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# Mechanics Basics

**Study Guide — Mechanics**

Pre-med/IB-style questions that build from Newton's laws and free-body diagrams to friction, tension, work–energy, momentum/impulse, circular motion, and torque—focused on conceptual reasoning and common traps.

**75 items — Study Guide with Answers**

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Generated February 20, 2026

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**1** **Which of the following is a vector quantity?**

A Energy

B Mass

C Time

D **Force** ✓

E Temperature

▶ **Explanation:** A vector has magnitude and direction. Force requires a direction (push/pull direction). Energy, mass, time, and temperature are scalars.

**2** **A hockey puck slides on nearly frictionless ice after being struck. After the stick loses contact, which best describes the puck's motion?**

A It must quickly come to rest because no force acts on it.

B **It continues with constant velocity (same speed and direction).** ✓

C It speeds up because motion continues automatically.

D It moves in a circle because it has momentum.

E Its acceleration stays constant and positive.

▶ **Explanation:** Newton's 1st law: if the net external force is ~0, velocity stays constant. "No force" does not mean "must stop"; it means no change in velocity.

**3** **Which property best measures an object's inertia?**

A Weight

B **Mass** ✓

C Speed

D Acceleration

E Volume

▶ **Explanation:** Inertia is resistance to changes in velocity. Mass measures inertia; weight depends on gravity and can change with location.

**4** **A car moves in a straight line at constant speed on a level road. What can you conclude about the net force on the car?**

A Net force is forward and large.

B Net force is backward and large.

C **Net force is zero.** ✓

D Net force must equal the car's weight.

E Net force must be zero only if the car is not moving.

▶ **Explanation:** Constant velocity means zero acceleration, so by Newton's 2nd law the net force must be zero. Engine force can exist, but it's balanced by resistive forces.

**5** **A book rests on a horizontal table with no other interactions. Which forces act on the book?**

A **Weight downward and normal force upward** ✓

B Weight downward and friction force upward

C Normal force downward and weight upward

D Weight downward, normal upward, and a "force of motion" forward

E Only weight downward (because the table is not a force)

▶ **Explanation:** The book experiences gravity (weight) downward and the table's contact force (normal) upward. With no horizontal push, friction is zero and there is no extra "force of motion."

**6** **Two identical forces act separately on two carts on a frictionless track. Cart X has mass m; cart Y has mass 2m. Compared with cart X, cart Y's acceleration is:**

A Twice as large

B The same

C **Half as large** ✓

D Four times as large

E Zero because it is heavier

▶ **Explanation:** Newton's 2nd law: $a = F/m$. Doubling mass with the same force halves the acceleration.

**7** **An astronaut travels from Earth to the Moon. Which statement is correct?**

A Her mass decreases because gravity is weaker.

B **Her weight decreases but her mass stays the same.** ✓

C Her mass increases because the Moon has less air resistance.

D Her weight stays the same because she is the same person.

E Her mass and weight both become zero.

▶ **Explanation:** Mass is an intrinsic property. Weight is the gravitational force ( mg), so it changes when g changes.

**8** **Ignoring air resistance, two balls (one heavy, one light) are dropped from the same height at the same time. Which is true?**

A The heavier one hits first because it has more weight.

B The lighter one hits first because it has less inertia.

C **They hit at the same time because they have the same acceleration g.** ✓

D They hit at the same time only if their masses are equal.

E Neither hits because gravity cancels inertia.

▶ **Explanation:** In free fall with no air resistance, all objects accelerate downward at the same rate g regardless of mass.

**9** **A person stands on a scale inside an elevator moving upward at constant speed. Compared to standing still on the ground, the scale reading is:**

A Greater

B Smaller

C **The same** ✓

D Zero

E Impossible to know without the elevator's mass

▶ **Explanation:** Constant speed means zero acceleration, so net force is zero and the normal force (scale reading) equals weight mg.

**10** **Which pair is a Newton's 3rd law action–reaction pair?**

A Weight of a book and the normal force on the book

B Friction on a box and weight of the box

C **Earth pulls the apple downward and the apple pulls Earth upward** ✓

D Tension in a rope and acceleration of the mass

E Normal force on the book and friction on the book

▶ **Explanation:** Action–reaction forces are equal and opposite and act on different objects. Earth-on-apple and apple-on-Earth are such a pair. Weight and normal on the book act on the same object, so they are not a 3rd-law pair.

