IIT-JAM 2022: Question Paper Physics

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Physics by fiziks

House No. 40-D, Ground Floor, Jia Sarai

Near IIT-Delhi, Hauz Khas, New Delhi-110016

IIT-JAM 2022

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

Q1. The equation $z^2+\bar{z}^2=4$ in the complex plane (where $\bar{z}$ is the complex conjugate of z) represents

(a) Ellipse (b) Hyperbola (c) Circle of radius 2 (d) Circle of radius 4

Ans. 1: (b)

Q2. A rocket (S') moves at a speed $\frac{c}{2}m/s$ along the positive x-axis, where c is the speed of light. When it crosses the origin, the clocks attached to the rocket and the one with a stationary observer (S) located at $x=0$ are both set to zero. If S observes an event at (x,t) the same event occurs in the S' frame at

(a) $x'=\frac{2}{\sqrt{3}}\left(x-\frac{ct}{2}\right)$ and $t'=\frac{2}{\sqrt{3}}\left(t-\frac{x}{2c}\right)$

(b) $x'=\frac{2}{\sqrt{3}}\left(x+\frac{ct}{2}\right)$ and $t'=\frac{2}{\sqrt{3}}\left(t-\frac{x}{2c}\right)$

(c) $x'=\frac{2}{\sqrt{3}}\left(x-\frac{ct}{2}\right)$ and $t'=\frac{2}{\sqrt{3}}\left(t+\frac{x}{2c}\right)$

(d) $x'=\frac{2}{\sqrt{3}}\left(x+\frac{ct}{2}\right)$ and $t'=\frac{2}{\sqrt{3}}\left(t+\frac{x}{2c}\right)$

Ans. 2: (a)

Q3. Consider a classical ideal gas of N molecules equilibrium at temperature T. Each molecule has two energy levels, $-\in$ and $\in$. The mean energy of the gas is

(a) 0 (b) $N\in\tanh\left(\frac{\in}{k_BT}\right)$ (c) $-N\in\tanh\left(\frac{\in}{k_BT}\right)$ (d) $\frac{\in}{2}$

Ans. 3: (c)

Q4. At a temperature T, let β and k denote the volume expansively and isothermal compressibility of a gas, respectively. Then $\frac{\beta}{k}$ is equal to

(a) $\left(\frac{\partial P}{\partial T}\right)_V$ (b) $\left(\frac{\partial P}{\partial V}\right)_T$ (c) $\left(\frac{\partial T}{\partial P}\right)_V$ (d) $\left(\frac{\partial T}{\partial V}\right)_P$

Ans. 4: (a)

Q5. The resultant of the binary subtraction $1110101 - 0011110$ is

(a) 1001111 (b) 1010111 (c) 1010011 (d) 1010001

Ans. 5: (b)

Q6. Consider a particle trapped in a three-dimensional potential well such that

$U(x,y,z)=0$ for $0 \le x \le a, 0 \le y \le a, 0 \le z \le a$ and $U(x,y,z)=\infty$ everywhere else. The degeneracy of the 5^{th} excited state is

(a) 1 (b) 3 (c) 6 (d) 9

Ans. 6: (c)

Q7. A particle of mass m and angular momentum L moves in space where its potential energy is $U(r)=kr^2\,(k>0)$ and r is the radial coordinate.

If the particle moves in a circular orbit, then the radius of the orbit is

(a) $\left(\frac{L^2}{mk}\right)^{\frac{1}{4}}$ (b) $\left(\frac{L^2}{2mk}\right)^{\frac{1}{4}}$ (c) $\left(\frac{2L^2}{mk}\right)^{\frac{1}{4}}$ (d) $\left(\frac{4L^2}{mk}\right)^{\frac{1}{4}}$

Ans. 7: (b)

Q8. Consider a two-dimensional force field

$$\vec{F}(x,y)=\left(5x^2+ay^2+bxy\right)\hat{x}+\left(4x^2+4xy+y^2\right)\hat{y}$$

If the force field is conservative, then the values of a and b are

(a) $a=2$ and $b=4$ (b) $a=2$ and $b=8$

(c) $a=4$ and $b=2$ (d) $a=8$ and $b=2$

Ans. 8: (b)

H.No. 40-D, G.F., Jia Sarai, Near IIT, Hauz Khas, New Delhi-16
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Q9. Consider an electrostatic field $\vec{E}$ in a region of space. Identify the INCORRECT statement.

