PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

CSIR NET Physics - June 2023 - Full Paper

Complete question paper with answer key

75 questions . Answer key included

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Q1. [June 2023] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2023 June	2M

When a student in Section A who scored 100 marks in a subject is exchanged for a student in Section B who scored 0 marks, the average marks of the Section A falls by 4, while that of Section B increases by 5. Which of the following statements is true?

1. A has the same strength as B
2. A has 5 more students than B
3. B has 5 more students than A
4. The relative strengths of the classes cannot be assessed from the data

Q2. [June 2023] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2023 June	2M

Which of the numbers $A = 162^3 + 327^3$ and $B = 612^3 - 123^3$ is divisible by 489 ?

1. Both A and B
2. A but not B
3. B but not A
4. Neither A nor B

Q3. [June 2023] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2023 June	2M

At a spot S en-route, the speed of a bus was reduced by 20% resulting in a delay of 45 minutes. Instead, if the speed were reduced at 60 km after S, it would have been delayed by 30 minutes. The original speed, in km/h, was

1. 90
2. 80
3. 70
4. 60

Q4. [June 2023] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2023 June	2M

Three consecutive integers a, b, c, add to 15 . Then the value of $(a-2)^2+(b-2)^2+(c-2)^2$ would be

1. 25
2. 27
3. 29
4. 31

Q5. [June 2023] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2023 June	2M

A 50 litre mixture of paint is made of green, blue, and red colours in the ratio 5: 3: 2. If another 10 litre of red colour is added to the mixture, what will be the new ratio?

1. 5:2:4
2. 4:3:2
3. 2:3:5
4. 5:3:4

Q6. [June 2023] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2023 June	2M

Price of an item is increased by 20% of its cost price and is then sold at 10% discount for Rs. 2160. What is its cost price?

1. 1680
2. 1700
3. 1980
4. 2000

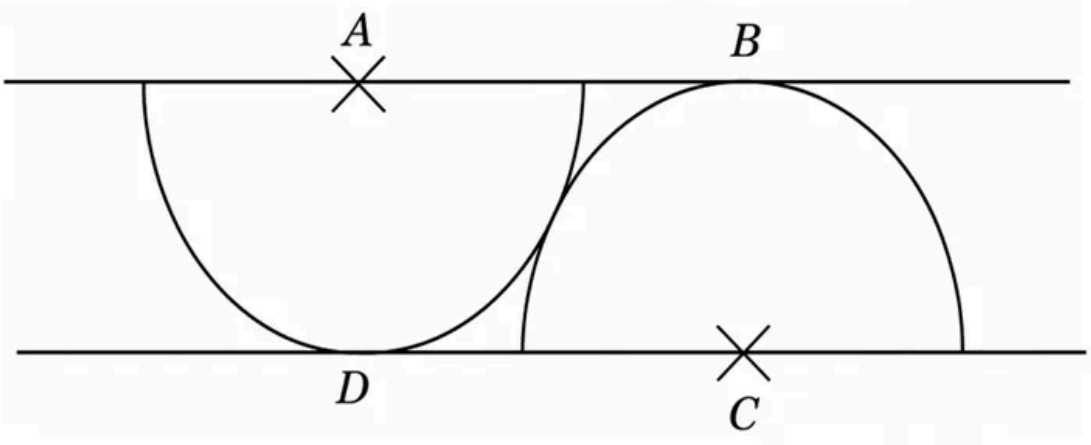
Q7. [June 2023] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2023 June	2M

Two semicircles of same radii centred at A and C, touching each other, are placed between two parallel lines, as shown in the figure. The angle BAC is

1. 30°
2. 35°
3. 45°
4. 60°



Q8. [June 2023] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2023 June	2M

What is the largest number of father-son pairs that can exist in a group of four men?

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

Q9. [June 2023] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2023 June	2M

Three friends having a ball each stand at the three corners of a triangle. Each of them throws her ball independently at random to one of the others, once. The probability of no two friends throwing balls at each other is

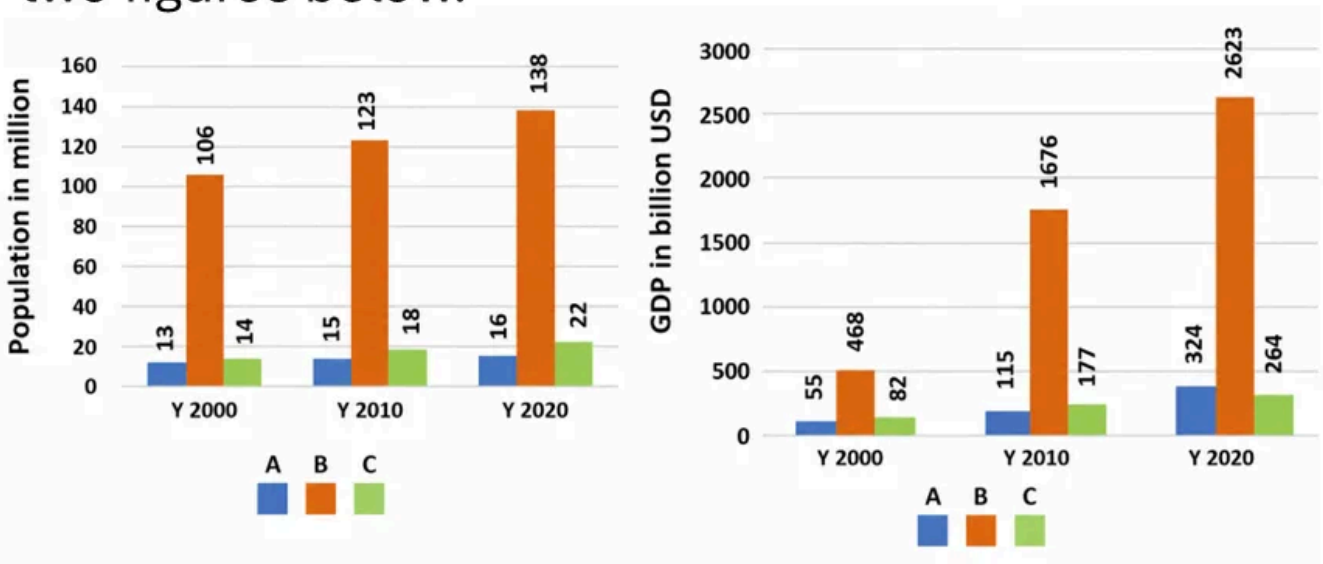
1. 1/4
2. 1/8
3. 1/3
4. 1/2

Q10. [June 2023] . 2.0 marks

General Aptitude > Data Analysis

CSIR NET	2023 June	2M

The populations and gross domestic products (GDP) in billion USD of three countries A,B and C in the years 2000, 2010 and 2020 are shown in the two figures below.



The decreasing order of per capita GDP of these countries in the year 2020 is

1. A, B, C
2. A, C, B
3. B, C, A
4. C, A, B

Q11. [June 2023] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2023 June	2M

Consider two datasets A and B, each with 3 observations, such that both the datasets have the same median. Which of the following MUST be true?

