Easy

1. If the net force on an object is zero, which statement is always true?
   A. The object must be at rest.
   B. The object's velocity is constant (could be zero).
   C. The object's acceleration is increasing.
   D. The object's mass is changing.
   E. The object must be moving in a circle.

2. Newton's First Law (inertia) states that an object at rest stays at rest unless:
   A. temperature changes.
   B. a net external force acts.
   C. its mass doubles.
   D. the object decides to move.
   E. time stops.

3. Two identical forces, one pushing right and one pushing left on a box, result in:
   A. a net force to the right.
   B. a net force to the left.
   C. zero net force.
   D. increasing speed.
   E. rotation only.

4. Which of the following is a vector quantity?
   A. Speed
   B. Distance
   C. Mass
   D. Displacement
   E. Temperature

5. Which best describes the normal force on a block sitting on a horizontal table?
   A. Always equal to the block's weight.
   B. Always directed downward.
   C. The table's contact force perpendicular to the surface.
   D. A frictional force parallel to the surface.
   E. A force that causes the block to move.

6. A box sits on an incline and does not move. Which forces balance so it stays at rest?
   A. Weight and friction only
   B. Component of weight down the slope balanced by static friction and normal force

balancing perpendicular component
C. Normal force equals zero
D. Tension equals weight
E. Friction equals kinetic friction

7. Static friction differs from kinetic friction in that:
   A. static friction acts when surfaces slide past each other.
   B. kinetic friction can be larger than static friction.
   C. static friction prevents motion up to a maximum value.
   D. kinetic friction pushes objects uphill.
   E. they point in the same direction as motion.

8. If you push a heavy crate with a constant horizontal force and it moves at constant speed, what is true about friction?
   A. Friction must be zero.
   B. Friction equals the applied push (in magnitude).
   C. Friction is greater than the applied push.
   D. Friction points forward.
   E. Friction depends on the crate's color.

9. A small car and a large truck collide head-on and exert forces on each other. Which is true during the collision?
   A. The car exerts a larger force on the truck.
   B. The truck exerts a larger force on the car.
   C. Each exerts an equal and opposite force on the other.
   D. Neither exerts any force.
   E. Forces depend on their speeds only.

10. Which scenario describes an object in mechanical equilibrium?
    A. Net force is nonzero, acceleration is nonzero.
    B. Net force is zero and acceleration is zero.
    C. Acceleration is nonzero but net torque is zero.
    D. Speed is increasing.
    E. Gravity vanished.

11. If you double the net force on an object while keeping its mass constant, its acceleration will:
    A. halve.
    B. double.
    C. stay the same.

D. quadruple.
E. become zero.

12. Two people push on opposite ends of a box with equal forces but one person is stronger; the box does not move. Which is true?
A. Stronger person applied a larger force but the weaker countered with a smaller force.
B. Each applied equal magnitude forces; net force is zero.
C. The stronger person did all the work.
D. The box's mass changed.
E. Friction must be zero.

13. A child pulls a toy with constant speed on a rough floor using a string at an angle upward. Compared to pulling horizontally with the same tension, pulling upward at an angle usually:
A. increases the normal force.
B. decreases the normal force and thus reduces friction.
C. eliminates friction.
D. always speeds the toy up.
E. reverses the direction of friction.

14. An object moving in a straight line slows down while a net force points opposite its velocity. Which Newton law primarily explains this?
A. Zeroth law
B. First law (inertia)
C. Second law (F = ma)
D. Third law (action–reaction)
E. Conservation of energy

15. Two identical boxes are pushed with the same horizontal force; one is on ice (low friction) and one on carpet (high friction). Which experiences greater acceleration?
A. The one on carpet
B. The one on ice
C. Both accelerate the same
D. Neither accelerates
E. Depends on color

16. When you stand in an elevator accelerating upward, your scale reading (apparent weight) will:
A. decrease compared to when elevator is at rest.
B. increase compared to when elevator is at rest.

C. stay exactly the same.
D. become zero.
E. equal the elevator’s mass.

17. A block slides down a frictionless incline. Which statement is true about the net force and acceleration along the slope?
A. Net force is zero and acceleration is zero.
B. Net force is downhill and acceleration is downhill.
C. Net force is uphill but acceleration is downhill.
D. Normal force causes the motion.
E. Friction propels the block.

18. A crate is pulled at constant speed with a rope at angle above horizontal. Which force does the rope provide that changes compared to pulling horizontally?
A. A larger frictional force.
B. A horizontal component that does all the work and an upward component that reduces the normal force.
C. Only a vertical force.
D. Only frictional force.
E. A torque that spins the crate.

19. If the only force acting on an object is gravity (free fall), then:
A. its acceleration is zero.
B. its acceleration is upward.
C. it experiences a constant downward acceleration g.
D. friction balances gravity.
E. its velocity is constant.

20. When an Atwood machine (two masses over a frictionless pulley) is released, what determines the system’s acceleration?
A. Only the larger mass.
B. The difference of the masses divided by the total mass times g.
C. The sum of the masses times g.
D. Only friction at the pulley.
E. The thickness of the string.

21. An object moves at constant speed in a circle. Which statement is true about forces?
A. No net force acts because speed is constant.
B. There is a net force toward the center (centripetal) that changes direction of velocity.
C. Net force is tangential, speeding the object up.

D. Gravity must be zero.
E. Friction always points toward the center.

22. A book rests on an inclined plane and does not slide. If the plane's angle increases slowly, which friction acts and how does it change?
A. Kinetic friction acts and is constant.
B. Static friction acts and adjusts up to a maximum to prevent sliding.
C. Friction disappears at steeper angles.
D. Friction becomes upward variable independent of angle.
E. Normal force becomes zero suddenly.

23. Two objects, 1 kg and 10 kg, are pulled by the same horizontal force on a frictionless floor. Which accelerates more?
A. The 10 kg object.
B. The 1 kg object.
C. Both accelerate the same.
D. Neither accelerates.
E. Acceleration depends on the force direction only.

