DU PhD in Physics

Topic:- DU_J18_PHD_PHY_Topic01

1) An infinite long wire carries a time independent current I=1 Ampere. The wire is bent and a semi-circle detour of radius R = 1 cm is made with the centre at the origin. The magnitude of magnetic field at the origin is

[Question ID = 19633]

1. $\frac{25\,\mu_0}{4\pi}$ T [Option ID = 48525]
2. $2.5\,\mu_0$ T [Option ID = 48523]
3. $25\,\mu_0$ T [Option ID = 48524]
4. $\frac{2.5\,\mu_0}{4\pi}$ T [Option ID = 48526]

Correct Answer :-

- $25\,\mu_0$ T [Option ID = 48524]

2) In a rotational structure of electronic bands (the transition between rotational levels of the different electronic levels) having larger rotational constant of the upper electronic level than the lower one,

[Question ID = 19617]

1. band head appears in R-branch [Option ID = 48460]
2. band head appears in P-branch [Option ID = 48459]
3. band head appears in Q-branch [Option ID = 48461]
4. no band head appears [Option ID = 48462]

Correct Answer :-

- band head appears in P-branch [Option ID = 48459]

3) In a bistable multivibrator, commutating capacitors are used to

[Question ID = 19610]

1. change the frequency of the output [Option ID = 48433]
2. provide a.c. coupling [Option ID = 48432]
3. increase the base storage output [Option ID = 48434]
4. increase the speed of response [Option ID = 48431]

Correct Answer :-

- increase the speed of response [Option ID = 48431]

4) In the Geiger Muller (GM) region, when the applied voltage is increased, which of the following happens: [Question ID = 19623]

1. The pulse amplitude increases but the counting rate remains nearly constant. [Option ID = 48483]
2. The pulse amplitude remains nearly constant and the counting rate increases. [Option ID = 48484]
3. Both the pulse amplitude and the counting rate increases. [Option ID = 48485]
4. Both the pulse amplitude and counting rate remain nearly constant. [Option ID = 48486]

Correct Answer :-

- The pulse amplitude increases but the counting rate remains nearly constant. [Option ID = 48483]

5) In the absorption spectra of harmonic vibrating diatomic oscillator, only one spectral line is observed. It is because [Question ID = 19618]

1. Separation between any two adjacent E-level is same [Option ID = 48465]
2. All other lines are very weak in intensity [Option ID = 48466]
3. Only one molecule is present in a particular E-level [Option ID = 48464]
4. Only one transition is possible from ground E-level to higher E-level [Option ID = 48463]

Correct Answer :-

- Separation between any two adjacent E-level is same [Option ID = 48465]

6) Magnetic field required to bend a non-relativistic charge particle of energy E in an arc of radius R is [Question ID = 19632]

1. inversely proportional to $\sqrt{E}$ and directly proportional to R. [Option ID = 48520]
2. directly proportional to E and inversely proportional to R^2. [Option ID = 48521]
3. directly proportional to $\sqrt{E}$ and inversely proportional to R. [Option ID = 48519]
4. inversely proportional to $\sqrt{E}$ and directly proportional to R^2. [Option ID = 48522]

Correct Answer :-

- directly proportional to $\sqrt{E}$ and inversely proportional to R. [Option ID = 48519]

7) The number of ways in which two particles can be distributed in six states, if the particles are indistinguishable and only one particle can occupy any one state, is [Question ID = 19612]

1. 31 [Option ID = 48440]
2. 36 [Option ID = 48439]
3. 21 [Option ID = 48442]
4. 25 [Option ID = 48441]

Correct Answer :-

8) Consider a 2-D harmonic oscillator with mass m and frequency ω. A perturbation $H' = bxy$ is applied to the system, where x and y are the two spatial coordinates. The first order correction to the ground state energy is

[Question ID = 19635]

1. 0 [Option ID = 48531]
2. $\pm\frac{b\hbar}{2m\omega}$ [Option ID = 48534]
3. $\frac{b\hbar}{2m\omega}$ [Option ID = 48532]
4. $-\frac{b\hbar}{2m\omega}$ [Option ID = 48533]

Correct Answer :-

- 0 [Option ID = 48531]

9) An electron of charge $-e$ is decelerated at a constant rate from an initial velocity v_0 to rest over a distance d $(v_0 \ll c)$. The energy lost to radiation is given by

[Question ID = 19630]