1. Sum of the observations in A = Sum of the observations in B.
2. Median of the squares of the observations in A = Median of the squares of the observations in B.
3. The median of the combined dataset = median of A + median of B.
4. The median of the combined dataset = median of A.

Q12. [June 2023] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2023 June	2M

Three fair cubical dice are thrown, independently. What is the probability that all the dice read the same?

1. 1/6
2. 1/36
3. 1/216
4. 13/216

Q13. [June 2023] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2023 June	2M

Persons A and B have 73 secrets each. On some day, exactly one of them discloses his secret to the other. For each secret A discloses to B in a given day, B discloses two secrets to A on the next day. For each secret B discloses to A in a given day, A discloses four secrets to B on the next day. The one who starts, starts by disclosing exactly one secret. What is the smallest possible number of days it takes for B to disclose all his secrets?

1. 5
2. 6
3. 7
4. 8

Q14. [June 2023] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2023 June	2M

a buffet, 4 curries A,B,C and D were served. A guest was to eat any one or more than one curry, but not the combinations having C and D together. The number of options available for the guest were

1. 3
2. 7
3. 11
4. 15

Q15. [June 2023] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2023 June	2M

Sum of all the internal angles of a regular octagon is ____ degrees.

1. 360
2. 1080
3. 1260
4. 900

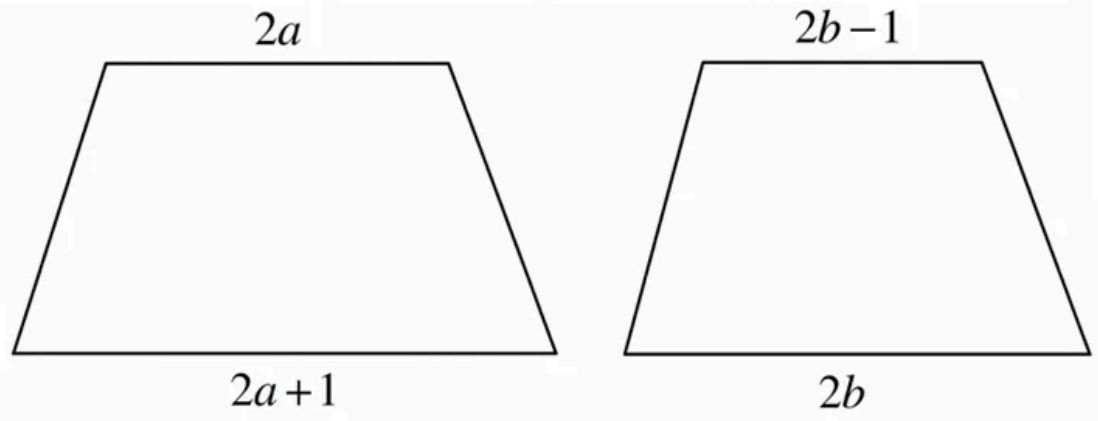
Q16. [June 2023] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2023 June	2M

If two trapeziums of the same height, as shown below, can be joined to form a parallelogram of area 2(a+b), then the height of the parallelogram will be

1. 4
2. 1
3. 1/2
4. 2



Q17. [June 2023] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2023 June	2M

If the sound of its thunder is heard 1 s after a lightning was observed, how far away (in m) was the source of thunder/lightning from the observer (given, speed of sound $= \mathrm{x\ m\ s^{-1}}$, speed of light $= \mathrm{y\ m\ s^{-1}}$)?

1. $\mathrm{x^2/y}$
2. $\mathrm{xy/(y-x)}$
3. $\mathrm{xy/(x-y)}$
4. $\mathrm{y^2/x}$

Q18. [June 2023] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2023 June	2M

Twenty litres of rainwater having a 2.0 μmol/L concentration of sulfate ions is mixed with forty litres water having 4.0 μmol/L sulfate ions. If 50% of the total water evaporated, what would be sulfate concentration in the remaining water

1. 3 μmol/L
2. 3.3 μmol/L
3. 4 μmol/L
4. 6.7 μmol/L

Q19. [June 2023] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2023 June	2M

A building has windows of sizes 2, 3 and 4 feet and their respective numbers are inversely proportional to their sizes. If the total number of windows is 26, then how many windows are there of the largest size?

1. 4
2. 6
3. 12
4. 9

Q20. [June 2023] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2023 June	2M

Given only one full 3 litre bottle and two empty ones of capacities 1 litre and 4 litres, all ungraduated, the minimum number of pourings required to ensure 1 litre in each bottle is

1. 2
2. 3
3. 4
4. 5

Q21. [June 2023] . 3.5 marks

Mathematical Physics > Basic Mathematics

CSIR NET	2023 June	3.5M

The value of the integral $I = \int_0^{\infty} e^{-x} x \sin(x) dx$ is

1. 3/4
2. 2/3
3. 1/2
4. 1/4

Q22. [June 2023] . 3.5 marks

Mathematical Physics > Probability

CSIR NET	2023 June	3.5M

A jar J1 contains equal number of balls of red, blue and green colours, while another jar J2 contains balls of only red and blue colours, which are also equal in number. The probability of choosing J1 is twice as large as choosing J2. If a ball picked at random from one of the jars turns out to be red, the probability that it came from

1. 2/3
2. 3/5
3. 2/5
4. 4/7

Q23. [June 2023] . 3.5 marks

Mathematical Physics > Complex analysis

CSIR NET	2023 June	3.5M

The locus of the curve $\mathrm{Im}\left(\frac{\pi(z-1)-1}{z-1}\right) = 1$ in the complex z-plane is a circle centred at (x_0, y_0) and radius R. The values of (x_0, y_0) and R, respectively, are

1. $\left(1, \frac{1}{2}\right)$ and $\frac{1}{2}$
2. $\left(1, -\frac{1}{2}\right)$ and $\frac{1}{2}$
3. $(1,1)$ and 1
4. $(1,-1)$ and 1

Q24. [June 2023] . 3.5 marks

Mathematical Physics > Matrices and Linear Algebra

CSIR NET	2023 June	3.5M

The matrix $M = \begin{pmatrix} 3 & -1 & 2 \\ -1 & 2 & 0 \\ 2 & 0 & 1 \end{pmatrix}$ satisfies the equation $M^3 + \alpha M^2 + \beta M + 3 = 0$ if (α, β) are

1. $(-2,2)$
2. $(-3,3)$
3. $(-6,6)$
4. $(-4,4)$

Q25. [June 2023] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2023 June	3.5M

A one-dimensional rigid rod is constrained to move inside a sphere such that its two ends are always in contact with the surface. The number of constraints on the Cartesian coordinates of the endpoints of the rod is

1. 3
2. 5
3. 2
4. 4

Q26. [June 2023] . 3.5 marks

Classical Mechanics > Central forces

CSIR NET	2023 June	3.5M

The minor axis of Earth's elliptical orbit divides the area within it into two halves. The eccentricity of the orbit is 0.0167. The difference in time spent by Earth in the two halves is closest to

