**Forces Practice**

**Multiple Choice**

*Identify the choice that best completes the statement or answers the question.*

\_\_\_\_ 1. The example of a book falling off of a table shows a(n) \_\_\_\_\_.

|  |  |  |  |
| --- | --- | --- | --- |
| a. | contact force | c. | absence of acceleration |
| b. | scalar quantity | d. | field force |

\_\_\_\_ 2. In a free body diagram, the force arrows always point \_\_\_\_\_.

|  |  |  |  |
| --- | --- | --- | --- |
| a. | away from the particle | c. | both toward and away from the particle |
| b. | toward the particle | d. | at right angles to each other |

\_\_\_\_ 3. Which of the following is not true about a free body diagram?

|  |  |
| --- | --- |
| a. | All forces point away from the particle. |
| b. | The arrows are proportional to the size of the forces. |
| c. | The system is represented by a particle model. |
| d. | You always know the magnitude of the forces ahead of time. |

\_\_\_\_ 4. Which of the following is NOT true?

|  |  |
| --- | --- |
| a. | The force on an object is equal to the mass of the object multiplied by the acceleration. |
| b. | The force exerted on an object is related in a linear fashion to the acceleration of the object. |
| c. | An object moving at constant velocity always has a force acting on it. |
| d. | An object moving with constant acceleration always has a force acting on it. |

\_\_\_\_ 5. Which of the following does NOT represent Newton’s second law?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | a = m/F | c. | F = ma |
| b. | m = F/a | d. | a = F/m |

\_\_\_\_ 6. When an object is in equilibrium, the net force is \_\_\_\_\_.

|  |  |  |  |
| --- | --- | --- | --- |
| a. | zero | c. | negative |
| b. | positive | d. | changing |

\_\_\_\_ 7. When the drag force on an object falling through the air equals the force of gravity, the object has reached

|  |  |  |  |
| --- | --- | --- | --- |
| a. | terminal force. | c. | terminal illness. |
| b. | terminal acceleration. | d. | terminal velocity. |

\_\_\_\_ 8. “ FA on B = -FB on A” is an expression of

|  |  |  |  |
| --- | --- | --- | --- |
| a. | Newton’s first law | c. | Newton’s third law |
| b. | Newton’s second law | d. | Fig Newton’s law |

\_\_\_\_ 9. Tension refers to

|  |  |  |  |
| --- | --- | --- | --- |
| a. | the force exerted by a string. | c. | dynamic displacement. |
| b. | terminal velocity. | d. | free fall. |

\_\_\_\_ 10. The normal force (FN) refers to

|  |  |
| --- | --- |
| a. | the parallel contact force exerted by a surface on another object. |
| b. | the perpendicular contact force exerted by a surface on another object. |
| c. | the perpendicular tension exerted by a surface on a rope. |
| d. | the parallel acceleration of a body at terminal velocity. |

\_\_\_\_ 11. A weight is hung from the ceiling of an elevator by a massless string. Under which circumstances will the tension in the cord be the greatest?

|  |  |
| --- | --- |
| a. | The elevator rises with decreasing speed. |
| b. | The elevator rises with increasing speed. |
| c. | The elevator is at rest. |
| d. | The elevator descends with increasing speed. |

\_\_\_\_ 12. A weight is hung from the ceiling of an elevator by a massless string. Under which circumstances will the tension in the cord be the smallest?

|  |  |
| --- | --- |
| a. | The elevator is at rest. |
| b. | The elevator rises with increasing speed. |
| c. | The elevator descends with decreasing speed. |
| d. | The elevator descends with increasing speed. |

\_\_\_\_ 13. Which graph best describes the movement of an object on which no net force is exerted?

|  |  |  |  |
| --- | --- | --- | --- |
| a. |  | c. |  |
| b. |  | d. |  |

\_\_\_\_ 14. The relationship between force and acceleration is

|  |  |  |  |
| --- | --- | --- | --- |
| a. | direct linear. | c. | direct quadratic. |
| b. | inverse linear. | d. | inverse quadratic. |

\_\_\_\_ 15. A 6.0-kg wooden block is pulled across a carpet with a force of *F* = 36 N. The block begins at rest and accelerates to a velocity of 0.25 m/s in 0.50 s. What is the force of friction acting on the block?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | 3.0 N | c. | 36 N |
| b. | 33 N | d. | 39 N |

\_\_\_\_ 16. A 1500-kg car can accelerate from rest to 72 km/h in 8.0 s. What is the net force acting on the car to cause this acceleration?

|  |  |  |  |
| --- | --- | --- | --- |
| a. | 3.8 kN | c. | 15 kN |
| b. | 14 kN | d. | 240 kN |

**Short Answer**

Identify the system, forces, and agents in each situation.

