THE OPTIMIST CLASSES
IIT-JAM TOPPERS

8 AIR

MANOJ KUMAR SINGH

9 AIR

ABHAY

12 AIR

PAWAN

15 AIR

SATYAM

21 AIR

SOUMIL GIRISH SAHU

29 AIR

BHOOMIJA

31 AIR

AKSHIT AGGARWAL

32 AIR

SHIKHAR CHAMOLI

33 AIR

RAVI SINGH ADHIKARI

44 AIR

GAURAV JHA

56 AIR

SWAPNIL JOSHI

65 AIR

LOKESH BHATT

75 AIR

GOPESH VISHVAKARMA

77 AIR

VAIBHAV

80 AIR

SHASWAT CHAMOLI

CSIR-NET-JRF RESULTS 2022

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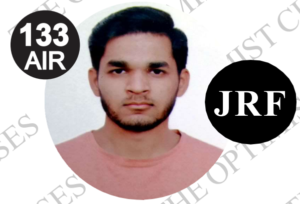


ALANKAR
UP15000162

SAHIL RANA
HR09000108

JAYESTHI
RJ11000161

DASRATH
RJ06000682

VIVEK
UK01000439

UZAIR AHMED
UP02000246

SURYA PRATAP SINGH
RJ06000232

HIMANSHU
UP10000095

CHANDAN
RJ09000159

SAIKHOM JOHNSON
MN01000196

AJAY SAINI
RJ06001744

VIKAS YADAV
RJ06001102

JYOTSNA KOHLI
UK02000262

SHYAM SUNDAR
RJ06000615

CSIR-UGC-NET/JRF-DEC 2018

PREVIOUS YEAR QUESTION

Assignment -1:PHYSICAL SCIENCES

21. One of the eigenvalues of the matrix e^A is e^a, where $A = \begin{pmatrix} a & 0 & 0 \\ 0 & 0 & a \\ 0 & a & a \end{pmatrix}$. The product of the other two eigenvalues of e^A is

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

22. The polynomial $f(x) = 1 + 5x + 3x^2$ is written as linear combination of the Legendre polynomials $\left(P_0(x) = 1, P_1(x) = x, P_2(x) = \frac{1}{2}(3x^2 - 1)\right)$ as $f(x) = \sum_n c_n P_n(x)$. The value of c_0 is

(a) $\frac{1}{4}$ (b) $\frac{1}{2}$ (c) 2 (d) 4

23. The value of the integral $\oint_c \frac{dz}{z} \frac{\tanh 2z}{\sin \pi z}$ where C is a circle of radius $\frac{\pi}{2}$, traversed counter-clockwise, with centre at z = 0, is:

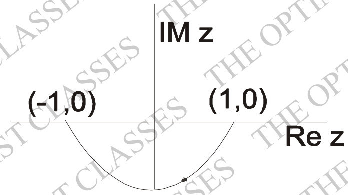
(a) 4 (b) $4i$ (c) $2i$ (d) 0

24. A particle of mass m, moving along the x-direction, experiences a damping force $-\gamma v^2$, where γ is a cosntant and v is its instantaneous speed. If the speed at $t = 0$ is v_0, the speed at time t is

(a) $v_0 e^{\frac{\gamma v_0 t}{m}}$ (b) $\frac{v_0}{1 + \mathrm{In}\left(1 + \frac{\gamma v_0 t}{m}\right)}$ (c) $\frac{m v_0}{m + \gamma v_0 t}$ (d) $\frac{2v_0}{1 + e^{\frac{\gamma v_0 t}{m}}}$

25. The integral $I = \int_c e^z dz$ is evaluated from the point (-1,0) to (1,0) along the contour C, which is an arc of the parabola $y = x^2 - 1$ as shown in the figure. The value of I is

(a) 0
(b) $2\sinh 1$
(c) $e^{2i}\sinh 1$
(d) $e+e^{-1}$



26. In terms of arbitrary constants A and B, the general solution to the differential equation

$$x^2\frac{d^2y}{dx^2}+5x\frac{dy}{dx}+3y=0 \text{ is}$$

(a) $y=\frac{A}{x}+Bx^3$ (b) $y=Ax+\frac{B}{x^3}$ (c) $y=Ax+Bx^3$ (d) $y=\frac{A}{x}+\frac{B}{x^3}$

27. In a attractive Kepler problem described by the central potential $V(r)=\frac{-k}{r}$ (where k is a positive constant), a particle of mass m with a non-zero angular momentum can never reach the centre due to the centrifugal barrier. If we modify the potential to

$$V(r)=-\frac{k}{r}-\frac{\beta}{r^3}$$

one finds that there is a critical value of th angular momentum l_c below which there is no centrifugal barrier. This value of l_c is

(a) $\left[12\,km^2\beta\right]^{1/2}$ (b) $\left[12\,km^2\beta\right]^{-1/2}$ (c) $\left[12\,km^2\beta\right]^{1/4}$ (d) $\left[12\,km^2\beta\right]^{-1/4}$

