CSIR-NET DECEMBER-2024

Part A

Question ID 705112

The value of $\left(1-\frac{1}{2025}\right)\left(1-\frac{1}{2024}\right)\left(1-\frac{1}{2023}\right)\ldots\left(1-\frac{1}{2001}\right)$ is

1. $\left(1-\frac{1}{79}\right)$ 2. $\left(1-\frac{1}{80}\right)$ 3. $\left(1-\frac{1}{81}\right)$ 4. $\left(1-\frac{1}{82}\right)$

Question ID 705101

A monkey covers exactly 10 m on ground in each jump. What is the least number of jumps required to reach a distance 1 m away from where the monkey jumps first?

1. 1 2. 2 3. 3 4. 9

Question ID 705108

A block of marble $4\ \mathrm{m} \times 3\ \mathrm{m} \times 2\ \mathrm{m}$ in size is cut into square tiles of 1 m side having thickness of 10 cm. Assuming there is no wastage in cutting, how many tiles will be made?

1. 120 2. 240 3. 360 4. 480

Question ID 705107

If A is B 's daughter, B is C 's brother and D is C's father, then what is A to D ?

1. Grandfather 2. Grandmother 3. Grandson 4. Granddaughter

Question ID 705111

Ramesh is taller than Rajesh but not taller than Rupesh. Suresh's height is the average of the heights of Naresh and Rajesh. If Rajesh is taller than Naresh then who is the shortest among them?

1. Suresh 2. Naresh

3. Rupesh 4. Cannot be determined

Question ID 705103

How many 5 -digit numbers, using 0 to 9, can be generated such that ' 123 ' appears as a string and no digit appears more than once?

1. 228 2. 108 3. 156 4.114

Question ID 705115

The square of the geometric mean of two positive integers is 30. The smallest possible sum of the two integers is

1. 10 2. 11 3. 13 4. 17

Question ID 705109

A lady walks one-tenth of the total distance at 3 km/h, one-sixth she runs at 5 km/h, one-fifth at 6 km/h, and covers the remaining 16 km at 16 km/h by cycle. What is the total distance?

1. 14 km 2. 16 km 3. 24 km 4. 30 km

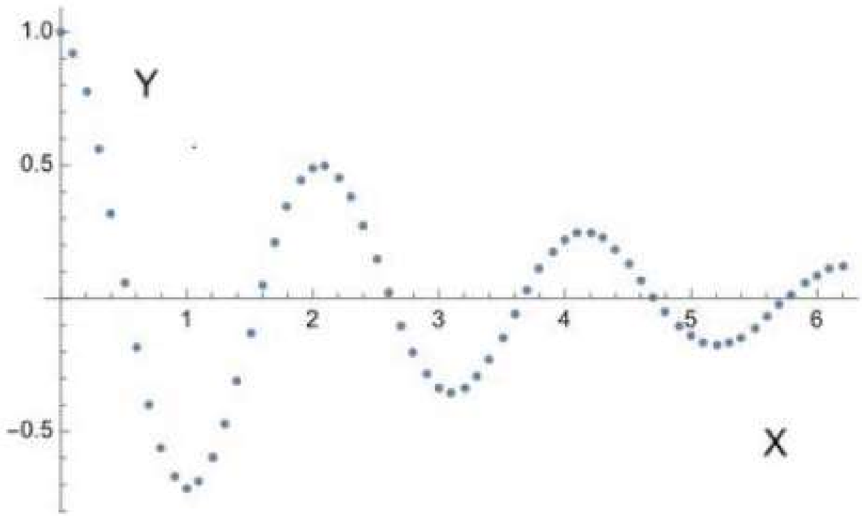
Question ID 705116

An electric heater uses approximately 1 KWH for increasing temperature of 1 L water by $1^{\circ}C$. If the heating element has a rating of 10 KW, what is the time taken to raise the temperature of 1 L water by $1^{\circ}C$?

1. 1 hour 2. 15 mins 3. 10 mins 4. 6 mins

Question ID 705117

An experiment has collected data in some units which is presented in the below X-Y graph.



What would be the best function to fit the data? (for some positive constant k)

1. $Y = \cos[kX]$ 2. $Y = \sin[kX^2]$ 3. $Y = \tan[kX^3]$ 4. $Y = e^{-\frac{x}{k}}\cos[kX]$

Question ID 705119

If Asha's mother is Tanisha's daughter's aunt and Tanisha has no nephew, then Asha is Tanisha's

1. mother 2. Niece 3. Grandmother 4. sister

Question ID 705114

Two fair dice are thrown at random independently. What is the probability that the average of the values on their upper faces is 4?

1. 5/36 2. 1/6 3. 7/36 4. 2/9

Question ID 705105

There are four containers of equal height, whose bases are a circle, a square, a rectangle and an equilateral triangle having the same area. Which one of the following statements about these containers is true?

1. Their volumes are equal.

2. Volume of the rectangular container is larger than that of the square container.

3. Volume of the triangular container is smaller than that of the square container.

4. Volume of the square container is larger than that of the circular container.

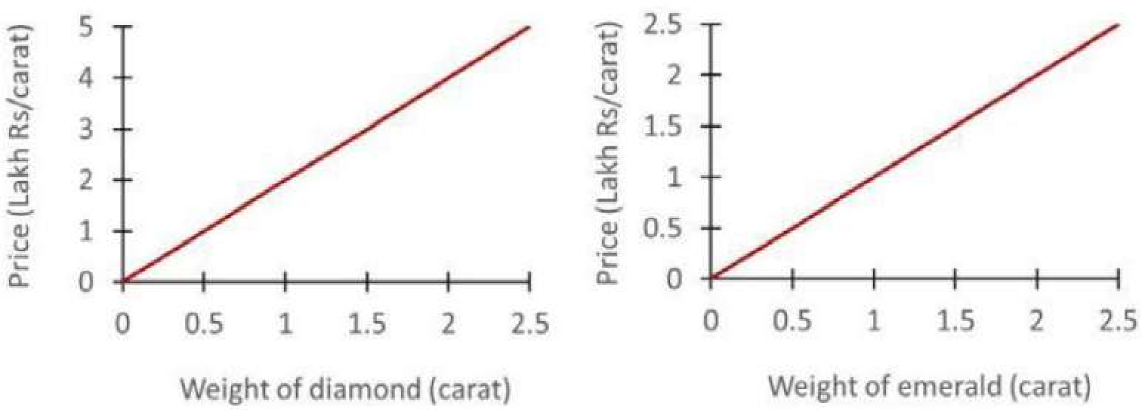
Question ID 705118

Ten litre (L) milk contains 10% water. How much water should be added to increase its proportion to 20% ?