(a) The work done in moving a charge in a closed path inside the region is zero

(b) The curl of $\vec{E}$ is zero

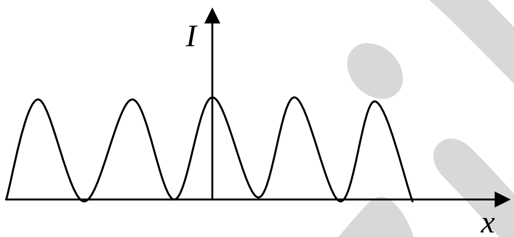
(c) The field can be expressed as the gradient of a scalar potential

(d) The potential difference between any two points in the region is always zero

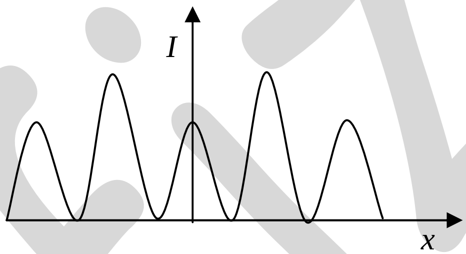
Ans. 9: (d)

Q10. Which one of the following figures correctly depicts the intensity distribution for Fraunhofer diffraction due to a single slit? Here, x denotes the distance from centre of the central fringe and I denotes the intensity.

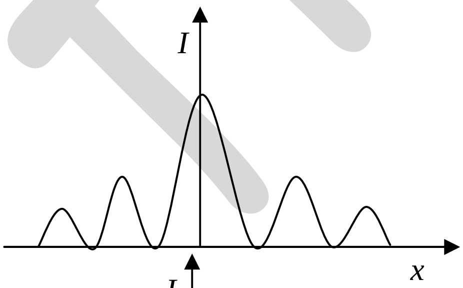
(a)



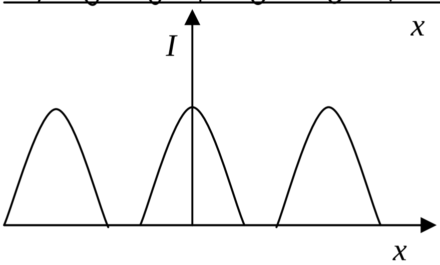
(b)



(c)



(d)



Ans. 10: (c)

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

Q11. The function $f(x)=e^{\sin x}$ is expanded as a Taylor series in x, around $x=0$, in the form $f(x)=\sum_{n=0}^{\infty}a_n x^n$. The value of $a_0+a_1+a_2$ is

(a) 0 (b) $\frac{3}{2}$ (c) $\frac{5}{2}$ (d) 5

Ans. 11: (c)

Q12. Consider a unit circle C in the xy plane, centered at the origin. The value of the integral $\oint\left[(\sin x-y)dx-(\sin y-x)dy\right]$ over the circle C, traversed anticlockwise, is

(a) 0 (b) 2π (c) 3π (d) 4π

Ans. 12: (b)

Q13. The current through a series RL circuit, subjected to a constant $emf\ \varepsilon$. Obeys $L\frac{di}{dt}+iR=\varepsilon$. Let $L=1mH, R=1k\Omega$ and $\varepsilon=1V$. The initial condition is $i(0)=0$ at $t=1\mu s$, the current in mA is

(a) $1-2e^{-2}$ (b) $1-2e^{-1}$ (c) $1-e^{-1}$ (d) $2-2e^{-1}$

Ans. 13: (c)

Q14. An ideal gas in equilibrium at temperature T expands isothermally to twice its initial volume. If $\Delta S,\Delta U$ and ΔF denote the changes in its entropy, internal energy and Helmholtz free energy respectively, then

(a) $\Delta S<0,\Delta U>0,\Delta F<0$ (b) $\Delta S>0,\Delta U=0,\Delta F<0$

(c) $\Delta S<0,\Delta U=0,\Delta F>0$ (d) $\Delta S>0,\Delta U>0,\Delta F=0$

Ans. 14: (b)

Q15. In a dilute gas, the number of molecules with free path length $\geq x$ is given by $N(x)=N_0e^{-x/\lambda}$, where N_0 is the total number of molecules and λ is the mean free path. The fraction of molecules with free path lengths between λ and 2λ is

(a) $\frac{1}{e}$ (b) $\frac{e}{e-1}$ (c) $\frac{e^2}{e-1}$ (d) $\frac{e-1}{e^2}$

Ans. 15: (d)

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Q16. Consider a quantum particle trapped in a one-dimensional potential well in the region $[-L/2 < x < L/2]$, with infinitely high barriers at $x = -L/2$ and $x = L/2$. The stationary wave function for the ground state is $\psi(x) = \sqrt{\frac{2}{L}}\cos\left(\frac{\pi x}{L}\right)$. The uncertainties in momentum and position satisfy