**11** **Why don't Newton's 3rd law force pairs cancel each other to give zero net force on a single object?**

A Because action and reaction are not equal in magnitude.

B Because one of them is always friction.

C **Because they act on different objects, not the same object.** ✓

D Because they happen at different times.

E Because net force depends on speed, not force.

▶ **Explanation:** Newton's 3rd law pairs act on different bodies. Net force on one object is the sum of forces acting on that object only.

**12** **A box is pushed to the right across a rough floor and is sliding. The friction force on the box points:**

A To the right

B **To the left** ✓

C Upward

D Downward

E Friction is zero because it is moving

▶ **Explanation:** Kinetic friction opposes relative motion between surfaces. If the box slides right relative to the ground, friction on the box acts left.

**13** **A block rests on a horizontal table with no horizontal forces applied. The static friction force on the block is:**

A μsN

B μkN

C **Zero** ✓

D Equal to the weight mg

E Always nonzero to prevent motion

▶ **Explanation:** Static friction only appears as needed to prevent relative motion. With no tendency to slide, the required static friction is 0 (even though a maximum exists).

**14** **Which statement about static friction is correct?**

A Static friction always equals μsN.

B **Static friction adjusts from 0 up to a maximum value μsN.** ✓

C Static friction is always larger than kinetic friction for all materials.

D Static friction acts in the direction of motion.

E Static friction can only act upward.

▶ **Explanation:** Static friction is self-adjusting: it matches the needed value to prevent slipping, up to the maximum $f_{s,max} = \mu_s N$. It does not have to equal μsN.

**15** **For most dry surfaces, compared to kinetic friction, the maximum static friction is typically:**

A Smaller

B Equal

C **Larger** ✓

D Zero

E Negative

▶ **Explanation:** Usually $\mu_s > \mu_k$, meaning it takes more force to start motion than to keep sliding once moving. This is a common experimental observation in the simple friction model.

**16** **A block rests on an incline at angle (no other forces). The normal force on the block equals:**

A mg

B mg sin

C **mg cos** ✓

D mg tan

E 0

▶ **Explanation:** The normal force balances the component of weight perpendicular to the plane, which is mg cos . It is smaller than mg unless = 0.

**17** **For the same incline (angle ), the component of the weight parallel to the plane is:**

A mg

B mg cos

C **mg sin** ✓

D mg / sin

E mg / cos

▶ **Explanation:** Resolving weight into components gives mg sin along the plane (downhill) and mg cos perpendicular to the plane.

**18** **As the angle of an incline increases (0° → 90°), which trend is correct?**

A mg sin decreases and mg cos increases

B Both mg sin and mg cos increase

C **mg sin increases and mg cos decreases** ✓

D Both mg sin and mg cos decrease

E Both stay constant because mg is constant

▶ **Explanation:** sin grows from 0 to 1, so mg sin increases. cos drops from 1 to 0, so mg cos decreases.

**19** **A box is pulled with a rope that makes an upward angle above the horizontal. Compared to pulling horizontally with the same rope tension, the friction force is usually:**

A Larger, because the rope adds force

B **Smaller, because the upward component reduces the normal force** ✓

C Unchanged, because friction is independent of normal force

D Zero, because the rope lifts it completely

E Impossible to compare without the rope length

▶ **Explanation:** In the basic model, friction magnitude  μN. An upward pull reduces N, so friction tends to decrease (making it easier to start/maintain motion).

**20** **A mass hangs motionless from a light vertical string. The tension in the string is:**

A Zero

B **Equal to mg** ✓

C Greater than mg

D Less than mg

E Equal to m/g

▶ **Explanation:** If it's motionless, acceleration is zero, so net force is zero. The upward tension must balance weight mg.

**21** **Two masses hang on either side of a frictionless, massless pulley connected by a massless rope. Which statement about tension is correct?**

A Tension is larger on the heavier side.