1. 1 L 2. 1.25 L 3. 2 L 4. 2.25 L

Question ID 705106

The diagrams show the rates of diamond and emerald in a range of sizes. A person wants to buy



a diamond and an emerald of identical size for a total of Rs. $6{,}75{,}000/-$. What is that size?

1. 1 carat 2. 1.5 carat 3. 2 carat 4. 2.5 carat

Question ID 705120

A chocolate bar of 5 cm length and 4 cm width has to be cut into $1\text{ cm} \times 1\text{ cm}$ pieces. How many minimum cuts would be required, if pieces are to be taken one-by-one? (One can start by cutting along either length or width, before removing $1\text{ cm} \times 1\text{ cm}$ pieces one by one)

1. 20 2. 19 3. 18 4. 10

Question ID 705102

Cube root of 0.0125% is closest to

1. 0.005% 2. 0.05% 3. 0.5% 4. 5%

Question ID 705113

One side and one diagonal of a rhombus are 13 cm and 24 cm, respectively. Then the area of the rhombus is

1. $90\ \mathrm{cm}^2$ 2. $100\ \mathrm{cm}^2$ 3. $110\ \mathrm{cm}^2$ 4. $120\ \mathrm{cm}^2$

Question ID 705104

The diagrams show two orientations of a die having numbers 1 to 6 written on different faces. The number on the face opposite the face showing 3

1. is 2
2. is 1
3. is 6
4. cannot be determined from the given data

Question ID 705110

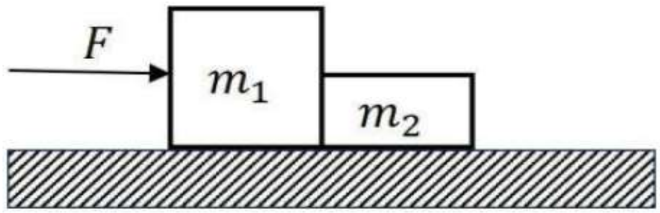
An OTP is made of six digits using 0 to 9. If three digits and their positions are known, what is the probability (in percentage) of discovering the full pin within 100 trials?

1. 10% 2. 20% 3. 30% 4. 40%

Part B

QID 705125:

Two blocks m_1 and m_2 are in contact on a frictionless horizontal table. A horizontal force is applied to one of the blocks, as shown in the figure.



If $m_1 = 2$ kg, $m_2 = 1$ kg, and $F = 3$ N, the force of contact between the blocks is

1. 1 N 2. $2N$ 3. 1.5 N 4. $3N$

Question ID 705121

Given the sum of the infinite series

$$\frac{1}{1^4} + \frac{1}{2^4} + \frac{1}{3^4} + \frac{1}{4^4} \cdots = \frac{\pi^4}{90}$$

the sum of the infinite series

$$\frac{1}{1^4} + \frac{1}{3^4} + \frac{1}{5^4} + \cdots$$

would be

1. $\frac{\pi^4}{128}$ 2. $\frac{\pi^4}{144}$ 3. $\frac{\pi^4}{120}$ 4. $\frac{\pi^4}{96}$

Question ID 705136

A sphere with uniform charge and mass density, having total charge Q and mass M, rotates about an axis through its center with angular velocity ω. The ratio of its magnetic dipole moment to its angular momentum is

1. $\frac{2Q}{M}$ 2. $\frac{Q}{M}$ 3. $\frac{Q}{2M}$ 4. $\frac{Q}{4M}$

Question ID 705137

An isolated box of volume V contains 5 identical, but distinguishable and noninteracting particles. The particles can either be in the ground state of zero energy or in an excited state of energy ε. The ground state is non-degenerate while the excited state is doubly degenerate. There is no restriction on the number of particles that can be put in a given state. The number of accessible microstates corresponding to the macrostate of the system with energy $E = 2\varepsilon$ are

1. 10 2. 20 3. 40 4. 30

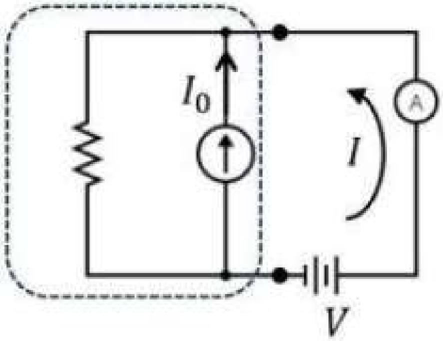
Question ID 705142

A DC motor operating at a voltage V and a current I is used to lift a mass m to a height h. The percentage uncertainty in the measurement of time t is 5% and that for the other parameters ($V, I, m,$ and h) are 1% each. If the measurements are independent and the errors are random, the uncertainty in the estimation of the efficiency $\left(\frac{\text{output power}}{\text{input power}}\right)$ of the motor is closest to

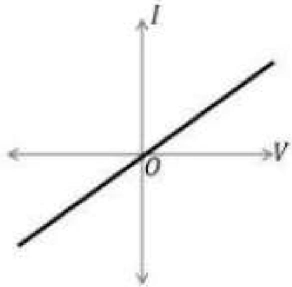
1. 3.1% 2. 5.4% 3. 4.8% 4. 6.3%

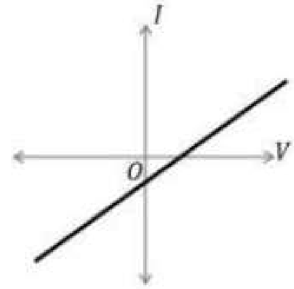
Question ID 705141

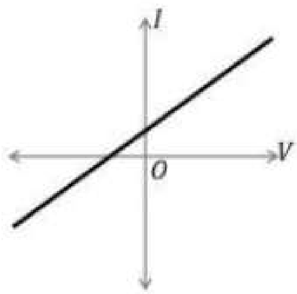
A circuit component consists of a resistor in parallel with an ideal current source. The I-V characteristics of the component was measured using a variable voltage source and an ammeter ' A '.

