WBJEE Physics Sample Paper-5

Duration: 60 Minutes **Maximum Marks: 50**

Instructions

- This paper contains a total of **40** Multiple Choice Questions.
- **Section A (Q1–Q30):** Each correct answer carries +1 mark. Incorrect answer: **0.25 marks**. Only **one** correct option.
- **Section B (Q31–Q35):** Each correct answer carries +2 mark. Incorrect answer: **0.5 marks**. Only **one** correct option.
- **Section C (Q36–Q40)**: Each correct answer carries **+2 marks**. **No negative marking.** One or **more** correct options may be correct; full marks only if all correct options are marked.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Section–A — 30 Questions × 1 Mark Each
(Negative Marking: 0.25) [Single Correct]

Q1. A physical quantity P is related to four observables a, b, c and d as

$$P = \frac{a^3 b^2}{cd}$$

The percentage errors of measurement in a, b, c and d are 1%, 3%, 4% and 2% respectively. The percentage error in the quantity P is:

(A) 13%

(B) 12%

(C) 15%

(D) 10%

Q2. The dimensions of $\frac{b}{a}$ in the equation

$$P = \frac{bx}{a - t^2},$$

where P is pressure, x is distance and t is time, are:

(A) $[M^2LT^{-3}]$

(B) $[MT^{-2}]$

(C) $[ML^2T^{-2}]$

(D) $[LT^{-3}]$

Q3. A particle is projected from the ground with a velocity

$$\vec{v} = (3\hat{i} + 10\hat{j}) \text{ m/s}.$$

The radius of curvature of its trajectory at the maximum height is (take $g = 10 \text{ m/s}^2$):

(A) 0.9 m

(B) 1.2 m

(C) 0.5 m

(D) 2.1 m

Q4. A boat which has a speed of 5 km/hr in still water crosses a river of width 1 km along the shortest possible path in 15 minutes. The velocity of the river water in km/hr is:

(A) 3

(B) 4

(C) $\sqrt{41}$

(D) 1

Q5. Three blocks of masses m_1, m_2 and m_3 are connected by massless strings and placed on a frictionless table. If a force F pulls m_3, the tension T_2 between m_2 and m_3 is:

(A) $\dfrac{m_3 F}{m_1 + m_2 + m_3}$

(B) $\dfrac{(m_1 + m_2)F}{m_1 + m_2 + m_3}$

(C) $\dfrac{m_2 F}{m_1 + m_2 + m_3}$

(D) $\dfrac{(m_2 + m_3)F}{m_1 + m_2 + m_3}$

Q6. A block of mass 2 kg is placed on a floor. The coefficient of static friction is 0.4. If a force of 2.8 N is applied on the block parallel to the floor, the force of friction between the block and floor is:

(A) 2.8 N

(B) 8 N

(C) 2.0 N

(D) zero

Q7. A body of mass 2 kg is driven by an engine delivering a constant power of 1 J/s. The body starts from rest and moves in a straight line. After 9 seconds, the body has moved a distance (in meters) of:

(A) 18

(B) 9

(C) 12

(D) 6

Q8. A ball falls from a height of 20 m on a floor and rebounds to a height of 5 m. The coefficient of restitution is:

(A) 0.5

(B) 0.25

(C) 0.75

(D) 0.2

Q9. A solid sphere and a hollow sphere of the same mass and same outer radius are released from the top of an inclined plane. The ratio of their accelerations

$$\frac{a_{\text{solid}}}{a_{\text{hollow}}}$$

is:

(A) $\frac{25}{21}$
(B) $\frac{15}{14}$
(C) $\frac{5}{3}$
(D) $\frac{7}{5}$

Q10. A disc of mass M and radius R is rolling without slipping on a horizontal surface with velocity v. Its total kinetic energy is:

(A) $\frac{1}{2}Mv^2$
(B) $\frac{1}{4}Mv^2$
(C) $\frac{3}{4}Mv^2$
(D) Mv^2

Q11. If the mass of the earth remains same but its radius shrinks by 1%, the value of g on the earth's surface would:

(A) increase by 2%
(B) decrease by 2%
(C) increase by 1%
(D) decrease by 1%

Q12. A capillary tube of radius r is immersed in water and water rises in it to a height h. The mass of water in the capillary tube is M. If the radius of the tube is doubled, the mass of water that will rise in the tube will be:

(A) M

(B) $2M$

(C) $\frac{M}{2}$

(D) $4M$

Q13. The terminal velocity of a small sphere of radius r in a viscous liquid is proportional to:

(A) r

(B) r^2

(C) $\frac{1}{r}$

(D) $\frac{1}{r^2}$

Q14. A large tank filled with water has a small hole at its bottom. If the pressure at the bottom is 3 atm, the velocity of efflux is approximately:

(A) 10 m/s

(B) 20 m/s

(C) 30 m/s

(D) 40 m/s

Q15. One mole of an ideal gas at temperature T_1 expands according to the law

$$PV^2 = \text{constant}.$$

The work done by the gas till its temperature reaches T_2 is:

(A) $R(T_2 - T_1)$

(B) $R(T_1 - T_2)$

(C) $\frac{R}{2}(T_2 - T_1)$

(D) $\frac{R}{2}(T_1 - T_2)$

Q16. The root mean square speed of hydrogen molecules at 300 K is 1930 m/s. The RMS speed of oxygen molecules at 1200 K will be:

(A) 1930 m/s

(B) 965 m/s

(C) 482.5 m/s

(D) 3860 m/s

Q17. In a thermodynamic process, pressure P and volume V are related as

$$PV^n = \text{constant}.$$

If the molar heat capacity is zero, then n is equal to:

(A) 1

(B) γ

(C) 0

(D) ∞

Q18. An ideal Carnot engine operates between 227°C and 127°C. If it absorbs 6×10^4 calories at the higher temperature, the amount of heat converted into work is:

(A) 1.2×10^4 cal

(B) 4.8×10^4 cal

(C) 3.5×10^4 cal

(D) 1.6×10^4 cal

Q19. The displacement of a particle executing SHM is given by

$$y = 5\sin(20\pi t + \pi/3).$$

The first time at which the velocity becomes maximum is:

(A) $\frac{1}{120}$ s

(B) $\frac{1}{60}$ s

(C) $\frac{1}{30}$ s

(D) $\frac{1}{40}$ s

Q20. A string of length 2 m is fixed at both ends. If the string vibrates in its fourth harmonic with a frequency of 500 Hz, the speed of the wave in the string is:

(A) 250 m/s

(B) 500 m/s

(C) 1000 m/s

(D) 125 m/s

Q21. An observer moves towards a stationary source of sound with a speed $\frac{1}{5}$th of the speed of sound. The percentage change in apparent frequency is:

(A) 20%

(B) 5%

(C) 10%

(D) 25%

Q22. Two point charges $+9e$ and $+e$ are kept 16 cm apart. At what distance from $+9e$ charge is the electric field zero?

(A) 12 cm

(B) 4 cm

(C) 8 cm

(D) 6 cm

Q23. A capacitor of 10 μF is charged to 500 V and then its plates are connected by a resistance of 10 Ω. The heat produced in the resistance is:

(A) 1.25 J

(B) 2.5 J

(C) 0.5 J

(D) 1.0 J

Q24. An infinite line charge produces a field of 9×10^4 N/C at a distance of 2 cm. The linear charge density is:

(A) 10^{-7} C/m

(B) 10^{-6} C/m

(C) 10^{-8} C/m

(D) 10^{-5} C/m

Q25. In a Wheatstone bridge, all four arms have resistance R. If the galvanometer resistance is also R, the equivalent resistance of the combination is:

(A) R

(B) $2R$

(C) $\frac{R}{2}$

(D) $\frac{R}{4}$

Q26. A potentiometer wire of length 10 m has a resistance of 20 Ω. It is connected in series with a battery of 3 V and a resistance of 10 Ω. The potential gradient of the wire is:

(A) 0.1 V/m

(B) 0.2 V/m

(C) 1.0 V/m

(D) 0.02 V/m

Q27. A wire of resistance R is stretched to twice its original length. The new resistance will be:

(A) $4R$

(B) $2R$

(C) $\frac{R}{2}$

(D) $\frac{R}{4}$

Q28. A proton enters a magnetic field of 1.5 T with a velocity of 2×10^7 m/s at an angle of 30° with the field. The force on the proton is:

(A) 2.4×10^{-12} N

(B) 4.8×10^{-12} N

(C) 1.2×10^{-12} N

(D) 0.6×10^{-12} N

Q29. Two long parallel wires carry currents I_1 and I_2 in the same direction. The force per unit length between them is f. If the current in one of them is doubled and direction reversed, the new force per unit length is:

(A) $-2f$

(B) $2f$

(C) $\frac{f}{2}$

(D) $-f$

Q30. A circular coil of 100 turns has a radius of 10 cm and carries a current of 0.1 A. The magnetic moment of the coil is:

(A) 0.314 Am^2

(B) 3.14 Am^2

(C) 0.0314 Am^2

(D) 1.0 Am^2

Section B – 5 Questions × 2 Marks Each
(Negative Marking: 0.5) [Single Correct]

Q31. The magnetic flux linked with a coil satisfies the relation

$$\phi = 3t^2 + 4t + 9 \text{ mWb}.$$

The induced emf in the coil at $t = 2$ seconds is:

(A) 16 mV

(B) 10 mV

(C) 9 mV

(D) 4 mV

Q32. In an AC circuit, $L = 0.4$ H and $R = 30\ \Omega$. If the frequency of the source is $\frac{50}{2\pi}$ Hz, the impedance of the circuit is:

(A) 50 Ω

(B) 40 Ω

(C) 10 Ω

(D) 70 Ω

Q33. Which of the following has the minimum wavelength?

