Knowledge/Understanding

Multiple Choice:

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

1. An airplane is moving at constant velocity in a straight level flight. What is the <u>net</u> force acting on the plane?
   (a) zero
   (b) upward
   (c) downward
   (d) in the direction of motion
   (e) opposite to the direction of motion

2. A football is thrown by a quarterback to a receiver deep in the end zone. Neglecting friction the acceleration of the football during the flight
   (a) depends on how the ball was thrown
   (b) depends on whether the ball is going up or coming down
   (c) is the same during the entire flight
   (d) is greatest at the top of its trajectory
   (e) is greatest at the beginning and end of its trajectory

3. A ball is thrown upward. After it is released, its acceleration
   (a) is zero
   (b) increases
   (c) decreases
   (d) remains constant
   (e) increases, then decreases

4. A ball of mass m_1 is dropped from the roof of a 10-storey building. At the same instant, another ball of mass m_2 is dropped out of a ninth-storey window, 10 m below the roof. The distance between the balls during the flight
   (a) remains at 10 m throughout
   (b) decreases
   (c) increases
   (d) depends on the ratio m_1/m_2

5. You drop a 1.0 kg stone off the roof of a 10-storey building. Just as the stone passes the fifth floor, your friend drops a 1.0 kg ball out of a fifth-floor window. If air resistance is neglected, which of the following statements is true?

Explain your reasoning.
   (a) The stone and the ball hit the ground at the same time and at the same speed.
   (b) The stone hits the ground first and with a greater speed than the ball does.
   (c) The stone and the ball hit the ground at the same time, but the speed of the stone is greater.
   (d) The ball hits the ground before the stone.

6. A cable on an elevator exerts a 6 k upward force. The downward force of gravity on the elevator is 4 k. The elevator could be
   (a) moving upward with constant speed
   (b) downward with a constant speed
   (c) moving upward with decreasing speed
   (d) moving downward with increasing speed
   (e) moving upward with increasing speed

7. 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

8. A hockey puck and a curling stone are at rest on a sheet of ice. If you apply equal impulses to each of them with a hockey stick
   (a) they will have the same acceleration
   (b) the forces applied were equal
   (c) they apply equal reaction forces to the hockey stick
   (d) they will have the same velocity, but different momenta
   (e) they will have the same momentum but different velocities

Short Answer

In your notebook, write a sentence or short paragraph to answer each of the following questions.

9. What could happen in each of the following situations?

(a) A vehicle tries to come to a stop at a traffic light on an icy street.

(b) A passenger in a car does not have their seat belt on when the driver must make a quick stop.

(c) A student has placed their textbooks in the back window of a car. While driving they have to make a sudden stop to avoid driving through a stop sign.

10. (a) Define what is meant by a *net* or *unbalanced force* acting on an object.

(b) Explain, with the aid of a free-body diagram, how an object can be experiencing no net force when it has at least three forces acting on it.

(c) Describe, with the aid of a free-body diagram, an object that is experiencing a net force. Identify in which direction the object will move and with what type of motion. Relate the direction and type of motion to the direction of the net force.

11. What is a normal force?

12. What is the difference between static and kinetic frictional forces?

13. A child is riding a merry-go-round that is travelling at a constant speed.

(a) Is he viewing the world from an inertial or non-inertial frame of reference? Explain your reasoning.

(b) What type of force does his horse exert on him to keep him travelling in a circle? In which direction does this force act?

(c) In what direction does the child feel that a force is pushing him? Explain why this perceived force is called a "fictitious force."

14. If you throw a ball against a wall, which of the three impulses is the greatest: throw, bounce, or catch?

15. How is it possible for an object to obtain a larger impulse from a smaller force than from a larger force?

Inquiry

16. Design a simple experiment involving the dropping of a coin to test Galileo's ideas of inertia on a train or subway moving with constant velocity. State your hypothesis, and write out a simple procedure. What variables will you need to control? What variable will you measure? If possible, carry out the experiment. What do you conclude?