(a) $\Delta p = \frac{\pi\hbar}{L}$ and $\Delta x = 0$

(b) $\Delta p = \frac{2\pi\hbar}{L}$ and $0 < \Delta x < \frac{L}{2\sqrt{3}}$

(c) $\Delta p = \frac{\pi\hbar}{L}$ and $\Delta x > \frac{L}{2\sqrt{3}}$

(d) $\Delta p = 0$ and $\Delta x = \frac{L}{2}$

Ans. 16: Marks to all

Q17. Consider a particle of mass m moving in a plane with a constant radial speed $\dot{r}$ and a constant angular speed $\dot{\theta}$. The acceleration of the particle in (r,θ) coordinates is

(a) $2r\dot{\theta}^2\hat{r} - \dot{r}\dot{\theta}\hat{\theta}$

(b) $-r\dot{\theta}^2\hat{r} + 2\dot{r}\dot{\theta}\hat{\theta}$

(c) $\ddot{r}\hat{r} + r\ddot{\theta}\hat{\theta}$

(d) $\ddot{r}\theta\hat{r} + r\ddot{\theta}\hat{\theta}$

Ans. 17: (b)

Q18. A planet of mass m moves in an elliptical orbit. Its maximum and minimum distances from the Sun are R and r, respectively. Let G denote the universal gravitational constant, and M the mass of the Sun. Assuming $M >> m$, the angular momentum of the planet with respect to the center of the Sun is

(a) $m\sqrt{\frac{2GMRr}{(R+r)}}$

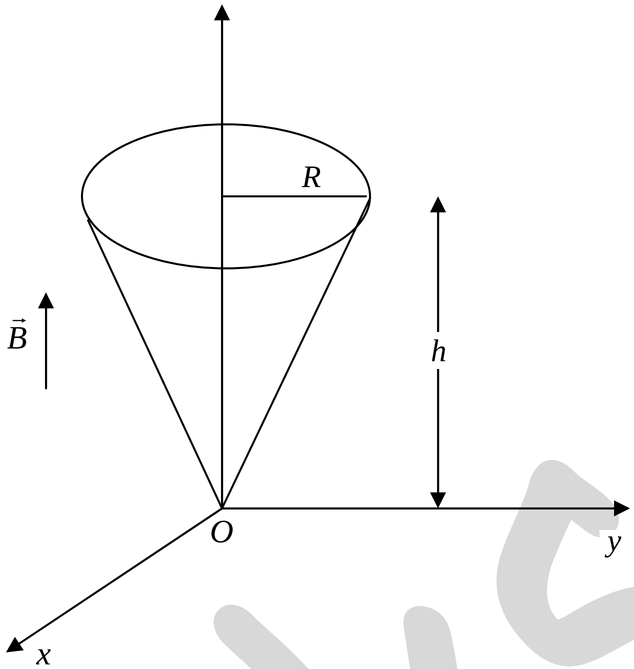
(b) $m\sqrt{\frac{GMRr}{2(R+r)}}$

(c) $m\sqrt{\frac{GMRr}{(R+r)}}$

(d) $2m\sqrt{\frac{2GMRr}{(R+r)}}$

Ans. 18: (a)

Q19. Consider a conical region of height h hand base radius R with its vertex at the origin, Let the outward normal to its base be along the positive z-axis, as shown in the figure. A uniform magnetic field, $\vec{B} = B_0\hat{z}$ exists everywhere. Then the magnetic flux through the base (ϕ_b) and that through the curved surface of the cone (ϕ_c) are



(a) $\phi_b = B_0 \pi R^2 ; \phi_c = 0$

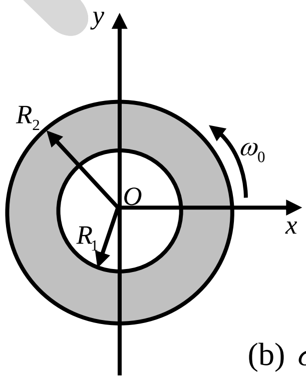
(b) $\phi_b = -\frac{1}{2} B_0 \pi R^2 ; \phi_c = \frac{1}{2} B_0 \pi R^2$

(c) $\phi_b = 0 ; \phi_c = -B_0 \pi R^2$

(d) $\phi_b = B_0 \pi R^2 ; \phi_c = -B_0 \pi R^2$

Ans. 19: (d)

Q20. Consider a thin annular sheet, lying on the xy-plane, with R_1 and R_2 as its inner and outer radii, respectively. If the sheet carries a uniform surface-charge density σ and spins about the origin O with a constant angular velocity $\vec{\omega} = \omega_0 \hat{z}$ then, the total current flow on the sheet is



(a) $\frac{2\pi\sigma\omega_0 \left(R_2^3 - R_1^3\right)}{3}$

(b) $\sigma\omega_0 \left(R_2^3 - R_1^3\right)$

(c) $\frac{\pi\sigma\omega_0 \left(R_2^3 - R_1^3\right)}{3}$

(d) $\frac{2\pi\sigma\omega_0 \left(R_2 - R_1\right)^3}{3}$

Ans. 20: (a)