(A) X-rays

(B) γ-rays

(C) Ultraviolet rays

(D) Cosmic rays

Q34. An object is placed at 20 cm from a convex mirror of focal length 20 cm. The distance of the image from the pole is:

(A) 10 cm

(B) 20 cm

(C) ∞

(D) 40 cm

Q35. A ray of light is incident on a glass slab at an angle of $60°$. If the reflected and refracted rays are perpendicular to each other, the refractive index of glass is:

(A) $\sqrt{3}$

(B) $\frac{3}{2}$

(C) $\frac{1}{\sqrt{3}}$

(D) $\sqrt{2}$

Section C — 5 Questions × 2 Marks Each (No Negative Marking) [One or More Correct]

Q36. A solid sphere of mass M and radius R is placed on a rough horizontal surface. A horizontal force F is applied at a height h from the center. If the sphere rolls without slipping, which of the following statements is/are correct?

(A) The acceleration of the center of mass is $a = \frac{5F(R+h)}{7MR}$

(B) The frictional force is zero if $h = \frac{2}{5}R$

(C) The frictional force acts in the direction of F if $h > \frac{2}{5}R$

(D) The acceleration of the center of mass is independent of h

Q37. A parallel plate capacitor is connected to a battery of voltage V. A dielectric slab of dielectric constant K is inserted completely while the battery remains connected. Which of the following is/are correct?

(A) The energy stored increases by a factor of K

(B) The electric field between the plates remains unchanged

(C) The charge on the plates increases by a factor of K

(D) The capacitance increases by a factor of K

Q38. Two simple harmonic motions are given by $y_1 = 10\sin(3\pi t + \pi/4)$ and $y_2 = 5(\sin 3\pi t + \sqrt{3}\cos 3\pi t)$. Then:

(A) The amplitude of y_2 is 10

(B) The phase difference between y_1 and y_2 is $\pi/12$

(C) The ratio of their maximum velocities is 1 : 1

(D) The phase difference between y_1 and y_2 is $\pi/6$

Q39. A point charge $+q$ is placed at a distance d from an infinite grounded conducting plane. Then:

(A) The total induced charge on the plane is $-q$

(B) The electric field at any point on the plane is zero

(C) The force of attraction is $\frac{1}{4\pi\epsilon_0}\frac{q^2}{4d^2}$

(D) The potential on the conducting plane is zero

Q40. In Young's double-slit experiment, the setup is immersed in a medium of refractive index μ. Then:

(A) Fringe width decreases by a factor of μ

(B) The central maximum remains unchanged in position

(C) Angular fringe width remains unchanged

(D) The fringe pattern disappears

Detailed Solutions

Q1.

Solution

Concept: For products and quotients, percentage errors are added with powers as multipliers.

Solution:

Given:

$$P = \frac{a^3 b^2}{cd}$$

Percentage error in P:

$$\frac{\Delta P}{P} \times 100 = 3\left(\frac{\Delta a}{a} \times 100\right) + 2\left(\frac{\Delta b}{b} \times 100\right) + \left(\frac{\Delta c}{c} \times 100\right) + \left(\frac{\Delta d}{d} \times 100\right)$$

Substituting values:

$$= 3(1) + 2(3) + 4 + 2$$

$$= 3 + 6 + 4 + 2$$

$$= 15\%$$

Final Answer: $\boxed{15\%}$

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: Use dimensional analysis by equating dimensions on both sides.

Solution:

Given:

$$P = \frac{bx}{a - t^2}$$

Since subtraction is possible only between quantities of same dimensions,

$$[a] = [t^2] = [T^2]$$

Pressure:

$$[P] = [ML^{-1}T^{-2}]$$

Distance:

$$[x] = [L]$$

Using:

$$[P] = \frac{[b][x]}{[a]}$$

$$[ML^{-1}T^{-2}] = \frac{[b][L]}{[T^2]}$$

$$[b] = [ML^{-2}]$$

Therefore,

$$\frac{[b]}{[a]} = \frac{[ML^{-2}]}{[T^2]} = [ML^{-2}T^{-2}]$$

Final Answer: $\boxed{[ML^{-2}T^{-2}]}$

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept: Radius of curvature at highest point:

$$R = \frac{v^2}{g}$$

where v is horizontal velocity.

Solution:

Given velocity:

$$\vec{v} = (3\hat{i} + 10\hat{j}) \text{ m/s}$$

Horizontal velocity:

$$v_x = 3 \text{ m/s}$$

At maximum height, vertical velocity becomes zero, so speed:

$$v = 3 \text{ m/s}$$

Thus,

$$R = \frac{v^2}{g}$$

$$R = \frac{3^2}{10}$$

$$R = \frac{9}{10} = 0.9 \text{ m}$$

Final Answer: $\boxed{0.9 \text{ m}}$

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept: For shortest path crossing, boat is aimed upstream so resultant velocity is perpendicular to river flow.

Solution:

Width of river:

$$d = 1 \text{ km}$$

Time taken:

$$t = 15 \text{ min} = \frac{1}{4} \text{ hr}$$

Effective velocity across river:

$$v_{\perp} = \frac{d}{t} = \frac{1}{1/4} = 4 \text{ km/hr}$$

Boat speed in still water:

$$v = 5 \text{ km/hr}$$

Let river speed be u.

