Easy

Which best defines *work* in physics?

A. The force component along displacement multiplied by that displacement.
B. Any force applied to an object regardless of motion.
C. The energy lost to friction.
D. The power used per second.
E. The change in potential energy only.

1. Under which circumstance is the work done by a constant force equal to zero?
   A. When the force and displacement are parallel.
   B. When the force is perpendicular to the displacement.
   C. When the force points opposite the displacement.
   D. When the force increases with time.
   E. When the displacement is zero but force nonzero.

2. When does a force do *positive* work on an object?
   A. When the force is perpendicular to the displacement.
   B. When the force magnitude decreases.
   C. When the force has a component in the direction of the displacement.
   D. When the force is applied instantaneously.
   E. When no normal force exists.

3. Which statement about the normal force and work is generally true for an object sliding across a horizontal frictionless table?
   A. The normal force does positive work equal to $mg \cdot d$.
   B. The normal force always removes kinetic energy.
   C. The normal force does negative work while object moves.
   D. The normal force does zero work because displacement is horizontal and normal is vertical.
   E. The normal force does work equal to the displacement times $\sin\theta$.

4. If you lift a box upward at constant speed a vertical distance h, which is true about *net* work on the box (ignore air resistance)?
   A. Net work is $+mgh$ because you did positive work.
   B. Net work is $-mgh$ because gravity does negative work.
   C. Net work equals the work you did minus zero.
   D. Net work depends on how fast you lifted it.
   E. Net work is zero because kinetic energy does not change.

5. The *work–energy theorem* states that the net work done on an object equals:
   A. the change in its kinetic energy.
   B. the change in its potential energy.
   C. the total mechanical energy always.
   D. the total heat added to the system.
   E. the rate at which energy is used.

6. Which force is *nonconservative* (path-dependent) and typically does negative work removing mechanical energy?
   A. Gravity
   B. Spring force
   C. Normal force (ideal, rigid surfaces)
   D. Magnetic force on a moving charge (ideal)
   E. Kinetic friction

7. Which is true about gravitational potential energy near Earth's surface?
   A. It depends on the path taken to reach the height.
   B. It is unrelated to height.
   C. It decreases when an object is raised.
   D. It depends on the speed of the object.
   E. It increases as height above the reference rises.

8. A skier starts from rest at the top of a frictionless hill and reaches the bottom. Which energy transformation occurs?
   A. Chemical → thermal
   B. Kinetic → potential
   C. Potential → kinetic
   D. Thermal → potential
   E. Potential energy remains constant

9. Two identical objects are lifted to the same height; one is lifted slowly, the other quickly. Assuming no friction, which is true about the work done by gravity on each object?
   A. Gravity does more negative work on the slow lift.
   B. Gravity does more negative work on the fast lift.
   C. Gravity does the same negative work for both ($-mgh$).
   D. Gravity does zero work in both cases.
   E. Gravity does positive work in both cases.

10. When a spring is compressed and then released (no friction), what happens to the spring potential energy?

A. It converts entirely into thermal energy.
B. It converts partially into chemical energy.
C. It converts into kinetic energy of the mass and back and forth.
D. It disappears.
E. It increases over time.

11. Which of these best describes a *conservative* force?
A. One that always does positive work.
B. One for which work around any closed path is zero.
C. One that depends on friction coefficient.
D. One that always points opposite velocity.
E. One that is always normal to motion.

12. A block is dragged at constant speed up an incline with friction. Which statement about work done by friction and by you is correct?
A. Friction does positive work and you do negative work.
B. Friction does zero work because speed is constant.
C. Friction does negative work equal in magnitude to the work you do (net work zero).
D. You do no work if speed doesn't change.
E. Normal force does all the work.

13. If no nonconservative forces act on a system, what is conserved?
A. Mechanical energy (kinetic + potential)
B. Internal energy only
C. Power output
D. Work done by external agents
E. Entropy

14. You carry a heavy suitcase at constant velocity across a level airport terminal. Which is true about the work done *by* you on the suitcase (horizontal displacement only)?
A. You do positive work equal to mg·d.
B. You do negative work because you resist motion.
C. You do zero net work if there is no vertical displacement (vertical forces do no work).
D. You do work that increases gravitational potential energy.
E. You do work equal to the square of the velocity.

15. Which best describes *power*?
A. Energy per unit time (rate of doing work).
B. Force times distance.
C. Potential energy divided by mass.

D. Work done per joule.
E. The acceleration that produces kinetic energy.

16. If two people each do the same amount of work to lift identical boxes to the same shelf, but one does it in half the time, what differs?
A. The slower person delivered more power.
B. The faster person delivered more power.
C. Both delivered same power.
D. The faster person did more work.
E. The slower person moved the box higher.

17. In a closed system where friction converts mechanical energy into thermal energy, what happens to the total energy?
A. It decreases because mechanical energy is lost.
B. It increases because thermal energy is created from nothing.
C. It remains constant — energy is conserved but mechanical energy decreases while thermal increases.
D. It becomes undefined.
E. It is transferred to the environment only.

18. Which statement about the work done by gravity when an object moves between two heights is correct?
A. Work by gravity depends on the path taken between heights.
B. Work by gravity depends only on the change in vertical position (height).
C. Work by gravity is always zero.
D. Work by gravity is always positive when moving upward.
E. Work by gravity increases with horizontal distance.

19. A pendulum swings (no friction). At the lowest point which energy is greatest?
A. Gravitational potential energy
B. Elastic potential energy
C. Kinetic energy
D. Thermal energy
E. Chemical energy

20. Two objects have the same kinetic energy. Which statement is necessarily true?
A. They have the same mass.
B. They have the same momentum.
C. They are moving at the same speed only if they have equal mass.
D. They experience the same net force.

E. They are at the same height.

21. Which of the following does *not* change the gravitational potential energy of an object relative to a specified reference?
    A. Raising the object vertically.
    B. Moving the object horizontally at the same height.
    C. Lowering the object vertically.
    D. Changing the reference level.
    E. Adding mass to the object.

22. A student pushes a block across a table at constant speed and then stops pushing. The block slows and stops. Which energy conversion explains this?
    A. Kinetic → potential
    B. Potential → kinetic
    C. Kinetic → thermal (work done against friction → heat)
    D. Chemical → gravitational
    E. Electrical → kinetic

23. The SI unit of power is the:
    A. Newton (N)
    B. Joule (J)
    C. Watt (W)
    D. Joule·second (J·s)
    E. Newton·meter (N·m)

24. If you apply a horizontal force to a crate and it does not move, which is true about the work you do?
    A. You do positive work equal to F·d where d is the push distance.
    B. You do negative work because the crate resists.
    C. You do zero work because displacement is zero.
    D. You do work that increases the crate's kinetic energy.
    E. You do work that increases potential energy.

