4.2 Inertia and Newton's First Law of Motion

1. **MC** Mass is related to an object's (a) weight, (b) inertia, (c) density, (d) all of the preceding. (d)

2. **MC** A force (a) always produces motion, (b) is a scalar quantity, (c) is capable of producing a change in motion, (d) both a and b. (c)

3. **MC** If an object is moving at constant velocity, (a) there must be a force in the direction of the velocity, (b) there must be no force in the direction of the velocity, (c) there must be no net force, (d) there must be a net force in the direction of the velocity. (c)

4. **MC** If the net force on an object is zero, the object could (a) be at rest, (b) be in motion at a constant velocity, (c) have zero acceleration, (d) all of the preceding. (d)

5. **MC** The force required to keep a rocket ship moving at a constant velocity in deep space is (a) equal to the weight of the ship, (b) dependent on how fast the ship is moving, (c) equal to that generated by the rocket's engines at half power, (d) zero. (d)

8. **CQ** An object weighs 300 N on Earth and 50 N on the Moon. Does the object also have less inertia on the Moon? no, same mass, same inertia

13. ● A net force of 4.0 N gives an object an acceleration of 10 m/s^2. What is the mass of the object? 0.40 kg

14. ● Two forces act on a 5.0-kg object sitting on a frictionless horizontal surface. One force is 30 N in the $+x$-direction, and the other 35 N in the $-x$-direction. What is the acceleration of the object? -1.0 m/s^2

18. ●● A 5.0-kg block at rest on a frictionless surface is acted on by forces $F_1 = 5.5 \text{ N}$ and $F_2 = 3.5 \text{ N}$, as illustrated in ▼ Fig. 4.28. What additional force will keep the block at rest? $\vec{\mathbf{F}}_3 = (-7.6 \text{ N})\hat{\mathbf{x}} + (0.64 \text{ N})\hat{\mathbf{y}}$

22. **IE** ●●● Three horizontal forces (the only horizontal ones) act on a box sitting on a floor. One (call it F_1) acts due east and has a magnitude of 150 lb. A second force (call it F_2) has an easterly component of 30.0 lb and a southerly component of 40.0 lb. The box remains at rest. (Neglect friction.) (a) Sketch the two known forces on the box. In which quadrant is the unknown third force: (1) the first quadrant; (2) the second quadrant; (3) the third quadrant; or (4) the fourth quadrant? (b) Find the unknown third force in newtons and compare your answer to the sketched estimate. (a) (2) the second quadrant (b) $F_3 = 184 \text{ N}$ at 12.5° above $-x$ axis

4.3 Newton's Second Law of Motion

23. **MC** The newton unit of force is equivalent to (a) $\text{kg}\cdot\text{m/s}$, (b) $\text{kg}\cdot\text{m/s}^2$, (c) $\text{kg}\cdot\text{m}^2/\text{s}$, (d) none of the preceding. (b)

24. **MC** The acceleration of an object is (a) inversely proportional to the acting net force, (b) directly proportional to its mass, (c) directly proportional to the net force and inversely proportional to its mass, (d) none of these. (c)

25. **MC** The weight of an object is directly proportional to (a) its mass, (b) its inertia, (c) the acceleration due to gravity, (d) all of the preceding. (d)

39. ●● When a horizontal force of 300 N is applied to a 75.0-kg box, the box slides on a level floor, opposed by a force of kinetic friction of 120 N. What is the magnitude of the acceleration of the box? 2.40 m/s^2

45. ●●● A car is skidding out of control on a horizontal icy (frictionless) road. It has a mass of 2000 kg and it is headed directly at Lois Lane at a speed of 45.0 m/s. When the car is 200 m from her, Superman begins to exert a steady force on the car, F, relative to the horizontal with a magnitude of $1.30 \times 10^4 \text{ N}$ (he's a strong dude) at a downward angle of 30°. Was Superman correct? Was this force enough to stop the car before hitting Lois? Lois is saved

