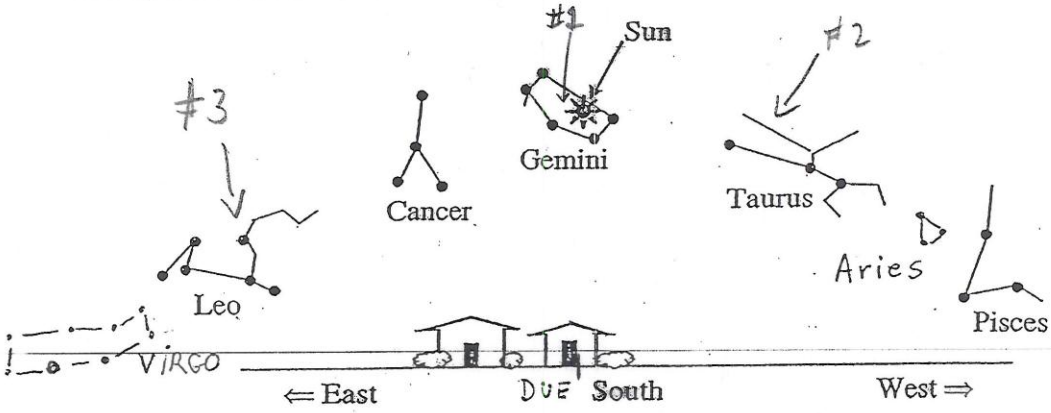
ASTR 2000 HOMEWORK#2 DUE THUR FEB 3 KEY_____

1. If you could see stars during the daytime, this is what the sky would look like on a certain day looking due south from Boulder. The Sun is "in" the stars of the constellation of Gemini at noon.




a). Why are these particular constellations shown in this chart? For instance, why isn't the Big Dipper or Orion shown? Another way to ask this question is what is so important about these particular constellations in relation to the Sun?

Zodiac constellations lie along ecliptic plane, the path of Sun, Moon & planets

b). Which constellation was the Sun "in" soon after sunrise on the particular morning shown in the sketch above. Explain.

Gemini
Sun moves only 1° (see below) in one day, so it barely moves thru stars since sunrise

c). There are 365 (or 366 during leap years) days in a year and there are 360 degrees in a full circle. So, by APPROXIMATELY how many degrees does the Sun move in relationship to the constellations of stars in one day?

$\frac{360 \text{ deg}}{365 \text{ days}} \approx$ 1 degree per day

d). What direction does the Sun move through these constellations of stars as the days, weeks and months go by? {HINT: this is the "annual motion" of the Sun, not the "diurnal motion" of the Sun}.

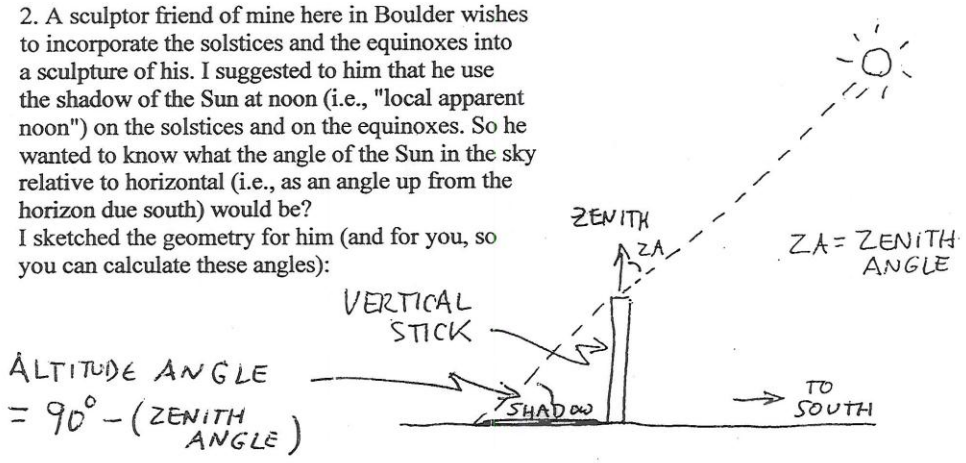
WEST TO EAST

e). The constellations pictured above are defined to be exactly 30 degrees in length along the Sun's path (called the ecliptic). There are twelve of these constellations along the ecliptic, each defined to be exactly 30 degrees wide. Where will the Sun be at noon on the very next day after the sketch above? (mark the approximate location with an arrow labeled #1).

