Chapter 3

Science Rekindles

3.1 Copernican Revolution

1. Copernicus changed the geocentric theory of Ptolemy to a heliocentric theory because

   (a) Ptolemy's theory disagreed with observation.
   (b) Copernicus came up with a theory that agreed much better with observation.
   (c) Ptolemy's theory was too complicated.
   (d) All of the above.
   (e) None of the above.

2. In Copernicus' time, students of medicine had to study mathematics because

   (a) medicine of that time was very mathematical.
   (b) it was fun for them.
   (c) it was required by law.
   (d) medicine used a lot of astrology.
   (e) All of the above

3. Copernicus lived around

   (a) 350 AD.
   (b) 540 BC.
   (c) 1800 AD.
   (d) 1500 AD.
   (e) 1060 AD

4. Heliocentric theory of Copernicus

   (a) was proposed for observational reasons.
   (b) was purely the product of human mind.
   (c) was proposed about 550 AD.
   (d) was proposed to overcome the *observational* deficiencies of geocentric theory.
   (e) is still valid today.

5. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 4 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth completes its first revolution, M is at

   (a) 12 o'clock of its orbit.
   (b) 9 o'clock of its orbit.
   (c) 6 o'clock of its orbit.
   (d) 4 o'clock of its orbit.
   (e) 3 o'clock of its orbit.

6. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 4 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth completes its third revolution, M is at

   (a) 12 o'clock of its orbit.
   (b) 9 o'clock of its orbit.
   (c) 6 o'clock of its orbit.
   (d) 4 o'clock of its orbit.
   (e) 3 o'clock of its orbit.

7. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 4 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 4 o'clock during its second revolution, M is at

   (a) 10 o'clock of its orbit.
   (b) 8 o'clock of its orbit.
   (c) 7 o'clock of its orbit.
   (d) 5 o'clock of its orbit.
   (e) 6 o'clock of its orbit.

8. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 4 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 8 o'clock during its third revolution, M is at

   (a) 10 o'clock of its orbit.
   (b) 8 o'clock of its orbit.
   (c) 6 o'clock of its orbit.
   (d) 5 o'clock of its orbit.
   (e) 2 o'clock of its orbit.

9. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 4 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 8 o'clock during its second revolution, M is at

   (a) 10 o'clock of its orbit.
   (b) 8 o'clock of its orbit.
   (c) 6 o'clock of its orbit.
   (d) 5 o'clock of its orbit.

(e) 2 o'clock of its orbit.

10. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 4 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 4 o'clock during its third revolution, M is at

   (a) 10 o'clock of its orbit.
   (b) 8 o'clock of its orbit.
   (c) 6 o'clock of its orbit.
   (d) 5 o'clock of its orbit.
   (e) 4 o'clock of its orbit.

11. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 4 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 6 o'clock during its second revolution, M is at

   (a) 6 o'clock of its orbit.
   (b) 7 o'clock of its orbit.
   (c) halfway between 6 o'clock and 7 o'clock.
   (d) halfway between 7 o'clock and 8 o'clock.
   (e) 8 o'clock of its orbit.

12. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 4 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 2 o'clock during its first revolution, M is at

   (a) 10 o'clock of its orbit.
   (b) 2 o'clock of its orbit.
   (c) halfway between 8 o'clock and 9 o'clock.
   (d) halfway between 2 o'clock and 3 o'clock.
   (e) halfway between 9 o'clock and 10 o'clock.

13. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 3 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth completes its first revolution, M is at

   (a) 12 o'clock of its orbit.
   (b) 10 o'clock of its orbit.
   (c) 8 o'clock of its orbit.
   (d) 6 o'clock of its orbit.
   (e) 4 o'clock of its orbit.

14. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 3 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth completes its third revolution, M is at

   (a) 12 o'clock of its orbit.
   (b) 9 o'clock of its orbit.
   (c) 6 o'clock of its orbit.