17. When you stand on your bathroom scales you measure your weight. But what will your scales show if you stand on them in an elevator at the moment when it begins to accelerate up? Down? Design and carry out an experiment to test your hypothesis.

Communication

18. A jet ski moving at 30 km/h on water can make a 90° turn in a very short distance, while a supertanker moving with the same velocity needs a distance of up to 20 kilometers to turn through the same angle. Explain this phenomenon in terms of Newton's First Law.

19. Create a concept map or graphic organizer that links the "derived" SI units for force, velocity, and acceleration, to the "basic" SI units for distance, mass, and time.

20. According to Newton's third law, for every action force, there is an equal and opposite reaction force. How, then, can a team win a tug-of-war contest?

21. Consider a block of wood on an incline. Determine the acceleration of the block and the normal force of the incline on the block for the two extreme cases where $\theta = 0°$ and $\theta = 90°$, and for the general case of $0° < \theta < 90°$. Discuss the results, particularly why an inclined plane could be described as a way of "diluting" gravity. (**Note:** Galileo recognized this.)

22. You probably have a working understanding of mass and velocity, but what about force and acceleration? At what rate can a person accelerate on a bicycle? What average force does a tennis racquet exert on a tennis ball?

(a) Construct examples of everyday situations involving accelerations of approximately 0.5 m/s^2, 2.0 m/s^2, 5.0 m/s^2, and 20 m/s^2.

(b) Construct examples of everyday situations involving forces of 1 N, 10 N, 50 N, 100 N, 1000 N, and 1.0×10^4 N.

23. A ball rolls down an inclined plane, across a horizontal surface, and then up another inclined plane. Assume there is no friction.

(a) What forces act on the ball at the beginning, middle, and end of its roll?

(b) If the angles of the inclined planes are equal and the ball begins its roll from a vertical height of 10 cm, how high will the ball roll up the second inclined plane?

(c) If the first inclined plane is twice as steep as the second and the ball begins its roll from a vertical height of 10 cm, to what height will the ball roll up the second inclined plane?

(d) If the ball begins its roll from a vertical height of 10 cm on the first inclined plane and the second inclined plane is removed, how far will the ball roll across the horizontal surface?

24. To bunt a baseball effectively, at the instant the ball strikes the bat, the batter moves the bat in the same direction as the moving baseball. Explain what effect this action has.

25. You drop a dish from the table. Explain whether the impulse will be less if the dish lands on a carpet instead of a bare floor.

Making Connections

26. How has tire manufacturing technology impacted transportation?

27. In automobiles, antilock braking systems were developed to slow down a car without letting the wheels skid and thus reduce the stopping distance, as compared to a braking system in which the wheels lock and skid. Explain the physics behind this technology, using the concepts of static friction and kinetic friction. Develop and solve a problem that demonstrates this situation. In which case, stopping without skidding or stopping with skidding, do you use the coefficient of kinetic friction and in which case do you use the coefficient of static friction?

28. Aristotle's theory of dynamics differed from Newton's and Galileo's theories partly because Aristotle tried to develop common sense explanations for real-life situations, whereas Newton and Galileo imagined ideal situations and tested them by experiment. Outline in an essay the differences in these two approaches and their results.

Problems for Understanding

Show complete solutions for all problems that involve equations and numbers.

29. An object weighs 78.3 N on the Moon. How much does it weigh on

(a) Earth   **(b)** Mars   **(c)** Jupiter

30. You are moving a 95 kg wood crate across a wood floor.

(a) What is the magnitude of the force with which you must push to start the crate moving?

(b) After it starts moving, how hard must you push to keep it moving at a constant velocity?

31. Imagine that you are on a Moon base. Solve problem number 30 above for the conditions on the Moon.

32. A hockey stick exerts a force of 575 N[E] on a 0.125 kg hockey puck. What is the acceleration of the puck?

33. An applied force with a magnitude of 335 N is required to push a chair across a living room with an acceleration of 0.722 m/s^2. If the coefficient of kinetic friction between the chair and the floor is 0.330, what is the mass of the chair?