B Tension is smaller on the heavier side.

C **Tension is the same in both vertical segments of the rope.** ✓

D Tension is zero because the rope is massless.

E Tension must equal the difference of the two weights.

▶ **Explanation:** In an ideal (massless rope, frictionless pulley) setup, the tension is uniform along the rope. Differences in acceleration come from different weights, not different tensions on each side.

**22** **In an Atwood machine, mass m1 is larger than mass m2. Neglecting friction and rope/pulley mass, which direction does the system accelerate?**

A m1 accelerates upward and m2 downward

B **m1 accelerates downward and m2 upward** ✓

C Both accelerate downward

D Both accelerate upward

E No acceleration occurs because forces cancel

▶ **Explanation:** The heavier mass has a larger weight, so the system accelerates with m1 going down and m2 going up, while tension is the same in the rope.

**23** **In an ideal Atwood machine where m1 = m2, which statement is correct?**

A The heavier side accelerates downward.

B **Acceleration is zero; tension equals each weight.** ✓

C Acceleration is g because both are falling.

D Tension is zero because forces cancel.

E Tension equals the difference between weights.

▶ **Explanation:** Equal masses mean equal weights, so the net driving force is zero and acceleration is zero. With no acceleration, each mass has $T = mg$.

**24** **Two blocks A and B push on each other on a frictionless surface and accelerate together. If you treat (A+B) as one combined system, the contact force between A and B is:**

A A net external force on the system

B **An internal force that cancels within the system** ✓

C The only force that can accelerate the system

D Equal to the system's total weight

E Zero because the surface is frictionless

▶ **Explanation:** Forces between A and B are internal to the combined system; they appear as equal and opposite and cancel when considering the net external force on (A+B).

**25** **A constant force acts on an object while it moves in the same direction as the force. The work done by this force is:**

A Negative

B Zero

C **Positive** ✓

D Always equal to the object's weight

E Always equal to the object's momentum

▶ **Explanation:** Work $W = F \cdot d = Fd\cos$ . If force and displacement are in the same direction, $= 0$ and $\cos = 1$, so work is positive.

**26** **A force acts perpendicular to an object's displacement. The work done by this force is:**

A Maximum and positive

B Maximum and negative

C **Zero** ✓

D Equal to the object's kinetic energy

E Equal to the object's momentum

▶ **Explanation:** Work depends on the component of force along the displacement. If force is perpendicular, $\cos 90^\circ = 0$ so $W = 0$.

**27** **A hiker climbs to a vertical height h by two different paths: a steep direct path and a longer gentle path. Ignoring friction, the work done against gravity is:**

A Greater on the longer path because the distance is longer

B Greater on the steep path because it feels harder

C **The same for both paths because it depends only on height gained** ✓

D Zero on both paths because gravity is conservative

E Impossible to compare without the hiker's speed

▶ **Explanation:** Gravity is conservative: work against gravity depends only on vertical height change (mgh), not on the path taken. "Feels harder" relates to power or force, not total work.

**28** **If the speed of an object doubles, its kinetic energy becomes:**

A Half as large

B Twice as large

C **Four times as large** ✓

D Eight times as large

E Unchanged

▶ **Explanation:** Kinetic energy $K = (1/2)mv^2$. Doubling v multiplies K by $2^2 = 4$.

**29** **Which statement is the work–energy theorem?**

A Net work equals the change in potential energy only

B **Net work equals the change in kinetic energy** ✓

C Net work equals the momentum

D Net work is always zero in motion

E Net work equals mass times velocity

▶ **Explanation:** The work–energy theorem states $W_{net} = \Delta K$. It's a powerful link between forces and changes in speed without needing detailed time analysis.

**30** **Two students lift the same box through the same height. Student A lifts it slowly; Student B lifts it quickly. Ignoring losses, the work done by each is:**

A A does more work because it takes longer

B B does more work because it is faster

C **They do the same work, but B has greater power** ✓

D A does more work because speed reduces gravity

E Work must be zero because the box starts and ends at rest

▶ **Explanation:** Work against gravity is mgh, same for both. Power = work/time, so doing the same work in less time means greater power.