Using:

$$v_{\perp} = \sqrt{v^2 - u^2}$$

$$4 = \sqrt{25 - u^2}$$

$$16 = 25 - u^2$$

$$u^2 = 9$$

$$u = 3 \text{ km/hr}$$

Final Answer: 3 km/hr

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept: Treat all blocks as a single system to find acceleration.

Solution:

Total mass:

$$m_1 + m_2 + m_3$$

Acceleration:

$$a = \frac{F}{m_1 + m_2 + m_3}$$

For subsystem containing m_1 and m_2, the pulling force is T_2.

Hence,

$$T_2 = (m_1 + m_2)a$$

Substituting a:

$$T_2 = (m_1 + m_2)\frac{F}{m_1 + m_2 + m_3}$$

Final Answer:

$$\boxed{\frac{(m_1 + m_2)F}{m_1 + m_2 + m_3}}$$

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Static friction adjusts itself up to maximum value:

$$f_s^{\max} = \mu_s N$$

Solution:

Given:

$$m = 2 \text{ kg}$$

$$\mu_s = 0.4$$

Normal reaction:

$$N = mg = 2 \times 10 = 20 \text{ N}$$

Maximum static friction:

$$f_s^{\max} = 0.4 \times 20 = 8 \text{ N}$$

Applied force:

$$F = 2.8 \text{ N}$$

Since

$$2.8 < 8$$

the block does not move.

Therefore friction equals applied force:

$$f = 2.8 \text{ N}$$

Final Answer: $\boxed{2.8 \text{ N}}$

Answer: (A)

Go Back to Question 6

Q7.

Solution

Concept: For a body moving under constant power, power is related to kinetic energy as:

$$P = \frac{d}{dt}\left(\frac{1}{2}mv^2\right)$$

Also, $P = Fv$, which helps relate force, velocity, and acceleration.

Solution: Given:

$$P = 1 \text{ W}, \quad m = 2 \text{ kg}, \quad t = 9 \text{ s}$$

Using energy:

$$Pt = \frac{1}{2}mv^2$$

$$9 = \frac{1}{2}(2)v^2 \Rightarrow v^2 = 9 \Rightarrow v = 3 \text{ m/s}$$

Now,

$$P = Fv \Rightarrow F = \frac{P}{v}$$

Acceleration:

$$a = \frac{F}{m} = \frac{P}{mv}$$

Using kinematics in differential form:

$$v\frac{dv}{dx} = a = \frac{1}{2v}$$

$$v\,dv = \frac{1}{2}\,dx$$

Integrating:

$$\int_0^3 v\,dv = \frac{1}{2}\int_0^x dx$$

$$\frac{9}{2} = \frac{x}{2}$$

$$x = 18 \text{ m}$$

Final Answer: $\boxed{18 \text{ m}}$

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept: Coefficient of restitution:

$$e = \frac{\text{speed after collision}}{\text{speed before collision}}$$

For bouncing from heights:

$$e = \sqrt{\frac{h_2}{h_1}}$$

Solution:

Initial height:

$$h_1 = 20 \text{ m}$$

Rebound height:

$$h_2 = 5 \text{ m}$$

Thus,

$$e = \sqrt{\frac{5}{20}}$$

$$e = \sqrt{\frac{1}{4}}$$

$$e = \frac{1}{2}$$

Final Answer: $\boxed{0.5}$

Answer: (A)

Go Back to Question 8

Q9.

Solution

Concept: Acceleration of a rolling body down an incline:

$$a = \frac{g \sin\theta}{1 + \frac{I}{mR^2}}$$

Solution:

For a solid sphere:

$$I = \frac{2}{5}mR^2$$

Thus,

$$a_{\text{solid}} = \frac{g \sin\theta}{1 + \frac{2}{5}} = \frac{5}{7}g \sin\theta$$

For a hollow sphere:

$$I = \frac{2}{3}mR^2$$

Thus,

$$a_{\text{hollow}} = \frac{g \sin\theta}{1 + \frac{2}{3}} = \frac{3}{5}g \sin\theta$$

Therefore,

$$\frac{a_{\text{solid}}}{a_{\text{hollow}}} = \frac{5/7}{3/5} = \frac{25}{21}$$

Final Answer: $\boxed{\frac{25}{21}}$

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept: Total kinetic energy of a rolling body:

$$K = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$$

Solution:

For a disc:

$$I = \frac{1}{2}MR^2$$

Rolling without slipping:

$$v = \omega R$$

Rotational kinetic energy:

$$= \frac{1}{2}\left(\frac{1}{2}MR^2\right)\left(\frac{v}{R}\right)^2$$

$$= \frac{1}{4}Mv^2$$

Total kinetic energy:

$$K = \frac{1}{2}Mv^2 + \frac{1}{4}Mv^2$$

$$K = \frac{3}{4}Mv^2$$

Final Answer: $\boxed{\frac{3}{4}Mv^2}$

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept: Acceleration due to gravity:

$$g = \frac{GM}{R^2}$$

Solution:

Since mass remains constant:

$$g \propto \frac{1}{R^2}$$

If radius decreases by 1%:

$$R' = 0.99R$$

Then,

$$g' = \frac{g}{(0.99)^2}$$

$$g' \approx 1.02g$$

Hence g increases approximately by 2%.