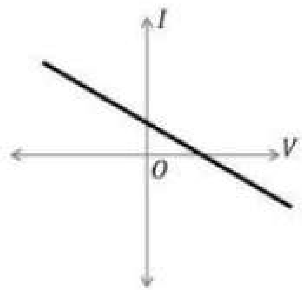


The arrow in the figure indicates the positive direction of current. The I-V characteristics of the component is best represented by

1.


2.


3.


4.


Question ID 705127

A certain elementary particle is created in the upper atmosphere. It then moves downward with speed $v = 0.9999c$ with respect to an observer on earth. Its lifetime in its rest frame is 2×10^{-6}sec. The distance (in the earth's frame) travelled by the elementary particle before it decays is closest to

1. 0.6 km 2. 42 km 3. 12 km 4. 72 km

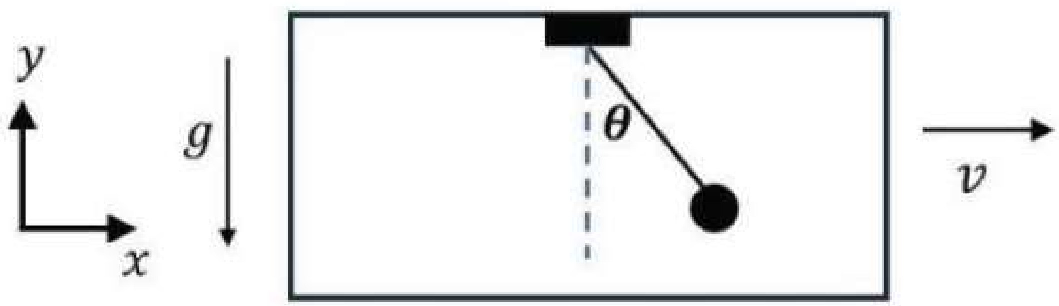
Question ID 705139

For an ideal Bose gas, the density of states is given by $\rho(E) = CE^2$, where C is a positive constant. Assume that the number of bosons is not conserved. The variation of the specific heat of the gas with temperature T is closest to

1. T^2 2. T^3 3. T 4. T^4

Question ID 705126

The point of support of a simple pendulum, of mass m and length l, is attached to the roof of a taxi as shown in the figure. The taxi is moving with uniform velocity v. The Lagrangian for the



pendulum is

1. $L = \frac{1}{2}ml^2\dot{\theta}^2 + \frac{1}{2}mv^2 + mlv\cos\,\theta\dot{\theta} - mgl\cos\,\theta$

2. $L = \frac{1}{2}ml^2\dot{\theta}^2 + \frac{1}{2}mv^2 + mlv\cos\,\theta\dot{\theta} + mgl\cos\,\theta$

3. $L = \frac{1}{2}ml^2\dot{\theta}^2 + \frac{1}{2}mv^2 + mlv\sin\,\theta\dot{\theta} + mgl\cos\,\theta$

4. $L = \frac{1}{2}ml^2\dot{\theta}^2 + \frac{1}{2}mv^2 + mlv\sin\,\theta\dot{\theta} - mgl\cos\,\theta$

Question ID 705134

A grating spectrometer in vacuum, illuminated by 500 nm light, gives first-order spectrum at an angle of 20°. When the vacuum chamber is filled with Argon gas at pressure P, this angle

1. increases, due to increase in the refractive index of the medium

2. decreases, due to increase in the refractive index of the medium

3. decreases, due to decrease in the frequency of light in argon gas

4. increases, due to decrease in the frequency of light in argon gas

Question ID 705122

If I is an $n \times n$ identity matrix and adj $(2I) = 2^k I$, then k is equal to

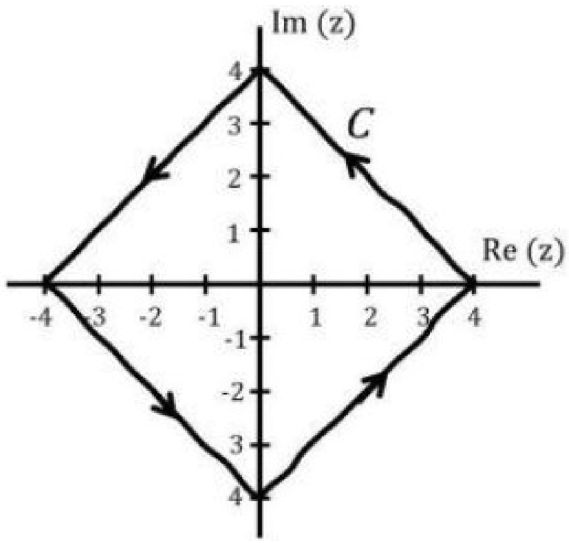
1. 1 2. n 3. $n-1$ 4. 2

Question ID 705145

The value of the integral (where k is a constant),

$$\frac{1}{2\pi i}\oint_C \frac{5}{(z-2)^2}\sin(kz)dz$$

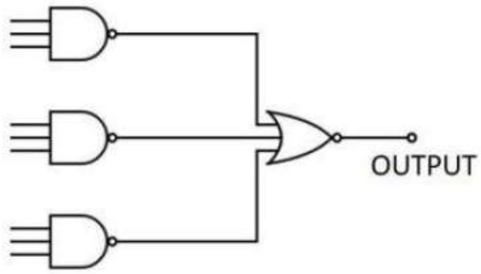
over the closed contour C as shown below, is



1. $5k\cos(2k)$ 2. $5k\sin(2k)$ 3. $5\cos(2k)$ 4. $-5k^2\sin(2k)$

Question ID 705143

The output of the following circuit is always found to be zero.