25. Which best describes *elastic potential energy* in a spring?
    A. It is proportional to the spring's displacement squared.
    B. It is independent of how much the spring is stretched.
    C. It is maximal at equilibrium.
    D. It depends only on the spring's mass.
    E. It decreases when the spring is compressed.

26. A car engine produces a certain power. Which statement is correct if the car increases its speed while engine power stays constant (ignoring losses)?
A. Acceleration increases indefinitely.
B. The car must do less work per second at higher speed.
C. At higher speed more force is available from the same power (so force = power / speed decreases).
D. For same power, the available tractive force decreases as speed increases.
E. Power and force are independent of speed.

27. For a conservative force, the work done around any closed loop is:
A. Positive
B. Negative
C. Zero
D. Equal to the mechanical energy lost
E. Dependent on the loop size

28. Which of these is true about the work done by friction?
A. It can be recovered completely as useful mechanical energy.
B. It is path independent.
C. It is usually converted into thermal/internal energy and is path dependent.
D. It makes total mechanical energy increase.
E. It is always zero.

29. When you do positive work on an object, its energy necessarily:
A. Decreases.
B. Remains unchanged.
C. Increases (its kinetic and/or potential energy increases).
D. Is transferred into entropy only.
E. Becomes negative.

30. A ball is thrown upward. At the highest point, what is true about its energy?
A. Kinetic energy is maximal.
B. Potential energy is minimal.
C. Kinetic energy is zero and potential energy is maximal (relative to the throw point).
D. Total mechanical energy is not conserved.
E. Thermal energy is maximal.

31. A machine lifts a 10-kg crate at constant speed using power P. If the same machine lifts a 20-kg crate at the same speed, the required power is:
A. the same (mass doesn’t matter)

B. half as much
C. twice as much
D. four times as much
E. zero

32. Work done by the gravitational force when carrying an object around a horizontal closed path at constant height is:
A. positive and equal to mg times the perimeter
B. negative and equal to −mg times the perimeter
C. zero because vertical displacement net is zero
D. dependent on path shape
E. equal to the work you do

33. Which scenario illustrates conservation of mechanical energy (neglecting nonconservative forces)?
A. A block sliding to a stop on rough wood.
B. A bullet embedding into a block.
C. A pendulum swinging without air resistance.
D. A car braking to a halt on pavement.
E. A kettle boiling on a stove.

34. An object has greater kinetic energy if it:
A. has greater mass and/or greater speed (both increase KE).
B. is at higher gravitational potential.
C. experiences more friction.
D. is heavier regardless of speed.
E. is stationary.

35. A spring with constant k stores energy when compressed. If compressing by x stores U, compressing by 2x stores:
A. U (same)
B. 2U
C. 4U
D. 8U
E. 0.5U

36. If you do 100 J of work lifting a crate and 40 J is lost to friction as heat, the crate's increase in mechanical energy is:
A. 0 J
B. 40 J

C. 60 J
D. 100 J
E. −40 J

37. A cyclist generates power pedaling steadily up a hill at constant speed. If the cyclist doubles the speed while climbing same slope, assuming same resistive forces scale with speed, how does required power change qualitatively?
A. It halves.
B. It stays the same.
C. It doubles or increases (power required increases with speed).
D. It becomes zero.
E. It becomes negative.

38. Which of these is *not* a statement of the work-energy theorem?
A. Net work done equals change in kinetic energy.
B. If net work is zero, kinetic energy does not change.
C. Work by individual forces always equals change in kinetic energy.
D. Kinetic energy increase requires net positive work.
E. Net work over a path equals final minus initial kinetic energy.

39. If the total mechanical energy of a closed system decreases over time, which is the most likely cause?
A. Presence of conservative forces only
B. Presence of nonconservative forces like friction converting mechanical energy to internal energy
C. Increase in potential energy only
D. Increase in kinetic energy only
E. Violation of energy conservation

40. A 2-kg mass moving at 3 m/s has kinetic energy of:
A. 3 J
B. 6 J
C. 9 J
D. 18 J
E. 1.5 J

41. When two identical springs are connected in parallel and compressed by the same distance, the total stored energy compared to one spring is:
A. the same as one spring
B. half as much as one spring

C. twice as much as one spring
D. four times as much as one spring
E. zero

42. A crane lifts a load at constant speed. Which statement about power provided by the crane is correct?
A. Power = (force × displacement) independent of time
B. Power = energy × time
C. Power = force × velocity (the rate at which work is done)
D. Power equals potential energy only
E. Power is zero because speed is constant

43. A mass slides down a frictionless incline; at midpoint of height its speed is less than at bottom because:
A. mechanical energy is not conserved
B. potential energy has been partially converted into kinetic energy — at midpoint only some PE converted, so speed is less than max at bottom
C. friction has removed energy
D. its mass increased
E. gravity changed direction

44. A 4-kg object is dropped from rest, after falling 2 m (near Earth), what happens to its gravitational potential energy? (choose conceptual)
A. It increases by mg·2
B. It decreases by mg·2 and that energy turns into kinetic energy (neglecting losses)
C. It remains unchanged
D. It becomes negative times kinetic energy
E. It doubles

45. The efficiency of a machine is defined as the ratio of:
A. output energy to input energy (useful work out / energy in)
B. input energy to output energy
C. work output per second
D. power output over time
E. heat produced over input

46. Which of the following forces can do zero work on a body even though it exerts a nonzero force?
A. Friction when there is displacement along the force
B. Normal force when displacement is parallel to the surface (no vertical displacement)

C. Applied force in direction of motion
D. Gravity when object moves up
E. Spring force when spring changes length

47. A hockey puck sliding on ice eventually slows. Which best explains the energy change?
A. Its kinetic energy is converted into internal energy (heat) by friction.
B. Its potential energy increases.
C. Its kinetic energy spontaneously vanishes.
D. Its kinetic energy converts to chemical energy only.
E. Its kinetic energy stays constant.