(d) 4 o'clock of its orbit.

(e) 3 o'clock of its orbit.

15. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 3 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 3 o'clock during its second revolution, M is at

   (a) 10 o'clock of its orbit.

   (b) 8 o'clock of its orbit.

   (c) 7 o'clock of its orbit.

   (d) 5 o'clock of its orbit.

   (e) 6 o'clock of its orbit.

16. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 3 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 9 o'clock during its third revolution, M is at

   (a) 10 o'clock of its orbit.

   (b) 8 o'clock of its orbit.

   (c) 6 o'clock of its orbit.

   (d) 5 o'clock of its orbit.

   (e) 3 o'clock of its orbit.

17. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 3 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 6 o'clock during its second revolution, M is at

   (a) 10 o'clock of its orbit.

   (b) 8 o'clock of its orbit.

   (c) 6 o'clock of its orbit.

   (d) 5 o'clock of its orbit.

   (e) 2 o'clock of its orbit.

18. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 3 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 6 o'clock during its third revolution, M is at

   (a) 10 o'clock of its orbit.

   (b) 8 o'clock of its orbit.

   (c) 6 o'clock of its orbit.

   (d) 5 o'clock of its orbit.

   (e) 2 o'clock of its orbit.

19. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 3 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is halfway between 7 and 8 o'clock during its second revolution, M is at

   (a) 6 o'clock of its orbit.

(b) 7 o'clock of its orbit.

(c) halfway between 6 o'clock and 7 o'clock.

(d) halfway between 7 o'clock and 8 o'clock.

(e) 8 o'clock of its orbit.

20. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 3 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is halfway between 4 and 5 o'clock during its third revolution, M is at

(a) 2 o'clock of its orbit.

(b) halfway between 3 o'clock and 4 o'clock.

(c) halfway between 4 o'clock and 5 o'clock.

(d) halfway between 2 o'clock and 3 o'clock.

(e) halfway between 1 o'clock and 2 o'clock.

21. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth completes its first revolution, M is at

(a) 12 o'clock of its orbit.

(b) 10 o'clock of its orbit.

(c) 8 o'clock of its orbit.

(d) 6 o'clock of its orbit.

(e) 4 o'clock of its orbit.

22. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth completes its third revolution, M is at

(a) 12 o'clock of its orbit.

(b) 9 o'clock of its orbit.

(c) 6 o'clock of its orbit.

(d) 4 o'clock of its orbit.

(e) 3 o'clock of its orbit.

23. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 6 o'clock during its second revolution, M is at

(a) 10 o'clock of its orbit.

(b) 9 o'clock of its orbit.

(c) 8 o'clock of its orbit.

(d) 5 o'clock of its orbit.

(e) 6 o'clock of its orbit.

24. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 9 o'clock during its third revolution, M is at

(a) 9 o'clock of its orbit.

(b) half way between 8 o'clock and 9 o'clock.

(c) 8 o'clock of its orbit.

(d) half way between 7 o'clock and 8 o'clock.

(e) 7 o'clock of its orbit.

25. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 3 o'clock during its second revolution, M is at

(a) 10 o'clock of its orbit.

(b) half way between 9 o'clock and 10 o'clock.

(c) 9 o'clock of its orbit.

(d) half way between 8 o'clock and 9 o'clock.

(e) 8 o'clock of its orbit.

26. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 6 o'clock during its third revolution, M is at

(a) 10 o'clock of its orbit.

(b) 8 o'clock of its orbit.

(c) 6 o'clock of its orbit.

(d) 5 o'clock of its orbit.

(e) 2 o'clock of its orbit.

27. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 9 o'clock during its third revolution, M is at

(a) 8 o'clock of its orbit.

(b) half way between 8 o'clock and 9 o'clock.

(c) 7 o'clock of its orbit.

(d) half way between 7 o'clock and 8 o'clock.