24. A skydiver reaches terminal velocity. What can be said about the forces?
A. Gravity is zero.
B. Air resistance exceeds gravity.
C. Air resistance balances gravity; net force is zero so acceleration is zero.
D. The skydiver keeps accelerating slowly.
E. The skydiver is weightless.

25. Which of the following is an example of a contact force?
A. Gravity
B. Magnetic force
C. Normal force from a table on a book
D. Electric force from a distant charge
E. Gravitational attraction between Earth and Sun

26. If you push a block across a rough floor and then suddenly stop pushing, what happens to the block?
A. It immediately stops because inertia vanishes.
B. It continues moving forward but slows due to kinetic friction until it stops.
C. It immediately reverses direction.
D. It will speed up because friction pushes it forward.

E. It levitates.

27. Two equal masses hang from either end of a frictionless, massless pulley. Which correctly describes the forces and motion?
    A. The heavier side falls because static friction acts.
    B. The system stays at rest because the masses balance (no net force).
    C. Both masses accelerate upward.
    D. Tension is zero.
    E. Tension equals weight of larger mass.

28. A cyclist pedals to increase speed. Which statement appropriately connects force and motion?
    A. The cyclist's pedaling creates a backward force on the ground and the ground pushes the cyclist forward (action–reaction), producing a net forward force and acceleration.
    B. The bicycle accelerates without any net force.
    C. Only internal forces inside the cyclist accelerate the bike.
    D. The bicycle moves because friction is absent.
    E. Gravity propels the cyclist forward.

29. A heavy book and a light book are dropped in a vacuum (no air). Which hits the ground first?
    A. Heavy book because it has more momentum.
    B. Light book because it is easier to move.
    C. They hit at the same time because acceleration due to gravity is the same.
    D. The heavier book hits with greater force so it lands first.
    E. Depends on the mass ratio.

30. When a car brakes and skids (tires locked), which friction acts and how does it compare to static friction?
    A. Kinetic friction acts and is usually less than the maximum static friction.
    B. Static friction acts and is greater than kinetic friction.
    C. Kinetic friction is greater than static friction.
    D. No friction acts while skidding.
    E. Friction reverses direction and becomes upward.

31. A person standing in a bus feels thrown backward when the bus suddenly accelerates forward because:
    A. a real backward force pushes the person.
    B. their inertia (tendency to remain at rest) makes them lag relative to the bus.
    C. gravity increased momentarily.

D. the bus created a vacuum behind the person.
E. friction from the floor pulls them backward.

32. A 5-N push and a 3-N push act in the same direction on a crate. What is the net force and resulting acceleration relative to mass?
A. Net force 2 N; acceleration equals 2/m.
B. Net force 8 N; acceleration equals 8/m.
C. Net force 3 N; acceleration equals 3/m.
D. Net force 5 N; acceleration equals 5/m.
E. Net force zero; no acceleration.

33. Which is true about the tension in a massless rope connecting two objects in equilibrium?
A. Tension is greater where the rope is pulled harder.
B. Tension varies randomly along the rope.
C. Tension is the same at every point in an ideal massless rope.
D. Tension is zero if the system is at rest.
E. Tension equals gravitational force always.

34. A block is at rest on a table. If the table is suddenly pulled horizontally very quickly, the block slides relative to the table. Which statements describe forces on the block during the pull?
A. Only gravity acts.
B. Normal force disappears.
C. Friction acts on the block opposing relative motion between block and table.
D. The block gains mass.
E. Tension in the table pulls the block forward.

35. A 2-kg object hangs from a spring scale at rest. The scale reads 19.6 N. If the object is in an elevator accelerating upward at 1.0 m/s^2, the scale reads approximately: ($g \approx 9.8$ m/s^2)
A. less than 19.6 N
B. 19.6 N
C. more than 19.6 N
D. zero
E. negative

36. A block is pulled at constant velocity up a ramp by a string parallel to the ramp. Which forces are present and how do they relate along the ramp direction?
A. Tension, component of gravity, and kinetic friction; they sum to zero along the ramp.
B. Only gravity acts.
C. Tension equals zero.

D. Normal force causes motion up the ramp.
E. Friction assists the motion.

37. A hockey puck glides on ice with negligible friction. A small constant horizontal force is then applied. Over time the puck's speed:
A. stays constant because friction is negligible.
B. decreases.
C. increases because net force accelerates it.
D. oscillates.
E. becomes negative.

38. You push a lawn mower and it accelerates. What determines the acceleration?
A. Total applied horizontal force divided by mower's mass (net force = ma).
B. The mower's color.
C. Only the engine's horsepower.
D. Gravity only.
E. Distance you push it.

39. A ball attached to a string whirled in a horizontal circle at constant speed is an example where:
A. there is no net force because speed is constant.
B. tension provides a centripetal force pointing toward the center.
C. tension points tangentially to speed.
D. gravity is the only force.
E. the string does work increasing kinetic energy.

40. Which of the following is NOT an example of Newton's Third Law pair?
A. Earth pulls down on you; you pull up on Earth.
B. A bat hits a ball; the ball hits the bat.
C. A car pushes air backward; air pushes car forward.
D. Gravity pulls Moon; Sun's gravity pulls Moon.
E. A book resting on a table: book pushes table down; table pushes book up.

41. A box rolls off a table and falls to the floor. While in the air, which forces act on it (ignore air resistance)?
A. Gravity and normal force from table.
B. Only gravity.
C. Gravity and forward push from table.
D. Gravity and drag.

E. None.

42. A mass slides down a rough ramp and reaches constant terminal speed. Which statement explains this?
    A. Gravity vanished.
    B. Normal force equals zero.
    C. The downhill component of gravity is balanced by kinetic friction; net force is zero.
    D. The ramp accelerates upward to match speed.
    E. The mass's mass changed.

43. A pupil balances a ruler horizontally by placing a fulcrum under it. This is an example primarily of:
    A. translational equilibrium where net force is zero (ignoring torques here).
    B. rotational motion only.
    C. internal energy conservation.
    D. Newton's third law exclusively.
    E. a violation of Newton's laws.

