Base your answers to questions 52 through 54 on the diagram below, which shows the altitude of the Sun at solar noon on certain dates. The positions of the Sun, labeled A, B, and C, were measured by an observer at 42° north latitude. The date when the Sun was observed at position A has been deliberately left blank.

![Diagram showing the positions of the Sun at different times of the year.]

52 Which season begins in New York State when the noontime Sun is observed at position A?  

winter.

53 Position B represents the Sun’s position at solar noon on March 21. On what other date of the year would the noontime Sun be observed at position B?

- September 21
- September 22
- September 23
- September 24
- autumnal equinox
- first day of fall

54 What is the total change in altitude that occurs as the noontime Sun appears to move from position A to position C?

47 degrees.
The diagram below shows a classroom demonstration. Two identical flashlights were placed in the positions shown and they illuminated areas of varying size, A and B, on a classroom globe. Thermometers were then placed at the center of each illuminated area to measure the rate of temperature increase. Readings were taken over a period of 30 minutes.

Students most likely observed that the temperature of area A increased at a

1. slower rate than the temperature of area B because area A received rays that were less concentrated
2. slower rate than the temperature of area B because area A received rays that were more slanted
3. faster rate than the temperature of area B because area A received rays that were more perpendicular to the surface
4. faster rate than the temperature of area B because area A received rays with less total energy
The diagram below represents Earth at four different positions, A, B, C, and D, in its orbit around the Sun.

(Not drawn to scale)

Between which positions would New York State be experiencing the summer season?

(1) A and B  (3) C and D
(2) B and C  (4) D and A
The table below shows the duration of insolation (hours of daylight) measured by four observers, W, X, Y, and Z, at four different Earth latitudes on both March 21 and June 21. There were clear skies at all four latitudes on both days.

<table>
<thead>
<tr>
<th>Observer</th>
<th>Duration of Insolation March 21</th>
<th>Duration of Insolation June 21</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>12 hr</td>
<td>0 hr</td>
</tr>
<tr>
<td>X</td>
<td>12 hr</td>
<td>12 hr</td>
</tr>
<tr>
<td>Y</td>
<td>12 hr</td>
<td>18 hr</td>
</tr>
<tr>
<td>Z</td>
<td>12 hr</td>
<td>24 hr</td>
</tr>
</tbody>
</table>

Which observer was located at the Equator?

(1) W
(2) X
(3) Y
(4) Z
The diagram below represents Earth at a specific position in its orbit as viewed from space. The shaded area represents nighttime.

Which Earth latitude receives the greatest intensity of insolation when Earth is at the position shown in the diagram?

(1) 0°  
(2) 23 1/2° N  
(3) 66 1/2° N  
(4) 90° N
Base your answers to questions 36 through 38 on the diagram below, which represents the position of the Sun with respect to Earth’s surface at solar noon on certain dates. The latitudes of six locations on the same line of longitude are shown. The observer is located at 42° N in New York State. The date for the Sun at position A has been deliberately left blank.

36 At which New York State location could the observer be located?
(1) Plattsburgh  (3) New York City
(2) Mount Marcy  (4) Slide Mountain

37 When the Sun is at position A, which latitude receives the most direct rays of the Sun?
(1) Tropic of Cancer (23.5° N)
(2) Tropic of Capricorn (23.5° S)
(3) Equator (0°)
(4) Antarctic Circle (66.5° S)

38 When the Sun is at the March 21 position, New York State will usually have
(1) longer days than nights
(2) 12 hours of daylight and 12 hours of darkness
(3) the lowest annual altitude of the Sun at solar noon
(4) the highest annual altitude of the Sun at solar noon
Which diagram best represents the angle of the Sun’s rays received at location C at noon on this day?

What is the latitude of location A?

90° N

On this day, which location has the greatest number of hours of daylight?