(e) half way between 6 o'clock and 7 o'clock.

28. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 3 o'clock during its fourth revolution, M is at

(a) 6 o'clock of its orbit.

(b) 5 o'clock of its orbit.

(c) halfway between 5 o'clock and 6 o'clock.

(d) halfway between 4 o'clock and 5 o'clock.

(e) 4 o'clock of its orbit.

29. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When earth is at 6 o'clock during its fifth revolution, M is at

(a) 3 o'clock of its orbit.

(b) halfway between 3 o'clock and 4 o'clock.

(c) 4 o'clock of its orbit.

(d) halfway between 2 o'clock and 3 o'clock.

(e) 3 o'clock of its orbit.

30. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When M is at 1 o'clock of its orbit, Earth is at

(a) 12 o'clock of its orbit.

(b) 9 o'clock of its orbit.

(c) 8 o'clock of its orbit.

(d) 6 o'clock of its orbit.

(e) Can't answer because I don't know which revolution of Earth you are talking about.

31. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When M is at 4 o'clock of its orbit, Earth is at

(a) 12 o'clock of its orbit.

(b) 9 o'clock of its orbit.

(c) 8 o'clock of its orbit.

(d) 6 o'clock of its orbit.

(e) Can't answer because I don't know which revolution of Earth you are talking about.

32. Planet M, located farther from sun than earth, moves around sun once as earth moves around sun 6 times. Both move counterclockwise on circles starting at the 12 o'clock location. When M is at midway between 2 o'clock and 3 o'clock of its orbit, Earth is at

(a) 3 o'clock of its orbit.

(b) 6 o'clock of its orbit.

(c) 9 o'clock of its orbit.

(d) 12 o'clock of its orbit.

(e) Can't answer because I don't know which revolution of Earth you are talking about.

33. Figure 3.1 shows the orbits of earth and Mars around sun. Earth moves around sun three times for each complete revolution of Mars. Suppose they both start at the location labeled 1, and that it takes earth 12 months to complete its revolution. Which of the lines shown in the figure describes the location (both direction and distance) of Mars relative to earth after 10 months? If you find no matches, mark (e) on your answer sheet.

34. Continuing with the previous question, which of the lines shown in the figure most closely describes the location of Mars relative to earth after two and a half years?
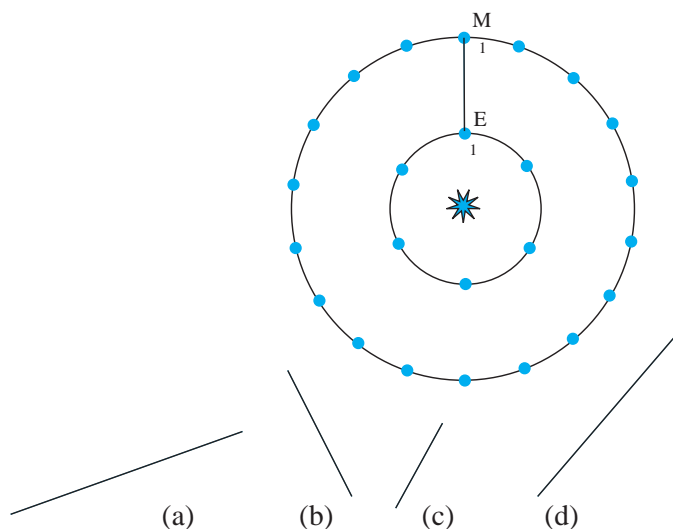
Figure 3.1: Earth and Mars start at 1. After 12 months earth is back to 1. Mars takes three times as long to complete its revolution.

35. Figure 3.2 shows the orbits of earth and Mars around sun. Earth moves around sun four times for each complete revolution of Mars. Suppose they both start at the location labeled 1, and that it takes earth 12 months to complete its revolution. Which of the lines shown in the figure describes the location (both direction and distance) of Mars relative to earth after 6 months? If none of the choices is correct, mark (e) in your scantron.