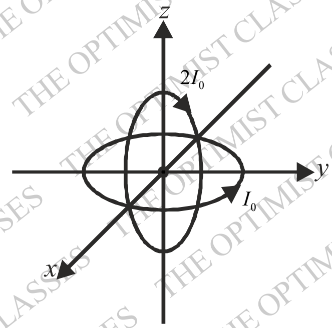
28. The time period of a particle of mass m, undergoing small oscillations around $x=0$, in the potential $V=V_0\cosh\left(\frac{x}{L}\right)$, is

(a) $\pi\sqrt{\frac{mL^2}{V_0}}$ (b) $2\pi\sqrt{\frac{mL^2}{2V_0}}$ (c) $2\pi\sqrt{\frac{mL^2}{V_0}}$ (d) $2\pi\sqrt{\frac{2mL^2}{V_0}}$

29. Consider the decay $A\rightarrow B+C$ of a relativistic spin $-\frac{1}{2}$ particle A. Which of the following statements is true in the rest frame of the particle A?

(a) The spin of both B and C may be $\frac{1}{2}$
(b) The sum of the masses of B and C is greater than the mass of A
(c) The energy of B is uniquely determined by the masses of the particles
(d) The spin of both B and C may be intergal

30. Two current-carrying circular loops, each of radius R, are placed perpendicular to each other, as shown in the figure. The loop in the xy-plane carries a current I_0 while that in the xz-plane carries a current $2I_0$. The resulting magnetic field $\vec{B}$ at the origin is



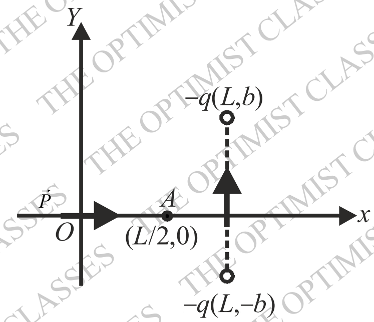
s

(a) $\frac{\mu_0 I_0}{2R}\left[2\hat{j}+\hat{k}\right]$ (b) $\frac{\mu_0 I_0}{2R}\left[2\hat{j}-\hat{k}\right]$

(c) $\frac{\mu_0 I_0}{2R}\left[-2\hat{j}+\hat{k}\right]$ (d) $\frac{\mu_0 I_0}{2R}\left[-2\hat{j}-\hat{k}\right]$

31. An electric dipole of dipole moment $\vec{p}=qb\hat{i}$ is placed at origin in the vicinity of two charges $+q$ and $-q$ at (L,b) and $(L,-b)$, respectively, as shown in the figure.

The electrostatic potential at the point $\left(\frac{L}{2},0\right)$ is



(a) $\frac{qb}{\pi\varepsilon_0}\left(\frac{1}{L^2}+\frac{2}{L^2+4b^2}\right)$ (b) $\frac{4qbL}{\pi\varepsilon_0\left[L^2+4b^2\right]^{3/2}}$

(c) $\frac{qb}{\pi\varepsilon_0 L^2}$ (d) $\frac{3qb}{\pi\varepsilon_0 L^2}$

32. A monochromatic and linear polarized light is used in a Young's double slit experiment. A linear polarizer, whose pass axis is at an angle 45° to the polarization of the incident wave, is placed in front of one of the slits. If I_{max} and I_{min}, respectively, denote the maximum and minimum intensities of the interference pattern on the screen, the visibility, defined as the ratio $\frac{I_{max}-I_{min}}{I_{max}+I_{min}}$, is

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

33. An electromagnetic wave propagates in a nonmagnetic medium with relative permittivity $\varepsilon=4$. The magnetic field for this wave is $\hat{k}H_0\cos\left(\omega t-\alpha x-\alpha\sqrt{3}y\right)$

where H_0 is a constant. The corresponding electric field $\vec{E}(x,y)$ is

(a) $\frac{1}{4}\mu_0 H_0 c\left(-\sqrt{3}\hat{i}+\hat{j}\right)\cos\left(\omega t-\alpha x-\alpha\sqrt{3}y\right)$ (b) $\frac{1}{4}\mu_0 H_0 c\left(\sqrt{3}\hat{i}+\hat{j}\right)\cos\left(\omega t-\alpha x-\alpha\sqrt{3}y\right)$

(c) $\frac{1}{4}\mu_0 H_0 c\left(\sqrt{3}\hat{i}-\hat{j}\right)\cos\left(\omega t-\alpha x-\alpha\sqrt{3}y\right)$ (d) $\frac{1}{4}\mu_0 H_0 c\left(-\sqrt{3}\hat{i}-\hat{j}\right)\cos\left(\omega t-\alpha x-\alpha\sqrt{3}y\right)$

34. The ground state energy of an anisotropic harmonic oscillator described by the potential

$V(x,y,z)=\frac{1}{2}m\omega^2x^2+2m\omega^2y^2+8m\omega^2z^2$ (in units of $\hbar\omega$) is

(a) $\frac{5}{2}$ (b) $\frac{7}{2}$ (c) $\frac{3}{2}$ (d) $\frac{1}{2}$

35. The product $\Delta x\ \Delta p$ of uncertainites in the position and momentum of a simple harmonic oscillator of mass m and angular frequency ω in the ground state $|0\rangle$, is $\frac{\hbar}{2}$. The value of the product $\Delta x\ \Delta p$ in the state, $e^{-i\hat{p}\ell/\hbar}|0\rangle$ (where l is a constant and $\hat{p}$ is the momentum operator) is