Where was the Sun ONE *month* BEFORE this sketch? (mark with an arrow labeled #2)

Where will the Sun be TWO *months* LATER? (mark with an arrow labeled #3)

2. A sculptor friend of mine here in Boulder wishes to incorporate the solstices and the equinoxes into a sculpture of his. I suggested to him that he use the shadow of the Sun at noon (i.e., "local apparent noon") on the solstices and on the equinoxes. So he wanted to know what the angle of the Sun in the sky relative to horizontal (i.e., as an angle up from the horizon due south) would be?
I sketched the geometry for him (and for you, so you can calculate these angles):




Taking this problem one step at a time:

a). What is the "declination" (celestial latitude) directly overhead in Boulder (i.e., at the zenith)?

40° N

b). What is the declination of the Sun at the summer solstice?

23½° N

c). What is the "zenith angle" (ZA), angle between the zenith and the Sun at the summer solstice? show your work below.

40 − 23½ = 16½° = ZA

d). Now by using a bit of geometry, what is the altitude of the Sun at the summer solstice? (The altitude is the angle between the dashed line that extends up to the Sun and the horizontal in the sketch above).
Show your work below. $90° - 16\frac{1}{2} = 73\frac{1}{2}°$ / pretty high!

e). Answer questions (b) and (c) again for the equinoxes and the winter solstice. Again show your work so I know you understand.

@ Equinoxes: Dec of ⊙ = 0

$40° - 0° = 40° = ZA$

$90° - 40° = 50°$ altitude ✗

@ Winter Solstice:

Dec of ⊙ $= -23\frac{1}{2}°$

$40° - (-23\frac{1}{2}) = 63\frac{1}{2} = ZA$

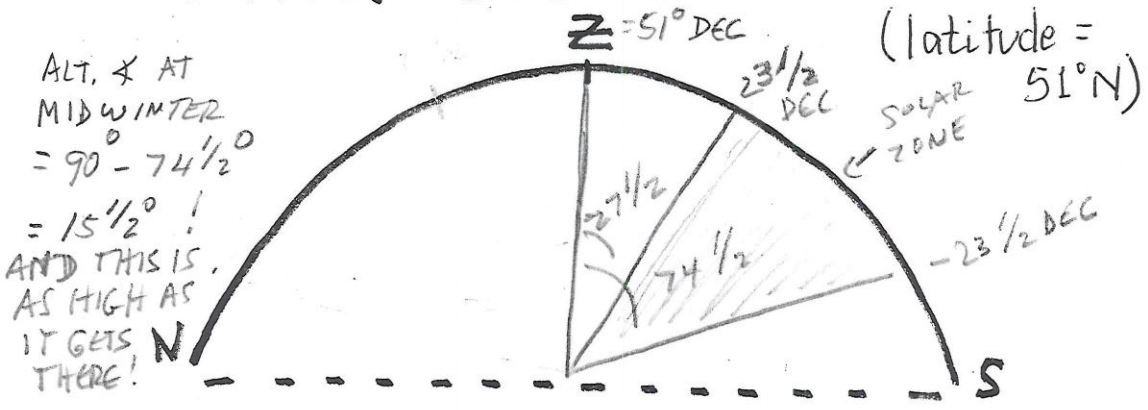
$90° - 63\frac{1}{2} = 26\frac{1}{2}° =$ ALTITUDE ✗

3. Here is a "Meridian Slice" question about the "Solar Zone", the range of angles along the meridian that the Sun moves through during one full year (i.e., winter solstice to summer solstice and back to winter solstice again). The "Solar Zone" is different for different latitudes on the Earth.

a). Using the three sketches of meridian slices below and on the reverse side of this page, locate the "Solar Zone: (celestial latitudes = ±23 ½ °) at the following three latitudes: Stonehenge @ 51°N), the Earth's Equator (0 °) and Cusco, Peru (13 ½ °S). List the specific **zenith angles** (angles down from the zenith) for the summer solstice and winter solstice locations of the Sun (i.e., the extreme positions). On these sketches also list the specific **Celestial Latitudes** at the zenith for each of these locations.