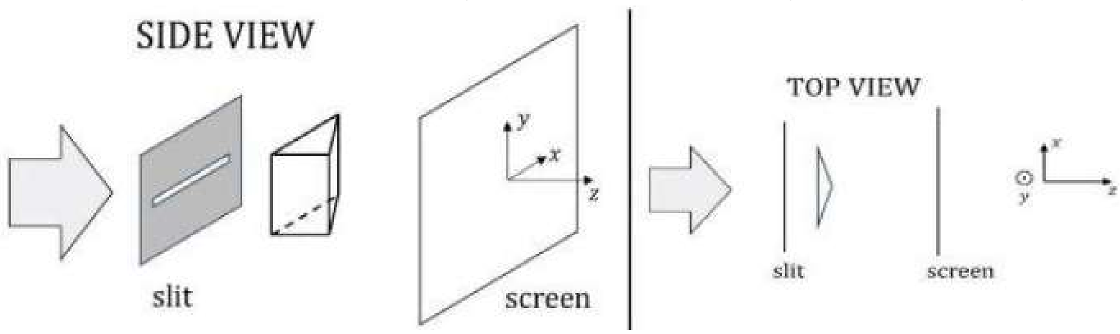


Such an observation can be due to

1. Two of the inputs of any one of the NAND gates being accidentally shorted to each other
2. One of the inputs to the NOR gate being accidentally grounded
3. One of the inputs to one of the NAND gates being accidentally grounded
4. Two of the inputs of the NOR gate being accidentally shorted to each other

Question ID 705133

A narrow horizontal slit is illuminated by an extended sodium lamp. A thin Fresnel biprism with



its edge aligned perpendicular to the slit is positioned, as shown in the figure.

Given that the length of the slit is larger than the base of the biprism, the pattern of illumination on the screen is best described by

1. Fringes in both x and y direction.
2. Almost uniform illumination.
3. Horizontal fringes periodic only along the x-axis.
4. Horizontal fringes periodic only along the y-axis.

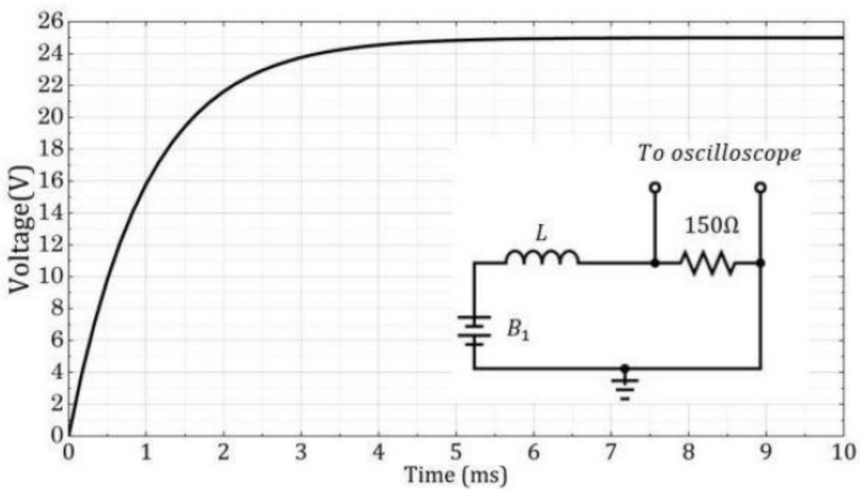
Question ID 705130

Consider a particle in a one-dimensional infinite potential well between $0 \leq x \leq L$. If a small perturbation, $V(x) = \lambda \cos\left(\frac{\pi x}{L}\right)$, (where $\lambda \ll 1$) is applied, the firstorder energy correction to the ground state is

1. λ 2. 0 3. $-\lambda$ 4. 2λ

Question ID 705144

An ideal inductor L is connected in series to a 150Ω resistor as shown in the circuit (inset). When the circuit is driven by a battery B_1, the voltage across the resistor as a function of time, as measured by an oscilloscope, is shown in the plot.



Based on this observation, the estimated value of L is closest to

1. 50 mH 2. 300 mH 3. 450 mH 4. 150 mH

Question ID 705123

The following table shows the relationship between an independent quantity x and an experimentally measured quantity y.

x	0	1	2	3	4	5
y	0.1	2.1	8.1	17.9	32.2	49.7

The relationship between x and y is best represented by

1. $y \propto x^3$ 2. $y \propto e^x$ 3. $y \propto x^2$ 4. $y \propto \sqrt{x}$

Question ID 705128

A particle of rest mass m_0 and energy E collides with another particle at rest, with the same rest mass. What is the minimum value of E so that after the collision, there may be four particles of rest mass m_0 ?

1. $4m_0c^2$ 2. $3m_0c^2$ 3. $7m_0c^2$ 4. $16m_0c^2$

Question ID 705140

A spherical cavity of volume V is filled with thermal radiation at temperature T. The cavity expands adiabatically to 8 times its initial volume. If σ is Stefan's constant and c is the speed of light in vacuum, what is the closest value of the work done in the process?