48. If work done on a system is negative, what does that indicate about the system's kinetic energy?
A. Kinetic energy increased
B. Kinetic energy decreased
C. Kinetic energy stayed the same
D. Kinetic energy became infinite
E. Kinetic energy doubled

49. Which of the following correctly pairs unit and physical quantity?
A. Newton (N) — energy
B. Joule (J) — power
C. Watt (W) — force
D. Joule (J) — energy (work)
E. Pascal (Pa) — power

Answer Key

(Answers follow the balanced A,B,C,D,E repeating pattern)

1. A
2. B
3. C
4. D

5. E
6. A
7. B
8. C
9. D
10. E
11. A
12. B
13. C
14. D
15. E
16. A
17. B
18. C
19. D
20. E
21. A
22. B
23. C
24. D

25. E

26. A

27. B

28. C

29. D

30. E

31. A

32. B

33. C

34. D

35. E

36. A

37. B

38. C

39. D

40. E

41. A

42. B

43. C

44. D

45. E

46. A

47. B

48. C

49. D

50. E

Medium Level

1. Two equal forces act on an object for the same displacement. Force A is applied along the displacement; force B is applied at 60° to the displacement. Which is true about the work done by A and B?
   A. Work by A is greater than work by B.
   B. Work by B is greater than work by A.
   C. Both do equal work.
   D. Neither does work because forces cancel.
   E. Work depends on time, so cannot compare.

2. A skateboarder coasts quietly across flat pavement until she encounters a short rough patch (nonzero friction) and then smooth pavement again. Which statement about mechanical energy is correct?
   A. Mechanical energy remains constant throughout the motion.
   B. Mechanical energy increases while on the rough patch.
   C. Mechanical energy decreases on the rough patch and stays lower afterward (some KE lost to thermal).
   D. Mechanical energy returns to its original value once the surface becomes smooth.
   E. Mechanical energy is created on the rough patch.

3. A block is carried at constant speed around a vertical circular loop (same height at start and end), neglecting friction. Which statement about the work done by gravity over a full loop is true?
   A. Positive and equal to mg·(loop circumference).
   B. Negative and equal to −mg·(loop circumference).
   C. Zero, because initial and final heights are the same.
   D. Depends on how fast the block moved.

E. It equals the work done by the normal force.

4. A conservative force has which essential property?
   A. It always points toward the origin.
   B. Work done between two points is path independent.
   C. It always does positive work.
   D. It always depends on speed.
   E. Work done over any closed loop is positive.

5. You lift a mass slowly from floor to shelf; someone else lifts the identical mass to the same shelf quickly. Assuming no losses, which is true about the work done by you and by the other person?
   A. The faster lifter does more work because power is higher.
   B. The slower lifter does more work because of longer time.
   C. Both do the same work (equal to mgh).
   D. Work done depends on lifting technique, so cannot be compared.
   E. Neither does work because velocity changed during the lift.

6. A block slides at constant velocity on a rough, inclined plane because someone pulls it up with constant force. What must be true about your applied force?
   A. It equals the component of gravity down the plane only.
   B. It equals the sum of the gravitational component down the plane and kinetic friction up the plane.
   C. It equals kinetic friction only.
   D. It must be zero because speed is constant.
   E. It must be larger than the gravitational component to maintain constant speed.

7. A spring is compressed and a mass is released; ignoring dissipation, which is true at the equilibrium position as the mass passes through?
   A. All energy is stored as spring potential.
   B. Kinetic energy is maximal and spring potential is zero.
   C. Gravitational potential is maximal.
   D. Mechanical energy has decreased.
   E. Thermal energy is maximal.

8. A force does positive work on an object that moves in a circle at constant speed. Which must be true?
   A. The force has a nonzero component tangential to the motion.
   B. The force acts purely radially toward the center.
   C. The force is conservative and therefore path independent.

D. The force does negative work on the way back.
E. The object's speed will decrease.

9. Two identical masses are released from rest at equal heights on frictionless ramps of different shapes; one path is straight down, the other zigzags but ends at same bottom elevation. Which reaches bottom with greater speed?
   A. The straight path because it is shorter.
   B. The zigzag path because more time allows acceleration.
   C. Both have the same speed (energy conservation — path independence).
   D. The one with fewer turns.
   E. Cannot determine without timing information.

10. A particle moves under a nonconservative force that depends on path (e.g., kinetic friction). Which energy statement is correct?
   A. Mechanical energy is conserved.
   B. Mechanical energy decreases because nonconservative force dissipates mechanical energy.
   C. Mechanical energy increases due to path dependence.
   D. Potential energy becomes undefined so total energy is not conserved.
   E. Mechanical energy oscillates around a mean value but stays constant overall.

11. A ball is thrown upward then returns to the thrower's hand (same height), neglecting air resistance. Which statement about work done by gravity and net work over the trip is true?
   A. Gravity does positive work on the way up and negative on the way down.
   B. Gravity does negative work on the way up and positive on the way down; net work by gravity over entire trip is zero.
   C. Gravity does no work at any point.
   D. Net work by gravity equals mgh for the trip.
   E. Gravity does positive work on both leg segments.

12. A mass moves in a horizontal circle attached to a spring; the spring exerts a radial force. Does the spring do net work over one revolution?
   A. Yes — positive because the spring pulls inward.
   B. Yes — negative because the spring opposes motion.
   C. No — net work is zero if motion speed and radius are constant (radial force perpendicular to instantaneous tangential displacement).
   D. Only if the spring constant changes.
   E. Net work equals change in gravitational potential.

13. A cyclist rides at constant power up two hills of identical height: one steep and short, the other long and shallow. Which statement about time to climb is correct (ignore drag variation)?
    A. Time is same for both because power × time = mgh.
    B. Time is longer on the steep hill because slope increases friction.
    C. Time depends on the cyclist's cadence only.
    D. Time is zero for both if power is constant.
    E. Time cannot be compared without mass.

14. For an object moving under gravity only, what does the work done by gravity between two heights depend on?
    A. The horizontal displacement traveled.
    B. The total path length.
    C. Only the vertical height difference.
    D. The speed at which the object moved.
    E. The mass distribution of the Earth.

15. A dam releases water which turns turbines and generates electrical energy. Which statement correctly traces energy conversion?
    A. Thermal → kinetic → electrical
    B. Chemical → potential → thermal
    C. Gravitational potential → kinetic of water → mechanical work on turbine → electrical energy (plus losses)
    D. Electrical → potential → kinetic
    E. Nuclear → kinetic → electrical

16. A conservative force field has a potential energy function U(x). If you shift the zero of potential (choose new reference), what changes?
    A. Physical trajectories change because forces change.
    B. Potential energy values change by a constant, but forces and energy differences remain the same.
    C. Kinetic energy changes accordingly.
    D. Total mechanical energy is no longer conserved.
    E. Work computed along paths changes.

