1. The diagram below shows a planet's orbit around the Sun.

At which location is the planet's orbital velocity greatest?

A) A  B) B  C) C  D) D

2. The modern heliocentric model of planetary motion states that the planets travel around

A) the Sun in slightly elliptical orbits
B) the Sun in circular orbits
C) Earth in slightly elliptical orbits
D) Earth in circular orbits

3. Earth’s orbital velocity is slowest on July 5 because

A) the Moon is closest to Earth
B) Earth’s distance from the Sun is greatest
C) Earth, the Moon, and the Sun are located along a straight line in space
D) the highest maximum temperatures occur in the Northern Hemisphere

4. Which graph best shows the general relationship between a planet's distance from the Sun and the Sun's gravitational attraction to the planet?

A)  
B)  
C)  
D)  
5. The diagram below represents the elliptical orbit of a moon revolving around a planet. The foci of this orbit are the points labeled $F_1$ and $F_2$.

What is the approximate eccentricity of this elliptical orbit?
A) 0.3  B) 0.5  C) 0.7  D) 1.4

6. Which observation is a direct result of changes in distance between Earth and the Sun?
A) A Foucault pendulum shows predictable changes in its direction of swing.
B) The apparent diameter of the Sun shows predictable changes in size.
C) The length of daylight at the poles changes from 0 to 24 hours during the year.
D) Summer occurs in the Northern Hemisphere at the same time that winter occurs in the Southern Hemisphere.

7. Which graph best represents the change in gravitational attraction between the Sun and a comet as the distance between them increases?
A)  
B)  
C)  
D)  

8. Which statement provides the best evidence that Earth revolves around the Sun?
A) The Sun follows an apparent daily path, rising in the east and setting in the west.
B) A Foucault pendulum appears to shift its direction of swing in a predictable manner.
C) The stars appear to follow circular paths around the North Star (Polaris).
D) The seasons of spring, summer, fall, and winter repeat in a pattern.
9. The symbols below represent two planets.

\[ \text{5} \] represents a planet with a mass 5 times Earth’s mass.

\[ \text{9} \] represents a planet with a mass 9 times Earth’s mass.

Which combination of planet masses and distances produces the greatest gravitational force between the planets?

A) \[ \text{5} \quad 100 \times 10^6 \text{ km} \]

B) \[ \text{5} \quad 200 \times 10^6 \text{ km} \]

C) \[ \text{9} \quad 100 \times 10^6 \text{ km} \]

D) \[ \text{9} \quad 200 \times 10^6 \text{ km} \]

Base your answers to questions 10 through 13 on the diagram of the solar system below.

10. Which planet has the most eccentric orbit?

A) Venus  
B) Mars  
C) Saturn  
D) Pluto

11. According to Kepler's Harmonic Law of Planetary Motion, the farther a planet is located from the Sun, the

A) shorter its period of rotation  
B) shorter its period of revolution  
C) longer its period of rotation  
D) longer its period of revolution

12. Which kind of model of the solar system is represented by the diagram?

A) heliocentric model  
B) geocentric model  
C) sidereal model  
D) lunar model
13. If the Earth's distance from the Sun were doubled, the gravitational attraction between the Sun and Earth would be

A) one-ninth as great  
B) nine times as great  
C) one-fourth as great  
D) four times as great

14. In which type of model are the Sun, other stars, and the Moon in orbit around the Earth?

A) heliocentric model  
B) tetrahedral model  
C) concentric model  
D) geocentric model

Base your answers to questions 15 through 19 on the diagram below which represents a planet, \( P \), in an elliptical orbit around a star located at \( F_1 \). The foci of the elliptical orbit are \( F_1 \) and \( F_2 \). Orbital locations are represented by \( P_1 \) through \( P_6 \).