1. $8\left(\frac{\sigma\pi^4 V}{c}\right)$ 2. $4\left(\frac{\sigma\pi^4 V}{c}\right)$ 3. $\frac{1}{2}\left(\frac{\sigma T^4 V}{c}\right)$ 4. $2\left(\frac{\sigma\pi^4 V}{c}\right)$

Question ID 705131

An electron is in the spin state $|\psi\rangle = \frac{1}{5}\binom{3i}{4}$ in the $\hat{S}_z$ basis. A measurement of $\hat{S}_x$ is made on this state. The probabilities of getting $\hbar/2$ and $-\hbar/2$ are

1. $\frac{1}{3}, \frac{2}{3}$ 2. $\frac{1}{4}, \frac{3}{4}$ 3. $\frac{1}{2}, \frac{1}{2}$ 4. $\frac{3}{7}, \frac{4}{7}$

Question ID 705138

A system comprises of N distinguishable atoms ($N \gg 1$). Each atom has two energy levels ω and $3\omega (\omega > 0)$. Let ε_{eq} denote the average energy per particle when the system is in thermal equilibrium, the upper limit of ε_{eq} is

1. $\frac{3\omega}{2}$ 2. 3ω 3. $\frac{5\omega}{2}$ 4. 2ω

Question ID 705129

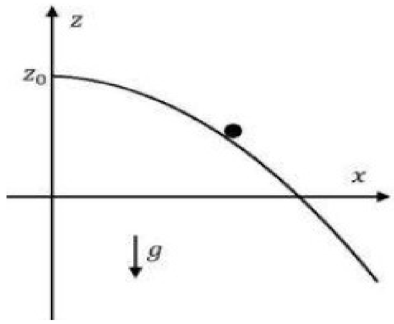
A particle of mass m is in a cubic box of side a. The potential inside the box ($0 \leq x \leq a, 0 \leq y \leq a, 0, \leq z \leq a$) is zero and infinite outside. If the particle is in an energy eigenstate with $E = \frac{7\pi^2\hbar^2}{ma^2}$, a possible wavefunction is

1. $\psi = \left(\frac{2}{a}\right)^{3/2} \sin\left(\frac{\pi x}{a}\right) \sin\left(\frac{\pi y}{a}\right) \sin\left(\frac{2\pi z}{a}\right)$ 2. $\psi = \left(\frac{2}{a}\right)^{3/2} \sin\left(\frac{\pi x}{a}\right) \sin\left(\frac{3\pi}{a}\right) \sin\left(\frac{\pi z}{a}\right)$

3. $\psi = \left(\frac{2}{a}\right)^{3/2} \sin\left(\frac{\pi x}{a}\right) \sin\left(\frac{2\pi y}{a}\right) \sin\left(\frac{3\pi}{a}\right)$ 4. $\psi = \left(\frac{2}{a}\right)^{3/2} \sin\left(\frac{\pi x}{a}\right) \sin\left(\frac{2\pi y}{a}\right) \sin\left(\frac{2\pi z}{a}\right)$

Question ID 705144

A frictionless track is defined by $z = z_0 - \frac{x^2}{4z_0}$, as shown in the figure.

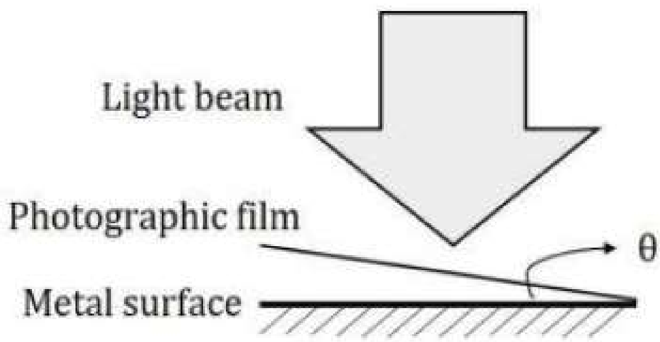


A particle is constrained to slide down the track under the action of gravity. The tangential acceleration at position (x, z) would be

1. $\frac{2gx}{\sqrt{x^2+4z_0{}^2}}$ 2. $\frac{gx}{\sqrt{x^2+4z_0^2}}$ 3. $\frac{gx}{2z_0}$ 4. $g\sqrt{\frac{x(x+z_0)}{x^2+4z_0^2}}$

Question ID 705135

When a photographic film is exposed to light, the electric field of light causes the film to turn dark after chemical processing. A photographic film of thickness 50 nm is kept inclined to a shiny metal surface at an angle of $\theta = 0.01$ radian, as shown in the figure.



After exposing this film to a linearly polarized beam of light of wavelength 500 nm incident normally to the metal surface, it developed periodic bright bands. We can explain this observation as the proof of

1. Interference between the incident wave and the wave reflected from the surface of the metal.
2. Diffraction pattern produced by the photographic film.
3. Interference of light due to the presence of photographic film.
4. Polarization of light due to photographic film.

Question ID 705132

Two non-interacting identical spin $-\frac{1}{2}$ particles, each of mass m, are placed in a two-dimensional infinite square well of side L. The single-particle spatial wavefunction is given by

$$\varphi_{n_x,n_y}(x,y) = \frac{2}{L}\sin\left(\frac{n_x \pi x}{L}\right)\sin\left(\frac{n_y \pi y}{L}\right)$$

where n_x and n_y are positive integers. If the particles are in a total spin state $|j = 1, m = 0\rangle$, the lowest possible energy eigenvalue is

1. $\frac{5\hbar^2\pi^2}{2mL^2}$ 2. $\frac{\hbar^2\pi^2}{mL^2}$ 3. $\frac{2\hbar^2\pi^2}{mL^2}$ 4. $\frac{7\hbar^2\pi^2}{2mL^2}$

Part C

Question ID 705146

A class has 60% boys and 40% girls. In an examination 8% of the boys and 12% of the girls got an ' A ' grade. If a randomly selected student had an ' A ' grade, what is the probability that the student is male?

1. 0.7   2. 0.6   3. 0.4   4. 0.5

Question ID 705161

Consider a free fermion gas in a hypercubic infinite potential well in hypothetical 4-dimensional space. What will be the expression for ground state energy per particle in term of the Fermi energy E_F ? (Ignore spin degeneracy of the fermions)

1. $\frac{4}{5} E_F$ 2. $\frac{2}{3} E_F$ 3. $\frac{1}{3} E_F$ 4. $\frac{2}{5} E_F$

Question ID 705163

Bose condensation experiments are carried out on two samples A and B of an ideal Bose gas. The same gas species is used in both. The condensate densities achieved at a given temperature below the critical temperature are $n_{\mathrm{A}}= 1.80 \times 10^{14} \mathrm{~cm}^{-3}$ and $n_{\mathrm{B}}=1.44 \times 10^{15} \mathrm{~cm}^{-3}$, respectively. If P_{A} and P_{B} are the pressures of the two gas samples, the ratio $\frac{P_{\mathrm{A}}}{P_{\mathrm{B}}}$ is

1. 1   2. $\left(\frac{1}{8}\right)^{\frac{3}{2}}$ 3. $\left(\frac{1}{8}\right)^{\frac{2}{3}}$ 4. 8

Question ID 705160

Energy of two Ising spins $\left(s=\pm \frac{1}{2}\right)$ is given by

$$E=s_1 s_2+s_1+s_2$$

At temperature T, the probability that both spins take the value $-\frac{1}{2}$ is 16 times the probability that both take the value $+\frac{1}{2}$. At the same temperature, what is the probability that the spins take opposite values?