 17. A bird egg falls freely from a nest.

 18. A UNICEF care package falls through the air.

 19. A tow truck uses a cable to pull a car onto the flat bed of the tow truck.

 20. A piano is hoisted up into an apartment via a cable winch.

 21. You are a skydiving physicist. During a dive, you observe that two unequal masses hung over a pulley remain balanced, that is, there is no tendency for the pulley to turn. What conclusions can you draw?

**Problem**

 22. A car of mass 1330 kg is traveling at 28.0 m/s. The driver applies the brakes to bring the car to rest over a distance of 79.0 m. Calculate the retarding force acting on the car.

 23. Two men pull a 31-kg box with forces 9.7 N and 7.6 N in the directions shown below. Find the resultant acceleration of the box and the direction in which the box moves.



 9.7 N 7.6 N

 24. Raindrops fall on Brian’s head at the rate of 4 drops per second. Each raindrop has a mass of 1.6 mg and falls with a speed of 25 m/s. Assuming that on making contact with Brian’s head the drops come to rest and do not rebound, calculate the force felt by Brian.

 25. A force of 5 N is the only force exerted on a sled on a slippery driveway. The acceleration is measured to be A. When the same force is exerted on a second sled, the acceleration is 1/4 A. What can you conclude about the masses of the two sleds?

 26. Derive Fg = mg from F = ma and explain your reasoning.

 27. Three crates of fruit are stacked on top of each other. The bottom crate contains apples and has a mass of 25.0 kg. The middle crate contains oranges and has a mass of 20.0 kg. The top crate contains strawberries and has a mass of 10 kg.

Identify and calculate any normal forces on the orange crate.

 28. Little Georgie Atwood was playing with his blocks and some massless string. He connected the first block with mass M1 on one end of the string, put the string over a frictionless pulley, and attached the other block with mass M2 on the other end of the string.

Draw a free body diagram that shows the forces acting on each block when .

 29. An Eskimo pushes a loaded sled with a mass of 300 kg for a distance of 25 m over the frictionless surface of hard-packed snow. He exerts a constant 170 N force as he does so. If the sled starts from rest, what is its final velocity?

 30. A mouse pushes a piece of cheese with a mass of 6.4 g for a distance of 75 cm over the frictionless surface of an air hockey table. He exerts a constant 0.5 N force as he does so. If the cheese starts from rest, what is its final velocity?

 31. A sky diver with a mass of 75.0 kg jumps out of an airplane as part of a local air show.

a. Calculate the drag force on the sky diver when she reaches her terminal velocity.

b. Each cord connecting the sky diver and her parachute is rated to hold up to 105 N of tension. How many cords must the parachute have in order to ensure safe operation when the sky diver opens the parachute after she reaches terminal velocity?

c. Upon opening, the parachute pulls upward on the sky diver with a force of 550 N. What is the sky diver’s acceleration with the open parachute? Neglect the mass of the parachute.

**Essay**

 32. How would you approach a motion problem that deals with changing acceleration?

 33. When riding in an elevator, why does a person appear to lose weight when accelerating downward?

 34. Laika the dog was the first animal from Earth to enter space, and was sent into orbit by the Soviet Union in 1957. Using words and mathematical formulas, describe what happened to Laika’s apparent weight during take-off, while in orbit 2100 km above Earth (g = 5.499 m /s2). What happened to her mass?

 35. Consider Newton’s second law. Describe an experiment that would verify this law.

 36. When riding on a subway, why would it be convenient to face to the side of the car when the train is stopping or starting, and to face the front or the rear when the train is running at constant speed?

 37. Your six-year-old nephew is asked to pull his sled up the hill. He refuses to try, citing Newton’s third law in his own defense: His pull on the sled is equal but opposite to the pull of the sled on him. “If I can never exert a greater force on the sled than it exerts on me, how can I ever start the sled moving?” How would you reply?

 38. A person’s mass is 60 kg. He or she is standing on a bathroom scale in an elevator. Starting from rest, the elevator accelerates downward at 3 m/s for 2 s and then continues at constant speed. Is the scale reading during acceleration greater than, equal to, or less than the scale reading when the elevator is at rest?

 39. There are many Hollywood movies which show a hero or a villain running, jumping, or riding a motorcycle through big plate glass windows without apparent injury. Why is this an incredible violation of Newton’s laws?