1. 3.9 days
2. 4.8 days
3. 12.3 days
4. 0 days

Q27. [June 2023] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2023 June	3.5M

The Hamiltonian of a two particle system is $H = p_1p_2 + q_1q_2$, where q_1 and q_2 are generalized coordinates and p_1 and p_2 are the respective canonical momenta. The Lagrangian of this system is

1. $\dot{q}_1\dot{q}_2 + q_1q_2$
2. $-\dot{q}_1\dot{q}_2 + q_1q_2$
3. $-\dot{q}_1\dot{q}_2 - q_1q_2$
4. $\dot{q}_1\dot{q}_2 - q_1q_2$

Q28. [June 2023] . 3.5 marks

Classical Mechanics > Rotation Motion

CSIR NET	2023 June	3.5M

A uniform circular disc on the xy-plane with its centre at the origin has a moment of inertia I_0 about the x axis. If the disc is set in rotation about the origin with an angular velocity $\omega = \omega_0(\hat{j} + \hat{k})$, the direction of its angular momentum is along

1. $-\hat{i} + \hat{j} + \hat{k}$
2. $-\hat{i} + \hat{j} + 2\hat{k}$
3. $\hat{j} + 2\hat{k}$
4. $\hat{j} + \hat{k}$

Q29. [June 2023] . 3.5 marks

Classical Mechanics > Central forces

CSIR NET	2023 June	3.5M

The trajectory of a particle moving in a plane is expressed in polar coordinates (r, θ) by the equations $r = r_0 e^{\beta t}$ and $\frac{d\theta}{dt} = \omega$, where the parameters r_0, β and ω are positive. Let v_r and a_r denote the velocity and acceleration, respectively, in the radial direction. For this trajectory

1. $a_r < 0$ at all times irrespective of the values of the parameters
2. $a_r > 0$ at all times irrespective of the values of the parameters
3. $\frac{dv_r}{dt} > 0$ and $a_r > 0$ for all choices of parameters
4. $\frac{dv_r}{dt} > 0$, however, $a_r = 0$ for some choices of parameters

Q30. [June 2023] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2023 June	3.5M

A long cylindrical wire of radius R and conductivity σ, lying along the z-axis, carries a uniform axial current density I. The Poynting vector on the surface of the wire is (in the following $\hat{\rho}$ and $\hat{\varphi}$ denote the unit vectors along the radial and azimuthal directions respectively)

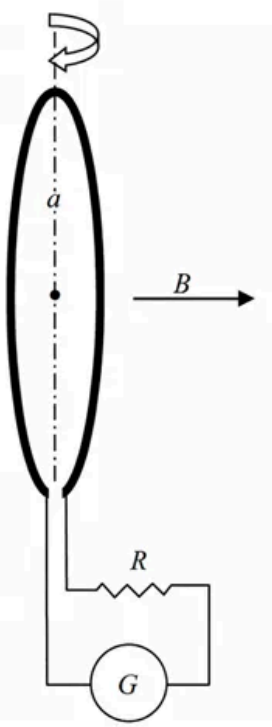
1. $\frac{I^2 R}{2\sigma}\hat{\rho}$
2. $-\frac{I^2 R}{2\sigma}\hat{\rho}$
3. $-\frac{I^2 \pi R}{4\sigma}\hat{\varphi}$
4. $\frac{I^2 \pi R}{4\sigma}\hat{\varphi}$

Q31. [June 2023] . 3.5 marks

Electromagnetism > Electrodynamics

CSIR NET	2023 June	3.5M

A small circular wire loop of radius a and number of turns N, is oriented with its axis parallel to the direction of the local magnetic field **B**. A resistance R and a galvanometer are connected to the coil, as shown in the figure.



When the coil is flipped (i.e., the direction of its axis is reversed) the galvanometer measures the total charge Q that flows through it. If the induced emf through the coil $E_F = IR$, then Q is

1. $\pi Na^2B/(2R)$
2. $\pi Na^2B/R$
3. $\sqrt{2}\pi Na^2B/R$
4. $2\pi Na^2B/R$

Q32. [June 2023] . 3.5 marks

Electromagnetism > Electrostatics

CSIR NET	2023 June	3.5M

The electric potential on the boundary of a spherical cavity of radius R, as a function of the polar angle θ, is $V_0 \cos^2 \frac{\theta}{2}$. The charge density inside the cavity is zero everywhere. The potential at a distance R/2 from the centre of the sphere is

1. $\frac{1}{2} V_0 \left(1 + \frac{1}{2} \cos \theta\right)$
2. $\frac{1}{2} V_0 \cos \theta$
3. $\frac{1}{2} V_0 \left(1 + \frac{1}{2} \sin \theta\right)$
4. $\frac{1}{2} V_0 \sin \theta$

Q33. [June 2023] . 3.5 marks

Optics > Polarization

CSIR NET	2023 June	3.5M

A charged particle moves uniformly on the xy-plane along a circle of radius a centred at the origin. A detector is put at a distance d on the x-axis to detect the electromagnetic wave radiated by the particle along the x direction. If $d \gg a$, the wave received by the detector is

1. Unpolarised
2. circularly polarized with the plane of polarization being the yz-plane
3. linearly polarized along the y-direction
4. linearly polarized along the z-direction

Q34. [June 2023] . 3.5 marks

Quantum Mechanics > Quantum Harmonic Oscillator

CSIR NET	2023 June	3.5M

The Hamiltonian of a two-dimensional quantum harmonic oscillator is

$$H = \frac{p_x^2}{2m} + \frac{p_y^2}{2m} + \frac{1}{2}m\omega^2 x^2 + 2m\omega^2 y^2$$

where m and ω are positive constants. The degeneracy of the energy level $\frac{27}{2}\hbar\omega$ is

1. 14
2. 13
3. 8
4. 7

Q35. [June 2023] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2023 June	3.5M

The value of $\langle L_x^2 \rangle$ in the state $|\varphi\rangle$ for which $L^2|\varphi\rangle = 6\hbar^2|\varphi\rangle$ and $L_z|\varphi\rangle = 2\hbar|\varphi\rangle$, is

1. 0
2. $4\hbar^2$
3. $2\hbar^2$
4. $\hbar^2$

Q36. [June 2023] . 3.5 marks

Quantum Mechanics > Pertubation theory

CSIR NET	2023 June	3.5M

A particle in one dimension is in an infinite potential well between $\frac{-L}{2} \leq x \leq \frac{L}{2}$. For a perturbation $\epsilon \cos\left(\frac{\pi x}{L}\right)$, where ϵ is a small constant, the change in the energy of the ground state, to first order in ϵ, is

1. $\frac{5\epsilon}{\pi}$
2. $\frac{10\epsilon}{3\pi}$
3. $\frac{8\epsilon}{3\pi}$
4. $\frac{4\epsilon}{\pi}$

