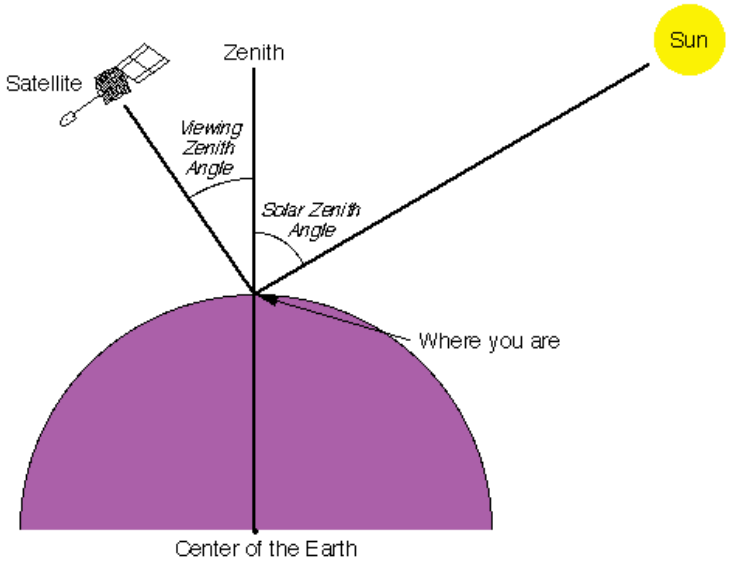
Shadows and Solar Zenith

Name_____

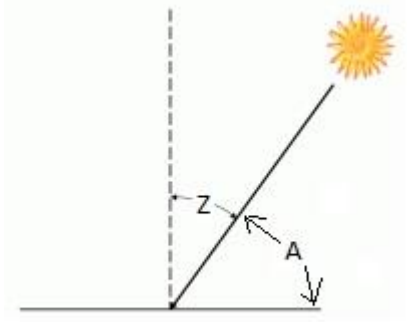
Lab Partner_____

Section_____

Introduction: The solar zenith angle is defined to be the angle between the sun and a line that goes straight up (to the zenith)