44. A 1-kg block and a 10-kg block are connected and pulled with the same force across frictionless surface. Which statement is true about their accelerations?
    A. The 10-kg accelerates more.
    B. The 1-kg accelerates more.
    C. Both accelerate the same if pulled together as a system.
    D. Acceleration is independent of mass.
    E. They cannot be pulled together.

45. You push a crate; if you increase the surface roughness (increase coefficient of friction) but keep your push the same, the crate's acceleration will:
    A. increase.
    B. decrease.
    C. stay the same.
    D. become infinite.
    E. reverse direction.

46. A rocket in space (away from planets) fires its engine to accelerate forward. Which pair of statements about forces are true?
    A. The rocket pushes on the expelled gas; gas pushes back on the rocket (action–reaction).
    B. The rocket accelerates without any forces.
    C. The rocket's mass increases when it accelerates.

D. No net force acts on the rocket.
E. Gravity must act to propel it.

47. For an object sliding on a horizontal surface, if the applied horizontal force is less than the maximum static friction, what happens?
A. The object accelerates.
B. The object moves at constant speed.
C. The object remains at rest (static friction balances the applied force).
D. The object breaks apart.
E. The normal force disappears.

48. Two astronauts in space push off each other and separate. Which describes their motions?
A. They exert equal and opposite forces, and if masses differ the lighter astronaut will have greater acceleration.
B. The heavier astronaut feels no force.
C. Only the lighter astronaut moves.
D. They both remain at rest.
E. Momentum is not conserved.

49. A student stands on a bathroom scale in an elevator that is accelerating downward. Compared to standing on Earth at rest, the scale reading will be:
A. larger.
B. smaller.
C. the same.
D. zero always.
E. negative.

50. Two blocks frictionlessly in contact are pushed by a force on the leftmost block. Which best describes the contact force between them?
A. It is zero because surface is frictionless.
B. It transmits a forward force from the left block to the right block; the contact force accelerates the right block.
C. It points backward on the right block only.
D. It equals the applied force regardless of masses.
E. It pulls them together with no push.

Answer Key

1. B
2. B
3. C
4. D
5. C
6. B
7. C
8. B
9. C
10. B
11. B
12. B
13. B
14. C
15. B
16. B
17. B
18. B
19. C
20. B

21. B

22. B

23. B

24. C

25. C

26. B

27. B

28. A

29. C

30. A

31. B

32. B

33. C

34. C

35. C

36. A

37. C

38. A

39. B

40. D

41. B

42. C

43. A

44. C

45. B

46. A

47. C

48. A

49. B

50. B

Medium

1. A crate sits on a frictionless horizontal floor. Two people push on it with equal magnitude forces in opposite directions. Which is true?
   A. The crate accelerates toward the stronger pusher.
   B. The crate remains at constant velocity (possibly zero).
   C. The crate experiences a net torque but no translation.
   D. The crate's mass must be changing.
   E. The crate must slide due to internal forces.

2. A car travels at constant speed around a circular track. Which statement is correct about the forces on the car?
   A. There is no net force because speed is constant.
   B. Net force is toward the center and perpendicular to the velocity.
   C. Net force acts tangentially and increases the speed.
   D. The normal force provides the tangential acceleration.
   E. Net force is zero and kinetic energy decreases.

3. A block rests on an incline. Increasing the incline angle very slowly, a point is reached where it begins to slide. Which force is directly responsible for initiating motion?
   A. Kinetic friction suddenly increasing.

B. Static friction reaching its maximum and being overcome by gravity's downslope component.
C. The normal force growing to pull the block down.
D. Air drag becoming negligible.
E. A normal reaction torque.

4. Two blocks, A and B, are connected over a massless, frictionless pulley. A heavier B descends. During the motion, which is always true?
A. The heavier block exerts a larger force on the lighter block.
B. The lighter block exerts a larger force on the heavier block.
C. The magnitudes of the forces they exert on each other (tension) are equal.
D. Tension equals the weight of the heavier block.
E. Neither block exerts any force on the other because they accelerate.

5. A book rests on a scale inside an elevator that accelerates downward. Which best describes what the scale reads?
A. The scale reads mg (true weight) regardless of elevator motion.
B. The scale reads $m(g - a)$ where a is the elevator's downward acceleration.
C. The scale reads $m(g + a)$ where a is the elevator's downward acceleration.
D. The scale reads zero whenever the elevator accelerates.
E. The scale reading depends on the book's color.

6. A block slides at constant speed down a rough incline. Which is true about forces along the slope?
A. Down-slope component of gravity exceeds friction producing net positive acceleration.
B. Friction balances the down-slope component of gravity so net force along slope is zero.
C. Normal force equals the block's weight and causes acceleration.
D. Static friction is acting to prevent motion.
E. Net upward force causes constant speed.

7. A large truck collides head-on with a compact car. The instant of contact, which is correct about forces during the collision?
A. The truck exerts a larger force on the car because it's bigger.
B. The car exerts a larger force on the truck because it decelerates more.
C. Each exerts an equal and opposite force on the other (Newton III).
D. There is no force between them if they stick together.
E. Forces depend only on their speeds, not masses.

8. A person applies a steady horizontal push to a heavy crate and it moves at constant speed. Which is true of the frictional force?
   A. Friction is zero because the crate moves.
   B. Friction equals the applied push in magnitude and opposes it.
   C. Friction acts in the same direction as the push.
   D. Friction must be kinetic and larger than static friction always, even at equilibrium.
   E. Friction is independent of the normal force here.

9. A box is pulled by a string that makes an angle above the horizontal. Compared to pulling horizontally with the same tension, pulling upward-angled typically:
   A. Increases the normal force and thereby increases friction.
   B. Decreases the normal force and thereby reduces friction.
   C. Leaves normal force unchanged.
   D. Eliminates kinetic friction.
   E. Reverses the direction of friction.

10. A mass moves in a straight line and its velocity passes through zero then becomes negative. At the instant the velocity is zero, which is always true?
   A. Acceleration must be zero at that instant.
   B. Acceleration must be positive.
   C. Acceleration must be negative.
   D. Acceleration can be any finite value (cannot be determined from v=0 alone).
   E. Net force is zero at that instant.

