

6. A car travels along a straight line at a constant speed of 20m/s for a distance d and then another distance d in the same direction at a constant speed of 36 km/hr. what is the average speed for the entire trip? (1)
- A. 23km/hr
B. ✓ 48km/hr
C. 54km/hr
D. 60km/hr

Answer: B

A speed of 20 m/s is equal to 72 km/hr. For two equal distances, the average speed is the harmonic mean: $v_{\text{avg}} = \frac{2v_1v_2}{v_1+v_2} = \frac{2(72)(36)}{72+36} = 48 \text{ km/hr}$.

7. If a long distance jumper athlete leaves the ground at an angle of 37° above the horizontal surface at a speed of 10.0m/s, how far does he jump in the horizontal direction? (1)
- A. 4.8m
B. 6m
C. ✓ 9.6m
D. 9m/s

Answer: C

The horizontal range is given by $R = \frac{v^2 \sin(2\theta)}{g} = \frac{v^2 (2 \sin \theta \cos \theta)}{g} = \frac{10^2 \times 2 \times 0.6 \times 0.8}{10} = 9.6 \text{ m}$.

8. Women is rotating a bucket of water in a vertical circle of radius 0.9m. The mass of bucket and water is 5kg. (1)
What is the bucket's minimum speed at the top of circle if no water is to spill out?
- A. 0
B. 1m/s
C. ✓ 3m/s
D. 9m/s

Answer: C

At the top of the vertical circle, the minimum speed required to maintain circular motion without water spilling is $v_{\text{min}} = \sqrt{gr} = \sqrt{10 \text{ m/s}^2 \times 0.9 \text{ m}} = 3 \text{ m/s}$.

9. A force of magnitude 20N is applied to a block of mass 2kg that lies on a rough, horizontal surface as shown in figure below. The coefficient of kinetic friction between the bock and surface is 0.4. What is the magnitude of the acceleration of the block? (1)
- [Figure: A shaded rectangular block labelled "Block" rests on a horizontal surface drawn as a solid line with hatching beneath it (the ground). From a point on the right-hand face of the block a straight arrow points up and to the right and is labelled F at its head. A dashed horizontal line runs to the right from that same point, and the angle between the dashed horizontal and the arrow F is marked 53° . A stray label "C(1,4)" is printed immediately after the angle; it is a scanning artifact carried over from a neighbouring figure and belongs to no part of this problem.]*
- A. 10 m/s^2
B. ✓ 5.2 m/s^2
C. 4 m/s^2
D. 2.8 m/s^2

Answer: B

Resolving forces: normal force $N = mg - F \sin(53^\circ) = 2(10) - 20(0.8) = 4 \text{ N}$. Friction force $f_k = \mu_k N = 0.4(4) = 1.6 \text{ N}$, leading to acceleration $a = \frac{F \cos(53^\circ) - f_k}{m} = \frac{12 - 1.6}{2} = 5.2 \text{ m/s}^2$.

- 10.** A hard ball moving on a horizontal frictionless surface with a speed of 5m/s in the positive x direction strikes a stationary hard ball of the same mass. After the collision, the first ball moves with a speed of 4m/s along a direction that makes an angle of 0.37° with its initial direction of motion. What is the struck ball's speed and the smallest angle between its direction of motion and the positive x axis after the collision?
- A. ✓ **3m/s and 53.0°** B. 3m/s and 37.0°
- C. 4m/s and 53.0° D. 4m/s and 37.0°

Answer: A

Since the collision is elastic between equal masses with initial speed 5 m/s and final speed of one ball 4 m/s, the other ball's speed is given by the Pythagorean relation $v = \sqrt{5^2 - 4^2} = 3$ m/s. The two velocity vectors are perpendicular, so the struck ball deflects at $90^\circ - 37^\circ = 53^\circ$.