(a) $\frac{\hbar}{2}\sqrt{\frac{m\omega l^2}{\hbar}}$ (b) $\hbar$ (c) $\frac{\hbar}{2}$ (d) $\frac{\hbar^2}{m\omega l^2}$

36. Let the wavefunction of the electron in a hydrogen atom be

$$\psi(\vec{r}) = \frac{1}{\sqrt{6}}\phi_{200}(\vec{r}) + \sqrt{\frac{2}{3}}\phi_{21-1}(\vec{r}) - \frac{1}{\sqrt{6}}\phi_{100}(\vec{r})$$

where $\phi_{nlm}(\vec{r})$ are the eigenstates of the Hamiltonian in the standard notation. The expectation value of the energy in this state is

(a) $-10.8\,eV$ (b) $-6.2\,eV$ (c) $-9.5\,eV$ (d) $-5.1\,eV$

37. Three identical spin $\frac{1}{2}$ particle of mass m are confined to a one-dimensional box of lenght L, but are otherwise free. Assuming that they are non-interacting, the energies of the lowest two energy eigen states, in units of $\frac{\pi^2\hbar^2}{2mL^2}$, are

(a) 3 and 6 (b) 6 and 9 (c) 6 and 11 (d) 3 and 9

38. The heat capacity C_V at constant volume of a metal, as a function of temperature, is $\alpha T + \beta T^3$, where α and β are constants. The temperature dependence of the entropy at constant volume is

(a) $\alpha T + \frac{1}{3}\beta T^3$ (b) $\alpha T + \beta T^3$ (c) $\frac{1}{2}\alpha T + \frac{1}{3}\beta T^3$ (d) $\frac{1}{2}\alpha T + \frac{1}{4}\beta T^3$

39. The rotatioinal energy levels of a molecule are $E_\ell = \frac{\hbar^2}{2I_0}l(l+1)$, where $l = 0,1,2,.......$ and I_0 is its moment of inertia. The contribution of the rotational motion to the Helmholtz free energy per molecule, at low temperatures in a dilute gas of these molecules, is approximately

(a) $-k_BT\left(1+\frac{\hbar^2}{I_0k_bT}\right)$ (b) $-k_BTe^{-\frac{\hbar^2}{I_0k_BT}}$ (c) $-k_BT$ (d) $-3k_BTe^{-\frac{\hbar^2}{I_0k_BT}}$

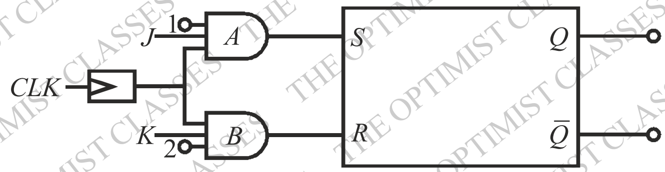
40. The vibrational motion of a diatomic molecule may be considered to be that of a simple harmonic oscillator with angular frequency ω. If a gas of these molecules is at temperatue T, what is the probability that a randomly picked molecule will be found in its lowest vibrational state?

(a) $1-e^{-\frac{\hbar\omega}{k_BT}}$ (b) $e^{-\frac{\hbar\omega}{2k_BT}}$ (c) $\tanh\left(\frac{\hbar\omega}{k_BT}\right)$ (d) $\frac{1}{2}\text{cosec}\,h\left(\frac{\hbar\omega}{2k_BT}\right)$

41. Consider an ideal Fermi gas in a grand canonical ensemble at a constant chemical potential. The variance of the occupation number of the single particle energy level with mean occupation number $\bar{n}$ is

(a) $\bar{n}(1-\bar{n})$ (b) $\sqrt{\bar{n}}$ (c) $\bar{n}$ (d) $\frac{1}{\sqrt{\bar{n}}}$

42. Consider the following circuit, consisting of an *RS* flip-flop and two AND gates.



Which of the following connections will allow the entire circuit to act as a *JK* flip-flop?

(a) connect Q to pin 1 and $\bar{Q}$ to pin 2

(b) connect Q to pin 2 and $\bar{Q}$ to pin 1

(c) connect Q to K input and $\bar{Q}$ to J input

(d) connect Q to J input and $\bar{Q}$ to K input

43. The truth table below gives the value $Y(A, B, C)$ where A, B and C are binary variables. The output Y can be represented by

(a) $Y = \bar{A}\bar{B}C + \bar{A}B\bar{C} + A\bar{B}C + AB\bar{C}$

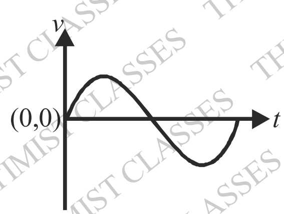
(b) $Y = \bar{A}\bar{B}\bar{C} + \bar{A}BC + A\bar{B}\bar{C} + ABC$

