D PHYSICS

CSIR-NET, GATE, SET, JEST, IIT-JAM, BARC, TIFR

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Question Paper With

Answer Key

PHYSICAL SCIENCE

1. An analog-to-digital converter monitors the dc voltage output from a battery. The output of the converter is a three-digit binary number ABC, corresponding to battery voltage in steps of 0.5 V , with A as the most significant bit (MSB). The output of the converter is fed into a logic circuit which produces a HIGH output when the battery voltage exceeds 2 V. The expression for this logic circuit is:

(a) AB + AC (b) AB + BC + AC (c) ABC (d) AC

2. A linearly polarized electromagnetic wave is incident normally on a material of refractive index n_R for right circular polarization and n_L for left circular polarization, where $n_R \neq n_L$. The reflected wave's polarization i:

(a) Linear (b) Elliptical (c) Circular (d) Random

3. The Lagrangian of a system is given by $L = x^2 + x\dot{x} + \frac{\dot{x}^2}{2}$. If p is the generalized momentum, then the corresponding Hamiltonian is:

(a) $\frac{(p^2 - x^2 - 2xp)}{2}$ (b) $\frac{(p^2 - x^2 + 2xp)}{2}$

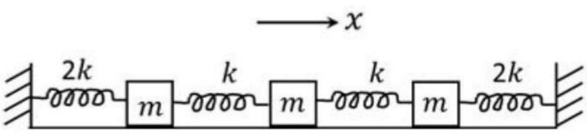
(c) $\frac{(p^2 + x^2 + 2xp)}{2}$ (d) $\frac{(p^2 + x^2 - 2xp)}{2}$

4. Consider the Poisson's equation $\nabla^2 V = -\frac{q}{\epsilon_0}\delta^3(\vec{r} - \vec{a})$ in half-space $z > 0$ with boundary condition $V = 0$ in the $z = 0$ plane. Here, $\vec{a} = a_0\hat{k}$ with $a_0 > 0$. If $\frac{q}{4\pi\epsilon_0 a_0} = 24$ Volt, then which of the following is correct?

(a) At $\vec{r} = (0,0,2a_0), V = 16$ Volt (b) At $\vec{r} = (0,0,3a_0), V = 8$ Volt

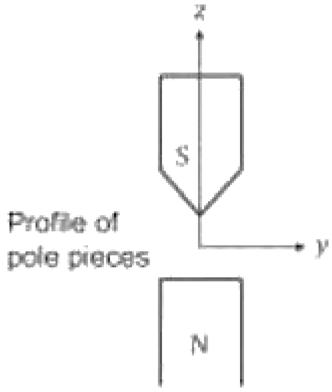
(c) At $\vec{r} = (0,0,4a_0), V = 4$ Volt (d) At $\vec{r} = (0,0,a_0/2), V = 32$ Volt

5. Three equal masses m are free to move along x-axis on a frictionless surface. The masses are coupled together, and to a rigid wall, by springs as shown in the figure. If $\omega_0 = \sqrt{\frac{k}{m}}$, and the angular frequencies of the three normal modes of this system are ω_1, ω_2 and ω_3 then the value of $\omega_1^2 + \omega_2^2 + \omega_3^2$ is:



(a) $9\omega_0^2$ (b) $6\omega_0^2$ (c) $10\omega_0^2$ (d) $8\omega_0^2$

6. A beam of copper atoms (Cu: [Ar]4 $s^1 3$ d^{10}) is passed through a Stern-Gerlach setup (see figure). If the gradient of the z-component of the magnetic field in the z-direction is 10^3Tesla/m, then the magnitude of the z-component of the force on an atom is:
(μ_B is the Bohr magneton)



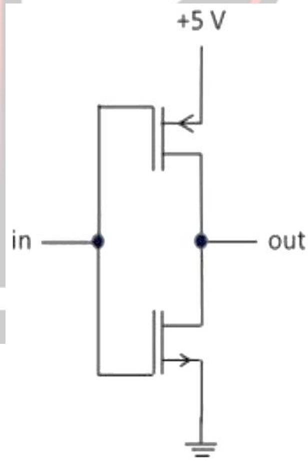
(a) $5 \times 10^2 \mu_B$ (b) $10^3 \mu_B$ (c) 0 (d) $2\pi \times 10^3 \mu_B$