11. A highway curve is banked (inclined) in such a way that a car traveling at a speed of 13.5m/s can round the curve without skidding, in the absence of friction. If the banking angle is 30° , what is the radius of the curve? (1)
- A. 10.5m B. 21.0m
C. ✓ 31.7m D. 36.7m

Answer: C

For an unbanked curve without friction, $\tan \theta = v^2 / (rg)$, which gives $r = v^2 / (g \tan \theta)$. Using $v = 13.5 \text{ m/s}$, $\theta = 30^\circ$, and $g \approx 10 \text{ m/s}^2$ (or 9.8 m/s^2), $r \approx (13.5)^2 / (10 \times \tan 30^\circ) \approx 182.25 / 5.77 \approx 31.7 \text{ m}$.

12. A car of mass 1500 kg is travelling at a uniform velocity of 30m/s due east. The driver applies the brakes to slow down the car to a velocity of 10m/s due east. What is the work done in slowing down the car?
- A. 15KJ B. 300KJ
C. ✓ 600KJ D. 750KJ

Answer: C

By the work-energy theorem, the work done equals the change in kinetic energy: $W = 0.5 \times 1500 \times (10^2 - 30^2) = 750 \times (-800) = -600,000 \text{ J} = -600 \text{ kJ}$ (magnitude is 600 kJ).

13. Which one of the following statements is true about a spring mass system oscillation on a horizontal frictionless surface? (1)
- A. The kinetic and potential energies are equal at all times.
 - B. The kinetic and potential energies are both constant.
 - C. The maximum potential energies is achieved when the mass passes through its equilibrium position.
 - D. ✓ **The maximum kinetic energy and maximum potential energy are equal.**

Answer: D

In a simple harmonic oscillator with no non-conservative forces, total mechanical energy is conserved, meaning the maximum kinetic energy at the equilibrium position equals the maximum potential energy at the turning points.

14. A block of mass 10kg is pulled up a rough inclined plane with a force of 100N parallel to the inclined plane. The inclined plane makes an angle of 37° with the horizontal. At the instant when the force is applied the block has a speed of 1.5m/s. If the coefficient of kinetic friction is 0.40, and the block is pulled up 5m, what is the change in the kinetic energy of the block? (1)
- A. 20J
B. 30J
C. ✓ 40J
D. 45.5J

Answer: C

Taking $g = 10 \text{ m/s}^2$, the net force along the incline is $F_{\text{net}} = F - mg \sin(37^\circ) - \mu mg \cos(37^\circ) = 100 - (10)(10)(0.6) - 0.4(10)(10)(0.8) = 100 - 60 - 32 = 8 \text{ N}$. The change in kinetic energy is $\Delta K = F_{\text{net}} \times d = 8 \text{ N} \times 5 \text{ m} = 40 \text{ J}$.

15. The particles shown in figure below are connected by rectangular rigid rods of negligible mass. The origin of the xy plane is the center of the rectangle. The system rotates in the xy plane about the z axis with an angular speed of 6.00 rad/s . what is the rotational kinetic energy of the system?

[Figure: A rectangle drawn on a set of x and y axes whose origin, labelled O , is at the centre of the rectangle; the y axis runs vertically up through the middle of the rectangle and the x axis runs horizontally to the right through the middle. A small particle (drawn as a small double circle) sits at each of the four corners. The top-right particle is labelled 2 kg , the bottom-right particle 3 kg , the bottom-left particle 2 kg ; the top-left particle carries the label " 3 " with its unit cut off at the edge of the scan (evidently 3 kg). A double-headed vertical arrow at the left of the figure spans the height of the rectangle and is labelled 6 m , with the annotation " $\text{Hyp}=?$ " written alongside it. A double-headed horizontal arrow along the bottom of the rectangle spans its width and is labelled 4 m .]

- A. 2574J
B. ✓ 2340J
C. 1287J
D. 1170J

Answer: B

The distance squared of each mass from the z-axis (the origin) is $r^2 = (4/2)^2 + (6/2)^2 = 2^2 + 3^2 = 13 \text{ m}^2$. The total moment of inertia is $I = (2 + 3 + 2 + 3) \times 13 = 130 \text{ kg}\cdot\text{m}^2$, yielding a rotational kinetic energy of $K = 0.5 \times 130 \times 6^2 = 2340 \text{ J}$.