Final Answer: $\boxed{\text{increase by } 2\%}$

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept: Capillary rise:

$$h = \frac{2T\cos\theta}{\rho g r}$$

Mass of liquid risen:

$$M = \rho\pi r^2 h$$

Solution:

Since

$$h \propto \frac{1}{r}$$

Therefore,

$$M \propto r^2 \cdot \frac{1}{r}$$

$$M \propto r$$

If radius is doubled:

$$M' = 2M$$

Final Answer: $\boxed{2M}$

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: Terminal velocity of a small spherical body moving through a viscous fluid is governed by Stokes' law. When a sphere falls through a viscous medium, viscous drag increases with velocity and balances the effective weight at terminal speed. For laminar flow and small Reynolds number, the drag force is proportional to radius and velocity, leading to a specific dependence of terminal velocity on radius.

Solution: For a sphere of radius r moving in a viscous liquid, the forces acting are: effective weight $(\rho_s - \rho_f)\frac{4}{3}\pi r^3 g$ downward and viscous drag $6\pi\eta r v$ upward.
At terminal velocity v_t, net force is zero:

$$(\rho_s - \rho_f)\frac{4}{3}\pi r^3 g = 6\pi\eta r v_t$$

Solving for v_t:

$$v_t = \frac{2}{9}\frac{(\rho_s - \rho_f)g}{\eta}r^2$$

Thus terminal velocity depends on the square of the radius of the sphere. This shows that larger spheres settle faster in a viscous medium because gravitational force increases with volume (r^3) while viscous resistance increases only linearly with radius (r). Hence net dependence becomes quadratic.
Therefore:

$$v_t \propto r^2$$

Final Answer: $\boxed{r^2}$

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Velocity of efflux:

$$v = \sqrt{\frac{2P}{\rho}}$$

Solution:

Pressure at bottom:

$$P = 3 \text{ atm} \approx 3 \times 10^5 \text{ Pa}$$

Density of water:

$$\rho = 1000 \text{ kg/m}^3$$

Thus,

$$v = \sqrt{\frac{2(3 \times 10^5)}{1000}}$$

$$= \sqrt{600}$$

$$\approx 24.5 \text{ m/s}$$

Closest option:

$$20 \text{ m/s}$$

Final Answer: $\boxed{20 \text{ m/s}}$

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: For a process PV^2 = constant, use ideal gas law $PV = RT$ to relate thermodynamic variables. Work done is:

$$W = \int P\,dV$$

Solution: Given:

$$PV^2 = C$$

Using $PV = RT$:

$$\frac{RT}{V} \cdot V^2 = C \Rightarrow RTV = C$$

So,

$$TV = \text{constant} \Rightarrow V \propto \frac{1}{T}$$

Work done:

$$W = \int_{V_1}^{V_2} \frac{C}{V^2}\,dV$$

$$W = C\left(\frac{1}{V_1} - \frac{1}{V_2}\right)$$

Since $C = RTV$, simplifying gives:

$$W = R(T_1 - T_2)$$

Final Answer: $\boxed{R(T_1 - T_2)}$

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: RMS speed:

$$v_{\text{rms}} \propto \sqrt{\frac{T}{M}}$$

Solution:
For hydrogen:

$$v_H = 1930 \text{ m/s}$$

For oxygen:

$$v_O = v_H \sqrt{\frac{T_O/M_O}{T_H/M_H}}$$

Given:

$$T_H = 300 \text{ K}, \quad M_H = 2$$

$$T_O = 1200 \text{ K}, \quad M_O = 32$$

Thus,

$$v_O = 1930\sqrt{\frac{1200/32}{300/2}}$$

$$= 1930\sqrt{\frac{1200 \times 2}{32 \times 300}}$$

$$= 1930\sqrt{\frac{1}{4}}$$

$$= 1930 \times \frac{1}{2}$$

$$= 965 \text{ m/s}$$

Final Answer: $\boxed{965 \text{ m/s}}$

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: For a polytropic process PV^n = constant, heat capacity becomes zero for a specific exponent.

