IIT-JAM 2025

Section A: Q. 1 - Q. 10 Carry ONE mark each.

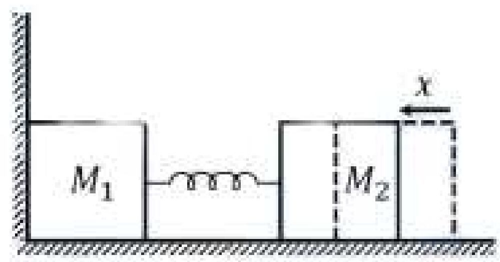
Q1. Consider a volume V enclosed by a closed surface S having unit surface normal $\hat{n}$. For $\mathbf{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$, the value of the surface integral

$$\frac{1}{9}\oiint \mathbf{r}\cdot\hat{n}dS$$

is

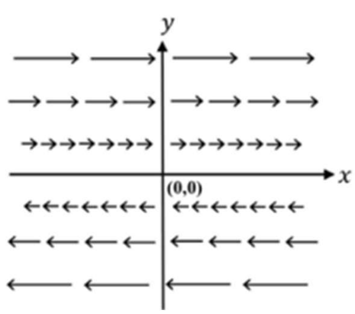
(A) V (B) 3 V (C) $\frac{V}{3}$ (D) $\frac{V}{9}$

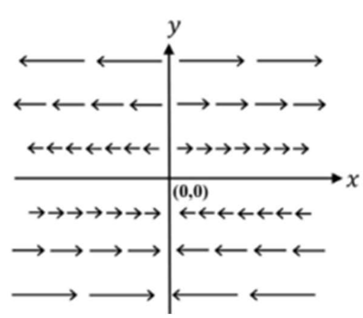
Q2. Two masses, M_1 and M_2, are connected through a massless spring of spring constant k, as shown in the figure below. The mass M_1 is at rest against a rigid wall. Both M_1 and M_2 are on a frictionless surface. The mass M_2 is pushed towards M_1 by a distance x from its equilibrium position and then released. After M_1 leaves the wall, the speed of the center of mass of the composite system is

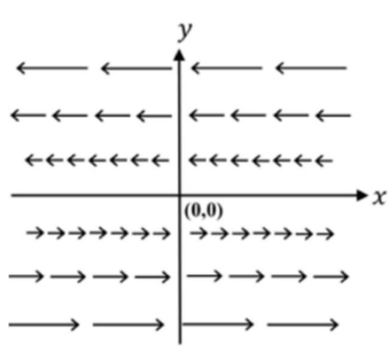


(A) $\sqrt{\frac{k}{M_2}}x$ (B) $\sqrt{\frac{k}{M_1+M_2}}x$ (C) $\frac{\sqrt{kM_2}}{M_1+M_2}x$ (D) $\frac{\sqrt{kM_1}}{M_1+M_2}x$

Q3. Which one of the following figures represents the vector field $A = y\hat{\imath}$? ($\hat{\imath}$ is the unit vector along the x-direction)

(a)


(b)


(c)


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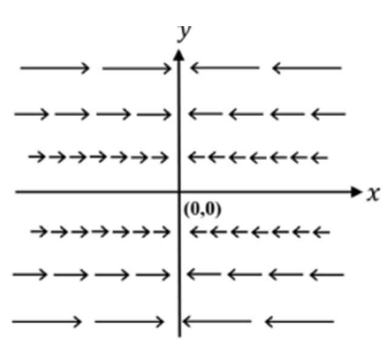
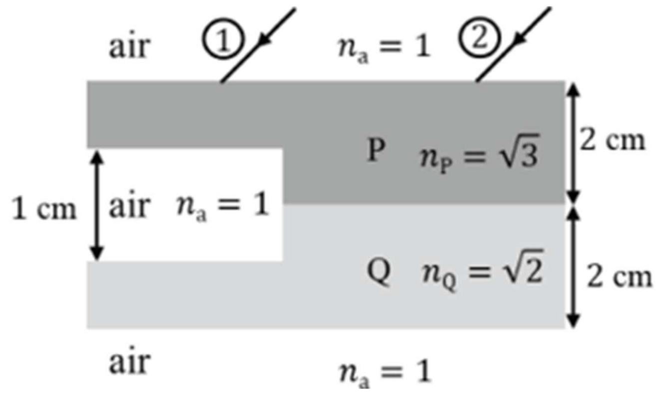


Q4. Two parallel light rays (1) and (2) are incident from air on a system consisting of media P, Q, and air, as shown in the figure below. The incident angle is 45°. Ray (1) passes through medium P, air and medium Q and ray (2) passes through media P and Q before leaving the system. After passing through the system, the angular deviation (in radians) between the two rays is

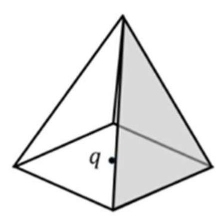


[The dimensions of the media and their refractive indices $(n_a, n_P$ and $n_Q)$ are shown in the figure].