1. $\frac{16}{25}$ 2. $\frac{8}{25}$ 3. $\frac{8}{33}$ 4. $\frac{16}{33}$

Question ID 705151

The Lagrangian of a system is

$$L = \frac{15}{2} m\dot{x}^2 + 6m\dot{x}\dot{y} + 3m\dot{y}^2 - mg(x + 2y)$$

Which one of the following is conserved?

1. $12\dot{x} + 3\dot{y}$ 2. $12\dot{x} - 3\dot{y}$ 3. $3\dot{x} - 12\dot{y}$ 4. $3\dot{x} + 3\dot{y}$

Question ID 705169

A hydrogen atom, excited to electronic configuration $3S_{1/2}$ (nL_j notation), relaxes to the ground state via electric dipole transitions. Considering only fine structure and ignoring hyperfine structure, the maximum number of emitted spectral lines is

1. 3 2. 6 3. 1 4. 4

Question ID 705150

A non-relativistic particle of mass m and charge q is moving in a magnetic field $\vec{B}(x, y, z)$. If $\vec{v}$ denotes its velocity and $\{\ldots\}_{P.B}$. denotes the Poisson Bracket, then $\epsilon_{ijk}\{v_i, v_j\}_{P.B.}$ is equal to

1. $-\frac{q}{m^2} B_k$ 2. 0 3. $\frac{2q}{m^2} B_k$ 4. $\frac{q}{m^2} B_k$

Question ID 705173

For the decay of the Δ-baryons, the ratio of the decay rates $\frac{\Gamma(\Delta^- \to n\pi^-)}{\Gamma(\Delta^0 \to p\pi^-)}$ is best approximated by

1. $\frac{3}{2}$ 2. 3 3. 1 4. $\frac{2}{3}$

Question ID 705157

A static charge distribution produces an electric field

$$\vec{E} = \frac{Q}{4\pi\epsilon_0} \frac{e^{-br}}{r^3} \vec{r}$$

where $Q, b > 0$ are constants. The charge density of the distribution is given by

1. $\frac{Q}{4\pi}\left[-\frac{b}{2r^2}\right]$ 2. $\frac{Q}{4\pi} e^{-b}\left[-\frac{b}{r^2} - 4\pi\delta(\vec{r})\right]$

3. $\frac{Q}{4\pi} e^{-b} \left[-\frac{2b}{r^2}\right]$ 4. $\frac{Q}{4\pi} e^{-b} \left[-\frac{b}{r^2} + 4\pi\delta(\vec{r})\right]$

Question ID 705152

For the transformation

$$Q = \ln\left(1 + q^{1/2}\cos\, p\right), P = 2q^{1/2}\left(1 + q^{1/2}\cos\, p\right)\sin\, p$$

the generating function is

1. $-(e^Q - 1)^2 \cot\, p$ 2. $(e^Q - 1)^2 \cot\, p$ 3. $(e^Q - 1)^2 \tan\, p$ 4. $-(e^Q - 1)^2 \tan\, p$

Question ID 705154

A particle of mass m is bound in one dimension by the potential $V(x) = V_0\delta(x)$ with $V_0 < 0$. If the probability of finding it in the region $|x| < a$ is 0.25 , then a is

1. $\frac{\hbar^2}{4mV_0}\ln\frac{3}{4}$ 2. $\frac{\hbar^2}{2mV_0}\ln\frac{3}{4}$ 3. $\frac{\hbar^2}{4mV_0}\ln\frac{1}{4}$ 4. $\frac{\hbar^2}{2mV_0}\ln\frac{1}{4}$

Question ID 705147

Gamma function with argument z is defined as

$$\Gamma[z] = \int_0^\infty dt t^{z-1}e^{-t}$$

where z is a complex variable and $\mathrm{Re}\ z \geq 0. \Gamma[z]$ has

1. a branch point at $z = 0$
2. a simple pole at $z = 0$
3. a removable singularity at $z = 0$
4. an essential singularity at $z = 0$

Question ID 705159

Consider a spherical region of radius $\frac{R}{2}$ centered at the origin of the coordinate system. Three point charges each of magnitude Q are placed at $(0,0,R), (0,R,0)$ and $(\sqrt{2}R, 0,0)$. What is the magnitude of the average electric field over the spherical region due to these charges in units of $\frac{Q}{4\pi\epsilon_0 R^2}$?

1. $\frac{3}{5}$ 2. 0 3. $\frac{5}{2}$ 4. $\frac{3}{2}$

Question ID 705155

A particle of mass m, moving in one-dimension is subjected to the potential

$$V(x) = \begin{cases} V_0\delta(x-a) & 0 < x < 2a \\ \infty & \text{otherwise} \end{cases}$$

The energy eigenvalues E satisfy

1. $\tan\frac{a\sqrt{2m}}{\hbar} = \frac{\hbar}{V_0}\sqrt{\frac{2E}{m}}$
3. $\tanh\frac{a\sqrt{2mE}}{\hbar} = \frac{\hbar}{V_0}\sqrt{\frac{2E}{m}}$
3. $\tan\frac{a\sqrt{2mE}}{\hbar} = -\frac{\hbar}{V_0}\sqrt{\frac{2E}{m}}$
4. $\tanh\frac{a\sqrt{2mE}}{\hbar} = -\frac{\hbar}{V_0}\sqrt{\frac{2E}{m}}$

Question ID 705165

Magnetization M as a function of applied magnetic field H for two different solid samples at temperature T are shown below. These samples are known to be superconducting below their respective critical temperatures (T_C).