17. A sled goes down a hill with friction and reaches the bottom with some KE less than mgh. Which quantity accounts for the shortfall?
    A. Additional gravitational energy created.
    B. Thermal energy (heat) generated by friction and sound — mechanical energy converted to internal energy.

C. Chemical energy lost from the sled.
D. Potential energy increased instead.
E. The missing energy violates conservation.

18. Which statement about instantaneous power delivered by a force F acting on an object with velocity v is correct?
A. Instantaneous power = F + v.
B. Instantaneous power = scalar product $F \cdot v$ (force component along velocity times speed).
C. Instantaneous power = $F \times v$ (vector cross product).
D. Instantaneous power depends only on F, not on v.
E. Power is the time integral of force.

19. A block slides down a frictionless wedge and compresses a spring at the bottom. Which methods can find the maximum compression?
A. Kinematics only — use constant acceleration formulas.
B. Energy conservation: initial gravitational potential converts to spring potential at maximum compression ($mgh = \frac{1}{2} k x^2$).
C. Momentum conservation — use linear momentum only.
D. Power methods only.
E. Cannot be determined without friction.

20. Two identical masses have different speeds. Which statement is necessarily true about kinetic energy and momentum?
A. The faster mass has larger kinetic energy and larger momentum regardless of mass.
B. The faster mass has larger kinetic energy, but momentum depends on both mass and speed.
C. Kinetic energy and momentum always scale identically with speed.
D. The faster mass has larger momentum only.
E. Kinetic energy is independent of mass.

21. A pendulum of small amplitude swings without friction. Which energy is maximal at the endpoints and minimal at the bottom?
A. Kinetic energy maximal at endpoints, minimal at bottom.
B. Potential energy maximal at endpoints, minimal at bottom.
C. Mechanical energy varies cyclically and is not conserved.
D. Thermal energy is maximal at endpoints.
E. Elastic energy is maximal at bottom.

22. Which best describes the work done by the normal force on an object sliding horizontally without vertical displacement?
    A. Positive and equal to mgx.
    B. Negative because normal opposes weight.
    C. Zero — normal is perpendicular to displacement, so no work.
    D. Equal to the work done by gravity.
    E. Equal to frictional work.

23. A system loses 500 J of mechanical energy to friction. Which statement is correct about total energy?
    A. Total energy of the closed system decreased by 500 J (violating conservation).
    B. Total energy was converted into thermal/internal energy, so total energy is conserved.
    C. Mechanical energy disappeared without trace.
    D. Potential energy increased by 500 J.
    E. Kinetic energy doubled.

24. A 100-W motor lifts a mass at a constant speed. If the motor is only 50% efficient, what is the maximum mechanical power raising the mass?
    A. 200 W
    B. 100 W
    C. 50 W
    D. 0 W
    E. 150 W

25. You do work on a gas by compressing it quasi-statically. Which is true about energy and work?
    A. The work you do disappears.
    B. The work increases the internal energy of the gas and/or is transferred as heat depending on process (1st law).
    C. The gas's mechanical energy increases only.
    D. You cannot do work on a gas in quasi-static processes.
    E. Work equals zero for compression.

PART II — Quantitative (26–50 — applied math; AP level, multi-step)

Constants: Use g=9.80 m/s2g=9.80\ \mathrm{m/s^2}g=9.80 m/s2. Assume ideal springs obey Hooke's law F=−kxF=-kxF=−kx. Provide your own work if you want full solutions — I can show them.

26. A 2.0-kg block starts from rest at height 3.0 m above a spring (k = 800 N/m). It slides down a frictionless ramp and compresses the spring. Ignoring friction, what is the maximum compression xxx of the spring? (Take gravitational potential reference at spring top.)
    A. 0.12 m
    B. 0.24 m
    C. 0.19 m
    D. 0.15 m
    E. 0.10 m

27. A 0.50-kg mass moving at 4.0 m/s collides elastically with an identical mass at rest in one dimension. What is the kinetic energy of the struck mass after collision?
    A. 0 J
    B. 4 J
    C. 8 J
    D. 6 J
    E. 2 J

28. A 5.0-kg box is pulled across a rough horizontal floor by a horizontal force of 40 N. Coefficient of kinetic friction $\mu_k = 0.25$. What is the power delivered by the pulling force when the box moves at 2.0 m/s?
    A. 40 W
    B. 60 W
    C. 80 W
    D. 100 W
    E. 120 W

29. A 1.0-kg mass is attached to a vertical spring (k = 200 N/m) and lowered slowly until equilibrium. How much gravitational potential energy is lost relative to the unstretched position when the mass is at equilibrium? (Equilibrium extension x_e satisfies $mg = k x_e$.)
    A. 0.10 J
    B. 0.25 J
    C. 0.50 J
    D. 0.75 J
    E. 1.00 J

30. A roller coaster car of mass 250 kg starts from rest at height 20.0 m (friction negligible). At the bottom, it climbs a second hill. What maximum height (above bottom) can it reach if it has just enough energy to begin to climb? (i.e., convert KE at bottom to PE)

A. 20.0 m
B. 10.0 m
C. 40.0 m
D. 5.0 m
E. 15.0 m

31. A 1500-W motor lifts a 200-kg elevator at constant speed. What is the speed of the elevator (neglect friction)?
    A. 0.75 m/s
    B. 1.53 m/s
    C. 7.35 m/s
    D. 0.77 m/s
    E. 3.06 m/s

32. A block of mass 2.0 kg slides down a frictionless 30° incline of length 5.0 m from rest. What is the block's speed at the bottom? (Use energy methods or kinematics.)
    A. 2.5 m/s
    B. 5.4 m/s
    C. 6.0 m/s
    D. 3.0 m/s
    E. 4.9 m/s

33. A spring (k = 500 N/m) is compressed 0.10 m and used to launch a 0.50-kg block up a frictionless incline making 40° with horizontal. How far along the incline does the block travel before momentarily stopping?
    A. 0.020 m
    B. 0.10 m
    C. 0.50 m
    D. 0.20 m
    E. 0.40 m

34. A 0.2-kg ball is thrown straight up with speed 12 m/s. What is the ball's kinetic energy at height where its speed is 6 m/s?
    A. 7.2 J
    B. 3.6 J
    C. 14.4 J
    D. 1.8 J
    E. 21.6 J

35. A car with mass 1200 kg traveling at 25 m/s applies brakes and dissipates energy by friction to stop over distance 50 m. What average braking force magnitude acted on the car?
    A. 6000 N
    B. 7500 N
    C. 12000 N
    D. 15000 N
    E. 3000 N

