General Solar Position Calculations

First, the fractional year ($\gamma$) is calculated, in radians.

$$\gamma = \frac{2\pi}{365} \times (day_{of}_{year} - 1 + \frac{hour - 12}{24})$$

From $\gamma$, we can estimate the equation of time (in minutes) and the solar declination angle (in radians).

$$eqtime = 229.18 \times (0.000075 + 0.001868\cos \gamma - 0.032077\sin \gamma - 0.014615\cos 2\gamma - 0.040849\sin 2\gamma )$$

$$decl = 0.006918 - 0.399912\cos \gamma + 0.070257\sin \gamma - 0.006758\cos 2\gamma + 0.000907\sin 2\gamma - 0.002697\cos 3\gamma + 0.00148\sin 3\gamma$$

Next, the true solar time is calculated in the following two equations. First the time offset is found, in minutes, and then the true solar time, in minutes.

$$time_{_offset} = eqtime - 4 \times longitude + 60 \times timezone$$

where eqtime is in minutes, longitude is in degrees, timezone is in hours from UTC (Mountain Standard Time = +7 hours).

$$tst = hr \times 60 + mn \times 60 + sc / 60 + time_{_offset}$$

where hr is the hour (0 - 23), mn is the minute (0 - 60), sc is the second (0 - 60).

The solar hour angle, in degrees, is:

$$ha = \frac{tst}{4} - 180$$

The solar zenith angle ($\phi$) can then be found from the following equation:

$$\cos \phi = \sin(lat) \sin(decl) + \cos(lat) \cos(decl) \cos(ha)$$

And the solar azimuth ($\theta$, clockwise from north) is:

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

\[ ha = \pm \arccos \left( \frac{\cos(90.833)}{\cos(lat) \cos(decl)} - \tan(lat) \tan(decl) \right) \]

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

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

\[ \text{sunrise} = 720 + 4(\text{longitude} - ha) - eqtime \]

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):

\[ \text{snoon} = 720 + 4 * \text{longitude} - eqtime \]