UNIT 5 Review

Knowledge/Understanding

Multiple Choice

In your notebook, write the letter of the best answer for each of the following questions.

1. If action and reaction forces are always equal and opposite then why do objects move at all?
   (a) one object has more mass than the other object
   (b) the forces act on different objects
   (c) the reaction forces take over since the action forces acted first
   (d) the reaction force is slower to react because of inertia
   (e) the action and reaction forces are not exactly equal
2. The value of g, the acceleration due to gravity is
   (a) the same for all points on the same planet or celestial body
   (b) constant and equal to 6.67×10^{-11} $N \cdot m^2/kg^2$
   (c) varies with altitude
   (d) the same for all planets in one solar system
3. Which of the following statements is *not* one of the simplifying assumptions that you make when solving a problem involving objects connected by ropes or cables?
   (a) The pulley over which a rope or cable runs is considered to be massless.
   (b) The objects connected by a rope or cable are always considered parts of one system.
   (c) The tension is the same throughout the rope or cable.
   (d) The mass of the rope or cable is so small that it does not affect the motion of the objects.
4. Which of the following is *not* true of inelastic collisions.
   (a) Total energy is conserved.
   (b) Kinetic energy is conserved.
   (c) Momentum is conserved.
   (d) Momentum is conserved in each dimension.
5. An astronaut in an orbiting spacecraft is said to be weightless because
   (a) no force of gravity is exerted on the astronaut
   (b) the spacecraft exerts a force opposite to Earth's gravity and acts to suspend the astronaut
   (c) the astronaut and the spacecraft are both in free fall
   (d) the astronaut wears a special gravity-resistant spacesuit
   (e) there is no air resistance in the region where the astronaut is orbiting
6. Two mass and spring systems, A and B, oscillate with periods T_A and T_B. If the force constants of the two springs are equal and $T_A = 2\ T_B$, how are the masses, m_A and m_B, related?
   (a) $m_A = m_B/2$
   (b) $m_A = 2\ m_B$
   (c) $m_A = 4\ m_B$
   (d) $m_A = m_B/4$
   (e) $m_A = m_B$

Short Answer

7. If you throw a ball against a wall, which of the three impulses is the greatest: throw, bounce, or catch?
8. How is it possible for an object to obtain a larger impulse from a smaller force than from a larger force?
9. **(a)** Describe the differences between solving problems for elastic and inelastic collisions.
   (b) How can you tell whether a collision is elastic or not?
   (c) What happens to the kinetic energy of each object in an elastic collision?
10. A football is kicked into the air. Where in its trajectory is the velocity at a minimum? Where is it at a maximum?
11. A bright orange ball is dropped from a hot-air balloon that is travelling with a constant velocity.
    (a) Draw a sketch of the path the ball will travel from the perspective of a person standing on the ground from the instant in time at which the ball was dropped until the instant it lands.
    (b) From the ground, what type of motion is observed in the horizontal dimension? Identify the mathematical equations that can be used to model this motion.

(c) From the ground, what type of motion is observed in the vertical dimension? Identify the mathematical equations that can be used to model this motion.
(d) Identify the variable that is common to the equations that describe the horizontal motion and those that describe the vertical motion.
(e) Describe, with the aid of sketches, how motion on a plane can be modelled by considering its component motion along two directions that are perpendicular to each other.

12. Use the equation for the range of a symmetrical trajectory, $R = \frac{v_i^2 \sin 2\theta}{g}$, to determine the angle that will give the maximum range for a given initial velocity.

13. Explain the meaning of the terms *radial* and *tangential* as they apply to circular motion. Why are they useful concepts for working with circular motion?

14. Distinguish between periodic motion and simple harmonic motion.

15. Why is simple harmonic motion sometimes referred to as sinusoidal motion?

16. Why was it acceptable to conclude that the motion of a mass oscillating on the end of a spring the same as the motion of the shadow of a marker that is moving with uniform circular motion?