36. Which of the lines shown in Figure 3.2 describes the location of Mars relative to earth after 18 months? If none of the choices is correct, mark (e) in your scantron.

37. Which of the lines shown in Figure 3.2 describes the location of Mars relative to earth after 34 months? If none of the choices is correct, mark (e) in your scantron.

38. Figure 3.3 shows the orbits of earth and Mars around sun. Earth moves around sun three times for each complete revolution of Mars. Suppose they both start at the location labeled 1, and that it takes earth 12 months to complete its revolution. Which of the lines shown in the figure most closely describes the location of Mars relative to earth after 12 months? If none of the choices is correct, mark (e) in your scantron.

39. Which of the lines shown in Figure 3.3 most closely describes the location of Mars relative to earth after 8 months? If none of the choices is correct, mark (e) in your scantron.

40. Figure 3.4 shows the circular orbits of Mars (outer circle) and Earth (inner circle). Suppose that Earth's period is three times that of Mars, and that they start in the location labeled 1. There are eleven arrows (labeled 1 through 11) which supposedly give the position of Mars relative to Earth. Considering indicated positions as the beginning of the a revolution (rather than the end of the previous revolution), the number of arrows occurring in the Earth's first revolution is
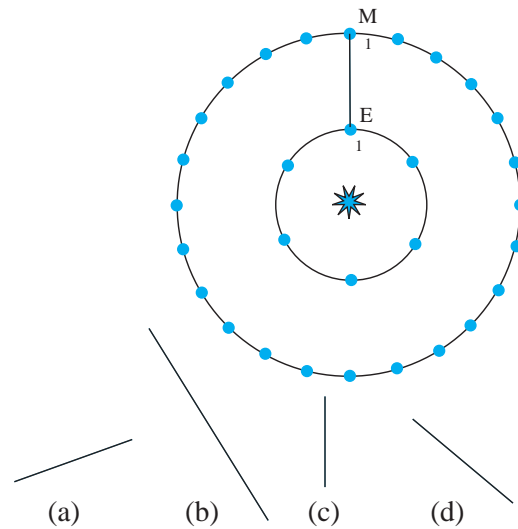
    (a) 0.

Figure 3.2: Earth and Mars start at 1. After 12 months earth is back to 1. Mars takes four times as long to complete its revolution.

(b) 1.

(c) 2.

(d) 3.

(e) more than 3.

41. Continuing with the previous question, the number of arrows occurring in the Earth's second revolution is

(a) 0.

(b) 1.

(c) 2.

(d) 3.

(e) more than 3.

42. Continuing with the previous question, the number of arrows occurring in the Earth's third revolution is

(a) 0.

(b) 1.

(c) 2.

(d) 3.

(e) more than 3.

43. Continuing with the previous question, the number of arrows that *do not* correspond to an actual position of Mars relative to Earth is
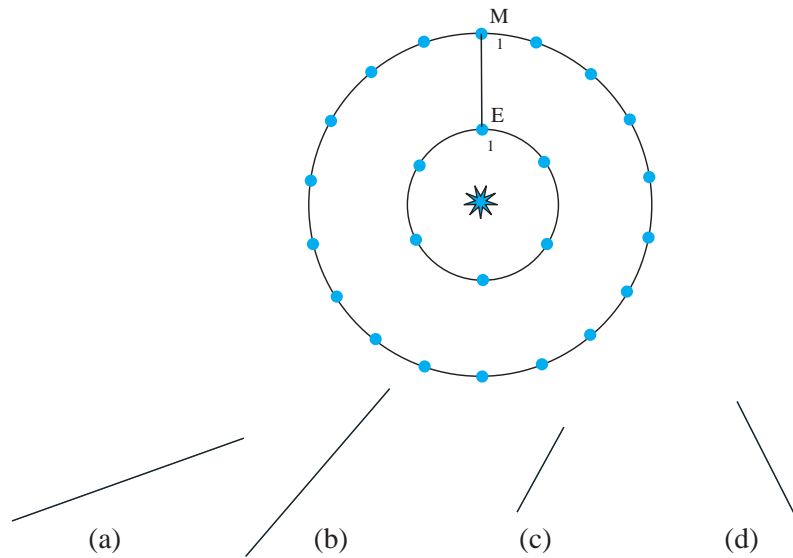
(a) 0.

