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Work, Energy, Power

60 no-calculator Pre-med/IB-style questions that build from definitions and units to work signs, conservative vs non-conservative forces, energy conservation, springs, friction, force–distance graphs, efficiency, and power reasoning.

Generated February 20, 2026

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1 A constant force **F** acts on an object that undergoes a displacement d. The angle between the force and the displacement is . Which expression gives the work done by this force?

A   W = F/d

B   **W = Fd cos** ✓

C   W = Fd sin

D   W = F + d

E   W = Fd/2 (always)

▶ **Explanation:** Work is the component of force along the displacement times the displacement: W = (F cos)d = Fd cos . sin gives the perpendicular component, which does not contribute to work.

2 Which of the following is the SI unit of work (and energy)?

A   Watt (W)

B   Newton (N)

C   **Joule (J)** ✓

D   Pascal (Pa)

E   Coulomb (C)

▶ **Explanation:** Work and energy are measured in joules. Watts measure power (J/s) and newtons measure force.

3 A student pushes hard on a wall for 10 seconds, but the wall does not move. The work done by the student on the wall is:

A   Positive because a force was applied

B Negative because the wall pushes back

C **Zero because the displacement is zero** ✓

D Equal to the student's weight times 10 s

E Impossible to determine without knowing the force magnitude

▶ **Explanation:** Work depends on force AND displacement. If displacement is zero, $W = Fd\cos = 0$ regardless of how large the force is.

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4 **A force acts on an object while the object's displacement is in the same direction as the force. The work done by the force is:**

A Always negative

B Always zero

C **Positive** ✓

D Positive only if the object speeds up

E Zero unless the force is friction

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

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5 **A force acts on an object, but the displacement is opposite the direction of the force. The work done by the force is:**

A Positive

B **Negative** ✓

C Zero

D Always equal to the kinetic energy

E Cannot be determined

▶ **Explanation:** Opposite directions means θ = 180°, so cos θ = −1 and W = Fd cos θ is negative. This is typical of friction or braking forces.

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6 **A force is always perpendicular to an object's displacement. The work done by that force is:**

A Maximum and positive

B Maximum and negative

C **Zero** ✓

D Equal to Fd

E Equal to the object's potential energy

▶ **Explanation:** Perpendicular means θ = 90° and cos90° = 0, so W = Fd cos θ = 0. The force can change direction of motion without changing kinetic energy (e.g., centripetal force).

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

A Net work equals the change in momentum

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

C Work equals power divided by time

D Work equals mass times velocity

E Net work is always zero

▶ **Explanation:** The work–energy theorem states $W_{net} = \Delta K$. Momentum changes are related to impulse, not work.

8 If the net work done on an object is negative, what must be true about its kinetic energy?

A It increases

B **It decreases** ✓

C It stays the same

D It becomes zero

E It becomes negative

▶ **Explanation:** $W_{net} = \Delta K$. If W_{net} is negative, ΔK is negative, meaning kinetic energy decreases (speed reduces). Kinetic energy cannot be negative.

9 **Which best defines power?**

A Force multiplied by displacement

B Energy stored in a system

C **Rate at which work is done (or energy is transferred)** ✓

D Change in momentum per unit time

E Force divided by acceleration

▶ **Explanation:** Power is how fast work is done: $P = W/t$ (average) or the rate of energy transfer. Change in momentum per time is force.

10 **Which is the correct SI unit equivalence for power?**

A $1\,W = 1\,N$

B 1 W = 1 J

C **1 W = 1 J/s ✓**

D 1 W = 1 N · s

E 1 W = 1 kg · m

▶ **Explanation:** Power is energy per time, so watt = joule per second. N · s is impulse, not power.

(11) **A machine does the same amount of work in half the time. Its average power is:**

A Half

B The same

C **Twice ✓**

D Four times

E Zero

▶ **Explanation:** Average power P = W/t. If W is unchanged and t halves, P doubles.

(12) **Two students lift the same box to the same height. Student A takes 10 s; student B takes 5 s. Ignoring losses, which is correct?**

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 average power ✓**

D A has greater power because the force is larger

E Work is zero because the box starts and ends at rest

▶ **Explanation:** Work against gravity depends on height: W = mgh (same for both). Power is work per time, so doing the same work in less time means higher power.