7. Internal energy of one mole of a non-ideal gas is given by $U = \frac{3}{2}RT - \frac{a}{V}$, where V is volume of the gas at temperature T and a is a positive constant. An insulated container of volume V_2 contains this gas confined in a volume V_1 at temperature T_1. The remaining volume $V_2 - V_1$ of this container, which is in vacuum, is separated by a wall. The wall is suddenly removed which makes the gas volume V_2 and temperature T_2. The temperature T_2 is:
(R is the molar gas constant)

(a) $T_1 + \frac{2a}{3R}\left(\frac{1}{V_2} + \frac{1}{V_1}\right)$ (b) $T_1 - \frac{2a}{3R}\left(\frac{1}{V_2} + \frac{1}{V_1}\right)$

(c) $T_1 + \frac{2a}{3R}\left(\frac{1}{V_2} - \frac{1}{V_1}\right)$ (d) $T_1 - \frac{2a}{3R}\left(\frac{1}{V_2} - \frac{1}{V_1}\right)$

8. The circuit shown below could be used as a:



(a)TTL NOT Gate (b)TTL Buffer (c)CMOS NOT Gate (d)CMOS Buffer

9. A particle moves in an orbit $r = k\exp(\alpha\theta)$ under a central force $F(r)$. Here, k and α are constants and $k > 0$. Then $F(r)$ is proportional to:

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

10. Vanadium has electron configuration $[Ar]3d^3 4s^2$. In LS coupling, its ground state configuration is

(a) $^4F_9$ (b) $^2P_{\frac{1}{2}}$ (c) $^4F_{\frac{3}{2}}$ (d) $^4S_{\frac{3}{2}}$

11. A three-state system is described by a certain Hamiltonian having eigen energies $E_0, 2E_0$ and $3E_0$ with the corresponding eigen states $\begin{pmatrix}1\\1\\1\end{pmatrix}, \begin{pmatrix}1\\0\\-1\end{pmatrix}$ and $\begin{pmatrix}1\\-2\\1\end{pmatrix}$, respectively. If the state of the system at time $t=0$ is $\begin{pmatrix}1\\0\\0\end{pmatrix}$, then what is the probability of finding the system in the same state at time $t=\frac{\pi\hbar}{2E_0}$?

(a) 1 (b) $\frac{1}{3}$ (c) $\frac{5}{18}$ (d) $\frac{2}{9}$

12. In a 4-dimensional vector space V_4, three linearly independent vectors are given by $\boldsymbol{e_1}=(1,1,0,0), \boldsymbol{e}_2=(0,1,1,0)$ and $\boldsymbol{e}_3=(0,0,1,1)$. Which of the following vector $\boldsymbol{e_4}$ will make $\{\boldsymbol{e_1},\boldsymbol{e_2},\boldsymbol{e_3},\boldsymbol{e_4}\}$ a basis of V_4 ?

(a)(1,1,1,1) (b)(1,1,1,0) (c)(1,0,-1,0) (d)(0,1,1,0)

13. Consider two operators $\hat{R}$ and $\hat{S}$ where $\hat{R}$ commutes with $[\hat{R},\hat{S}]$. If α is a constant, then $\left[e^{\alpha\hat{R}},\hat{S}\right]$ is:

(a)$\left[\hat{R}^{\alpha},\hat{S}\right]$ (b)$\alpha e^{\alpha\hat{R}}[\hat{R},\hat{S}]$ (c)0 (d)$\alpha e^{\hat{R}}\left[e^{\alpha}\hat{R},\hat{S}\right]$

14. A bead of mass M slides along a smooth frictionless and massless wire which is bent in the shape of a parabola $z=cr^2$ in cylindrical coordinates (r,ϕ,z). Here c is a positive constant. The wire is made to rotate about z-axis at constant angular velocity. Which of the following statements about this system of the wire and the bead is correct?