Q37. [June 2023] . 3.5 marks

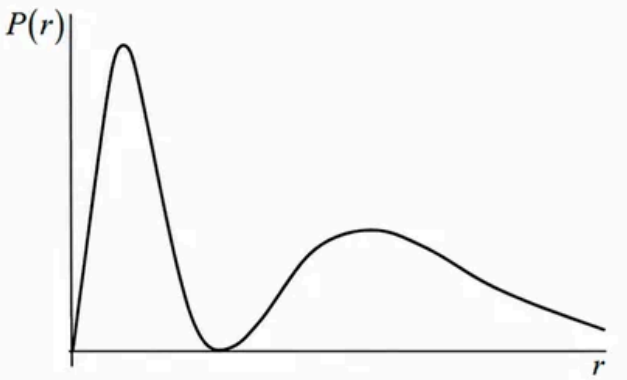
Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2023 June	3.5M

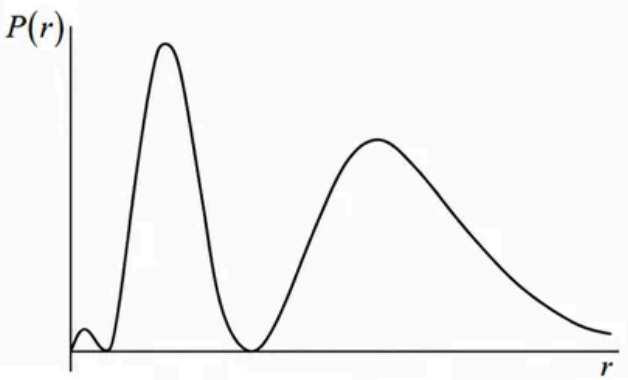
The radial wavefunction of hydrogen atom with the principal quantum number $n = 2$ and the orbital quantum number $\ell = 0$ is $R_{20} = N\left(1 - \frac{r}{2a}\right)e^{-\frac{r}{2a}}$, where N is the normalization constant. The best schematic representation of the probability density $P(r)$ for the electron to be between r and $r + dr$ is

1.

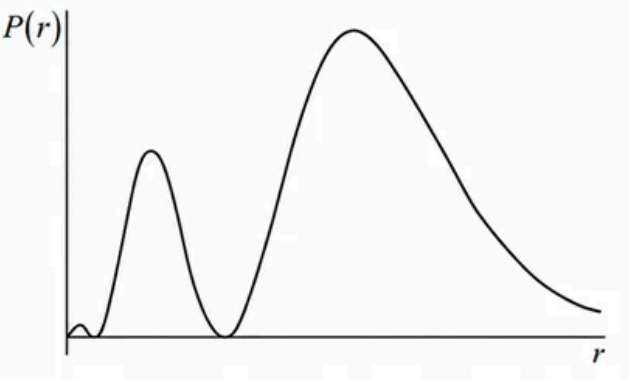
2.



3.



4.



Q38. [June 2023] . 3.5 marks

Statistical Mechanics > Microcanonical Ensemble

CSIR NET	2023 June	3.5M

Two energy levels, 0 (non-degenerate) and ϵ (doubly degenerate), are available to N non-interacting distinguishable particles. If U is the total energy of the system, for large values of N the entropy of the system is $k_B\left[N\ln N-\left(N-\frac{U}{\epsilon}\right)\ln\left(N-\frac{U}{\epsilon}\right)+X\right]$. In this expression, X is

1. $-\frac{U}{\epsilon}\ln\frac{U}{2\epsilon}$
2. $-\frac{U}{\epsilon}\ln\frac{2U}{\epsilon}$
3. $-\frac{2U}{\epsilon}\ln\frac{2U}{\epsilon}$
4. $-\frac{U}{\epsilon}\ln\frac{U}{\epsilon}$

Q39. [June 2023] . 3.5 marks

Statistical Mechanics > Microstates and Macrostates

CSIR NET	2023 June	3.5M

The single particle energies of a system of N non-interacting fermions of spin s (at $T = 0$) are $E_n = n^2 E_0$, $n = 1,2,3 \cdots$. The ratio $\epsilon_F\left(\frac{3}{2}\right)/\epsilon_F\left(\frac{1}{2}\right)$ of the Fermi energies for fermions of spin $3/2$ and spin $1/2$, is

1. 1/2
2. 1/4
3. 2
4. 1

Q40. [June 2023] . 3.5 marks

Statistical Mechanics > Quantum Statistical Mechanics

CSIR NET	2023 June	3.5M

The dispersion relation of a gas of non-interacting bosons in two dimensions is $E|k| = c\sqrt{|k|}$, where c is a positive constant. At low temperatures, the leading dependence of the specific heat on temperature T, is

1. T^4
2. T^3
3. T^2
4. $T^{3/2}$

Q41. [June 2023] . 3.5 marks

Statistical Mechanics > Microstates and Macrostates

CSIR NET	2023 June	3.5M

The energy levels available to each electron in a system of N non-interacting electrons are $E_n = nE_0$, $n = 0,1,2,\cdots$. A magnetic field, which does not affect the energy spectrum, but completely polarizes the electron spins, is applied to the system. The change in the ground state energy of the system is

1. $\frac{1}{2}N^2E_0$
2. N^2E_0
3. $\frac{1}{8}N^2E_0$
4. $\frac{1}{4}N^2E_0$

Q42. [June 2023] . 3.5 marks

Electronics > "Errors , curve fitting and data analysis"

CSIR NET	2023 June	3.5M

A DC motor is used to lift a mass M to a height h from the ground. The electric energy delivered to the motor is VIt, where V is the applied voltage, I is the current and t the time for which the motor runs. The efficiency e of the motor is the ratio between the work done by the motor and the energy delivered to it. If $M = 2.00 \pm 0.02 \text{kg}, h = 1.00 \pm 0.01 \text{ m}$, $V = 10.0 \pm 0.1 \text{ V}, I = 2.00 \pm 0.02 \text{ A}$ and $t = 300 \pm 15 \text{ s}$, then the fractional error $|\delta e/e|$ in the efficiency of the motor is closest to

