Physics of Motion, Forces and Energy

Use this key to check answers and read the explanations.

1. Which description gives both the speed and the direction of a moving cart?
   A. 4 meters per second east
   B. 4 meters per second
   C. 4 meters from the wall
   D. 4 seconds after the start
   Correct answer: A. 4 meters per second east
   Velocity includes direction as well as speed. Only the description that says east gives both.

2. Two people pull a crate horizontally with equal forces of 6 newtons in opposite directions. No other horizontal force acts. What is the net horizontal force?
   A. 12 newtons
   B. 6 newtons
   C. 0 newtons
   D. 36 newtons
   Correct answer: C. 0 newtons
   The two forces have the same size but opposite signs along the horizontal line. Their vector sum is zero.

3. A rolling marble has which form of energy because its center is moving?
   A. Gravitational potential energy
   B. Kinetic energy
   C. Chemical potential energy
   D. Elastic potential energy
   Correct answer: B. Kinetic energy
   Kinetic energy is associated with motion. It depends on the marble’s mass and speed.

4. The same book rests first on a low shelf and then on a higher shelf. Which energy is larger on the higher shelf?
   A. Chemical potential energy
   B. Kinetic energy
   C. Elastic potential energy
   D. Gravitational potential energy
   Correct answer: D. Gravitational potential energy
   The book is at rest on both shelves. Its gravitational potential energy relative to the floor is greater at the greater height.

5. A sled is already sliding east along level ground. In which direction does sliding friction from the ground act on the sled?

A. East
B. West
C. Straight upward
D. Straight downward

Correct answer: B. West
Sliding friction acts along the contact surface and opposes the relative sliding. The sled slides east across the ground, so friction acts west.

6. A toy train travels a total distance of 24 meters in 6 seconds. What is its average speed?

A. 4 meters per second
B. 6 meters per second
C. 18 meters per second
D. 144 meters per second

Correct answer: A. 4 meters per second
Divide the total distance by the elapsed time. The calculation is 24 divided by 6, or 4 meters per second.

7. A cart’s eastward velocity increases from 2 to 8 meters per second in 3 seconds. What is its average acceleration?

A. 3 meters per second squared east
B. 2 meters per second squared west
C. 6 meters per second squared east
D. 2 meters per second squared east

Correct answer: D. 2 meters per second squared east
The velocity increases eastward by 6 meters per second. Dividing by the elapsed 3 seconds gives an eastward acceleration of 2 meters per second squared.

8. A net force of 20 newtons acts on a 4-kilogram cart. What is the magnitude of its acceleration?

A. 16 meters per second squared
B. 4 meters per second squared
C. 5 meters per second squared
D. 80 meters per second squared

Correct answer: C. 5 meters per second squared
Acceleration is net force divided by mass. Dividing 20 newtons by 4 kilograms gives 5 meters per second squared.

9. A cart is moving north at 3 meters per second on a level track. The net force becomes zero and stays zero. What happens next?

A. It keeps moving north at 3 meters per second.
B. It immediately stops.
C. It keeps moving north and steadily speeds up.
D. It slowly turns south without changing speed.

Correct answer: A. It keeps moving north at 3 meters per second.
Zero net force means zero acceleration. The cart’s existing velocity keeps the same speed and direction.

10. A runner’s shoe pushes backward on the track. What is the paired horizontal force under Newton’s third law?

A. The track pushes straight up on the shoe.
B. The track pushes backward on the shoe.
C. The runner’s other shoe pushes forward on the track.
D. The track pushes forward on the shoe.

Correct answer: D. The track pushes forward on the shoe.
The partner force acts between the same two objects in the opposite direction. The track therefore pushes forward on the shoe.

11. A toy car circles a round track at constant speed. Which statement describes its acceleration?

A. It accelerates outward because its distance from the center increases.
B. It has zero acceleration because its speed is constant.
C. It accelerates toward the center because its velocity changes direction.
D. It accelerates forward along the track because its speed increases.

Correct answer: C. It accelerates toward the center because its velocity changes direction.
Constant speed can accompany changing velocity when direction changes. In uniform circular motion, that directional change produces acceleration toward the center.

12. A 3-kilogram cart is pushed with 14 newtons east while friction exerts 5 newtons west. What is its horizontal acceleration?

A. 3 meters per second squared west
B. 3 meters per second squared east
C. 9 meters per second squared east
D. About 6.3 meters per second squared east

Correct answer: B. 3 meters per second squared east
The net force is 14 minus 5, or 9 newtons east. Divide that by the cart’s 3-kilogram mass to get 3 meters per second squared east.

13. The same moving puck increases its speed from 3 to 6 meters per second. By what factor does its kinetic energy change?

A. It stays the same.
B. It becomes twice as large.
C. It becomes six times as large.
D. It becomes four times as large.

Correct answer: D. It becomes four times as large.
With mass fixed, kinetic energy is proportional to speed squared. Doubling speed multiplies that squared term by four.

14. Two identical carts start from rest at the same height on differently shaped ramps. Both reach the same lower height without friction or air resistance. Treat both carts as sliding objects. How do their final speeds compare?

A. They have the same final speed.
B. The cart on the longer ramp is faster.
C. The cart on the steeper ramp is necessarily faster.
D. Both carts have zero speed at the bottom.

Correct answer: A. They have the same final speed.
Both carts lose the same gravitational potential energy. In this friction-free model that energy becomes kinetic energy, so identical carts reach the same speed.

15. A 2-kilogram object starts from rest and falls 5 meters. Use a gravitational acceleration of 10 meters per second squared and ignore air resistance. What is its speed after the drop?

A. 20 meters per second
B. 5 meters per second
C. 10 meters per second
D. 50 meters per second

Correct answer: C. 10 meters per second
The object loses 2 times 10 times 5, or 100 joules of gravitational potential energy. It gains 100 joules of kinetic energy. Solving one-half times mass times speed squared equal to 100 gives 10 meters per second.