Figure 3.3: Earth and Mars start at 1. After 12 months earth is back to 1. Mars takes three times as long to complete its revolution.

    (b) 1.

    (c) 2.

    (d) 3.

    (e) more than 3.

44. Figure 3.5, in which all curves are circles, shows the planets and the sun as first proposed by

    (a) Ptolemy.

    (b) Pythagoras.

    (c) Plato.

    (d) Kepler.

    (e) Copernicus.

45. Figure 3.5 shows the path of planets as seen from

    (a) Earth.

    (b) Sun.

    (c) another planet.

    (d) moon.

    (e) a distant star.

The following 5 questions refer to Figure 3.6. Assume that the outer circle corresponds to the orbit of Mars and the inner one to that of Earth. The Earth moves 4 times
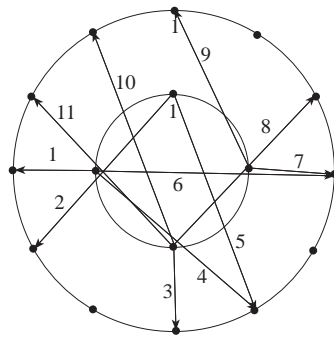
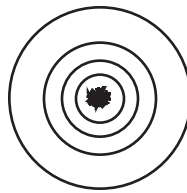Figure 3.4: The orbits of Mars (outer circle) and Earth (inner circle) around the Sun.

Figure 3.5: Circular orbits.

around the sun as Mars moves once, each starting at the top of its orbit moving counterclockwise. The numbered arrows show possible (or impossible!) locations of Mars relative to earth. Match the following questions with the choices that follow them. (One answer may correspond to more than one question.)

46. Arrow number 1 occurs during   (a) the first revolution of Earth.

47. Arrow number 2 occurs during   (b) the second revolution of Earth.

48. Arrow number 3 occurs during   (c) the third revolution of Earth.

49. Arrow number 4 occurs during   (d) the fourth revolution of Earth.

50. Arrow number 5 occurs during   (e) The arrow never occurs.

51. According to ... Earth is a planet revolving around the sun.

    (a) Pythagoras theory (the very first astronomical theory)
    (b) the multiple-sphere theory of Eudoxus
    (c) the geocentric theory of Ptolemy
    (d) the heliocentric theory of Copernicus
    (e) All of the above

52. The difference between the geocentric theory and the heliocentric theory is that

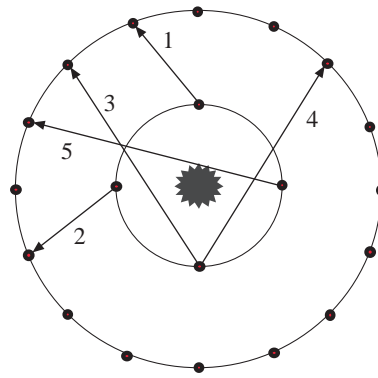   (a) geocentric theory explains the retrograde motion, but heliocentric theory does not.

Figure 3.6: Earth and Mars.

(b) heliocentric theory explains the retrograde motion, but geocentric theory does not.

(c) geocentric theory explains the brightness change in the retrograde motion, but heliocentric theory does not.

(d) heliocentric theory explains the brightness change in the retrograde motion, but geocentric theory does not.