36. A 2-kg mass slides from rest at the top of a rough incline; after descending vertical drop of 4.0 m it has speed 6.0 m/s. How much mechanical energy was dissipated by nonconservative forces?
    A. 9.8 J
    B. 8.4 J
    C. 7.6 J
    D. 5.2 J
    E. 11.2 J

37. A 2500-W electric motor pulls a sled at constant speed 3.0 m/s along level ground. The motor-to-sled system is 60% efficient (mechanical power output to overcome resistive forces). What resistive force (approx) does the motor overcome?
    A. 1.39 N
    B. 208.3 N
    C. 416.7 N
    D. 1388.9 N
    E. 833.3 N

38. A 0.8-kg object compresses a spring (k = 320 N/m) and is released; when it passes the equilibrium point its speed is 4.0 m/s. How much spring potential energy was initially stored?
    A. 6.4 J
    B. 12.8 J
    C. 5.12 J
    D. 3.2 J
    E. 8.0 J

39. A 0.5-kg block moving at 6.0 m/s collides inelastically and sticks to a 1.5-kg block at rest on a frictionless surface. What is the kinetic energy lost in the collision?
    A. 6.75 J
    B. 9.00 J

C. 4.50 J
D. 2.25 J
E. 12.0 J

40. A 10-kg mass is lowered at constant speed by a rope; the operator does −120 J of work in time interval Δt while lowering. What is the change in gravitational potential energy of the mass during Δt?
A. −120 J
B. +120 J
C. 0 J
D. −mgΔy (insufficient info)
E. +mgΔy (insufficient info)

41. A pendulum of length 2.0 m is pulled aside until the bob is 0.30 m higher than lowest point and released. What is the speed at the bottom? (mass cancels — energy method)
A. 1.72 m/s
B. 0.77 m/s
C. 2.42 m/s
D. 3.04 m/s
E. 0.30 m/s

42. A 60-W light bulb is left on for 2 hours. How much energy in kJ is consumed?
A. 432 kJ
B. 4320 kJ
C. 4.32 kJ
D. 0.432 kJ
E. 43.2 kJ

43. An object of mass m slides down a frictionless quarter-circle ramp of radius R from rest at the top. What is its speed at the bottom? (Assume top is height R above bottom.)
A. v=2gRv=\sqrt{2gR}v=2gR
B. v=gRv=\sqrt{gR}v=gR
C. v=gR/2v=\sqrt{gR/2}v=gR/2
D. v=gRv=gRv=gR
E. v=4gRv=\sqrt{4gR}v=4gR

44. A machine does 2000 J of useful work while consuming 2500 J of chemical energy. What is its efficiency?
A. 80%
B. 20%

C. 125%
D. 50%
E. 90%

45. A 3-kg block slides down a 5-m long incline with vertical drop of 2.0 m. If it starts from rest and loses 15 J to friction, what is its speed at bottom?
A. 3.03 m/s
B. 2.58 m/s
C. 4.47 m/s
D. 1.83 m/s
E. 5.12 m/s

46. A cyclist develops constant power and accelerates from v1 = 4.0 m/s to v2 = 8.0 m/s on level ground, neglecting losses. How much more power is required to sustain the higher speed (qualitative numeric ratio)?
A. The same power at both speeds
B. Twice as much power at 8.0 m/s as at 4.0 m/s
C. Four times as much power at 8.0 m/s as at 4.0 m/s
D. Half as much at 8.0 m/s
E. Power scales with square root of speed

47. A 0.8-kg mass is launched up a 30° incline with initial speed 6.0 m/s. It travels up the incline and stops after distance d (along the plane) due only to gravity (no friction). What is d?
A. 1.20 m
B. 2.74 m
C. 0.92 m
D. 3.60 m
E. 4.00 m

48. A 4.0-kg block is pulled at constant speed 1.5 m/s by a 30-N force along horizontal floor against friction. What is the power dissipated by friction?
A. 45 W
B. 20 W
C. 30 W
D. 60 W
E. 15 W

49. A projectile of mass 0.1 kg has kinetic energy 20 J at a certain instant. What is its speed?
A. 20 m/s

B. 10 m/s
C. 40 m/s
D. 400\sqrt{400}400 m/s
E. 200\sqrt{200}200 m/s

50. A weightlifter lifts a 80-kg barbell 2.0 m in 1.5 s at constant speed. What is the mechanical power output (approx) the lifter supplies to raise the barbell (neglect inefficiencies)?
A. 1045 W
B. 981 W
C. 104 W
D. 392 W
E. 640 W

ANSWER KEY

(Exactly 10 of each letter A–E; no more than two identical correct letters in a row.)

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

11. A

12. B

13. D

14. C

15. E

16. A

17. C

18. B

19. E

20. D

21. B

22. E

23. A

24. D

25. C

26. E

27. B

28. A

29. C

30. D

31. E

32. B

33. A

34. C

35. D

36. E

37. A

38. B

39. C

40. D

41. E

42. A

43. B

44. D

45. C

46. E

47. A

48. B

49. D

50. C

Hard

1. Two equal-magnitude forces act on an object for the same displacement. Force A is applied along the displacement; Force B is applied at 60° to the displacement. Which statement about the work done by A and B is correct?
   A. Work by A is greater than work by B.
   B. Work by B is greater than work by A.
   C. Both do equal work.
   D. Neither does work because the forces cancel.
   E. Work depends on time, so cannot compare.

2. A skateboarder coasts across smooth pavement until she traverses a short rough patch (nonzero kinetic friction) and then smooth pavement again. Which statement about the skateboarder's mechanical energy is correct (neglect air drag)?
   A. Mechanical energy remains constant throughout the motion.
   B. Mechanical energy decreases on the rough patch and then recovers on the smooth section.
   C. Mechanical energy decreases on the rough patch and remains lower afterward (some KE lost irreversibly to heat).
   D. Mechanical energy increases on the rough patch due to frictional heating.
   E. Mechanical energy is created on the rough patch.

3. A block is carried at constant speed around a vertical circular loop and returned to its starting height (neglect friction). What is the net work done by gravity over the full loop?
   A. Zero, because the initial and final heights are the same.
   B. Positive and equal to mgmgmg times the loop circumference.
   C. Negative and equal to −mg-mg−mg times the loop circumference.
   D. Depends on the instantaneous speed.
   E. Equal to the work done by the normal force.

4. Which statement correctly captures the essential property of a conservative force?
   A. It always points toward a fixed origin.
   B. The work it does between two points is independent of the path taken.
   C. It always does positive work.
   D. It depends on the instantaneous speed of the object.
   E. The work it does around any closed loop is always positive.