1. $\frac{\mu_0\, e^2 v_0^3}{6\,\pi\, c\, d}$ [Option ID = 48512]
2. $\frac{\mu_0\, e^2 v_0^3}{3\,\pi\, c\, d}$ [Option ID = 48511]
3. Cannot be determined from the information supplied. [Option ID = 48514]
4. $\frac{\mu_0\, e^2 v_0^3}{12\,\pi\, c\, d}$ [Option ID = 48513]

Correct Answer :-

- $\frac{\mu_0\, e^2 v_0^3}{12\,\pi\, c\, d}$ [Option ID = 48513]

10)

The lattice constant and saturation magnetization of BCC iron at 0 K are 2.87 Å and 1950 kAm^{-1}, respectively. The net magnetic moment per iron atom in the crystal is

[Question ID = 19597]

1. 2.30×10^{-23} A m^2 [Option ID = 48380]
2. 0.67×10^{-21} A m^2 [Option ID = 48382]
3. 7.30×10^{-25} A m^2 [Option ID = 48379]
4. 1.87×10^{-22} A m^2 [Option ID = 48381]

Correct Answer :-

- 2.30×10^{-23} A m^2 [Option ID = 48380]

11) Consider the density matrix of a two level system given by

$$\rho = \frac{2}{3}|1\rangle\langle 1| + \frac{1}{3}|2\rangle\langle 2| .$$

Then

[Question ID = 19615]

1. The expectation value of the operator $O_2 = \frac{\hbar}{2}(|1\rangle\langle 2| + |2\rangle\langle 1|)$ is $\frac{5\hbar}{6}$. [Option ID = 48452]
2. The expectation value of the operator $O_1 = \frac{\hbar}{2}(|1\rangle\langle 1| - |2\rangle\langle 2|)$ is $\frac{\hbar}{6}$. [Option ID = 48451]
3. The system is in a pure state. [Option ID = 48453]
4. $\langle O_1 \rangle = 0$, where $O_1 = \frac{\hbar}{2}(|1\rangle\langle 1| - |2\rangle\langle 2|)$. [Option ID = 48454]

Correct Answer :-

- The expectation value of the operator $O_1 = \frac{\hbar}{2}(|1\rangle\langle 1| - |2\rangle\langle 2|)$ is $\frac{\hbar}{6}$. [Option ID = 48451]

12) A quantum-mechanical particle of mass m and charge q is subjected to a potential of the form $V(\vec{r}) = \frac{1}{2}m\omega^2 \vec{r}^2$, where ω is a constant. An electric field $\vec{E} = E_0\hat{x}$ is now switched on (E_0 being a constant). What is the consequent change, upto second order in E_0, in the energy of the second excited state?

[Question ID = 19594]

1. $\frac{q^2E_0^2}{m\hbar\omega}$ [Option ID = 48368]
2. $\frac{q^2E_0^2\langle x^2\rangle}{(m\hbar\omega)^2}$ [Option ID = 48370]
3. $\frac{q^2E_0^2}{2m\omega^2}$ [Option ID = 48367]
4. $\frac{2q^2E_0^2}{m\omega^2}$ [Option ID = 48369]

Correct Answer :-

- $\frac{q^2E_0^2}{2m\omega^2}$ [Option ID = 48367]

13)

For the infinite square well potential the unperturbed wave functions are

$$\psi_n^0(x) = \sqrt{\frac{2}{a}}\sin(\frac{n\pi}{a}\ x)$$

If the floor of the well is raised by V_o, the first order correction to the energy is

[Question ID = 19591]

1. $\frac{V_o}{4}$ [Option ID = 48358]
2. $\frac{V_o}{2}$ [Option ID = 48356]
3. $\frac{V_o}{3}$ [Option ID = 48357]
4. V_o [Option ID = 48355]

Correct Answer :-

- V_o [Option ID = 48355]

14) Lead (Pb) starts superconducting at 7.19 K when the applied magnetic field is zero. When a magnetic field of 0.074 Tesla is applied at 2 K, superconductivity disappears. The critical magnetic field for Lead (Pb) is

[Question ID = 19599]

1. 0.04 T [Option ID = 48388]
2. 0.08 T [Option ID = 48390]
3. 0.034 T [Option ID = 48387]
4. 0.068 T [Option ID = 48389]

Correct Answer :-

- 0.08 T [Option ID = 48390]

15) If $\hat{A}$ and $\hat{B}$ are two linear operators, then the commutator bracket $[\hat{A}, \hat{B}^{-1}]$ is equal to

[Question ID = 19586]

