Chapter 2 Exercises

33. In countless movie and television scenes, the hero punches a brawny villain who doesn’t even flinch at the impact. Why is the immovable villain a Hollywood fantasy?

   E.33 To avoid accelerating when pushed on with a force, the villain would have to have infinite mass. That’s impossible.

34. Why can’t an acrobat stop himself from spinning while he is in midair?

   E.34 The acrobat has angular momentum and cannot change that angular momentum without experience an external torque. While in the air, he can't experience an external torque.

35. While a gymnast is in the air during a leap, which of the following quantities must remain constant for her: velocity, momentum, angular velocity, or angular momentum?

   E.35 Angular momentum.

36. If you sit in a good swivel chair with your feet off the floor, the chair will turn slightly as you move about but will immediately stop moving when you do. Why can’t you make the chair spin without touching something?

   E.36 Because of your rotational inertia (as measured by your rotational mass), you need an external torque in order to begin spinning. While you aren't touching anything in the swivel chair, you can't obtain any external torque and can't start spinning.

37. When a star runs out of nuclear fuel, gravity may crush it into a neutron star about 20 km (12 miles) in diameter. While the star may have taken a year or so to rotate once before its collapse, the neutron star rotates several times a second. Explain this dramatic increase in angular velocity.

   E.37 The collapsing star’s angular momentum can’t change. Since its rotational mass decreases, its angular velocity must increase.

38. A toy top spins for a very long time on its sharp point. Why does it take so long for friction to slow the top’s rotation?

   E.38 Any frictional force on the toy top is exerted so close to the top's axis of rotation that it exerts almost zero torque. Without any significant external torque, the top's angular momentum keeps it spinning for a very long time.

39. It’s easier to injure your knees and legs while hiking downhill than while hiking uphill. Use the concept of energy to explain this observation.

   E.39 As you descend, you land hard and your knees and legs must convert your kinetic energy into thermal energy. Injuries can occur.

40. When you first let go of a bowling ball, it’s not rotating. But as it slides down the alley, it begins to rotate. Use the concept of energy to explain why the ball’s forward speed decreases as it begins to spin.

   E.40 When the bowling ball is rotating, it has rotational kinetic energy. That energy must come from somewhere and since the only type of energy the ball has as it first begins to slide down the lane is translational kinetic energy, the rotational energy must come from the translational kinetic energy. As a result, the translational kinetic energy must decrease, so the ball must slow down.

41. Firefighters slide down a pole to get to their trucks quickly. What happens to their gravitational potential energy, and how does it depend on the slipperiness of the pole?

   E.41 Sliding friction converts some into heat, but a slippery pole converts a considerable fraction into kinetic energy.

Chapter 2 Problems

9. Your car is broken, so you’re pushing it. If your car has a mass of 800 kg, how much momentum does it have when it’s moving forward at 3 m/s (11 km/h)?

   P.9 2400 kg·m/s forward.

13. You’re at the roller-skating rink with a friend who weighs twice as much as you do. The two of you stand motionless in the middle of the rink so that your combined momentum is zero. You then push on one another and begin to roll apart. If your momentum is then 450 kg·m/s to the left, what is your friend’s momentum?

   P.13 450 kg·m/s to the right.
Additional Exercises

1. Explain the difference between static friction and sliding friction?
   a. Static friction is a force that occurs when 2 objects are not moving against each other. The value of the force can vary from zero to a maximum. Sliding friction occurs when 2 objects move against each other. The value of the friction does not vary with speed.

2. Which type of friction can vary in value (sliding or static)?
   a. Static

3. Which type of friction consumes energy (sliding or static)?
   a. Sliding

4. What is the difference between ordered energy and disordered energy?
   a. Ordered energy is “useful.” It can be used to perform work. Disordered energy (usually internal energy) cannot be used to perform work.

5. Explain how roller bearings reduce the amount of energy needed to pull a cart. Be sure to use static and sliding friction in your explanation.
   a. If a wheel is mounted on an axle without a bearing, there is sliding friction between the inside of the wheel and the axle. This wastes energy. If a roller bearing is present, it almost eliminates the sliding friction and only static friction is present (which does not consume energy).