H.No. 40-D, G.F., Jia Sarai, Near IIT, Hauz Khas, New Delhi-16
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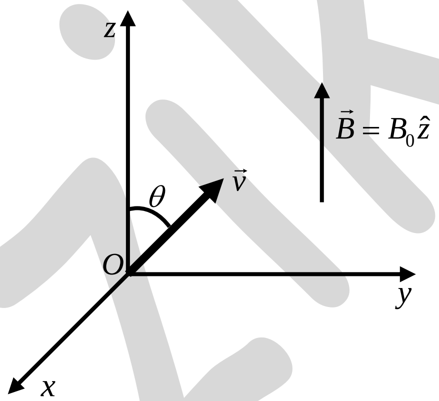
Q21. A radioactive nucleus has a decay constant λ and its radioactive daughter nucleus has a decay constant 10λ. At time $t=0, N_0$. No is the number of parent nuclei and there are no daughter nuclei present. $N_1(t)$ and $N_2(t)$ are the number of parent and daughter nuclei present at time t, respectively. The ratio $N_2(t)/N_1(t)$ is

(a) $\frac{1}{9}\left[1-e^{-9\lambda t}\right]$ (b) $\frac{1}{10}\left[1-e^{-10\lambda t}\right]$ (c) $\left[1-e^{-10\lambda t}\right]$ (d) $\left[1-e^{-9\lambda t}\right]$

Ans. 21: (a)

Q22. A uniform magnetic field $\vec{B}=B_0\hat{z}$, where $B_0>0$ exists as shown in the figure. A charged particle of mass m and charge $q(q>0)$ is released at the origin, in the yz-plane, with a velocity $\vec{v}$ directed at an angle $\theta=45^\circ$ with respect to the positive z-axis. Ignoring gravity, which one of the following is TRUE.



(a) The initial acceleration $\vec{a}=\frac{qvB_0}{\sqrt{2}m}\hat{x}$

(b) The initial acceleration $\vec{a}=\frac{qvB_0}{\sqrt{2}m}\hat{y}$

(c) The particle moves in a circular path

(d) The particle continues in a straight. line with constant in a straight line with constant speed

Ans. 22: (a)

Q23. For an ideal intrinsic semiconductor, the Fermi energy at $0\,K$

(a) Lies at the top of the valence band

(b) Lies at the bottom of the conduction band

(c) Lies at the center of the band gap

(d) Lies midway between center of the band gap and bottom the of conduction band

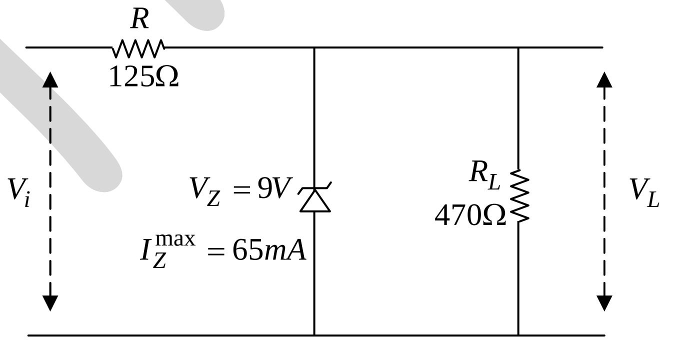
Ans. 23: (c)

Q24. A circular loop of wire with radius R is centered at the origin of the xy-plane. The magnetic field at a point within the loop is, $\vec{B}(\rho,\phi,z,t) = k\rho^3 t^3 \hat{z}$, where k is a positive constant of appropriate dimensions. Neglecting the effects of any current induced in the loop, the magnitude of the induced emf in the loop at t it is

(a) $\frac{6\pi k t^2 R^5}{5}$ (b) $\frac{5\pi k t^2 R^5}{6}$ (c) $\frac{3\pi k t^2 R^5}{2}$ (d) $\frac{\pi k t^2 R^5}{2}$

Ans. 24: (a)

Q25. For the given circuit, $R = 125\,\Omega, R_L = 470\,\Omega, V_z = 9V$, and $I_z^{\max} = 65\,mA$. The minimum and maximum value of the input voltage ($V_i^{\min}$ and $V_i^{\max}$) for which the Zener diode will be in the $'ON'$ state are



(a) $V_i^{\min} = 9.0V$ and $V_i^{\max} = 11.4V$ (b) $V_i^{\min} = 9.0V$ and $V_i^{\max} = 19.5V$

(c) $V_i^{\min} = 11.4V$ and $V_i^{\max} = 15.5V$ (d) $V_i^{\min} = 11.4V$ and $V_i^{\max} = 19.5V$

Ans. 25: (d)