(e) None of the above

53. In Figure 3.7, Mars (outer planet) goes around the sun counterclockwise (CCW) once when earth (inner planet) goes around the sun CCW three times. Seven arrows labeled a through g are shown, some of which may be incorrect. An arrow that occurs during the second revolution of the earth is

(a) d.

(b) e.

(c) f.

(d) Any of the above.

(e) None of the above.

54. (Continuing with the previous question.) An arrow that will never occur is

(a) a.

(b) b.

(c) c.

(d) e.

(e) g.

3.2 Fall of Spherical Dynasty

55. By the last decade of 16th century, new observations, made primarily by the Danish astronomer Tycho Brahe, indicated that
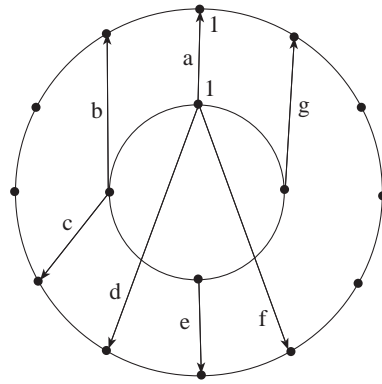
Figure 3.7: The outer planet (Mars) goes around the sun once while the inner planet (Earth) goes around three times.

(a) geocentric theory was wrong.

(b) heliocentric theory was wrong.

(c) both geocentric and heliocentric theories were wrong.

(d) both geocentric and heliocentric theories were correct.

56. Faced with the new observations of Tycho Brahe, Johannes Kepler decided to improve the existing theories. To do so, he chose

(a) geocentric theory because of its simplicity.

(b) heliocentric theory because of its huge number of arbitrary parameters that he could fine-tune.

(c) geocentric theory because of its complexity.

(d) heliocentric theory because of its simplicity.

(e) None of the above

57. Kepler's contribution to heliocentric theory of Copernicus

(a) was proposed for observational reasons.

(b) was purely the product of his mind.

(c) was proposed about 1400 AD.

(d) was proposed to overcome the observational deficiencies of geocentric theory.

(e) also had to be changed due to newer observations.

58. Faced with the new observations of Tycho Brahe, Johannes Kepler decided to improve the existing theories. To do so, he chose

(a) geocentric theory because it agreed better with observation.

(b) heliocentric theory because it agreed better with observation.

(c) geocentric theory because of its simplicity.

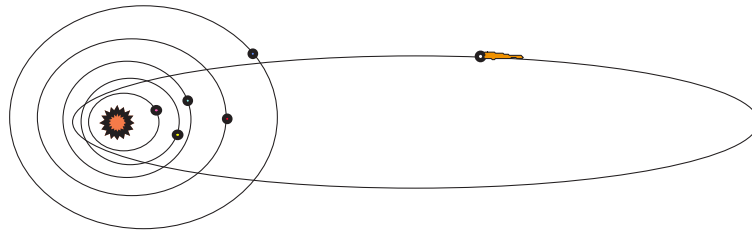(d) heliocentric theory because of its huge number of arbitrary parameters that he could fine-tune.

Figure 3.8: Non-circular orbits.

    (e) None of the above

59. Kepler's theory is different from ... in that ...

    (a) geocentric theory; Kepler's theory uses ellipses instead of epicycles.

    (b) Copernicus' heliocentric theory; Kepler's theory uses ellipses instead of circles.

    (c) geocentric theory; Kepler's theory has a way of explaining the retrograde motion.

    (d) Copernicus' heliocentric; Kepler's theory has a way of explaining the retrograde motion.

    (e) None of the above

60. Figure 3.8 shows the planets and the sun as proposed by

    (a) Tycho.

    (b) Brahe.

    (c) Plato.

    (d) Kepler.

    (e) Copernicus.

61. Figure 3.9 shows a planet moving around the sun. Suppose that all areas shown are equal. In which region does the planet move the fastest?