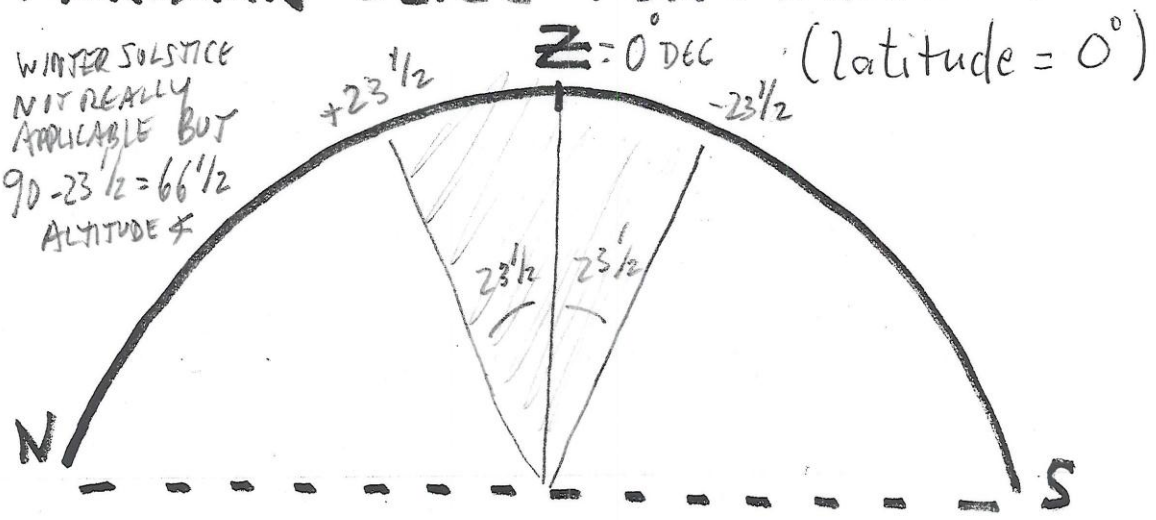
b). From these sketches compute the **altitude** of the Sun at **mid-Winter (Winter Solstice)** at each location. The Winter Solstice celebration at Cusco, Peru is called *Inti Raymi*, the Festival of the Sun (note well, be careful which calendar date you ascribe to *Inti Raymi* since Cusco is in the southern hemisphere). In Europe during the Roman Empire the Winter Solstice ceremony was called *Dies Natalis Solis Invicti* (the night of the Unconquerable Sun) and was celebrated on December 25th (a familiar date?).

MERIDIAN SLICE FOR: STONEHENGE (latitude = 51°N)

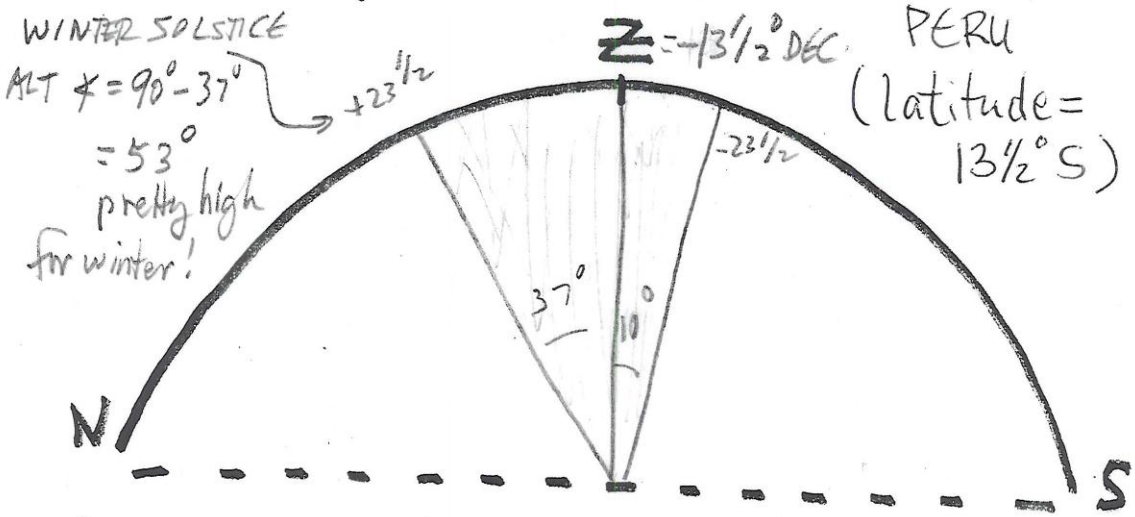



ALT. ✗ AT MIDWINTER $= 90° - 74\frac{1}{2}° = 15\frac{1}{2}°$ ! AND THIS IS AS HIGH AS IT GETS THERE!

## MERIDIAN SLICE FOR: EQUATOR




## MERIDIAN SLICE FOR: CUSCO, PERU




WINTER SOLSTICE IN SOUTHERN HEMISPHERE OCCURS ON JUNE 21.