15. If the mass of planet \( P \) were tripled, the gravitational force between the star and planet \( P \) would

A) remain the same  
B) be two times greater  
C) be three times greater  
D) be nine times greater

16. If the shaded portions of the orbital plane are equal in area, the time period between \( P_1 \) and \( P_2 \) will be equal to the time period between

A) \( P_2 \) and \( P_3 \)  
B) \( P_4 \) and \( P_5 \)  
C) \( P_3 \) and \( P_4 \)  
D) \( P_6 \) and \( P_1 \)

17. What is the approximate eccentricity of planet \( P \)'s orbit?

A) 0.52  
B) 0.83  
C) 2.11  
D) 4.47

18. When observed from the planet, the star would have its greatest apparent angular diameter when the planet is located at position

A) \( P_1 \)  
B) \( P_2 \)  
C) \( P_3 \)  
D) \( P_4 \)

19. The gravitational attraction between planet \( P \) and the star is greatest when the planet is located at position

A) \( P_1 \)  
B) \( P_2 \)  
C) \( P_3 \)  
D) \( P_4 \)
20. The graph below shows the varying amount of gravitational attraction between the Sun and an asteroid in our solar system. Letters A, B, C, and D indicate four positions in the asteroid's orbit. Which diagram best represents the positions of the asteroid in its orbit around the Sun? [Note: The diagrams are not drawn to scale.]

A) They have the same period of revolution.
B) They are perfect spheres.
C) They exert the same gravitational force on each other.
D) They have elliptical orbits with the Sun at one focus.

21. In what way are the planets Mars, Mercury, and Earth similar?
   A) They have the same period of revolution.
   B) They are perfect spheres.
   C) They exert the same gravitational force on each other.
   D) They have elliptical orbits with the Sun at one focus.
22. An observer on Earth measures the angle of sight between Venus and the setting Sun.

![Diagram of Venus and Sun with 45° angle](image)

(Not drawn to scale)

Which statement best describes and explains the apparent motion of Venus over the next few hours?

A) Venus will set 1 hour after the Sun because Earth rotates at 45° per hour.
B) Venus will set 2 hours after the Sun because Venus orbits Earth faster than the Sun orbits Earth.
C) **Venus will set 3 hours after the Sun because Earth rotates at 15° per hour.**
D) Venus will set 4 hours after the Sun because Venus orbits Earth slower than the Sun orbits Earth.

23. Which planet’s orbit around the Sun is most nearly circular?

A) Mercury  
B) Neptune  
C) Pluto  
D) **Venus**

24. The constructed ellipse below is a true scale model of the orbit of a planet in our solar system. This ellipse best represents the orbit of the planet

![Elliptical Orbit Diagram](image)

A) Neptune  
B) Jupiter  
C) **Pluto**  
D) Mars

25. Which diagram shows a planet with the *least* eccentric orbit?

A) ![Circular Orbit](image)  
B) ![Eccentric Orbit](image)  
C) ![Planetary Orbit](image)  
D) ![Distant Orbit](image)

26. Which object is located at one foci of the elliptical orbit of Mars?

A) **the Sun**  
B) Betelgeuse  
C) Earth  
D) Jupiter
27. The diagram below shows a satellite in four different positions as it revolves around a planet.

Which graph best represents the changes in this satellite's orbital velocity as it revolves around the planet?

A)  

B)  

C)  

D)  

28. The table below shows gravitational data for a planet traveling in an elliptical orbit around a star. The table shows the relative gravitational force between the star and this planet at eight positions in the orbit (letters A through H). Higher numbers indicate stronger gravitational attraction.

<table>
<thead>
<tr>
<th>Planet's Position in the Orbit</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Gravitational Force Between Star and Planet</td>
<td>52</td>
<td>42</td>
<td>25</td>
<td>12</td>
<td>10</td>
<td>12</td>
<td>25</td>
<td>42</td>
</tr>
</tbody>
</table>

Which diagram best represents the positions of the planet in its orbit that would produce the gravitational forces shown in the data table?

A)  

B)  

C)  

D)  

29. Which change always occurs as the distance between the Earth and the Sun decreases?

A) The gravitational force between the Earth and the Sun decreases.

B) The Sun's apparent diameter decreases.

C) The Sun's rate of rotation increases.