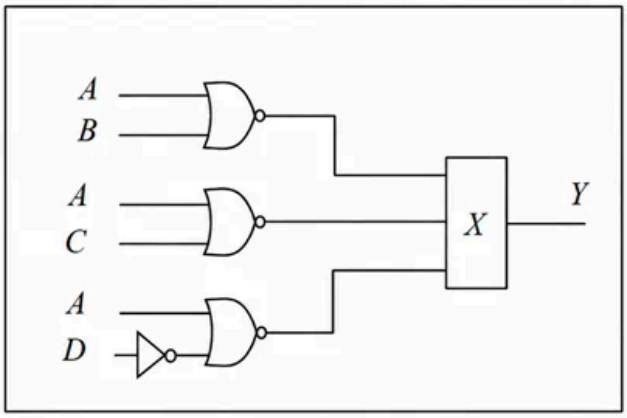
1. 0.05
2. 0.09
3. 0.12
4. 0.15

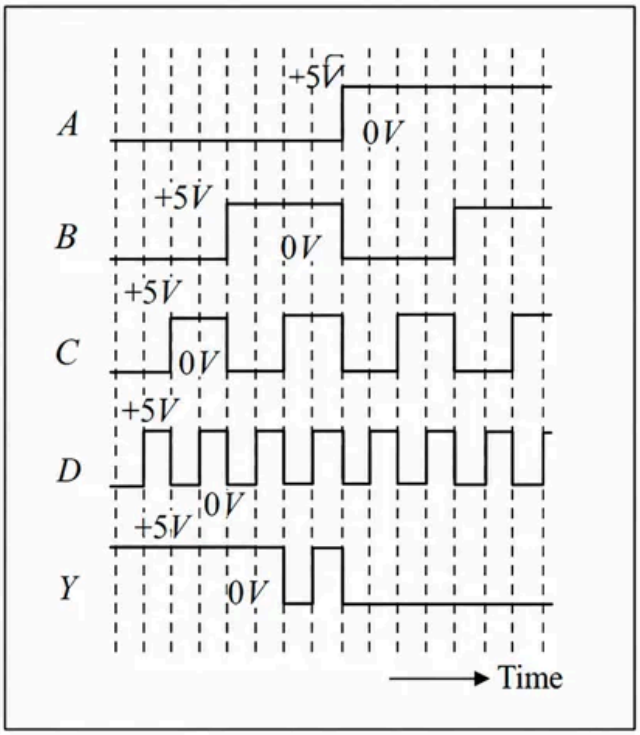
Q43. [June 2023] . 3.5 marks

Electronics > Digital Electronics

CSIR NET	2023 June	3.5M

For the given logic circuit, the input waveforms A, B, C and D are shown as a function of time





To obtain the output Y as shown in the figure, the logic gate X should be

1. an AND gate
2. an OR gate
3. a NAND gate
4. a NOR gate

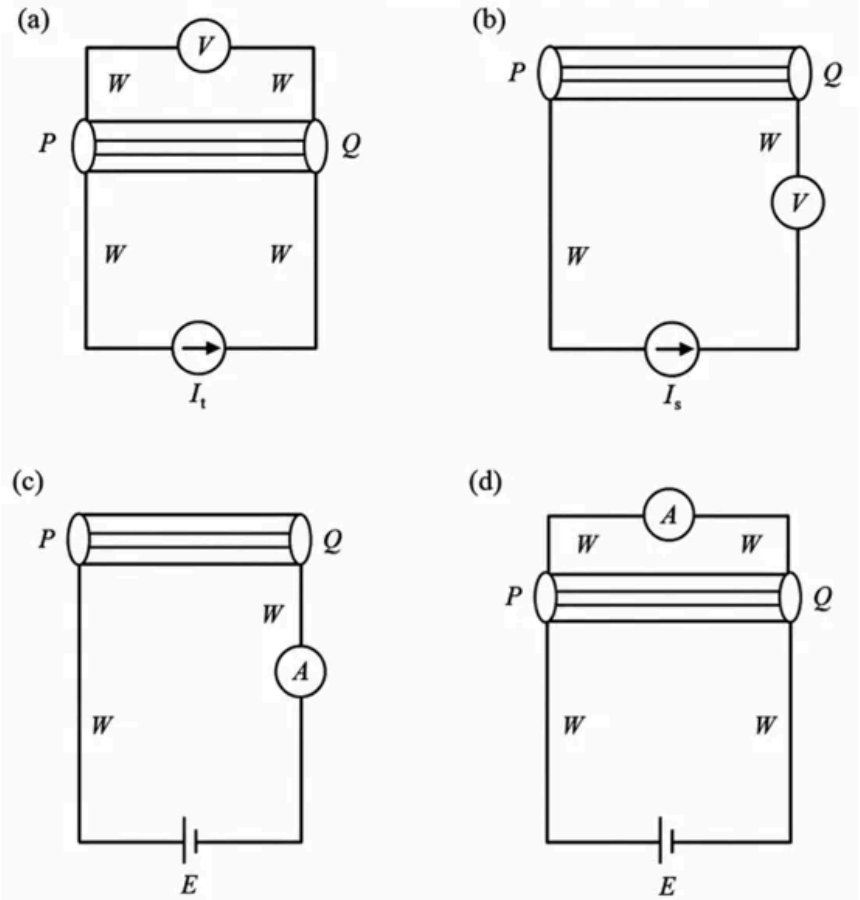
Q44. [June 2023] . 3.5 marks

Electronics > Instruments

CSIR NET	2023 June	3.5M

A circuit needs to be designed to measure the resistance R of a cylinder PQ to the best possible accuracy, using an ammeter A, a voltmeter V, a battery E and a current source I_s (all assumed to be ideal). The value of R is known to be approximately 10Ω, and the resistance W of each of the connecting wires is close to 10Ω. If the current from the current source and voltage from the battery are known exactly, which of the following circuits provides the most accurate measurement of R?

1. (b)
2. (a)
3. (d)
4. (c)