**Forces Practice**

**Answer Section**

**MULTIPLE CHOICE**

 1. ANS: D

A field force causes the book to fall.

PTS: 1 DIF: Bloom’s Level 2 REF: p. 88

NAT: B.4

 2. ANS: A

The force arrows of a free-body diagram always point away from the particle.

PTS: 1 DIF: Bloom’s Level 2 REF: p. 89

NAT: B.4

 3. ANS: D

You do not always know the magnitude of the forces ahead of time for a free-body diagram.

PTS: 1 DIF: Bloom’s Level 2 REF: p. 89

NAT: B.4

 4. ANS: C

An object moving at a constant velocity has no net force acting on it.

PTS: 1 DIF: Bloom’s Level 2 REF: pp. 90-94

NAT: B.4

 5. ANS: A

Newton’s second law is F = ma, a = F/m, or m = F/a.

PTS: 1 DIF: Bloom’s Level 2 REF: p. 93

NAT: B.4

 6. ANS: A

The net force on an object in equilibrium is zero.

PTS: 1 DIF: Bloom’s Level 2 REF: p. 92

NAT: B.4

 7. ANS: D

An object reaches terminal velocity when the drag force equals the gravitational force on the object.

PTS: 1 DIF: Bloom’s Level 2 REF: pp. 100-101

NAT: B.4

 8. ANS: C

Newton’s third law states that every force of A on B has an equal and opposite force of B on A.

PTS: 1 DIF: Bloom’s Level 1 REF: pp. 102-103

NAT: B.4

 9. ANS: A

The force exerted by a string or rope is called tension.

PTS: 1 DIF: Bloom’s Level 1 REF: p. 105

NAT: B.6

 10. ANS: B

The perpendicular contact force exerted by a surface on another object is called the normal force.

PTS: 1 DIF: Bloom’s Level 1 REF: p. 107

NAT: B.4

 11. ANS: B

The tension in the cord will be greatest if the cord is accelerating the elevator upward.

PTS: 1 DIF: Bloom’s Level 4 REF: p. 98

NAT: B.4

 12. ANS: D

The tension in the cord will be greatest if the cord allows the elevator to accelerate downward.

PTS: 1 DIF: Bloom’s Level 4 REF: p. 98

NAT: B.4

 13. ANS: D

**Explanation**

If no net force is exerted on an object, its acceleration will be zero. Graph D, which shows position increasing at a constant rate—that is, shows a constant velocity—is the only one that shows zero acceleration. In graph A, the slope of the position-time graph is changing, so the velocity is increasing; the acceleration is nonzero. Graph B shows a constant acceleration, but it does not show zero acceleration. Graph C shows a constantly increasing acceleration.

PTS: 1

 14. ANS: A

**Explanation**

Newton’s second law of motion states that *F* = *ma*, where *F* is force, *m* is mass, and *a* is acceleration. It can be rewritten as . This is a variation on *y* = *bx*, which describes a direct linear relationship between *y* and *x*. When graphed, *a* versus *F* is a straight line with a positive slope.

PTS: 1

 15. ANS: B

**Rationale**

a. net force on the block

b. correct answer

c. applied force exerted on the block

d. applied force + net force

**Explanation**

The force of friction *F*friction can be calculated using the equation

*F*net = *F*applied – *F*friction (friction is opposite from the direction of motion).

This equation can be rearranged to solve for the force of friction:

*F*friction = *F*applied – *F*net

Given

*F*applied = 36 N

*m* = 6.0 kg

To calculate Fnet, we first need to find *a*:



where *v*f = final velocity, *v*i = initial velocity, *t*f = final time, *t*i = initial time.

Given

*v*f = 0.25 m/s

*v*i = 0 m/s (rest)

*t*f = 0.50 s

*t*i = 0 s



Now, calculate the net force on the block:

*F*net = *ma*

= (6.0 kg)(0.50 m/s2)

= 3.0 kg·m/s2

= 3.0 N

Then substitute *F*net into the equation to solve for *F*friction

Ffriction = *F*applied – *F*net

= 36 N – 3.0 N

= 33 N

PTS: 1

 16. ANS: A

Rationale

a. correct answer

b. forgot to convert km/h to m/s

c. used *a* = 9.8 m/s2

d. used *a* = *v*f*t*f

Explanation

Given

*m* = 1500 kg

*v*i = 0 m/s (rest)



= 2.0101 m/s

*t*i = 0 s

*t*f = 8.0 s

First find the acceleration using 



Then use Newton’s second law, *F*net = *ma*, to find *F*net.