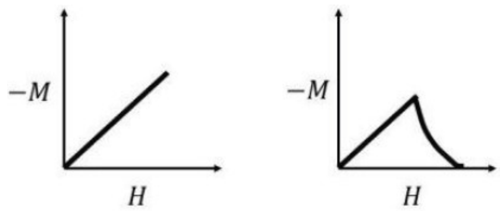


Fig. 1 Fig. 2

The correct set of statements is

1. Fig. 1: Type I superconductor above T_C;
Fig. 2: Type II superconductor below T_C and upto upper critical field;
2. Fig. 1: Type II superconductor below T_C and upto upper critical field;
Fig. 2: Type II superconductor below T_C and upto lower critical field.
3. Fig. 1: Type I superconductor below T_C and below critical field;
Fig. 2: Type II superconductor below T_C upto upper critical field;
4. Fig. 1: Type I superconductor below T_C and below critical field;
Fig. 2: Type II superconductor below T_C and below lower critical field.

Question ID 705156

For a system of two electrons, define an operator

$$\hat{A}=\frac{3}{a^2}\left(\hat{\vec{S}}_1\cdot\vec{a}\right)\left(\hat{\vec{S}}_2\cdot\vec{a}\right)-\hat{\vec{S}}_1\cdot\hat{\vec{S}}_2$$

where $\vec{a}$ is an arbitrary vector, and $\hat{\vec{S}}_1$ and $\hat{S}_2$ are spin operators. The eigenvalues of $\hat{A}$ (in units of $\hbar^2$) are

1. $-1,1,\frac{3}{2},\frac{3}{2}$ 2. $-1,-\frac{1}{2},-\frac{1}{2},0$ 3. $\frac{1}{2},1,\frac{3}{2},\frac{3}{2}$ 4. $0,\frac{1}{2},\frac{1}{2},-1$

Question ID 705168

Consider the Bromine ion Br^{+}in its ground state. The atomic number of Br is 35. The fine structure term symbol $\left({}^{2S+1}L_J\right)$ under the LS coupling scheme for the lowest energy state of this ion would be

1. ${}^3P_2$ 2. ${}^3P_0$ 3. ${}^1D_2$ 4. ${}^4S_{3/2}$

Question ID 705149

The complex integral $\int_C z^4 \exp\left(\frac{1}{2z}\right) dz$, where C is the unit circle centered around the origin traversed counter-clock-wise, equals

1. $\frac{\pi i}{120}$ 2. $\frac{\pi i}{960}$ 3. 0 4. $\frac{\pi i}{1920}$

Question ID 705153

A spherical cavity of radius r_0 has an impenetrable wall. A quantum particle of mass m inside the cavity is in its ground state. The pressure exerted on the cavity wall is

1. $\frac{\pi\hbar^2}{4mr_0^5}$ 2. $\frac{\pi\hbar^2}{mr_0^5}$ 3. $\frac{\pi^2\hbar^2}{2mr_0^5}$ 4. $\frac{\pi^2\hbar^2}{4mr_0^5}$

Question ID 705158

An electron enters a region of uniform electric and magnetic fields $\vec{E}_0$ and $\vec{B}_0$. Its velocity, $\vec{E}_0$ and $\vec{B}_0$ are mutually perpendicular to each other. Initially, E_0 is so adjusted that the electron suffers no deflection. E_0 is then switched off and the electron moves in a circular path of radius R. The speed of the electron and its charge to mass ratio would be

1. $\frac{2E_0}{B_0}, \frac{E_0}{2B_0^2R}$ 2. $\frac{2E_0}{B_0}, \frac{E_0}{B_0^2R}$ 3. $\frac{E_0}{B_0}, \frac{E_0}{B_0^2R}$ 4. $\frac{E_0}{B_0}, \frac{2E_0}{B_0^2R}$

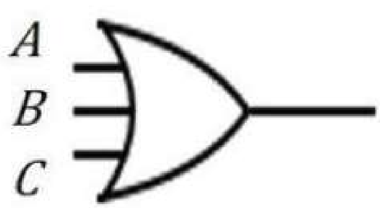
Question ID 705170

The logic circuit that will have the output

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

is

1.



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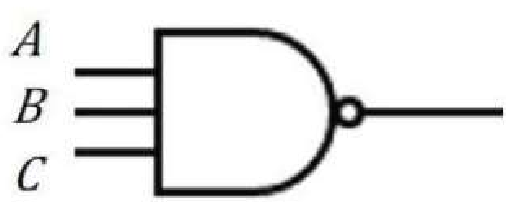
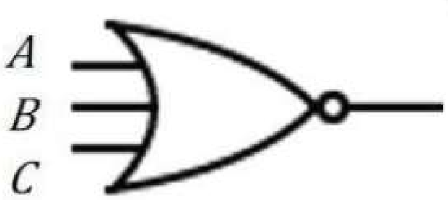
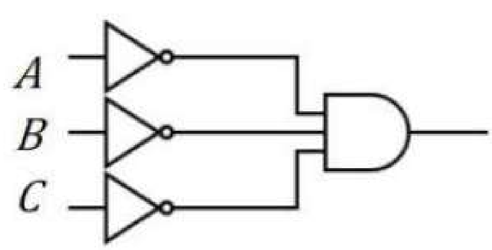


3.



4.