D) The Earth's orbital speed increases.
30. Which graph best represents the force of gravity between Earth and the Sun during one revolution of Earth around the Sun?

A) geocentric model with the Sun near the center
B) geocentric model with Earth near the center
C) heliocentric model with the Sun near the center
D) heliocentric model with Earth near the center

31. This diagram of our solar system represents a
A) geocentric model with the Sun near the center
B) geocentric model with Earth near the center
C) heliocentric model with the Sun near the center
D) heliocentric model with Earth near the center

32. Which statement best describes the geocentric model of our solar system?
A) The Earth is located at the center of the model.
B) All planets revolve around the Sun.
C) The Sun is located at the center of the model.
D) All planets except the Earth revolve around the Sun.

33. The actual shape of the Earth's orbit around the Sun is best described as
A) a very eccentric ellipse
B) a slightly eccentric ellipse
C) an oblate spheroid
D) a perfect circle

34. The diagram below represents the construction of a model of an elliptical orbit of a planet traveling around a star. The focal point and the center of the star represent the foci of the orbit.

The eccentricity of this orbit is approximately
A) 1.3 B) 0.8 C) 0.5 D) 0.3
35. Compared to the orbit of the Jovian planets, the orbit of Halley's comet is
A) less elliptical, with a shorter distance between its foci
B) less elliptical, with a greater distance between its foci
C) more elliptical, with a shorter distance between its foci
D) more elliptical, with a greater distance between its foci

36. The diagram below represents a planet revolving in an elliptical orbit around a star.

As the planet makes one complete revolution around the star, starting at the position shown, the gravitational attraction between the star and the planet will
A) decrease, then increase
B) increase, then decrease
C) continually decrease
D) remain the same

37. The diagram below shows the orbits of planets A and B in a star-planet system.

The period of revolution for planet B is 40 days. The period of revolution for planet A most likely is
A) less than 40 days
B) greater than 40 days
C) 40 days

38. The shape of the orbits of most of the planets in the solar system would best be described as
A) elliptical and very elongated
B) parabolic
C) nearly circular
D) perfectly circular

39. Base your answer to the following question on the diagram below which represents nine positions of the Earth in orbit around the Sun during one complete orbit of the Moon around the Earth.

The elliptical shape of the Moon's orbit around the Earth causes
A) changes in the gravitational attraction between the Moon and the Earth
B) the Earth to have an equatorial bulge
C) the Moon's period of rotation to equal its period of revolution
D) the $23^\circ \frac{1}{2}$ tilt of the Earth's axis of rotation

40. An observer on Earth determines that the apparent diameter of the Moon as viewed from Earth varies in a cyclic manner. The best explanation for this observation is that the
A) Moon is rotating
B) Moon’s orbit is elliptical
C) atmospheric transparency of the Moon changes
D) distance between the Moon and the Sun changes

41. The period of time a planet takes to make one revolution around the Sun is most dependent on the planet's average
A) rotation rate
B) mass
C) insolation from the Sun
D) distance from the Sun
42. The force of gravity between two objects will be greatest if their masses are
A) small and they are far apart
B) small and they are close together
C) large and they are far apart
D) large and they are close together

43. Base your answer to the following question on the diagram below, which represents an exaggerated view of Earth revolving around the Sun. Letters A, B, C, and D represent Earth's location in its orbit on the first day of each of the four seasons.

A) Stars seen from Earth appear to circle Polaris.
B) Earth's planetary winds are deflected by the Coriolis effect.
C) The change from high ocean tide to low ocean tide is a repeating pattern.
D) Different star constellations are seen from Earth at different times of the year.

Which observation provides the best evidence that Earth revolves around the Sun?
A) Stars seen from Earth appear to circle Polaris.
B) Earth's planetary winds are deflected by the Coriolis effect.
C) The change from high ocean tide to low ocean tide is a repeating pattern.
D) Different star constellations are seen from Earth at different times of the year.

44. In the geocentric model (the Earth at the center of the universe), which motion would occur?
A) The Earth would revolve around the Sun.
B) The Earth would rotate on its axis.
C) The Moon would revolve around the Sun.
D) The Sun would revolve around the Earth.