11. A block is at rest on a rough horizontal surface with a horizontal push P gradually increased from zero. Which is true as P increases but before the block slips?
   A. Static friction remains constant equal to $\mu_k N$.
   B. Static friction adjusts to match P up to a maximum $\mu_s N$.
   C. Kinetic friction acts and equals $\mu_k N$ even before motion.
   D. Normal force changes dramatically.
   E. The block moves spontaneously without exceeding $\mu_s N$.

12. Two astronauts of equal mass push off each other in space (no external forces). Which is true?
   A. They exert equal and opposite forces and, if one has less mass, that one accelerates more.
   B. They exert unequal forces because one pushes harder.
   C. Only the lighter astronaut moves.
   D. Total momentum is not conserved because forces act internally.

E. Neither can move because there is no external support.

13. A car turns a corner at constant speed. Which statement about forces is correct?
    A. No net force acts because the speed is constant.
    B. A net inward (centripetal) force acts, changing the direction of velocity.
    C. Friction must always speed the car up in the tangential direction.
    D. The engine provides a radial force to turn the car.
    E. The car's mass changes to allow turning.

14. A block connected to a spring on a horizontal frictionless surface is released from rest at $x = +A$. Which statement is true immediately after release?
    A. The mass has zero acceleration at $x = +A$.
    B. Acceleration is directed toward the equilibrium point and has magnitude kA/m.
    C. The mass immediately attains maximum speed.
    D. The net force is zero at $t = 0$.
    E. The normal force does all the work.

15. A heavy box and a light box are dropped from the same height in air. Which statement best describes their accelerations?
    A. The heavier box accelerates faster because of greater weight.
    B. The light box accelerates faster because it has less inertia.
    C. Near vacuum (no air) both accelerate equally; with air, drag causes lighter/less streamlined objects to deviate.
    D. Both accelerate equally even with air resistance always.
    E. The heavier box always hits later.

16. In an Atwood machine (two masses $m1$ and $m2$ over a light frictionless pulley), which affects the magnitude of acceleration?
    A. Only the larger mass matters.
    B. The difference $m2 - m1$ and the sum $m1 + m2$ through $a = (m2 - m1)g/(m1 + m2)$.
    C. The pulley radius directly determines acceleration.
    D. Acceleration is independent of masses.
    E. Friction in the rope is the only determinant.

17. A block slides down a rough incline and eventually reaches constant terminal speed. Which best explains the terminal speed?
    A. Gravity vanishes at terminal speed.
    B. The component of gravity down the slope equals kinetic friction up the slope, producing zero net force.
    C. The normal force increases with speed to balance gravity.

D. Air drag pushes the block down to maintain speed.
E. Terminal speed cannot occur on an incline.

18. A massless rope connects two blocks on a frictionless surface pulled by force F on one end. The rope is massless and inextensible. Which is true about the tension?
A. Tension varies along the rope proportional to distance.
B. Tension is the same everywhere in the rope.
C. Tension equals zero when the system accelerates.
D. Tension equals F regardless of block masses.
E. Tension acts only on the heavier block.

19. A block on a horizontal surface has two horizontal forces: 40 N right and 30 N left; coefficient kinetic friction is 0.2 and mass 5 kg. Which determines its acceleration?
A. Only the larger applied force; friction irrelevant.
B. Net applied force minus friction (if moving) divided by mass.
C. Sum of applied magnitudes divided by mass.
D. Friction cancels applied forces so acceleration is zero.
E. Normal force produces the horizontal acceleration.

20. A 1-kg object on the floor has $\mu_s = 0.6$ and $\mu_k = 0.5$. A 5-N horizontal force is applied. If 1 kg * g = 9.8 N, what happens?
A. The object will move because 5 N > μ_s N.
B. The object will not move because 5 N < μ_s N.
C. The object will move because 5 N > μ_k N.
D. The object's normal force becomes 0.
E. The object floats.

21. A box being dragged at constant velocity across a rough floor requires a pulling force of 80 N. If the same box is pulled at constant velocity by an upward-angled rope (reducing normal force) with the same rope tension magnitude of 80 N, which is true?
A. Horizontal component of tension is smaller than 80 N and cannot match required friction, so it will slow.
B. The horizontal component can still provide the same horizontal pull if the tension remains 80 N; however the reduced normal force reduces friction, so less horizontal force may be needed.
C. Vertical component does no work.
D. Friction always increases in angled pull.
E. The box will levitate.

22. A crate is pushed and then released; friction causes it to come to rest. Which Newton's law best explains why the crate slows once the push is removed?
    A. Zeroth law.
    B. First law — inertia until acted on by net force (friction).
    C. Second law only.
    D. Third law only.
    E. Conservation of energy prevents stopping.

23. A block rests on a 25° frictionless incline, connected to a hanging mass that exactly balances it so the system is at rest. If the incline angle is slowly increased, why will the system eventually move?
    A. Because static friction decreases with angle.
    B. Because the component of gravity along the incline increases until the hanging mass can no longer balance it.
    C. Because the normal force becomes zero.
    D. Because tension vanishes with angle.
    E. Because the pulley gains mass.

24. Two identical boxes are pushed with identical horizontal forces on two different floors: one icy (very low μ) and one rough (high μ). If both move at constant speed, what can you infer about the applied forces?
    A. The applied forces must be equal to zero.
    B. Each applied force equals the kinetic friction on each surface, so the one on the rough floor had a larger frictional force balanced by the applied push.
    C. The force on ice must be larger than that on rough to overcome friction.
    D. Both pushes must be exactly the same fraction of the boxes' weights.
    E. The boxes have different masses.

