

## Questions

How does a stick's shadow behave as observed from halfway between North Carolina and the tip of Africa?

## Materials Needed

For this activity, you will need the following materials:

- a simulation of a stick's shadow
- a ruler
- a pencil (do not use ink)
- the ability to read and follow directions
- you must have previously completed either Activity0101 or Activity0102, but you need not have done both.

## Points To Remember

Unless otherwise explicitly instructed, your responses must not contain personal opinions. All of your responses must be in the form of complete sentences; the fewer sentences the better. Spelling and grammar must be correct. Effective communication is essential for both learning and doing science.

Don't ask instructors for answers to questions posed in activities; you won't get them. You may ask questions regarding the clarity of the instructions or the soundness of your reasoning. If you encounter a word you are not familiar with, don't ask the instructor about it. Look it up first in your glossary and then a dictionary or some other source if necessary. Ensure that all definitions are unanimously agreed upon before proceeding. There are, of course, sound reasons for these policies. See the instructor if you have questions, but do not complain about these policies. They are not negotiable.

Don't attempt to draw any inferences unless you are asked to do so. Don't confuse a simple description of an observation, the explanation of that observation, and what can be learned from that observation. You cannot draw inferences until you have assembled a sufficient number of accurate observations. You'll recognize when you're expected to draw inferences.

Don't rely on what you may already know or think you may already know about topics addressed in these activities. You must develop a reliance on observations rather than preconceived knowledge, which may have been incorrectly learned. With few exceptions, your observations will tell you everything you need to know. Not being able to rely on prior knowledge or the perception of prior knowledge will probably be very frustrating for you, but it is necessary for learning how to make accurate observations and how to rely on them.

Don't use any terms that have not been precisely defined, and that includes terms you may already be familiar with but haven't encountered in this course. Many scientific terms aren't used correctly by nonscientists (and sometimes even by scientists). Some terms have one meaning in science and another meaning in other disciplines. Not being able to use what you may think is correct terminology will be frustrating for you, but

it's necessary if you're to form precise and correct operational definitions of technical terms. Inconsistent and incorrect terminology can cause problems for you, but you can prevent those problems by forming good terminology habits early on in your introduction to science.

## 1 Shadows During Daylight

### 1.1 Same Location, Same Month

Select a location as close as possible to exactly halfway between North Carolina and the tip of Africa measured from the screen's top to the screen's bottom parallel to the sides of the screen. You may want to **very carefully** place a **plastic** ruler on the computer screen to help you do this. The precise location is not important, but try to get close as close as possible to halfway between North Carolina and the tip of Africa. Do not change locations until instructed to do so.

Select a date around December 18. Observe the behavior of the stick's shadow for about five consecutive days. Pay particular attention to the shadow's length and direction at different times **during daylight**. As you answer the following questions, be as specific as possible but do not be too wordy. Do not use any words that either you or anyone else in your class would not understand. You must use complete sentences. Scientists keep meticulous records of everything they observe, and you should begin learning to do that too. You will need to refer back to your observations later in the course and you will have to rely on your written records. **Use complete sentences in all of your responses. Use as few sentences as possible.**

Is the shadow's length the same throughout the day? Do not mention anything about the shadow's direction.

Is the shadow's direction the same throughout the day? Do not mention anything about the shadow's length.

Does anything about the stick itself physically change during the day? If so, what? Do not mention anything about the shadow.

Does anything about the source of illumination change during the day? If so, what? Do not mention anything about the stick or the shadow.

Describe the general direction in which the shadow points at sunrise. Choose **only** from among the following to use in your answer: north, east, south, west, north of east, north of west, south of east, south of west.

Describe the general direction in which the shadow points at sunset. Choose **only** from among the following to use in your answer: north, east, south, west, north of east, north of west, south of east, south of west.

At what time or times of day is the shadow's length greatest? Do not use times that require numbers.

At what time or times of day is the shadow's length least, but still visible? Do not use times that require numbers.

Does the shadow ever completely vanish while Sun is above the horizon? If so, when?

## 1.2 Same Location, Different Month

Now select a date around March 18 and for about five consecutive days, carry out the same observations that you did in the previous section. Remember that your location hasn't changed. If anything is different, describe it in the space provided.

## 1.3 Same Location, Different Month

Now select a date around June 18 and for about five consecutive days, carry out the same observations that you did in the previous section. Remember that your location hasn't changed. If anything is different, describe it in the space provided.

### 1.4 Same Location, Different Month

Now select a date around September 18 and for about five consecutive days, carry out the same observations that you did in the previous section. Remember that your location hasn't changed. If anything is different, describe it in the space provided.

## 2 Inquiry

Determine, to the nearest day, when the stick's shadow satisfies each of the following conditions as indicated in the table. If a condition is never satisfied, leave that entry's space blank. If a condition is satisfied on more than one date, give all relevant dates.

Condition	Date(s) condition is satisfied
max. angle between sunrise shadow and western half of east-west line	
min. angle between sunrise shadow and northern half of north-south line	
sunrise shadow points west	
min. angle between sunrise shadow and southern half of north-south line	
noon shadow max. length	
noon shadow min. length (but still visible)	
noon shadow vanishes	
max. angle between sunset shadow and eastern half of east-west line	
min. angle between sunset shadow and northern half of north-south line	
sunset shadow points east	
min. angle between sunset shadow and southern half of north-south line	

If these dates have any significance that you may be aware of, discuss that significance. If these dates have no significance that you know of, you may need to repeat this part.

Determine all locations from where a person would see a stick's noon shadow vanish on the same date(s) on which it vanishes as seen from exactly halfway between North Carolina and the tip of Africa. (HINT: Think about establishing the north-south

and east-west lines at the location where the noon shadow vanishes. Would the noon shadow vanish for an observer some distance away along the north-south line? Would the noon shadow vanish for an observer some distance away along the east-west line?)

Determine all locations from where a person would see a stick's noon shadow vanish on exactly one day of the year. (HINT: If you're standing where a noon shadow vanishes on exactly one day of the year, think about establishing the north-south and east-west lines at that place. Would the noon shadow vanish for an observer some distance away along the east-west line?)

From your findings in the previous two questions, determine whether there are limits to where an observer must be to see a stick's noon shadow vanish on at least one day of the year. If such limits exist, quantify them somehow. You may wish to refer to observations from previous activities. You may also wish to invoke the concept of *symmetry*. Fill in the table as appropriate.

one limit	
other limit	

If these limits have any significance that you may be aware of, discuss that significance. If these limits have no significance that you know of, you may need to repeat this part.

Using everything you have discovered, construct a framework that defines the behavior of a stick's shadow from the location you used in this activity.



What could be done to make this activity more interesting? Please be honest.



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Student