45. The diagram below shows the elliptical orbit of a planet revolving around a star. The star and $F_2$ are the foci of this ellipse.

What is the approximate eccentricity of this ellipse?
A) 0.22  B) 0.47  C) 0.68  D) 1.47

46. Which planet has an orbit with an eccentricity most similar to the eccentricity of the Moon’s orbit around Earth?
A) Earth  B) Jupiter  C) Pluto  D) Saturn

47. The diagram below represents a simple geocentric model. Which object is represented by the letter X?

A) Earth  B) Sun  C) Moon  D) Polaris
48. The diagram below represents a planet in orbit around a star.

Which statement best describes how the planet's energy is changing as it moves from point A to point B?

A) **Kinetic energy is increasing and potential energy is decreasing.**
B) Kinetic energy is decreasing and potential energy is increasing.
C) Both kinetic and potential energy are decreasing.
D) Both kinetic and potential energy are increasing.

49. The symbols below represent star masses and distances.

Which diagram shows two stars that have the greatest gravitational force between them?

A) ![Diagram A](image)
B) ![Diagram B](image)
C) ![Diagram C](image)
D) ![Diagram D](image)
50. Base your answer to the following question on the diagram below, which shows positions of the Moon in its orbit and phases of the Moon as viewed from New York State.

What is the eccentricity of the Moon’s orbit?

A) 0.017  B) 0.055  C) 0.386  D) 0.723

51. Why are some constellations visible to New York State observers at midnight during April, but not visible at midnight during October?

A) Constellations move within our galaxy.
B) Constellations have elliptical orbits.
C) **Earth revolves around the Sun.**
D) Earth rotates on its axis.
52. Base your answer to the following question on the diagram below, which shows a portion of the solar system.

![Diagram of the solar system](image)

(Not drawn to scale)

The actual orbits of the planets are

A) elliptical, with Earth at one of the foci  
B) **elliptical, with the Sun at one of the foci**  
C) circular, with Earth at the center  
D) circular, with the Sun at the center

53. Differences in Earth's orbital velocity around the Sun are caused primarily by changes in the

A) inclination of Earth's axis  
B) rate of rotation of Earth  
C) **distance between Earth and the Sun**  
D) oblate spheroid shapes of Earth and the Sun

54. The force of gravity between two objects is greatest when

A) masses are small and the objects are close together  
B) masses are small and the objects are far apart  
C) **masses are large and the objects are close together**  
D) masses are large and the objects are far apart

55. Base your answer to the question below on the diagram below. The diagram represents the path of a planet orbiting a star. Points A, B, C, and D indicate four orbital positions of the planet.

![Diagram of a planet orbiting a star](image)

When viewed by an observer on the planet, the star has the largest apparent diameter at position

A) A  
B) B  
C) C  
D) D
56. The diagram below represents the elliptical orbit of the Earth around the Sun.

Which equation should be used to find the eccentricity of the Earth's orbit?

A) eccentricity =\frac{299,000,000 \text{ km}}{5,000,000 \text{ km}}

B) eccentricity = \frac{5,000,000 \text{ km}}{299,000,000 \text{ km}}

C) eccentricity = 299,000,000 \text{ km} - 5,000,000 \text{ km}

D) eccentricity = \frac{5,000,000 \text{ km}}{299,000,000 \text{ km} - 5,000,000 \text{ km}}

57. Which graph best represents the relationship between the gravitational attraction of two objects and their distance from each other?

A)

B)

C)

D)

58. In our solar system, the orbits of the planets are best described as

A) circular, with the planet at the center

B) circular, with the Sun at the center

C) elliptical, with the planet at one of the foci

D) elliptical, with the Sun at one of the foci
59. The bar graph below shows one planetary characteristic, identified as $X$, plotted for the planets of our solar system.

![Bar Graph]

Which characteristic of the planets in our solar system is represented by $X$?

