

Part I
Discovering the Science of Astronomy

Kit Activity 4-1



Measuring Northern Stars with Quadrant and Cross-staff

When you have completed this activity, you should be able to do the following:

- Use a sky map as a guide to find the principal constellations and stars in the northern part of the sky at any time of year.
- Determine your latitude from the altitude of the polestar.
- Use your quadrant and cross-staff to measure the positions and motions of stars in the sky, and interpret the measurements.



Use the answer sheet at the end of the Activity.

On a clear night, find a location as far from interfering lights as possible. A horizon that is relatively free of obscurations such as buildings and trees, especially in the north, is also desirable. Consult your star maps to see what stars you should expect to find in the north for the time of year it is, and find them in the sky. Make a sketch showing your horizon and its landmarks and the rough positions of the stars you can see.

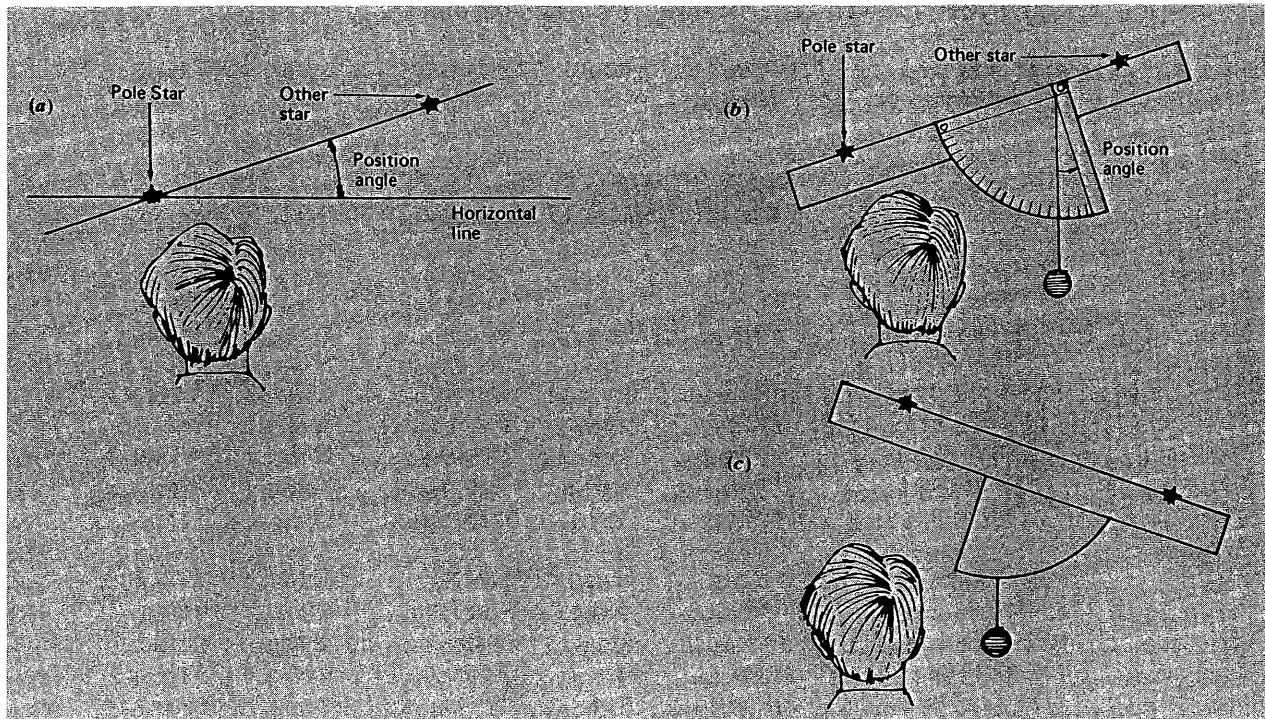
At least twice during the evening use your instruments to make the observations indicated below. Be sure to make at least three (and preferably five) independent measurements of each angle and, if they appear consistent, average them together to minimize random errors. In addition, be sure to estimate the errors of the observations. For your data to be usable, you will need to let nearly two hours elapse between your two sets of measurements; *your results will be much better if you let more time pass* (thus giving the sky time to "move").

In addition to Polaris, you will need to choose two easily recognized stars to the east of Polaris and two west. For example, in September, you would probably want to choose two stars in the Big Dipper and two in Cassiopeia. Note that you do not need to know the names of the stars you use, but *you must learn the patterns well enough to guarantee that when you take your second set of measurements, you are measuring the same stars*. For each star chosen, you should measure:

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1. The altitude of the star, with the quadrant.
2. The angular separation between Polaris and the star, with the cross-staff.
3. The *position angle* of the star with respect to Polaris, with the quadrant (see the following discussion).