25. A 2 kg block is pulled to the right by 10 N and to the left by 7 N; no other horizontal forces act. What is the block's acceleration?
    A. 0 m/s^2
    B. 1.5 m/s^2 to the right
    C. 1.5 m/s^2 to the left
    D. 3.5 m/s^2 to the right
    E. 0.5 m/s^2 to the right

Quantitative (26–50 — require algebra & multiple relations)

26. Two masses, 3.00 kg and 5.00 kg, hang on either side of a frictionless, massless pulley. What is the magnitude of the acceleration of the system?
    A. 1.96 m/s²
    B. **2.45 m/s²**
    C. 3.27 m/s²
    D. 0.82 m/s²
    E. 4.90 m/s²

27. A 10.0-kg block lies on a 30.0° incline. $\mu_s = 0.40$ and $\mu_k = 0.30$. Will it start to slide? If so, what is its acceleration down the plane (use $g = 9.80$ m/s²)?
    A. No, it will remain at rest.
    B. Yes; **2.35 m/s²** down the plane.
    C. Yes; 0.50 m/s² up the plane.
    D. Yes; 4.50 m/s² down the plane.
    E. Yes; 9.80 m/s² down the plane.

28. A 4.0-kg block on a horizontal surface is pushed by a constant horizontal 20.0-N force. The coefficient of kinetic friction is 0.20. What is the block's acceleration? ($g = 9.80$ m/s²)
    A. 1.60 m/s²
    B. 2.45 m/s²
    C. **3.04 m/s²**
    D. 4.90 m/s²
    E. 0.96 m/s²

29. A 2.00-kg mass is attached to a spring ($k = 200$ N/m) on a frictionless surface and released from $x = +0.100$ m (from equilibrium) at rest. What is its maximum speed?
    A. 0.50 m/s
    B. 1.00 m/s
    C. **1.00 m/s**
    D. 2.00 m/s
    E. 0.10 m/s

30. A 4.00-kg block on a horizontal table is attached to a 6.00-kg hanging mass via a string over a frictionless pulley. The coefficient of kinetic friction between the 4-kg block and the table is 0.10. Find the acceleration of the system (take $g = 9.80$ m/s²).
    A. 2.94 m/s²
    B. 4.90 m/s²
    C. **5.488 m/s²**
    D. 1.23 m/s²

E. 0.98 m/s²

31. A 70.0-kg person stands on a scale inside an elevator accelerating upward at 2.00 m/s². What does the scale read (nearest newton)?
A. 686 N
B. 772 N
C. **826 N**
D. 910 N
E. 700 N

32. Two masses (5.00 kg on a 37° frictionless incline, and 3.00 kg hanging) are connected over a pulley. Which way does the system accelerate and with what magnitude? (g = 9.80 m/s²)
A. 3.00 kg goes down with 1.23 m/s²
B. 5.00 kg goes down the incline with 0.50 m/s²
C. System is exactly balanced and acceleration is 0.00 m/s²
D. **The hanging 3.00 kg accelerates upward slightly; a ≈ 0.0111 m/s² (very small magnitude).**
E. 5.00 kg goes down with 2.45 m/s²

33. A 2.00-kg block is pulled on a horizontal surface by a 30.0-N force at 30.0° above the horizontal. The coefficient of kinetic friction is 0.25. What is the block's acceleration? (g = 9.80 m/s²)
A. 8.00 m/s²
B. 4.90 m/s²
C. **12.415 m/s²**
D. 2.45 m/s²
E. 0.98 m/s²

34. A 1.0-kg block hangs on one side, and a 3.0-kg block rests on a frictionless 45° incline on the other side, connected over a pulley. What is the magnitude of the acceleration? (g = 9.80 m/s²)
A. 0.49 m/s²
B. 1.23 m/s²
C. **2.747 m/s²**
D. 4.90 m/s²
E. 9.80 m/s²

35. A net horizontal force produces an acceleration of 2.00 m/s² on an 8.00-kg object. If the exact same net force is applied to a 16.0-kg object, what acceleration results?

A. 4.00 m/s²
B. 2.00 m/s²
C. **1.00 m/s²**
D. 0.50 m/s²
E. 8.00 m/s²

36. A 5.00-kg block is pulled on a horizontal floor by 40.0 N. μ_s = 0.40 and μ_k = 0.30. Will the block move and, if so, what is the acceleration? (g = 9.80 m/s²)
A. No, block remains at rest.
B. Yes; **a ≈ 5.06 m/s²**.
C. Yes; a ≈ 0.80 m/s².
D. Yes; a ≈ 12.00 m/s².
E. Yes; a ≈ 2.00 m/s².

37. A 4.00-kg block sits on a 25.0° incline and is connected to a 6.00-kg hanging mass via a massless string over a frictionless pulley. The coefficient of kinetic friction on the incline is 0.10. What is the system's acceleration (g = 9.80 m/s²)?
A. 1.23 m/s²
B. 0.00 m/s²
C. 2.00 m/s²
D. **3.868 m/s²**
E. 5.00 m/s²

38. A 2.00-kg block rests on a 15.0° incline. It's pulled up the plane by a 20.0-N force parallel to the plane. μ_k = 0.20. What is the block's acceleration up the plane? (g = 9.80 m/s²)
A. 1.20 m/s² up
B. 3.50 m/s² up
C. **5.57 m/s² up**
D. 0.00 m/s²
E. 9.80 m/s² up

39. A 1200-kg car decelerates at 6.00 m/s². What net braking force (magnitude) acts on it?
A. 2000 N
B. 720 N
C. 7200 N
D. **7200 N (opposite velocity)**
E. 1200 N

40. A 2.00-kg mass hangs from a rope in an elevator that accelerates downward at 3.00 m/s². What is the rope tension?
    A. 9.80 N
    B. 19.6 N
    C. 6.00 N
    D. **13.60 N**
    E. 0 N

41. A 10.0-kg block has two horizontal forces: 50.0 N to the right and 20.0 N to the left. Neglect friction. What is its acceleration?
    A. 1.0 m/s² right
    B. 2.0 m/s² right
    C. **3.0 m/s² right**
    D. 0.0 m/s²
    E. 7.0 m/s² right

42. Two blocks (6.0 kg and 4.0 kg) on a frictionless surface are connected; a horizontal 50.0-N force pulls the pair. What is the acceleration of the system and the tension in the connector between the blocks?
    A. a = 2.50 m/s², T = 15.0 N
    B. a = 4.17 m/s², T = 20.0 N
    C. a = 5.00 m/s², T = 30.0 N
    D. **a = 5.00 m/s², T = 20.0 N**
    E. a = 10.0 m/s², T = 50.0 N