(a)Energy is conserved but angular momentum is not conserved

(b)Energy is not conserved but angular momentum is conserved

(c)Both energy and angular momentum are conserved

(d)Both energy and angular momentum are not conserved

15. You are given a time-independent observable O for a system with time independent Hamiltonian H and a general time dependent state $|\phi(t)\rangle$. If the expectation value $\langle O(t)\rangle_{\phi}=\langle\phi(t)|O|\phi(t)\rangle$, then consider the following statements (A) to (D) and choose the correct option.
(A)If O commutes with H then $\langle O(t)\rangle_{\phi}$ is independent of time.
(B)If $|\phi(t)\rangle$ is an eigen state of H then $\langle O(t)\rangle_{\phi}$ is independent of time.
(C)If $|\phi(t)\rangle$ is an eigen state of O then $\langle O(t)\rangle_{\phi}$ is independent of time.
(D)If $|\phi(t)\rangle$ is an eigen state of $[O,H]$ then $\langle O(t)\rangle_{\phi}$ is independent of time.

(a)Only (A) and (B) are correct (b)Only (A) is correct

(c)Only (B), (C) and (D) are correct (d)Only (A), (B) and (C) are correct

16. The eigen energies and the normalized eigenfunctions in the n^{th} state of a particle, confined in a one-dimensional infinite potential well, are denoted by E_n and ψ_n, respectively. If $E_1=1.2\text{eV}$ then the expectation value of energy in the state $\psi=3\psi_1+2\psi_2+\sqrt{3}\psi_4$ is close to:

(a)5.5 eV (b)5.0 eV (c)4.5 eV (d)6.0 eV

17. Consider the spin matrix S_r projected along the radial direction in spherical polar coordinates (r,θ,φ). The probability that a measurement of S_r on the state $|\beta\rangle = \begin{pmatrix} \sin\frac{\theta}{2} \\ e^{i\varphi}\cos\frac{\theta}{2} \end{pmatrix}$ will yield the value $\frac{\hbar}{2}$ is:

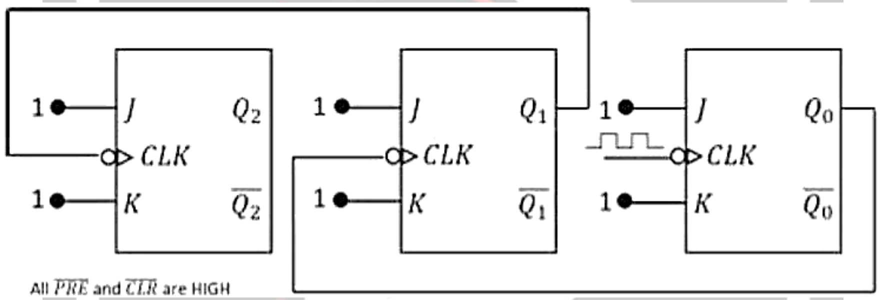
(a)$\sin^2\theta$ (b)$\cos^2\theta$ (c)$\frac{1}{2}$ (d)$\cos^2\frac{\theta}{2}$

18. Two particles occupy ten degenerate energy levels. There are three possible scenarios where the two particles are either identical bosons or identical fermions or distinguishable particles, with the associated number of accessible microstates denoted as Ω_B, Ω_F and Ω_C, respectively. Then, which of the following options is correct?

(a)$\Omega_B = 55, \Omega_F = 45, \Omega_C = 100$ (b)$\Omega_B = 65, \Omega_F = 55, \Omega_C = 100$

(c)$\Omega_B = 45, \Omega_F = 25, \Omega_C = 55$ (d)$\Omega_B = 55, \Omega_F = 45, \Omega_C = 75$

19. Three J-K flip-flops are connected together to make a counter as shown in the figure. The J and K inputs are tied to logical 1 and a clock pulse is applied only to CLK input of the flip flop Q_0. If the counter is initially in the state $Q_2Q_1Q_0 = 100$, then the state of the counter after 9 clock cycles is:
Figure:



(a)$Q_2Q_1Q_0 = 001$ (b)$Q_2Q_1Q_0 = 110$ (c)$Q_2Q_1Q_0 = 101$ (d)$Q_2Q_1Q_0 = 111$