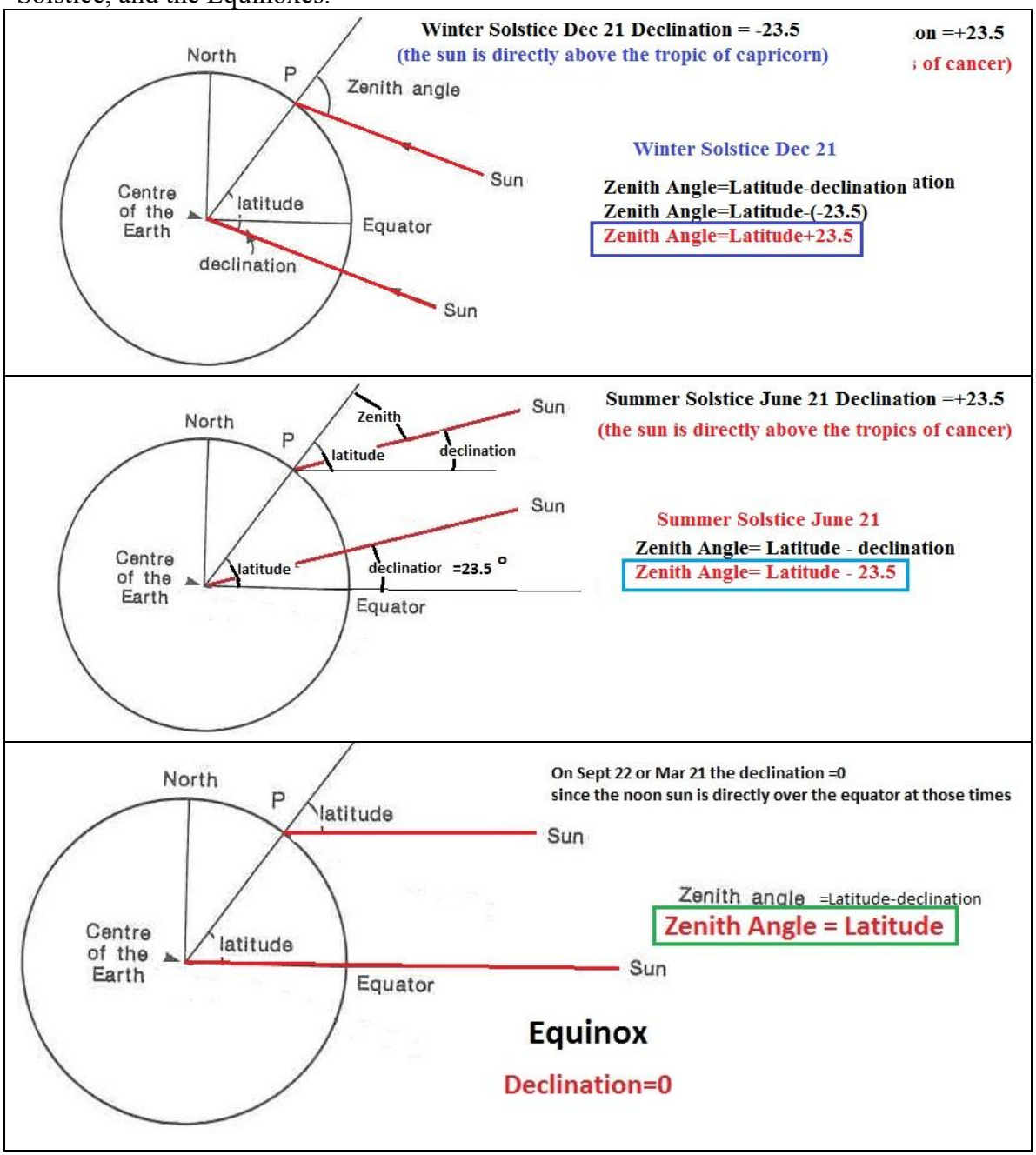


In reality the sun is very far from Earth and relative to this distance the Earth is very small. In the drawing (below right) The Earth is drawn much larger than it should be if the vertical scale matched the horizontal scale. The main point is that all rays that leave the sun and hit the Earth travel essentially parallel to each other as they reach Earth.



In the figure at left Z is the zenith angle and A is the altitude (A=90-z); the angle from the horizon to the sun.

Below are 3 figures showing the position of the sun for Winter Solstice, Summer Solstice, and the Equinoxes.



In Summary, to calculate the solar Zenith Angle at noon for your latitude:
1. determine your latitude
2. determine the latitude for which the sun is directly overhead at noon (the declination).
3. subtract the declination from your latitude.

For example:

The noon zenith angle at the tropic of cancer on June 21 is zero since the sun is directly overhead 23.5 N on June 21.
***The noon zenith angle at the North pole (90 N) on June 21 is 66.5 since the sun is directly overhead 23.5 N on June 21. I.e. 90-23.5 = 66.5
The noon zenith angle at in Anchorage (60 N) on Dec 21 is 83.5 since the sun is directly overhead -23.5 (23.5 S) on Dec 21. i.e. 60- (-23.5) = 83.5. The **altitude** of the sun above the horizon is **90 - zenith angle**. For Anchorage on Dec. 21 the sun is 6.5 degrees above the horizon at noon.

Questions to test your understanding.

When the sun is directly over your head the solar zenith angle is _____ and the solar Altitude is _____.