(A) 0 (B) $\tan^{-1}\sqrt{\frac{3}{2}}$ (C) $\tan^{-1}\sqrt{\frac{2}{3}}$ (D) $\tan^{-1}\sqrt{\frac{1}{3}}$

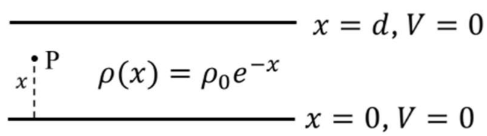
Q5. A charge q is placed at the centre of the base of a square pyramid. The net outward electric flux across each of the slanted faces is

(Consider permittivity as ε_0)



(A) $\frac{q}{\varepsilon_0}$ (B) $\frac{q}{2\varepsilon_0}$ (C) $\frac{q}{4\varepsilon_0}$ (D) $\frac{q}{8\varepsilon_0}$

Q6. Consider a parallel plate capacitor (distance between the plates d, and permittivity ε_0) as shown in the figure below. The space charge density between the plates varies as $\rho(x) = \rho_0 e^{-x}$. Voltage $V = 0$ both at $x =$ 0 and $x = d$.



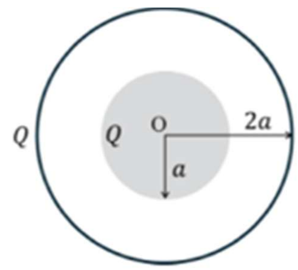
The voltage $V(x)$ at point P between the plates is

[ρ_0 is a constant of appropriate dimensions]

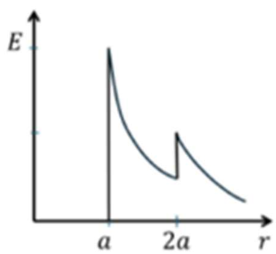
(A) $\frac{\rho_0}{\varepsilon_0}\left[e^{-x} + \frac{1-e^{-d}}{d}x - 1\right]$ (B) $\frac{2\rho_0}{\varepsilon_0}\left[e^{-x} + \frac{1-e^{-d}}{d}x - 1\right]$

(C) $\frac{\rho_0}{2\varepsilon_0}\left[e^{-x} + \frac{1-e^{-d}}{d}x - 1\right]$ (D) $\frac{3\rho_0}{\varepsilon_0}\left[e^{-x} + \frac{1-e^{-d}}{d}x - 1\right]$

Q7. Consider a metal sphere enclosed concentrically within a spherical shell. The inner sphere of radius a carries charge Q. The outer shell of radius $2a$ also has charge Q. The variation of the magnitude E of the electric field as a function of distance r from the center O is



(a)



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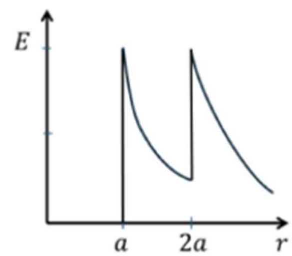

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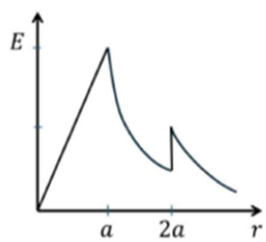

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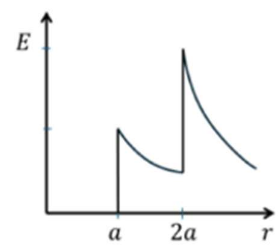


Q8. Consider radioactive decays $A \to B$ with half-life $\left(T_{1/2}\right)_A$ and $B \to C$ with half-life $\left(T_{1/2}\right)_B$. At any time t, the number of nuclides of B is given by

$$(N_B)_t = \frac{\lambda_A}{\lambda_B - \lambda_A}(N_A)_0\left(e^{-\lambda_A t} - e^{-\lambda_B t}\right)$$

where $(N_A)_0$ is the number of nuclides of A at $t = 0$. The decay constants of A and B are λ_A and λ_B, respectively.

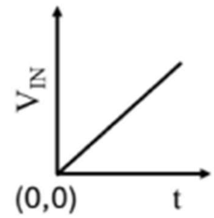
If $\left(T_{1/2}\right)_B < \left(T_{1/2}\right)_A$, then the ratio $\frac{(N_B)_t}{(N_A)_t}$ at time $t \gg \left(T_{1/2}\right)_A$ is [$(N_A)_t$ is the number of nuclides of A at time t]

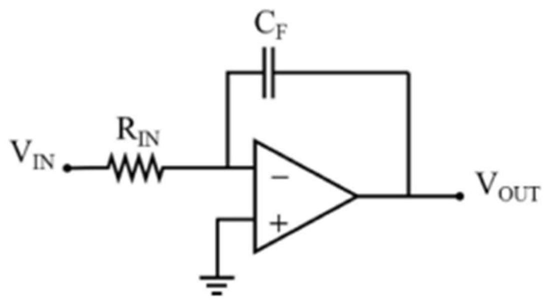
(a) $\frac{\lambda_A}{\lambda_B - \lambda_A}$ (b) $\frac{\lambda_B}{\lambda_A}$ (c) $\frac{\lambda_A}{\lambda_B}$ (d) $\frac{\lambda_B}{\lambda_B - \lambda_A}$

Q9. For a non-relativistic free particle, the ratio of phase velocity to group velocity is