A) mass  
B) density  
C) eccentricity of orbit  
D) period of rotation

60. For what reason did the heliocentric model of the universe replace the geocentric model of the universe?

A) The geocentric model no longer predicted the positions of the constellations.  
B) The geocentric model did not predict the phases of the Moon.  
C) The heliocentric model provided a simpler explanation of the motions of the planets.  
D) The heliocentric model proved that the Earth rotates.

61. The speed of a planet in its orbit around the Sun depends primarily on the planet's

A) direction of revolution  
B) distance from the Sun  
C) polar circumference  
D) axial tilt

62. The diagram below represents our solar system.

![Solar System Diagram]

This system is best classified as

A) geocentric, with elliptical orbits  
B) geocentric, with circular orbits  
C) heliocentric, with elliptical orbits  
D) heliocentric, with circular orbits
63. The diagram below represents a student's constructed laboratory drawing.

The student's drawing best represents the

A) shape of Earth's Moon  
B) **shape of an elliptical orbit**  
C) path of an earthquake wave  
D) path of a projectile deflected by Earth's rotation

64. Which planet has the *least* distance between the two foci of its elliptical orbit?

A) **Venus**  B) Earth  
C) Mars  D) Jupiter
65. The diagram below represents planets A and B, of equal mass, revolving around a star.

Compared to planet A, planet B has a
A) weaker gravitational attraction to the star and a shorter period of revolution
B) **weaker gravitational attraction to the star and a longer period of revolution**
C) stronger gravitational attraction to the star and a shorter period of revolution
D) stronger gravitational attraction to the star and a longer period of revolution

66. If the **average distance** between Earth and the Sun were **doubled**, what changes would occur in the Sun's gravitational pull on Earth and Earth's period of revolution?

A) **Gravitational pull would decrease and period of revolution would increase.**
B) Gravitational pull would decrease and period of revolution would decrease.
C) Gravitational pull would increase and period of revolution would increase.
D) Gravitational pull would increase and period of revolution would decrease.

67. Compared to the velocity of Jupiter in its orbit, the velocity of Halley’s comet is
A) always less
B) always greater
C) always the same
D) **sometimes less and sometimes greater**
68. The diagram below shows one model of a portion of the universe.

What type of model does the diagram best demonstrate?

A) a heliocentric model, in which celestial objects orbit Earth
B) a heliocentric model, in which celestial objects orbit the Sun
C) a geocentric model, in which celestial objects orbit Earth
D) a geocentric model, in which celestial objects orbit the Sun

69. Which diagram represents a geocentric model?
[Key: E = Earth, P = Planet, S = Sun]
70. The diagram below represents the position of Earth in its orbit and the position of a comet in its orbit around the Sun.

Which inference can be made about the comet's orbit, when it is compared to Earth's orbit?

A) Earth's orbit and the comet's orbit have the same distance between foci.
B) Earth's orbit has a greater distance between foci than the comet's orbit.
C) The comet's orbit has one focus, while Earth's orbit has two foci.
D) The comet's orbit has a greater distance between foci than Earth's orbit.

71. Which object orbits Earth in both the Earth-centered (geocentric) and Sun-centered (heliocentric) models of our solar system?

A) the Moon  B) the Sun  C) Venus  D) Polaris

72. Which apparent motion can be explained by a geocentric model?

A) deflection of the wind  B) curved path of projectiles  C) motion of a Foucault pendulum  D) the sun's path through the sky

73. The elliptical shape of the Earth's orbit results in

A) changes in the orbital velocity of the Earth  B) tilting of the Earth's axis  C) the oblate spheroid shape of the Earth  D) the phases of the Moon

74. The diagram below shows four positions of a planet in its orbit around the Sun.

At which position is the planet's orbital speed greatest?

A) A  B) B  C) C  D) D
75. In each diagram below, the mass of the star is the same. In which diagram is the force of gravity greatest between the star and the planet shown?

A) ![Diagram A](image1.png)

B) ![Diagram B](image2.png)

C) ![Diagram C](image3.png)

D) ![Diagram D](image4.png)

76. Earth is farthest from the Sun during the Northern Hemisphere's summer, and Earth is closest to the Sun during the Northern Hemisphere's winter. During which season in the Northern Hemisphere is Earth's orbital velocity greatest?