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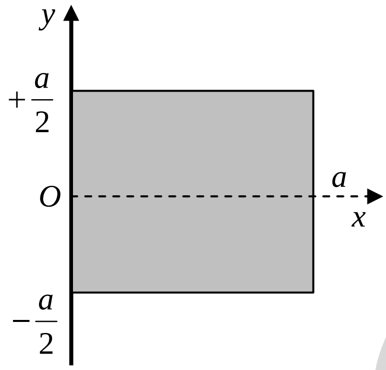
Q26. A square laminar sheet with side a and mass M, has mass per unit area given by $\sigma(x)=\sigma_0\left[1-\frac{x}{a}\right]$, (see figure). Moment of inertia of the sheet about y-axis is



(a) $\frac{Ma^2}{2}$ (b) $\frac{Ma^2}{4}$ (c) $\frac{Ma^2}{6}$ (d) $\frac{Ma^2}{12}$

Ans. 26:(c)

Q27. A particle is subjected to two simple harmonic motions along the x and y axes, described by $x(t)=a\sin(2\omega t+\pi)$ and $y(t)=2a\sin(\omega t)$. The resultant motion is given by

(a) $\frac{x^2}{a^2}+\frac{y^2}{4a^2}=1$ (b) $x^2+y^2=1$

(c) $y^2=x^2\left(1-\frac{x^2}{4a^2}\right)$ (d) $x^2=y^2\left(1-\frac{y^2}{4a^2}\right)$

Ans. 27: (d)

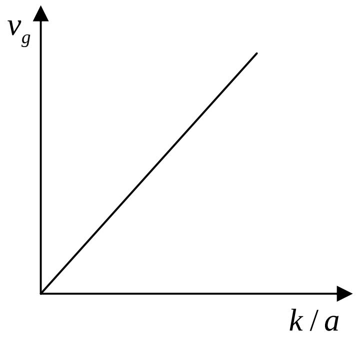
Q28. For a certain thermodynamic system, the internal energy $U=PV$ and P is proportional to T^2. The entropy of the system is s proportional to

(a) UV (b) $\sqrt{\frac{U}{V}}$ (c) $\sqrt{\frac{V}{U}}$ (d) $\sqrt{UV}$

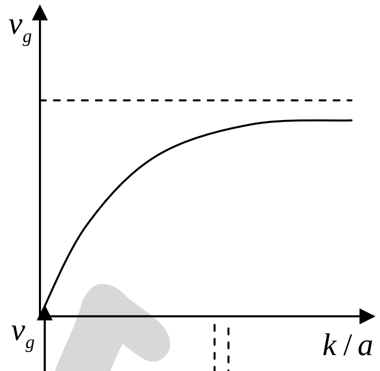
Ans. 28: (d)

Q29. The dispersion relation for certain type of wave is given by $\omega = \sqrt{k^2 + a^2}$, where k is the wave vector and a is a constant. Which one of the following sketches represents v_g , the group velocity?

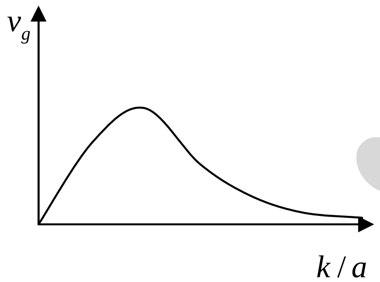
(a)



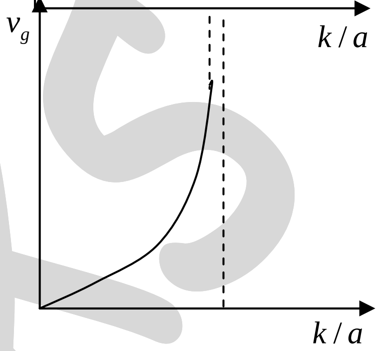
(b)



(c)



(d)



Ans. 29: (b)

Q30. Consider a binary number with m digits, where m is an even number. This binary number has alternating $1's$ and $0's$, with digit 1 in the highest place value. The decimal equivalent of this binary number is

(a) $2^m - 1$ (b) $\frac{(2^m - 1)}{3}$ (c) $\frac{(2^{m+1} - 1)}{3}$ (d) $\frac{2}{3}(2^m - 1)$

Ans. 30: (d)

Section B: Q.31 -0.4 Q.40 Carry TWO marks arks each.