17. Define the term restoring force.

Inquiry

18. A wooden T-bar attached to a cable is used at many ski hills to tow skiers and snowboarders up the hill in pairs. Design a T-bar lift for a ski hill. Estimate how much tension the cable for an individual T-bar should be able to withstand, assuming that it transports two adults, the slope is 10.0˚, and the T-bar cable pulls the people at an angle of 25.0˚ to the slope. Determine how the tension is affected when the steepness of the slope, the angle of the T-bar cable to the slope, or the coefficient of friction of the snow changes.

19. Examine three different ways of suspending signs (for example, for stores) in front of buildings or above sidewalks by using cables or rods (that is, the sign is not attached directly to the building). Determine which method can support the heaviest sign.

20. Review the meaning of the kinematics equations for constant acceleration by deriving them for yourself. Begin with the following situation. In a time interval, Δt, a car accelerates uniformly from an initial velocity, v_i, to a final velocity, v_f. Sketch the situation in a velocity-versus-time graph. By determining the slope of the graph and the area under the graph (Hint: What quantities do these represent?), see how many of the kinematics equations you can derive.

21. The total momentum vector of a projectile is tangent to its path. This vector changes in magnitude and direction due to the force of gravity.
(a) Sketch the path of a projectile and draw momentum vectors at several points along the path.
(b) The equation $\vec{F} = \Delta\vec{p}/\Delta t$ indicates that a change in momentum is evidence of a net force. Draw vectors that show the change in momentum at several points on the path and thus indicate the direction of the net force. (Neglect air resistance.) Discuss your result.

22. Consider the motion of a highly elastic rubber ball bouncing up and down on an elastic steel plate, always returning to the same height from which it fell. Set a frame of reference so that you can describe the ball's motion. Does the ball's velocity change smoothly or abruptly at its peak altitude and during impact? Sketch a graph of the displacement of the ball versus time. Is the ball undergoing simple harmonic motion? Explain.

23. Explain whether you could put a satellite in an orbit that kept it stationary over the North or South Pole.

Communication

24. Design a section of a new roller coaster and create a schematic diagram of a roller coaster car, with people in it, at several locations on this section. For each location, draw a free body diagram of the forces acting on the car. Based on this, make some safety recommendations for the structural engineer to consider.
25. A jet engine intakes air in the front and mixes it with fuel. The mixture burns and is exhausted from the rear of the engine. Use the concept of momentum to explain how this process results in a force on the airplane that is directed forward.
26. Explain the difference between g and G.
27. Suppose you could place a satellite above Earth's atmosphere with a gigantic crane. In which direction would the satellite travel when the crane released it? Explain your answer.
28. Explain why the kinematics equations, which describe the motion of an object that has constant acceleration, cannot be applied to uniform circular motion.

Making Connections

29. Choose an Olympic sport and estimate the magnitude of realistic accelerations and forces involved in the motion. For example, approximately how fast do Olympic athletes accelerate during the first 10 m of the 100 m dash? What average force is applied during this time? What average force do shot-putters exert on the shot-put as they propel it? How does this compare to the force exerted by discus throwers?
30. Tycho Brahe built two observatories and had his assistants observe the same things independently. He also repeated observations in order to understand his errors. He is recognized as the greatest astronomical observer prior to development of the telescope. Research the contribution he made to observational astronomy and the role his methods played in developing the scientific method.
31. Volcanoes on Mars, such as Olympus Mons, are much taller than those on Earth. Compare the sizes of volcanoes on different bodies in the solar system and discuss the role that gravity plays in determining the size of volcanoes.
32. When Robert Goddard first proposed sending a rocket to the Moon early in the twentieth century, he was ridiculed in the newspapers. People thought that the rocket would have nothing to push against in the vacuum of space and therefore could not move.
    - **(a)** How does a rocket move?
    - **(b)** Contrast the rocket's motion with the motion produced by a propeller or a wheel.
    - **(c)** A rocket can be considered to represent a case of the inverse of an inelastic collision. Explain this statement.
    - **(d)** Develop three analogies that could help explain rocket motion.
    - **(e)** To test his idea, Goddard set up a pistol in a bell jar from which the air had been evacuated and fired a blank cartridge. What do you think happened?