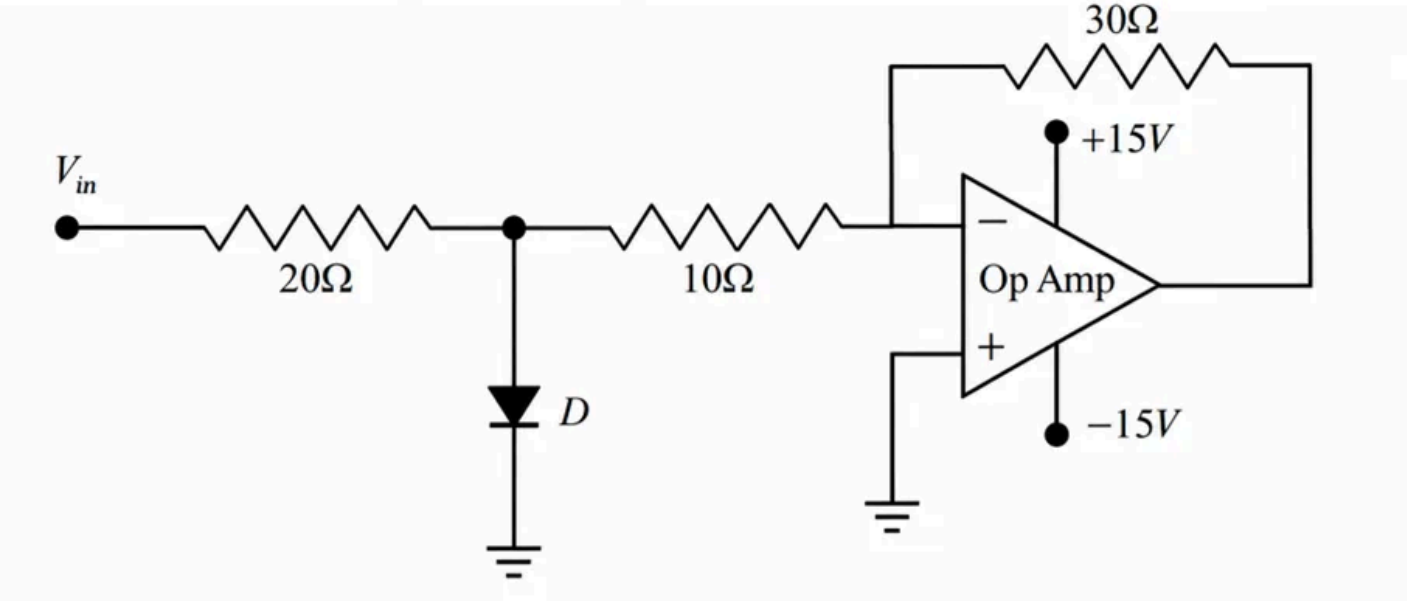


Q45. [June 2023] . 3.5 marks

Electronics > OPAMP

CSIR NET	2023 June	3.5M

In the circuit below, there is a voltage drop of 0.7 V across the diode D in forward bias, while no current flows through it in reverse bias.



If V_{in} is a sinusoidal signal of frequency 50 Hz with an RMS value of 1 V , the maximum current that flows through the diode is closest to

1. 1 A
2. 0.14 A
3. 0 A
4. 0.07 A

Q46. [June 2023] . 5.0 marks

Mathematical Physics > Probability

CSIR NET	2023 June	5M

A random variable Y obeys a normal distribution

$$P(Y) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{(Y-\mu)^2}{2\sigma^2}\right]$$

The mean value of e^r is

1. $e^{\mu+\frac{\sigma^2}{2}}$
2. $e^{\mu-\sigma^2}$
3. $e^{\mu+\sigma^2}$
4. $e^{\mu-\frac{\sigma^2}{2}}$

Q47. [June 2023] . 5.0 marks

Mathematical Physics > Numerical Methods

CSIR NET	2023 June	5M

The bisection method is used to find a zero x_0 of the polynomial $f(x) = x^3 - x^2 - 1$. Since $f(1) = -1$, while $f(2) = 3$, the values $a = 1$ and $b = 2$ are chosen as the boundaries of the interval in which the x_0 lies. If the bisection method is iterated three times, the resulting value of x_0 is

1. 15/8
2. 13/8
3. 11/8
4. 9/8

Q48. [June 2023] . 5.0 marks

Mathematical Physics > Dirac Delta Function

CSIR NET	2023 June	5M

The value of the integral $\int_{-\infty}^{\infty} dx 2^{-\frac{|x|}{\pi}} \delta(\sin x)$ where $\delta(x)$ is the Dirac delta function, is

1. 3
2. 0
3. 5
4. 1

Q49. [June 2023] . 5.0 marks

Mathematical Physics > Special Functions

CSIR NET	2023 June	5M

If the Bessel function of integer order n is defined as $J_n(x) = \sum_{k=0}^{\infty} \frac{(-1)^k}{k!(n+k)!}\left(\frac{x}{2}\right)^{2k+n}$ then $\frac{d}{dx}[x^{-n}J_n(x)]$ is

1. $-x^{-[n+1]}J_{n+1}(x)$
2. $-x^{-[n+1]}J_{n-1}(x)$
3. $-x^{-n}J_{n-1}(x)$
4. $-x^{-n}J_{n+1}(x)$

Q50. [June 2023] . 5.0 marks

Mathematical Physics > Matrices and Linear Algebra

CSIR NET	2023 June	5M

The matrix $R_{\hat{n}}(\theta)$ represents a rotation by an angle

to the matrix $\begin{pmatrix} -1 & 0 & 0 \\ 0 & -\frac{1}{3} & \frac{2\sqrt{2}}{3} \\ 0 & \frac{2\sqrt{2}}{3} & \frac{1}{3} \end{pmatrix}$, respectively, are

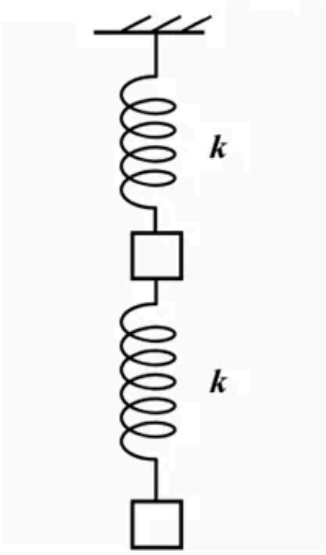
1. $\pi/2$ and $\left(0, -\sqrt{\frac{2}{3}}, \frac{1}{\sqrt{3}}\right)$
2. $\pi/2$ and $\left(0, \frac{1}{\sqrt{3}}, \sqrt{\frac{2}{3}}\right)$
3. π and $\left(0, -\sqrt{\frac{2}{3}}, \frac{1}{\sqrt{3}}\right)$
4. π and $\left(0, \frac{1}{\sqrt{3}}, \sqrt{\frac{2}{3}}\right)$

Q51. [June 2023] . 5.0 marks

Classical Mechanics > Oscillations

CSIR NET	2023 June	5M

A system of two identical masses connected by identical springs, as shown in the figure, oscillates along the vertical direction. The ratio of the frequencies of the normal modes is



1. $\sqrt{3-\sqrt{5}} : \sqrt{3+\sqrt{5}}$
2. $3-\sqrt{5} : 3+\sqrt{5}$
3. $\sqrt{5-\sqrt{3}} : \sqrt{5+\sqrt{3}}$
4. $5-\sqrt{3} : 5+\sqrt{3}$

Q52. [June 2023] . 5.0 marks

Classical Mechanics > Canonical transformations

CSIR NET	2023 June	5M

For the transformation $x \to X = \frac{\alpha p}{x}, p \to P = \beta x^2$ between conjugate pairs of a coordinate and its momentum, to be canonical, the constants α and β must satisfy

1. $1 + \frac{1}{2}\alpha\beta = 0$
2. $1 - \frac{1}{2}\alpha\beta = 0$
3. $1 + 2\alpha\beta = 0$
4. $1 - 2\alpha\beta = 0$

Q53. [June 2023] . 5.0 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2023 June	5M

The charge density and current of an infinitely long perfectly conducting wire of radius a, which lies along the z-axis, as measured by a static observer are zero and a constant I, respectively. The charge density measured by an observer, who moves at a speed $v = \beta c$ parallel to the wire along the direction of the current, is

1. $-\frac{I\beta}{\pi a^2 c\sqrt{1-\beta^2}}$
2. $-\frac{I\beta\sqrt{1-\beta^2}}{\pi a^2 c}$
3. $\frac{I\beta}{\pi a^2 c\sqrt{1-\beta^2}}$
4. $\frac{I\beta\sqrt{1-\beta^2}}{\pi a^2 c}$