4.4 Newton's Third Law of Motion

46. **MC** The action and reaction forces of Newton's third law (a) are in the same direction, (b) have different magnitudes, (c) act on different objects, (d) can be the same force. (c)

47. **MC** A brick hits a glass window. The brick breaks the glass, so (a) the magnitude of the force of the brick on the glass is greater than the magnitude of the force of the glass on the brick, (b) the magnitude of the force of the brick on the glass is smaller than the magnitude of the force of the glass on the brick, (c) the magnitude of the force of the brick on the glass is equal to the magnitude of the force of the glass on the brick, (d) none of the preceding. (c)

48. **MC** A freight truck collides head-on with a passenger car, causing a lot more damage to the car than to the truck. From this condition, we can say that (a) the magnitude of the force of the truck on the car is greater than the magnitude of the force of the car on the truck, (b) the magnitude of the force of the truck on the car is smaller than the magnitude of the force of the car on the truck, (c) the magnitude of the force of the truck on the car is equal to the magnitude of the force of the car on the truck, (d) none of the preceding. (c)

49. **CQ** Here is a story of a horse and a farmer: One day, the farmer attaches a heavy cart to the horse and demands that the horse pull the cart. “Well,” says the horse, “I cannot pull the cart, because, according to Newton’s third law, if I apply a force to the cart, the cart will apply an equal and opposite force on me. The net result will be that I cannot pull the cart, since all the forces will cancel. Therefore, it is impossible for me to pull this cart.” The farmer was very upset! What could he say to persuade the horse to move? the forces on different objects (one on horse, one on cart) cannot cancel

54. ●● Jane and John, with masses of 50 kg and 60 kg, respectively, stand on a frictionless surface 10 m apart. John pulls on a rope that connects him to Jane, giving Jane an acceleration of 0.92 m/s^2 toward him. (a) What is John’s acceleration? (b) If the pulling force is applied constantly, where will Jane and John meet? (a) 0.77 m/s^2 toward Jane (b) 4.5 m from John’s original position

55. **IE** ●●● During a daring rescue, a helicopter rescue squad initially accelerates a little girl (mass 25.0 kg) vertically off the roof of a burning building. They do this by dropping a rope down to her, which she holds onto as they pull her up. Neglect the mass of the rope. (a) What force causes the girl to accelerate vertically upward: (1) Her weight; (2) the pull of the helicopter on the rope; (3) the pull of the girl on the rope; or (4) the pull of the rope on the girl? (b) Determine the pull of the rope (the tension) if she initially accelerates at $a_y = +0.750 \text{ m/s}^2$. (a) (4) the pull of the rope on the girl (b) 264 N

4.5 More on Newton’s Laws: Free-Body Diagrams and Translational Equilibrium

56. **MC** The kinematic equations of Chapter 2 can be used (a) only with constant forces, (b) only with constant velocities, (c) with variable accelerations, (d) all of the preceding. (a)

57. **MC** The condition(s) for translational equilibrium is (are) (a) $\sum F_x = 0$, (b) $\sum F_y = 0$, (c) $\sum \vec{\mathbf{F}}_i = 0$, (d) all of the preceding. (d)

65. ●● (a) A 75-kg water skier is pulled by a boat with a horizontal force of 400 N due east with a water drag on the skis of 300 N. A sudden gust of wind supplies another horizontal force of 50 N on the skier at an angle of 60° north of east. At that instant, what is the skier’s acceleration? (b) What would be the skier’s acceleration if the wind force were in the opposite direction to that in part (a)? (a) 1.7 m/s^2 at 19° north of east (b) 1.2 m/s^2 at 30° south of east

73. **IE** ●● A rope is fixed at both ends on two trees and a bag is hung in the middle of the rope (causing the rope to sag vertically). (a) The tension in the rope depends on (1) only the tree separation, (2) only the sag, (3) both the tree separation and sag, (4) neither the tree separation nor the sag. (b) If the tree separation is 10 m, the mass of the bag is 5.0 kg, and the sag is 0.20 m, what is the tension in the line? (a) (3) both the tree separation and sag (b) 6.1×10^2 N