*F*net = ma

*F*net = (1500 kg)  (2.5 m/s2)

*F*net = 3800 N, or 3.8 kN

PTS: 1

**SHORT ANSWER**

 17. ANS:

Egg -- system

Gravity & air resistance -- forces

Mass of earth and air molecules -- agents

PTS: 1 DIF: Bloom’s Level 2 REF: p. 88

NAT: B.4

 18. ANS:

Care package -- system

Gravity & air resistance -- forces

Mass of earth and air molecules -- agents

PTS: 1 DIF: Bloom’s Level 2 REF: p. 88

NAT: B.4

 19. ANS:

Car -- system

cable pulling -- force

resistance to being pulled -- force

tow truck winch -- agent

surface of flat bed -- agent

PTS: 1 DIF: Bloom’s Level 2 REF: p. 88

NAT: B.4

 20. ANS:

Piano -- system

Gravity & upward pull of winch -- forces

Mass of Earth & winch -- agents

PTS: 1 DIF: Bloom’s Level 2 REF: p. 88

NAT: B.4

 21. ANS:

Either you and your masses and pulley and string are all falling at the same velocity, or your pulley has jammed.

PTS: 1 DIF: Bloom’s Level 4 REF: p. 98

NAT: B.4

**PROBLEM**

 22. ANS:

 N

PTS: 1 DIF: Bloom’s Level 3 REF: Page 87

OBJ: 4.1.2 Apply Newton's second law to solve problems. NAT: B.4

TOP: Apply Newton's second law to solve problems. KEY: Newton's second law

MSC: 3

NOT: Calculate the acceleration using the initial and final velocities. The product of the mass and acceleration gives the force.

 23. ANS:

 m/s2 to left

PTS: 1 DIF: Bloom’s Level 3 REF: Page 87

OBJ: 4.1.2 Apply Newton's second law to solve problems. NAT: B.4

TOP: Apply Newton's second law to solve problems. KEY: Newton's second law

MSC: 3

NOT: The resultant acceleration is obtained on dividing the net force by the mass of the box.

 24. ANS:

 N

PTS: 1 DIF: Bloom’s Level 2 REF: Page 87

OBJ: 4.1.1 Define force. NAT: B.4 TOP: Define force.

KEY: Force MSC: 3 NOT: The rate of change of momentum is equal to the force.

 25. ANS:

The mass of the second sled = 4 times the mass of the first sled.

PTS: 1 DIF: Bloom’s Level 4 REF: p. 93

NAT: B.4

 26. ANS:

Fg = the force due to gravity.

Let a equal the acceleration due to gravity. Thus a = g.

If F = ma, and a = g, then F = mg and F = Fg.

PTS: 1 DIF: Bloom’s Level 3 REF: p. 93

NAT: B.4

 27. ANS:

The normal force is equal and opposite to the force of the orange crate resting on the apple crate. The force of the orange crate on the apple crate is the mass of the orange crate plus the mass of the strawberry crate, multiplied by g.

Normal force (apple crate on orange crate) = (20.0 kg + 10.0 kg)  9.8 m/s2 = 294 N

PTS: 1 DIF: Bloom’s Level 4 REF: p. 107

NAT: B.4

 28. ANS:



PTS: 1 DIF: Bloom’s Level 5 NAT: B.4

 29. ANS:

a = F/m

a = 170 N / 300 kg

a = 0.57 m/s2

Recall that

vf2 = vi2 + 2a(df -di)

vf2 = 0 + 2(0.57 m/s2 )(25 m - 0)

vf2 = 28.5 m2/s2

 vf = 5.3 m/s

PTS: 1 DIF: Bloom’s Level 6 REF: pp. 79, 93

NAT: B.4

 30. ANS:

a = F/m

a = 0.5 N / 0.0064 kg

a = 78.125 m/s2

Recall that

vf2 = vi2 + 2a(df -di)

vf2 = 0 + 2(78.125 m/s2 )(0.75 m - 0)

vf2 = 117.2 m2/s2

 vf = 10.8 m/s

PTS: 1 DIF: Bloom’s Level 6 REF: p. 79, 93

NAT: B.4

 31. ANS:

a. At terminal velocity, the drag force is equal and opposite to the gravitational acceleration:

*F*drag = –*F*gravity

= –*mg*

= –(75.0 kg)(–9.80 m/s2)

= 735 N.

b. The force the sky diver exerts on her parachute is

*F*sky diver = *mg*

= (75.0 kg)(–9.80 m/s2)

= –735 N.

