

RGO ASTRONOMICAL INFORMATION SHEET No. 7



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for the Particle Physics and Astronomy Research Council

A note on sunrise, sunset and twilight times and on the illumination conditions during twilight.

The sunrise and sunset times prepared by Her Majesty's Nautical Almanac Office are the times when the zenith distance of the centre of the Sun is $90^{\circ} 50'$: this allows $34'$ for refraction in the atmosphere and $16'$ for the angular semi-diameter of the Sun. (The zenith distance of an object is the angle between the direction to the zenith (i.e. the point vertically overhead) and the direction to that object.) At these times the upper edge of the Sun would appear to an observer at sea level to be just coincident with the horizon, provided, of course, that the horizon is level, the sky is clear and the refraction is normal. The actual times at which the Sun will just appear, or disappear, will depend on the difference of the heights of the observer and the horizon and the actual refraction, which depends on the atmospheric pressure, temperature and humidity along the light path. Differences of a minute or so from the tabulated times are to be expected.

Under normal meteorological conditions, the general illumination of terrestrial objects decreases after sunset as the angular depression of the Sun below the horizon increases. Correspondingly, the illumination before sunrise increases as the Sun's depression decreases. In order to provide a guide to the times at which certain levels of illumination will be reached, it is the practice to tabulate the times at which the depression of the Sun has standard values of 6° , 12° , and 18° . These depressions refer to the angle in the vertical plane between the horizontal plane and the straight line from the observer to the centre of the Sun. The conditions to be expected at these times in the absence of cloud and haze and of illumination from the Moon and other natural or artificial sources are as follows.

Depression of Sun	Evening	Morning	Illumination conditions
$0^{\circ} 50'$	Sunset	Sunrise	Illumination is generally good and only the very brightest planets can be seen.
6°	End of CIVIL TWILIGHT	Beginning of CIVIL TWILIGHT	Large terrestrial objects, but no detail, can be distinguished; the sea horizon is clearly defined and the brightest stars and planets are visible.
12°	End of NAUTICAL TWILIGHT	Beginning of NAUTICAL TWILIGHT	It is dark for all normal practical purposes and the sea horizon is not normally visible.
18°	End of ASTRONOMICAL TWILIGHT	Beginning of ASTRONOMICAL TWILIGHT	The illumination due to scattered light from the Sun is rather less than that from starlight and other minor natural sources.

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The times at which these various astronomical phenomena occur vary from day to day and from place to place. The times at a given place on a given date are not quite the same from year to year. The changes from place to place on a given date are much greater than are generally realized - there are always differences (in Greenwich Mean Time) of up to half-an-hour between East Anglia and Wales, and there may be differences of an hour in the time of, say, sunset between southern England and northern Scotland. During June and July the depression of the Sun does not reach 18° in many parts of the British Isles, and it does not reach 12° in the north of Scotland. On the other hand, in low latitudes there is much less variation during the year and the lengths of these twilight periods are much shorter. For example, on the equator the period between sunset and the end of astronomical twilight varies only between 1h 08m and 1h 16m.

Before 1 November 1989 the Road Traffic Acts defined the beginning and end of the lighting-up period to occur at half-an-hour after sunset and half-an-hour before sunrise. These times are always within the period of civil twilight, but the corresponding depression of the Sun, and hence the illumination conditions at these times, vary considerably throughout the year even when the sky is clear. The Road Vehicle Lighting Regulation 1989 introduces the term "hours of darkness" in place of "lighting-up period". During the hours of darkness vehicle headlights must be used. From sunset to the beginning of hours of darkness and from the end of hours of darkness to sunrise at least sidelights must be used.

There is no general agreement on a precise definition of "dawn"; it is sometimes even identified with sunrise itself. If, however, it is interpreted as the time of "first light", dawn corresponds to a depression between 18° and 12° but it is not possible to be more precise.

The colour of the scattered light from the sky is different from that of direct sunlight so that during twilight it is not possible to judge colours accurately, even if the illumination is above the threshold for normal colour vision.

The actual illumination during these twilight periods is very strongly dependent on the prevailing meteorological conditions. In the presence of thick cloud cover the illumination at sunset, for example, may well be similar to, or less than, that at the end of civil twilight under good conditions. (On the other hand, the illumination from street-lighting in a built-up area will tend to be increased in the presence of cloud.) The illumination at a particular place depends on local conditions, such as the ground topography and the presence of nearby trees and buildings.

If the Moon is above the horizon, the illumination may be significantly increased and so the twilight periods may appear to be longer, especially if the Moon is nearly full. The presence of the Moon affects considerably the visibility of the fainter stars.