I. Objectives

1. Utilize your calibrated angular measuring device to determine angular distance.
2. Explain the difference between synodic period and sidereal period.
3. Calculate Earth's sidereal and synodic periods.

II. Introduction

The Sun, Moon, planets and stars rise and set every day because of Earth's rotation on its axis. Astronomers use two different periods of Earth's rotation. The first is sidereal period and the second is synodic period. We can calculate the Earth's angular velocity and sidereal period by making two observations of the same star, on the same night, approximately an hour apart by measuring the angular distance the star appears to have moved relative to a fixed object on Earth.

We can calculate Earth's synodic period with the assistance of another observation about a week or two later. The star we will use is Mintaka, right ascension, a = 5*h* 31*m* 57.3*s*, and declination, d = -00^{o} 18' 02", because it is almost on the celestial equator. If we were to select a star that was not on or near the celestial equator or calculations would be more difficult.

III. Theory

We need to use a little arithmetic, one of our calibrated angular measuring devices, Mintaka, the eastern star in Orion's belt, and two observations made on the same night to determine the sidereal period of the Earth. About two weeks later a second observation of Mintaka made from the same location earlier in the evening will help us determine the synodic period of the Earth.

The mathematical process we will use is similar to that we use everyday in determining the time it takes us to drive from one location to another, using rate, also called speed or velocity, distance and time. We know that r = d/t or rate = distance/time. In this lab we will use three similar equations.

- The first is $\omega = \theta$/t where ω = angular velocity, θ = angular distance, and t = time between the observations made on the same night.
- The second is $\Delta = \omega \ x$ T, where Δ = the shift over approximately two weeks and T = time difference between the observations made approximately two weeks apart.
- The third is v = Δ/n where v = angular velocity in degrees per day and n = the number of days between observations.

IV. Prelab Definitions

1. right ascension

2. declination

3. synodic period

4. sidereal period

5. angular velocity

V. Prelab Questions

1. What does ω represent?

2. What does θ represent?

3. What specific time interval does t represent?

4. What does Δ represent?

5. What specific time interval does T represent?

6. What does v represent?

7. What does n represent?

8. In what constellation and in what part of the evening sky is Mintaka located?

VI. Lab Procedure

1. Consult your Orion star chart and find Mintaka. Find a rigid structure, such as the edge or corner of a building, a telephone pole, or any other stationary object. Don't use a tree, any other object that may move, or an object that is close enough that it appears to move if you move a few steps to the left or right. You may need to choose an object that is fairly far away. Position yourself so that Mintaka appears to balance on the top of the object you selected. Mark your location so that you will be able to locate it later in the semester. Write the location in row A of the *Rotation and Revolution Data* table below.

2. With Mintaka balancing on the top or corner of the object you selected record the date in row B and the exact time of the first observation in row C.

3. Return to the exact location of your first observation in about an hour. Record the exact time of the second observation in row D.

4. Using one of your calibrated angular measuring devices, estimate the angular distance θ, in degrees, that Mintaka has moved since your first observation and record it in row G.

5. Calculate the time between observations in hours. E = D - C.

6. Calculate the time between observations in minutes. F = E x 60

7. The calculated angular velocity, ω, in degrees per hour is equal to the angular distance, θ, in degrees, divided by the time between observations t, measured in hours, $\omega = \theta/t$. H = G/E.

8. Calculate the time it would take for the star to travel 360^0 around the entire sky, so that a star appears in the sky in exactly the same place as it did on the previous night. This is Earth's calculated sidereal period. I = 360^0/H.

9. Earth's true sidereal period = 23h 56m = row J.

10. Calculate the difference between Earth's calculated sidereal period and Earth's true sidereal period = | I - J | and record it in row K.

11. Make your next observation about two weeks after the first observation from exactly the same location, but you will need to make this observation about an hour earlier than the first observation. Again position yourself so that Mintaka appears to balance on the top of the same object you selected for your first observation. Record the date in row L and the exact time of the third observation in row M.

12. Calculate the number of days between the first and the third observations in row N.

13. Calculate T, the time between the first observation and the third observation in hours.
P = C - M.

14. Calculate T, the time between the first observation and the third observation in minutes.
Q = P x 60.

15. The true value of ω is 15^0/hr so use this value for the rest of the calculations that require ω. Calculate the shift Δ that has taken place since the first observation, $\Delta = \omega\ x$ T.
R = 15 *x* P.

16. The calculated angular velocity v, in degrees per day is equal to the shift s divided by the number of days between the first and third observations. v = Δ/n. S = R/N

17. The number of degrees in a circle or orbit = 360^0 = row U.

18. Calculate Earth's synodic period, the number of days in a year. V = U/S.

19. Earth's true synodic period in days = 365.25 = row W.

20. Calculate the difference between Earth's calculated synodic period and Earth's true synodic period. X = | V - W |. If the difference is more than 365.25, subtract 365.25 from the result.

Rotation and Revolution Data

A	location	
B	date	
C	time of first observation in military time	
D	time of second observation in military time	
E	time between observations t in hours, E = D – C	
F	time between observations t in minutes, F = E x 60m/h	
G	angular distance θ in degrees	
H	calculated angular velocity in degrees per hour H = G/E	
I	Earth's calculated sidereal period in hours I = 360^o/H	
J	Earth's true sidereal period	23h 56m
K	difference between Earth's calculated sidereal period and Earth's true sidereal period, K = | I - J |	
L	date of third observation	
M	time of third observation in military time	
N	number of days between first and third observations	
P	time of first observation - time of third observation in hours, P = C - M	
Q	time of first observation - time of third observation in minutes, Q = P x 60m/h	
R	shift θ in degrees, R = 15^0/h *x* P	
S	angular velocity v in degrees per day, S = R/N	
U	degrees in an orbit	360^0
V	Earth's calculated synodic period in days, V = U/S	
W	Earth's true synodic period in days	365.25 days
X	difference between Earth's calculated synodic period and Earth's true synodic period, X = | V - W | in days	

VII. Lab Discussion

1. Explain why Earth's sidereal period is not exactly 24 hours.

2. How close was your answer to Earth's true sidereal period? Other than mathematical error, what are the possible sources of error?

3. How close was your answer to Earth's true synodic period? Other than mathematical error, what are the possible sources of error?