In order to remain intact, the parachute must tolerate a greater force than that applied by the sky diver:

*F*parachute = –*F*sky diver = 735 N.

Assume that each cord connects with the harness and is able to hold

up to 105 N:  = 7.04 cords.

The parachute must have more than seven cords to ensure safe operation.

c. Using up as the positive direction,

*F*total = *F*gravity + *F*parachute

= *mg* + *F*parachute

= (75.0 kg)(–9.80 m/s2) + 550 N

= –185 N



Verify: Because the acceleration is negative, the sky diver is still falling, but at a slower rate than she would without her parachute.

PTS: 1

**ESSAY**

 32. ANS:

Motion problems that deal with changing accelerations need to be broken into parts. Whenever the acceleration changes, there is a new part to the problem that should be approached with the appropriate constant acceleration equation. (A knowledgeable student may also correctly suggest using calculus as an appropriate tool here.)

PTS: 1 DIF: Bloom's Level 6 REF: pp. 65-68

NAT: B.4

 33. ANS:

A person’s apparent weight is equal to the normal force on him or her. This force decreases below mg when he or she accelerates downward.

PTS: 1 DIF: Bloom’s Level 4 REF: p. 98

NAT: B.4

 34. ANS:

During take-off, Laika would have been subjected to a great deal of force and her apparent weight would have been much greater than it was on Earth. Once in orbit, she would have been experiencing acceleration due to gravity at a much lower level than on Earth, and her apparent weight would have been near zero.

Her mass would not have changed due to any of her launch conditions; however, she only had enough food and water aboard to live for approximately 10 days. Sadly, she died 5 to 7 hours into the mission due to stress and overheating.

PTS: 1 DIF: Bloom’s Level 4 REF: p. 98

NAT: B.4

 35. ANS:

Newton’s second law is that the acceleration of a system is equal to the net force acting on the system divided by the mass of the system.

Answers will vary, but one way to verify this law would be to have two people push on a table and vary the force exerted while measuring the acceleration. The acceleration is directly proportional to the force, and inversely proportional to the mass of the table.

PTS: 1 DIF: Bloom’s Level 5 REF: pp. 90-93

NAT: B.4

 36. ANS:

When the car is stopping or starting, a subway passenger experiences many forces due to forward and backward acceleration. Standing sideways can help a passenger keep his or her balance by allowing the body weight to be shifted from one foot to the other in order to compensate for the forces generated by these accelerations.

When traveling at constant speed, it may be more convenient to face forward or backward because most of the forces being experienced will be side-to-side, as the train goes around curves. Again, it would be easier to compensate by shifting weight from one foot to the other, instead of from heel to toe.

PTS: 1 DIF: Bloom’s Level 5 REF: pp. 94-95

NAT: B.4

 37. ANS:

Answers can vary.

One effective reply would be, “If you want to ride your sled again, you’re going to have to pull it up the hill yourself. I’ll see you up there.”

Your nephew is correct that the force the sled applies on him is the same magnitude as he applies to the sled. However, these two forces have different agents and different systems. Therefore, they do not cancel each other out.

PTS: 1 DIF: Bloom’s Level 5 REF: pp. 102-103

NAT: B.4

 38. ANS:

Fnet = ma

Fnet = Fscale + Fg

At rest, Fscale = Fnet  Fg = Fg = mg = 60 kg \* 9.8 m/s2 = 588 N

During acceleration,

Fscale = ma  mg

 = m (ag)

 = 60 (1.5 m/s2  (9.8 m/s2))

 = 498 N

The reading on the scale during downward acceleration is less than it would be at rest.

PTS: 1 DIF: Bloom’s Level 5 REF: pp. 108-109

NAT: B.4

 39. ANS:

Broken glass can injure a person through two mechanisms: Weight and inertia. Large, heavy shards of broken glass can fall like guillotines. In order to stop this heavy, accelerating mass, a force would need to be applied in the opposite direction. If the force is applied by the limb of a person, it is much more likely that the person will lose the limb than the glass will be stopped.

When a character jumps or drives a motorcycle through a window, the shards of glass will tend to stay in place due to inertia. The only way to move them out of the way is to apply a force. If the person's body provides this force by pushing on the edge of a piece of glass, it can slice right through clothing, skin, and flesh. In the real world, jumping or driving through a plate glass window would be deadly.

PTS: 1 DIF: Bloom’s Level 6 REF: p. 93

NAT: B.4