The **position angle** of a star is the angle made by a line from Polaris to the star with respect to a line parallel to the horizon.¹ **Kit Figure 4-1-1** shows how to measure the position angle of a star with respect to Polaris by using the quadrant sideways and reading off the angle as indicated. For some stars, the quadrant string will not fall on the scale of the instrument. In these cases, you need to turn the quadrant around so that the scale is facing *away* from you and record the *negative* of the angle shown on the scale. What you will be finding from these data is how much the angle changes and in what direction.



Kit Figure 4-1-1 Position angle. (a) Definition. (b) Measurement. (c) Measurement if the star on the left is higher (negative position angle).

¹While this is a different definition of position angle than is customary in astronomy, it is easier to apply with these instruments.

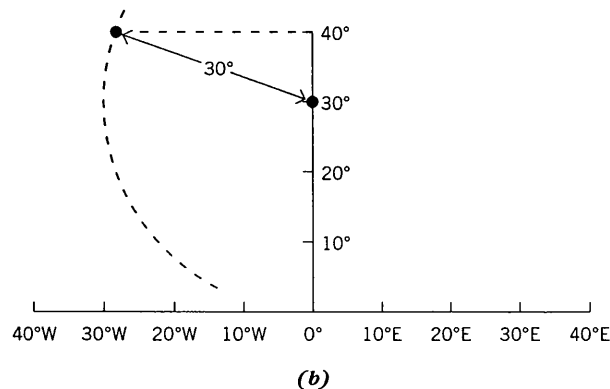
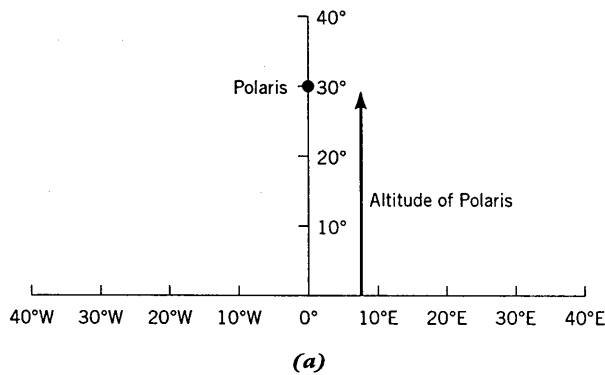
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Record all angles and the times of observation on your answer sheet. Wait for nearly two hours (preferably more), and then repeat all your observations again. After making your observations, plot them on graph paper so that you can more easily visualize the motions of the stars in the northern sky. If you follow steps 1 and 2 in the next paragraph carefully, you should have no difficulty in plotting the measurements you have made.

1. Locate Polaris on your graph by plotting a point on the line above the north point of the horizon at the altitude that you measured for Polaris. **Kit Figure 4-1-2** shows this done for an altitude of 45° .

2. Using your measurements, locate each of the other stars you observed relative to Polaris: For example, suppose the measured altitude of a star was 50° , and its distance from Polaris was found to be 30° . **Kit Figure 4-1-2** shows how to plot this star on the graph. Using a compass, or a pencil tied to a piece of string, measure 30° on the axis of the graph. Strike an arc 30° in radius, using Polaris as the center. The star will be located at that point on the arc that has an altitude of 50° . **NOTE:** *You must use a compass or string to plot the point; you cannot just mark your point above the 30 mark on the horizontal scale.*

- **Kit Inquiry 4-1a** Why is it incorrect simply to mark this data point above 30°E on the horizontal scale?



Kit Figure 4-1-2 Locating Polaris (a) and a second star (b) on the graph. In this example, the second star is located at an altitude of 40° (horizontal line) and a distance of 30° from the pole (arc of circle). The intersection of these two lines fixes the position of the star on the graph.

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After completing your graph, answer the following questions by referring to it and to your recorded data.

- **Kit Inquiry 4-1b** *On the basis of your observations*, which stars (those to the east or those to the west) have altitudes that increase? Decrease? Maintain constant altitudes?
- **Kit Inquiry 4-1c** *On the basis of your observations*, describe in your own words the motions of the northern sky. Do the angular distances of stars you measured from Polaris increase, decrease, or remain the same?
- **Kit Inquiry 4-1d** On the basis of your observations of the position angles of the various stars, how many degrees does the position angle of a star change in an hour? According to your measurements, how long will it take the stars to rotate a full 360° ? (You have just determined the Earth's sidereal period!)
- **Kit Inquiry 4-1e** On the basis of your observations in this activity, what was the latitude of the place where you made your measurements?

Between your first and second set of measurements, you can refer to your star maps and find other northern stars. If you are also doing Kit Activity 4-2, you can carry out those measurements while waiting for the necessary time interval to pass before making your second set of measurements for the current activity.