43. A 5.0-kg block on a horizontal surface is attached to an 8.0-kg hanging block over a pulley; coefficient of kinetic friction on the horizontal surface is 0.15. What is the acceleration of the system? (g = 9.80 m/s²)
    A. 1.00 m/s²
    B. 0.50 m/s²
    C. **5.465 m/s²**
    D. 2.00 m/s²
    E. 9.80 m/s²

44. A 3.0-kg block has two horizontal forces: 10 N right and 4 N left. No friction. What is its acceleration?
    A. 0.67 m/s² right
    B. **2.00 m/s² right**
    C. 3.33 m/s² right
    D. 1.50 m/s² left

E. 0 m/s²

45. Two masses are connected: 2.0 kg hanging and 3.0 kg on a 30° frictionless incline. What is the acceleration (use g = 9.80 m/s²)?
A. 1.96 m/s² up the incline
B. 0.98 m/s² down the incline
C. 0.00 m/s² (balanced)
D. **−0.980 m/s²** (negative sign indicates the assumed positive direction is opposite actual motion; magnitude 0.98 m/s²)
E. 9.80 m/s²

46. A 20.0-kg box on a horizontal floor is pushed with 100 N. μ_s = 0.30 and μ_k = 0.20. Will it move and if so what is its acceleration? (g = 9.80 m/s²)
A. No, it remains at rest.
B. Yes; a ≈ **3.04 m/s²**.
C. Yes; a ≈ 1.00 m/s².
D. Yes; a ≈ 5.00 m/s².
E. Yes; a ≈ 0.10 m/s².

47. A 0.50-kg mass is attached to a spring (k = 200 N/m), stretched 0.10 m and released from rest. What is the maximum acceleration the mass experiences?
A. 10.0 m/s²
B. 20.0 m/s²
C. 5.0 m/s²
D. **40.0 m/s²**
E. 0.0 m/s²

48. Two masses, 8.0 kg on a table (μ_k = 0.20) and 2.0 kg hanging, are connected over a pulley. What is the acceleration? (g = 9.80 m/s²)
A. 0.392 m/s² up for hanging mass
B. 1.00 m/s² down for hanging mass
C. 2.00 m/s² down for hanging mass
D. **0.392 m/s²** (system accelerates, small value)
E. 9.80 m/s²

49. A 1.50-kg block is pulled by a 12.0-N force at 45° above horizontal; μ_k = 0.10. What is its horizontal acceleration? (g = 9.80 m/s²)
A. 2.00 m/s²
B. 3.50 m/s²
C. **5.243 m/s²**

D. 0.50 m/s²
E. 9.80 m/s²

50. A 50.0-kg crate is lowered downward with acceleration 2.00 m/s² by a rope. What is the tension in the rope? (g = 9.80 m/s²)
A. 490 N
B. 450 N
C. **390 N**
D. 1000 N
E. 0 N

Answer Key (correct letter for each question)

1. B
2. B
3. B
4. C
5. B
6. B
7. C
8. B
9. B
10. D
11. B
12. A

13. B

14. B

15. C

16. B

17. B

18. B

19. B

20. B

21. B

22. B

23. B

24. B

25. B

26. B

27. B

28. C

29. C

30. C

31. C

32. D

33. C

34. C

35. C

36. B

37. D

38. C

39. D

40. D

41. C

42. D

43. C

44. B

45. D

46. B

47. D

48. D

49. C

50. C

Hard
Two identical horizontal forces act on a frictionless crate from opposite sides. Suddenly, one pushes a little longer than the other for an instant, but overall the average forces are equal. Which statement best describes the crate’s motion after many such small asymmetric pushes?

A. It must remain at rest because instantaneous forces cancel.
B. Net force is undefined in such impulsive sequences.
C. It will oscillate in place unless a dominant direction emerges.
D. It will drift with constant nonzero velocity if the time-averaged net impulse is nonzero.
E. It will have zero kinetic energy overall because pushes oppose.

2.

A car travels at constant speed around a circular track. An observer claims “no net force acts because speed is constant.” The best reply is:

A. Correct only if the car’s tires exert zero friction.
B. Incorrect — a net centripetal force toward the center exists even though speed is constant.
C. Incorrect — net force is tangential only.
D. Correct — constant speed implies zero net force always.
E. Partially correct — net force is zero in the tangential direction only.

3.

A block on an incline resists sliding. The static frictional force is at its maximum value when:

A. the block slides slowly and static friction equals kinetic friction value.
B. the block is about to start sliding and the downslope component equals μ□N.
C. the block is accelerating upward.
D. the normal force is zero.
E. the block is at rest with no external push and static friction is always μ□N.

4.

Two masses hang over a frictionless pulley: heavier mass B descends slowly. At an instant, is the tension in the rope equal to the weight of the lighter mass A?

A. Yes — tension always equals lighter mass’s weight.
B. Only if the rope is massless and frictionless.
C. No — tension is less than A’s weight if the system accelerates.
D. Yes — because rope transmits full weight.
E. No — tension must equal the heavier mass’s weight.

5.

A bathroom scale holds a book in an elevator accelerating downward at 2.0 m/s². The scale reading will be:

A. zero because elevator moves downward.
B. exactly mg always.
C. m(g − 2.0), less than the book's true weight.
D. unrelated because scale measures only mass.
E. m(g + 2.0), more than the book's true weight.

6.

A block slides down a rough incline with constant speed. Which combination of forces along the slope must be true?

A. Static friction is doing work up the slope.
B. Gravity is entirely balanced by the normal force.
C. Component of gravity down the slope equals kinetic friction up the slope.
D. Net force is up the slope but balanced by air resistance.
E. Kinetic friction is zero since speed is constant.

7.

A very large truck and a small car collide head-on. Which statement about the interaction forces during the collision is correct?

A. The truck always exerts a larger force.
B. The forces are equal in magnitude and opposite in direction at every instant.
C. The car exerts a larger force because it accelerates more.
D. Neither exerts force when they touch.
E. Only the heavier object feels the force.

8.

You push a heavy crate with constant horizontal force and it slides at constant speed on a rough floor. Which statement is correct about friction?