**31** **A ball is dropped from rest from a height h (ignore air). As it falls, which energy transformation occurs?**

A Kinetic energy → gravitational potential energy

B **Gravitational potential energy → kinetic energy** ✓

C Thermal energy → kinetic energy

D Kinetic energy stays constant

E Gravitational potential energy stays constant

▶ **Explanation:** As height decreases, gravitational potential energy decreases. With no air resistance, that lost potential becomes kinetic energy (speed increases).

**32** **A block slides across a rough surface and slows down. Which statement is best?**

A Mechanical energy is destroyed.

B **Mechanical energy is converted mainly into thermal energy due to friction.** ✓

C Total energy is not conserved when friction acts.

D Friction increases the block's kinetic energy.

E Friction does positive work because it is a force.

▶ **Explanation:** Friction does negative work on the moving block, reducing kinetic energy and converting it into internal/thermal energy. Total energy is still conserved overall.

**33** **A spring is compressed by a distance x. If the compression is doubled to 2x, the elastic potential energy stored becomes:**

A Half

B Twice

C **Four times** ✓

D Eight times

E Unchanged

▶ **Explanation:** Spring energy is $U = (1/2)kx^2$, so it scales with $x^2$. Doubling x multiplies energy by 4.

**34** **An object falling through air reaches terminal velocity. At terminal velocity, which is true?**

A Acceleration is maximum

B **Net force is zero and speed is constant** ✓

C Weight is zero

D Air resistance is zero

E Gravity stops acting

▶ **Explanation:** Terminal velocity means drag balances weight, so net force is zero and acceleration is zero. The object can still move with a nonzero constant speed.

**35** **Which statement about momentum is correct?**

A Momentum is a scalar and depends only on speed

B **Momentum is a vector and equals mass × velocity** ✓

C Momentum is the same as kinetic energy

D Momentum is conserved only in elastic collisions

E Momentum has units of joules

▶ **Explanation:** Momentum p = mv is a vector (direction matters). Momentum is conserved in any isolated system, not only elastic collisions (elastic affects kinetic energy conservation).

**36** **Momentum of a system is conserved when:**

A There are no internal forces

B **The net external impulse on the system is zero** ✓

C The collision is elastic

D Objects have equal masses

E Objects have equal speeds

▶ **Explanation:** Internal forces cancel in pairs (Newton's 3rd law). Conservation of momentum requires no net external impulse (external force over time). Elasticity matters for kinetic energy, not momentum.

**37** **Impulse is best defined as:**

A Force divided by time

B Force multiplied by distance

C **Change in momentum** ✓

D Change in kinetic energy

E Mass multiplied by acceleration

▶ **Explanation:** Impulse J equals the change in momentum $\Delta p$. For constant force, $J = F\Delta t$, showing why longer stopping time can reduce force for the same $\Delta p$.

**38** **Two different methods stop the same cart from the same initial speed to rest. Method 1 stops it in a short time; Method 2 stops it in a longer time. Which is correct?**

A Method 1 gives smaller average force

B **Method 2 gives smaller average force** ✓

C Average force is the same because $\Delta p$ is the same

D Average force depends only on mass, not time

E The cart cannot be stopped without changing momentum

▶ **Explanation:** Stopping means the same $\Delta p$. Impulse $J = F_{avg}\Delta t = \Delta p$, so a larger $\Delta t$ implies a smaller average force.

**39** **In a perfectly inelastic collision (objects stick together), which statement is correct for an isolated system?**

A Momentum is not conserved

B Kinetic energy is conserved

C **Momentum is conserved but kinetic energy decreases** ✓

D Both momentum and kinetic energy increase

E Both momentum and kinetic energy become zero

▶ **Explanation:** With no external impulse, momentum is conserved. In inelastic collisions, some kinetic energy becomes internal energy (heat, deformation, sound), so kinetic energy is not conserved.

