Forces and Motion

Use this key to check answers and read the explanations.

1. What force does a horizontal table exert upward on a book resting on it?
   A. Normal force
   B. Kinetic friction
   C. Gravitational force
   D. Tension
   Correct answer: A. Normal force
   The table presses on the book perpendicular to its surface. That contact force is the normal force.

2. Which SI unit would a correctly marked spring scale use to report the force needed to stretch it?
   A. Joule
   B. Kilogram
   C. Newton
   D. Watt
   Correct answer: C. Newton
   A newton measures force. A kilogram measures mass, a joule measures energy, and a watt measures power.

3. A wagon travels west in a straight line without speeding up or slowing down. What is its net force?
   A. A nonzero force west
   B. Zero
   C. A nonzero force east
   D. A nonzero force upward
   Correct answer: B. Zero
   The wagon’s velocity is constant. Newton’s second law makes the net force zero when acceleration is zero.

4. Which force can act on a ball while it is in the air just after leaving a player’s hand, even in a vacuum?
   A. The support force from the hand
   B. The hand’s upward push
   C. Friction from the floor
   D. Earth’s gravitational pull
   Correct answer: D. Earth’s gravitational pull
   Gravity acts at a distance. The hand and the floor can exert contact forces only while touching the ball.

5. The carts in two separate tests receive the same net force. Cart A has twice the mass of cart B. What is A’s acceleration compared with B’s?

A. Twice as large
B. Half as large
C. Four times as large
D. The same

Correct answer: B. Half as large
Since acceleration equals net force divided by mass, doubling the mass at fixed force halves the acceleration.

6. Two horizontal cords pull a cart with forces of 6 newtons east and 8 newtons north. No other horizontal forces act. What is the magnitude of the net horizontal force?

A. 10 newtons
B. 2 newtons
C. 14 newtons
D. 48 newtons

Correct answer: A. 10 newtons
The perpendicular components form a right triangle. Its hypotenuse is the square root of 6 squared plus 8 squared, or 10 newtons.

7. A crate hangs motionless from a rope. Which pair belongs on the free-body diagram for the crate alone?

A. The crate’s pull on Earth and Earth’s pull on the crate
B. The crate’s weight and the rope’s weight
C. Rope tension and the pull of the crate on the rope
D. Rope tension and the crate’s weight

Correct answer: D. Rope tension and the crate’s weight
A free-body diagram includes forces acting on the selected object. Earth pulls down on the crate, and the rope pulls up on it.

8. A heavier skater’s hand and a lighter skater’s hand push against each other. While their hands touch, how do the push forces compare?

A. The lighter skater exerts the larger force
B. The heavier skater exerts the larger force
C. Their magnitudes are equal
D. They match only if the skaters have the same acceleration

Correct answer: C. Their magnitudes are equal
The two pushes form a Newton’s third-law pair. Equal forces can produce different accelerations when the masses differ.

9. A rider stands on a scale in an elevator. The elevator moves upward but slows down. How does the scale reading compare with the rider’s weight?

A. It is smaller
B. It is larger
C. It is equal
D. It must be exactly zero

Correct answer: A. It is smaller
The acceleration points downward, so weight exceeds the scale’s upward force. The scale measures that upward force.

10. A cable pulls a crate with 18 newtons to the right. The crate stays at rest and the cable is the only other horizontal force. What does static friction exert?

A. More than 18 newtons left
B. 18 newtons right
C. Zero newtons
D. 18 newtons left

Correct answer: D. 18 newtons left
Static friction adjusts to counter the applied pull while the crate stays at rest. The two horizontal forces sum to zero.

11. A 60-newton crate is at rest on level ground. A cable pulls straight up on it with 25 newtons, and the crate remains on the ground. What normal force does the ground exert?

A. 85 newtons upward
B. 60 newtons upward
C. 35 newtons upward
D. 25 newtons upward

Correct answer: C. 35 newtons upward
The upward rope force and normal force add to the downward weight of 60 newtons. Subtract 25 newtons to get 35.

12. A block presses on a level surface with a normal force of 50 newtons. The coefficient of static friction is 0.40. How large a horizontal pull can static friction balance before the block starts to slide?

A. 0.8 newton
B. 20 newtons
C. 50 newtons
D. 125 newtons

Correct answer: B. 20 newtons
The maximum static friction is the coefficient times the normal force. Multiplying 0.40 by 50 newtons gives 20 newtons.

13. On a frictionless floor, a 2-kilogram front cart pulls a 4-kilogram rear cart with a taut, massless cord. An 18-newton horizontal force pulls the front cart. What is the cord’s tension?

A. 3 newtons
B. 6 newtons
C. 18 newtons
D. 12 newtons

Correct answer: D. 12 newtons
All 6 kilograms accelerate at 3 meters per second squared. Tension is the only horizontal force on the 4-kilogram rear cart, so it is 4 times 3, or 12 newtons.

14. A floating foam block is pulled completely underwater and held still by a cord attached to the bottom. The block weighs 15 newtons and the cord pulls it down with 9 newtons. What is the buoyant force?

A. 24 newtons upward
B. 15 newtons upward
C. 9 newtons upward
D. 6 newtons upward

Correct answer: A. 24 newtons upward
The upward buoyant force must balance both downward forces. Its magnitude is 15 plus 9, or 24 newtons.

15. A box slides down a ramp. The downslope component of weight is 24 newtons and the normal force is 32 newtons. If the coefficient of kinetic friction is 0.25, what is the net force along the ramp?

A. 24 newtons down the ramp
B. 8 newtons up the ramp
C. 16 newtons down the ramp
D. 32 newtons down the ramp

Correct answer: C. 16 newtons down the ramp
Kinetic friction acts up the ramp with magnitude 0.25 times 32, or 8 newtons. Subtract that from 24 to get 16 newtons downslope.