16. Two blocks are connected by a string of negligible mass passing over a pulley of radius $r = 0.2 \text{ m}$ and moment of inertia I as shown on figure below. The block on the horizontal frictionless surface is moving with a constant acceleration $= 2.0 \text{ m/s}^2$. If the pulley axis is frictionless, the string is inextensible and does not slip on pulley, what should be the moment of inertial of the pulley?

[Figure: A shaded block labelled 2 kg rests on a horizontal surface drawn as a line with hatching beneath it. A horizontal string labelled T_1 runs from the right-hand face of the block to a small pulley mounted at the right-hand edge of the surface. From the pulley a vertical string labelled T_2 hangs straight down and is attached to the top of a second, unshaded rectangular block labelled 3 kg.]

- A. $\checkmark$ 0.40 kgm^2 B. 0.80 kgm^2
C. 0.6 kgm^2 D. 0.2 kgm^2

Answer: A

Using $g = 10 \text{ m/s}^2$, the tensions are $T_1 = m_1 a = 2(2) = 4 \text{ N}$ and $T_2 = m_2(g - a) = 3(10 - 2) = 24 \text{ N}$. From torque $(T_2 - T_1)r = I(a/r)$, we find $I = (T_2 - T_1)r^2 / a = (20)(0.2)^2 / 2 = 0.40 \text{ kg}\cdot\text{m}^2$.

17. An object with a mass of $m = 3.0\text{kg}$ is attached to the free end of a light string wrapped around a pulley of radius $R = 0.50\text{m}$ and moment of inertia $I = 0.75\text{kgm}^2$. The pulley is free to rotate in a vertical plane about a fixed frictionless axis passing through its center as shown in figure. The suspended object is released from rest at 3.60m above the floor. What is the angular momentum of the pulley at the time when the object strikes the floor?

[Figure: A large circle representing the pulley, drawn with a thick rim and a small dot at its centre; a line runs from the centre out to the rim and is labelled R . A string leaves the right-hand side of the pulley rim and runs vertically downward to the top of a rectangular block labelled $M=3$.]

- A. $4.5 \text{ kgm}^2/\text{s}$ B. ✓ $9.0 \text{ kgm}^2/\text{s}$
C. $12.3 \text{ kgm}^2/\text{s}$ D. $18 \text{ kgm}^2/\text{s}$

Answer: B

By conservation of energy, $mgh = 0.5(m + I/R^2)v^2 = 0.5(3 + 0.75/0.25)v^2 = 3v^2$, so using $g = 10 \text{ m/s}^2$, $v = \sqrt{(10 \times 3.6)} = 6 \text{ m/s}$.
The angular speed of the pulley is $\omega = v/R = 12 \text{ rad/s}$, giving angular momentum $L = I\omega = 0.75 \times 12 = 9.0 \text{ kg}\cdot\text{m}^2/\text{s}$.

18. Which one of the following statements is not correct about a particle that is in equilibrium? (1)
- A. It can have a velocity different from zero.
 - B. Its velocity can be equal to zero.
 - C. It can be under the action of more than one force.
 - D. ✓ **It can have an acceleration different from zero.**

Answer: D

A particle in translational equilibrium has a net external force of zero, which by Newton's second law requires its acceleration to be zero.

19. Which one of the following laws best describes the behaviour of elastic materials? (1)
- A. Gay Lussae's law
 - B. ✓ **Hook's law**
 - C. Newton's second law
 - D. Newton's law of gravitation

Answer: B

Hooke's law states that within the elastic limit, stress is directly proportional to strain (or restoring force is proportional to displacement), which governs the behavior of elastic materials.