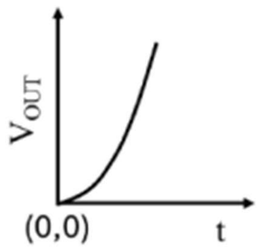
(A) 2 (B) $\frac{1}{2}$ (C) 1 (D) $\frac{1}{4}$

Q10. If the input voltage waveform V_{IN} is a ramp function (as shown in the V_{IN}-t plot below), then the output wave form (V_{OUT}) for the given circuit diagram having an ideal operational amplifier (Op-Amp) is

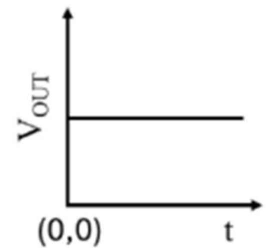




(a)



(b)



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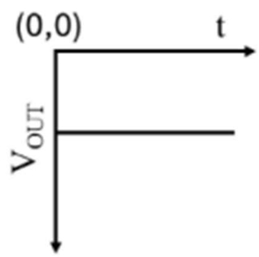
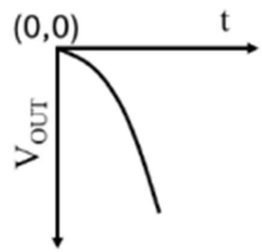
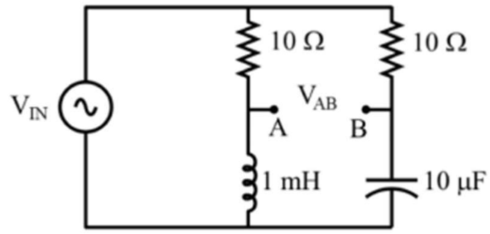


(d)



Section A: Q. 11 - Q. 30 Carry TWO marks each.

Q11. In the circuit given below, the frequency of the input voltage V_{IN} is $\omega = 10^4 \mathrm{rad/s}$. The output voltage V_{AB} leads V_{IN} by



(A) $0°$ (B) $45°$ (C) $90°$ (D) $-90°$

Q12. Given a function $f(x, y) = \frac{x}{a}e^y + \frac{y}{b}e^x$, where $x = at$ and $y = bt$ (a and b are non-zero constants), the value of $\frac{df}{dt}$ at $t = 0$ is

(A) -1 (B) 0 (C) 1 (D) 2

Q13. If the system of linear equations

$$x + my + az = 0$$
$$2x + ay + mz = 0$$
$$ax + 2y - z = 0$$

with m and a as non-zero constants, admits a non-trivial solution, then which one of the following conditions is correct?

(A) $m^2 - a^2 = 3$ (B) $m^2 - a^2 = -3$ (C) $a^2 - 2m^2 = -3$ (D) $m^2 - 2a^2 = 3$

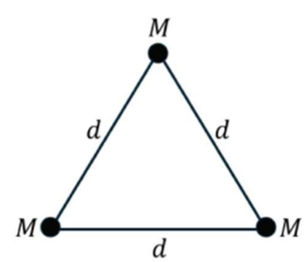
Q14. If $\left(\frac{1-i}{1+i}\right)^{\frac{n}{2}} = -1$, where $i = \sqrt{-1}$, one possible value of n is

(A) 2 (B) 4 (C) 6 (D) 8

Q15. In Cartesian coordinates, consider the functions $u(x, y) = \frac{1}{2}(x^2 - y^2)$ and $v(x, y) = xy$. If (r, θ) are the polar coordinates, the Jacobian determinant $\left|\frac{\partial(u,v)}{\partial(r,\theta)}\right|$ is

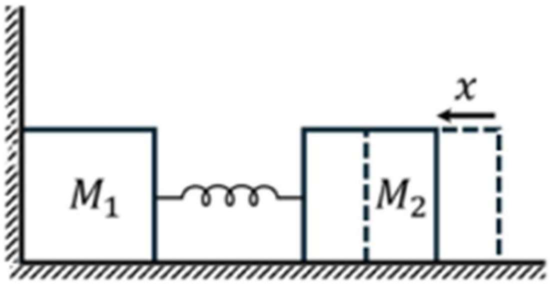
(A) r (B) $\frac{1}{r}$ (C) r^2 (D) r^3

Q16. Three particles of equal mass M, interacting via gravity, lie on the vertices of an equilateral triangle of side d, as shown in the figure below. The whole system is rotating with an angular velocity ω about an axis perpendicular to the plane of the system and passing through the center of mass. The value of ω, for which the distance between the masses remains d, is (G is the universal gravitational constant)



(A) $\sqrt{\frac{2GM}{d^3}}$ (B) $\sqrt{\frac{3GM}{d^3}}$ (C) $\sqrt{\frac{GM}{3d^3}}$ (D) $\sqrt{\frac{GM}{d^3}}$

Q17. Two masses, M_1 and M_2, are connected through a massless spring of spring constant k, as shown in the figure below. The mass M_1 is at rest against a rigid wall. Both M_1 and M_2 are on a frictionless surface. The mass M_2 is pushed towards M_1 by a distance x from its equilibrium position and then released. After M_1 leaves the wall, the speed of the center of mass of the composite system is