E
Astronomers have discovered strong evidence for the existence of three large extrasolar (outside our solar system) planets that orbit *Upsilon Andromedae*, a star located 44 light years from Earth. The three planets are called planet *B*, planet *C*, and planet *D*. Some of the information gathered about these three new planets is shown in the table below. The period of revolution for planet *C* has been deliberately left blank.

**Characteristics of Planets B, C, and D Orbiting Star *Upsilon Andromedae***

<table>
<thead>
<tr>
<th>Planet</th>
<th>Mass</th>
<th>Distance from <em>Upsilon Andromedae</em></th>
<th>Period of Revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>B</em></td>
<td>$\frac{3}{4}$ of the mass of Jupiter</td>
<td>0.06 AU</td>
<td>4.6 Earth days</td>
</tr>
<tr>
<td><em>C</em></td>
<td>2 times the mass of Jupiter</td>
<td>0.83 AU</td>
<td></td>
</tr>
<tr>
<td><em>D</em></td>
<td>4 times the mass of Jupiter</td>
<td>2.50 AU</td>
<td>3.5 to 4.0 Earth years</td>
</tr>
</tbody>
</table>

[1 AU = average distance of Earth from the Sun]

The diagram below compares a part of our solar system to the *Upsilon Andromedae* planetary system. Planet distances from their respective star and the relative size of each planet are drawn to scale. [The scale for planet distances is not the same scale used for planet size.]

![Diagram showing planet distances and relative sizes](image)

Planet *D*’s diameter is 10 times greater than Earth’s diameter. What planet in our solar system has a diameter closest in size to the diameter of planet *D*?

**Saturn.**

As planet *B* travels in its orbit, describe the change in orbital velocity of planet *B* as the distance between *Upsilon Andromedae* and planet *B* decreases.

As the distance between them decreases, the orbital velocity increases.

It speeds up.

Increases

If our solar system had a planet located at the same distance from the Sun as planet *C* is from *Upsilon Andromedae*, what would be its approximate period of revolution?

Allow 1 credit for any answer from 224.7 days to less than 365.26 days.
The table below shows the altitude and compass direction of one planet, as viewed by an observer in New York State at 10 p.m. on the first day of each month from April through November.

<table>
<thead>
<tr>
<th>Month</th>
<th>Altitude</th>
<th>Compass Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>20°</td>
<td>SW</td>
</tr>
<tr>
<td>May</td>
<td>23°</td>
<td>SSW</td>
</tr>
<tr>
<td>June</td>
<td>25°</td>
<td>S</td>
</tr>
<tr>
<td>July</td>
<td>29°</td>
<td>SSE</td>
</tr>
<tr>
<td>August</td>
<td>33°</td>
<td>SE</td>
</tr>
<tr>
<td>September</td>
<td>38°</td>
<td>S</td>
</tr>
<tr>
<td>October</td>
<td>42°</td>
<td>SW</td>
</tr>
<tr>
<td>November</td>
<td>45°</td>
<td>S</td>
</tr>
</tbody>
</table>

Which graph best represents a plot of this planet’s apparent path, as viewed by the observer over the 7-month period?
The diagram below represents two planets in our solar system drawn to scale, Jupiter and planet A.

Planet A most likely represents

(1) Earth  (2) Venus  (3) Saturn  (4) Uranus
Calculate the eccentricity of the ellipse to the nearest thousandth.

0.333 (±0.026)

State how the eccentricity of the given ellipse compares to the eccentricity of the orbit of Mars.

The given ellipse has a higher eccentricity than the orbit of Mars. The orbit of Mars is more circular than the given ellipse.
Base your answers to questions 36 through 38 on the diagram below, which represents the elliptical orbit of a planet traveling around a star. Points A, B, C, and D are four positions of this planet in its orbit.