**40** **A gun fires a bullet. Immediately after firing, the gun moves backward (recoils). The best explanation is:**

A The bullet pulls the gun backward with a force larger than the gun's force on the bullet

✓ **B** **Total momentum is conserved, so the gun gains opposite momentum to the bullet**

**C** The gun recoils because gravity pushes it backward

**D** The gun recoils because air pushes it backward

**E** Recoil happens only if the bullet is heavy

▶ **Explanation:** Before firing, total momentum is (approximately) zero. After firing, bullet momentum forward must be balanced by equal and opposite gun momentum backward (conservation of momentum).

**41** **Torque about a pivot is largest when the applied force is:**

**A** Applied close to the pivot and along the lever

**B** **Applied far from the pivot and perpendicular to the lever arm** ✓

**C** Applied at the pivot

**D** Applied far from the pivot but parallel to the lever arm

**E** Applied with smaller force but any direction

▶ **Explanation:** Torque magnitude is $= rF \sin$, maximized when r is large and $\sin = 1$ (force perpendicular). Parallel forces ($\sin = 0$) produce no torque.

**42** **A rigid body is in complete static equilibrium. Which must be true?**

**A** Net force is zero only

**B** Net torque is zero only

**C** **Both net force and net torque are zero** ✓

**D** Velocity must be zero

**E** Acceleration must be nonzero to maintain balance

▶ **Explanation:** For a rigid body to neither translate nor rotate (static equilibrium), you need $\Sigma F = 0$ and $\Sigma$ $= 0$. Zero net force alone can still allow rotation.

**43** **Why is it easier to loosen a tight bolt using a longer wrench (applying the same force)?**

A A longer wrench reduces friction in the bolt threads

B **A longer wrench increases torque because the lever arm r is larger** ✓

C A longer wrench increases your mass, increasing force

D A longer wrench reduces the bolt's weight

E A longer wrench changes the bolt's material properties

▶ **Explanation:** Torque $=$ rF sin . With the same force applied similarly, increasing r increases torque, making rotation easier.

**44** **Which design generally makes an object harder to tip over?**

A Higher center of mass and narrow base

B **Lower center of mass and wider base** ✓

C Higher center of mass and wider base

D Lower center of mass and narrow base

E Center of mass does not affect tipping

▶ **Explanation:** Stability increases when the center of mass is low and the base is wide. Then the line of action of weight stays within the base for larger tilts.

**45** **A tall box begins to topple when pushed. The box will start to tip (rather than just slide) when:**

A The net force becomes zero

B **The line of action of the weight passes outside the base of support** ✓

C The friction coefficient becomes negative

D The normal force becomes equal to the weight

E Its mass becomes smaller

▶ **Explanation:** Tipping occurs when the torque from weight can rotate the object about an edge: that happens when the vertical line through the center of mass falls outside the contact base.

**46** **An object moves at constant speed in a circle. Which statement is correct?**

A Net force is zero because speed is constant

B **There is a net force toward the center of the circle** ✓

C Acceleration is zero because speed is constant

D The net force points outward because the object wants to fly away

E Gravity must be the centripetal force in all cases

▶ **Explanation:** Even if speed is constant, velocity changes direction, so acceleration exists toward the center. That requires a net inward (centripetal) force.

**47** **For uniform circular motion, if an object's speed doubles while the radius stays the same, the required centripetal force changes by a factor of:**

A 2

B **4** ✓

C 1/2

D 1/4

E No change

▶ **Explanation:** Centripetal force $F_c$ $v^2/r$. Doubling v makes $v^2$ four times larger, so required centripetal force quadruples (if r and m are unchanged).

**48** **For uniform circular motion, if the radius doubles while speed stays the same, the centripetal acceleration becomes:**

A Twice as large

B Four times as large

C **Half as large** ✓

D One quarter as large

E Zero

▶ **Explanation:** Centripetal acceleration $a_c = v^2/r$. If r doubles and v stays the same, $a_c$ halves.

**49** **A car turns on a flat (unbanked) road. What provides the centripetal force needed to follow the curve?**

A The car's weight

B The normal force

C **Static friction between tires and road** ✓

D A real outward "centrifugal force" from the road

E The engine force always points inward

▶ **Explanation:** On a flat curve, the required inward centripetal force comes from horizontal static friction. If friction is too small, the car cannot maintain the circular path and slides outward.