1. $\hat{A}^{-1}[\hat{A}, \hat{B}]\,\hat{B}^{-1}$ [Option ID = 48335]
2. $-\hat{A}^{-1}[\hat{A}, \hat{B}]\,\hat{A}^{-1}$ [Option ID = 48336]
3. $\hat{B}^{-1}[\hat{A}, \hat{B}]\,\hat{A}^{-1}$ [Option ID = 48337]
4. $-\hat{B}^{-1}[\hat{A}, \hat{B}]\,\hat{B}^{-1}$ [Option ID = 48338]

Correct Answer :-

- $-\hat{B}^{-1}[\hat{A}, \hat{B}]\,\hat{B}^{-1}$ [Option ID = 48338]

16) For a simple harmonic oscillator of mass m and angular frequency ω, let $|n\rangle$ represent the n-th energy eigenstate so that $\hat{H}\,|n\rangle = \hbar\omega\,\left(n+\frac{1}{2}\right)|n\rangle$. The physical state at time $t=0$ is represented by $|\psi(0)\rangle = \frac{1}{\sqrt{3}}|2\rangle - \frac{1}{\sqrt{2}}|3\rangle - \frac{1}{\sqrt{6}}|1\rangle$. If one makes a measurement of the energy of the system at any subsequent time t, the probability of finding the energy to be $3\hbar\omega/2$:

[Question ID = 19589]

1. depends on time t. [Option ID = 48350]
2. is $\frac{1}{2}$. [Option ID = 48348]
3. is 1/6. [Option ID = 48349]
4. is 0. [Option ID = 48347]

Correct Answer :-

- is 1/6. [Option ID = 48349]

17) For temperatures 10 K and 20 K, a superconductor has the critical magnetic field as 0.15 Tesla and 0.60 Tesla, respectively. The transition temperature for this superconductor in Kelvin is

[Question ID = 19596]

1. 23.3 [Option ID = 48378]
2. 15.0 [Option ID = 48376]
3. 22.4 [Option ID = 48377]
4. 4.2 [Option ID = 48375]

Correct Answer :-

18) A theory has equally spaced nondegenerate energy levels starting from $E_{min} = E_o$ all the way upto $E = \infty$. The system of many such particles is at equilibrium at a temperature T. If the average energy-squared of the particles is given by

$$\langle E^2 \rangle = 5E_0^2$$

What is T ?

[Question ID = 19614]

1. $T = E_0/2k_B$ [Option ID = 48449]
2. $T = 2\,E_0/k_B$ [Option ID = 48448]
3. $T = 3\,E_0/2k_B$ [Option ID = 48450]
4. $T = E_0/k_B$ [Option ID = 48447]

Correct Answer :-

- $T = E_0/k_B$ [Option ID = 48447]

19) The Hamiltonian for a spin 1/2 particle of mass m in an external field is given by

$$\hat{H} = \frac{\vec{p}.\vec{p}}{2m} + g(t)\vec{\sigma}.\vec{p}$$

where g(t) is a time-dependent coupling constant and $\vec{\sigma}$ are the Pauli matrices. Which of the following statements is true?

[Question ID = 19590]

1. The energy and all the components of the spin angular momentum of the particle are conserved. [Option ID = 48351]
2. The linear momentum and all the components of the spin angular momentum of the particle are conserved. [Option ID = 48354]
3. The linear momentum and the magnitude of the spin angular momentum of the particle are conserved. [Option ID = 48353]
4. The linear momentum and the energy of the particle are conserved. [Option ID = 48352]

Correct Answer :-

. The linear momentum and the magnitude of the spin angular momentum of the particle are conserved. [Option ID = 48353]

20) A solid contains N spin-half magnetic atoms. At sufficiently high temperatures, the atoms are randomly oriented, while at sufficiently low temperatures, they are perfectly aligned. The heat capacity is given by

$$C(T) = \begin{cases} C_0\left(\frac{T}{T_0} - 1\right), & T_0 \le T \le 3T_0 \\ 0, & Otherwise \end{cases}$$

where C_o and T_o are constants. Determine the maximum value of C_o.

[Question ID = 19613]

1. $\frac{Nk_B \ln 2}{2-\ln 3}$ [Option ID = 48445]
2. $\frac{Nk_B \ln 2}{2}$ [Option ID = 48443]
3. $\frac{2Nk_B \ln 2}{2+\ln 3}$ [Option ID = 48446]
4. $\frac{Nk_B \ln 2}{\ln 3}$ [Option ID = 48444]

Correct Answer :-

. $\frac{Nk_B \ln 2}{2-\ln 3}$ [Option ID = 48445]