36 The calculated eccentricity of this orbit is approximately
(1) 0.1     (3) 0.3
(2) 0.2     (4) 0.4

37 The gravitational attraction between the star and the planet will be greatest at position
(1) A     (3) C
(2) B     (4) D

38 As the planet revolves in orbit from position A to position D, the orbital velocity will
(1) continually decrease
(2) continually increase
(3) decrease, then increase
(4) increase, then decrease
Which graph best represents the force of gravity between Earth and the Sun during one revolution of Earth around the Sun?

- **Month (1)**
- **Month (2)**
- **Month (3)**
- **Month (4)**
the diagram below shows the orbit of planet $D$ around the star *Upsilon Andromeda*. The dashed lines show where the paths of the first four planets of our solar system would be located if they were going around *Upsilon Andromeda* instead of the Sun. All distances are drawn to scale.

Describe the eccentricity of planet $D$’s orbit relative to the eccentricities of the orbits of the planets shown in our solar system.

Planet $D$ has a much more eccentric orbit than any of the first four planets of our solar system.

The first four planets of our solar system have less eccentric orbits than planet $D$.

Describe the changes in gravitational force between planet $D$ and the star *Upsilon Andromeda* during one complete orbit around the star. Be sure to describe where the force is greatest and where the force is least.

The gravitational pull is greatest when planet $D$ is closest to the star and the pull is least when planet $D$ is farthest from the star.
The diagram below shows the Moon orbiting Earth as viewed from space above the North Pole. The Moon is shown at eight different positions in its orbit.

At which two positions of the Moon is an eclipse of the Sun or Moon possible?

(1) 1 and 5
(2) 2 and 6
(3) 3 and 7
(4) 4 and 8
The diagram below shows the positions of the Moon and the Sun at sunset during an evening in New York State. Points A, B, C, and D represent positions along the western horizon.

At sunset on the following evening, the Moon will be located at position

(1) A  (2) B  (3) C  (4) D
The diagram below shows the Moon at four positions in its orbit around Earth as viewed from above the North Pole.

(Not drawn to scale)

Beginning with the Moon at position X (the new-Moon phase), which sequence of Moon phases would be seen by an observer on Earth during 1 month?

(1) [Diagram of sequence 1]

(2) [Diagram of sequence 2]

(3) [Diagram of sequence 3]

(4) [Diagram of sequence 4]
Base your answers to questions 45 and 46 on the data table below. The data table provides information about the Moon, based on current scientific theories.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Current Scientific Theories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin of the Moon</td>
<td>Formed from material thrown from a still-liquid Earth following the impact of a giant object 4.5 billion years ago</td>
</tr>
<tr>
<td>Craters</td>
<td>Largest craters resulted from an intense bombardment by rock objects around 3.9 billion years ago</td>
</tr>
<tr>
<td>Presence of water</td>
<td>Mostly dry, but water brought in by the impact of comets may be trapped in very cold places at the poles</td>
</tr>
<tr>
<td>Age of rocks in terrae highlands</td>
<td>Most are older than 4.1 billion years; highland anorthosites (igneous rocks composed almost totally of feldspar) are dated at 4.4 billion years</td>
</tr>
<tr>
<td>Age of rocks in maria plains</td>
<td>Varies widely from 2 billion to 4.3 billion years</td>
</tr>
<tr>
<td>Composition of terrae highlands</td>
<td>Wide variety of rock types, but all contain more aluminum than rocks of maria plains</td>
</tr>
<tr>
<td>Composition of maria plains</td>
<td>Wide variety of basalts</td>
</tr>
<tr>
<td>Composition of mantle</td>
<td>Varying amounts of mostly olivine and pyroxene</td>
</tr>
</tbody>
</table>

45 Which statement is supported by the information in the table?

(1) The Moon was once a comet.
(2) The Moon once had saltwater oceans.
(3) Earth is 4.5 billion years older than the Moon.
(4) Earth was liquid rock when the Moon was formed.

46 Which Moon feature is an impact structure?

(1) crater
(2) maria plain
(3) terrae highland
(4) mantle