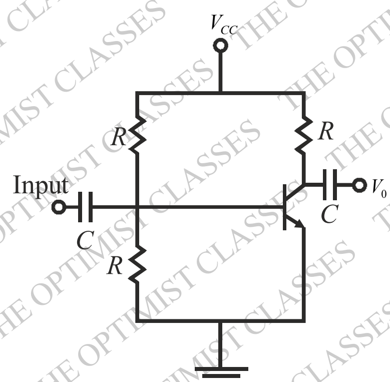
(c) $Y = \bar{A}\bar{B}C + \bar{A}BC + A\bar{B}C + ABC$

(d) $Y = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + A\bar{B}\bar{C} + AB\bar{C}$

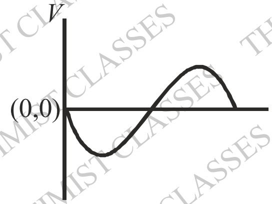
A	*B*	*C*	*Y*
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	1	0	0
1	1	1	1

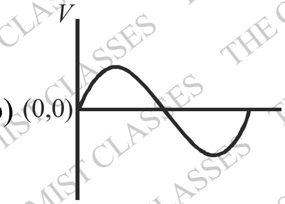
44. A sinusoidal signal is an input to the following circuit

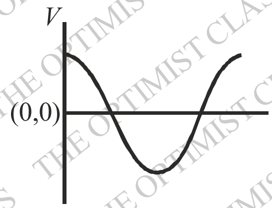


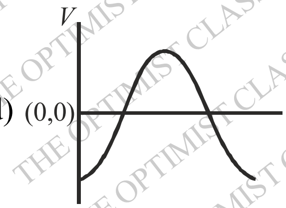


Which of the following graphs best described the output wave function?

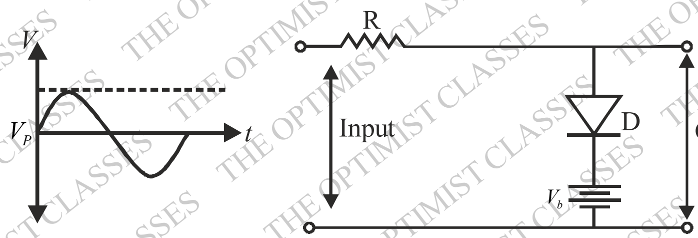
(a) 

(b) 

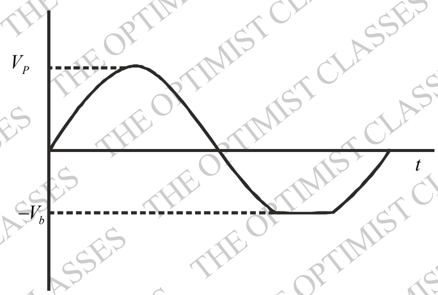
(c) 

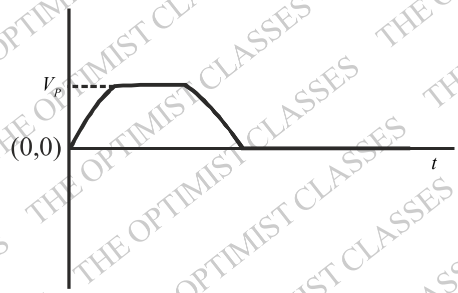
(d) 

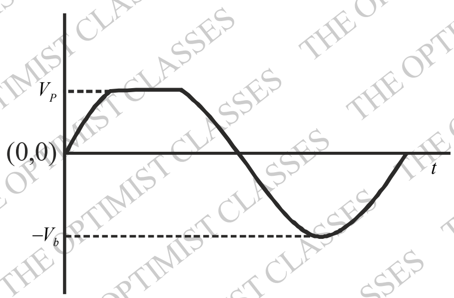
45. A sinusoridal voltage having a peak value of V_p is an input to the following circuit, in which the DC voltage is V_b

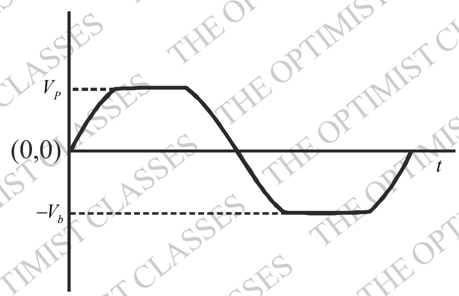


Assuming an ideal diobe which of the following best describes the output waveform?

(a) 

(b) 

(c) 

(d) 

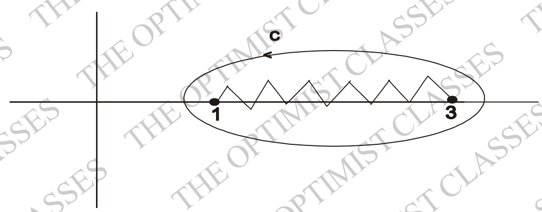
46. The Green's function $G(x,x')$ for the equation $\frac{d^2y(x)}{dx^2} = f(x)$, with the boundary values $y(0)=0$ and $y(1)=0$, is