(A) $\sqrt{\frac{k}{M_2}}x$ (B) $\sqrt{\frac{k}{M_1+M_2}}x$ (C) $\frac{\sqrt{kM_2}}{M_1+M_2}x$ (D) $\frac{\sqrt{kM_1}}{M_1+M_2}x$

Q18. One end of a long chain is lifted vertically from flat ground to a height H with constant speed v by a force of magnitude F. Assume that the length of the chain is greater than H and that it has a uniform mass per unit length ρ. The magnitude of the force F at height H is (g is the acceleration due to gravity)

(A) $\rho(gH+v^2)$ (B) $\rho(gH+2v^2)$ (C) $\rho(2gH+v^2)$ (D) $\frac{\rho}{2}(gH+v^2)$

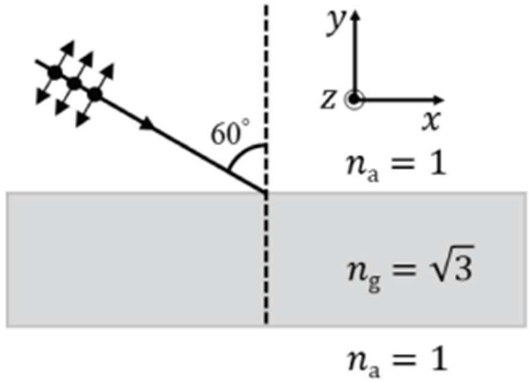
Q19. For a two-slit Fraunhofer diffraction, each slit is 0.1 mm wide and separation between the two slits is 0.8 mm . The total number of interference minima between the first diffraction minima on both sides of the central maxima is

(A) 16 (B) 18 (C) 8 (D) 9

Q20. Consider the superposition of two orthogonal simple harmonic motions $y_1 = a\cos 2\omega t$ and $y_2 = b\cos(\omega t+\phi)$. If $\phi = \pi$, the resultant motion will represent (a, b and ω are constants with appropriate dimensions)

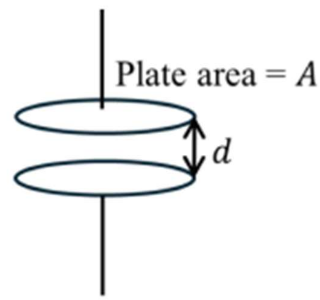
(A) a parabola (B) a hyperbola (C) an ellipse (D) a circle

Q21. An unpolarized light ray passing through air (refractive index $n_a = 1$) is incident on a glass slab (refractive index $n_g = \sqrt{3}$) at an angle of 60°, as shown in the figure below. The amplitude of the in-plane ($x-y$) electric field component of the incident light is $4\ \mathrm{V/m}$ and amplitude of the out of plane (z) electric field component is $3\ \mathrm{V/m}$. After passing through the glass slab, the electric field amplitude (in V/m) of the light is



(A) 5 (B) 4 (C) 7 (D) 3

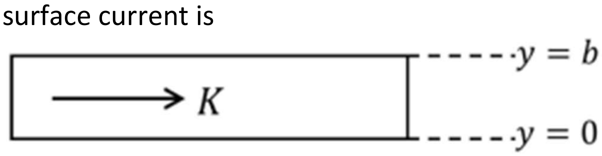
Q22. Consider a slowly charging parallel plate capacitor (distance between the plates is d) having circular plates each with an area A, as shown in the figure below. An electric field of magnitude $E = E_0 \sin(\omega t)$ exists between the plates while charging. The associated magnitude of the magnetic field B at the periphery (outer edge) of the capacitor is (Neglect fringe effects)



(A) $\frac{1}{2c^2}\sqrt{\frac{A}{\pi}}E_0\omega\cos(\omega t)$ (B) $\frac{1}{2c^2}\sqrt{\frac{A}{\pi}}E_0\omega\sin(\omega t)$

(C) $\frac{1}{c^2}\sqrt{\frac{A}{\pi}}E_0\omega\cos(\omega t)$ (D) $\frac{1}{c^2}\sqrt{\frac{A}{\pi}}E_0\omega\sin(\omega t)$

Q23. A surface current density $K = ae^{-y}$ exists on a thin strip of width b, as shown in the figure below. The associated surface current is



(a is a constant of appropriate dimensions)

(A) $a(1-e^{-b})$ (B) $a(1+e^{-b})$ (C) $a(e^{-b}-1)$ (D) $a(e^{b}+e^{-b})$

Q24. For an electromagnetic wave, consider an electric field $E = E_0 e^{-i[a(x+y)-\omega t]}\hat{k}$. The corresponding magnetic field B is

(E_0, a, ω are constants of appropriate dimensions and c is the speed of light)

(A) $\frac{1}{c\sqrt{2}} E_0 e^{-i[a(x+y)-\omega t]}(\hat{\imath} - \hat{\jmath})$ (B) $\frac{1}{c\sqrt{2}} E_0 e^{-i[a(x+y)-\omega t]}(\hat{\imath} + \hat{\jmath})$