20. A micro-canonical ensemble consists of six non-interacting and distinguishable spin 1 particles in a uniform magnetic field. Each particle can thus be in energy states $-E_0$, 0 and E_0. The number of microstates in the state with total energy zero is:

(a)51 (b)191 (c)141 (d)55

21. The value of the integral:

$$\oint \frac{d\theta}{5 - 4\cos\theta}$$

over the circle $|z| = 1$ in the anti-clockwise direction can be calculated by substituting $z = e^{i\theta}$. The value of the integral is:

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

22. A particle with charge q, which is confined to move in the xy-plane, is subjected to a magnetic field with magnitude B pointing in the $+z$ direction. The particle moves in a circle (C) of radius R. If $\vec{p}$ is the canonical momentum then the following integral

$$\oint_C \vec{p} \cdot d\vec{l}$$

has the magnitude:
($d\vec{l}$ is in the direction of motion)

(a)$qB\pi R^2$ (b)$2qB\pi R^2$ (c)$3qB\pi R^2$ (d)$4qB\pi R^2$

23. In spherical polar coordinates (r, θ, ϕ), $\frac{\partial \hat{\theta}}{\partial \phi}$ is :

(a)$\cos\theta\hat{\phi}$ (b)0 (c)$\sin\theta\hat{\phi}$ (d)$-\cos\theta\hat{r}$

24. A particle is in the ground state of a one-dimensional infinite well potential with walls at $x = 0$ and at $x = a$. The wall at $x = a$ is moved to $x = 2a$ in two separate, sudden and adiabatic, protocols so that $\langle E\rangle_s$ and $\langle E\rangle_a$ are the respective expectation values of the energy in the final states. Then the ratio $\frac{\langle E\rangle_s}{\langle E\rangle_a}$ is :

(a) 4:1 (b)2:1 (c)1:1 (d)1:4

25. Water, having density 1gm/cm^3, freezes into ice at 273 K temperature and 1 atm pressure. The latent heat of melting of ice is 334 J/gm and the density of ice is 0.917gm/cm^3. Then for the melting temperature (T_m) which of the following options is correct?

(a) At 140 atm pressure, $T_m \simeq 274$ K. (b) At 420 atm pressure, $T_m \simeq 274$ K.

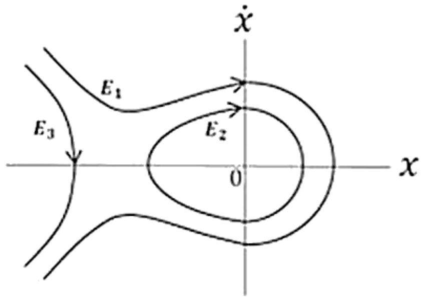
(c) At 140 atm pressure, $T_m \simeq 272$ K. (d) At 420 atm pressure, $T_m \simeq 272$ K.

26. A particle is moving in one dimension in the potential

$$V(x) = \frac{1}{2}x^2 + \frac{1}{3}x^3.$$

The schematic phase-space diagrams for the total energies $E_1 > E_2 > E_3$ are best represented by:

1.



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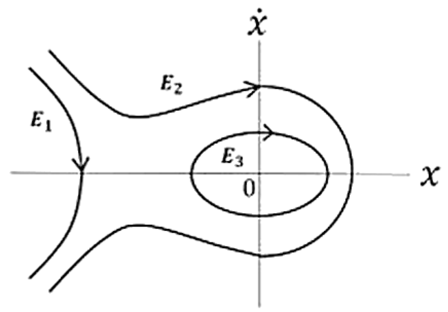

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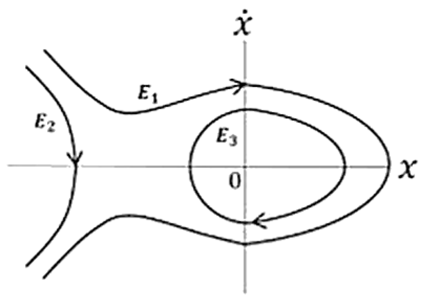