Solution:

Molar heat capacity for polytropic process:

$$C = \frac{R(\gamma - n)}{1 - n}$$

Given:

$$C = 0$$

So numerator must be zero:

$$\gamma - n = 0$$

$$n = \gamma$$

Final Answer: $\boxed{\gamma}$

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept: Carnot efficiency:

$$\eta = 1 - \frac{T_C}{T_H}$$

Solution:

Convert temperatures:

$$T_H = 227 + 273 = 500 \text{ K}, \quad T_C = 127 + 273 = 400 \text{ K}$$

Efficiency:

$$\eta = 1 - \frac{400}{500}$$

$$\eta = 1 - 0.8 = 0.2$$

Heat absorbed:

$$Q_H = 6 \times 10^4 \text{ cal}$$

Work done:

$$W = \eta Q_H$$

$$W = 0.2 \times 6 \times 10^4$$

$$W = 1.2 \times 10^4 \text{ cal}$$

Final Answer: $\boxed{1.2 \times 10^4 \text{ cal}}$

Answer: (A)

Go Back to Question 18

Q19.

Solution

Concept: Velocity in SHM:

$$v = \omega\sqrt{A^2 - y^2}$$

Maximum velocity occurs at equilibrium $y = 0$.

Solution:

Given:

$$y = 5\sin(20\pi t + \pi/3)$$

Angular frequency:

$$\omega = 20\pi$$

Velocity is maximum at:

$$y = 0$$

So:

$$20\pi t + \frac{\pi}{3} = n\pi$$

For first occurrence after $t > 0$, take $n = 1$:

$$20\pi t + \frac{\pi}{3} = \pi$$

$$20\pi t = \frac{2\pi}{3}$$

$$t = \frac{1}{30}$$

Final Answer: $\boxed{\frac{1}{30}\text{ s}}$

Answer: (C)

Go Back to Question 19

Q20.

Solution

Concept: For nth harmonic:

$$f_n = \frac{nv}{2L}$$

Solution:

Given:

$$L = 2 \text{ m}, \quad n = 4, \quad f = 500 \text{ Hz}$$

$$500 = \frac{4v}{2 \times 2}$$

$$500 = \frac{v}{1}$$

$$v = 500 \text{ m/s}$$

Final Answer: $\boxed{500 \text{ m/s}}$

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept: Doppler effect for moving observer:

$$f' = f\left(\frac{v + v_o}{v}\right)$$

Solution:

Given:

$$v_o = \frac{v}{5}$$

$$f' = f\left(1 + \frac{1}{5}\right)$$

$$f' = \frac{6}{5}f$$

Percentage increase:

$$\frac{f' - f}{f} \times 100 = \frac{1}{5} \times 100 = 20\%$$

Final Answer: $\boxed{20\%}$

Answer: (A)

Go Back to Question 21

Q22.

Solution

Concept: Electric field due to point charges cancels at a point where magnitudes are equal.

Solution:

Let distance from $+9e$ be x. Then distance from $+e$ is $16 - x$.

$$\frac{9}{x^2} = \frac{1}{(16 - x)^2}$$

Taking square root:

$$\frac{3}{x} = \frac{1}{16 - x}$$

$$3(16 - x) = x$$

$$48 - 3x = x$$

$$48 = 4x$$

$$x = 12 \text{ cm}$$

Final Answer: $\boxed{12 \text{ cm}}$

Answer: (A)

Go Back to Question 22

Q23.

Solution

Concept: Energy stored in capacitor:

$$U = \frac{1}{2}CV^2$$

This energy converts into heat.

Solution:

Given:

$$C = 10\ \mu F = 10 \times 10^{-6} F$$

$$V = 500\ V$$

Energy:

$$U = \frac{1}{2} \times 10 \times 10^{-6} \times (500)^2$$

$$U = \frac{1}{2} \times 10 \times 10^{-6} \times 2.5 \times 10^5$$

$$U = \frac{1}{2} \times 2.5$$

$$U = 1.25\ J$$

Final Answer: 1.25 J

Answer: (A)

Go Back to Question 23

Q24.

Solution

Concept: Field due to infinite line charge:

$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$

Solution:

Given:

$$E = 9 \times 10^4, \quad r = 2 \text{ cm} = 2 \times 10^{-2} \text{ m}$$

$$\lambda = 2\pi\epsilon_0 r E$$

Substitute:

$$\lambda = 2\pi(8.85 \times 10^{-12})(2 \times 10^{-2})(9 \times 10^4)$$

$$\lambda \approx 10^{-7} \text{ C/m}$$

Final Answer: $\boxed{10^{-7} \text{ C/m}}$

Answer: (A)

Go Back to Question 24

Q25.

Solution

Concept: Wheatstone bridge with equal resistances is balanced, so galvanometer carries no current.

Solution:

All four resistances are equal:

$$R, R, R, R$$

So the bridge is balanced, hence no current through galvanometer.

Equivalent circuit reduces to two series branches in parallel:

Each branch:

$$R + R = 2R$$

Now in parallel:

$$R_{eq} = \frac{(2R)(2R)}{2R + 2R}$$

$$R_{eq} = \frac{4R^2}{4R} = R$$

Final Answer: $\boxed{R}$

Answer: (A)

Go Back to Question 25

Q26.

Solution

Concept: Potential gradient:

$$k = \frac{V}{L}$$

where current depends on total resistance in series.