(a) $G(x,x') = \begin{cases} \frac{1}{2}x(1-x'), & 0 < x < x' < 1 \\ \frac{1}{2}x'(1-x) & 0 < x' < x < 1 \end{cases}$ (b) $G(x,x') = \begin{cases} x(x'-1), & 0 < x < x' < 1 \\ x'(1-x) & 0 < x' < x < 1 \end{cases}$

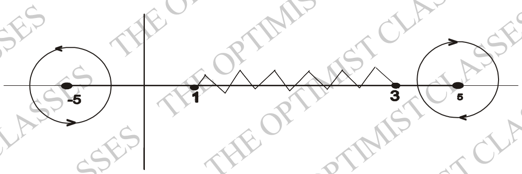
(c) $G(x,x') = \begin{cases} -\frac{1}{2}x(1-x'), & 0 < x < x' < 1 \\ \frac{1}{2}x'(1-x) & 0 < x' < x < 1 \end{cases}$ (d) $G(x,x') = \begin{cases} x(x'-1), & 0 < x < x' < 1 \\ x'(x-1) & 0 < x' < x < 1 \end{cases}$

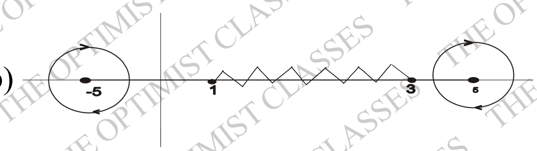
47. A 4×4 complex matrix A satisfies the relation $A^\dagger A = 4I$, where I is the 4×4 identity matrix. The number of independent real parameters of A is
(a) 32 (b) 10 (c) 12 (d) 16

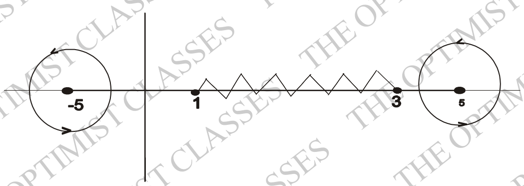
48. The contour C of the following integral $\oint_c dz \frac{\sqrt{(z-1)(z-3)}}{(z^2-25)^3}$ in the complex z-plane is shown in the figure below.

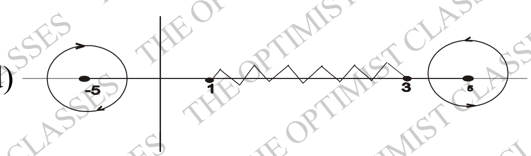


The integral is equivalent to an integral along the contours

(a) 

(b) 

(c) 

(d) 

49. The value of the integral $\int_0^1 x^2 dx$, evaluted using the trapezoidal rule with a step size of 0.2, is
(a) 0.30 (b) 0.39 (c) 0.34 (d) 0.27

50. The motion of a particle in one dimension is described by the Langrangian $L = \frac{1}{2}\left(\left(\frac{dx}{dt}\right)^2 - x^2\right)$ in suitable units. The value of the action along the classical path from $x = 0$ at $t = 0$ to $x = x_0$ at $t = t_0$, is

(a) $\frac{x_0^2}{2\sin^2 t_0}$ (b) $\frac{1}{2}x_0^2 \tan t_0$ (c) $\frac{1}{2}x_0^2 \cot t_0$ (d) $\frac{x_0^2}{2\cos^2 t_0}$

51. The Hamiltonian of a classical one-dimensional harmonic oscillator is $H = \frac{1}{2}\left(p^2 + x^2\right)$, in suitable units. The total time derivative of the dynamical variable $\left(p + \sqrt{2}x\right)$ is

(a) $\sqrt{2}p - x$ (b) $p - \sqrt{2}x$ (c) $p + \sqrt{2}x$ (d) $x + \sqrt{2}p$

52. A relativistic particle of mass m and charge e is moving in a uniform electric field of strength ε. Starting from rest at $t = 0$, how much time will it take to reach the speed $\frac{c}{2}$?

(a) $\frac{1}{\sqrt{3}}\frac{mc}{e\varepsilon}$ (b) $\frac{mc}{e\varepsilon}$ (c) $\sqrt{2}\frac{mc}{e\varepsilon}$ (d) $\sqrt{\frac{3}{2}}\frac{mc}{e\varepsilon}$

53. In an inertial frame uniform electric and magnetic field $\vec{E}$ and $\vec{B}$ are perpendicular to each other and satisfy $\left|\vec{E}\right|^2 - \left|\vec{B}\right|^2 = 29$ (in suitable units). In another inertial frame, which moves at a constant velocity with respect to the first frame, the magnetic field is $2\sqrt{5}\hat{k}$. In the second frame, an electric field consistent with the previous observations is

(a) $\frac{7}{\sqrt{2}}\left(\hat{i} + \hat{j}\right)$ (b) $7\left(\hat{i} + \hat{k}\right)$ (c) $\frac{7}{\sqrt{2}}\left(\hat{i} + \hat{k}\right)$ (d) $7\left(\hat{i} + \hat{j}\right)$

54. Electromagnetic wave of angular frequency ω is propagating in a medium in which, over a band of frequencies the refractive index is $n(\omega) \approx 1 - \left(\frac{\omega}{\omega_0}\right)^2$, where ω_0 is a constant. The ratio $\frac{v_g}{v_p}$ of the group velocity to the phase velocity at $\omega = \frac{\omega_0}{2}$ is