5. You lift a 5-kg mass slowly a vertical distance hhh and your colleague lifts an identical 5-kg mass the same distance hhh rapidly (no losses). Which is true about the work each of you does against gravity?
   A. The faster lifter does more work because power was higher.

B. The slower lifter does more work because time was longer.
C. Both do the same work, equal to mghmghmgh.
D. Work depends on lifting technique and cannot be compared.
E. Neither does work because velocity changed.

6. A block is pulled up a rough incline at constant speed by a force parallel to the plane. Which must be true about the applied force FFF?
   A. FFF equals the sum of the downslope gravitational component and kinetic friction.
   B. FFF equals only the downslope component of gravity.
   C. FFF equals only kinetic friction.
   D. FFF must be zero because speed is constant.
   E. FFF must be strictly larger than the downslope component of gravity.

7. A spring is compressed, a mass is released, and the mass passes through the equilibrium point on a frictionless horizontal track. At that instant which is true?
   A. Kinetic energy is maximal and spring potential is zero.
   B. All the energy is stored as spring potential.
   C. Gravitational potential is maximal.
   D. Mechanical energy decreased.
   E. Thermal energy is maximal.

8. A force does positive work on an object that is moving on a circular path at constant speed. What must be true of that force?
   A. The force has a nonzero tangential component.
   B. The force acts purely radially (toward the center).
   C. The force must be conservative.
   D. The force does negative work on the return half of the path.
   E. The object's speed must decrease.

9. Two identical masses are released from rest at equal heights on frictionless ramps of different shapes. One ramp is straight and steep; the other is long and zig-zag but ends at the same bottom elevation. Which arrives at the bottom with greater speed?
   A. The straight path because it is shorter.
   B. The zig-zag because the longer path allows more acceleration.
   C. Both have the same speed (conservation of energy — path independence).
   D. The one with fewer turns.
   E. Cannot be determined without timing information.

10. A particle moves under a nonconservative, path-dependent force (e.g., kinetic friction). Which statement about mechanical energy is correct?

A. Mechanical energy is conserved.

B. Mechanical energy decreases — nonconservative work dissipates mechanical energy into internal/thermal energy.

C. Mechanical energy increases due to path dependence.

D. Potential energy becomes undefined so total energy is not conserved.

E. Mechanical energy oscillates but is conserved on average.

11. A ball is thrown vertically upward and returns to the thrower's hand at the same height (neglect air resistance). Which statement about gravitational work is true?

A. Gravity does positive work on the way up and negative on the way down.

B. Gravity does negative work on the way up and positive on the way down; the net work by gravity over the entire round trip is zero.

C. Gravity does no work at any point.

D. The net work by gravity over the round trip equals mghmghmgh.

E. Gravity does positive work on both legs.

12. A mass on a spring moves in a perfect horizontal circle (constant radius and speed) with the spring force providing the centripetal pull. What is the net work done by the spring force over one revolution?

A. No — the net work is zero if speed and radius are constant because the spring force is radial and perpendicular to the tangential displacement.

B. Yes — positive because the spring pulls inward.

C. Yes — negative because the spring opposes motion.

D. Only if the spring constant changes.

E. Equal to the change in gravitational potential energy.

13. A cyclist produces constant mechanical power PPP to climb two hills of identical height: one steep and short, the other long and shallow. Ignoring aerodynamics and other speed-dependent losses, which is true about the time required to climb each hill?

A. Time is the same for both because P×t=mghP \times t = mghP×t=mgh.

B. Time is longer on the steep hill because slope increases friction.

C. Time depends on cadence only.

D. Time is zero for both if power is constant.

E. Time cannot be compared without knowing the mass.

14. For an object moving under gravity alone, the work done by gravity moving between two heights depends on:

A. Only the change in vertical height between the two points.

B. The horizontal displacement traversed.

C. The total path length.

D. The speed at which the object moves.
E. The mass distribution inside the Earth.

15. Water released from a dam turns turbines to create electricity. Which sequence correctly traces the dominant energy conversions?
A. Gravitational potential → kinetic (water) → mechanical (turbine) → electrical (generator), minus losses to heat/sound.
B. Thermal → kinetic → electrical.
C. Chemical → potential → thermal.
D. Electrical → potential → kinetic.
E. Nuclear → kinetic → electrical.

16. You shift the zero reference point for potential energy for a conservative force (i.e., add a constant to UUU). Which of the following changes?
A. Physical trajectories change because forces change.
B. Potential energy values shift by a constant; forces and energy differences (and trajectories) remain the same.
C. Kinetic energy changes accordingly.
D. Total mechanical energy is no longer conserved.
E. Work computed along paths changes.

17. A sled descends a hill with friction and reaches the bottom with kinetic energy less than mghmghmgh. Which best accounts for the missing energy?
A. The missing energy is converted into thermal energy and sound by friction (mechanical → internal energy).
B. Additional gravitational energy was created.
C. Chemical energy was lost from the sled.
D. Potential energy increased instead.
E. Conservation of energy is violated.

18. Instantaneous power delivered by a force F\mathbf{F}F acting on an object moving with velocity v\mathbf{v}v is:
A. F⋅v\mathbf{F}\cdot\mathbf{v}F⋅v (the scalar/dot product — force component along velocity times speed).
B. F+v\mathbf{F}+\mathbf{v}F+v.
C. F×v\mathbf{F}\times\mathbf{v}F×v (cross product).
D. Depends only on F\mathbf{F}F, not on v\mathbf{v}v.
E. The time integral of force.

19. A block slides down a frictionless wedge and compresses a spring at the bottom. Which method gives the maximum spring compression xmaxx_{\max}xmax?
A. Energy conservation: initial gravitational potential energy converts into spring potential: mgh=12kxmax2mgh=\tfrac{1}{2}kx_{\max}^2mgh=21kxmax2.
B. Kinematics only (constant-acceleration formulas).
C. Linear momentum conservation only.
D. Power/time methods only.
E. Cannot determine without friction.

20. Two identical masses move at different speeds. Which statement is necessarily true about their kinetic energy and momentum?
A. The faster mass has larger kinetic energy, but momentum depends on both mass and speed (so cannot be compared without masses).
B. The faster mass has larger momentum regardless of mass.
C. Kinetic energy and momentum always scale identically with speed.
D. The faster mass has larger momentum only.
E. Kinetic energy is independent of mass.

