Topics

1. Newton’s Laws
   a. First Law – a body in motion tends to stay in motion, a body at rest tends to stay at rest.
   b. Second Law – Force and acceleration are directly related, \( F = ma \)
   c. Third Law – Forces come in pairs.

2. Free-body diagrams and word problems
   a. Horizontal – Applied forces and friction, \( F = \mu F_N \)
   b. Vertical – Force of gravity and the normal force
   c. Inclines - Components

\[
a = \frac{(V_f - V_i)}{t} \quad V_f^2 = V_i^2 + 2ad \quad d = V_it + \frac{1}{2}at^2 \quad V = \frac{(V_i + V_f)}{2}
\]

Multiple Choice Questions

1. In the diagram below, a 10-kilogram block is at rest on a plane inclined at 15° to the horizontal. As the angle of the incline is increased to 30°, the mass of the block will

   (a) decrease
   (b) increase
   (c) remain the same.

2. Two carts are pushed apart by an expanding spring as shown below. If the average force on the 1-kilogram cart is 1 newton, what is the average force on the 2 kilogram cart?

   (a) 1 N  (b) 0.5 N  (c) 0.0 N  (d) 4 N

3. Compared to the force needed to start sliding a crate across a rough level floor, the force needed to keep it sliding once it is moving is

   (a) less
   (b) greater
   (c) the same

4. A 400 newton girl standing on a dock exerts a horizontal force of 100 newtons on a 10,000 newton sailboat as she pushes it away from the dock with constant velocity. How much force does the sailboat exert on the girl?

   (a) 25 N  (b) 400 N  (c) 100 N  (d) 10,000 N

5. A satellite weighs 200 newtons on the surface of Earth. What is the satellite’s mass on the surface of the moon?

   (a) 200 N  (b) 20 N  (c) 20 kg  (d) 200 kg
6. The diagram below shows a 5.00 kilogram block at rest on a horizontal, frictionless table.

Which diagram best represents the force exerted on the block by the table?

7. If a person gets onto an elevator and the elevator begins to accelerate upward, which of the following statements must be true?

(a) The normal force that the elevator floor exerts on the person is less than the person’s weight.
(b) The normal force that the elevator floor exerts on the person is equal to the person’s weight.
(c) The normal force that the elevator floor exerts on the person is greater than the person’s weight.

8. A box is pushed toward the right across a floor. The force of friction on the box is directed toward the

(a) left  (b) ceiling  
(c) right  (d) floor

9. A lab cart is loaded with different masses and moved at various constant velocities. Which diagram shows the cart-mass system with the greatest inertia?
10. The diagram below shows a sled and rider sliding down a snow-covered hill that makes an angle of 30.° with the horizontal.

Which vector best represents the direction of the normal force, $F_N$, exerted by the hill on the sled?

Short Answer Questions (Show all work)

11. The coefficient of kinetic friction between a 780 newton crate and a level warehouse floor is 0.200. Calculate the magnitude of the horizontal force required to move the crate across the floor at constant speed. Show all work, including the equation and substitutions with units.
12. You and a friend decide to go bowling. There are two bowling balls sitting in the rack, one black and the other blue. You walk up to the two balls and push them. You then tell your friend that the black bowling ball has more mass than the blue ball. Your friend walks up to the balls and picks them up and then says, “You’re right, but how did you know without picking them up?” Explain based on your understanding of Newton’s Laws.

13. What is the friction equation. Define all variables and constants. What is the difference between static and kinetic friction on the molecular level? Can the coefficient of friction exceed 1.0? Explain.
14. A person stands on a bathroom scale in a motionless elevator. When the elevator begins to move, the scale briefly reads 0.75 of the person’s regular weight. What direction is the elevator moving and calculate the acceleration of the elevator.

15. A 0.140 kg baseball traveling 45 m/s strikes the catcher’s mitt, which in bringing the ball to rest recoils backward 11.0 cm. What was the average force applied by the ball on the glove?
16. One 3.0 kg bucket is hanging by a massless cord from another 3.0 kg bucket, also hanging by a massless cord. (a) If the buckets are at rest, what is the tension in each of the cords? (b) If the two buckets are pulled upward with an acceleration of 1.60 m/s\(^2\) by the upper cord, calculate the tension in each cord.

17. An 18.0 kg box is released on a 37° incline and it accelerates down the incline at 0.270 m/s\(^2\). Find the friction force impeding its motion. How large is the coefficient of friction?
Answers

1. C
2. A
3. A
4. C
5. C
6. 1
7. c
8. a
9. 4
10. 3
11. -156 N
12. The heavier ball required more force to accelerate, Newton’s second law.
13.
14. -2.45 m/s² down
15. -1.3 x 10³ N
16. (a) 29.4 and 58.8 N; (b) 34.8 N and 69.6 N
17. -101 N