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The Angle of Solar Radiation and the Heating of the Earth

Introduction:

The source of almost all of the Earth's energy is the sun. The sun gives off its heat energy in the form of radiant energy, which travels through space in the form of rays, or radiation.

When the radiant energy strikes on object part of the radiant energy is absorbed by the object. As a result, the radiant energy makes the molecules in an object move faster. And when the molecules in the object move faster the object becomes hotter. In this way, the energy produced by the sun warms the Earth.

Purpose: In this investigation you will study how the angle of sunlight affects the heating of the Earth's surface

Part 1

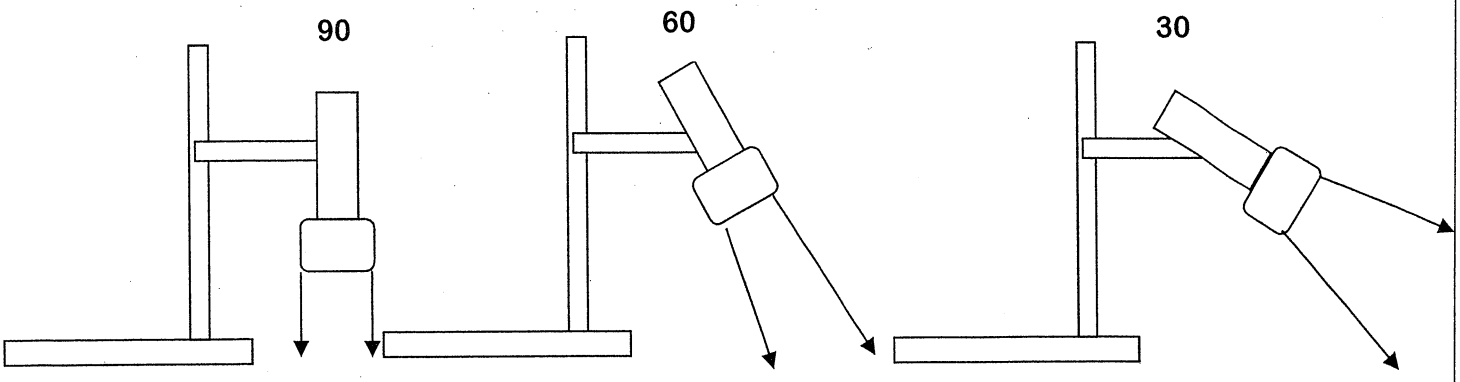
The angle at which solar radiation (the sun's rays) strikes the surface of the Earth is an important factor in the amount of heat any part of the surface receives.

Materials: Ring stand, clamp, flashlight, ruler, and protractor.

1. The graph paper (provided by the teacher) represents the surface of the Earth, and the flashlight represents sunlight. Clamp the flashlight so the flashlight is shining 15 centimeters from the paper at a ninety (90) degrees perpendicular to the graph paper.
   Note that the light from the flashlight covers a certain "area" on the paper. With a pencil; trace the circumference of this area that is covered by the light. Trace the brightest circle of light that you see.

2. Count the number of squares units covered. It will be necessary to estimate by combining partial squares to equal one whole square unit. Record this in the data table on the next page.

3. Repeat the procedure 1 and 2 aiming the flashlight at an angle of 60 degrees, and then at an angle of 30 degrees. Use protractors to calculate and set the flashlight to the correct angle.



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4. Determine the intensity of energy per square unit of area for each of the three different angles of light
   To do this it will be necessary to give the light energy a numerical value
   Let the light energy equal 1000 Joules per second
   Use the following formula