(a) 3 (b) $\frac{1}{4}$ (c) $\frac{2}{3}$ (d) 2

55. A rotating spherical shell of uniform surface charge and mass density has total mass M and charge Q. If its angular momentum is L and magnetic moment is μ, then the ratio $\frac{\mu}{L}$ is

(a) $\frac{Q}{3M}$ (b) $\frac{2Q}{3M}$ (c) $\frac{Q}{2M}$ (d) $\frac{3Q}{4M}$

56. Considser the operator $A_x = L_y p_z - L_z p_y$, where L_i and p_i denote, respectively, the components of the angular momentum and momentum operators. The commutator $\left[A_x, x\right]$, where x is the x-component of the position operator, is

(a) $-i\hbar\left(zp_z + yp_y\right)$ (b) $-i\hbar\left(zp_z - yp_y\right)$ (c) $i\hbar\left(zp_z + yp_y\right)$ (d) $i\hbar\left(zp_z - yp_y\right)$

57. A one-dimensional system is described by the Hamiltonian $H = \frac{p^2}{zm} + \lambda|x|$ (where $\lambda = 0$). The ground state energy varies as a function of λ as

(a) $\lambda^{5/3}$ (b) $\lambda^{2/3}$ (c) $\lambda^{4/3}$ (d) $\lambda^{1/3}$

58. If the position of the electron in the ground state of a Hydrogen atom is measured, the probability that

it will be found at a distance $r \geq a_0$ (a_0 being Bohr radius) is nearest to

(a) 0.91 (b) 0.66 (c) 0.32 (d) 0.13

59. A system of spin $\frac{1}{2}$ particles is prepared to be in the eigenstate of σ_z with eigenvalue +1. The system is rotated by at angle 60° about the x-axis. After the rotation, the fraction of the particles that will be measured to be in the eigenstate of σ_z with eigenvalue +1 is

(a) $\frac{1}{3}$ (b) $\frac{2}{3}$ (c) $\frac{1}{4}$ (d) $\frac{3}{4}$

60. The Hamiltonian of a one-dimensional Ising model of N spin (N large) is

$$H = -J\sum_{i=1}^{N} \sigma_i \sigma_{i+1}$$

where the spin $\sigma_i = \pm 1$ and J is a positive costant. At inverse temperature $\beta = \frac{1}{k_B T}$, the correlation function between the nearest spins $(\sigma_i \sigma_{i+1})$ is

(a) $\frac{e^{-\beta J}}{\left(e^{\beta J} + e^{-\beta J}\right)}$ (b) $e^{-2\beta J}$ (c) $\tanh(\beta J)$ (d) $\coth(\beta J)$

61. At low temperatures, in the Debye approximation, the contribution of the phonons to the heat capacity of a two dimensional solid is proportional to

(a) T^2 (b) T^3 (c) $T^{1/2}$ (d) $T^{3/2}$

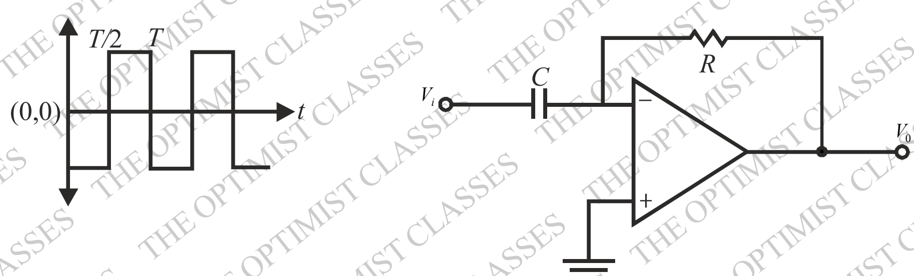
62. A particle hops on a one-dimensional lattice with lattice spacing a. The probability of the particle to hop to the neighbouring site to its right is p, while the corresponding probability to hop to the left is $q = 1 - p$. The root-mean squared deviation $\Delta x = \sqrt{\langle x^2 \rangle - \langle x \rangle^2}$ in displacement after N steps, is