20. Two solid spheres made of gold and silver having equal masses are suspended by strings and fully submerged in a tank of water. Given that the density of gold is greater than that of silver, which one of the following statement is true? (1)
- A. The buoyant force on each sphere is the same.
 - B. The volume of water displaced by the gold sphere is larger than that of the silver sphere.
 - C. The tension in the string supporting each sphere is the same.
 - D. ✓ **The buoyant force on the silver sphere is greater than that on the gold sphere.**

Answer: D

Since both spheres have the same mass and the density of silver is less than that of gold, the silver sphere has a larger volume ($V = m/\rho$). Consequently, the silver sphere displaces a greater volume of water and experiences a greater buoyant force ($F_B = \rho_{\text{water}} V g$).

21. The cross section areas of the small and large pistons of a hydraulic lift shown in figure are 4.0 cm^2 and 0.02 m^2 , respectively. What is the magnitude of the force that must be applied to the small piston to lift a weight $w = 15,000 \text{ N}$ placed on the larger piston? (1)
- [Figure: A U-shaped vessel drawn in cross section with thick walls, holding a fluid. Its left limb is narrow and its right limb is wide; each limb is closed by a piston. A vertical arrow pointing downward is drawn inside the left limb, above the small piston, and is labelled F_1 . A shaded rectangular block labelled W rests on top of the large piston in the right limb, which sits higher than the small piston.]
- A. ✓ **$3 \times 10^2 \text{ N}$**
 - B. $2 \times 10^4 \text{ N}$
 - C. $3 \times 10^5 \text{ N}$
 - D. $3 \times 10^6 \text{ N}$

Answer: A

By Pascal's principle, $F_1/A_1 = F_2/A_2$. Converting A_1 gives $4.0 \times 10^{-4} \text{ m}^2$, so $F_1 = 15,000 \text{ N} \times (4.0 \times 10^{-4} \text{ m}^2 / 0.02 \text{ m}^2) = 300 \text{ N} = 3 \times 10^2 \text{ N}$.

22. An incompressible fluid flows through a horizontal pipe whose diameter varies along its length. The sum of the kinetic energy per unit volume and pressure of the fluid at different section of the pipe would_____ (1)
- A. depend on the length of the pipe.
- B. Increase as the pipe diameter increases.
- C. Increase as the pipe diameter decreases.
- D. ✓ **Remain the same as the pipe diameter changes.**

Answer: D

According to Bernoulli's equation for horizontal flow, $P + \frac{1}{2}\rho v^2 = \text{constant}$, meaning the sum of the static pressure and kinetic energy per unit volume is conserved along streamlines regardless of pipe diameter.

- 23.** The amount of heat required to raise the temperature of an object of mass $m = 1\text{Kg}$ by 1 Kelvin is known as_____
- A. ✓ **specific heat capacity** B. heat capacity
C. expansion coefficient D. internal energy

Answer: A

Specific heat capacity is defined as the quantity of heat required to raise the temperature of a unit mass (1 kg) of a substance by 1 Kelvin (or 1°C). Heat capacity, by contrast, is defined for an entire object regardless of its mass.

- 24.** The first law of thermodynamics takes the form $dU = dW$. This equation is valid if the process is_____
- A. isobaric B. isochoric
C. isothermal D. ✓ **adiabatic**

Answer: D

The first law of thermodynamics states $dU = dQ + dW$ (or $dU = dQ - dW$ depending on the sign convention for work). When there is no heat exchange with the surroundings ($dQ = 0$), which defines an adiabatic process, the equation reduces to $dU = dW$.

- 25.** An ideal gas undergoes an isothermal process starting with a pressure of 2×10^5 pa and a volume of 6 cm^3 . Which one of the following might be the pressure and volume of the final state?
- A. 4×10^5 pa and 4 cm^3 B. ✓ 4×10^5 **pa** and 3 cm^3
- C. 5×10^5 pa and 3 cm^3 D. 10^5 pa and 10 cm^3

Answer: B

For an isothermal process of an ideal gas, Boyle's law holds: $P_1 V_1 = P_2 V_2$. The initial product is $(2 \times 10^5 \text{ Pa})(6 \text{ cm}^3) = 12 \times 10^5 \text{ Pa} \cdot \text{cm}^3$, which matches option B where $(4 \times 10^5 \text{ Pa})(3 \text{ cm}^3) = 12 \times 10^5 \text{ Pa} \cdot \text{cm}^3$.

