76. Ganymede, Jupiter's largest moon (discovered by Galileo Galilei in 1610), has an orbital period of approximately 7.15455296 earth days; its *periapsis* (distance from Jupiter upon closest approach) is approximately 1,069,008 kilometers, while its *apoapsis* (its greatest distance from Jupiter) is about 1,071,792 km. Use these data to estimate the mass of Jupiter. (**Hint:** See Exercise 10 of Section 12.4.)

77. Given that a day on Jupiter lasts a mere 9 hours and 55.5 minutes, use Exercise 76 along with Kepler's Third Law to estimate the necessary height above Jupiter's surface for a stationary satellite. (**Hint:** See Exercise 12 in Section 12.4. Approximate Jupiter's radius by 69,911 kilometers.)

78. The aphelion of Jupiter's orbit is 5.458104 AU (astronomical units), while its perihelion is 4.950429 AU. Use these along with Earth's orbital data to estimate the period of Jupiter in Earth years.

79. Use Exercise 78 to find the speeds of Jupiter when it is **a.** closest to and **b.** farthest from the sun. Express your answer in kilometers per second, then convert it to miles per hour. (**Hint:** See Exercise 23 in Section 12.4.)

Concept Check

80–89 Determine whether the given statement is true or false. In case of a false statement, explain or provide a counterexample.

80. $d\mathbf{T}/ds$ is perpendicular to $\mathbf{T}$.

81. If the graph of $\mathbf{r}(t)=\langle f(t),g(t),h(t)\rangle$ is a straight line, then f, g, and h are linear polynomials.

82. The torsion of a curve satisfies the formula

$$\tau=-\left(\frac{1}{|\mathbf{v}(t)|}\right)\frac{d\mathbf{B}}{dt}\cdot\mathbf{N}.$$

83. The tangential component of acceleration satisfies $a_T=\mathbf{T}\cdot\mathbf{a}$.

84. The normal component of acceleration satisfies $a_N=\mathbf{T}\times\mathbf{a}$.

85. If $f''(x)=0$, then the curvature of the graph of $y=f(x)$ is constant.

86. If $\mathbf{r}(t)$ is a space curve with $\kappa=0$, then $\mathbf{r}(t)$ can only "bend" in the direction of the unit binormal vector $\mathbf{B}$.

87. The magnitudes of the curvature and torsion of a space curve depend on the parametrization (i.e., "how fast the curve is being traced out,") unless the curve is parametrized with respect to arc length.

88. The maximum curvature of an ellipse occurs at the endpoints of its major axis.

89. $\frac{d}{dt}\left[\mathbf{r}(t)\times\mathbf{r}'(t)\right]=\mathbf{r}(t)\times\mathbf{r}''(t)$

Chapter 12 Technology Exercises

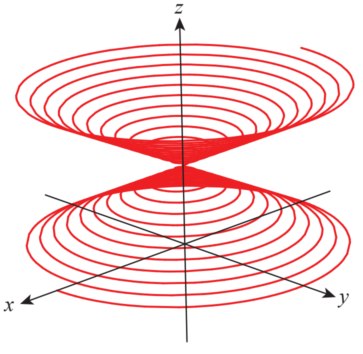
90. **a.** Use a graphing utility to graph and explore the following curve.

$$\mathbf{r}(t)=\left\langle\frac{\sin 15t}{2},(3+\cos 15t)\sin t,(3+\cos 15t)\cos t\right\rangle$$

(Such curves are nicknamed "slinky curves." Can you see why?)

b. It is possible to create "slinky curves" where the spiral is wound around a helix. Find a formula for such a curve. (**Hint:** A good starting point is appropriately modifying the formula in part a. Answers will vary.)

91. Assuming $|x|,|y|\le 10$, z is nonnegative, and $0\le t\le 10\pi$, use a graphing utility to find a formula for a vector function whose graph is as close as possible to the one displayed in the figure below. (Answers may vary.)



92. Write a program for a computer algebra system or programmable calculator that returns the equations for the osculating, normal, and rectifying planes associated with a given space curve at a specified point. Use your program to check the answers you have given to Exercises 37–40.