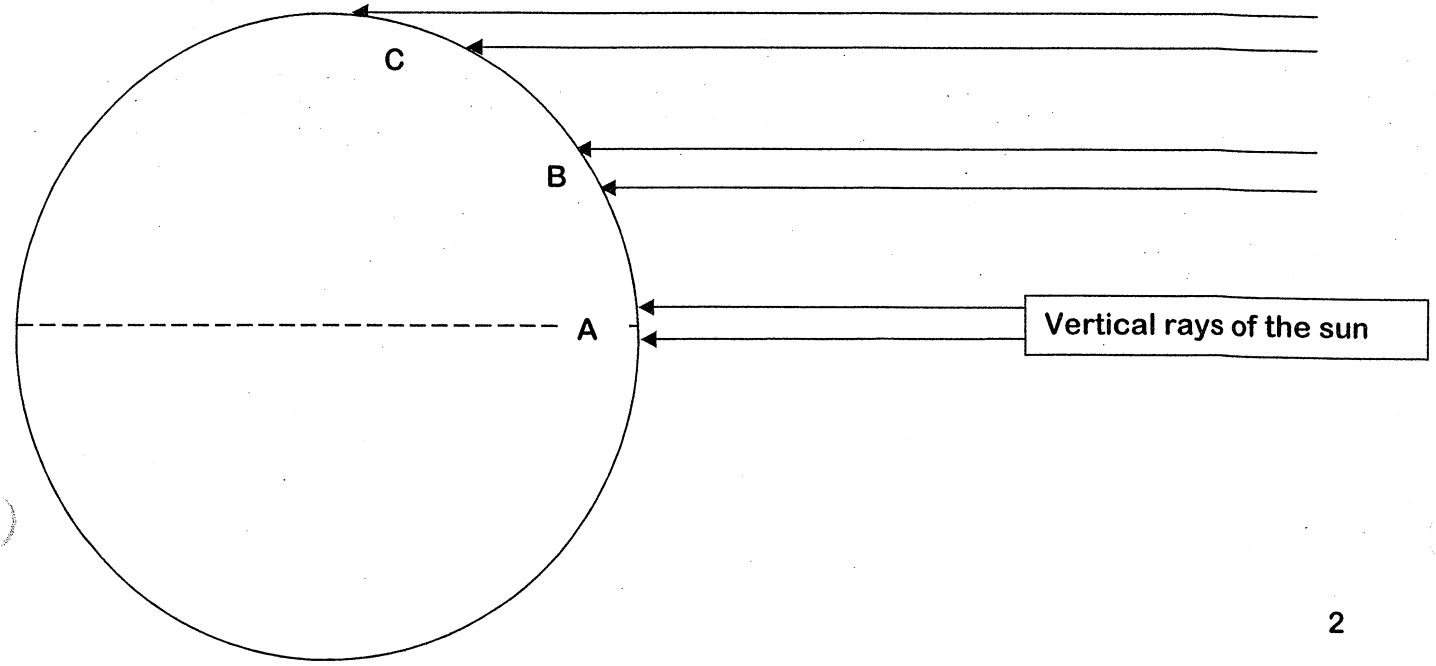
   1000 Joules per second / Number of squares = Intensity of Sunlight
   Or
   Amount of Energy per Second / Number of square = units Intensity of Sunlight

Angle of Light	Surface area covered by the light (the number of squares	Intensity of Energy Joules per second/squared

Part 2

1. The spherical shape of the Earth is one of the factors that determine the angle at which sunlight strikes the surface of the Earth. The sun is so distant from the Earth that the rays of sunlight reaching the Earth are practically parallel to one another. If the Earth was flat and perpendicular to the suns rays all areas facing the sun would receive the same intensity (strength) of sunlight. But since the Earth is spherical, its surface is curved, and therefore there is only one place on earth where the rays of the sun can be perpendicular at any given time. At all other locations the angle of the sunlight will be less than 90 degrees.

The diagram below shows three equal beams of radiant energy from the sun striking the Earth. The rays of the sun that strike the Earth at an angle of 90 are called vertical or direct rays. In the diagram below, the vertical or direct rays of the sun are striking the Earth at the equator; this occurs only twice a year, on the vernal equinox (March 21) and the autumnal equinox (September 21)



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Definition:
Insolation: "Incoming solar Radiation" the portion of the suns radiation that is received by the Earth.

