

# Analemma Observing Program

## Analemma Observing Program Coordinator:

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### Introduction

Just about everyone knows that the Sun's altitude at culmination, the highest point above the observer's horizon, varies through the year – high in the summer, and low in the winter. However, outside of navigators, cartographers and astronomers, it is not commonly realized that the Sun's apparent angular velocity also varies – sometimes “fast” (west of the meridian at Local Noon), and sometimes “slow” (east of the Meridian at Local Noon).

Participants in the Analemma Observing Program will monitor the Sun's motion throughout the year and note changes in the Sun's position, both in altitude and azimuth. They will then, with reference only to their analemma and observing apparatus:

- Calculate their observing latitude and the tilt of the Earth's axis
- Sketch or plot the path of the Sun on the Celestial Sphere
- Calculate the Equation of Time
- Calculate the eccentricity of the Earth's orbit

Quick View of Requirements	
Analemma Observing Program	
Uses Eyes	Yes
Uses Binoculars	
Uses Telescopes	
Must be an AL Member	Yes
Date Deadline for Submission	
Minimum Instrument Size	
Manual Observations Required	Yes
Go-To Telescopes Allowed	
Remote Telescopes Allowed	
Number of Observations	
Option for Imaging	
Special Equipment Required	Yes
Equipment Must Be Constructed	Yes
Observations Must Be Submitted to an On-Line Database	

### Rules and Regulations

To qualify for the AL's Analemma Observing Program certificate and pin, you need only be a member of the Astronomical League, either through an affiliated Club or as a Member at Large, generate an analemma, and analyze the data of the analemma by completing the four “activities” listed below in their prescribed order.

- For non-photographic techniques, the analemma should be formed by a minimum of 50 observations spread approximately evenly throughout the year (i.e., about one per week).
- For photographic techniques, the analemma should be formed by a minimum of 100 observations spread approximately evenly throughout the year (i.e., about two per week).

**DO NOT ATTEMPT DIRECT OBSERVATIONS OF THE SUN! Due to hazards associated with direct observation of the Sun, only indirect observations will be accepted. Submissions using direct observations of the Sun will be rejected. Looking at the sun can cause permanent damage to your eyes.**

Observation Requirements	
Analemma Observing Program	
Object Name/Number	
Observer's Latitude	Yes
Observer's Longitude	Yes
Observer's Location (City)	
Observer's Altitude	
Date of Observation (LT or UT)	Yes
Time of Observation (LT or UT)	Yes
Description of Object	
Sketch of Object	
Seeing	
Transparency	
Sky Conditions	
Size of Instrument Used	
Power/Magnification	
Filters Used	

Though not necessary to observe on specific days, both the Vernal and Autumnal Equinox, both the Summer and Winter Solstice, and the days of perihelion and aphelion should be noted on the analemma. The Observer's Latitude, Longitude, and Local Observing Time should also be noted.

**IT IS STRONGLY RECOMMENDED THAT YOU CONTACT THE PROGRAM COORDINATOR PRIOR TO STARTING THIS PROGRAM TO REVIEW PROCEDURES, TIPS AND ASK AND RECEIVE ANSWERS TO ANY QUESTIONS**

Some pre-observing activity is required:

- Select your observing site. The site must allow full-year observation of the Sun – either a ray through a hole in an obstruction, or a shadow. You will need to obtain the site's Latitude, Longitude, and Magnetic Variation (if you use a magnetic compass to identify true north/south). The purpose of "starting with the answer" for these pre-observing activities is to assure the observations will fit on the chosen media ... nothing more; once the analemma is complete, the analysis of the analemma is to be completed with reference *only* to the analemma and measured dimensions of the observing apparatus. All observations need to be made at the selected observing site.
- Specify your Observing Time: Most observers will find it least complicated to record their observations at Local Noon; it can be calculated from the Observing Site's Longitude, and should be calculated to the second. A source for accurate times (e.g., W W V or a cell phone) is required to *assure* that the observations are taken at the same clock time (even when using a small enclosure, being off by 15-20 seconds makes a small but noticeable change in the observed position of the Sun). Be sure to add 1 hour when Daylight Savings Time is in effect. All observations need to be made at the selected observing site and all observations should be made at the same time of day.