(C) $\frac{1}{c\sqrt{2}} E_0 e^{-i[a(x+y)-\omega t]}(-\hat{\imath} - \hat{\jmath})$ (D) $\frac{1}{c\sqrt{2}} E_0 e^{-i[a(x+y)-\omega\ ]}(-\hat{\imath} + \hat{\jmath})$

Q25. Consider Maxwell's relation $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$. The equation of state of a thermodynamic system is given as $P = \frac{AT}{V^2} + \frac{BT^3}{V}$, where A and B are constants of appropriate dimensions. Then $\left(\frac{\partial C_V}{\partial V}\right)_T$ of the system varies with temperature as (C_V is the heat capacity at constant volume)

(A) T^2 (B) T (C) T^{-1} (D) T^3

Q26. Consider a relativistic particle of rest mass $2m$ moving with a speed v along the x direction. It collides with another relativistic particle of rest mass m moving with the same speed but in the opposite direction. These two particles coalesce to form one particle whose rest mass M is

($\beta = \frac{v}{c}$, where c is the speed of light)

(A) $m\sqrt{\frac{9-\beta^2}{1-\beta^2}}$ (B) $2m\sqrt{\frac{3-\beta^2}{1-\beta^2}}$ (C) $\frac{m}{2}\sqrt{\frac{9-\beta^2}{2-\beta^2}}$ (D) $\frac{m}{4}\sqrt{\frac{1-\beta^2}{2-\beta^2}}$

Q27. A particle of mass m is subjected to a potential $V(x)$. If its wavefunction is given by

$$\psi(x,t) = \alpha x^2 e^{-\beta x} e^{i\gamma t/\hbar}, x > 0$$
$$\psi(x,t) = 0, x \le 0$$

then $V(x)$ is

(α, β and γ are constants of appropriate dimensions)

(A) $-\gamma + \frac{\hbar^2}{2m}\left(\frac{2}{x^2} - \frac{4\beta}{x} + \beta^2\right)$ (B) $-\gamma + \frac{\hbar^2}{2m}\left(\frac{2}{x^2} + \frac{4\beta}{x} + \beta^2\right)$

(C) $-\gamma + \frac{\hbar^2}{2m}\left(\frac{2}{x^2} - \frac{4\beta}{x} - \beta^2\right)$ (D) $-\gamma + \frac{\hbar^2}{2m}\left(-\frac{2}{x^2} - \frac{4\beta}{x} + \beta^2\right)$

Q28. Two non-relativistic particles with masses m_1 and m_2 move with momenta $\boldsymbol{p}_1$ and $\boldsymbol{p}_2$, respectively, in an inertial frame S. In another inertial frame S', moving with a constant speed with respect to S, the same particles are observed to have momenta $\boldsymbol{p}_1'$ and $\boldsymbol{p}_2'$, respectively. Galilean invariance implies that

(A) $m_2 p_1' - m_1 p_2' = m_2 p_1 - m_1 p_2$ (B) $m_2 p_1' + m_1 p_2' = m_2 p_1 + m_1 p_2$

(C) $m_1 p_1' - m_2 p_2' = m_1 p_1 - m_2 p_2$ (D) $m_1 p_1' + m_2 p_2' = m_1 p_1 + m_2 p_2$

Q29. The binding energy $B(A,Z)$ of an atomic nucleus of mass number A, atomic number Z, and number of neutrons $N = A - Z$, can be expressed as

$$B(A,Z) = a_1 A - a_2 A^{\frac{2}{3}} - a_3 \frac{Z^2}{A^{\frac{1}{3}}} - a_4 \frac{(A-2Z)^2}{A},$$

where a_1, a_2, a_3, and a_4 are constants of appropriate dimensions. Let $B(A,Z')$ be the binding energy of a mirror nucleus (which has the same A, but the number of protons and neutrons are interchanged).

Then, at constant A, $[B(A,Z) - B(A,Z')]$ is

(A) proportional to Z^2 (B) Proportional to $(Z^2 - N^2)$

(C) Proportional to N^2 (D) Constant

Q30. A magnetic field is given by $B = \nabla \times A$ where A is the magnetic vector potential. If $A = (ax^2 + by^2)\hat{\imath}$, the corresponding current density J is (a and b are non-zero constants)

(A) $-\frac{1}{\mu_0}(2a + 2b)\hat{\imath}$ (B) $\frac{1}{\mu_0}(2a + 2b)\hat{\imath}$ (C) $-\frac{1}{\mu_0}(2a)\hat{\imath}$ (D) $-\frac{1}{\mu_0}(2b)\hat{\imath}$

Section B: Q. 31 - Q. 40 Carry TWO marks each.

Q31. In the logic circuit shown below, for which of the following combination(s) of inputs P and Q, the output Y will be 0 ?

(A) $P=0, Q=0$ (B) $P=0, Q=1$ (C) $P=1, Q=0$ (D) $P=1, Q=1$

Q32. Two particles of masses m_1 and m_2, interacting via gravity, rotate in circular orbits about their common center of mass with the same angular velocity ω.

