ASTR 2000 HOMEWORK #1 DUE THURS Sept 8th NAME:_____
Daily (Diurnal) Motion of the Heavens & Celestial Navigation

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-east** or **south-of-east**, **at due east or "does not rise"**…also locate their meridian location as a specific ***altitude angles*** **(provide an exact number of degrees)** and either **north-of-zenith, south-of-zenith or at the zenith**. All of these values are for here in Boulder (40^o 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^o N**	**north of east**	**at zenith; altitude = 90 degrees**
Orion's Belt	**0^o**		
Antares	**25 ^{o} S**		
Polaris	**90^o N**		
Hokule'a (Arcturus)	**19^o N**		
Sirius (Sothis)	**17 ^{o} S**		

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

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?

How many miles on the Earth are equal to 1 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.

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

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^{o} 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 ½ ^{o}. As you did in question 2a above, calculate the accuracy in latitude that this traditional observing technique yields? Show your work.

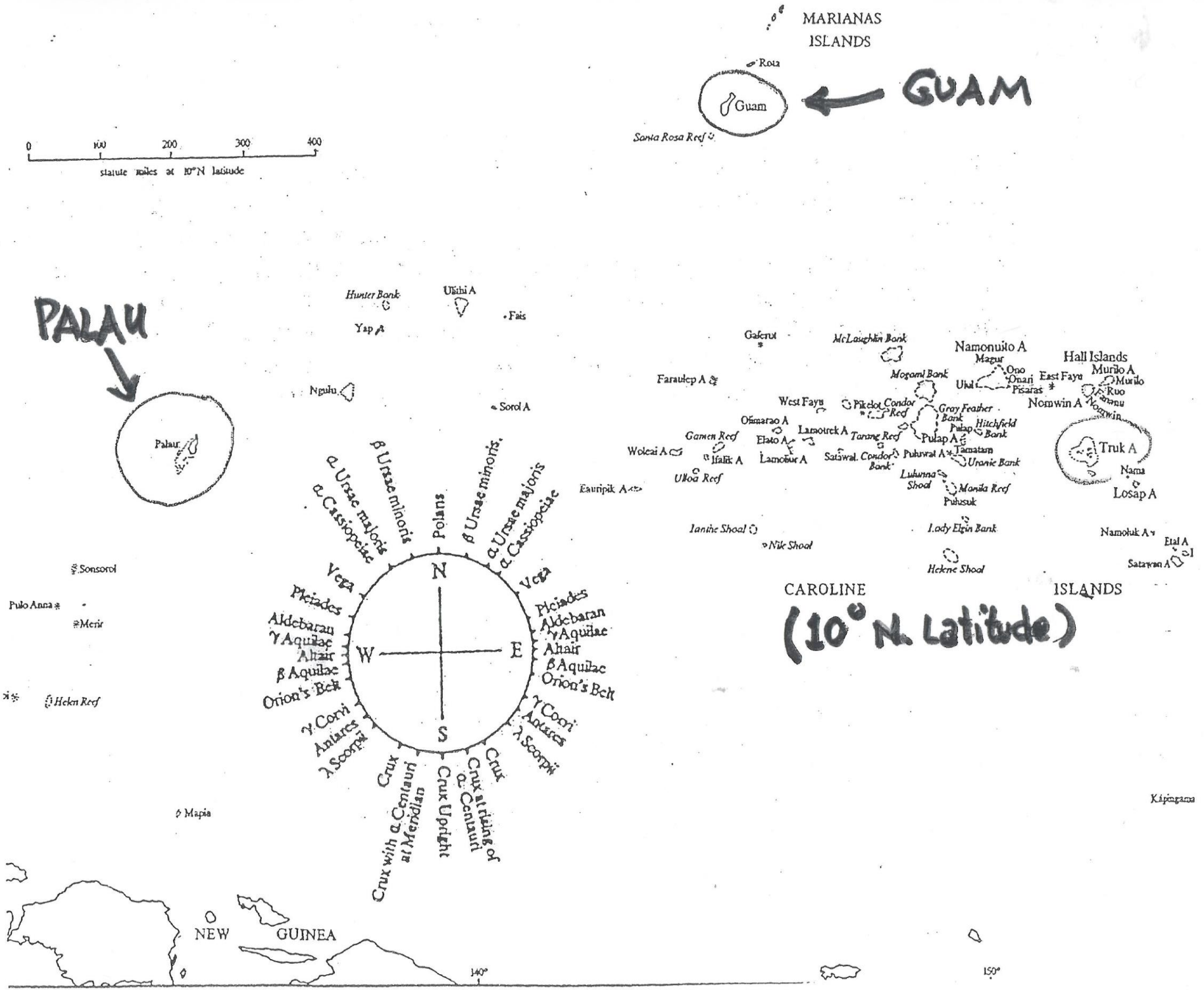
d). Is this accuracy good enough for the wayfinder to find Hawaii? **Explain** using your knowledge of the techniques for making "land fall" described in class.

3. The chart on the backside of this page is a **map of the Caroline Islands** at 10^{o} 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).

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

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^{o} N; i.e., to Weno in the Truk Atolls). Explain your answer.


MARIANAS ISLANDS
Rota
Guam
GUAM
Santa Rosa Reef
0 100 200 300 400
statute miles at 10°N latitude
PALAU
Palau
Hunter Bank
Ulithi A
Fais
Yap A
Ngulu
Sorol A
Gaferut
McLaughlin Bank
Namonuito A
Magur
Hall Islands
Murilo A
Murilo
Ruo
Onoo
Onari
Pisaras
East Fayu
Nomwin A
Nomwin
Mogami Bank
Faraulep A
Ulul
West Fayu
Pikelot
Condor Reef
Gray Feather Bank
Pulap
Hitchfield Bank
Ofamarao A
Elato A
Lamotrek A
Gamen Reef
Tarang Reef
Pulap A
Truk A
Nama
Losap A
Woleai A
Ifalik A
Lamotrur A
Satawal
Condor Bank
Puluwat A
Tamatam
Uranie Bank
Ulloa Reef
Lukunna Shoal
Manila Reef
Pulusuk
Eauripik A
Ianthe Shoal
Nik Shoal
Lady Elgin Bank
Hekeme Shoal
Namoluk A
Etal A
Satawan A
CAROLINE ISLANDS
(10° N. Latitude)
Sonsorol
Pulo Anna
Merir
Helen Reef
Mapia
Kapingama
Polaris
β Ursae minoris
α Ursae minoris
α Cassiopeiae
β Ursae majoris
α Cassiopeiae
Vega
Pleiades
Aldebaran
γ Aquilae
Altair
β Aquilae
Orion's Belt
γ Corvi
Antares
λ Scorpii
Crux
Crux with α Centauri at Meridian
Crux Upright
Crux striking of α Centauri
Crux
λ Scorpii
N
E
S
W
NEW GUINEA
140°
150°