A) winter        B) spring        C) summer        D) fall

Base your answers to questions 77 and 78 on the diagram below, which represents the current locations of two planets, A and B, orbiting a star. Letter X indicates a position in the orbit of planet A. Numbers 1 through 4 indicate positions in the orbit of planet B.

![Diagram](image5.png)

(Not drawn to scale)

77. As planet A moves in orbit from its current location to position X, planet B most likely moves in orbit from its current location to position

A) 1        B) 2        C) 3        D) 4

78. If the diagram represents our solar system and planet B is Venus, which planet is represented by planet A?

A) Mercury        B) Jupiter        C) Earth        D) Mars
79. Which bar graph correctly shows the orbital eccentricity of the planets in our solar system?

A)  

B)  

C)  

D)  

80. Which planet has an orbital eccentricity most like the orbital eccentricity of the Moon?

A) Pluto  
B) Saturn  
C) Mars  
D) Mercury

81. One factor responsible for the strength of gravitational attraction between a planet and the Sun is the

A) degree of tilt of the planet’s axis  
B) distance between the planet and the Sun  
C) planet’s period of rotation  
D) amount of insolation given off by the Sun

82. Which diagram best represents a portion of the heliocentric model of the solar system? [\(S = \text{Sun}, \ E = \text{Earth}, \ M = \text{Moon}\)]

A)  
B)  
C)  
D)  

83. When the distance between the foci of an ellipse is increased, the eccentricity of the ellipse will

A) decrease  
B) increase  
C) remain the same

84. Which graph best represents the relationship between the gravitational attraction of two objects and their distance from each other?

A)  
B)  
C)  
D)  

85. Which motion causes some constellations to be visible in New York State only during winter nights and other constellations to be visible only during summer nights?

A) Stars in constellations revolve around Earth.  
B) Stars in constellations revolve around the Sun.  
C) Earth revolves around the Sun.  
D) Earth rotates on its axis.
86. What is the main reason that the gravitational attraction between Earth and the Moon changes each day?

A) Earth’s axis is tilted at 23.5°.
B) Earth’s rotational speed varies with the seasons.
C) The Moon has an elliptical orbit.
D) The Moon has a spherical shape.

87. The diagram below represents the Earth's orbital path around the Sun. The Earth takes the same amount of time to move from A to B as from C to D.

Which values are equal within the system?

A) The shaded sections of the diagram are equal in area.
B) The distance from the Sun to the Earth is the same at point A and at point D.
C) The orbital velocity of the Earth at point A equals its orbital velocity at point C.
D) The gravitational force between the Earth and the Sun at point B is the same as the gravitational force at point D.

88. Which diagram best represents the motions of celestial objects in a heliocentric model?

Key:
\( P_e \) = Planet
\( M_m \) = Moon
\( S \) = Sun

A) [Diagram A]
B) [Diagram B]
C) [Diagram C]
D) [Diagram D]

89. One factor responsible for the strength of gravitational attraction between a planet and the Sun is the

A) degree of tilt of the planet's axis
B) distance between the planet and the Sun
C) planet's period of rotation
D) amount of insolation given off by the Sun
Answer Key
Orbits and Eccentricity

1. A  36. A  71. A
2. A  37. A  72. D
3. B  38. C  73. A
5. C  40. B  75. B
6. B  41. D  76. A
7. A  42. D  77. A
8. D  43. D  78. A
9. C  44. D  79. A
10. D  45. C  80. B
12. A  47. A  82. C
14. D  49. C  84. A
15. C  50. B  85. C
16. B  51. C  86. C
17. A  52. B  87. A
20. A  55. A
22. C  57. D
23. D  58. D
24. C  59. C
25. A  60. C
27. C  62. C
28. B  63. B
29. D  64. A
30. C  65. B
31. C  66. A
32. A  67. D
33. B  68. C
34. B  69. C
35. D  70. D