47. A pulley system is used to lift a piano 3.0 m. If a force of 2200 N is applied to the rope as the rope is pulled in 14 m, what is the efficiency of the machine? Assume the mass of the piano is 750 kg.

48. A pulley system has an efficiency of 87.5 percent. How much of the rope must be pulled in if a force of 648 N is needed to lift a 150 kg desk 2.46 m? (Disregard friction.)

49. Jupiter's four large moons—Io, Europa, Ganymede, and Callisto—were discovered by Galileo in 1610. Jupiter also has dozens of smaller moons. Jupiter's rocky, volcanically-active moon Io is about the size of Earth's moon. Io has radius of about 1.82×10^6 m, and the mean distance between Io and Jupiter is 4.22×10^8 m.

a. If Io's orbit were circular, how many days would it take for Io to complete one full revolution around Jupiter?

b. If Io's orbit were circular, what would its orbital speed be?

50. A 13 500 N car traveling at 50.0 km/h rounds a curve of radius 2.00×10^2 m. Find the following:

a. the centripetal acceleration of the car

b. the centripetal force

c. the minimum coefficient of static friction between the tires and the road that will allow the car to round the curve safely

51. The arm of a crane at a construction site is 15.0 m long, and it makes an angle of 20.0° with the horizontal. Assume that the maximum load the crane can handle is limited by the amount of torque the load produces around the base of the arm.

a. What is the magnitude of the maximum torque the crane can withstand if the maximum load the crane can handle is 450 N?

b. What is the maximum load for this crane at an angle of 40.0° with the horizontal?

52. At the sun's surface, the gravitational force between the sun and a 5.00 kg mass of hot gas has a magnitude of 1370 N. Assuming that the sun is spherical, what is the sun's mean radius?

53. An automobile with a tangential speed of 55.0 km/h follows a circular road that has a radius of 40.0 m. The automobile has a mass of 1350 kg. The pavement is wet and oily, so the coefficient of kinetic friction between the car's tires and the pavement is only 0.500. How large is the available frictional force? Is this frictional force large enough to maintain the automobile's circular motion?

Graphing Calculator Practice

Torque

One of the terms introduced in this chapter is *torque*. Torque is a measure of the ability of a force to rotate an object around an axis. As you learned earlier in this chapter, torque is described by the following equation:

$$\tau = Fd\sin\theta$$

In this equation, F is the applied force, d is the distance from the axis of rotation, and θ is the angle at which the force is applied. A mechanic using a long wrench to loosen a "frozen" bolt is a common illustration of this equation.

In this graphing calculator activity, you will determine how torque relates to the angle of the applied force and to the distance of application.

Visit go.hrw.com and type in the keyword **HF6CMGX** to find this graphing calculator activity. Refer to **Appendix B** for instructions on downloading the program for this activity.