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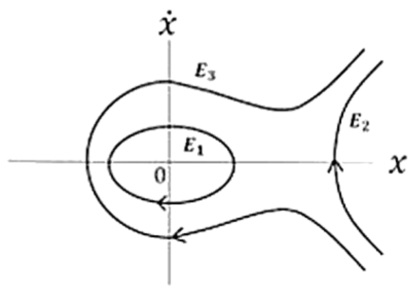


27. Potassium chloride (KCl) crystallizes in NaCl structure. The atomic form factors of K^+ and Cl^- are the same. Then the first four X-ray diffraction peaks for KCl are:

(a) (100), (110), (111), (200) (b) (110), (200), (222), (310)

(c) (111), (200), (220), (311) (d) (200), (220), (222), (400)

28. A dynamical system is described by a differential equation $\ddot{x} - \dot{x} + x^2 - 2x = 0$. The nature of the fixed point at the origin is:

(a) unstable spiral (b) stable node (c) unstable hyperbola (d) stable spiral

29. The Hamiltonian of a quantum mechanical system is given by $\hat{H} = \alpha\hat{L}^2 + \beta\hbar\hat{L}_z$. Here, α and β are positive constants and $\hat{L}$ represents the orbital angular momentum operator. If l and m are the azimuthal and magnetic quantum numbers then the lowest energy state for this system is:

(a) $l = 1, m = -1$ for $\alpha = \beta$ (b) $l = 0, m = 0$ for $\alpha < \frac{\beta}{2}$

(c) $l = 1, m = -1$ for $\alpha < \frac{\beta}{2}$ (d) $l = 1, m = +1$ for $\alpha < \frac{\beta}{2}$

30. In an experiment, a student generates 100 random numbers drawn from a uniform distribution in the interval $(0,1)$ and calculates their mean. If the experiment is repeated 100 times, then the standard deviation of the means is:

(a) $\frac{1}{20\sqrt{3}}$ (b) $\frac{1}{2\sqrt{3}}$ (c) $\frac{1}{\sqrt{3}}$ (d) $\frac{1}{200\sqrt{3}}$

31. In a superconductor, the current density $\vec{J}$ and magnetic field $\vec{B}$ are related by the equation:
(Here, n is the number density of electrons, e is electron charge, m_e is electron mass and μ_0 is permeability of vacuum.)

(a) $\frac{\partial}{\partial t}\left(\vec{\nabla} \times \vec{J} - \frac{ne^2}{m_e}\vec{B}\right) = 0$ (b) $\left(\vec{\nabla} \times \vec{J} + \frac{ne^2}{m_e}\vec{B}\right) = 0$

(c) $\left(\nabla^2\vec{B} - \mu_0\vec{\nabla} \times \vec{J}\right) = 0$ (d) $\left(\nabla^2\vec{J} - \mu_0\vec{\nabla} \times \vec{B}\right) = 0$

32. Consider a particle of mass m in an infinite potential well with walls at $x = 0$ and $x = 2L$. The particle is perturbed by a weak perturbation $H' = V_0 L\delta(x - 3L/2)$. The first-order correction to its first excited state energy is:

(a) $2V_0$ (b) V_0 (c) $\frac{V_0}{2}$ (d) 0

33. Assume a spherically uniform charge distribution in a nucleus having mass number A and radius $R = R_0 A^{1/3}$ with $R_0 \approx 1.5$fm. If the difference in electrostatic energy between two mirror nuclei, ${}^{A}_{Z}X$ and ${}^{A}_{Z-1}Y$, is 3.53 MeV, then the value of atomic number Z is closest to:
(Given: $\frac{e^2}{4\pi\epsilon_0} \approx 1.44\text{MeV.fm}$ and $1\text{fm} = 10^{-15}$ m)

(a) 6 (b) 8 (c) 10 (d) 12

34. An inertial observer S finds the electric field due to a large rectangular parallel plate capacitor to be directed along the y-axis. For another observer, moving at a relativistic speed with respect to S along the positive x-axis, which of the following statements is correct for the electric field:

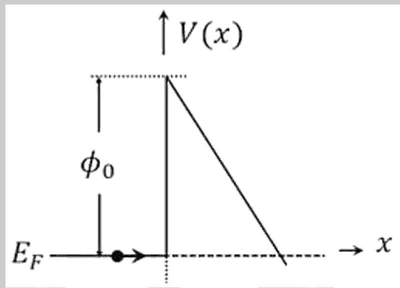
(a) Direction remains same but magnitude increases

(b) Direction remains same but magnitude decreases

(c) Direction and magnitude both remain the same

(d) Direction tilts towards x-axis but the magnitude remains same

35. The surface of a metal of work function ϕ_0 is subjected to an electric field $\mathcal{E}$. As a result, the electric potential profile just outside the surface is given by $V(x) = \phi_0 - x\mathcal{E}$ as shown in the figure. For electric field $\mathcal{E}$, the probability $p(\mathcal{E})$ of tunneling of an electron moving at the Fermi energy (E_F) can be found using the WKB approximation. If $\lambda = \sqrt{\frac{2me\phi_0^3}{\hbar^2}}$, then the value of the ratio $\frac{p(\varepsilon=2\lambda)}{p(\varepsilon=\lambda)}$ will be:
(Here, e and m are electron's charge and mass, respectively)

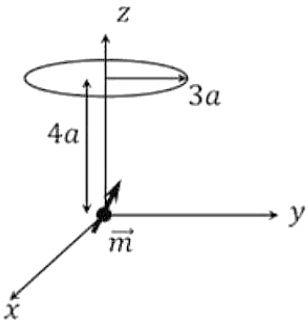


(a) 1.36 (b) 2.73 (c) 1.94 (d) 5.13

36. A container has a gas at temperature T with its N_1 molecules in the ground state and N_2 molecules in the excited state of energy $h\nu$. Both the levels are non-degenerate and A and B are the Einstein coefficients for spontaneous and stimulated emissions, respectively, between the two levels. Then the spectral density $\rho(\nu, T)$ of radiation inside the container is proportional to:

(a) $\frac{A}{B}\left(\frac{N_2}{N_1 - N_2}\right)$ (b) $\frac{A}{B}\left(\frac{N_2}{N_1 + N_2}\right)$ (c) $\frac{N_2}{\left(\frac{A}{B}\right) N_1 - N_2}$ (d) $\frac{N_2}{\left(\frac{A}{B}\right) N_1 + N_2}$

37. A magnetic dipole $\vec{m}$ is kept at the origin with its direction along $+z$-axis. At time $t = 0$ it starts spinning about x-axis with angular speed ω. A wire loop of radius $3a$ is kept with its plane parallel to xy-plane and centered at $z = 4a$ as shown in the figure. The emf E induced in the loop for $t > 0$ is:
(Note that the magnetic flux through the given loop will be the same as through an appropriate section of a spherical shell of radius $5a$ with its center at the origin.)



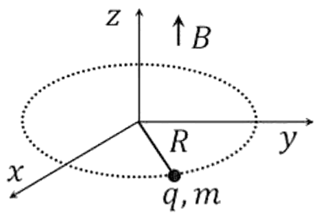
(a) $\left(\frac{9\mu_0 m\omega}{500a}\right)\sin\omega t$

(b) $\left(\frac{9\mu_0 m\omega}{500a}\right)\cos\omega t$

(c) $\left(\frac{9\mu_0 m\omega}{250a}\right)\sin\omega t$

(d) $\left(\frac{9\mu_0 m\omega}{250a}\right)\cos\omega t$

38. A particle of mass m and charge q is fixed at one end of a rigid insulating rod of length R. The other end of the rod is pivoted such that it can rotate about the z-axis in the xy-plane as shown in the figure. A time dependent magnetic field $\vec{B} = \beta t\hat{z}$ is turned on at $t = 0$. Here β is a constant. Then the force in the rod at time t will be:



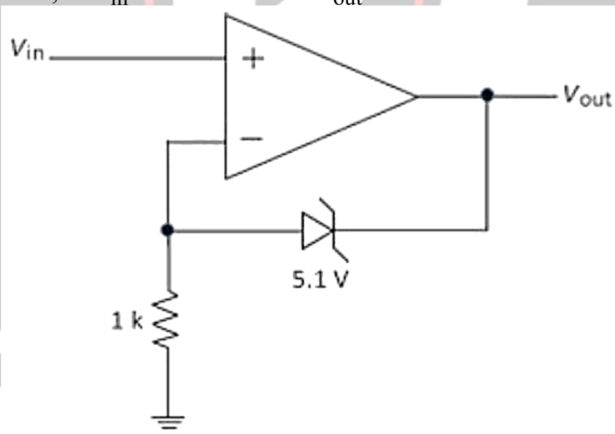
(a) Compressive and of magnitude $q^2\beta^2t^2R/m$

(b) Zero

(c) Compressive and of magnitude $q^2\beta^2t^2R/(4m)$

(d) Tensile and of magnitude $q^2\beta^2t^2R/(4m)$

39. In the circuit shown below, if $V_{\text{in}} = 2.0$ V then V_{out} is



(a) 2.0 V

(b) 3.1 V

(c) 5.1 V

(d) 7.1 V

40. A particle of mass m with momentum $\hbar\vec{k}$ scatters elastically to momentum $\hbar(\vec{k} + \vec{q})$ from a spherical potential

$$V(\vec{r}) = \begin{cases} V_0 \text{ for } r \leq R \\ 0 \text{ for } r > R \end{cases}.$$

Here, $q^2 = 4k^2\sin^2\frac{\theta}{2}$ with θ being the scattering angle. Within the firstorder Born approximation and for $qR \ll 1$, the differential scattering crosssection to the leading order in R is proportional to:

(a) R^2

(b) R^4

(c) R^6

(d) R^8

41. In four dimensions, a rank four tensor is given by T_{abcd}. It is symmetric under interchange of the indices a, b and interchange of the indices c, d. Moreover, the tensor is anti-symmetric under the interchange of pair of indices ab and cd. The number of independent components of the tensor is:

(a) 100 (b) 45 (c) 36 (d) 21

42. Consider a complex analytic function $f(x, y) = u(x, y) + iv(x, y)$. If $u(x, y) = x^3 - 3xy^2$, then $v(x, y)$ is:

(a) $y^3 - 3xy^2$ (b) $3xy^2 - y^3$ (c) $3x^2y - y^3$ (d) $y^3 + 3xy^2$

43. Consider the following decay processes of ρ^0 :

(A) $\rho^0 \rightarrow \pi^+ + \pi^-$

(B) $\rho^0 \rightarrow \pi^0 + \pi^0$

For the conservation of angular momentum and parity, which of the following options is correct?

(a) Both processes (A) and (B) are allowed (b) Both processes (A) and (B) are forbidden

(c) Only process (A) is allowed (d) Only process (B) is allowed

44. Modulation techniques are used to shift a signal to higher frequencies to

(a) remove the effects of white noise. (b) reduce the effects of $1/f$-noise and drift.

(c) reduce shot noise and Johnson noise. (d) smoothen the signal and amplify it.

45. For a one-dimensional system the Hamiltonian is given by $H = \frac{p^2}{2} - \frac{1}{2q^2}$. If a constant of motion of the system is $\left(apq + bp^2t + \frac{ct}{q^2}\right)$, where a, b and c are constants and t denotes the time, then which of the following options is correct:

(a) $a = b = c$ (b) $a = -b = c$ (c) $a = -b = -c$ (d) $a = b = -c$

46. Transverse electric modes TE_{mn} propagate in a hollow straight infinite metallic waveguide having rectangular cross section of sides 3 cm and 2 cm. The frequency (in GHz) of the lowest degenerate mode is:
(Given: speed of light $= 3 \times 10^8$ m/s)

(a) 5.0 (b) 7.5 (c) 9.0 (d) 15.0

47. A biased random walker confined to the x-axis moves, at each step, with probability 0.6 to the right and with probability 0.4 to the left. If the walker takes 1000 steps starting from the origin, the probability that the walker is found exactly 200 steps to the right of the origin is close to:

(a) 0.026 (a) 0.125 (a) 0.250 (a) 0.375

48. The integral

$$\int_0^4 x^4 dx$$

when computed numerically using Simpson's $1/3^{\text{rd}}$ method and trapezoidal method, each with unit step size, yields values I_s and I_t, respectively. Then which of the following options is correct?