21) Green's function corresponding to the Laplacian operator ∇^2 is

$$G(\vec{r}, \vec{r}') = -\frac{1}{4\pi|\vec{r} - \vec{r}'|}$$

The value of $\phi(\vec{0})$ corresponding to the solution of the inhomogeneous differential equation

$$\nabla^2\phi = \frac{A\exp(-\beta r)}{r}$$

(where A and β are positive numbers) is equal to,

[Question ID = 19625]

1. 0 [Option ID = 48491]
2. $\frac{A}{4\pi\beta}$ [Option ID = 48494]
3. $-\frac{A}{\beta}$ [Option ID = 48492]
4. $\frac{\pi\beta}{A}$ [Option ID = 48493]

Correct Answer :-

. $-\frac{A}{\beta}$ [Option ID = 48492]

22) A star is pulsating isotropically. Its gravitational force on any body, at distances much larger than its own mean radius, is given by

$$\vec{F}(\vec{r}) = \left(\frac{-k}{r^3} + \frac{a}{r^4}\right)\vec{r}$$

where k and a are positive constants. Which of the following is true about the motion of the body?

[Question ID = 19604]

1. Any bounded motion is described by a precessing ellipse. [Option ID = 48407]
2. No bounded motion exists at all. [Option ID = 48410]
3. Any bounded motion is described by a pulsating ellipse. [Option ID = 48408]
4. Any bounded motion is still in an elliptical path, but the parameters of the ellipse are shifted from those in the Newtonian case. [Option ID = 48409]

Correct Answer :-

Any bounded motion is described by a precessing ellipse. [Option ID = 48407]

23) The Hamiltonian for a particle in one dimension is given by

$$H(x,p) = \frac{p^2}{2m} + \lambda p x + \frac{\lambda}{2} x^2$$

where m, λ are constants. The corresponding Lagrangian is

[Question ID = 19603]

1. $L = \frac{m}{2}(\dot{x})^2 - \lambda m x \dot{x} - \frac{\lambda}{2}x^2$ [Option ID = 48405]
2. $L = \frac{m}{2}(\dot{x} - \lambda x)^2 - \lambda m x \dot{x} - \frac{\lambda}{2}x^2$ [Option ID = 48406]
3. $L = \frac{m}{2}(\dot{x} - \lambda x)^2 - \frac{\lambda}{2}x^2$ [Option ID = 48404]
4. $L = \frac{m}{2}(\dot{x})^2 - \frac{\lambda}{2}x^2$ [Option ID = 48403]

Correct Answer :-

$L = \frac{m}{2}(\dot{x} - \lambda x)^2 - \frac{\lambda}{2}x^2$ [Option ID = 48404]

24) Consider the 2π −periodic function $f(x)$ defined as

$$f(x) = \begin{cases} x(\pi - x), & x \in [0, \pi] \\ x(x - \pi), & x \in [-\pi, 0] \end{cases}$$

Which of the following is true?

[Question ID = 19627]

1. $f(x) = \frac{4}{\pi}\sum_{k=0}^{\infty} \frac{\sin[(2k+1)x]}{(2k+1)^2}$ [Option ID = 48502]
2. $f(x) = \frac{8}{\pi}\sum_{k=0}^{\infty} \frac{\sin(kx)}{k^3}$ [Option ID = 48500]
3. $f(x) = \frac{4}{\pi}\sum_{k=0}^{\infty} \frac{\sin(kx)}{k^3} + \frac{4}{\pi}\sum_{k=0}^{\infty} \frac{\cos(kx)}{k^3}$ [Option ID = 48499]
4. $f(x) = \frac{8}{\pi}\sum_{k=0}^{\infty} \frac{\sin[(2k+1)x]}{(2k+1)^3}$ [Option ID = 48501]

Correct Answer :-

$f(x) = \frac{8}{\pi}\sum_{k=0}^{\infty} \frac{\sin[(2k+1)x]}{(2k+1)^3}$ [Option ID = 48501]

25) In 3-dimensional space, a particle of mass m moves in a potential $A\cos^2\beta r$ where r is the distance of the particle from the origin, A and β are real constants. Which of the following statements are correct?