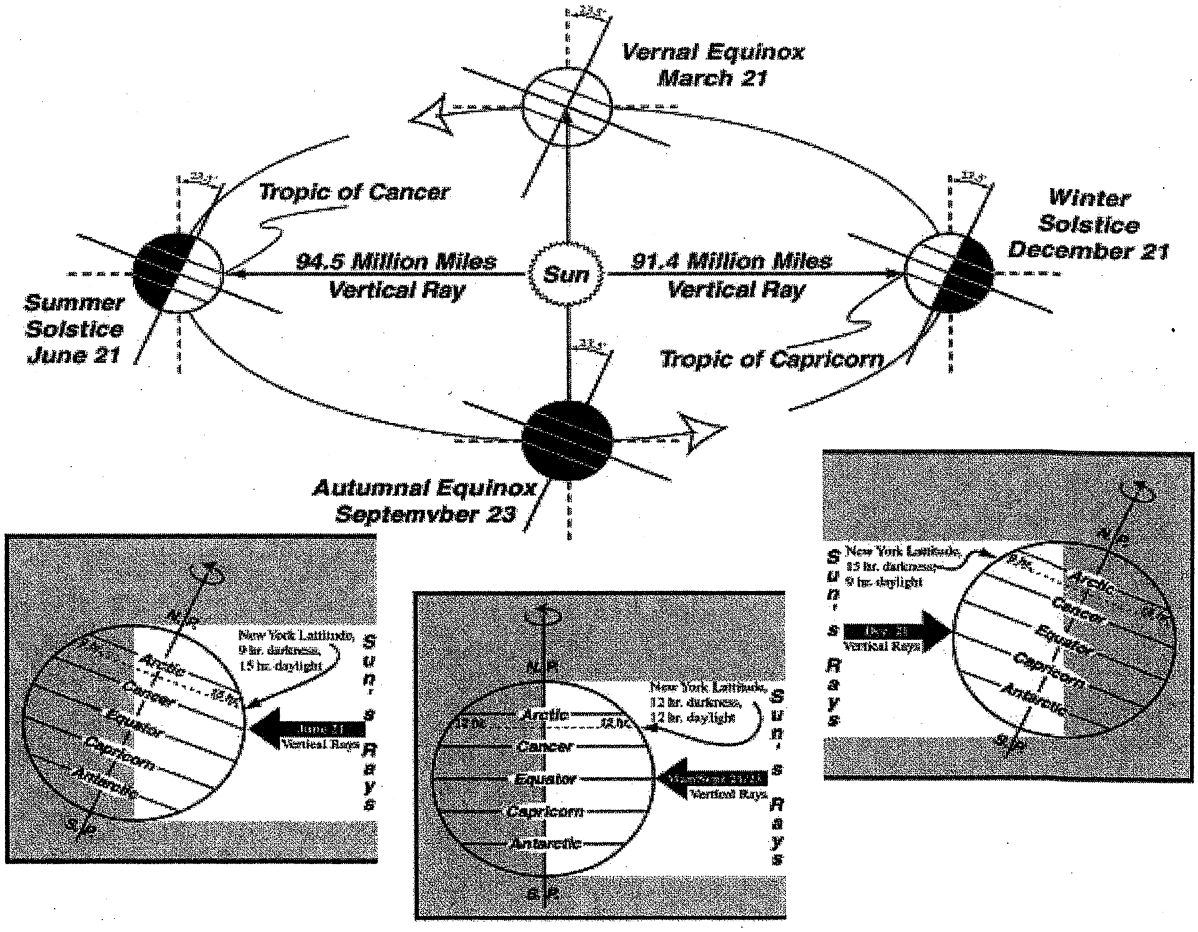
Use the diagram on page 2 to answer the following questions

1. Which beam of sunlight (A,B, or C) would have the greatest intensity per unit area, thus heating the earth's surface more.
   This is because:
   1. The insolation is less direct and the energy is less concentrated
   2. The insolation is less direct and the energy is more concentrated
   3. The insolation is more direct and the energy is less concentrated
   4. The insolation more direct and the energy is more concentrated

2. Which beam of sunlight (A, B, or C) would have the least intensity per unit area and thus heating the earth's surface least?
   This is because:
   1. The insolation is less direct and the energy is less concentrated
   2. The insolation is less direct and the energy is more concentrated
   3. The insolation is more direct and the energy is less concentrated
   4. The insolation more direct and the energy is more concentrated