Activity 4-1

Measuring Northern Stars with Quadrant and Cross-staff

Answer Sheet NAME _____

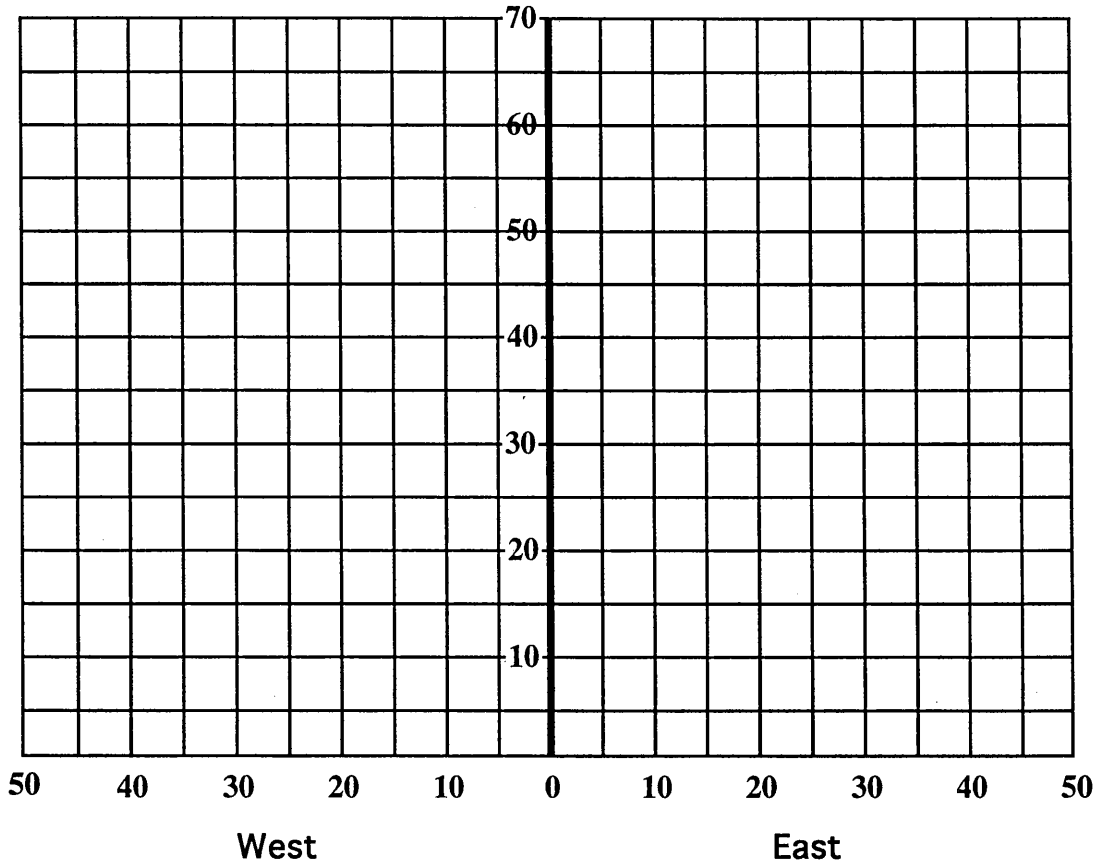
1. For the first set of measurements, record your results on the left side of the table below. Use the right side for the second set. Record your three measurements of each angle in columns #1, #2, and #3. After completing the measurements, calculate and record the averages and the errors. Remember not to start the second set of measurements until nearly two hours (and preferably longer) after your first set.

Date of your measurements: _____

	<u>FIRST MEASUREMENTS</u>					<u>SECOND MEASUREMENTS</u>				
	Time Started:					Time Started:				
	Time Ended:					Time Ended:				
	Measurement					Measurement				
<u>ALTITUDES</u>	#1	#2	#3	Ave.	Error	#1	#2	#3	Ave.	Error
Polaris	—	—	—	—	—	—	—	—	—	—
Eastern Star #1	—	—	—	—	—	—	—	—	—	—
Eastern Star #2	—	—	—	—	—	—	—	—	—	—
Western Star #1	—	—	—	—	—	—	—	—	—	—
Western Star #2	—	—	—	—	—	—	—	—	—	—
<u>ANGLES FROM POLARIS</u>	#1	#2	#3	Ave.	Error	#1	#2	#3	Ave.	Error
Eastern Star #1	—	—	—	—	—	—	—	—	—	—
Eastern Star #2	—	—	—	—	—	—	—	—	—	—
Western Star #1	—	—	—	—	—	—	—	—	—	—
Western Star #2	—	—	—	—	—	—	—	—	—	—
<u>POSITION ANGLES</u>	#1	#2	#3	Ave.	Error	#1	#2	#3	Ave.	Error
Eastern Star #1	—	—	—	—	—	—	—	—	—	—
Eastern Star #2	—	—	—	—	—	—	—	—	—	—
Western Star #1	—	—	—	—	—	—	—	—	—	—
Western Star #2	—	—	—	—	—	—	—	—	—	—

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2. Use the graph paper below to plot the positions of each star you measured for both the first and second set of measurements. Label each position carefully.



3. Answer Inquiries 4-1a on a separate piece of paper.