[Question ID = 19600]

1. The motion is periodic in r with an oscillation distance π/β. [Option ID = 48394]
2. The motion is periodic in r with an oscillation distance $2\pi/\beta$. [Option ID = 48392]
3. The trajectory of the particle is always confined to some plane passing through the origin. [Option ID = 48391]
4. The radial momentum p_r is conserved because of the periodic nature of the potential. [Option ID = 48393]

Correct Answer :-
- The trajectory of the particle is always confined to some plane passing through the origin. [Option ID = 48391]

26) The $^{90}Sr \xrightarrow{\beta^-} {}^{90}Y \xrightarrow{\beta^-} {}^{90}Zr$ chain decays with a half-life of 28 years and 64 hours, respectively. If 1g of pure ^{90}Sr is allowed to decay, then the ratio (N_{Sr}/N_Y) after 1 hour is

[Question ID = 19621]

1. 3.56×10^4 [Option ID = 48477]
2. 3.56×10^5 [Option ID = 48475]
3. 4.56×10^4 [Option ID = 48478]
4. 4.56×10^5 [Option ID = 48476]

Correct Answer :-
- 3.56×10^5 [Option ID = 48475]

27) For the electronic configuration $2p3d$, the complete spectroscopic terms in Russel-Saunders coupling scheme are

[Question ID = 19587]

1. ^1P, ^1D, ^1F, ^1G, ^1H, ^3P, ^3D, ^3F, ^3G, ^3H [Option ID = 48339]
2. ^2P, ^2D, ^2F, ^4P, ^4D, ^4F [Option ID = 48342]
3. ^2S, ^2P, ^2D, ^2F, ^4S, ^4P, ^4D, ^4F [Option ID = 48340]
4. ^1P, ^1D, ^1F, ^3P, ^3D, ^3F [Option ID = 48341]

Correct Answer :-
- ^1P, ^1D, ^1F, ^3P, ^3D, ^3F [Option ID = 48341]

28) The Hamiltonian of a two-level system is given by $H=\frac{1}{2}\hbar\omega\sigma_z$. At time $t=0$ the system is in the eigenstate of σ_x having the largest eigenvalue. The expectation values $\langle\sigma_x\rangle(t)$, $\langle\sigma_y\rangle(t)$ and $\langle\sigma_z\rangle(t)$ (where σ_i are Pauli matrices) are respectively

[Question ID = 19592]

1. $\sin\left(\frac{\omega t}{2}\right)$, 0, and $\cos\left(\frac{\omega t}{2}\right)$ [Option ID = 48361]
2. $\cos\left(\frac{\omega t}{2}\right)$, $\sin\left(\frac{\omega t}{2}\right)$ and 0 [Option ID = 48359]
3. 0, $\cos\left(\frac{\omega t}{2}\right)$ and $\sin\left(\frac{\omega t}{2}\right)$ [Option ID = 48360]

4. $-\cos\left(\frac{\omega t}{2}\right), 0,$ and $\sin\left(\frac{\omega t}{2}\right)$ [Option ID = 48362]

Correct Answer :-

$\cos\left(\frac{\omega t}{2}\right), \sin\left(\frac{\omega t}{2}\right)$ and 0 [Option ID = 48359]

29) The Lagrangian for a system is given by $L = \dot{q}_1\dot{q}_2 - \omega^2 q_1 q_2$ where ω is a constant and $\dot{q}_i = \frac{dq_i}{dt}$. L is invariant under the following transformations $q_1 = e^{\alpha}\, q_1$ and $q_2 = e^{-\alpha}\, q_2$, α is a constant. The conserved quantity corresponding to this symmetry transformation is

[Question ID = 19601]

1. $q_1\dot{q}_1 + q_2\dot{q}_2$ [Option ID = 48398]
2. $q_1\dot{q}_2 - q_2\dot{q}_1$ [Option ID = 48395]
3. $q_1\dot{q}_2 + q_2\dot{q}_1$ [Option ID = 48396]
4. $q_1\dot{q}_1 - q_2\dot{q}_2$ [Option ID = 48397]

Correct Answer :-

$q_1\dot{q}_2 - q_2\dot{q}_1$ [Option ID = 48395]

30) An integral is defined to be,

$$I = \int_0^{\infty} \frac{\sin x}{x}\, dx.$$

Then I is equal to:

[Question ID = 19628]

1. $-\frac{\pi}{\cos\sqrt{2}}$ [Option ID = 48506]
2. $\pi/2$ [Option ID = 48503]
3. $2/\pi$ [Option ID = 48505]
4. $-\frac{\cos\sqrt{2}}{\pi}$ [Option ID = 48504]

Correct Answer :-

$\pi/2$ [Option ID = 48503]

31) In the given astable multivibrator, the frequency of the square wave generated is

[Question ID = 19607]

1. 32.4 kHz [Option ID = 48421]
2. 3.5 kHz [Option ID = 48419]
3. 324 Hz [Option ID = 48422]
4. 3.5 Hz [Option ID = 48420]

Correct Answer :-

32)

