

$$\cos(180 - \theta) = - \frac{\sin(lat) \cos \phi - \sin(decl)}{\cos(lat) \sin(\phi)}$$

1. Sunrise/Sunset Calculations:

For the special case of sunrise or sunset, the zenith is set to 90.833° (the approximate correction for atmospheric refraction at sunrise and sunset), and the hour angle becomes:

$$ha = \pm \arccos \left(\frac{\cos(90.83)}{\cos(lat) \cos(decl)} - \tan(lat) \tan(decl) \right)$$

Where the positive number corresponds to sunrise, negative to sunset.

Then the UTC time of sunrise (or sunset) in minutes is:

$$sunrise = 720 + 4(longitude - ha) - eqtime$$

Where longitude and hour angle are in degrees and the equation of time is in minutes. Solar noon for a given location is found from the longitude (in degrees) and the equation of time (in minutes):

$$snoon = 720 + 4 * longitude - eqtime$$