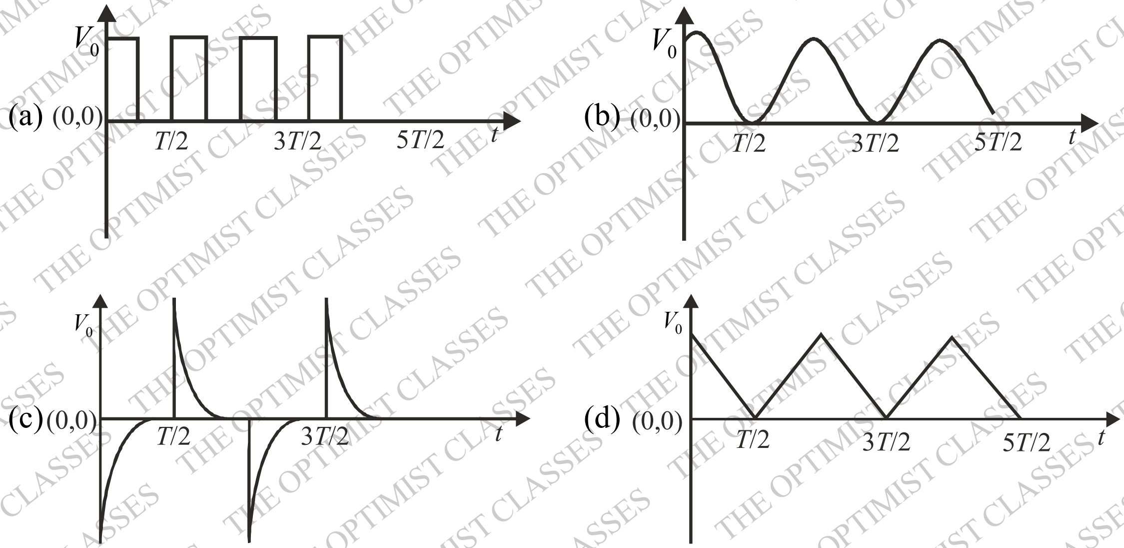
(a) $a\sqrt{Npq}$ (b) $aN\sqrt{pq}$ (c) $2a\sqrt{Npq}$ (d) $a\sqrt{N}$

63. The energy levels accessible to a molecule have energies $E_1 = 0, E_2 = \Delta$ and $E_3 = 2\Delta$ (where Δ is a constant). A gas of these molecules is in thermal equilibrium at temperature T. The specific heat at constant volume in the high temperature limit $(k_B T \gg \Delta)$ varies with temperature as

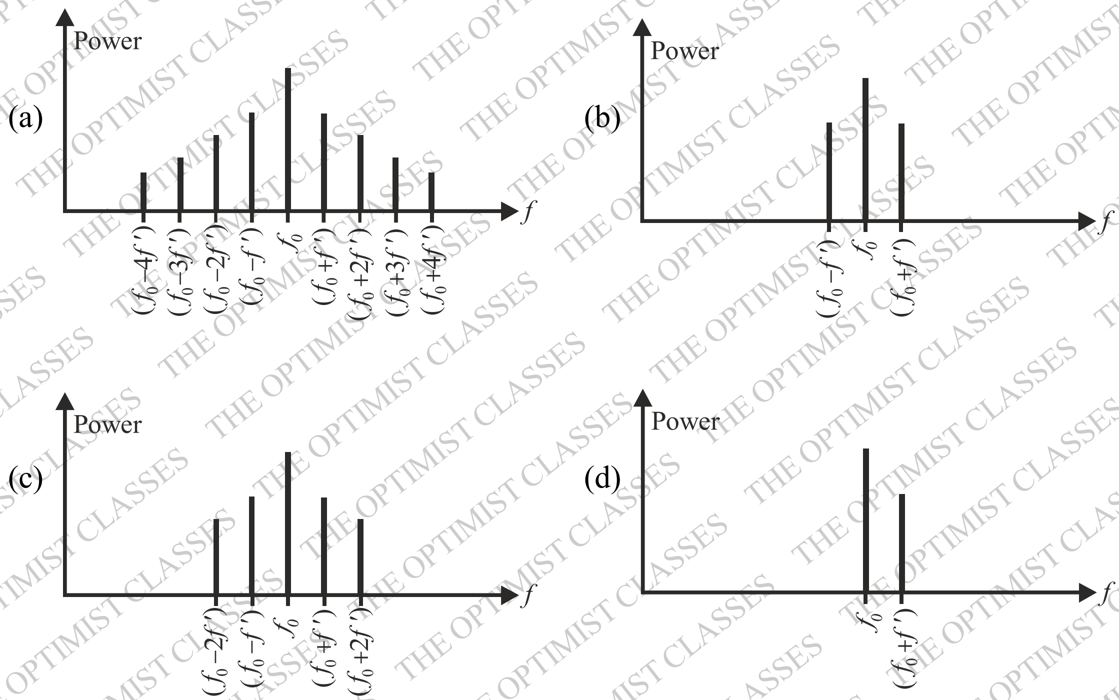
(a) $\frac{1}{T^{3/2}}$ (b) $\frac{1}{T^3}$ (c) $\frac{1}{T}$ (d) $\frac{1}{T^2}$

64. The input V_i to the following circuit is a square wave as shown in the following figure. which of the waveforms best describes the output?





65. The amplitude of a carrier signal of frequency f_0 is sinusoildally modulated at a frequency $f' \ll f_0$. Which of the following graphs best describes its power spectrum?



66. The standard deviation of the following set of data $\{10.0, 10.0, 9.9, 9.9, 9.8, 9.9, 9.9, 9.9, 9.8, 9.9\}$ is nearest to
(a) 0.10 (b) 0.07 (c) 0.01 (d) 0.04

67. The diatomic molecule HF has an absorption line in the rotational band at $40\,cm^{-1}$ for the isotope ^{18}F. The corresponding line for the isotope ^{19}F will be shifted by approximately
(a) $0.05\,cm^{-1}$ (b) $0.11\,cm^{-1}$ (c) $0.33\,cm^{-1}$ (d) $0.01\,cm^{-1}$

68. The excited state $(n=4, l=2)$ of an election in an atom may decay to one or more of the lower energy levels shown in the diagram below.