- 26.** The position of a particle moving with simple harmonic motion is given by an expression $x = A \cos(\omega t + \Phi)$, where A is the amplitude of the oscillation, t is time, ω is angular frequency, and Φ is the phase constant. If $\Phi = \pi/2$, what will be the sign of the particle's position and velocity at $t = 7T/8$, where T is the period of oscillation?
- A. ✓ The position is positive, and the velocity is negative.**
- B. The position and velocity are both positive.
- C. The position and velocity are both negative.
- D. The position is negative and the velocity is positive.

Answer: A

With a phase constant of $\pi/2$, $x(t) = -A \sin(\omega t)$ and $v(t) = -A\omega \cos(\omega t)$. At $t = 7T/8$, the phase is $\omega t = 7\pi/4$, where $\sin(7\pi/4) < 0$ making $x > 0$ (positive), and $\cos(7\pi/4) > 0$ making $v < 0$ (negative).

27. A given minimum point (trough) of a sinusoidal wave is traveling 480 cm long a rope in 12s. If the oscillator that generates the wave completes 48 vibrations in 30s, what is the wave length of the wave? (1)
- A. 25m
B. 15m
C. ✓ 0.25m
D. 0.15m

Answer: C

The wave speed is $v = 4.8 \text{ m}/12 \text{ s} = 0.4 \text{ m/s}$ and the frequency is $f = 48/30 \text{ s} = 1.6 \text{ Hz}$. The wavelength is $\lambda = v/f = 0.4/1.6 = 0.25 \text{ m}$.

28. A wave traveling from a medium of index of refraction n_1 toward a medium of index of refraction n_2 undergoes partly transmission and partly reflection. If n_2 is greater than n_1 which one of the following statements is not correct? (1)
- A. ✓ **The speed of the wave in the medium with reflective index n_1 is smaller than with n_2**
B. The incident and the reflected waves are in phase.
C. The angle of reflection is the same as the angle of incidence.
D. The reflection angle is less than the incidence angle.

Answer: A

29. Which one of the following statement is correct? (1)
- A. **The electric field strength due to two point charges of equal magnitude and the same sign is zero only at one point on the line joining the two charges.**
✓
B. If a point charge of mass m is released from the rest in uniform electric field, it will move along a line of force with uniform speed.
C. The variation of the strength of the electric field due to an electric dipole is inversely proportional with the square of the distance from its center of mass.
D. An electric dipole moment p in a uniform external electric field E is in stable equilibrium if p and E are in opposite directions.

Answer: A

For two identical point charges of the same sign, their electric fields oppose each other only in the region between them and cancel solely at the midpoint; outside this segment on the line, the fields point in the same direction and cannot cancel.

30. In a certain region of space, a uniform electric field is directed in the positive x direction. If a particle with negative charge is carried from $x = 20\text{cm}$ to $x = 60\text{cm}$, what can we conclude about the electric potential and the electric potential energy of the charge-field system? (1)
- A. The electric potential at $x = 20\text{cm}$ is larger than that at $x = 60\text{cm}$.
B. The electric potential at $x = 20\text{cm}$ is the same as that at $x = 60\text{cm}$.
C. The electric potential energy decrease.
D. ✓ **The electric potential energy increase.**

Answer: D

31. A parallel plate capacitor has a capacitance of $10\ \mu\text{F}$. If the distance between the plates is doubled, keeping all other quantities constant, what is the new capacitance of the capacitor? (1)
- A. $0.2\ \mu\text{F}$ B. ✓ $5\ \mu\text{F}$
C. $10\ \mu\text{F}$ D. $20\ \mu\text{F}$

Answer: B

Capacitance of a parallel plate capacitor is inversely proportional to the plate separation ($C = \epsilon_0 A/d$). Doubling the distance halves the capacitance from $10\ \mu\text{F}$ to $5\ \mu\text{F}$.