A point mass m is attached, through a massless incompressible rod of length ℓ, to a fixed point. The mass is allowed to have any motion consistent with the above. If θ be the instantaneous angle of the rod with the vertical, which of the following is necessarily true? (Here $\kappa \geq 0$ is an arbitrary constant)

[Question ID = 19605]

1. $\ddot{\theta} + \frac{g}{\ell} sin\theta = 0$ [Option ID = 48412]
2. $\ddot{\theta} + \frac{\kappa\, sin\theta}{cos^3\theta} + \frac{g}{\ell} sin\theta = 0$ [Option ID = 48413]
3. $\ddot{\theta} + \frac{g}{\ell}\theta = 0$ [Option ID = 48411]
4. $\ddot{\theta} - \frac{\kappa cos\theta}{sin^3\theta} + \frac{g}{\ell}\sin\theta = 0$ [Option ID = 48414]

Correct Answer :-

- $\ddot{\theta} - \frac{\kappa cos\theta}{sin^3\theta} + \frac{g}{\ell}\sin\theta = 0$ [Option ID = 48414]

33) Neutrons are captured by ^{10}B to form ^{11}B , which breaks into an alpha particles and the ^{7}Li nucleus. Then, the kinetic energy of the ^{7}Li and the Q value of the reaction are (Given M(^{10}B) = 10.01611 amu; M(^{1}n) = 1.008987 amu; M (^{7}Li) = 7.01822 amu ; M (^{4}He)= 4.003879 amu)

[Question ID = 19620]

1. 1.01 MeV and 2.59 MeV [Option ID = 48473]
2. 1.78 MeV and 2.79 MeV [Option ID = 48472]
3. 1.01 MeV and 2.79 MeV [Option ID = 48471]
4. 1.78 MeV and 2.59 MeV [Option ID = 48474]

Correct Answer :-

- 1.01 MeV and 2.79 MeV [Option ID = 48471]

34) An ultrafast laser produces a sequence of pulses with a repetition time of T. The pulse is a wavepacket of energy E and a central wavelength of λ. The laser beam hits a mirror at an angle θ to the normal and is reflected. The average force on the mirror is

[Question ID = 19629]

1. None of these [Option ID = 48510]
2. $\frac{2\,E\cos\theta}{c\,T}$ [Option ID = 48509]
3. $\frac{E\cos\theta}{c\,T}$ [Option ID = 48507]
4. $\frac{E\cos 2\theta}{c\,T}$ [Option ID = 48508]

Correct Answer :-

- $\frac{2\,E\cos\theta}{c\,T}$ [Option ID = 48509]

35) The canonical partition function for a system of N non interacting particles is given by $\frac{1}{N!}(\alpha kT)^{3N}$, where α and k are constants. The internal energy of the system is (large N)

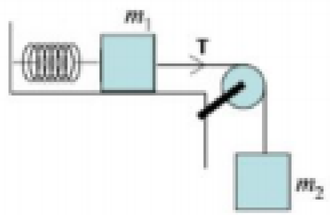
[Question ID = 19616]

1. 3NkT [Option ID = 48457]
2. $\frac{3}{2}NkT$ [Option ID = 48455]
3. $2NkT$ [Option ID = 48456]
4. $6NkT$ [Option ID = 48458]

Correct Answer :-

- 3NkT [Option ID = 48457]

36) The acceleration of the system given in the figure , where k is the spring constant and x is the displacement relative to the relaxed length of the spring, is



[Question ID = 19626]

1. $\frac{-kx + m_1 g}{m_1 + m_2}$ [Option ID = 48497]
2. $\frac{kx - m_2 g}{m_1 + m_2}$ [Option ID = 48496]
3. $\frac{-kx + m_2 g}{m_1 + m_2}$ [Option ID = 48495]
4. $\frac{kx - m_1 g}{m_1 + m_2}$ [Option ID = 48498]

Correct Answer :-

- $\frac{-kx + m_2 g}{m_1 + m_2}$ [Option ID = 48495]

37) A system, in three dimensions, is described by the Lagrangian

$$L = \frac{m}{2}(\dot{x}^2 + \dot{y}^2 + \dot{z}^2) + \dot{x}\sin(t) - \frac{k}{x^2 + y^2} + x\cos(t)$$

where k is constant. Of energy (E), linear momentum ($\vec{p}$) and angular momentum ($\vec{J}$), which are conserved?