Q54. [June 2023] . 5.0 marks

Electromagnetism > Electrodynamics

CSIR NET	2023 June	5M

An infinitely long solenoid of radius r_0 centred at origin which produces a time-dependent magnetic fiel $\frac{\alpha}{\pi r_0^2}\cos\omega t$ (where α and ω unit line charge density is placed, initially at rest, on the xy-plane with its centre on the z-axis. If $R > r_0$, the magnitude of the angular momentum of the loop is

1. $\alpha R(1-\cos\omega t)$
2. $\alpha R\sin\omega t$
3. $\frac{1}{2}\alpha R(1-\cos 2\omega t)$
4. $\frac{1}{2}\alpha R\sin 2\omega t$

Q55. [June 2023] . 5.0 marks

Electromagnetism > EM Waves

CSIR NET	2023 June	5M

he electric and magnetic fields at a point due to two independent sources are $\mathbf{E}_1 = \mathrm{E}(\alpha\hat{\mathrm{i}} + \beta\hat{\mathrm{j}}), \mathbf{B}_1 = \mathrm{B}\hat{\mathrm{k}}$ and $\mathbf{E}_2 = \mathrm{E}\hat{\mathrm{i}}, \mathbf{B}_2 = -2\mathrm{B}\hat{\mathrm{k}}$, where $\alpha, \beta, \mathrm{E}$ and B are constants. If the Poynting vector is along $\hat{\mathrm{i}} + \hat{\mathrm{j}}$, then

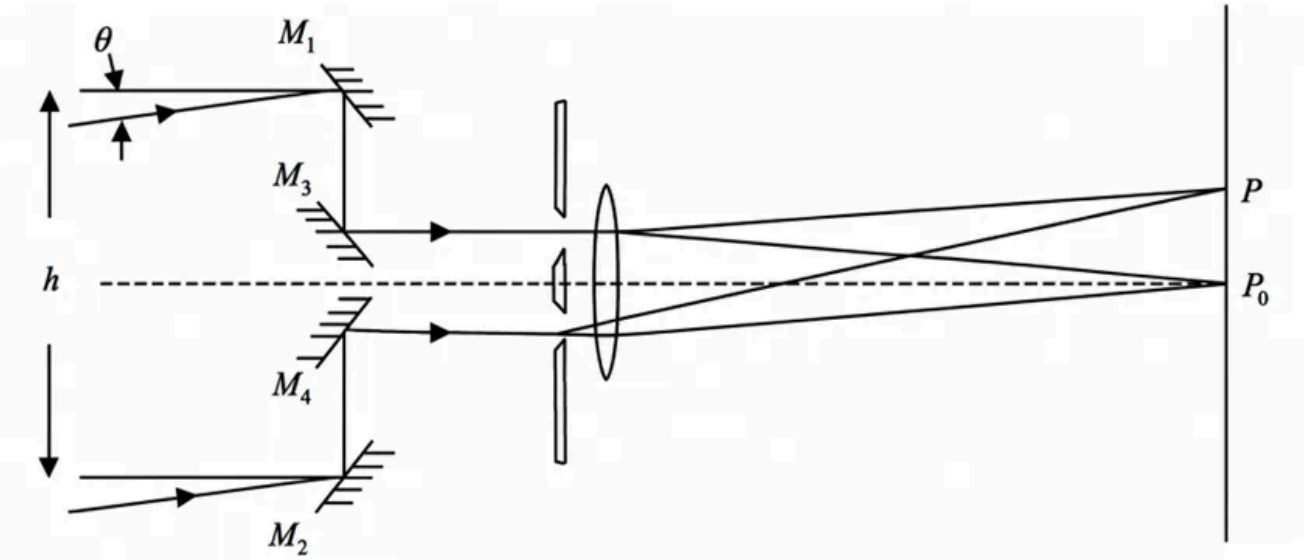
1. $\alpha + \beta + 1 = 0$
2. $\alpha + \beta - 1 = 0$
3. $\alpha + \beta + 2 = 0$
4. $\alpha + \beta - 2 = 0$

Q56. [June 2023] . 5.0 marks

Optics > Interference and diffraction

CSIR NET	2023 June	5M

The angular width θ of a distant star can be measured by the Michelson radiofrequency stellar interferometer (as shown in the figure below).



The distance h between the reflectors M_1 and M_2 (assumed to be much larger than the aperture of the lens), is increased till the interference fringes (at P_0, P on the plane as shown) vanish for the first time. This happens for $h = 3$ m for a star which emits radiowaves of wavelength 2.7 cm. The measured value of θ (in degrees) is closest to

1. 0.63
2. 0.32
3. 0.52
4. 0.26

Q57. [June 2023] . 5.0 marks

Quantum Mechanics > Basic Quantum Mechanics

CSIR NET	2023 June	5M

Two operators A and B satisfy the commutation relations $[H, A] = -\hbar\omega B$ and $[H, B] = \hbar\omega A$, where ω is a constant and H is the Hamiltonian of the system. The expectation value $\langle A\rangle_\psi(t) = \psi|A|\psi)$ in a state $|\psi\rangle$, such that at time $t = 0, \langle A\rangle_\psi(0) = 0$ and $B_\psi(0) = i$, is

1. $\sin(\omega t)$
2. $\sinh(\omega t)$
3. $\cos(\omega t)$
4. $\cosh(\omega t)$

Q58. [June 2023] . 5.0 marks

Quantum Mechanics > Two particle System

CSIR NET	2023 June	5M

Two distinguishable non-interacting particles, each of mass m are in a one-dimensional infinite square well in the interval $[0, a]$. If x_1 and x_2 are position operators of the two particles, the expectation value $\langle x_1 x_2 \rangle$ in the state in which one particle is in the ground state and the other one is in the first excited state, is

1. $\frac{1}{2}a^2$
2. $\frac{1}{2}\pi^2 a^2$
3. $\frac{1}{4}a^2$
4. $\frac{1}{4}\pi^2 a^2$