A. Friction must be larger than your push.
B. Friction acts with the push.
C. Friction is zero because the crate is moving.
D. Friction equals your push in magnitude and opposes it.

E. Friction acts perpendicular to the surface.

9.

Pulling a wagon with the same tension but at an upward angle (vs. horizontal) usually changes motion because:

A. pulling upward converts friction into lift.
B. the vertical component reduces the normal force, reducing friction.
C. tension no longer has a horizontal component.
D. pulling angle does not change friction.
E. it always increases the normal force.

10.

A particle moving to the right slows to zero and then moves left. At the instant its velocity is zero, which can be concluded about acceleration?

A. Acceleration must be negative.
B. Acceleration must be zero.
C. Acceleration equals gravity.
D. Acceleration must be positive.
E. Nothing definite — acceleration depends on forces.

You slowly increase a horizontal push on a block sitting on a rough floor. Before it breaks loose, static friction:

A. remains fixed at μ□N regardless of applied force
B. suddenly disappears once motion begins
C. increases up to a maximum value equal to μ□N
D. always equals the applied force exactly
E. acts only after motion begins

12.

Two astronauts of equal mass push off each other in deep space with no external forces. Which statement is correct?

A. Only one astronaut moves
B. The astronaut who pushes harder moves faster
C. Momentum is not conserved
D. Both accelerate away with equal magnitude accelerations
E. Neither astronaut accelerates

13.

A car drives around a frictionless banked curve at exactly the design speed. Which force supplies the required centripetal acceleration?

A. Friction alone
B. Gravity
C. The horizontal component of the normal force
D. Air resistance
E. The vertical component of the normal force

14.

A mass attached to a spring on a frictionless surface is released from maximum displacement. Immediately after release, the acceleration:

A. is zero because velocity is zero
B. points toward equilibrium with maximum magnitude
C. points away from equilibrium
D. is undefined
E. equals the normal force divided by mass

15.

Two objects are dropped simultaneously from the same height. One has much greater mass. In real air, which statement is most accurate?

A. The heavier object always lands first
B. The lighter object always lands first
C. Both land at the same time regardless of shape

D. Air resistance can cause different accelerations depending on shape and mass
E. Gravity acts more strongly on heavier objects, so they accelerate faster

---

16.

In an ideal Atwood machine, which modification increases the magnitude of acceleration the most?

A. Increasing the mass difference while keeping total mass constant
B. Increasing both masses equally
C. Increasing pulley radius
D. Increasing string length
E. Adding mass to both sides equally

17.

A block slides down a rough incline and eventually reaches terminal speed. Why does this happen?

A. Gravity disappears
B. Static friction replaces kinetic friction
C. Air resistance becomes dominant
D. The net force along the incline becomes zero
E. The normal force equals the weight

18.

Two blocks are connected by a massless rope and pulled across a frictionless surface. Which statement is true?

A. Tension varies along the rope
B. The rope exerts no force because it has no mass
C. Both blocks accelerate at the same rate
D. The block closer to the pull accelerates more
E. Tension equals the applied force everywhere

19.

A 2.0-kg object experiences a 5-N force to the right and a 3-N force to the left. What is its acceleration?

A. 1.0 m/s² to the left
B. 1.0 m/s² to the right
C. 4.0 m/s² to the right
D. 0.0 m/s²
E. 2.5 m/s² to the right

20.

A 1-kg block rests on a surface with $\mu_s = 0.6$ and $\mu_k = 0.4$. A 5-N horizontal force is applied. What happens?

A. The block remains at rest
B. The block accelerates at 5 m/s²
C. The block accelerates at 1 m/s²
D. The normal force becomes zero
E. The block begins sliding with acceleration

21.

A crate is pulled across a floor at constant speed. The pulling force is increased slightly, but the crate still moves at constant speed. What must have changed?

A. The frictional force increased to match the pull
B. The normal force decreased
C. The crate's mass changed
D. Acceleration increased briefly
E. Gravity increased

22.

A box slides across a rough surface and slows to a stop after the applied force is removed. Why?

A. Newton’s First Law
B. Conservation of energy
C. Kinetic friction provides a net force opposite motion
D. Static friction dominates
E. Air resistance is dominant

23.

A block rests on an incline and is connected to a hanging mass. Increasing the incline angle eventually causes motion. Why?

A. Normal force disappears
B. Static friction decreases with angle
C. Component of gravity along the incline increases
D. Tension increases
E. Gravity weakens

24.

Two identical forces pull identical boxes at constant speed on different surfaces. Which inference is valid?

A. Friction is zero on both surfaces
B. Each applied force equals the kinetic friction force
C. Both boxes accelerate equally
D. One box must be heavier
E. Forces cancel internally

25.

A 2-kg block has forces of 10 N right and 7 N left acting on it. What is its acceleration?

A. 3.5 m/s^2 right
B. 1.5 m/s^2 left
C. 0.0 m/s^2
D. 1.5 m/s^2 right
E. 0.5 m/s^2 right

26.

Two masses of 3.0 kg and 5.0 kg hang over a frictionless pulley. What is the system's acceleration?

A. 1.96 m/s²
B. 2.45 m/s²
C. 3.27 m/s²
D. 4.90 m/s²
E. 0.82 m/s²

27.

A 10-kg block rests on a 30° incline. $\mu_s = 0.40$, $\mu_k = 0.30$. Does it slide? If so, what is its acceleration?

A. No motion
B. 0.98 m/s²
C. 4.9 m/s²
D. 1.5 m/s²
E. 2.35 m/s²

28.

A 4-kg block is pushed with 20 N on a horizontal surface. $\mu_k = 0.20$. What is its acceleration?

A. 3.04 m/s²
B. 1.60 m/s²
C. 4.90 m/s²
D. 0.96 m/s²
E. 2.45 m/s²

29.

A 2-kg block attached to a spring (k = 200 N/m) is released from rest at x = 0.10 m. What is its maximum speed?

A. 0.50 m/s
B. 2.00 m/s
C. 1.41 m/s
D. 1.00 m/s
E. 0.10 m/s

30.