Solution:

Total resistance:

$$R_{total} = 20 + 10 = 30\ \Omega$$

Current:

$$I = \frac{3}{30} = 0.1\ \text{A}$$

Voltage across wire:

$$V_{wire} = IR = 0.1 \times 20 = 2\ \text{V}$$

Length of wire:

$$L = 10\ \text{m}$$

Potential gradient:

$$k = \frac{2}{10} = 0.2\ \text{V/m}$$

Final Answer: $\boxed{0.2\ \text{V/m}}$

Answer: (B)

Go Back to Question 26

Q27.

Solution

Concept: When a wire is stretched, volume remains constant:

$$R \propto L^2$$

Solution:

Length doubles:

$$L' = 2L$$

Since volume constant:

$$A' = \frac{A}{2}$$

Resistance:

$$R' = \rho \frac{2L}{A/2}$$

$$R' = 4R$$

Final Answer: $\boxed{4R}$

Answer: (A)

Go Back to Question 27

Q28.

Solution

Concept: Magnetic force on moving charge:

$$F = qvB \sin\theta$$

Solution:
Given:

$$q = 1.6 \times 10^{-19} C$$

$$v = 2 \times 10^{7}$$

$$B = 1.5$$

$$\sin 30^\circ = \frac{1}{2}$$

$$F = 1.6 \times 10^{-19} \times 2 \times 10^{7} \times 1.5 \times \frac{1}{2}$$

$$F = 2.4 \times 10^{-12}\ \text{N}$$

Final Answer: $\boxed{2.4 \times 10^{-12}\ \text{N}}$

Answer: (A)

Go Back to Question 28

Q29.

Solution

Concept: Force per unit length between currents:

$$f \propto I_1 I_2$$

Solution:
Initial force:

$$f \propto I_1 I_2$$

New case: - one current doubled: $2I_1$ - direction reversed: negative sign

$$f' \propto (2I_1)(-I_2)$$

$$f' = -2f$$

Final Answer: $\boxed{-2f}$

Answer: (A)

Go Back to Question 29

Q30.

Solution

Concept: Magnetic moment:

$$M = NIA$$

Solution:
Given:

$$N = 100, \quad I = 0.1 \text{ A}$$

$$r = 0.1 \text{ m}$$

Area:

$$A = \pi r^2 = \pi(0.1)^2 = 0.01\pi$$

Magnetic moment:

$$M = 100 \times 0.1 \times 0.01\pi$$

$$M = \pi \approx 3.14 \text{ Am}^2$$

Final Answer: $\boxed{3.14 \text{ Am}^2}$

Answer: (B)

Go Back to Question 30

Q31.

Solution

Concept: Induced emf:

$$e = -\frac{d\phi}{dt}$$

Solution:
Given:

$$\phi = 3t^2 + 4t + 9$$

Differentiate:

$$\frac{d\phi}{dt} = 6t + 4$$

At $t = 2$:

$$e = -(12 + 4) = -16 \text{ mV}$$

Magnitude:

$$|e| = 16 \text{ mV}$$

Final Answer: $\boxed{16 \text{ mV}}$

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept: Impedance of L-R circuit:

$$Z = \sqrt{R^2 + X_L^2}$$

Solution:

Given:

$$L = 0.4 \text{ H}, \quad R = 30\ \Omega$$

$$f = \frac{50}{2\pi}$$

Angular frequency:

$$\omega = 2\pi f = 50$$

Inductive reactance:

$$X_L = \omega L = 50 \times 0.4 = 20$$

Impedance:

$$Z = \sqrt{30^2 + 20^2}$$

$$Z = \sqrt{900 + 400}$$

$$Z = \sqrt{1300} \approx 36$$

Closest option:

$$40\ \Omega$$

Final Answer: $\boxed{40\ \Omega}$

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept: Electromagnetic waves are arranged in order of decreasing wavelength (or increasing frequency/energy). The sequence is:

$$\gamma\text{-rays} < X\text{-rays} < UV < \text{visible light} < \cdots$$

Wavelength is inversely proportional to frequency:

$$\lambda \propto \frac{1}{\nu}$$

Thus, higher energy radiation has smaller wavelength.

Solution: Among the given options, cosmic rays, X-rays, ultraviolet rays, and gamma rays, the electromagnetic radiation with the highest frequency and energy is gamma rays. Cosmic rays are generally not purely electromagnetic but high-energy particles; however, in standard physics classification of EM spectrum, gamma rays are considered to have the shortest wavelength.

Since wavelength decreases as energy increases, gamma rays possess the minimum wavelength among the given electromagnetic options.

Final Answer: $\boxed{\gamma\text{-rays}}$

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept: For a convex mirror, image formation follows the mirror formula:

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

A convex mirror always forms a virtual, erect, and diminished image behind the mirror. The focal length of a convex mirror is positive according to sign convention.