**50** **Why do seatbelts reduce injury in a collision (conceptually)?**

A They reduce the change in momentum to zero

**B They increase stopping time, reducing average force for the same change in momentum** ✓

C They increase the car's mass, reducing acceleration

D They remove friction, so you slide safely

E They increase kinetic energy so the stop is smoother

▶ **Explanation:** Stopping requires a large change in momentum. If that change happens over a longer time, the average force ($\Delta p/\Delta t$) is smaller, reducing injury risk.

**51** **Two masses attract gravitationally. If the distance between their centers doubles, the gravitational force becomes:**

A Twice as large

B Four times as large

C Half as large

**D One quarter as large** ✓

E Zero

▶ **Explanation:** Newton's law of gravitation has an inverse-square dependence: F $1/r^2$. Doubling r makes the force 1/4 as large.

**52** **Compared to sea level, your weight at the top of a high mountain is slightly smaller mainly because:**

A Your mass is smaller at high altitude

B **The distance from Earth's center is larger, reducing gravitational force** ✓

C Air pressure pushes you upward more

D Your inertia decreases

E Gravity reverses direction at high altitude

▶ **Explanation:** Weight is the gravitational force. Being farther from Earth's center slightly reduces gravitational attraction (inverse-square trend). Mass and inertia do not change.

**53** **Astronauts in a circular orbit around Earth feel "weightless" mainly because:**

A There is no gravity in space

B **They are in continuous free fall with the spacecraft, so there is no normal force on them** ✓

C Their mass becomes zero

D Air resistance cancels gravity

E Earth's gravity pushes them outward

▶ **Explanation:** Weightlessness refers to zero apparent weight (normal force). In orbit, gravity still acts, but astronauts and spacecraft fall together, so there's little/no supporting normal force.

**54** **A satellite moves in a higher circular orbit (larger radius) around Earth than another satellite. Ignoring atmosphere, its orbital speed is generally:**

A Larger because it has farther to travel

B **Smaller because the required centripetal acceleration is smaller at larger radius** ✓

C The same because gravity is constant

D Zero because it is weightless

E Impossible to compare without the satellite's mass

▶ **Explanation:** In a larger orbit, gravitational force is weaker and the needed centripetal acceleration for circular motion is smaller, so orbital speed is lower (v decreases as orbit radius increases).

**55** **A ball moves to the right (+x) but is slowing down. Which statement about net force is correct?**

A Net force is to the right because the ball is moving right

B Net force is zero because it is still moving

C **Net force is to the left (−x)** ✓

D Net force must be upward

E Net force depends only on the ball's mass, not motion

▶ **Explanation:** Slowing down means acceleration is opposite the velocity. Since velocity is to the right, acceleration (and net force) must point left.

**56** **A person stands on a scale in an elevator accelerating upward. Compared to mg, the scale reading (normal force) is:**

A **Greater than mg** ✓

B Equal to mg

C Less than mg

D Zero

E Negative

▶ **Explanation:** Upward acceleration means net force upward: $N - mg = ma > 0$, so $N > mg$. The scale reads N, so you feel heavier.

**57** **A person stands on a scale in an elevator accelerating downward (but not in free fall). Compared to mg, the scale reading is:**

A Greater than mg

B Equal to mg

C **Less than mg** ✓

D Exactly zero for any downward acceleration

E Negative if acceleration is downward

▶ **Explanation:** Downward acceleration means $N - mg = ma$ with a negative (if up is positive), so $N < mg$. Only in true free fall does N become zero.

**58** **If an elevator cable snaps and the elevator falls freely (ignoring air), the scale reading for a person inside is approximately:**

A mg

B 2mg

C **0** ✓

D Depends on the person's mass

E Negative

▶ **Explanation:** In free fall, person and scale accelerate downward together at g, so there is essentially no supporting normal force. Apparent weight (scale reading) is ~0.

**59** **A horizontal force F is applied to a block on a rough horizontal surface. The block does NOT move. Which is correct about static friction (fs) if F is below the maximum static friction?**

A fs = 0 always when there is no motion

**B fs = F (opposite direction), so net force is zero ✓**

C fs = μsN always

D fs points in the same direction as F

E fs must be larger than F to prevent motion

▶ **Explanation:** If the block is at rest, net horizontal force must be zero. Static friction adjusts to match the applied force (up to its maximum), opposing the would-be motion.