A 4-kg block on a table is connected to a 6-kg hanging mass. μ□ = 0.10. What is the acceleration?

A. 1.23 m/s²
B. 2.94 m/s²
C. 0.98 m/s²
D. 4.90 m/s²
E. 5.49 m/s²

31.

A 70-kg person stands on a scale in an elevator accelerating upward at 2.0 m/s². What does the scale read?

A. 826 N
B. 686 N
C. 772 N
D. 910 N
E. 700 N

32.

A 5-kg block on a frictionless 37° incline is connected to a 3-kg hanging mass. What happens?

A. 5-kg slides down rapidly
B. 3-kg moves downward

C. System is balanced
D. Acceleration is extremely small
E. 5-kg accelerates upward

33.

A 2-kg block is pulled by a 30-N force at 30° above horizontal. μ□ = 0.25. What is its acceleration?

A. 4.9 m/s²
B. 8.0 m/s²
C. 12.4 m/s²
D. 2.45 m/s²
E. 0.98 m/s²

34.

A 1-kg hanging mass is connected to a 3-kg block on a 45° incline. What is the acceleration?

A. 2.75 m/s²
B. 0.49 m/s²
C. 1.23 m/s²
D. 4.90 m/s²
E. 9.80 m/s²

35.

An 8-kg object accelerates at 2.0 m/s² under a force. What acceleration does the same force produce on a 16-kg object?

A. 4.0 m/s²
B. 0.5 m/s²
C. 1.0 m/s²
D. 2.0 m/s²
E. 8.0 m/s²

36.

A 5-kg block is pulled with 40 N on a surface where $\mu_k = 0.40$ and $\mu_s = 0.30$. What happens?

A. It remains at rest
B. It accelerates at 5.06 m/s²
C. It accelerates at 0.80 m/s²
D. It accelerates at 12.0 m/s²
E. It accelerates at 2.0 m/s²

37.

A 4-kg block on a 25° incline is connected to a 6-kg hanging mass. $\mu_k = 0.10$. What is the acceleration?

A. 1.23 m/s²
B. 3.87 m/s²
C. 0.0 m/s²
D. 5.00 m/s²
E. 2.00 m/s²

38.

A 2-kg block is pulled up a 15° incline by a 20-N force. $\mu_k = 0.20$. What is its acceleration?

A. 5.57 m/s²
B. 1.20 m/s²
C. 3.50 m/s²
D. 0.0 m/s²
E. 9.80 m/s²

39.

A 1200-kg car decelerates at 6.0 m/s². What is the braking force?

A. 2000 N
B. 1200 N

C. 720 N
D. 7200 N
E. 12,000 N

40.

A 2-kg mass hangs in an elevator accelerating downward at 3.0 m/s². What is the tension?

A. 9.8 N
B. 19.6 N
C. 15.6 N
D. 6.0 N
E. 13.6 N

41.

A 10-kg block experiences 50 N right and 20 N left. What is its acceleration?

A. 3.0 m/s² right
B. 1.0 m/s² right
C. 2.0 m/s² left
D. 0.0 m/s²
E. 7.0 m/s² right

42.

Two blocks (6 kg and 4 kg) are pulled by 50 N on a frictionless surface. What is the system acceleration and contact force?

A. a = 2.5 m/s², F = 15 N
B. a = 4.17 m/s², F = 20 N
C. a = 5.0 m/s², F = 30 N
D. a = 5.0 m/s², F = 20 N
E. a = 10.0 m/s², F = 50 N

43.

A 5-kg block on a table is connected to an 8-kg hanging mass. μ□ = 0.15. What is the acceleration?

A. 1.00 m/s²
B. 0.50 m/s²
C. 5.47 m/s²
D. 2.00 m/s²
E. 9.80 m/s²

44.

A 3-kg block has 10 N right and 4 N left acting. What is its acceleration?

A. 0.67 m/s²
B. 1.33 m/s²
C. 3.00 m/s²
D. 2.00 m/s²
E. 0.0 m/s²

45.

A 2-kg hanging mass is connected to a 3-kg block on a 30° incline. What is the acceleration of the incline block (positive up)?

A. 1.96 m/s²
B. 0.98 m/s²
C. 0.0 m/s²
D. −0.98 m/s²
E. −9.80 m/s²

46.

A 20-kg box is pushed with 100 N. $\mu_{\square} = 0.30$, $\mu_{\square} = 0.20$. What happens?

A. It remains at rest
B. It accelerates at 3.04 m/s²
C. It accelerates at 1.0 m/s²
D. It accelerates at 5.0 m/s²
E. It accelerates at 0.10 m/s²

47.

A 0.50-kg mass on a spring (k = 200 N/m) is stretched 0.10 m. What is the maximum acceleration?

A. 10.0 m/s²
B. 20.0 m/s²
C. 5.0 m/s²
D. 40.0 m/s²
E. 0.0 m/s²

48.

An 8-kg block on a table (μ□ = 0.20) is connected to a 2-kg hanging mass. What is the acceleration?

A. 0.784 m/s²
B. 1.00 m/s²
C. 2.00 m/s²
D. 0.392 m/s²
E. 9.80 m/s²

49.

A 1.5-kg block is pulled with 12 N at 45° above horizontal. μ□ = 0.10. What is its horizontal acceleration?

A. 2.00 m/s²
B. 3.50 m/s²
C. 1.00 m/s²
D. 5.24 m/s²
E. 0.50 m/s²

50.

A 50-kg crate is lowered downward with acceleration 2.0 m/s². What is the rope tension?

A. 490 N
B. 450 N
C. 390 N
D. 1000 N
E. 0 N

Question Answer Question Answer

1	D	26	B
2	B	27	E
3	B	28	A
4	C	29	D
5	C	30	E
6	C	31	A
7	B	32	D
8	D	33	C
9	B	34	A
10	E	35	C
11	A	36	B
12	D	37	E
13	C	38	A
14	B	39	D
15	E	40	C
16	A	41	B
17	D	42	E
18	C	43	A
19	B	44	C
20	E	45	D
21	A	46	B
22	C	47	E
23	D	48	A
24	B	49	C
25	E	50	D