Problems for Understanding

33. A tug-of-war has started over a popular toy. One child pulls with a force of 2.0×10^1 N[W], a second child pulls with a force of 15 N[N] and a third child pulls with a force of 4.0×10^1 N[E30°S]. Calculate the net force on the toy.
34. A 1.2×10^3 kg car is pulled along level ground by a tow rope. The tow rope will break if the tension exceeds 1.7×10^3 N. What is the largest acceleration the rope can give to the car? Assume that there is no friction.
35. Soon after blast-off, the acceleration of the *Saturn* V rocket is 80.0 m/s^2[up].
    - **(a)** What is the apparent weight of a 78.0 kg astronaut during this time?
    - **(b)** What is the ratio of the astronaut's apparent weight to true weight?
36. A 2.5 kg brick is placed on an adjustable inclined plane. If the coefficient of static friction between the brick and the plane is 0.30, calculate the maximum angle to which the plane can be raised before the brick begins to slip.

37. Superman tries to stop a speeding truck before it crashes through a store window. He stands in front of it and extends his arm to stop it. If the force he exerts is limited only by the frictional force between his feet and the ground, and $\mu_s = \mu_k = 1.0$, **(a)** what is the maximum force he can exert? (Let Superman's mass be 1.00×10^2 kg, the truck's mass 4.0×10^4 kg, and the truck's velocity 25 m/s.) **(b)** What is the minimum distance over which he can stop the truck?

38. Two bricks, with masses 1.75 kg and 3.5 kg, are suspended from a string on either side of a pulley. Calculate the acceleration of the masses and the tension in the string when the masses are released. Assume that the pulley is massless and frictionless.

39. A soccer player redirects a pass, hitting the ball toward the goal 21.0 m in front of him. The ball takes off with an initial velocity of 22.0 m/s at an angle of 17.0° above the ground.
   (a) With what velocity does the goalie catch the ball in front of the goal line?
   (b) At what height does the goalie catch the ball?
   (c) Is the ball on its way up or down when it is caught?

40. A Ferris wheel of radius 10.0 m rotates in a vertical circle of 7.0 rev/min. A 45.0 kg girl rides in a car alone. What (vertical) normal force would she experience when she is:
   (a) halfway towards the top, on her way up?
   (b) at the top?
   (c) halfway towards the bottom?
   (d) at the bottom?
   Compare this to her weight in each case.

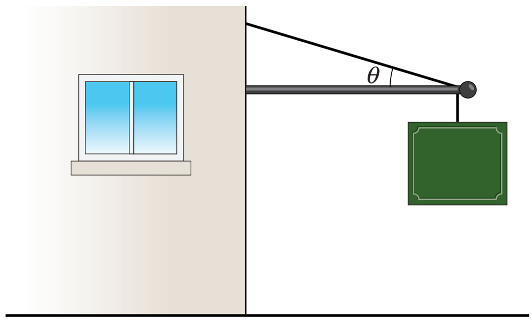
41. Suppose you attach a rope to a 5.0 kg brick and lift it straight up. If the rope is capable of holding a 20.0 kg mass at rest, what is the maximum upward acceleration you can give to the brick?

42. You want to launch a satellite into a circular orbit at an altitude of 16 000 km (above Earth's surface). What orbital speed will it have?

43. **(a)** Calculate your velocity on the surface of Earth (at the equator) due to Earth's rotation.
   (b) What velocity would you require to orbit Earth at this distance? (Neglect air resistance and obstructions.)

44. In 1851, Jean Foucault suspended a pendulum from the ceiling of the Pantheon in Paris to demonstrate the rotation of Earth. If the period of the pendulum was 15.5 s, how long was it?

45. A 36 kg sign hangs from the end of a uniform 24 kg beam with a length of 1.2 m. The beam is perpendicular to the side of a building. A cable supports the beam at an angle θ with the beam, as shown in the figure. If the tension in the cable exceeds 675 N, the cable might break. What is the smallest angle at which the cable will safely support the sign?



46. A 325 g mass oscillates with an amplitude of 15.0 cm on the end of a horizontal spring. The period of the motion is 0.650 s.
   (a) Find the total energy of the spring and mass system.
   (b) Find the maximum velocity of the mass.