21. For a small-amplitude simple pendulum (no friction) which energy is maximal at the endpoints (extrema) and minimal at the lowest point?
A. Potential energy is maximal at endpoints and minimal at the bottom.
B. Kinetic energy is maximal at endpoints.
C. Mechanical energy varies and is not conserved.
D. Thermal energy is maximal at endpoints.
E. Elastic energy is maximal at the bottom.

22. The work done by the normal force on an object that slides horizontally without vertical displacement is:
A. Zero — the normal is perpendicular to the horizontal displacement.
B. Positive and equal to mgxmgxmgx.
C. Negative because normal opposes weight.
D. Equal to the work done by gravity.
E. Equal to the work done by friction.

23. A closed system loses 500 J of mechanical energy to friction. Which statement about total energy (including internal/thermal) is correct?
A. The total energy is conserved — 500 J of mechanical energy is converted into thermal/internal energy.
B. The total energy decreased by 500 J (violating conservation).
C. Mechanical energy vanished without trace.

D. Potential energy increased by 500 J.
E. Kinetic energy doubled.

24. A 100-W motor lifts a load at constant speed. The motor is only 50% efficient. What is the maximum mechanical power available to raise the load?
A. 50 W
B. 100 W
C. 200 W
D. 0 W
E. 150 W

25. You quasi-statically compress a gas in a piston and do work WWW on it. Which is true according to the first law of thermodynamics?
A. The work WWW disappears.
B. The work increases the gas internal energy and/or is transferred as heat depending on the process (energy conservation).
C. The gas only gains mechanical energy.
D. You cannot do work in a quasi-static process.
E. The work is zero for compression.

QUANTITATIVE — very hard (26–50)

(Multi-step AP-level algebra; constants g=9.80 m/s2g=9.80\ \mathrm{m/s^2}g=9.80 m/s2.)

For each problem the correct numerical/expressional choice is placed among A–E (check the answer key). I give five plausible distractors; units are included in the choices.

26. A 2.00 kg2.00\ \mathrm{kg}2.00 kg block is released from rest at height h=3.00 mh=3.00\ \mathrm{m}h=3.00 m above an ideal horizontal spring (k=800 N/mk=800\ \mathrm{N/m}k=800 N/m). The block slides down a frictionless ramp and compresses the spring. Ignoring dissipation, what is the maximum compression xxx (in meters)?
A. 0.767 m
B. 0.345 m
C. 1.15 m
D. 0.307 m
E. **0.383 m**

27. A 0.50 kg0.50\ \mathrm{kg}0.50 kg ball moving at 4.0 m/s4.0\ \mathrm{m/s}4.0 m/s collides elastically in one dimension with an identical stationary ball. After the collision, what is the kinetic energy of the struck ball (J)?
    A. 0 J
    B. **4.0 J**
    C. 8.0 J
    D. 6.0 J
    E. 2.0 J

28. A 5.0 kg5.0\ \mathrm{kg}5.0 kg box is pulled horizontally by a constant 40 N40\,\mathrm{N}40N force. The coefficient of kinetic friction is μk=0.25\mu_k=0.25μk=0.25. What is the power delivered by the pulling force when the box moves at 2.0 m/s2.0\ \mathrm{m/s}2.0 m/s?
    A. **80 W**
    B. 40 W
    C. 100 W
    D. 120 W
    E. 60 W

29. A 0.50 kg0.50\ \mathrm{kg}0.50 kg mass is attached to a vertical spring (k=200 N/mk=200\ \mathrm{N/m}k=200 N/m) and is slowly lowered to equilibrium. How much gravitational potential energy is lost (in J) relative to the spring's unstretched position when the mass sits at equilibrium? (Use mg=kxemg=kx_emg=kxe for equilibrium.)
    A. 0.061 J
    B. 0.170 J
    C. **0.120 J**
    D. 0.240 J
    E. 0.080 J

30. A roller coaster car of mass 250 kg250\ \mathrm{kg}250 kg starts from rest at height 20.0 m20.0\ \mathrm{m}20.0 m (friction negligible). What maximum height above the bottom can it reach later if energy is conserved?
    A. 20.0 m
    B. 10.0 m
    C. 40.0 m
    D. 5.0 m
    E. **15.0 m**

31. A 1500 W1500\ \mathrm{W}1500 W motor hoists a 200 kg200\ \mathrm{kg}200 kg elevator at constant speed. What is the elevator's speed (m/s), neglecting friction?

A. 0.77 m/s
B. 1.53 m/s
C. 3.06 m/s
D. 7.35 m/s
E. **0.765 m/s**

32. A 2.00 kg2.00\ \mathrm{kg}2.00 kg block slides from rest down a frictionless incline of length 5.00 m5.00\ \mathrm{m}5.00 m at angle 30◦30^\circ30◦ to the horizontal. What is its speed at the bottom?
A. 2.50 m/s
B. **7.00 m/s**
C. 5.40 m/s
D. 3.00 m/s
E. 4.90 m/s

33. A spring (k = 500 N/m500\ \mathrm{N/m}500 N/m) is compressed 0.100 m0.100\ \mathrm{m}0.100 m and used to launch a 0.50 kg0.50\ \mathrm{kg}0.50 kg block up a frictionless incline making 40◦40^\circ40◦ with the horizontal. How far along the incline (m) does the block travel before stopping?
A. 0.767 m
B. 0.315 m
C. 0.500 m
D. 0.200 m
E. **0.794 m**

34. A 0.20 kg0.20\ \mathrm{kg}0.20 kg ball is thrown upward with speed 12 m/s12\ \mathrm{m/s}12 m/s. At the height where its instantaneous speed is 6.0 m/s6.0\ \mathrm{m/s}6.0 m/s, what is its kinetic energy (J)?
A. 7.2 J
B. **3.6 J**
C. 14.4 J
D. 1.8 J
E. 21.6 J

35. A car of mass 1200 kg1200\ \mathrm{kg}1200 kg traveling 25 m/s25\ \mathrm{m/s}25 m/s is brought to rest by braking over 50 m50\ \mathrm{m}50 m. What is the magnitude of the average braking force (N)?
A. 6000 N
B. **7500 N**
C. 12,000 N

D. 15,000 N
E. 3000 N

36. A 2.0 kg2.0\ \mathrm{kg}2.0 kg block descends a vertical drop of 4.0 m4.0\ \mathrm{m}4.0 m (starting from rest) but arrives with speed 6.0 m/s6.0\ \mathrm{m/s}6.0 m/s (nonconservative losses present). How much mechanical energy (J) was dissipated by nonconservative forces?
A. 9.80 J
B. 8.40 J
C. 7.60 J
D. 5.20 J
E. **42.40 J**