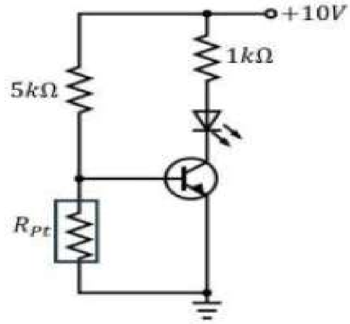


Question ID 705172

An LED is required to glow brightly when the temperature sensed by a Platinum resistance thermometer exceeds a certain value. In the circuit shown below, the resistance of the Pt thermometer (in ohms) varies as

$$R_{Pt}(T) = 100 + 0.4\,T$$

where T is temperature in degree Celsius. The transistor turns on when $V_{BE} > 0.7$ V and it has a very high current gain. The temperature at which the LED would start glowing is closest to



1. 850°C 2. 400°C 3. 500°C 4. 700°C

Question ID 705174

The masses of proton, neutron, Polonium and Lead nuclei are as follows:

$$m_p = 1.007825\text{a.u}, m_n = 1.008665\text{a.u}$$
$$m({}^{210}_{84}Po) = 209.982876\text{a.u}, m({}^{206}_{82}\text{Pb}) = 205.974455\text{a.u.}$$

Binding energy of ${}^4_2$He is 28.80 MeV and $1\text{a.u} = 931.99\frac{\text{MeV}}{c^2}$.

The binding energies of ${}^{210}_{84}$Po, ${}^{206}_{82}$Pb and the Q value of the α-decay of ${}^{210}_{84}$Po are closest to

1. 1645.21MeV, 1622.33MeV, 5.92MeV 2. 1645.21MeV, 1622.33MeV, −5.92MeV

3. 1545.21MeV, 1522.33MeV, −5.92MeV 4. 1645.21MeV, 1522.33MeV, 5.92MeV

Question ID 705162

Eigenstates of a system are specified by two non negative integers n_1 and n_2. The energy of the system is given by

$$E_n = \left(n_1 + \frac{1}{2}\right)\hbar\omega + \left(n_2 + \frac{1}{2}\right)2\hbar\omega.$$

If $\alpha \equiv \exp\left(-\frac{\hbar\omega}{k_BT}\right)$, what is the probability that at temperature T the energy of the system will be less than $4\hbar\omega$?

1. $(1-\alpha^2)(1-\alpha)(2+\alpha+2\alpha^2)$ 2. $(1-\alpha)^2(1-\alpha)(2+\alpha+\alpha^2)$

3. $(1-\alpha^2)(1+\alpha)(1+\alpha+2\alpha^2)$ 4. $(1-\alpha)^2(1+\alpha)(1+\alpha+2\alpha^2)$

Question ID 705167

The hyperfine splitting of the ground state of the hydrogen atom is given as

$$\Delta E \propto \frac{g_p g_e}{m_p m_e a^3}$$

where g_p and g_e are the nuclear and electron Landê g factors respectively, and a is the orbital radius of the ground state. It is given that g (proton) $= 5.59$. In Hydrogen, transition between these split levels corresponds to radiation of wavelength 21 cm .

If the proton is replaced by a positron, the corresponding wavelength would be

1. 2.6 mm 2. 3.2 mm 3. 3.2 cm 4. 2.6 cm

Question ID 705175

Naturally occurring uranium is a mixture of the ^{238}U (99.28%) and $^{235}U(0.72\%)$ isotopes. The life times are $\tau(^{235}U) = 1 \times 10^9$ years and $\tau(^{238}U) = 6.6 \times 10^9$ years. What is the closest value of the age of the solar system if one assumes that at its creation both isotopes were present in equal quantities?

1. 6.2×10^9 years 2. 5.8×10^9 years 3. 4.7×10^9 years 4. 7.2×10^9 years

Question ID 705164

Consider N mutually non-interacting electrons moving in a crystal where the ionic potential seen by an electron satisfies the condition $V(\vec{r}) = V(\vec{r} + \vec{R})$, where $\vec{R}$ is one of the lattice translation vectors. The energy eigenstates of the electrons are labelled as $\psi_{\vec{k}}(\vec{r})$ where $\vec{k}$ is a vector in the first Brillouin zone. Which of the following is true?

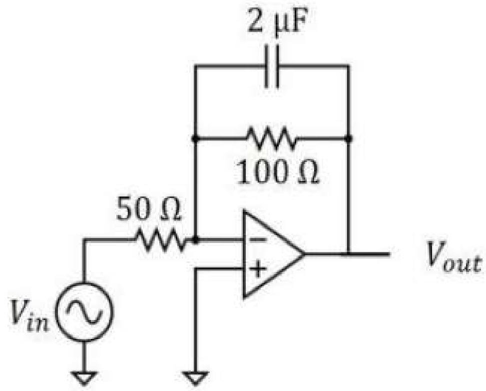
1. $|\psi_{\vec{k}}(\vec{r})|$ is constant.
2. $\psi_{\vec{k}}(\vec{r})$ is also an eigenstate of the momentum operator.
3. $\psi_{\vec{k}}(\vec{r}) = \psi_{\vec{k}}(\vec{r} + \vec{R})$
4. $|\psi_{\vec{k}}(\vec{r})| = |\psi_{\vec{k}}(\vec{r} + \vec{R})|$

Question ID 705171

In the circuit shown below, the input voltage (in volts) is given by

$$V_{in}(t) = 0.1\sin(\omega_1 t) + \sin(\omega_2 t)$$

where $\omega_1 = 5 \times 10^2\ \mathrm{s}^{-1}$ and $\omega_2 = 5 \times 10^4\ \mathrm{s}^{-1}$.



The time varying part of the output voltage $V_{\mathrm{out}}(t)$ (in volts) is closest to

1. $-0.2\sin(\omega_1 t) - 2\sin(\omega_2 t)$
2. $-0.2\sin(\omega_1 t) + 0.2\cos(\omega_2 t)$
3. $2\cos(\omega_1 t) + 0.2\cos(\omega_2 t)$
4. $2\cos(\omega_1 t) - 2\sin(\omega_2 t)$

Question ID 705166

The lattice spacing in a simple cubic lattice is given to be $5\mathrm{\AA}$. The number of lattice points per square nanometer in the lattice plane with Miller index (212) is closest to

1. 7.5
2. 3
3. 1.33
4. 0.66

Question ID 705148

The constant B which makes e^{-ax^2} an eigenfunction of the operator $\left(\frac{d^2}{dx^2} - Bx^2\right)$ is

1. $4a^2$
2. 0
3. $2a$
4. 1