

## The Day Through the Seasons

### RISING AND SETTING OF THE SUN: SEASONS AND LATITUDE

The azimuths where an object at a **declination**  $\delta$  will rise and set, and the length of time that object will be above the horizon as seen by an observer at a **latitude**  $\lambda$  are given by:

$$A_{\text{rise}} = \cos^{-1}\left(\frac{\sin \delta}{\cos \lambda}\right) \text{ degrees} \quad A_{z_{\text{Max}}} = (90 - \lambda) + \delta \text{ degrees} \quad \Delta t = \frac{2}{15} \cos^{-1}(-\tan \lambda \tan \delta) \text{ hours}$$

Using these, find the rising and setting azimuths and the length of the day for the following locations and dates, using the declination of the sun given by the analemma:

Date	$\delta_{\odot}$	Canton, New York ( $\lambda = 44^{\circ} 36' \text{ N}$ )			Quito, Equador ( $\lambda = 0^{\circ} \text{ N}$ )			Igloolik, Nunavut, Canada ( $\lambda = 69^{\circ} 24' \text{ N}$ )		
		$A_{\text{rise}}$	$A_{z_{\text{max}}}$	$\Delta t_{\text{day}}$	$A_{\text{rise}}$	$A_{z_{\text{max}}}$	$\Delta t_{\text{day}}$	$A_{\text{rise}}$	$A_{z_{\text{max}}}$	$\Delta t_{\text{day}}$
Sep. 11	<b>6°</b>	<b>82.3°</b>	<b>50.9°</b>	<b>12.7 h</b>						
Dec. 25										
Jun. 25										

### VARIATION OF THE SOLAR DAY: THE ANALEMMA

If you mark the position of the tip of a sundial's shadow at noon each day of the year, it will scribe the shape known as the ANALEMMA. This shape describes the difference between *mean solar noon* (or clock noon) and *solar noon*. The analemma's shape is due to both the tilt of the Earth's axis, and the elliptical shape of the Earth's orbit. Check out [www.analemma.com](http://www.analemma.com) for details.



This is used to find the declination of the Sun and the time by which the Sun is early or late for clock noon (mean solar noon ... not accounting for the observer's position within the time zone).

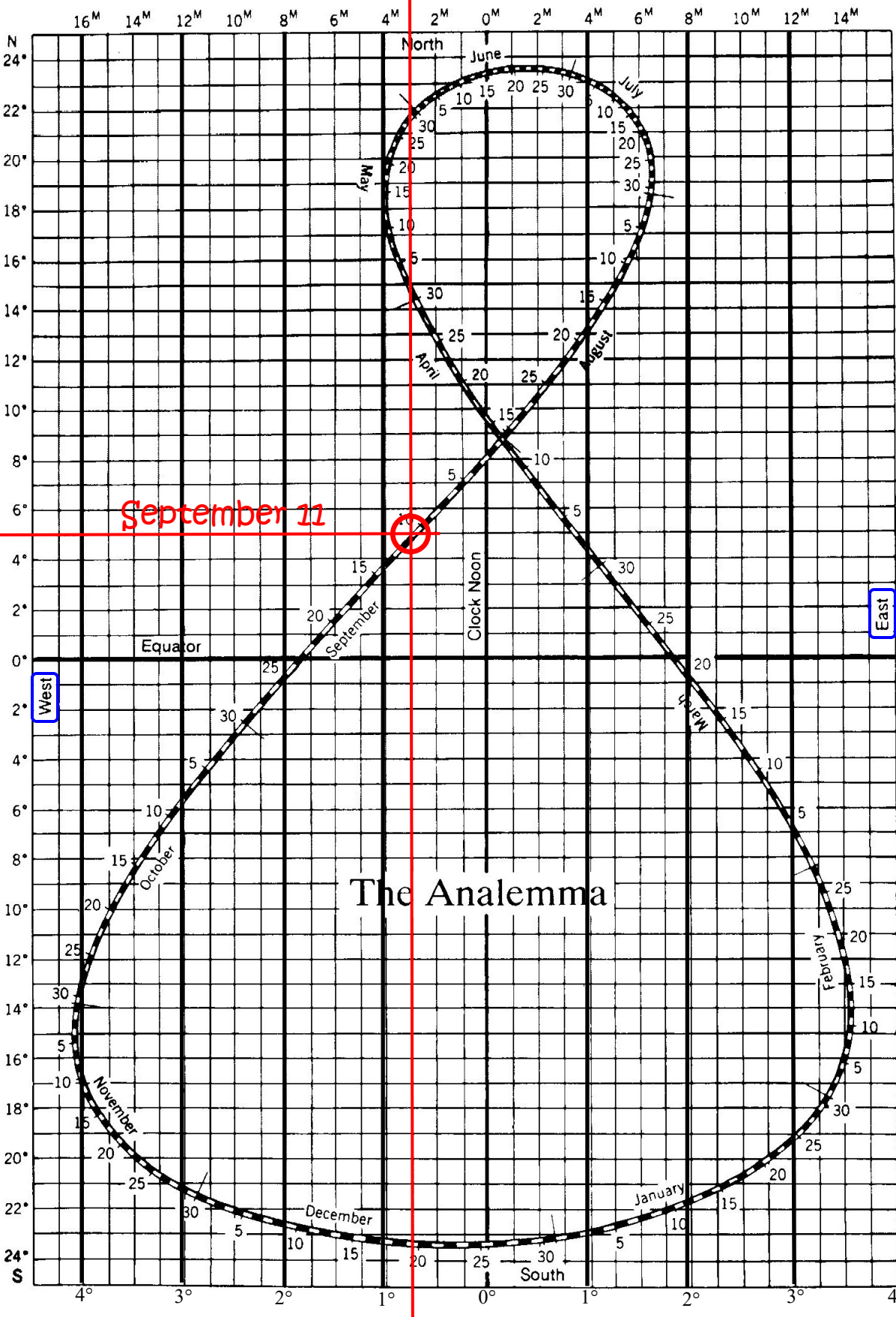
**LATE:** Sol is to the **east** of the meridian at clock noon (Sun has not yet arrived at noon)

**EARLY:** Sol is to the **west** of the meridian at clock noon (Sun has already passed noon).

TAKE POSITION TO THE CLOSEST  $\frac{1}{2}$  DEGREE, TIME TO THE CLOSEST  $\frac{1}{2}$  MINUTE.

Date	Declination of Sun	Sol's position in degrees <b>East or West</b> of clock noon	Minutes by which Sol will be <b>early or late</b> for clock noon	<b>Clock time of solar noon</b>
September 11	<b>5°</b>	<b>0.75° West</b>	<b>3 min Early</b>	<b>11:57:00 am</b>
June 25				
February 12				
December 25				
Your Birthday <i>Date:</i> _____				

3 min  
TIME IN MINUTES



West: Sun  
already  
crossed  
meridian

East: Sun  
not yet to  
meridian

0.75° W