2. Latitude and 3. Season of the year are two other factors that determine the angle of the insolation.

From the previous section you learned that the angle of sunlight insolation varies with latitude because of the shape of the earth. The only parts of the earth ever to receive vertical or direct rays of the sun are those latitudes between 23.5 N and 23.5 S depending on the time of year. As Earth travels around the sun in the course of a year, the angle of insolation at given latitude varies with the seasons. At any given time the intensity strength of insolation is maximum at the latitude of the vertical rays and is less at other latitudes



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Base your answers to the questions below on the diagram on page 3

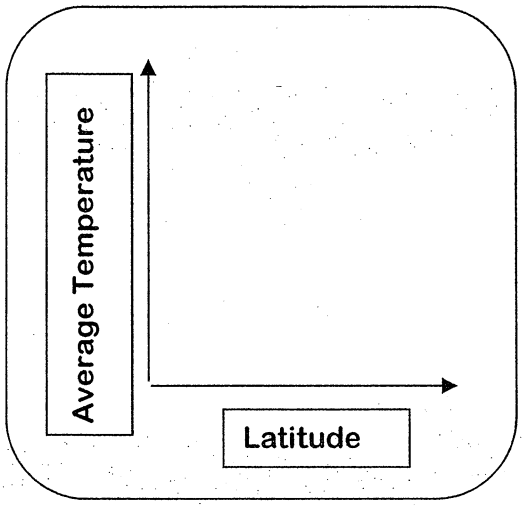
1. Explain why the average temperature decreases from the equator to the poles? _____

_____

2. Write the relationship between average temperature and latitude

_____

3. Complete the graph below



Complete the data table below:

Name of the Season	Date	Location of the Sun's Vertical Rays (maximum intensity)

Name _____ Block _____ Date _____

4. Time of day is yet another factor that determines the angle at which insolation strikes the surface of the earth.

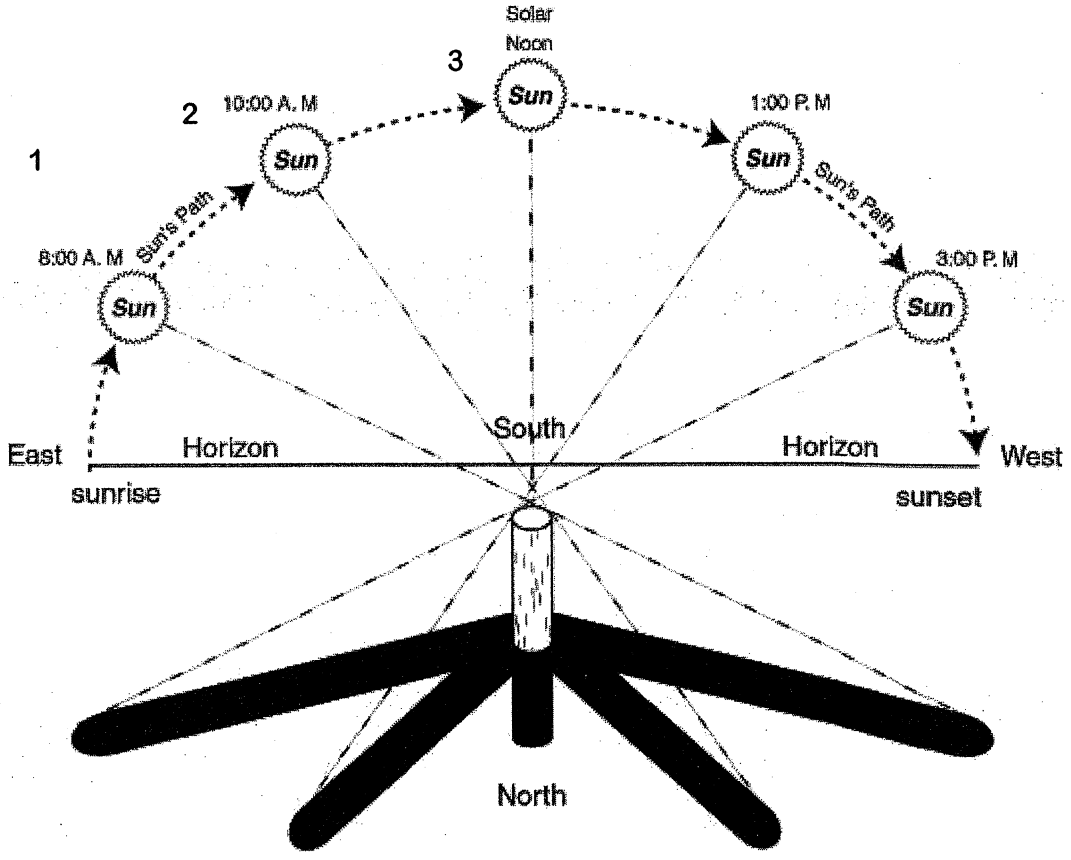
Both the angle and the intensity of insolation change constantly during the course of a day. In the morning when the sun is low in the sky, they insolation arrives at a very low angle. As the day progresses, the sun raise higher and higher in the sky it's the angle with the ground increases and insolation becomes more and more intense.