At sunrise or sunset the solar zenith angle is _____ and the solar Altitude is _____.
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What is the noon zenith angle in Orlando Florida (latitude 28.5^{o}) on Sept 21? _____

What is the noon zenith angle in Anchorage (60 N) on June 21? (show your calculations)

Part 1. Calculate noon solar zenith angle and the solar altitude at noon for Vancouver, WA (45.6 N) on:

Dec. 21 noon zenith angle =_____ ; Solar Altitude=_____

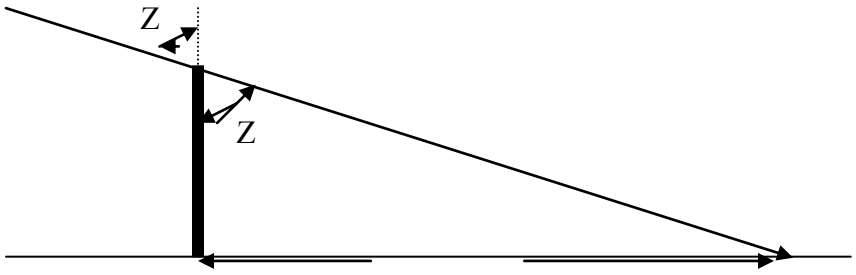
June 21 noon zenith angle =_____; Solar Altitude=_____

March 21 or Sept 21. noon zenith angle =_____; Solar Altitude=_____

Using a protractor, a ruler, and a separate sheet of paper (see next) estimate noon solar zenith angle and the length of your shadow at noon for Vancouver, WA (45.6 N) on:

What is your actual height? =_____

See **video on shadow length**. To calculate your shadow length, make a careful drawing like the one below. The heavy thick vertical line is drawn to scale to represent your height and a ray from the sun coming in at an angle Z from the vertical grazes your head and hits the ground at the end of your shadow. Using a scale of 1.0 cm =1.0 ft makes all measurements and conversion from your drawing very easy, or easier yet use the gridlines on the next page with 1 square equal 1 ft. For example if you are 6 ft tall draw the vertical line 6 cm (or 6 squares). Feel free to use the grid markings on the grid sheet provided as a scale. You also may want to use the grid space in landscape orientation to give you plenty of room for the long shadows of winter.



After drawing your careful sketches using the gridlines provided on the next page obtain your estimated shadow length for noon at the time of year specified below.