Q31. Consider the 2×2 matrix $M = \begin{pmatrix} 0 & a \\ a & b \end{pmatrix}$. where $a, b > 0$. Then,

(a) M is a real symmetric matrix

(b) One of the eigenvalues of M is greater than b

(c) One of the eigenvalues of M is negative

(d) Product of eigenvalues M is b

Ans. 31: (a), (b), (c)

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Q32. In the Compton scattering of electrons, by photons incident with wave length λ,

(a) $\frac{\Delta\lambda}{\lambda}$ is independent of λ

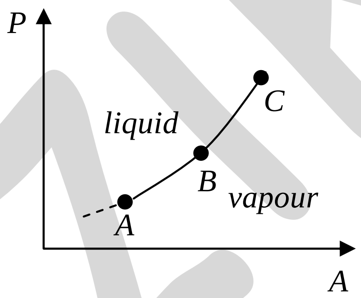
(b) $\frac{\Delta\lambda}{\lambda}$ increases with decreasing λ

(c) there is no change in photon's wave length for all angle of deflection of the photon

(d) $\frac{\Delta\lambda}{\lambda}$ increases with increasing angle of deflection of the photon

Ans. 32: (b), (d)

Q33. The figure shows a section of the phase boundary separating the vapour (1) and liquid (2) states of water in the $P-T$ plane. Here, C is the critical point. μ_1, v_1 and s_1 are the chemical potential, specific volume and specific entropy of the vapour phase respectively, while μ_2, v_2 and s_2 respectively denote the same for the liquid phase. Then



(a) $\mu_1 = \mu_2$ along AB

(b) $v_1 = v_2$ along AB

(c) $s_1 = s_2$ along AB

(d) $v_1 = v_2$ at the point C

Ans. 33: (a), (d)

Q34. A particle is executing simple harmonic motion with time period T. Let x, v and a denote the displacement, velocity and acceleration of the particle, respectively, at time t. Then,

(a) $\frac{aT}{x}$ does not change with time

(b) $(aT + 2\pi v)$ does not change with time

(c) x and v are related by an equation of a straight line

(d) v and a are related by an equation of an ellipse

Ans. 34: (a), (d)

Q35. A linearly polarized light beam travels from origin to point $A(1,0,0)$. At the point A, the light is reflected by a mirror towards point $B(1,-1,0)$. A second mirror located at point B then reflects the light towards point $C(1,-1,1)$. Let $\hat{n}(x,y,z)$ represent the direction of polarization of light at (x,y,z).

(a) If $\hat{n}(0,0,0)=\hat{y}$, then $\hat{n}(1,-1,1)=\hat{x}$ (b) If $\hat{n}(0,0,0)=\hat{z}$, then $\hat{n}(1,-1,1)=\hat{y}$

(c) If $\hat{n}(0,0,0)=\hat{y}$, then $\hat{n}(1,-1,1)=\hat{y}$ (d) If $\hat{n}(0,0,0)=\hat{z}$, then $\hat{n}(1,-1,1)=\hat{x}$

Ans. 35: (a), (b)

Q36. Let (r,θ) denote the polar coordinates of a particle moving in a plane. If $\hat{r}$ and $\hat{\theta}$ represent the corresponding unit vectors, then

(a) $\frac{d\hat{r}}{d\theta}=\hat{\theta}$ (b) $\frac{d\hat{r}}{dr}=-\hat{\theta}$ (c) $\frac{d\hat{\theta}}{d\theta}=-\hat{r}$ (d) $\frac{d\hat{\theta}}{dr}=\hat{r}$

Ans. 36: (a), (c)

Q37. The electric field associated with an electromagnetic radiation is given by $E=a(1+\cos\omega_1 t)\cos\omega_2 t$. Which of the following frequencies are present in the field?

(a) ω_1 (b) $\omega_1+\omega_2$ (c) $|\omega_1-\omega_2|$ (d) ω_2

Ans. 37: (b), (c), (d)

Q38. A string of length L is stretched between two points $x=0$ and $x=L$. The endpoints are rigidly clamped. Which of the following can represent the displacement of the string from the equilibrium position?

(a) $x\cos\left(\frac{\pi x}{L}\right)$ (b) $x\sin\left(\frac{\pi x}{L}\right)$ (c) $x\left(\frac{x}{L}-1\right)$ (d) $x\left(\frac{x}{L}-1\right)^2$

Ans. 38: (b), (c), (d)

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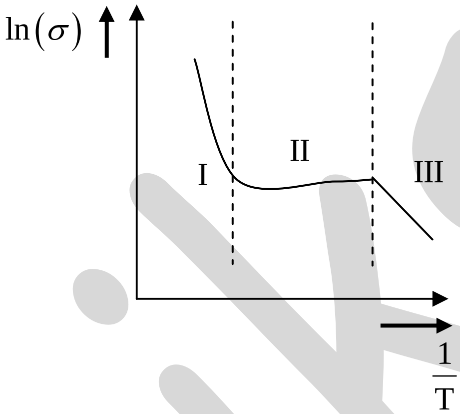
Q39. The Boolean expression $Y = \overline{PQ}R + Q\bar{R} + \bar{P}QR + PQR$ simplifies to