**60** **A block is sliding on a rough horizontal surface. You flip it to rest on a different face, changing the contact area but keeping the same mass and same materials. In the basic dry-friction model, the kinetic friction force is:**

A Larger with larger contact area

B Smaller with larger contact area

**C The same because fk = μkN and N is the same ✓**

D Zero because the surfaces are the same

E Impossible to predict without the block's speed

▶ **Explanation:** In the ideal model, kinetic friction depends on μk and the normal force N ( mg on a horizontal surface), not contact area. Real materials can deviate, but this is the standard exam model.

**61** **A constant horizontal pulling force is applied to a block sliding on a rough surface. If the block's mass is doubled (same surface, same μk, same applied force), the acceleration will most likely:**

A Increase because mass increases friction

B Stay the same because force is unchanged

C **Decrease because inertia increases and friction also increases** ✓

D Become zero automatically

E Reverse direction

▶ **Explanation:** Doubling mass increases inertia (harder to accelerate) and increases normal force N, which increases kinetic friction μkN. With the same applied force, the net force per mass is smaller, so acceleration decreases.

**62** **Two objects of different masses slide down the same frictionless incline from rest. Which statement is correct about their accelerations down the slope?**

A Heavier object has larger acceleration

B Lighter object has larger acceleration

C **They have the same acceleration down the slope** ✓

D Acceleration depends on mass because weight depends on mass

E Acceleration is zero because there is no friction

▶ **Explanation:** On a frictionless incline, a = g sin , which is independent of mass. Weight scales with mass, but so does inertia, so mass cancels out.

**63** **In an ideal Atwood machine, suppose you add the same small mass to BOTH sides (so the difference between the two sides stays the same). What happens to the acceleration magnitude?**

A It increases because the system is heavier

B It stays the same because the difference in weights is unchanged

**C It decreases because the total mass (inertia) increases while the driving difference stays the same ✓**

D It becomes zero

E It reverses direction

▶ **Explanation:** The driving force depends on the difference in weights, but acceleration depends on driving force divided by total mass. Increasing total mass while keeping the difference the same reduces acceleration.

**64 In a collision between a large truck and a small car, during the impact the force exerted by the truck on the car is:**

A Larger than the force the car exerts on the truck

B Smaller than the force the car exerts on the truck

**C Equal in magnitude to the force the car exerts on the truck ✓**

D Zero because the truck is heavier

E Equal only if their masses are equal

▶ **Explanation:** Newton's 3rd law: interaction forces are equal and opposite regardless of masses. The accelerations differ because $a = F/m$.

**65 A rocket accelerates forward in deep space by ejecting exhaust gas backward. This is possible because:**

A Space provides air for the rocket to push on

B The rocket reduces its mass to zero

**C** **Momentum is conserved: the exhaust gains backward momentum and the rocket gains forward momentum** ✓

**D** Gravity in space is always zero

**E** The rocket's thrust violates Newton's 3rd law

▶ **Explanation:** The rocket doesn't need to push on air. It pushes exhaust backward; the exhaust pushes the rocket forward (3rd law), conserving momentum of the rocket+exhaust system.

**66** **If the net work done on an object over an interval is zero, which statement must be true?**

**A** The object must be at rest at the end

**B** **The object's speed must be unchanged** ✓

**C** The object's velocity must be unchanged

**D** The object's displacement must be zero

**E** The net force must be zero at every moment

▶ **Explanation:** Net work equals change in kinetic energy. If net work is zero, kinetic energy is unchanged, so speed (which depends on kinetic energy) is unchanged. Velocity can still change direction (e.g., uniform circular motion).

**67** **In uniform circular motion at constant speed, the centripetal force does no work on the object because:**

**A** The force is zero

**B** **The force is always perpendicular to the instantaneous displacement** ✓

**C** The object has no kinetic energy

**D** Work is not defined for circular motion

E Centripetal force is always friction

▶ **Explanation:** Work depends on the component of force along displacement. In uniform circular motion, centripetal force points radially inward while displacement is tangential, so they are perpendicular and work is zero.