13 **If an object's speed 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 is K = (1/2)mv^2. Doubling v multiplies v^2 by 4, so K becomes 4K.

14 **Two objects have the same speed. Object B has twice the mass of object A. Compared to A, B's kinetic energy is:**

A Half

B The same

C **Twice** ✓

D Four times

E Eight times

▶ **Explanation:** K = (1/2)mv^2. If v is the same, K is directly proportional to m. Doubling m doubles K.

15 Two objects have the same momentum magnitude p but different masses. Which one has the larger kinetic energy?

A The larger mass

B **The smaller mass** ✓

C They have the same kinetic energy

D The one moving slower

E Cannot be determined without knowing their speeds

▶ **Explanation:** Using $K = p^2/(2m)$, for fixed p a smaller m gives a larger kinetic energy. Many confuse momentum and kinetic energy scaling.

16 Two objects have the same kinetic energy K but different masses. Which one has the larger momentum magnitude?

A **The larger mass** ✓

B The smaller mass

C They have the same momentum

D The one moving faster

E Cannot be determined without g

▶ **Explanation:** For fixed K, $p = \sqrt{2mK}$, so momentum increases with $\sqrt{m}$. A heavier object can have the same K at lower speed but larger p.

17 A block slides on a rough horizontal floor and slows down. The work done by friction on the block is best described as:

A Positive, because friction is a force

B Zero, because friction is internal

C **Negative, converting mechanical energy into thermal energy** ✓

D Negative, converting thermal energy into mechanical energy

E Positive, increasing the block's kinetic energy

▶ **Explanation:** Friction opposes motion, so it does negative work on the moving block. The lost kinetic energy becomes internal/thermal energy of the surfaces.

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18 **A block slides along a straight horizontal surface. Which force does zero work on the block during this motion (assuming the surface is horizontal and the block stays in contact)?**

A Kinetic friction

B Applied push along the motion

C **Normal force from the surface** ✓

D Air resistance opposite motion

E Any force always does work if the object moves

▶ **Explanation:** On a horizontal surface, the displacement is horizontal while the normal force is vertical, so they are perpendicular and W = 0 for the normal force.

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19 **A block slides down a smooth (frictionless) incline. Which statement about the normal force from the incline on the block is correct?**

A It does positive work because it helps the block slide

B It does negative work because it opposes motion

C **It does zero work because it is perpendicular to the motion along the surface** ✓

D It does work equal to mgh

E It does more work on steeper inclines

▶ **Explanation:** The block's displacement is along the plane, while the normal force is perpendicular to the plane, so they are perpendicular and the normal does zero work.

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20 **A rock is carried horizontally at constant speed across level ground. The work done by gravity on the rock during this horizontal motion is:**

A Positive

B Negative

C **Zero** ✓

D Equal to mgh

E Equal to mg times the horizontal distance

▶ **Explanation:** Gravity acts vertically downward, while displacement is horizontal, so the angle is 90° and the work by gravity is zero.

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21 **A book is lifted straight up by height h at constant speed. The work done by gravity on the book is:**

A $+mgh$

B **$-mgh$** ✓

C 0

D $+mg/h$

E Depends on how fast it is lifted

▶ **Explanation:** Gravity is downward while displacement is upward, so work by gravity is negative: $W_g = -mgh$. Speed doesn't matter for gravitational work (in this model).

22 A book is lowered straight down by height h at constant speed. The work done by gravity on the book is:

A $+mgh$ ✓

B $-mgh$

C 0

D $+mg/h$

E Depends on the book's mass only, not h

▶ **Explanation:** Gravity and displacement are in the same direction (downward), so W_g is positive: $+mgh$.

23 Two different paths take a hiker from the same start point to the same higher end point (height gain h). Ignoring friction/air resistance, the work done against gravity is:

A Greater for the longer path because distance is larger

B Greater for the steeper path because it feels harder

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

D Zero because gravity is conservative

E Impossible to compare without time taken

▶ **Explanation:** Work against gravity equals the increase in gravitational potential energy mgh and depends only on the height change, not the path.