(a) $\bar{P}R + Q$ (b) $PR + \bar{Q}$ (c) $P + R$ (d) $Q + R$

Ans. 39: (d)

Q40. For an n-type silicon, an extrinsic semiconductor, the natural logarithm of normalized conductivity (σ) is plotted as a function of inverse temperature. Temperature interval-I corresponds to the intrinsic regime, interval-II corresponds to saturation regime and interval-III corresponds to the freeze-out regime, respectively. Then



(a) The magnitude of the slope of the curve in the temperature interval-I is proportional to the band gap, E_g

(b) The magnitude of the slope of the curve in the temperature interval-III is proportional to the ionization n energy of the donor, E_d

(c) In the temperature interval-II, the carrier density in the conduction band is equal to the density of donors

(d) In the temperature interval-III, all the donor levels are ionized

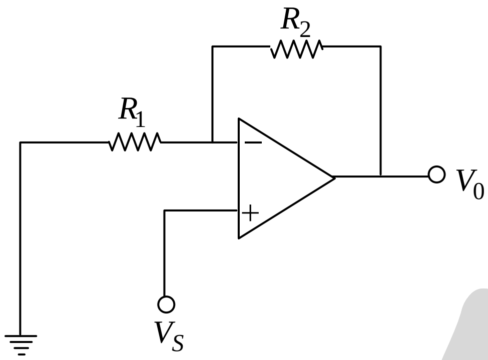
Ans. 40: (a), (b), (c)

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

Q41. The integral $\iint (x^2 + y^2)\,dxdy$ over the area of a disk of radius 2 in the xy plane is ____ π.

Ans. 41: 8 to 8

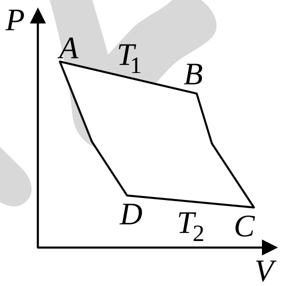
Q42. For the given operational amplifier circuit $R_1 = 120\,\Omega, R_2 = 1.5\,k\Omega$ and $V_s = 0.6V$, then the output current I_0 is ___________ mA.



Ans. 42: 5 to 5

Q43. For an ideal gas, AB and CD are two isothermals at temperatures T_1 and $T_2\,(T_1 > T_2)$, respectively. AD and BC represent two adiabatic paths as shown in figure.

Let V_A, V_B, V_C and V_D be the volumes of the gas at A, B, C and D respectively. If $\frac{v_C}{v_B} = 2$, then $\frac{v_D}{v_A} =$ _____________ .



Ans. 43: 2 to 2

Q44. A satellite is revolving around the Earth in a closed orbit. The height of the satellite above Earth's surface at perigee and apogee are $2500\,km$ and $4500\,km$, respectively. Consider the radius of the Earth to be $6500\,km$. The eccentricity of the satellite's orbit is _____ (Round off to 1 decimal place).

Ans. 44: 0.1 to 0.1

H.No. 40-D, G.F., Jia Sarai, Near IIT, Hauz Khas, New Delhi-16
Phone: 011-26865455/+91-9871145498, Website: www.physicsbyfiziks.com, Email: fiziks.physics@gmail.com

Q45. Three masses $m_1 = 1, m_2 = 2$ and $m_3 = 3$ are located on the x-axis such that their center of mass is at $x = 1$. Another mass $m_4 = 4$ is placed at x_0, and the new center of mass is at $x = 3$. The value of x_0 is ______ .

Ans. 45: 6 to 6

Q46. A normal human eye can distinguish two objects separated by $0.35\,m$ when viewed from a distance of $1.0\,km$. The angular resolution of eye is ___________ seconds (Round off to the nearest integer).

Ans. 46: 71 to 73

Q47. A rod with a proper length of $3m$ moves along x-axis, making an angle of 30° with respect to the x-axis. If its speed is $\frac{c}{2} m/s$, where c is the speed of light, the change in length due to Lorentz contraction is_______ m (Round off to 2 decimal places).

$\left[\text{Use}\, c = 3\times10^8\, m/s\right]$

Ans. 47: 0.29 to 0.31

Q48. Consider the Bohr model of hydrogen atom. The speed of an electron in the second orbit $(n = 2)$ is _________ $\times10^6\, m/s$ (Round off to 2 decimal places).

[Use $h = 6.63\times10^{-34}\, Js, e = 1.6\times10^{-19}\, C, \epsilon_0 = 8.85\times10^{-12}\, C^2 m^2 / N$]

Ans. 48: 1.08 to 1.12

Q49. Consider unit circle C in the xy plane with center at the origin. The line integral of the vector field, $\vec{F}(x, y, z) = -2y\hat{x} - 3z\hat{y} + x\hat{z}$, taken anticlockwise over C is _______ π .

