Name ___Solution___

The Day Through the Seasons

RISING AND SETTING OF THE SUN: SEASONS AND LATITUDE

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

$$A_{rise} = \cos^{-1}\left(\frac{\sin\delta}{\cos\lambda}\right) \text{ degrees} \quad Az_{Max} = (90-\lambda)+\delta \text{ degrees} \quad \Delta t = \frac{2}{15}\cos^{-1}(-\tan\lambda\tan\delta) \text{ hours}$$
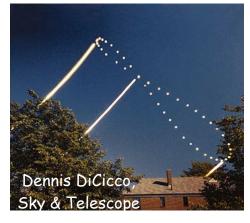
Using these, find the rising and setting azimuths and the length of the day for the following locations and dates, using the declination of the sun given by the analemma:

Date	$\delta_\odot$	Canton, New York (λ = 44° 36′ N)			Quito, Equador (λ = 0° N)			Igloolik, Nunavut, Canada (λ = 69° 24′ N)		
		A_{rise}	Az_{max}	Δt_{day}	A_{rise}	Az_{max}	Δt_{day}	A_{rise}	Az_{max}	Δt_{day}
Sep. 11	5°	82.3°	50.9°	12.7 h	84.5°	95.5°	12.0 h	74.2°	26.1°	14.0 h
Dec. 25	-23.5°	124.1°	21.9°	8.6 h	113.5°	66.5°	12.0 h	No rise!	-2.9°	0 h
Jun. 25	+23.5°	55.9°	68.9°	15.4 h	66.5°	113.5°	12.0 h	No set!	44.1°	24 h

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 for details.

Dennis DiCicco, Sky & Telescope

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 ½ DEGREE, TIME TO THE CLOSEST ½ MINUTE.

Date	Declination of Sun	Sol's position in degrees **East or West** of clock noon	Minutes by which Sol will be **early or late** for clock noon	**Clock time of solar noon**
September 11	5°	0.75° West	3 min Early	11:55:00 am
June 25	+23.5°	0.5° East	2 min Late	12:02 pm
February 12	-14°	3.5° East	14 min Late	12:14 pm
December 25	-23.5°	0°	0 min	12:00:00 pm
Your Birthday Date: _9/7_	6°	0.5° West	2 min Early	11:58:00 am

The Analemma

TIME IN MINUTES

DECLINATION OF THE SUN

3 min — 0.75° W

0 min — 0°

2 min — 0.5° E — 6/25

14 min — ~3.5° E

+23.

+5° — September 11

-14° — 2/12

-23.5°

West: Sun already crossed meridian

East: Sun not yet to meridian

Clock Noon

Equator