Solution: Given:

$$u = -20 \text{ cm}, \quad f = +20 \text{ cm}$$

Using mirror formula:

$$\frac{1}{20} = \frac{1}{v} - \frac{1}{20}$$

Rearranging:

$$\frac{1}{v} = \frac{1}{20} + \frac{1}{20} = \frac{2}{20} = \frac{1}{10}$$

So,

$$v = 10 \text{ cm}$$

This positive value indicates the image is formed behind the mirror at a distance of 10 cm. The image is virtual and diminished. Convex mirrors always produce images between the pole and focus.

Final Answer: $\boxed{10 \text{ cm}}$

Answer: (A)

Go Back to Question 34

Q35.

Solution

Concept: When reflected and refracted rays are perpendicular, the angle of incidence satisfies Brewster's law:

$$\tan i_B = n$$

where n is refractive index of the medium. At Brewster angle, reflected light is completely polarized.

Solution: Given:

$$i = 60^\circ$$

Using Brewster condition:

$$n = \tan 60^\circ$$

$$n = \sqrt{3}$$

Thus, the refractive index of glass is $\sqrt{3}$. This condition arises when reflected and refracted rays are perpendicular, i.e.,

$$i + r = 90^\circ$$

This leads to polarization condition where reflected light becomes plane polarized. The refractive index depends only on angle of incidence at this special condition.

Final Answer: $\boxed{\sqrt{3}}$

Answer: (A)

Go Back to Question 35

Q36.

Solution

Concept: For rolling motion, we use translational and rotational equations together with the condition of no slipping.

Solution:

Translational motion:

$$F + f = Ma$$

Rotational motion about center:

$$Fh - fR = I\alpha = \frac{2}{5}MR^2 \cdot \frac{a}{R}$$

$$Fh - fR = \frac{2}{5}MRa$$

Solving with $f = Ma - F$:

$$a = \frac{5F(R+h)}{7MR}$$

Now:

$$f = Ma - F = F \cdot \frac{5h - 2R}{7R}$$

So: - $f = 0 \Rightarrow h = \frac{2R}{5}$ - $f > 0$ (same direction as F) if $h > \frac{2R}{5}$ - a depends on h

Final Answer: $\boxed{A, B, C}$

Answer: (A,B,C)

Go Back to Question 36

Q37.

Solution

Concept: For a capacitor connected to a battery, voltage remains constant. Inserting a dielectric increases capacitance by factor K.

Solution:

$$C' = KC$$

Since battery is connected:

$$V = \text{constant}$$

Charge:

$$Q' = C'V = KCV$$

Energy:

$$U' = \frac{1}{2}C'V^2 = K \cdot \frac{1}{2}CV^2$$

Electric field:

$$E = \frac{V}{d} \Rightarrow \text{unchanged}$$

Final Answer: $\boxed{A, B, C, D}$

Answer: (A,B,C,D)

Go Back to Question 37

Q38.

Solution

Concept: Convert SHM expressions into standard form $A\sin(\omega t + \phi)$.

Solution:

$$y_1 = 10\sin(3\pi t + \pi/4)$$

For y_2:

$$y_2 = 5(\sin 3\pi t + \sqrt{3}\cos 3\pi t)$$

Using identity:

$$\sin x + \sqrt{3}\cos x = 2\sin(x + \pi/3)$$

$$y_2 = 10\sin(3\pi t + \pi/3)$$

So: - Amplitude of $y_2 = 10$ - Phase difference:

$$\frac{\pi}{3} - \frac{\pi}{4} = \frac{\pi}{12}$$

- Maximum velocity $v_{max} = \omega A$, hence ratio 1 : 1

Final Answer: $\boxed{A, B, C}$

Answer: (A,B,C)

Go Back to Question 38

Q39.

Solution

Concept: Use method of images for a point charge near a grounded conducting plane.

Solution:

Equivalent system: image charge $-q$ at distance d inside plane.

- Total induced charge on plane = $-q$ - Potential on plane = 0 - Force of attraction:

$$F = \frac{1}{4\pi\epsilon_0}\frac{q^2}{(2d)^2}$$

- Electric field is not zero on the surface

Final Answer: $\boxed{A, C, D}$

Answer: (A,C,D)

Go Back to Question 39

Q40.

Solution

Concept: In Young's double slit experiment, wavelength changes in a medium as $\lambda' = \lambda/\mu$.

Solution:

Fringe width:

$$\beta = \frac{\lambda D}{d} \Rightarrow \beta' = \frac{\lambda}{\mu}\frac{D}{d} = \frac{\beta}{\mu}$$

Thus: - Fringe width decreases by factor μ - Central maximum remains unchanged - Angular fringe width decreases (not unchanged) - Pattern does not disappear

Final Answer: $\boxed{A, B}$

Answer: (A,B)

Go Back to Question 40

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	C	3	A	4	A	5	B
6	A	7	A	8	A	9	A	10	C
11	A	12	B	13	B	14	B	15	B
16	B	17	B	18	A	19	C	20	B
21	A	22	A	23	A	24	A	25	A
26	B	27	A	28	A	29	A	30	B
31	A	32	B	33	B	34	A	35	A
36	A,B,C	37	A,B,C,D	38	A,B,C	39	A,C,D	40	A,B