[Question ID = 19602]

1. p_z alone [Option ID = 48399]
2. E, p_z and J_z alone. [Option ID = 48402]
3. $E, \vec{p}, \vec{J}$ [Option ID = 48401]
4. $\vec{p}$ alone [Option ID = 48400]

Correct Answer :-

- p_z alone [Option ID = 48399]

38) For a simple harmonic oscillator of mass m and angular frequency ω, if $|n\rangle$ represents the n-th energy eigenstate, then the expectation value $\langle n|\hat{p}^2|n\rangle$ is equal to:

[Question ID = 19588]

1. $m\hbar n\omega$ [Option ID = 48345]

2. $mh\omega\,(n+1/2)$ [Option ID = 48343]
3. $mh\omega\,(2n+1)$ [Option ID = 48344]
4. 0 [Option ID = 48346]

Correct Answer :-

. $mh\omega\,(n+1/2)$ [Option ID = 48343]

39) A feedback amplifier has an open loop gain of -100. If 4% of the output is fed back in a degenerative loop, the closed loop gain of the amplifier would be:

[Question ID = 19609]

1. +25 [Option ID = 48430]
2. +33 [Option ID = 48429]
3. -30 [Option ID = 48428]
4. -20 [Option ID = 48427]

Correct Answer :-

. -20 [Option ID = 48427]

40) In the first order X-ray (wavelength of 0.3 nm) diffraction measurement of a crystal having a body-centered cubic structure of lattice constant 0.4 nm, the diffracted beam for the (111) plane will emerge at an angle

[Question ID = 19598]

1. 20.25° [Option ID = 48384]
2. 40.5° [Option ID = 48385]
3. 81.0° [Option ID = 48386]
4. 10.12° [Option ID = 48383]

Correct Answer :-

. 40.5° [Option ID = 48385]

41) A particle of mass m moves in a screened coulomb potential given as $(\vec{r}) = -k\frac{e^{-ar}}{r}$, where k and a are positive constants. The condition for the existence of circular orbits for this motion would be given by

[Question ID = 19606]

1. $\dot{\theta} = \sqrt{\frac{k}{m}}(1 + ar_0)\; r_0^{-1/2} e^{-ar_0/2}$ [Option ID = 48417]
2. $\dot{\theta} = \sqrt{\frac{k}{m}}(1 + ar_0)\; r_0^{-3/2} e^{-ar_0/2}$ [Option ID = 48415]
3. $\dot{\theta} = \sqrt{\frac{k}{m}}(1 - ar_0)\; r_0^{-3/2} e^{-ar_0/2}$ [Option ID = 48416]
4. $\dot{\theta} = \sqrt{\frac{k}{m}}(1 - ar_0)\; r_0^{-1/2} e^{-ar_0/2}$ [Option ID = 48418]

Correct Answer :-

. $\dot{\theta} = \sqrt{\frac{k}{m}}(1 + ar_0)\; r_0^{-3/2} e^{-ar_0/2}$ [Option ID = 48415]

42) In a field effect transistor (FET), when the drain current changes from 1 mA to 1.9 mA with a change in gate-to-source voltage of 0.3 V, the transconductance is

[Question ID = 19608]

1. $3.0 \quad A/V$ [Option ID = 48425]
2. $3.0 \quad mA/V$ [Option ID = 48423]
3. $9.6 \quad A/V$ [Option ID = 48426]
4. $9.6 \quad mA/V$ [Option ID = 48424]

Correct Answer :-

- $3.0 \quad mA/V$ [Option ID = 48423]

43) The solution to the non-linear differential equation,

$$\frac{df}{dx} + \alpha f^2 = 0$$

with boundary condition $f(0) = 1$ and α a constant is given by,

[Question ID = 19624]

1. $\cos \alpha x$ [Option ID = 48487]
2. $\frac{\sin \alpha x}{\alpha x}$ [Option ID = 48488]
3. $(\alpha x + 1)^{-1}$ [Option ID = 48489]
4. $(\alpha x + 1)^{-2}$ [Option ID = 48490]

Correct Answer :-

- $(\alpha x + 1)^{-1}$ [Option ID = 48489]

44) The Hamiltonian for a particle of mass m in one dimension is given by

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2 + \lambda|x|$$

where ω and λ are real positive constants. For a small value of λ, the ground state energy to the leading order in λ is

[Question ID = 19593]

1. $E_0 = \frac{1}{2}\hbar\omega + 2\lambda\sqrt{\frac{\hbar}{m\pi\omega}}$ [Option ID = 48366]
2. $E_0 = \frac{1}{2}\hbar\omega + \frac{3\lambda}{2}\sqrt{\frac{\hbar}{m\pi\omega}}$ [Option ID = 48364]
3. $E_0 = \frac{1}{2}\hbar\omega + \lambda\sqrt{\frac{\hbar}{m\pi\omega}}$ [Option ID = 48365]
4. $E_0 = \frac{1}{2}\hbar\omega + \frac{\lambda}{2}\sqrt{\frac{\hbar}{m\pi\omega}}$ [Option ID = 48363]

Correct Answer :-

- $E_0 = \frac{1}{2}\hbar\omega + \lambda\sqrt{\frac{\hbar}{m\pi\omega}}$ [Option ID = 48365]

45)

Three 32×32 matrics A_i are known to obey the commutation rule

$$[A_i, A_j] = i\epsilon_{ijk}A_k$$

The matrix A_1 has the following eigen values:

± 2 (*twice each*), ± 1 (7 *times each*) and 0(14 *times*).