Of the total emitted light, a fraction $\frac{1}{4}$ comes from the decay to the state $(n=2, l=1)$. Based on selection rules, the fractional intensity of the emission line due to the decay to the state $(n=3, l=1)$

(a) $\frac{3}{4}$ (b) $\frac{1}{2}$ (c) $\frac{1}{4}$ (d) 0

69. The volume of an optical cavity is $1\,cm^3$. The number of modes it can support within a bandwidth of $0.1\,nm$, centered at $\lambda = 500\,nm$, is of the orders of

(a) 10^3 (b) 10^5 (c) 10^{10} (d) 10^7

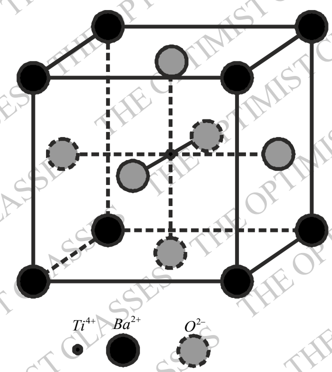
70. Barium Titanate $(BaTiO_3)$ crystal has a cubic perovskite structure, where the Ba^{2+} ions are at the vertices of a unit cube, the O^{2-} ions are at the centres of the faces while the Ti^{2+} is at the centre. The number of optical phonon modes of the crystal is

(a) 12

(b) 15

(c) 5

(d) 18



71. The dispersion relation of optical phonons in a cubic crystal is given by $\omega(k) = \omega_0 - ak^2$ where ω_0 and a are positive constants. The contribution to the density of states due to these phonons with frequencies just below ω_0 is proportional to

(a) $(\omega_0 - \omega)^{1/2}$ (b) $(\omega_0 - \omega)^{3/2}$ (c) $(\omega_0 - \omega)^2$ (d) $(\omega_0 - \omega)$

72. A silicon crystal is doped with phosphorus atoms. (The binding energy of a H atom is 13.6 eV, the dielectric constant of silicon is 12 and the effective mass of electons in the crystal is 0.4 m_e). The gap between the donor energy level and the bottom of the conduction band is nearest to

(a) $0.01\,eV$ (b) $0.08\,eV$ (c) $0.02\,eV$ (d) $0.04\,eV$

73. Assume that pion-nucleon scatterina at low energies, in which isospin is conserved is described by the effective interaction potential $V_{eff} = F(r)\vec{I}_\pi, \vec{I}_N$, where $F(r)$ is a function of the radial separation r and $\vec{I}_\pi$ and $\vec{I}_N$ denote, respectively, the isospin vectors of a pion and the nucleon. The ratio $\frac{\sigma_{I=3/2}}{\sigma_{I=1/2}}$ of the scattering cross-sections corresponding to total isospins $I = \frac{3}{2}$ and $\frac{1}{2}$ is

(a) $\frac{3}{2}$ (b) $\frac{1}{4}$ (c) $\frac{5}{4}$ (d) $\frac{1}{2}$

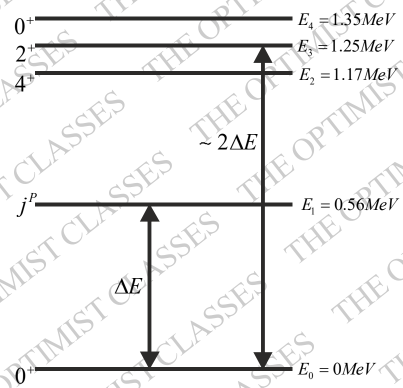
74. A nucleus decays by the emission of a gamma ray from an excited state of spin parity 2^+ to the

ground state with spin-parity 0^+ what is the type of the corresponding radiation?

(a) magnetic dipole (b) electric quadrupole

(c) electric dipole (d) magnetic quadrupole

75. The low lying energy levels due to the vibrational excitations of an even-even nucleus are shown in the figure below.



The spin-parity j^p of the level E_1 is

(a) 1^+ (b) 1^- (c) 2^- (d) 2^+

ANSWER KEY

21.	(d)	22.	(c)	23.	(b)	24.	(c)	25.	(b)	26.	(d)
27.	(c)	28.	(c)	29.	(c)	30.	(c)	31.	(c)	32.	(b)
33.	(a)	34.	(b)	35.	(c)	36.	(d)	37.	(b)	38.	(a)
39.	(d)	40.	(a)	41.	(a)	42.	(b)	43.	(b)	44.	(a)
45.	(c)	46.	(d)	47.	(d)	48.	(b)	49.	(c)	50.	(c)
51.	(a)	52.	(a)	53.	(a)	54.	(a)	55.	(c)	56.	(a)
57.	(b)	58.	(b)	59.	(d)	60.	(c)	61.	(a)	62.	(c)
63.	(d)	64.	(c)	65.	(b)	66.	(b)	67.	(b)	68.	(a)
69.	(c)	70.	(a)	71.	(a)	72.	(d)	73.	(b)	74.	(b)
75.	(d)										