At noon the sun is at its highest point in the sky and intensity of the insolation is greatest. During the afternoon, the angle of insolation becomes smaller and smaller and the intensity of insolation decreases accordingly.

The diagram below illustrates the changes in the angle of insolation in the course of one day.

The shadow of a vertical post indicates how the angle of insolation varies during a day

Base your answers to the questions below on the diagram to the side



1. A. At which position in the diagram (1, 2, or 3) is the angle of insolation greatest?

   b. What time of day does this occur?_____

2. At which time of day would the shadow of a post be Longest? _____

   Shortest? _____

3. In what direction does the noon time shadow always point? _____

4. As the angle of insolation increases the length of a shadow will? _____

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Lab review questions

1. What is the primary factor about insolation that determines its intensity and thus its ability to heat the earth's surface?

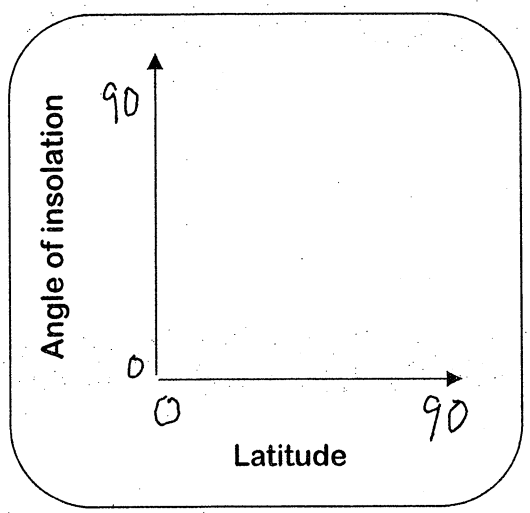
   _____

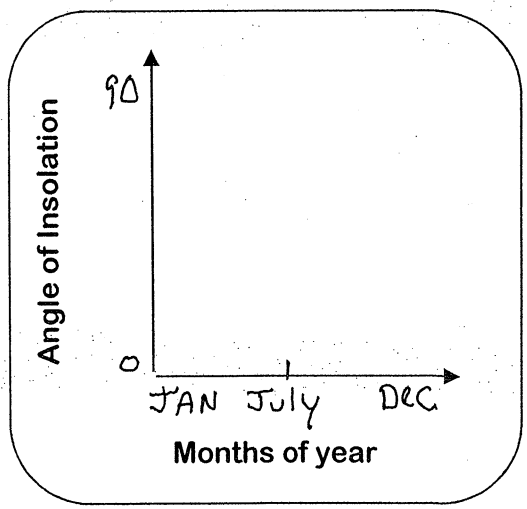
2. What four (4) factors determine the "angle of insolation?"