62. Figure 3.9 shows a planet moving around the sun. Suppose that all areas shown are equal. In which region does the planet move the slowest?
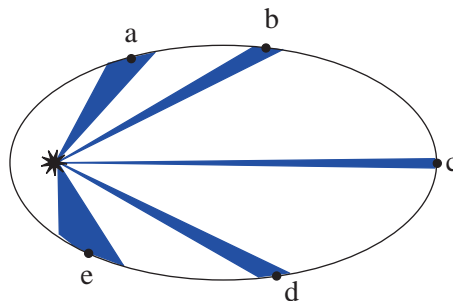

Figure 3.9: The planet moving around the sun. All areas are equal.

63. When a planet gets close to the sun

    (a) it melts.
    (b) it moves slower than when it is far.
    (c) it moves faster than when it is far.
    (d) its dark side gets brighter.
    (e) No planet changes its distance from the sun.

64. The star Herates has only two planets Zameen and Zohal, both of whose orbits are circular. Zameen is three million km away from Herates and has a period of 120 days. The k in Kepler's third law $T^2 = ka^3$ for this star system—in scientific units—is

    (a) 5.3×10^{-16}.
    (b) 4×10^{-6}.
    (c) 3.6×10^7.
    (d) 4.8×10^{-3}.
    (e) 4×10^{-15}.

65. Continuing with the previous question, Zohal is nine million km away from Herates. The period of Zohal is approximately...days

    (a) 360
    (b) 43,200
    (c) 208
    (d) 388,800
    (e) 624

66. The star Sheed has two planets Neemaz and Sram, both of whose orbits are circular. Neemaz is 5 million km away from Sheed and has a period of 100 days. Sram is 7.5 million km away from Sheed. The period of Sram is approximately

    (a) 150 days.
    (b) 225 days.
    (c) 337 days.
    (d) 180 days.
    (e) 122 days.

67. The star Sheed has two planets Neemaz and Sram, both of whose orbits are circular. Neemaz is three million km away from Sheed and has a period of 100 days. Sram is six million km away from Sheed. The period of Sram is approximately

    (a) 200 days.
    (b) 800 days.
    (c) 80,000 days.
    (d) 20,000 days.
    (e) 280 days.

68. The Sheed star system has three planets: Zoha, Neemaz, and Kublai. Zoha has a semimajor axis of 700,000 km and goes around Sheed in 30 Earth days. Neemaz and Kublai have periods of 20 and 45 Earth days, respectively. The proportionality constant, *in scientific units*, in Kepler's third law for this star system is approximately

    (a) 3×10^{-19}.

    (b) 2×10^{-14}.

    (c) 2.6×10^{-15}.

    (d) 2×10^{-5}.

    (e) 2.6×10^{-6}.

69. Continuing with the previous question, Neemaz has a semimajor axis of approximately

    (a) 530,000 km.

    (b) 5.3×10^{8} km.

    (c) 1.5×10^{26} m.

    (d) 4.4 million km.

    (e) 44,000 km.

70. The star Herates has only two planets Zameen and Zohal, both of whose orbits are circular. Zameen is two million km away from Herates and has a period of 100 days. Zohal is 4 million km away from Herates. The period of Zohal is approximately

    (a) 50 days.

    (b) 200 days.

    (c) 70 days.

    (d) 280 days.

    (e) 80,000 days.

71. There would be ... days in a year if the distance between earth and sun were doubled.

    (a) 182.5

    (b) 365

    (c) 730

    (d) 1030

    (e) 1730

72. Generally speaking, the farther the planets are from the sun, the longer it takes for them to go around it.

    (a) true

    (b) false

3.3   Lessons of Astronomy

73. One of the lessons we learn from our study of astronomy is that

    (a) it is important to make general statements about the universe from the outset.
    (b) universal theories result from looking at the "big picture."
    (c) universal statements result from studying specific objects.
    (d) astronomy is the same as astrology.
    (e) collective movement of planets controls the events on earth.