Ans. 49: 2 to 2

Q50. Consider a $p-n$ junction at $T = 300\,K$. The saturation current density at reverse. bias is $-20\,\mu A/cm^2$. For this device, a current density of magnitude $10\,\mu A/cm^2$ is realized with a forward bias voltage V_F. The same magnitude of current density can also be realized with a reverse bias voltage, V_R. The value of $|V_F / V_R|$ is____________ (Round off to 2 decimal places).

Ans. 50: 0.57 to 0.61

Section C: Q.51-Q60 Carry TWO marks each.

Q51. Consider the second order ordinary differential equation, $y''+4y'+5y=0$. If $y(0)=0$ and $y'(0)=1$, then the value of $y(\pi/2)$ is __________ (Round off to 3 decimal places).

Ans. 51: 0.041 to 0.045

Q52. A box contains a mixture of two different ideal monoatomic, 1 and 2, in equilibrium at temperature T. Both gases are present in equal proportions. The atomic mass for gas 1 is m, while the same for gas 2 is $2m$. If the rms speed of a gas molecule selected at random is $v_{rms}=x\sqrt{\frac{k_BT}{m}}$ then x is _____________ (Round off to 2 decimal places).

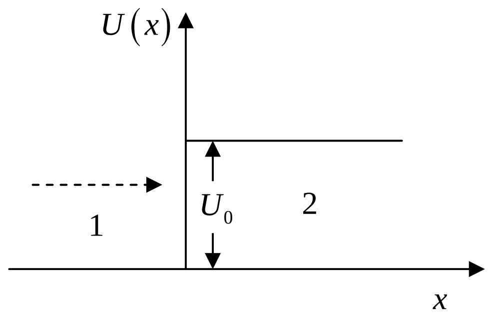
Ans. 52: 1.49 to 1.51

Q53. A hot body with constant heat capacity $800\,J/K$ at temperature $925\,K$ is dropped gently into a vessel containing $1\,kg$ of water at temperature $300\,K$ and the combined system is allowed to reach equilibrium. The change in the total entropy ΔS is J/K (Round off to 1 decimal place).

[Take the specific heat capacity of water to be $4200\,J/kg\,K$. Neglect any loss of heat to the vessel and air and change in the volume of water.]

Ans. 53: 537.5 to 537.7

Q54. Consider an electron with mass m and energy E moving along the x-axis towards a finite step potential of height U_0 as shown in the figure. In region $1(x<0)$, the momentum of the electron is $p_1=\sqrt{2mE}$. The reflection coefficient at the barrier is given by $R=\left(\frac{p_1-p_2}{p_1+p_2}\right)^2$, where p_2 is the momentum in region 2. If, in the limit $E \gg U_0, R\approx\frac{U_0^2}{nE^2}$, then the integer n is _______.



Ans. 54: 16 to 16

Q55. A current density for a fluid flow is given by, $\vec{J}(x,y,z,t)=\dfrac{8e^t}{(1+x^2+y^2+z^2)}\hat{x}$.

At time $t=0$, the mass density $\rho(x,y,z,0)=1$.

Using the equation of continuity, $\rho(1,1,1,1)$ is found to be _______ (Round off to 2 decimal places).

Ans. 55: 2.70 to 2.74

Q56. The work done in moving a $-5\,\mu C$ charge in an electric field $\vec{E}=\left(8r\sin\theta\hat{r}+4r\cos\theta\hat{\theta}\right)V/m$, from a point $A(r,\theta)=\left(10,\dfrac{\pi}{6}\right)$ to a point $B(r,\theta)=\left(10,\dfrac{\pi}{2}\right)$, is ________ mJ.

Ans. 56: 1 to 1

Q57. A pipe of $1m$ length is closed at one end. The air column in the pipe resonates at frequency of $400\,Hz$. The number of nodes in the sound wave formed in the pipe is _______.

[Speed of sound $=320\,m/s$]

Ans. 57: 5

Q58. The critical angle of a crystal is 30°. Its Brewster angle is ________ degree (Round off to the nearest integer).

Ans. 58: 63 to 63

Q59. In an LCR series circuit, a non-inductive resistor of $150\,\Omega$, a coil of $0.2\,H$ inductance and negligible resistance, and a $30\,\mu F$ capacitor are connected across an ac power source of $220\,V, 50\,Hz$. The power loss across the resistor is _______ W (Round off to 2 decimal places).

Ans. 59: 297 to 299

Q60. A charge q is uniformly distributed over the volume of a dielectric sphere of radius a. If the dielectric constant $\in_r = 2$, then the ratio of the electrostatic energy stored inside the sphere to that stored outside is ________ (Round off to 1 decimal place).

Ans. 60: 0.1 to 0.1

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