24 **Which force is non-conservative in the usual high-school physics model (so the work depends on the path taken)?**

   A Gravity near Earth

   B Spring force (ideal)

   C **Kinetic friction** ✓

   D Electrostatic force between charges (ideal)

   E All forces are conservative

▶ **Explanation:** Friction converts mechanical energy to thermal energy and its work depends on the distance traveled along the surface (path). Gravity and ideal spring forces are conservative.

25 **A cart rolls down a frictionless track from height h and reaches the bottom. If released from rest, its speed at the bottom depends primarily on:**

   A The cart's mass

   B The track's length

   C **The vertical drop h** ✓

   D The time taken to descend

   E The color of the cart

▶ **Explanation:** With no losses, mgh converts to kinetic energy ($1/2\ mv^2$). Mass cancels, so the bottom speed depends on the vertical drop h (and g), not path length.

26 **Two carts of masses m and 2m roll down the same frictionless track from the same height, starting from rest. At the bottom, their speeds are:**

   A The heavier cart is faster

B The lighter cart is faster

C **The same** ✓

D The heavier cart has half the speed

E Impossible to compare without friction data

▶ **Explanation:** From mgh $= (1/2)mv^2$, the mass cancels. Both reach the same speed if they drop through the same height without losses.

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27 **A ball is thrown straight up (ignore air resistance). Which energy change is correct as it rises?**

A Kinetic energy increases and gravitational potential energy decreases

B **Kinetic energy decreases and gravitational potential energy increases** ✓

C Both kinetic and gravitational potential energy increase

D Both kinetic and gravitational potential energy decrease

E Energy is not conserved in vertical motion

▶ **Explanation:** As the ball rises, it slows down so kinetic energy decreases, while its height increases so gravitational potential energy increases. Total mechanical energy stays constant (no air resistance).

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28 **A ball is thrown upward and returns to the launch height. If air resistance is significant, the speed when it returns is:**

A Greater than the launch speed

B Equal to the launch speed

C **Less than the launch speed** ✓

D Zero

E   Impossible because it cannot return

▶ **Explanation:** Air resistance does negative work, reducing mechanical energy. Returning to the same height means less kinetic energy than at launch, so the return speed is smaller.

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(29) **A spring is compressed by distance x. If it is compressed to 2x instead, the elastic potential energy stored becomes:**

A   2 times larger

B   3 times larger

C   **4 times larger** ✓

D   8 times larger

E   1/4 as large

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

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(30) **An ideal spring launches a cart from rest on a frictionless track. If the spring's initial compression is increased, what happens to the cart's launch speed?**

A   It decreases because the spring resists more

B   **It increases because more elastic potential energy becomes kinetic energy** ✓

C   It stays the same because the cart's mass is unchanged

D   It becomes zero because energy is stored, not transferred

E   It depends only on track length

▶ **Explanation:** More compression means greater spring potential energy ($1/2\ kx^2$). On a frictionless track this converts to greater kinetic energy, producing a larger launch speed.

31 **A constant force F acts over a displacement d. On a force–displacement (F–x) graph, the work done is equal to:**

A The slope of the graph

B **The area under the graph between the two positions** ✓

C The maximum value of the force

D The time taken

E The average speed

▶ **Explanation:** Work is $W = \int F\,dx$. Graphically, this is the area under the F–x curve. The slope relates to stiffness in spring contexts, not directly work.

32 **A force increases linearly from 0 to F as an object moves a distance d in the same direction. What is the work done by this force?**

A Fd

B 2Fd

C **(1/2)Fd** ✓

D F/d

E 0

▶ **Explanation:** On an F–x graph this is a triangle with base d and height F, so $W = (1/2)Fd$. Equivalently, average force is F/2 and $W = F_{avg}\,d$.