For masses m_1 and m_2, respectively,

- r_1 and r_2 are the constant distances from the center of mass,
- L_1 and L_2 are the magnitudes of the angular momenta about the center of mass, and
- K_1 and K_2 are the kinetic energies.

Which of the following is(are) correct?

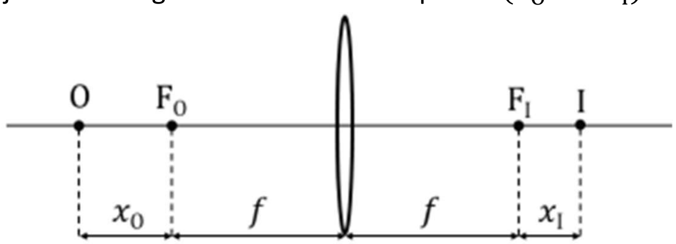
(G is the universal gravitational constant)

(A) $\frac{L_1}{L_2}=\frac{m_2}{m_1}$ (B) $\frac{K_1}{K_2}=\frac{m_2}{m_1}$ (C) $\omega=\sqrt{\frac{G(m_1+m_2)}{(r_1+r_2)^3}}$ (d) $m_2 r_1 = m_1 r_2$

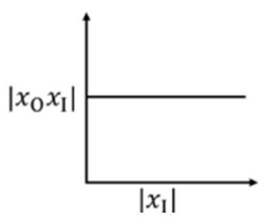
Q33. Which of these cubic lattice plane pairs is(are) perpendicular to each other?

(A) (100), (010) (B) (220), (001) (C) (110), (010) (D) (112), (220)

Q34. For a thin convex lens of focal length f, the image of an object at 0 is formed at I, as shown in the figure below. The distances of object and image from the two focal points (F_O and F_I) are x_O and x_I, respectively. Which of the following graphs correctly represent(s) the variation of the quantities shown in the figure?



(a)



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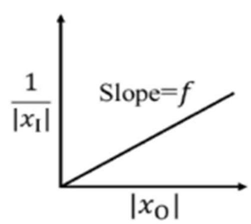

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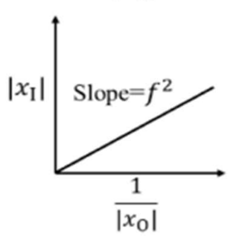

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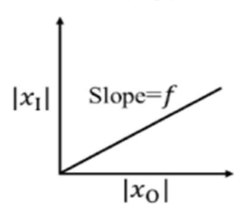


Q35. Identify which of the following wave functions describe (s) travelling wave (s).

(A_0, B_0, a and b are positive constants of appropriate dimensions)

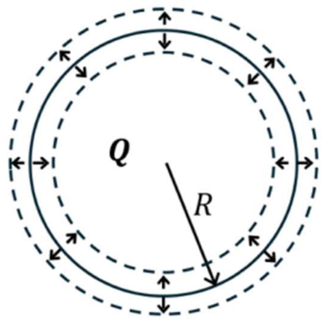
(A) $\psi(x,t) = A_0(x+t)^2$

(B) $\psi(x,t) = A_0\sin\left(ax^2 + bt^2\right)$

(C) $\psi(x,t) = \frac{A_0}{B_0(x-t)^2+1}$

(D) $\psi(x,t) = A_0 e^{(ax+bt)^2}$

Q36. A spherical ball having a uniformly distributed charge Q and radius R pulsates with frequency ω such that the radius changes by $\pm 10\%$, as shown in the figure below. Which of the following is(are) correct?



(A) The net outward electric flux across a spherical surface of radius $r > 1.5R$ pulsates with a frequency ω

(B) The net outward electric flux across a spherical surface of radius $r = 2R$ is $\frac{Q}{\varepsilon_0}$

(C) The potential fluctuates with frequency ω at $r = 2R$

(D) The electric field inside the sphere at $r = 0.5R$ will not be time dependent

Q37. Which of the following relations is(are) valid for linear dielectrics? [$\boldsymbol{E}$ = Electric field, $\boldsymbol{P}$ = Polarization, $\boldsymbol{D}$ = Electric displacement, ε_0 = Permittivity of free space, ε = Dielectric permittivity, χ_e = Electric susceptibility, ρ_f = Free charge density, ρ_b = Bound charge density]

(A) $P = \varepsilon_0 \chi_e E$

(B) $\varepsilon = \varepsilon_0(1+\chi_e)$

(C) $D = \varepsilon_0 E + P$

(D) $\nabla \cdot D = \rho_f + \rho_b$

Q38. Three gaseous systems, G_1, G_2, and G_3 with pressure and volume $(P_1, V_1), (P_2, V_2)$, and (P_3, V_3), respectively, are such that

(I) when G_1 and G_2 are in thermal equilibrium, $P_1V_1 - P_2V_2 + \alpha P_2 = 0$, is satisfied, and

(II) when G_1 and G_3 are in thermal equilibrium, $P_3V_3 - P_1V_1 + \frac{\beta P_1 V_1}{V_3} = 0$, is satisfied.