80. ●● The *Atwood machine* consists of two masses suspended from a fixed pulley, as shown in ▸ Fig. 4.36. It is named after the British scientist George Atwood (1746–1807), who used it to study motion and to measure the value of *g*. If $m_1 = 0.55$ kg and $m_2 = 0.80$ kg, (a) what is the acceleration of the system, and (b) what is the magnitude of the tension in the string? (a) 1.8 m/s^2 (b) 6.4 N

83. **IE** ●●● Two blocks are connected by a light string and accelerated upward by a pulling force F. The mass of the upper block is 50.0 kg and that of the lower block is 100 kg. The upward acceleration of the system as a whole is 1.50 m/s^2. Neglect the mass of the string. (a) Draw the free-body diagram of each block. Use the diagrams to determine which of the following is true for the magnitude of the string tension T compared to other forces: (1) $T > w_2$ and $T < F$; (2) $T > w_2$ and $T > F$; (3) $T < w_2$ and $T < F$; or (4) $T = w_2$ and $T < F$? (b) Apply Newton’s laws to find the required pull, *F*. (c) Find the tension in the string, *T*. (a) (1)

4.6 Friction

87. **MC** In general, the frictional force (a) is greater for smooth than rough surfaces, (b) depends on sliding speeds, (c) is proportional to the normal force, (d) depends significantly on the surface area of contact. (c)

88. **MC** The coefficient of kinetic friction, μ_k, (a) is usually greater than the coefficient of static friction, μ_s; (b) usually equals μ_s; (c) is usually smaller than μ_s; (d) equals the applied force that exceeds the maximum static force. (c)

89. **MC** A crate sits in the middle of the bed of a flatbed truck. The driver accelerates the truck gradually from rest to a normal speed, but then has to make a sudden stop to avoid hitting a car. If the crate slides as the truck stops, the frictional force would be (a) in the forward direction, (b) in the backward direction, (c) zero. (b)

and $T < F$ (b) 1.70×10^3 N (c) 1.13×10^3 N

90. **CQ** Identify the direction of the friction force in the following cases: (a) a book sitting on a table; (b) a box sliding on a horizontal surface; (c) a car making a turn on a flat road; (d) the initial motion of a machine part delivered on a conveyor belt in an assembly line. (a) no friction (b) opposite its direction of velocity (c) sideways (d) forward, in direction of velocity

100. ●● A 1500-kg automobile travels at 90 km/h along a straight concrete highway. Faced with an emergency situation, the driver jams on the brakes, and the car skids to a stop. What will be the car's stopping distance for (a) dry pavement and (b) wet pavement? (a) 38 m (b) 53 m

101. ●● A hockey player hits a puck with his stick, giving the puck an initial speed of 5.0 m/s. If the puck slows uniformly and comes to rest in a distance of 20 m, what is the coefficient of kinetic friction between the ice and the puck? 0.064

111. ●●● If the coefficient of kinetic friction between the block and the table in Fig. 4.35 is 0.560, and $m_1 = 0.150 \text{ kg}$ and $m_2 = 0.250 \text{ kg}$, (a) what should m_3 be if the system is to move with a constant speed? (b) If $m_3 = 0.100 \text{ kg}$, what is the magnitude of the acceleration of the system? (a) 0.179 kg (b) 0.862 m/s^2

Comprehensive Exercises

117. A 5.00-kg block (*M*) on a 30° incline is connected by a light string over a frictionless pulley to an unknown mass, *m*. The coefficient of kinetic friction between the block and the incline is 0.100. When the system is released from rest, mass *m* accelerates upward at 2.00 m/s^2. Determine (a) the string tension and (b) the value of *m*. (a) 10.3 N (b) 0.954 kg