If $A^2 = A_1{}^2 + A_2{}^2 + A_3{}^2$, How often does A^2 have the eigenvalue 0?

[Question ID = 19595]

1. 14 times [Option ID = 48372]
2. The information is incomplete [Option ID = 48374]
3. 7 times [Option ID = 48371]
4. Never [Option ID = 48373]

Correct Answer :-

- 7 times [Option ID = 48371]

46) For a Geiger Muller (GM) Counter experiment, which of the following statement is true?

[Question ID = 19622]

1. GM counter cannot detect gamma-rays [Option ID = 48482]
2. GM counter can measure the energy of the both the beta and gamma-rays [Option ID = 48481]
3. GM Counter cannot discriminate between beta rays and gamma rays [Option ID = 48479]
4. Efficiency of the GM counter for gamma rays is more than that for beta rays. [Option ID = 48480]

Correct Answer :-

- GM Counter cannot discriminate between beta rays and gamma rays [Option ID = 48479]

47) For the molecules of an ideal gas the ratio of most probable speed to average speed to root mean square velocity is given by

[Question ID = 19611]

1. $\sqrt{2} : \sqrt{\pi/8} : \sqrt{3}$ [Option ID = 48438]
2. $\sqrt{3} : \sqrt{\pi/8} : \sqrt{2}$ [Option ID = 48437]
3. $\sqrt{3} : \sqrt{8/\pi} : \sqrt{2}$ [Option ID = 48436]
4. $\sqrt{2} : \sqrt{8/\pi} : \sqrt{3}$ [Option ID = 48435]

Correct Answer :-

- $\sqrt{2} : \sqrt{8/\pi} : \sqrt{3}$ [Option ID = 48435]

48) Consider an atom in a flame emitting in optical wavelengths. What would the typical Doppler broadening of a line be? [Question ID = 19619]

1. 10^{12} Hz [Option ID = 48467]
2. 10^{3} Hz [Option ID = 48470]
3. 10^{6} Hz [Option ID = 48469]
4. 10^{9} Hz [Option ID = 48468]

Correct Answer :-

- 10^{9} Hz [Option ID = 48468]

49) Which of the following equation is not gauge invariant? [Question ID = 19631]

1. $\nabla^2 \vec{B} - \frac{1}{c^2}\frac{\partial^2 \vec{B}}{\partial t^2} = 0$ [Option ID = 48517]

2. $\vec{\nabla}.\vec{E} = 0$ [Option ID = 48518]
3. $\nabla^2\vec{E} - \frac{1}{c^2}\frac{\partial^2\vec{E}}{\partial t^2} = 0$ [Option ID = 48516]
4. $\vec{\nabla}.\vec{A} + \frac{1}{c}\frac{\partial \phi}{\partial t} = 0$ [Option ID = 48515]

Correct Answer :-

- $\vec{\nabla}.\vec{A} + \frac{1}{c}\frac{\partial \phi}{\partial t} = 0$ [Option ID = 48515]

50) A small mass m with a charge q is attached to a spring constant k and allowed to oscillate with amplitude A. Assuming that the amplitude of the oscillations and the speed of the mass is small, the time averaged power radiated by the system is

[Question ID = 19634]

1. $\frac{\mu_0 q^2 A^2 k^2}{6\pi c\, m}$ [Option ID = 48529]
2. $\frac{1}{\sqrt{\epsilon_0 \mu_0^3}} \frac{q^2 A^2 k^2}{m^2}$ [Option ID = 48527]
3. $\frac{\mu_0 q^2 A^2 k^2}{12\pi c\, m^2}$ [Option ID = 48530]
4. $\sqrt{\epsilon_0 \mu_0^3}\, \frac{q A^2 k^2}{12\,\pi\, m^2}$ [Option ID = 48528]

Correct Answer :-

- $\frac{\mu_0 q^2 A^2 k^2}{12\pi c\, m^2}$ [Option ID = 48530]