The relation(s) valid at thermal equilibrium is(are)

(α and β are constants of appropriate dimensions)

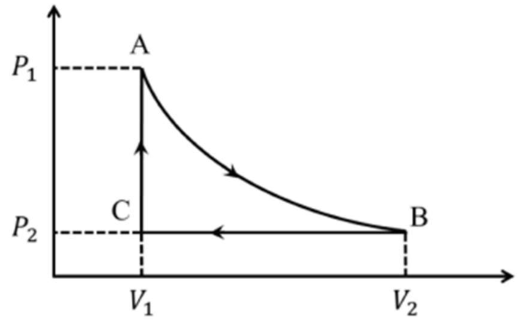
(A) $P_3V_3 - (P_2V_2 - \alpha P_2)\left(1 - \frac{\beta}{V_3}\right) = 0$

(B) $P_3V_3 + (P_2V_2 + \alpha P_2)\left(1 + \frac{\beta}{V_3}\right) = 0$

(C) $P_1V_1 = P_2V_2 = P_3V_3$

(D) $P_3V_3 + P_1V_1\left(\frac{\beta}{V_3} - 1\right) = 0$

Q39. An ideal mono-atomic gas is expanded adiabatically from A to B . It is then compressed in an isobaric process from B to C. Finally, the pressure is increased in an isochoric process from C to A . The cyclic process is shown in the figure below. For this system, which of the following is(are) correct?



(A) Work done along the path AB is $(P_1V_1 - P_2V_2)$

(B) Total work done during the entire process is $\frac{3}{2}(P_1V_1 - P_2V_2) + P_2(V_1 - V_2)$

(C) Total heat absorbed during the entire process is $\frac{3}{2}(P_1 - P_2)V_1$

(D) Total change in internal energy during the entire process is $\frac{5}{2}P_2(V_2 - V_1)$

Q40. For a body centered cubic (bcc) system, the x-ray diffraction peaks are observed for the following $h^2 + k^2 + l^2$ value(s)

[h, k, and l are Miller indices]

(A) 3 (B) 4 (C) 5 (D) 7

Section C: Q. 41 - Q. 50 Carry ONE mark each.

Q41. Two solid cylinders of the same density are found to have the same moment of inertia about their respective principal axes. The length of the second cylinder is 16 times that of the first cylinder. If the radius of the first cylinder is 4 cm , the radius of the second cylinder is _______cm . (in integer)

Q42. The shortest distance between an object and its real image formed by a thin convex lens of focal length 20 cm is______cm . (in integer)

Q43. Consider two media 1 and 2 having permittivities ε_0 and $\varepsilon_1(=2\varepsilon_0)$, respectively. The interface between the two media aligns with the $x-y$ plane. An electric field $\boldsymbol{E}_{\mathbf{1}}=4\hat{\imath}-5\hat{\jmath}-\hat{k}$ exists in medium 1. The magnitude of the displacement vector $\boldsymbol{D}_{\mathbf{2}}$ in medium 2 is_______ε_0. (up to two decimal places)

Q44. G1 and G2 are two ideal gases at temperatures T_1 and T_2, respectively. The molecular weight of the constituents of G1 is half that of G2 If the average speeds of the molecules of both gases are equal, then assuming Maxwell-Boltzmann distributions for the molecular speeds, the ratio $\frac{T_2}{T_1}$ is________(in integer)

Q45. An ideal p-n junction diode (ideality factor $\eta=1$) is operating in forward bias at room temperature (thermal energy $=26\mathrm{meV}$). If the diode current is 26 mA for an applied bias of 1.0 V , the dynamic resistance (r_{ac}) is______Ω. (up to two decimal places)

Q46. In a two-level atomic system, the excited state is 0.2 eV above the ground state. Considering the Maxwell-Boltzmann distribution, the temperature at which 2% of the atoms will be in the excited state is__________K. (up to two decimal places)
(Boltzmann constant $k_B=8.62\times10^{-5}\mathrm{eV/K}$)

Q47. Neutrons of energy 8 MeV are incident on a potential step of height 48 MeV . As they penetrate the classically forbidden region, the distance at which the probability density of finding neutrons decreases by a factor of 100 is______________________fm. (up to two decimal places) (Take $\hbar c=200\mathrm{MeVfm}$, and the rest mass energy of neutron $=1\mathrm{GeV}$.)

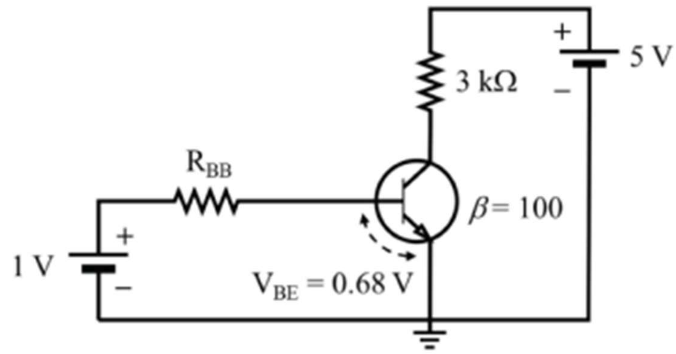
Q48. At a particular temperature T, Planck's energy density of black body radiation in terms of frequency is $\rho_T(v)=8\times10^{-18}\frac{\mathrm{J/m^3}}{\mathrm{Hz}}$ at $v=3\times10^{14}$ Hz. Then Planck's energy density $\rho_T(\lambda)$ at the corresponding wavelength (λ) has the value_______ $\times10^2\frac{\mathrm{J/m^3}}{\mathrm{m}}$. (in integer)
[Speed of light $c=3\times10^8$ m/s]