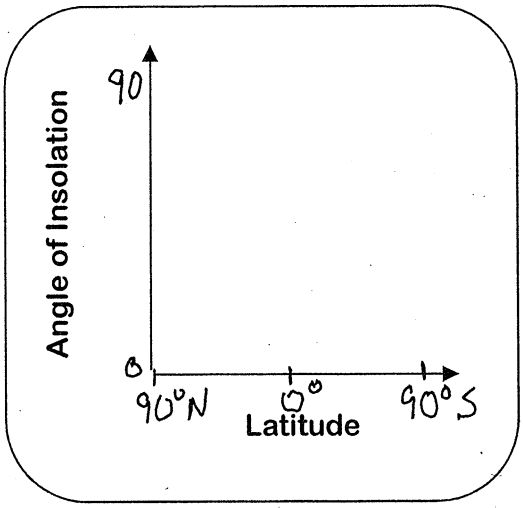
1. _____ 3. _____

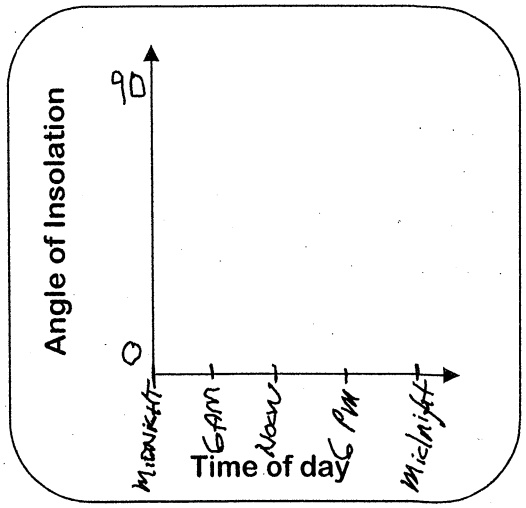
2. _____ 4. _____

Complete the graphs below









Please complete the following multiple choice answers put answers in the answers in answer column

A N S W E R S

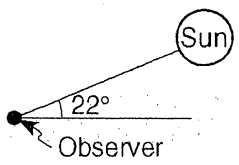
1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
9. ____
10. ____

Name: _____

1) The average temperature at Earth's equator is *higher* than the average temperature at Earth's South Pole because the South Pole
   1) has less land area
   2) receives less intense insolation
   3) has more cloud cover
   4) receives more infrared radiation

2) In New York State, summer is warmer than winter because in summer New York State has
   1) more hours of daylight and receives low-angle insolation
   2) fewer hours of daylight and receives low-angle insolation
   3) fewer hours of daylight and receives high-angle insolation
   4) more hours of daylight and receives high-angle insolation

3) In which diagram is the observer experiencing the *greatest* intensity of insolation?

1)


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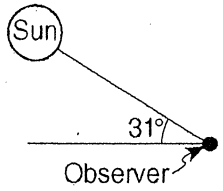

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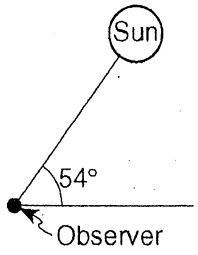

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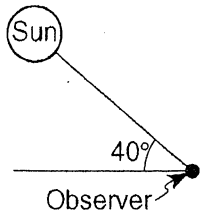
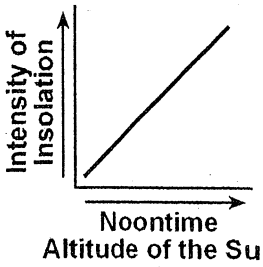
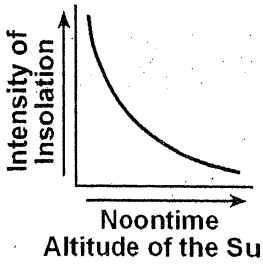


4) Which graph *best* shows the general relationship betwe the altitude of the noontime Sun and the intensity of insolation received at a location?