32. If several resistors are connected in parallel, the equivalent resistance is (1)
- A. greater than any of the resistances in the group.
B. is equal to the average resistances of the group.
C. ✓ **less than any of the resistances in the group.**
D. equal to the sum of the resistances in the group.

Answer: C

The reciprocal of the equivalent resistance in a parallel combination is the sum of the reciprocals of the individual resistances ($1/R_{\text{eq}} = \sum 1/R_i$), which guarantees that R_{eq} is always strictly less than the smallest individual resistance.

33. In aluminium and copper wires with circular cross sections have equal length and equal resistance, then the ratio of the radius of aluminium to that of copper should be the same as that of the_____ (1)
- A. ratio of the resistivity of aluminium to copper
B. ratio of the resistivity of copper to aluminium
C. ✓ **square root of the ratio of the resistivity of aluminium to copper**
D. square root of the ratio of the resistivity of copper to aluminium

Answer: C

Resistance is $R = \rho L/(\pi r^2)$. For wires of equal length and resistance, $\rho_{\text{Al}}/r_{\text{Al}}^2 = \rho_{\text{Cu}}/r_{\text{Cu}}^2$, which yields $r_{\text{Al}}/r_{\text{Cu}} = \sqrt{\rho_{\text{Al}}/\rho_{\text{Cu}}}$.

34. In the circuit shown below, what is the potential difference between point b and a? (1)
- [Figure: A circuit made of three horizontal branches joined between a left-hand vertical wire and a right-hand vertical wire. Point a is marked as a node on the left wire where the middle branch meets it; point b is marked as a node on the right wire where the middle branch meets it. Top branch: a resistor labelled $16\ \Omega$, with a current arrow drawn just beneath it pointing to the LEFT and labelled I_3 . Middle branch, running from a to b: a resistor labelled $12\ \Omega$, then a battery labelled $24\ \text{V}$, with a current arrow drawn beneath the resistor pointing to the RIGHT and labelled I_2 . Bottom branch: a battery labelled $12\ \text{V}$ on the left and a resistor labelled 9 on the right, with a current arrow drawn beneath the resistor pointing to the LEFT and labelled I_1 .]
- A. 19.2V B. 24.0V
C. ✓ **13.0V** D. 12.0V

Answer: C

35. An electron moving at a speed of $1.5 \times 10^7\ \text{m/s}$ enters a region of uniform magnetic field of magnitude $2 \times 10^{-3}\ \text{T}$, direction perpendicular to the field. The path followed by the electron is circular. What is the radius of the circular path? (1)
- A. 0.43cm B. ✓ **4.3cm**
C. 43cm D. 430cm

Answer: B

The radius of the circular path is given by $r = \frac{mv}{qB} = \frac{(9.11 \times 10^{-31}\ \text{kg})(1.5 \times 10^7\ \text{m/s})}{(1.6 \times 10^{-19}\ \text{C})(2 \times 10^{-3}\ \text{T})} \approx 0.0427\ \text{m} = 4.3\ \text{cm}$.

36. If a wire carrying current in the plane of this paper toward the top of the page experiences a magnetic force toward the right edge of the page, what will be the direction of the magnetic field causing this force? (1)
- A. In the plane of the page and toward the left edge.
 B. In the plane of the page and toward the bottom edge.
 C. ✓ **Perpendicular and directed out of the plane of the page.**
 D. Perpendicular and directed in to the plane of the page.

Answer: C

Using the right-hand rule for magnetic force, $\vec{F} = I\vec{L} \times \vec{B}$, pointing the index finger along the current (upward, $+\hat{j}$) and the thumb in the direction of the force (to the right, $+\hat{i}$) requires the magnetic field to point out of the page ($+\hat{k}$).