Observers, who find it impractical to return to their observing location at Local Noon over the year, may choose between two alternatives:

1. They may take readings within three hours of Local Noon, and use a published (e.g., map-derived) value for their Observing Latitude to calculate how their points would have appeared at Local Noon. They should then complete the four Activities, in their prescribed order, using the calculated Local Noon points. For an overview of using non-Local Noon observations, click here (Appendix B).
2. They may set-up a camera for unattended operation, photograph the area where they expect the indication to be, and determine the distances from the image. Observers are cautioned about several inherent weaknesses of this technique:
  - a. These images will likely contain distortion (i.e., scaling factors will vary across the image) due to curvilinear perspective; wide-angle lenses should not be used as they increase the severity of this effect
  - b. Automatic exposure control may washout surface markings used to locate the analemma point
  - c. The Field of View will change if the camera is moved
  - d. The accuracy of locating individual analemma points decreases as the camera angle shallows (here, “camera angle” refers to the angle downward from horizontal that the camera is pointing ...  $0^\circ$  denotes pointing horizontally, and  $90^\circ$  denotes pointing vertically downward); observers should not attempt to use camera angles less than  $60^\circ$

Observers are required to develop their technique for accurately determining distances to the individual analemma points.

Reminder: Observers using a photographic technique are required to collect a minimum of 100 data points, spread approximately uniformly throughout the year.

- Specify your observing apparatus: If using a transmitted light ray or shadow for your observations, a box containing a sheet of paper can be constructed – for a procedure to build such a box, click here (Appendix A ... there are many ways to cast a light ray or shadow; this is only one of them). The points of the analemma are to be marked during the year, with the points of Solstices, Equinoxes, and aphelion and perihelion identified on the analemma.
- Note: The date of all observations will be required to do the calculations.

When the Analemma is complete, a number of parameters about the Earth and its journey around the Sun are to be calculated. The following four activities are to be done in their prescribed order:

- **Activity #1:** with reference *only* to your analemma and measured dimensions of your observing apparatus, calculate (1) the tilt of the Earth’s axis off the normal (i.e., the perpendicular vector) to its orbital plane, and (2) your observing latitude.

For a recommended calculation procedure, click here (Appendix F)

- **Activity #2:** with reference *only* to your analemma and measured dimensions of your observing apparatus, calculate the Sun's path in the sky and produce a sketch or plot to depict that path.

For a recommended calculation procedure, click here (Appendix G)

- **Activity #3:** with reference *only* to your analemma and measured dimensions of your observing apparatus, calculate the Equation of Time curve across the year.

For a recommended calculation procedure, click here (Appendix H).

- **Activity #4:** with reference *only* to your analemma and measured dimensions of your observing apparatus, calculate the eccentricity of the Earth's orbit.

For a recommended calculation procedure, click here (Appendix I).

### Submitting for Certification

To receive your Analemma Observing Program certificate and Award Pin, mail the following to the AL Observing Program Coordinator (do *not* mail originals):

- A description of your observing setup (with dimensions). This includes a description of your observing location (Latitude, Longitude, and Magnetic Variation, if used) and Local Observing Time.
- A copy of your analemma, with the points of Solstices, Equinoxes, and aphelion and perihelion identified

Submission Requirements	
Analemma Observing Program	
Observer's Name	Yes
Observer's Mailing Address	Yes
Observer's Club Affiliation	Yes
Observer's Phone Number	Yes
Observer's E-Mail Address	Yes
Information for Person to Send the Award To For Presentation	Yes

- A description of how you derived the tilt of the Earth's axis and your observing Latitude. If an observing time other than Local Noon was used, a description of how the data was transformed into Local Noon data is to be included as well. (Activity #1)
- A copy of your sketch or plot of the Sun's path in the sky, and a brief description of how you derived it (Activity #2)
- A copy of your Equation of Time curve, and a brief description of how you derived it (Activity #3)
- Your estimate of the eccentricity of Earth's orbit, and a brief description of how you derived it (Activity #4)

Include with your submission, your name as you want it to appear on the certificate, mailing address, phone number, email, and society affiliation. Upon verification of your observations, your certificate and pin will be forwarded to you or your club's Awards Coordinator, whomever

## **Special Thanks**

We would like to make special note of the amateur astronomer who put this Analemma Observing Program together; Lowell Martin. Thank you Lowell for providing this program that challenges not only our observing skills in a whole new way, and also challenges our thinking and understanding about the mechanics of how the Earth-Sun system really works.

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