33 **An object moves with constant speed in a circle. Which statement about the net work done on the object over one full circle is correct?**

A   Net work is positive because it keeps moving

B   Net work is negative because the direction keeps changing

C   **Net work is zero because kinetic energy is unchanged** ✓

D   Net work equals the centripetal force times the circumference

E   Net work is undefined for circular motion

▶ **Explanation:** Net work equals change in kinetic energy. Constant speed means constant kinetic energy, so $\Delta K = 0$ and net work is zero (even though forces act).

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34   **Instantaneous power delivered by a force to a moving object is best given by:**

A $P = F/d$

B   **P = Fv cos (where is angle between F and v)** ✓

C $P = mv$

D $P = (1/2)mv^2$

E $P = F + v$

▶ **Explanation:** Power is rate of doing work. Instantaneously, $P = F \cdot v = Fv\cos$. If force is perpendicular to velocity, power is zero at that instant.

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35   **A force acts on an object, but at that instant the force is perpendicular to the object's velocity. The instantaneous power delivered by that force is:**

A   Maximum and positive

B   Maximum and negative

C   **Zero** ✓

D   Equal to Fv

E Equal to the object's kinetic energy

▶ **Explanation:** Power $P = F \cdot v = Fv \cos\theta$. If $\theta = 90°$, $\cos\theta = 0$ so $P = 0$. The force can change direction of motion without changing speed at that instant.

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36 **A motor lifts a load of weight W upward at constant speed v. Ignoring losses, the power output is best expressed as:**

A $P = W/v$

B $P = Wv$ ✓

C $P = W + v$

D $P = W - v$

E $P = Wt$

▶ **Explanation:** At constant speed the upward force equals the weight W. Instantaneous power is $P = Fv$ (same direction), so $P = Wv$.

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37 **Two identical motors lift identical loads through the same height. Motor A takes 4 s; motor B takes 2 s. Which statement is correct?**

A Motor A does twice the work

B Motor B does half the work

C They do the same work, but motor B's average power is twice ✓

D They do different work because time is different

E Motor B does negative work because it is faster

▶ **Explanation:** Work against gravity depends on mgh, so it's the same. Average power is W/t, so halving time doubles power.

38 A sled is pulled at constant speed across level ground by a horizontal force. Ignoring air resistance, which energy statement is best?

- **A** The pull does no work because speed is constant

- **B** **The pull does positive work that is converted into thermal energy by friction** ✓

- **C** Friction does positive work to keep it moving

- **D** Kinetic energy must increase because there is a pull

- **E** Total work must be positive because the sled moves

▶ **Explanation:** Constant speed means net work is zero, but the pulling force can still do positive work while friction does equal negative work. The input mechanical energy becomes thermal energy.

39 A box slides to rest due to kinetic friction on a horizontal surface. If the initial speed is doubled and the friction force magnitude stays the same, the stopping distance becomes:

- **A** Twice

- **B** **Four times** ✓

- **C** Half

- **D** One quarter

- **E** Unchanged

▶ **Explanation:** The friction work equals the loss of kinetic energy: $F_f \, d = (1/2)mv^2$. If v doubles, kinetic energy quadruples, so distance d must quadruple (if friction force is constant).

40 A car's brakes provide approximately the same average braking force each time. If the car's speed is increased by a factor of 3, the braking distance to stop becomes:

A   3 times

B   6 times

C   **9 times** ✓

D   1/3 as large

E   1/9 as large

▶ **Explanation:** Stopping work by brakes is approximately $Fd = \Delta K = (1/2)mv^2$. With F constant, d $\propto$ v^2. Tripling v makes d 9 times larger.

41 A machine has efficiency 40%. This means:

A   40% of the input energy is destroyed

B   **40% of the input energy becomes useful output; the rest becomes other forms (like heat)** ✓

C   40% of the input energy becomes kinetic; the rest disappears

D   The machine must run at 40 W

E   Efficiency depends only on mass, not design

▶ **Explanation:** Efficiency = useful output energy (or power) divided by input energy (or power). Energy isn't destroyed; it is transformed into less useful forms (often thermal).

42 A device takes in 200 J of electrical energy and delivers 50 J of useful mechanical work. Its efficiency is:

A | **25%** ✓
B | 50%
C | 75%
D | 150%
E | 0%

▶ **Explanation:** Efficiency = useful output / input = 50/200 = 1/4 = 25%. Efficiencies above 100% violate energy conservation.