Q49. The ratio of the density of atoms between the (111) and (110) planes in a simple cubic (sc) lattice is__________. (up to two decimal places)

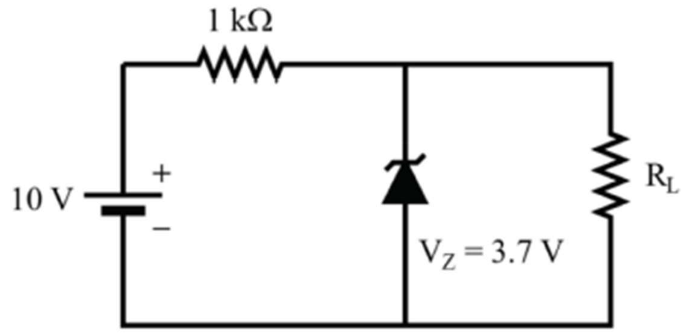
Q50. The packing fraction for a two-dimensional hexagonal lattice having sides $2r$ with atoms of radii r placed at each vertex and at the center is________. (up to two decimal places)

Section C: Q. 51 - Q. 60 Carry TWO marks each.

Q51. A NPN bipolar junction transistor (BJT) is connected in common emitter (CE) configuration as shown in the circuit diagram below. The amplifier is operating in the saturation regime. The collector-emitter saturation voltage (V_{CE}^{sat}) is 0.2 V . The current gain $\beta = 100$. The maximum value of base resistance R_{BB} is ________ $k\Omega$. (in integer)



Q52. For a Zener diode as shown in the circuit diagram below, the Zener voltage V_Z is 3.7 V. For a load resistance (R_L) of $1k\Omega$, a current I_1 flows through the load. If R_L is decreased to 500Ω, the current changes to I_2.



The ratio $\frac{I_2}{I_1}$ is__________ . (up to two decimal places)

Q53. One kg of water at 27°C is brought in contact with a heat reservoir kept at 37°C. Upon reaching thermal equilibrium, this mass of water is brought in contact with another heat reservoir kept at 47°C. The final temperature of water is 47°C. The change in entropy of the whole system in this entire process is_______cal/K. (up to two decimal places)

[Take specific heat at constant pressure of water as $1cal/(gK)$]

Q54. Consider a vector $\boldsymbol{F} = \frac{1}{\pi}[-\sin\, y\hat{\imath} + x(1 - \cos\, y)\hat{\jmath}]$. The value of the integral $\oint \mathbf{F} \cdot d\mathbf{r}$ over a circle $x^2 + y^2 = 1$ evaluated in the anti-clockwise direction is________. (in integer)

Q55. A particle is moving with a constant angular velocity $2rad/s$ in an orbit on a plane. The radial distance of the particle from the origin at time t is given by $r = r_0 e^{2\beta}$ where r_0 and β are positive constants. The radial component of the acceleration vanishes for $\beta =$ _____rad/s. (in integer)

Q56. A planet rotates in an elliptical orbit with a star situated at one of the foci. The distance from the center of the ellipse to any foci is half of the semi-major axis. The ratio of the speed of the planet when it is nearest (perihelion) to the star to that at the farthest (aphelion) is_______. (in integer)

Q57. A light beam given by $\boldsymbol{E}(z,t) = E_{01}\sin\,(kz-\omega t)\hat{\imath} + E_{02}\sin\,\left(kz-\omega t+\frac{\pi}{6}\right)\hat{\jmath}$ passes through an ideal linear polarizer whose transmission axis is tilted by 60° from x-axis (in x-y plane). If $E_{01} = 4\ \mathrm{V/m}$ and $E_{02} = 2\ \mathrm{V/m}$, the electric field amplitude of the emerging light beam from the polarizer is _______ V/m. (up to two decimal places)

Q58. A wedge-shaped thin film is formed using soap-water solution. The refractive index of the film is 1.25 . At near normal incidence, when the film is illuminated by a monochromatic light of wavelength $600\ \mathrm{nm}$, 10 interference fringes per cm are observed. The wedge angle (in radians) is_________ $\times 10^{-5}$. (in integer)

Q59. In an orthorhombic crystal, the lattice constants are $3.0\text{Å}, 3.2\text{Å}$, and $4.0\ \text{Å}$. The distance d_{101} between the successive (101) planes is_______Å. (up to one decimal place)

Q60. Consider a chamber at room temperature $(27^\circ\mathrm{C})$ filled with a gas having a molecular diameter of 0.35 nm . The pressure (in Pascal) to which the chamber needs to be evacuated so that the molecules have a mean free path of 1 km is________$\times 10^{-5}$ Pa. (up to two decimal places) (Boltzmann constant $k_B = 1.38\times 10^{-2}\ \ \mathrm{J/K}$)