1)


2)


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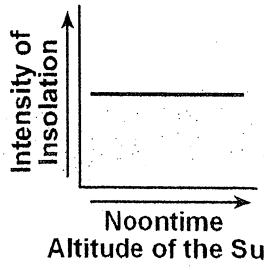

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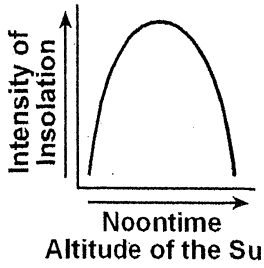
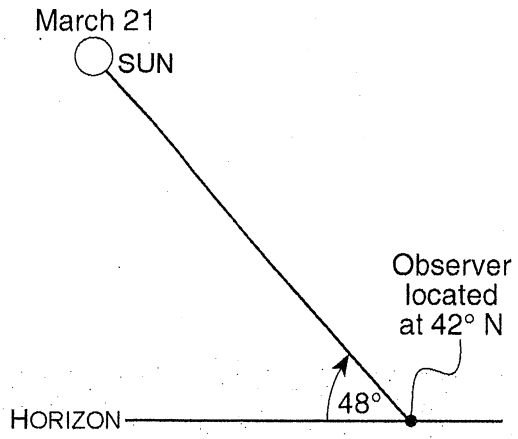


5) The diagram below shows the altitude of the Sun at solar noon on March 21, as seen by an observer at 42D N latitude.

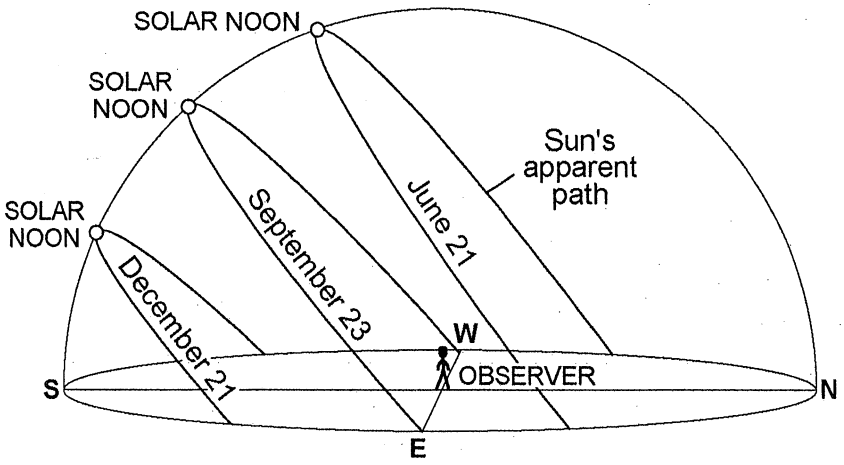


Compared to the altitude of the Sun observed at solar noon on March 21, the altitude of the Sun observed at solar noon on June 21 will be

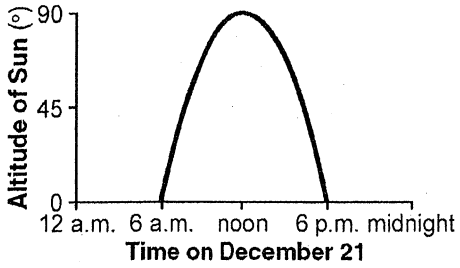
1) 48D higher in the sky
2) 42D higher in the sky
3) 23.5D higher in the sky
4) 15D higher in the sky

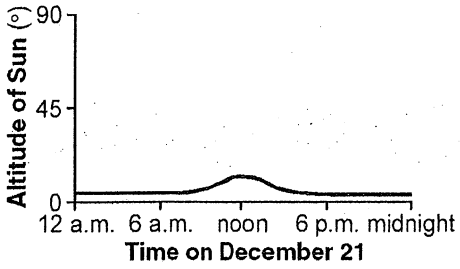
Questions 6 and 7 refer to the following:

The diagram below represents the Sun's apparent paths and the solar noon positions for an observer at 42D N latitude on December 21, September 23, and June 21.



6) Which graph *best* shows the altitude of the Sun, as measured by the observer located at 42D N, at various times on December 21?