(a) $I_s = 205.3, I_t = 226.0$ (b) $I_s = 205.3, I_t = 205.3$

(c) $I_s = 204.8, I_t = 226.0$ (d) $I_s = 226.0, I_t = 226.0$

49. The Hamiltonian of a particle of mass m, moving in a circle of a fixed radius R, is given by $H_0 = \frac{L_z^2}{2mR^2}$, where $L_z = -i\hbar\frac{d}{d\phi}$ and ϕ is the azimuthal angle. This particle is perturbed by $H' = V\cos(2\phi)$ with $V \ll \frac{\hbar^2}{2mR^2}$. Within the first-order degenerate perturbation theory, the magnitude of the energy splitting of the first excited state is:

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

50. The table shows the g-factors of proton (p) and neutron (n) for orbital (g_l) and spin (g_s) angular momentum.

	g_l	g_s
p	1	5.58
n	0	-3.82

The magnetic moment of ${}^{17}_{8}\text{O}$ nucleus, according to the single particle shell model, in units of nuclear magneton (μ_N) is:

(a) 0.55 (b) 4.79 (c) -1.91 (d) -3.82

51. A kaon (K^0) decays into two neutral pions (π^0). Given that the mass of the K^0 is $495 MeV/c^2$ and the mass of the π^0 is $135 MeV/c^2$, the final momentum of the π^0 (in MeV/c) in the center of mass frame is approximately:

(a) 207 (b) 359 (c) 157 (d) 103

52. Resistivity of a monovalent metal, having atomic density 4×10^{22} atoms $/\text{cm}^3$, is found to be $1\mu\Omega - \text{cm}$. The approximate value of the mean free path of electrons in this metal is:
(Given: $\hbar = 10^{-34}$ J $-$ s and $e = 1.6 \times 10^{-19}$C)

(a) 1 nm (b) 100 nm (c) 10^4 nm (d) 10^6 nm

53. Newton-Raphson method is used for finding the roots of the polynomial $(x^2 - 1)(x - 2)$. If the initial trial solutions are chosen as 0 and 0.5, the algorithm converges to p and q, respectively. Then, which of the following is correct?

(a) $p = 1, q = -1$ (b) $p = -1, q = 1$ (c) $p = 2, q = 1$ (d) $p = 1, q = 2$

54. Given is a set of 5 data points of the form (x_i, y_i, σ_i) with σ_i as the estimated uncertainty in y_i. This data is fitted to the form $y = ax + b$ and the minimized χ^2 (chi-square) is found to be 5.1. The reduced χ^2 for this fitting is:

(a) 1.0 (b) 1.2 (c) 1.5 (d) 1.7

55. There is a ferromagnetic interaction J between two Ising spins, $S_1, S_2 = \pm 1$, and they are under the influence of an external magnetic field h. The Hamiltonian of this system is,

$$H = -JS_1S_2 - hS_1 - hS_2.$$

The spins are in equilibrium at temperature T and $\beta = 1/k_BT$ with k_B as Boltzmann constant. The average value of either spin, for small h, is:

(a) $\frac{4h\exp(\beta J)}{\cosh(\beta J)}$ (b) $\frac{h\exp(2\beta J)}{\cos(\beta J)}$ (c) $\frac{8h\exp(4\beta J)}{\sinh(\beta J)}$ (d) $\frac{2h\exp(2\beta J)}{\sin(\beta J)}$

Answer Key									
1. a	2. b	3. a	4. a,d	5. d	6. b	7. c	8. c	9. c	10. c
11. c	12. b	13. b	14. d	15. d	16. a	17. a	18. a	19. c	20. c
21. a	22. a	23. a	24. a	25. c	26. a	27. d	28. 3	29. c	30. a
31. b	32. b	33. b	34. a	35. c	36. a	37. c	38. c	39. d	40. c
41. b	42. c	43. c	44. b	45. b	46. d	47. a	48. a	49. b	50. c
51. a	52. b	53. c	54. d	55.					