**68** **A block slides on a rough surface over a distance d and stops. Which statement about friction's work is correct?**

A Friction does positive work, increasing kinetic energy

B **Friction does negative work, reducing kinetic energy** ✓

C Friction does zero work because it is a contact force

D Friction does work equal to mgh

E Friction does work only if the surface is inclined

▶ **Explanation:** Friction opposes motion, so its force is opposite displacement and the work is negative. That negative work removes kinetic energy (converted to thermal/internal energy).

**69** **The same amount of work W is done on two objects, A and B, starting from rest. Object A has smaller mass than object B. Ignoring losses, which is correct about their final speeds?**

A Both have the same final speed because the same work was done

B The heavier object ends with greater speed

C **The lighter object ends with greater speed** ✓

D Final speed depends only on force, not mass

E Both remain at rest because work cannot change speed

▶ **Explanation:** Work becomes kinetic energy: $W = \Delta K = (1/2)mv^2$ (from rest). For the same W, v $1/\sqrt{m}$, so the smaller mass reaches a larger speed.

**70** **Two objects have the same momentum magnitude p, but different masses. Which object has larger kinetic energy?**

A The one with larger mass

B **The one with smaller mass** ✓

C They have the same kinetic energy

D Kinetic energy depends only on direction, so cannot compare

E Kinetic energy must be zero if momentum is the same

▶ **Explanation:** Using $K = p^2/(2m)$, for fixed p a smaller m gives a larger K. This is a common trap because many students associate "more mass" with "more energy."

**71** **Two objects have the same kinetic energy K, but different masses. Which object has larger momentum magnitude?**

A **The one with larger mass** ✓

B The one with smaller mass

C They have the same momentum

D Momentum depends only on acceleration, so cannot compare

E Momentum must be zero if kinetic energy is the same

▶ **Explanation:** For fixed K, $p = \sqrt{(2mK)}$, so momentum increases with $\sqrt{m}$. Heavier objects can have the same kinetic energy at a lower speed but still larger momentum.

**72** **A firework explodes in midair. Just before the explosion, it is momentarily at rest. Neglecting external forces during the very short explosion, the total momentum of the fragments immediately after is:**

- A **Zero (vector sum)** ✓
- B Equal to the total kinetic energy
- C Equal to the weight mg
- D Nonzero and pointing upward
- E Nonzero and pointing in the direction of the largest fragment

▶ **Explanation:** If the system's initial momentum is zero and external impulse during the explosion is negligible, momentum is conserved, so the vector sum of fragment momenta remains zero (they balance in different directions).

**73** **Two identical balls collide head-on on a frictionless surface. Ball A moves toward stationary Ball B. The collision is perfectly elastic. Which outcome is correct?**

- A Both balls stop
- B **Ball A stops and Ball B moves off with Ball A's original speed** ✓
- C Ball A rebounds with the same speed and Ball B stays still
- D Both balls move forward, each with half the original speed
- E They stick together and move with half the original speed

▶ **Explanation:** For equal masses in a perfectly elastic head-on collision, the moving object transfers its velocity to the stationary one (a classic result consistent with conservation of momentum and kinetic energy).

**74** **A car of mass m moving at speed v is brought to rest. If the stopping distance is doubled (same initial speed), the magnitude of the average stopping force is:**

A Doubled

B **Halved** ✓

C Unchanged

D Quadrupled

E Zero

▶ **Explanation:** The kinetic energy lost is the same, so the work done by stopping forces is the same: W $F_{avg}$ d = ΔK. If d doubles, $F_{avg}$ must halve to keep the product the same.

**75** **Crumple zones in cars help reduce injuries mainly because they:**

A Increase the change in momentum during a crash

B Decrease the stopping distance and time

C **Increase stopping distance/time, reducing the average force needed to remove the same kinetic energy** ✓

D Make collisions perfectly elastic

E Eliminate friction during impact

▶ **Explanation:** The car must lose roughly the same kinetic energy and momentum. By increasing the distance/time over which the car stops, the average force required is reduced (work–energy and impulse ideas).