37. A square flat loop of wire is placed in a uniform magnetic field that is in the y direction. The magnetic flux through the loop is a maximum if the plane of the loop is in the (1)
- A. xy plane
 B. ✓ **xz plane**
 C. yz plane
 D. inclined 45° with respect to the xy plane

Answer: B

Magnetic flux is maximal when the surface normal of the loop is parallel to the magnetic field. Since the field is along the y-direction, the normal must be along the y-axis, meaning the loop itself lies in the xz plane.

38. Which one of the following actions increases the magnetic energy density in the interior of a very long current carrying solenoid? (1)
- A. ✓ **Increasing the number of turns per unit length of the solenoid.**
 B. Increasing the cross section area of the solenoid.
 C. Increasing the length of the solenoid keeping the number of turns per unit length fixed.
 D. Decreasing the cross section area of the solenoid.

Answer: A

The magnetic energy density inside a long solenoid is $u = \frac{B^2}{2\mu_0} = \frac{1}{2}\mu_0 n^2 I^2$, which depends directly on the square of the number of turns per unit length n and is independent of the cross-sectional area or total length.

39. Figure below shows a rectangular loop of wire of width L and resistance R. one end of the loop is in a uniform magnetic field of strength B directed perpendicular in to the plane of the page, the loop is pulled to the right at a constant speed v. what are the magnitude and direction of the induced current in the loop? (1)
- [Figure: On the left, a shaded rectangular region filled with four rows of X symbols, representing a uniform magnetic field directed into the plane of the page. A rectangular loop of wire is drawn across the figure so that its left-hand portion lies inside the field region (its left side is buried among the X symbols) and its right-hand side lies outside the field region, clear of the X symbols. A short double-headed vertical arrow beside the loop's right side marks the loop's width and is labelled L. A horizontal arrow points to the right from the loop's right side and is labelled v.]*
- A. $I = BLv/R$ and clockwise
 B. ✓ **$I = BLv/R$ and clockwise**
 C. $I = BLv/R$ and counter clockwise
 D. $I = BLv/R$ and counter clockwise

Answer: B

The induced emf is $\mathcal{E} = BLv$, giving a current of $I = \frac{BLv}{R}$. As the loop is pulled to the right, the inward magnetic flux decreases, so by Lenz's law the induced current flows clockwise to create an inward magnetic field opposing the change.

40. A series RLC circuit has a total impedance of $75.0\ \Omega$. If the resistance is $R = 45.0\ \Omega$ and the average power delivered to the circuit is $P = 352.8\ \text{W}$, what is the root mean square value of the ac voltage source? (1)
- A. 83V
B. 116V
C. ✓ 210V
D. 297V

Answer: C

The average power dissipated in an RLC circuit is dissipated purely in the resistor: $P = I_{\text{rms}}^2 R$, so $I_{\text{rms}} = \sqrt{352.8/45.0} = 2.8\ \text{A}$. The source voltage is then $V_{\text{rms}} = I_{\text{rms}} Z = 2.8\ \text{A} \times 75.0\ \Omega = 210\ \text{V}$.

41. Which of the following phenomena most clearly demonstrates the wave nature of electrons? (1)
- A. The photoelectric effect
B. Blackbody radiation
C. The Compton effect
D. ✓ Diffraction of electrons by crystals

Answer: D

The diffraction of electrons by crystals (the Davisson-Germer experiment) directly confirms the wave nature and de Broglie wavelength of electrons, whereas the photoelectric and Compton effects demonstrate the particle nature of electromagnetic radiation.

42. When the radioactive element $^{144}\text{Nd}_{60}$ decays to $^{140}\text{Ce}_{58}$, which one of the following particles is emitted? (1)
- A. A beta particle
B. ✓ An alpha particle
C. a proton
D. a gamma ray

Answer: B

The mass number decreases by 4 ($144 - 140 = 4$) and the atomic number decreases by 2 ($60 - 58 = 2$), which corresponds to the emission of an alpha particle (^4_2He).

— END OF MARKING KEY —

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