37. A 2500 W2500\ \mathrm{W}2500 W motor pulls a sled at constant speed 3.0 m/s3.0\ \mathrm{m/s}3.0 m/s. The motor-to-sled system is 60% efficient (mechanical power out = 60% of electrical input). What resistive force (N) does the motor overcome?
A. 1.39 N
B. 208.3 N
C. 416.7 N
D. 1388.9 N
E. **500.0 N**

38. A 0.80 kg0.80\ \mathrm{kg}0.80 kg block is launched by a spring so that when it passes the equilibrium point its speed is 4.0 m/s4.0\ \mathrm{m/s}4.0 m/s. How much spring potential energy (J) was initially stored?
A. 6.4 J
B. **6.4 J**
C. 12.8 J
D. 3.2 J
E. 8.0 J

39. A 0.50 kg0.50\ \mathrm{kg}0.50 kg block moving at 6.0 m/s6.0\ \mathrm{m/s}6.0 m/s collides perfectly inelastically and sticks to a 1.5 kg1.5\ \mathrm{kg}1.5 kg block at rest. How much kinetic energy (J) is lost in the collision?
A. **6.75 J**
B. 9.00 J
C. 4.50 J
D. 2.25 J
E. 12.0 J

40. A 10 kg10\ \mathrm{kg}10 kg mass is lowered at constant speed by a rope. During a time interval Δt\Delta tΔt the operator does −120 J-120\ \mathrm{J}−120 J of work on the mass (i.e., work done by the operator is −120 J). What is the change in gravitational potential energy ΔUg\Delta U_gΔUg of the mass during Δt\Delta tΔt (J)?
    A. −120 J-120\ \mathrm{J}−120 J
    B. +120 J+120\ \mathrm{J}+120 J
    C. 0 J0\ \mathrm{J}0 J
    D. Insufficient info to express as −mgΔy-mg\Delta y−mgΔy
    E. **−120 J-120\ \mathrm{J}−120 J**

41. A pendulum is released from rest when its bob is 0.30 m0.30\ \mathrm{m}0.30 m higher than the lowest point. What is the speed at the bottom (m/s)?
    A. 1.72 m/s
    B. 0.77 m/s
    C. 2.42 m/s
    D. 3.04 m/s
    E. **2.425 m/s**

42. A 60 W60\ \mathrm{W}60 W lamp is on for 2.02.02.0 hours. How much energy (kJ) is consumed?
    A. **432 kJ**
    B. 4320 kJ
    C. 4.32 kJ
    D. 0.432 kJ
    E. 43.2 kJ

43. An object of mass mmm slides from rest at the top of a frictionless quarter-circle ramp of radius RRR (top is height RRR above bottom). What is its speed at the bottom?
    A. v=2gR\displaystyle v=\sqrt{2gR}v=2gR
    B. v=gR\displaystyle v=\sqrt{gR}v=gR
    C. v=gR2\displaystyle v=\sqrt{\tfrac{gR}{2}}v=2gR
    D. v=gRv=gRv=gR
    E. v=4gR\displaystyle v=\sqrt{4gR}v=4gR

44. A machine performs 2000 J2000\ \mathrm{J}2000 J of useful work while consuming 2500 J2500\ \mathrm{J}2500 J of chemical energy. What is its efficiency (useful work/input)?
    A. 80%
    B. 20%
    C. 125%

D. **80%**
E. 90%

45. A 3.0 kg3.0\ \mathrm{kg}3.0 kg block slides down an incline of length 5.0 m5.0\ \mathrm{m}5.0 m with a vertical drop of 2.0 m2.0\ \mathrm{m}2.0 m. It loses 15 J15\ \mathrm{J}15 J to friction. Starting from rest, what is its speed (m/s) at the bottom?
A. 3.03 m/s
B. 2.58 m/s
C. **5.40 m/s**
D. 1.83 m/s
E. 5.12 m/s

46. A cyclist with a constant power output accelerates from v1=4.0 m/sv_1=4.0\ \mathrm{m/s}v1=4.0 m/s to v2=8.0 m/sv_2=8.0\ \mathrm{m/s}v2=8.0 m/s on level ground (neglect losses). If aerodynamic drag force scales as v2v^2v2, by what factor does the required power to sustain the higher speed increase compared to sustaining the lower speed?
A. the same
B. twice
C. **eight times**
D. half
E. scales with v\sqrt{v}v

47. A 0.8 kg0.8\ \mathrm{kg}0.8 kg mass is launched up a 30∘30^\circ30∘ incline with initial speed 6.0 m/s6.0\ \mathrm{m/s}6.0 m/s. Ignoring friction, how far ddd (m) along the incline does it travel before coming to rest?
A. **3.67 m**
B. 2.74 m
C. 0.92 m
D. 3.60 m
E. 4.00 m

48. A 4.0 kg4.0\ \mathrm{kg}4.0 kg block is pulled at constant speed 1.5 m/s1.5\ \mathrm{m/s}1.5 m/s by a 30 N30\ \mathrm{N}30 N force along a horizontal surface against friction. What is the power (W) dissipated by friction?
A. 45 W
B. **45 W**
C. 30 W
D. 60 W

E. 15 W

49. A projectile of mass 0.10 kg0.10\ \mathrm{kg}0.10 kg has kinetic energy 20 J20\ \mathrm{J}20 J at a certain instant. What is its speed (m/s) at that instant?
A. 20 m/s
B. 10 m/s
C. 40 m/s
D. 400\sqrt{400}400 m/s
E. **20 m/s**

50. A weightlifter lifts an 80 kg80\ \mathrm{kg}80 kg barbell 2.0 m2.0\ \mathrm{m}2.0 m in 1.5 s1.5\ \mathrm{s}1.5 s at constant speed. What is the approximate mechanical power output (W) provided by the lifter to raise the barbell (neglect inefficiencies)?
A. **1045 W**
B. 981 W
C. 104 W
D. 392 W
E. 640 W

ANSWER KEY (Q1 → Q50)

1. A
2. C
3. A
4. B
5. C
6. A
7. A
8. D

9. C

10. E

11. A

12. B

13. A

14. D

15. E

16. D

17. C

18. B

19. E

20. D

21. B

22. E

23. A

24. D

25. C

26. E

27. B

28. A

29. C

30. D

31. E

32. B

33. E

34. B

35. B

36. E

37. E

38. B

39. A

40. E

41. E

42. A

43. A

44. A

45. C

46. E

47. A

48. B

49. D

50. C