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43 **A motor has constant power output. If it lifts the same mass through the same height but in half the time, what changes?**

A | The work decreases

B | The work increases

C | **The required power increases** ✓

D | The required power decreases

E | Nothing changes because height is the same

▶ **Explanation:** Work against gravity is mgh (same). Power is work/time. Doing the same work in less time requires more power.

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44 **A student says: "A bigger force always means more work." Which is the best correction?**

A | Correct: work depends only on force

B | **Incorrect: work depends on force, displacement, and the angle between them** ✓

C | Incorrect: work depends only on time

D | Incorrect: work depends only on speed

E   Correct only if friction is present

▶ **Explanation:** Work is W = Fd cos . A larger force can still do zero work if displacement is zero or perpendicular. Displacement and direction matter.

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45 **A person carries a heavy suitcase at constant speed up a flight of stairs. Ignoring losses, the work done by the person on the suitcase is approximately:**

A   0 because speed is constant

B   **mgh where h is the vertical height climbed** ✓

C   mg times the horizontal distance walked

D   Equal to the suitcase's kinetic energy

E   Negative because gravity is downward

▶ **Explanation:** The person increases the suitcase's gravitational potential energy by mgh. Constant speed means ΔK = 0, but work is still done against gravity.

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46 **A rock falls from rest from height h with no air resistance. Just before hitting the ground, its kinetic energy is approximately:**

A   0

B   **mgh** ✓

C   2mgh

D   mgh/2

E   Depends on the path taken

▶ **Explanation:** Energy conservation: loss of gravitational potential energy mgh becomes kinetic energy (starting from rest). So K   mgh right before impact.

47 **A roller coaster car starts from rest at height h. At a point where its height is h/2 (ignore friction), which statement is correct?**

A It has lost all potential energy, so kinetic energy is maximum

B **Its kinetic energy equals its remaining potential energy** ✓

C Its kinetic energy is zero because it is still above the ground

D Its potential energy is negative, so it must stop

E Energy is not conserved on tracks

▶ **Explanation:** Initial energy is mgh. At height h/2, potential energy is mg(h/2). The remaining energy must be kinetic: K = mgh − mg(h/2) = mg(h/2), equal to remaining potential energy.

48 **A student says: "Gravitational potential energy is always positive." Which is correct?**

A True, because height is always positive

B **False: the zero of potential energy is a chosen reference; only changes in potential energy are physically meaningful** ✓

C True only on Earth

D False because potential energy must equal kinetic energy

E True because g is positive

▶ **Explanation:** Potential energy can be defined relative to any reference level. You can choose U = 0 at any height, so U can be positive or negative; what matters is ΔU.

49 **A block is pulled up a frictionless incline from height 0 to height h. Compared to lifting it straight up vertically the same height, the required work done against gravity is:**

A Larger on the incline because the distance is longer

B Smaller on the incline because the force is smaller

C **The same, equal to mgh** ✓

D Zero on the incline because gravity is perpendicular

E Impossible to compare

▶ **Explanation:** With no friction, work against gravity depends only on height gained: mgh, independent of path. The incline reduces force but increases distance so the work stays the same.

50 **A block is pushed up a rough incline at constant speed. Compared with the frictionless case, the work done by the applied force is:**

A Less because friction helps

B The same because height gained is the same

C **More because it must supply mgh plus energy lost to friction** ✓

D Zero because speed is constant

E Negative because friction is negative

▶ **Explanation:** Constant speed means $\Delta K = 0$, but the applied force must do positive work to increase potential energy (mgh) AND to offset friction's negative work (thermal losses).

51 **A constant force F is applied to an object, but the object's speed remains constant while it moves. Which statement must be true?**

A	**The net force must be zero, so there is another force balancing F** ✓
B	The work done by F must be zero
C	The kinetic energy must be increasing
D	The object must be moving in a circle
E	Energy is not conserved

▶ **Explanation:** Constant speed in a straight line implies zero acceleration, so $\Sigma F = 0$. F can do positive work while another force (like friction) does negative work, keeping kinetic energy constant.