34. Three children pull a sled loaded with logs by tying ropes to the sled. Angie pulls with a force of 7.3 N[E25.0°N], Sean pulls with a force of 9.2 N[E], and Sid pulls with a force of 8.8 N[E20.6°S]. The friction between the sled and the snow is negligible. If the mass of the load is 192 kg , what is the velocity of the sled after 3.50 s? Use scale diagrams in your solution.

35. A toboggan is being pulled with an applied force that is at an angle of 30° to the horizontal.
  (a) Draw a free-body diagram to illustrate all the forces acting on the toboggan.
  (b) Predict the motion of the toboggan if the horizontal component of the applied force is greater than the frictional force.
  (c) Predict the motion of the toboggan if the horizontal component of the applied force is equal to the frictional force.
  (d) Predict the motion of the toboggan if the horizontal component of the applied force is less than the frictional force.

36. A parachutist jumps from a plane and falls faster and faster through the air. At one point in time her acceleration is 8.0 m/s^2 [down]. If she has a mass of 65 kg, calculate the force of air resistance that is acting opposite to her motion.

37. Two objects, m_1 and m_2, are accelerated independently by forces of equal magnitude. Object m_1 accelerates at 10.0 m/s^2 and m_2 at 20.0 m/s^2. What is the ratio of **(a)** their inertial masses? **(b)** their gravitational masses?

38. A 1500 kg car stands at rest on a hill that has an incline of 15°. If the brakes are suddenly released, describe the dynamics of the car's motion by calculating the following: **(a)** the car's weight, **(b)** the component of the weight parallel to the incline, **(c)** the car's acceleration, **(d)** the velocity acquired after travelling 100.0 m (in m/s and km/h), and **(e)** the time for the car to travel 100.0 m.

39. How much force is needed to push a 75.0 kg trunk at constant velocity across a floor, if the coefficient of friction between the floor and the crate is 0.27?

40. A car can accelerate from rest to 100 km/h (1.00×10^2 km/h) in 6.0 s. If its mass is 1.5×10^3 kg, what is the magnitude and direction of the applied force?

41. A 62.4 kg woman stands on a scale in an elevator. What is the scale reading (in newtons) for the following situations.
  (a) The elevator is at rest.
  (b) The elevator has a downward acceleration of 2.80 m/s^2.
  (c) The elevator has an upward acceleration of 2.80 m/s^2.
  (d) The elevator is moving upward with a constant velocity of 2.80 m/s.

42. (a) If you want to give an 8.0 g bullet an acceleration of 2.1×10^4 m/s^2, what average net force must be exerted on the bullet as it is propelled through the barrel of the gun?
  (b) With this acceleration, how fast will the bullet be travelling after it has moved 2.00 cm from rest?

43. A 1575 kg car is pulling a 982 kg trailer. If the car and trailer are accelerating at 1.07 m/s^2 west, what force is the road exerting on the wheels of the car? What force does the trailer hitch exert on the trailer?

44. A 1400 kg car travels north at 25 m/s. What is its momentum?

45. What impulse is needed to stop the following?
  (a) 150 g baseball travelling at 44 m/s
  (b) 5.0 kg bowling ball travelling at 8.0 m/s
  (c) 1200 kg car rolling forward at 2.5 m/s

46. A 0.80 kg ball travelling at 12 m/s[N] strikes a wall and rebounds at 9.5 m/s[S]. The impact lasts 0.065 s.
  (a) What was the initial momentum of the ball?
  (b) What was the change of momentum of the ball?
  (c) What was the impulse on the wall?
  (d) What was the average force acting on the wall?
  (e) What was the average force acting on the ball?

47. A tennis player smashes a serve so that the racquet is in contact with the ball for 0.055 s, giving it an impulse of 2.5 N·s.
  (a) What average force was applied during this time?
  (b) Assume that the vertical motion of the ball can be ignored. If the ball's mass is 0.060 kg, what will be the ball's horizontal velocity?