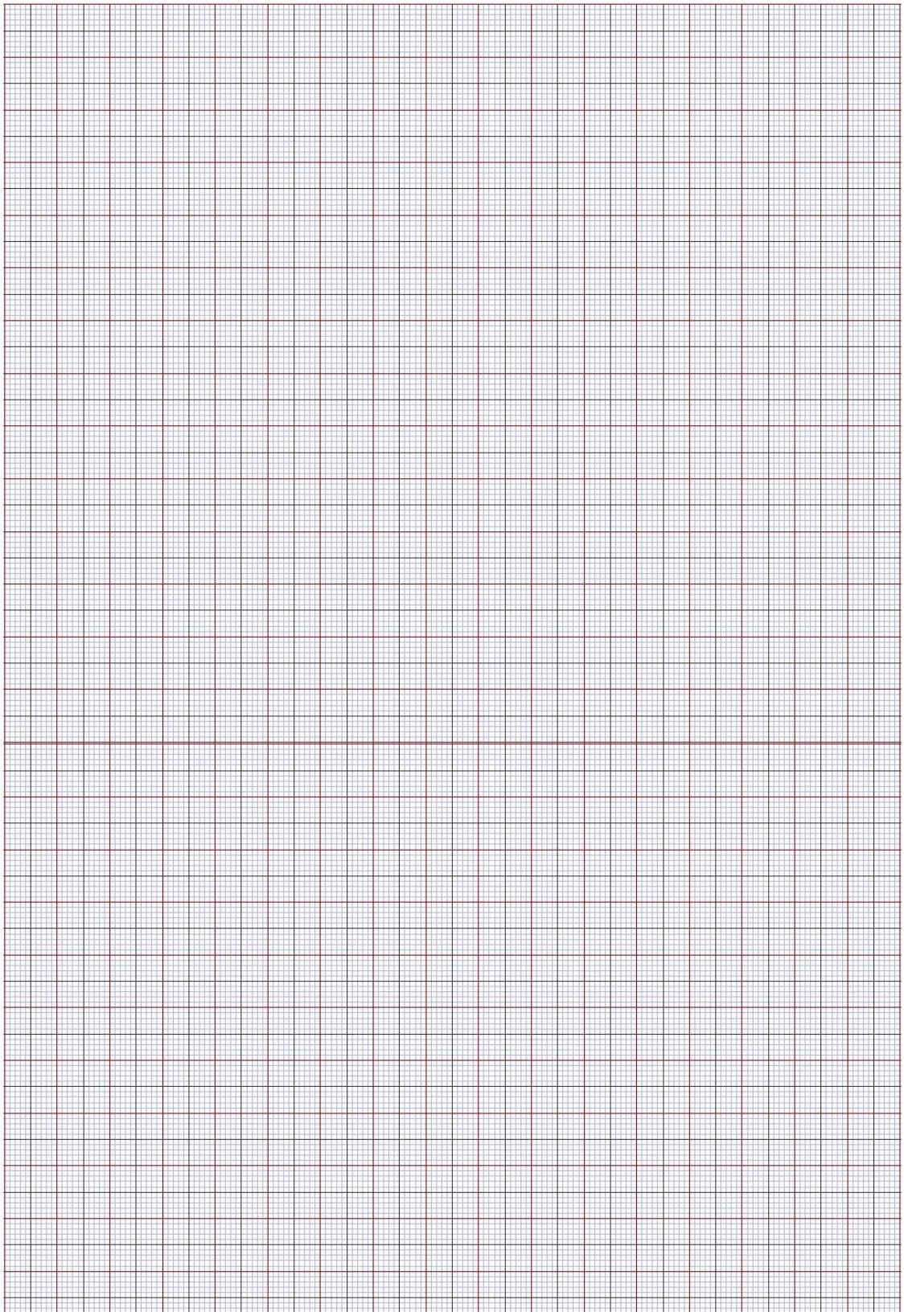
ANSWERS:

Dec. 21 shadow length =_____

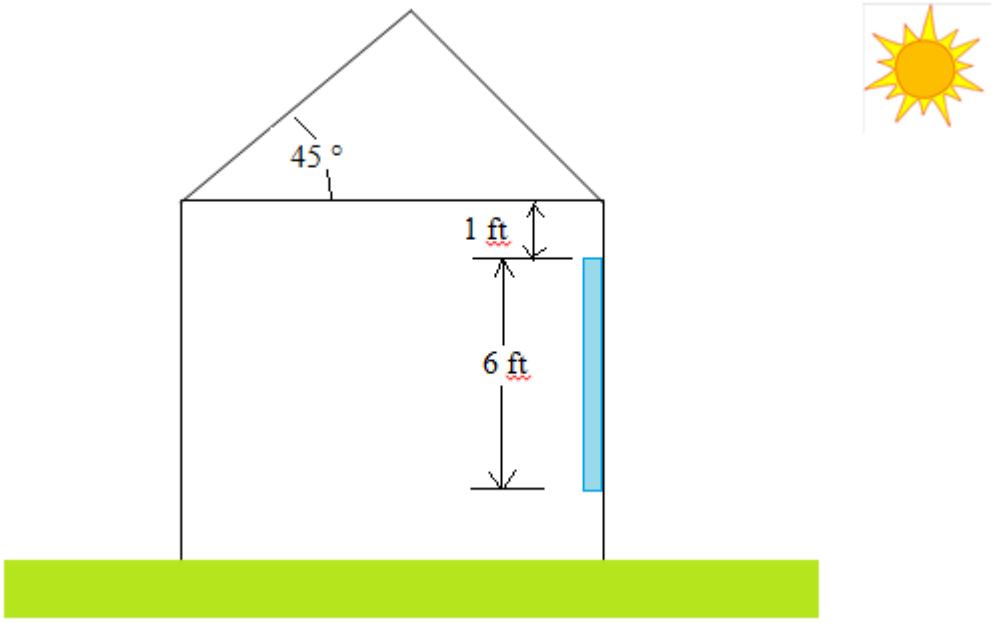
June 21 shadow length =_____

March 21 or Sept 21. shadow length =_____

Use a drawing to answer the following question: The length of the shadow cast by the chime tower at noon on the first day of Fall term is 200 ft. From this information estimate the height of the chime tower. There should be room to do this on the same set of gridlines.



Part 2. Home design for energy efficiency. (see video)



The House above has a roof angle of 45°. It has a southward facing window that is 6 ft tall and 1 ft from the roof top. Assume your design is for Vancouver, WA.

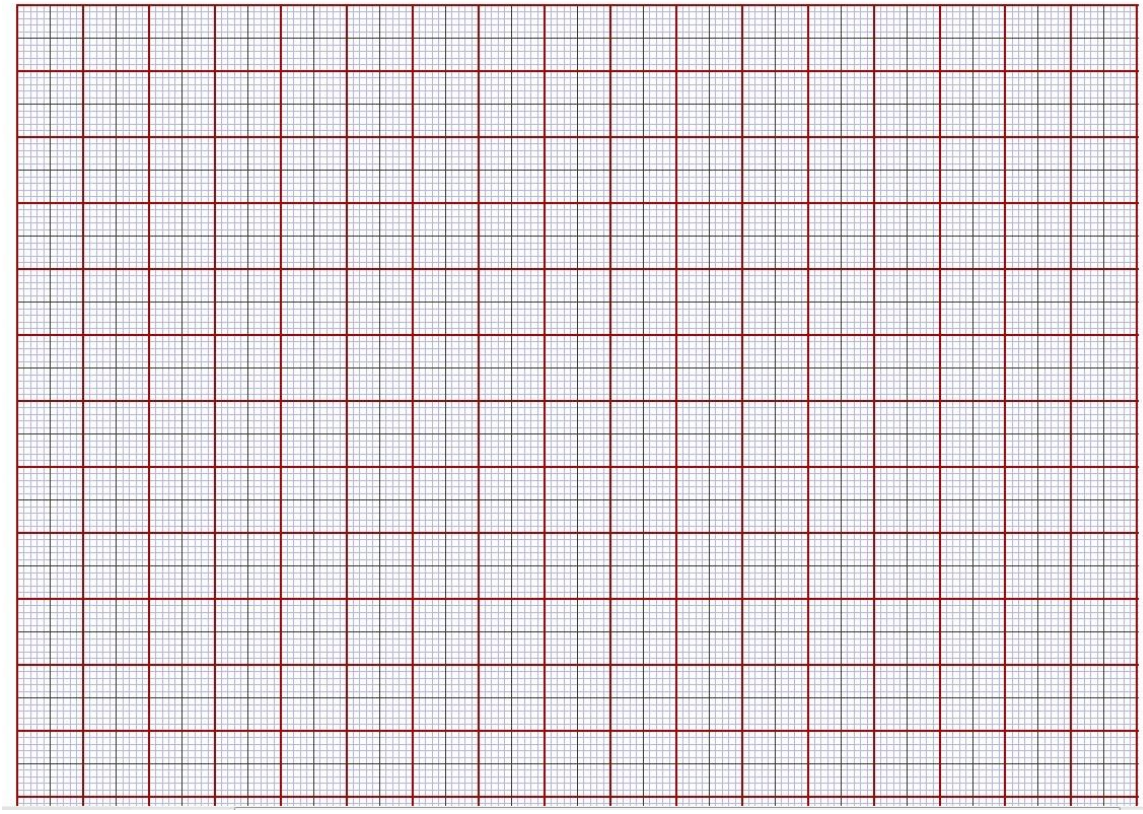
Using the grid space on the next page draw a careful scale drawing of this home (The drawing above is just a sketch and cannot be used for good results.)