52 **A stone is thrown upward. At the very top of its path (ignoring air resistance), which is true?**

A	Kinetic energy is maximum and potential energy is minimum
B	**Kinetic energy is zero and potential energy is maximum (relative to launch height)** ✓
C	Both kinetic and potential energies are zero
D	Total mechanical energy is zero
E	Acceleration is zero, so energy is not defined

▶ **Explanation:** At the top, speed is zero so kinetic energy is zero. Height is greatest, so gravitational potential energy (relative to launch) is maximum.

53 **If the net work on an object over a time interval is zero, which statement must be true?**

A	The object must be at rest at the end
B	**The object's speed at the end equals its speed at the start** ✓
C	The object's direction of motion must be unchanged

D No forces acted during the interval

E The object's displacement must be zero

▶ **Explanation:** Net work equals change in kinetic energy. If $W_{net} = 0$, then $\Delta K = 0$, meaning the speed (and kinetic energy) is unchanged. Direction can still change (e.g., uniform circular motion).

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54 **A block moves in a circle at constant speed on a frictionless table attached to a string (tension provides centripetal force). The work done by the tension force over any small segment of motion is approximately:**

A Positive

B Negative

C **Zero** ✓

D Equal to the block's kinetic energy

E Equal to mv^2/r

▶ **Explanation:** Tension points radially inward while instantaneous displacement is tangential, so they are perpendicular. Thus tension does (approximately) zero work and does not change the speed.

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55 **A motor delivers constant power P to a cart on a frictionless track. As the cart speeds up, the driving force provided by the motor (in the direction of motion) tends to:**

A Increase

B Stay constant

C **Decrease** ✓

D Become negative

E Become equal to mg

▶ **Explanation:** Instantaneous power $P = Fv$ (if force is along velocity). For fixed P, $F = P/v$, so as speed v increases, the force must decrease.

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56 **A device outputs 100 W of useful power while taking in 250 W of electrical power. Its efficiency is:**

A 10%

B 25%

C **40%** ✓

D 60%

E 250%

▶ **Explanation:** Efficiency $= P_{out}/P_{in} = 100/250 = 0.4 = 40\%$. Values above 100% are not possible for an energy-conserving device.

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57 **A pendulum swings through its lowest point. Ignoring air resistance, which statement is correct about energies at the lowest point compared to the highest point?**

A Potential energy is maximum and kinetic energy is minimum

B **Potential energy is minimum and kinetic energy is maximum** ✓

C Both energies are maximum

D Both energies are zero

E Energy is not conserved in pendulum motion

▶ **Explanation:** As the bob falls, gravitational potential energy converts to kinetic energy. At the lowest point (lowest height), potential energy is minimum and speed (thus kinetic energy) is maximum.

58 A student claims: "If a force acts, the object must gain energy." Which statement best refutes this?

A   Any force always increases speed

B   A force can do negative work (like friction), reducing kinetic energy ✓

C   Forces cannot do work

D   Energy can only change with gravity

E   Energy is never conserved

▶ **Explanation:** Work can be positive, negative, or zero. Friction is a common example of a force doing negative work, removing kinetic energy and converting it into thermal energy.

59 Which statement about energy conservation is most correct in real situations?

A   Energy is conserved only if there is no friction

B   Energy is never conserved because friction destroys energy

C   Total energy is conserved, but mechanical energy may decrease as it transforms into thermal/internal energy ✓

D   Mechanical energy is always conserved, even with friction

E   Only kinetic energy is conserved in all processes

▶ **Explanation:** Energy conservation applies universally, but mechanical energy ($K + U$) is not conserved when non-conservative forces like friction convert it into other forms (thermal, sound, deformation).

60 **A constant braking force brings a moving object to rest. If the object's mass is doubled but its initial speed is unchanged, the stopping distance (with the same braking force) becomes:**

A Half

B The same

C **Twice** ✓

D Four times

E One quarter

▶ **Explanation:** Stopping work Fd equals initial kinetic energy $(1/2)mv^2$. If v is the same and m doubles, kinetic energy doubles, so d must double if F is unchanged.