1)


2)


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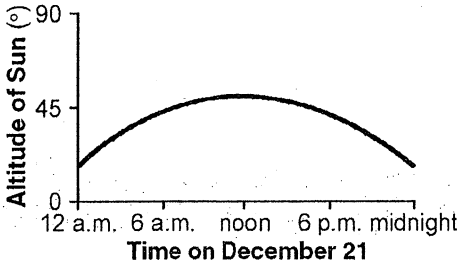

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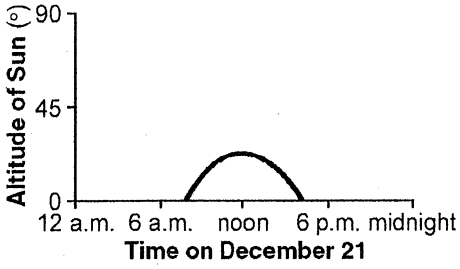


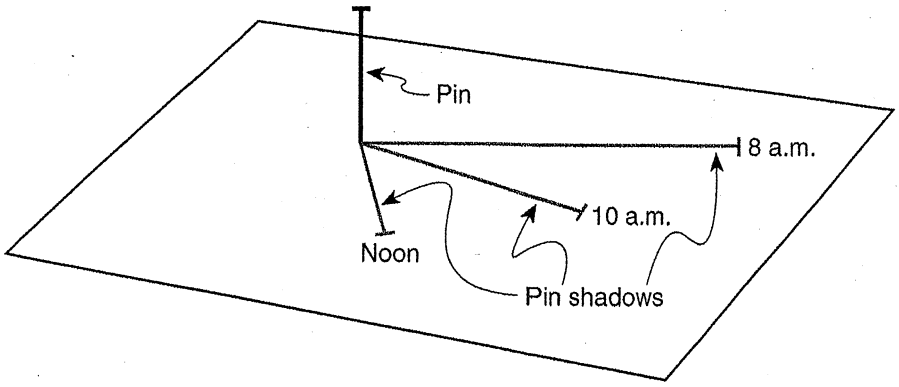
7) How many hours occurred between sunrise and solar noon on September 23 in the given diagram?

1) 12 2) 6 3) 8 4) 24

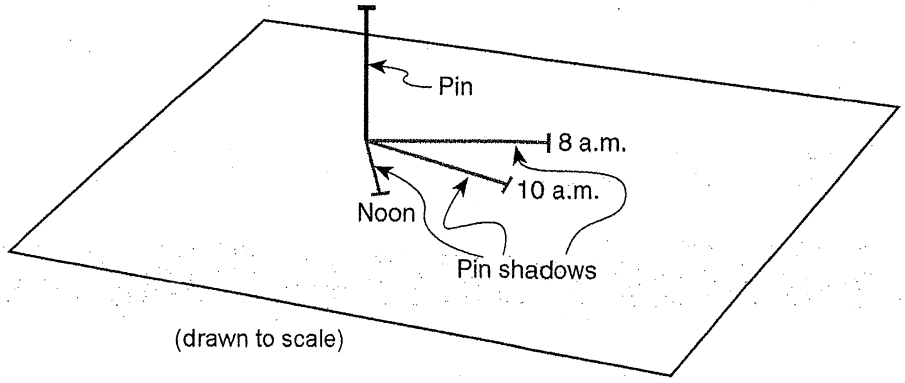
8) Which of the following statements *best* describes the position of the Sun at sunrise and sunset as seen by an observer in New York State on June 21?

1) The Sun rises north of due east and sets south of due west.
2) The Sun rises south of due east and sets north of due west.
3) The Sun rises north of due east and sets north of due west.
4) The Sun rises south of due east and sets south of due west.

9) The diagram below shows a pin perpendicular to a card. The card was placed outdoors in the sunlight on a horizontal surface. The positions of the pin's shadow on the card were recorded several times on March 21 by an observer in New York State.



On June 21, the card and pin were placed in the same position as they were on March 21 in the original diagram. The diagram below shows the positions of the pin's shadow.



Which statement *best* explains the decreased length of each shadow on June 21?

1) The Sun's apparent path varies with the seasons.
2) The intensity of insolation is lower on June 21.
3) The duration of insolation is shorter on June 21.
4) The Sun's distance from Earth varies with the seasons.

10) At which of the following latitudes is the Sun directly overhead on certain days of the year?

1) 23.5DN
2) 90DN
3) 42DN
4) 66.5DN