

ASTR 2000 HOMEWORK #1 DUE THURS September 10th NAME: _____ KEY _____
Daily (Diurnal) Motion of the Heavens

1. All stars are called “fixed stars” because they are all at fixed celestial locations. This means that at any one specific location on Earth they have fixed rising and setting locations (setting locations ALWAYS symmetrical to rising locations around the meridian) and a fixed angle with respect to the zenith when each star crosses the meridian...regardless of the time of day or night that they rise or the time of year when they are seen! This makes them great, “fixed” beacons for celestial navigation!

a). For the following stars, locate their rising points as either **north-of** or **south-of** due east or **at due east**...also locate their meridian location as a specific altitude *angle* and specify either **north-of, south-of or at the zenith**. All of these values are for here in Boulder (40° N latitude). I have filled in the values for **Vega** below as an example. You fill in the rest.

Star	Celestial Latitude	Rises @	On Meridian @
Vega	40° N	N of due east	at zenith 90° altitude
Orion’s Belt	0°	due east	50° altitude S of zenith
Antares	25° S	S of east	25° altitude S of zenith
Polaris	89.5° N	circum-polar → Never sets	40.5° altitude (40° OK) N of zenith
Hokule’a (Arcturus)	19° N	N of east	69° altitude S of zenith
Sirius (Sothis)	17° S	S of east	33° altitude S of zenith

b). Which one of these stars stays up in the sky for the **least** amount of time here in Boulder?
 Explain your answer.

Antares since this star is furthest south of all those listed

Celestial Navigation Polynesian and 1800s style

2. With a sextant it is possible to determine the altitude of a star (or the Sun) to a fraction of a degree of arc; in fact, with some skill it is possible to make this measurement, even from the heaving deck of a ship, to approximately **6 arc-minutes (1/10th of a degree)**.

RECALL: 360 degrees is the full range of longitudes (at the equator) or latitudes around the Earth's poles. 60 arc-minutes = 1 degree; 60 arc-seconds = 1 arc-minute.

a). Given that the Earth's circumference is about 24,000 miles in diameter, to what accuracy in miles can one's latitude be determined using a sextant to its best accuracy as quoted above?

Go through this one step at a time to get a final answer as follows:

How many miles on the Earth are equal to 1 degree of arc?

24000 miles/360 degrees = 67 miles per degree

How many miles on the Earth are equal to 1 arc-minute?

67 miles per degree / 60 arc-minutes per degree = 1.1 miles per arc-minute

Now answer question (a) and **Explain**. In your explanation use the example of the altitude of Polaris and its relationship to latitudes on the Earth to show how the accuracy in measuring the altitude of a star translates directly into the accuracy in determining your location on the Earth.

1.1 miles per arc-minute X 6 arc-minute accuracy of sextant = 6.6. mile accuracy

altitude of Polaris \approx latitude \rightarrow accuracy of altitude measurement \approx latitude accuracy

b). Which geographical coordinate, **latitude or longitude or both**, can you determine in this way? **Explain**.

Latitude only; to measure longitude you need a clock, specifically a clock set to Greenwich England time (called variously: "Greenwich mean Time or Universal time or Zulu time"); Greenwich is located at the arbitrary zero point of longitude.

c). What if you were a Polynesian "wayfinder" (navigator) and did not use a compass or any other very accurate measuring device but you used measurements of a star's altitude made using your hand and fingers to determine when you were on the correct latitude to make "land fall". For example, to sail to Hawaii from the south, the wayfinder would watch the Southern Cross (when it is "upright" and so crossing the meridian) descend as she/he sailed north until the bottom star is 6° above the horizon, (the same distance as between the two stars in the long arm of the Southern Cross).

I estimate that someone familiar with this technique could determine the altitude of the bottom star in the Southern Cross (or any other star close to the horizon) to an accuracy of $\frac{1}{2}^\circ$. As you did in question 2a above, calculate the accuracy in latitude that this traditional observing technique yields? Show your work.

$\frac{1}{2}$ degree accuracy = 67 miles per degree / 2 = 33 miles accuracy.

d). Is this accuracy good enough for the wayfinder to find Hawaii? **Explain** using your knowledge of the techniques for making “land fall” described in class.

Yes, clouds can be seen over the Big Island for > 100 miles away. Specific types of birds fly out from their nests each morning and return each evening. The white birds, the fairy terns, range up to 100 miles from land; the brown, noddy terns range 30-40 miles from land. There are other indicators, colors in sky, seaweed, reef fish, etc, etc. that land is near. Ocean currents can also indicate land if you are down wind/current from islands.

3. The chart on the backside of this page is a map of the Caroline Islands at 10° N latitude. Also included is a traditional Polynesian "Star Compass" for use in and around the Carolines. Satawal in the Caroline Islands is the home of Mau Piailug, the famous traditional Polynesian navigator. Using the star compass determine the following:

a). Which rising or setting star would you use to steer from Guam to the island of Palau? (Specify star and whether you steer by its rising or setting).

Setting point of γ Corvi (Gamma Corvi; third brightest star in constellation Corvus, the Crow). Setting point of Antares also acceptable.

b). Same question but for the return voyage: Palau to Guam (specify star and rising or setting).

Rising point of Vega

c). Based upon the star compass and your knowledge of the way that stars track across the sky near to the Earth's equator, determine which star you would watch go through the zenith to get on the right latitude to sail to the central Caroline Islands (10° N; i.e., to Weno in the Truk Atolls). Explain your answer.

The star γ (Gamma) Aquilae or Altair or Aldebaren (although this star is a little too far north). Close to the equator stars rise and set nearly vertically and so those stars very close to rising due east and setting due west go through zenith. Extra credit if you mention that at 10° North, stars track *slightly* (10° off vertical) to the south and so γ (Gamma) Aquilae is a better choice than Altair, but either is acceptable.