4. How long does an eve (overhang) have to be to just block out all sunlight from getting into the window at noon on June 21? Hint: A ray of sunlight that just hits the bottom of the window will not get into the window. So carefully draw this specifc ray and then draw your eve to block out all other rays above that key ray.

Length of eve (overhang) = _____ ft

5. With this overhang how high up the window does the sunlight get at noon on Dec. 21? Your eve has been established. Draw a ray of sunlight coming from the direction of the winter zenith that also just touches the tip of your eve. Al rays of sunlight below this special ray will go into the window and warm the house.

Height up the window at noon on Dec 21=_____



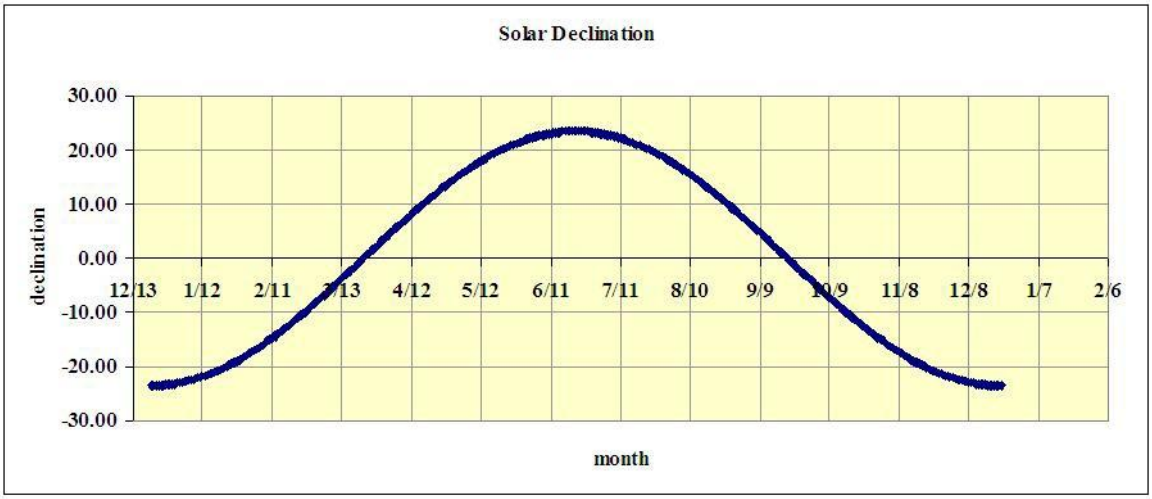
It's easiest if you draw your house on the right side of the grid lines so you have plenty of room to draw in your solar rays. Also, you really only need to draw the front of the house (window side) and the 45^0 roof line to answer the questions.

Part 3.

The photo below of a beer setting on a flat rock was taken on August 26, 2006.

What time of day is it?
a. early morning
b. late morning
c. noon
d. early afternoon
e. late afternoon.
f. not enough information

The graph below shows the solar declination for different times of year. Remember that the declination is the latitude for which the sun is directly overhead at that specific time of year.



Using this information, at what latitude was the beer photo taken?
Latitude=_____

Other questions

The sun is directly overhead at Bangkok Thailand (latitude 14^{o}N):
a.once a year
b.twice a year
c.four times a year
d.never

On what day would you expect the sun to be overhead at Bangkok Thailand (latitude 14^{o}N):?
a.September 15
b.December 22
c.February 4
d.March 10
e.April 27

On what day would you expect the sun to be overhead at Miami Florida (latitude 26^{o}N):?
a.September 15
b.December 22
c.February 4
d.March 10
e.April 27
f. never