is defined as the instant when, in the western sky, under ideal meteorological conditions, with standard refraction of the Moon's rays, the upper edge of the Moon's disk is coincident with an ideal horizon.Moon phasesAs the relative position of the Sun, Moon and Earth changes, differing proportions of the Moon's visible surface are illuminated by the Sun. The phases of the Moon are specific instances in this process.New moonA new Moon occurs when the apparent longitudes of the Moon and Sun differ by 0°. At this time, the Moon does not appear to be illuminated.First quarterOccurs when the apparent longitudes of the Moon and Sun differ by 90°. At this time 50 per cent of the Moon's visible surface is illuminated.Full moonOccurs when the apparent longitudes of the Moon and Sun differ by 180°. At this time 100 per cent of the Moon's visible surface is illuminated.Last quarterOccurs when the apparent longitudes of the Moon and Sun differ by 270°. At this time 50 per cent of the Moon's visible surface is illuminated.Rise and set of five planetsThe planets which are generally visible to the naked eye are: Mercury, Venus, Mars, Jupiter and Saturn.The rise and set times for these planets is the instant when, under ideal meteorological conditions, with standard refraction of their rays, the planet is coincident with an ideal horizon.Ideal HorizonAn ideal horizon exists when the surface forming the horizon is at a right angle to the vertical line passing through the observer's position on the Earth. If the terrain surrounding the observer was flat and all at the same height above sea level, the horizon seen by the observer standing on the Earth would approximate the ideal horizon.Zenith DistanceThe zenith distance is a vertical angle measured from directly overhead, down to the required point. An ideal horizon has a zenith distance of 90 degrees.True AzimuthTrue azimuth is the clockwise horizontal angle from true north to the object being sighted.True northTrue north is the direction towards the north pole along the meridian of longitude which passes through the observer's position on the Earth.Vertical angleThe vertical angle is the angle measured in a vertical plane, from the horizon to the required point. Directly overhead would have a vertical angle of 90 degrees.The perigee and apogee tableAll dates and times are Universal Time (UTC) . To convert to local time add or subtract the difference between your time zone and UTC, remembering to include any additional offset due to summer time for dates when it is in effect. For each perigee and apogee the distance in kilometres between the centres of the Earth and Moon is given. Perigee and apogee distances are usually accurate to within a few kilometres compared to values calculated with the definitive ELP 2000-82 theory of the lunar orbit; the maximum error over the years 1977 through 2022 is 12km in perigee distance and 6km at apogee.The closest perigee and most distant apogee of the year are marked with "++" if closer in time to full Moon or "--" if closer to new Moon. Other close-to-maximum apogees and perigees are flagged with a single character, again indicating the nearer phase. Following the flags is the interval between the moment of perigee or apogee and the closest new or full phase; extrema cluster on the shorter intervals, with a smaller bias toward months surrounding the Earth's perihelion in early January. "F" indicates the perigee or apogee is closer to full Moon, and "N" that new Moon is closer. The sign indicates whether the perigee or apogee is before ("-") or after ("+") the indicated phase, followed by the interval in days and hours. Scan for plus signs to find "photo opportunities" where the Moon is full close to apogee and perigee.Perihelion and AphelionPerihelion is the point in the orbit of a planet, asteroid, or comet at which it is closest to the Sun, while Aphelion is the point in a planet's orbit at which it is furthest from the sun, which is the opposite to Perihelion.Equinoxes and SolsticesThe equinoxes represents either of two times of the year when the Sun crosses the plane of the Earth's equator and day and night are of equal length, while the solstices is either of the two times of the year when the Sun is at its greatest distance from the celestial equator. Equation to derive time of sunset and sunrise This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed.Find sources: "Sunrise equation" – news · newspapers · books · scholar · JSTOR (June 2018) (Learn how and when to remove this message) A contour plot of the hours of daylight as a function of latitude and day of the year, using the most accurate models described in this article. It can be seen that the area of constant day and constant night reach up to the polar circles (here labeled "Anta. c." and "Arct. c."), which is a consequence of the earth's inclination. A plot of hours of daylight as a function of the date for changing latitudes. This plot was created using the simple sunrise equation, approximating the sun as a single point and does not take into account effects caused by the atmosphere or the diameter of the Sun. The sunrise equation or sunset equation can be used to derive the time of sunrise or sunset for any solar declination and latitude in terms of local solar time when sunrise and sunset actually occur. It is formulated as: cos ω ∘ = − tan ϕ × tan δ {\displaystyle \cos \omega _{\circ }=-\tan \phi \times \tan \delta } where: ω ∘ {\displaystyle \omega _{\circ }} is the solar hour angle at either sunrise (when negative value is taken) or sunset (when positive value is taken); ϕ {\displaystyle \phi } is the latitude of the observer on the Earth; δ {\displaystyle \delta } is the sun declination. The Earth rotates at an angular velocity of 15°/hour. Therefore, the expression ω ∘ / 15 ∘ {\displaystyle \omega _{\circ }/\mathrm {15} ^{\circ }} , where ω ∘ {\displaystyle \omega _{\circ }} is in degree, gives the interval of time in hours from sunrise to local solar noon or from local solar noon to sunset. The sign convention is typically that the observer latitude ϕ {\displaystyle \phi } is 0 at the equator, positive for the Northern Hemisphere and negative for the Southern Hemisphere, and the solar declination δ {\displaystyle \delta } is 0 at the vernal and autumnal equinoxes when the sun is exactly above the equator, positive during the Northern Hemisphere summer and negative during the Northern Hemisphere winter. The expression above is always applicable for latitudes between the Arctic Circle and Antarctic Circle. North of the Arctic Circle or south of the Antarctic Circle, there is at least one day of the year with no sunrise or sunset. Formally, there is a sunrise or sunset when − 90 ∘ + δ < ϕ < 90 ∘ − δ {\displaystyle -90^{\circ }+\delta