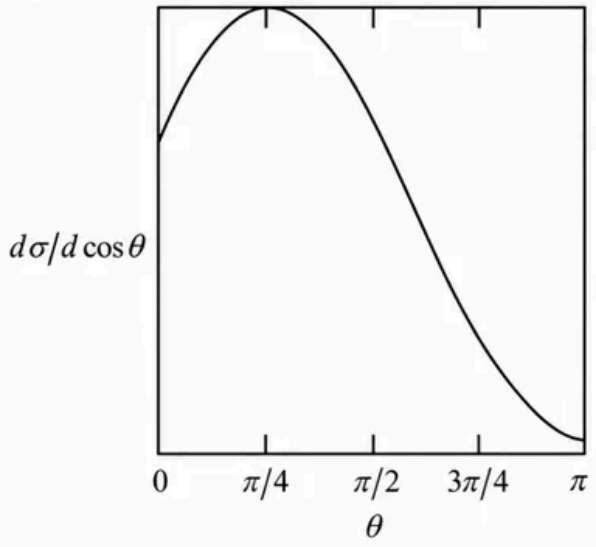
Q59. [June 2023] . 5.0 marks

Quantum Mechanics > Scattering theory

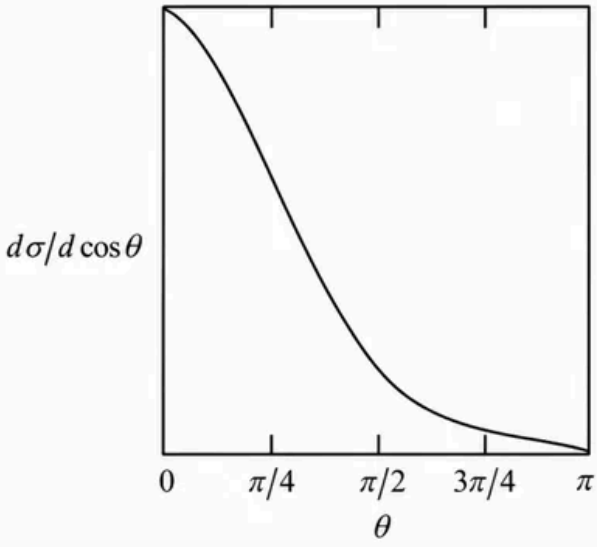
CSIR NET	2023 June	5M

The phase shifts of the partial waves in an elastic scattering at energy E are $\delta_0 = 12^\circ$, $\delta_1 = 4^\circ$ and $\delta_{\ell \geq 2} \approx 0^\circ$. The best qualitative depiction of θ-dependence of the differential scattering cross-section $\frac{d\sigma}{d\cos\theta}$ is

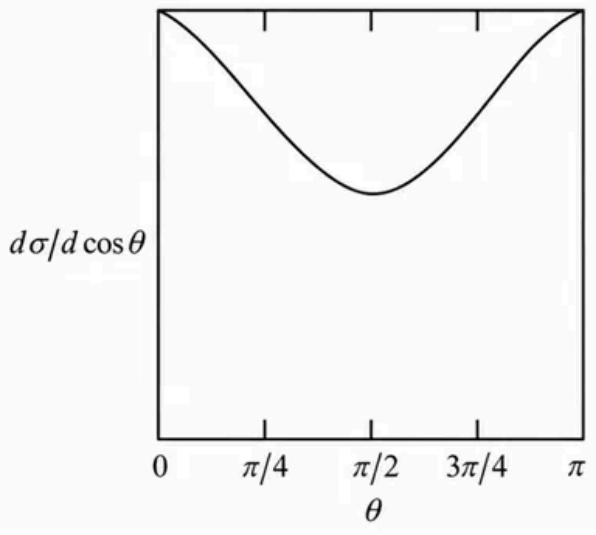
1.



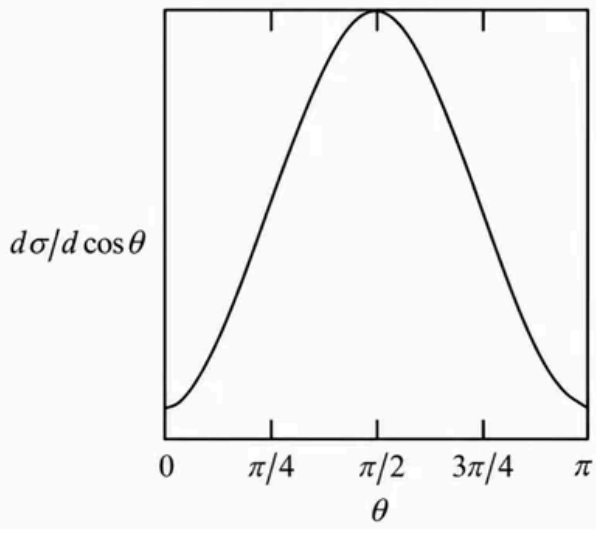
2.



3.



4.



Q60. [June 2023] . 5.0 marks

Quantum Mechanics > Pertubation theory

CSIR NET	2023 June	5M

Electrons polarized along the x-direction are in a magnetic field $B_1\hat{\imath} + B_2(\hat{\jmath}\cos\omega t + \hat{k}\sin\omega t)$, where $B_1 \gg B_2$ and ω are positive constants. The value of $\hbar\omega$ for which the polarization-flip process is a resonant one, is

1. $2\mu_B|B_2|$
2. $\mu_B|B_1|$
3. $\mu_B|B_2|$
4. $2\mu_B|B_1|$

Q61. [June 2023] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2023 June	5M

Two random walkers A and B walk on a one-dimensional lattice. The length of each step taken by A is one, while the same for B is two, however, both move towards right or left with equal probability. If they start at the same point, the probability that they meet after 4 steps, is

1. 9/64
2. 5/32
3. 11/64
4. 3/16

Q62. [June 2023] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2023 June	5M

In a one-dimensional system of N spins, the allowed values of each spin are $\sigma_i = \{1,2,3,\ldots,q\}$, where $q \geq 2$ is an integer. The energy of the system is $-J\sum_{i=1}^{N} \delta_{\sigma_i,\sigma_{i+1}}$ where $J > 0$ is a constant. If periodic boundary conditions are imposed, the number of ground states of the system is

1. q
2. Nq
3. q^N
4. 1

Q63. [June 2023] . 5.0 marks

Thermodynamics > Phase transitions

CSIR NET	2023 June	5M

A layer of ice has formed on a very deep lake. The temperature of water, as well as that of ice at the ice-water interface, are $0^{\circ}C$, whereas the temperature of the air above is $-10^{\circ}C$. The thickness $L(t)$ of the ice increases with time t. Assuming that all physical properties of air and ice are independent of temperature, $L(t) \sim L_0 t^{\alpha}$ for large t. The value of α is

1. 1/4
2. 1/3
3. 1/2
4. 1

Q64. [June 2023] . 5.0 marks

Solid State Physics > Hall effect

CSIR NET	2023 June	5M

The Hall coefficient R_H of a sample can be determined from the measured Hall voltage $V_H = \frac{1}{d} R_H BI + RI$, where d is the thickness of the sample, B is the applied magnetic field, I is the current passing through the sample and R is an unwanted offset resistance. A lock-in detection technique is used by keeping I constant with the applied magnetic field being modulated as $B = B_0 \sin \Omega t$, where B_0 is the amplitude of the magnetic field and Ω is frequency of the reference signal. The measured V_H is

1. $B_0 \left(\frac{R_H I}{d}\right)$
2. $\frac{B_0}{\sqrt{2}} \left(\frac{R_H I}{d}\right)$
3. $\frac{I}{\sqrt{2}} \left(\frac{R_H B_0}{d} + R\right)$
4. $I \left(\frac{R_H B_0}{d} + R\right)$

Q65. [June 2023] . 5.0 marks

Electronics > Instruments

CSIR NET	2023 June	5M

A train of impulses of frequency 500 Hz, in which the temporal width of each spike is negligible compared to its period, is used to sample a sinusoidal input signal of frequency 100 Hz. The sampled output is

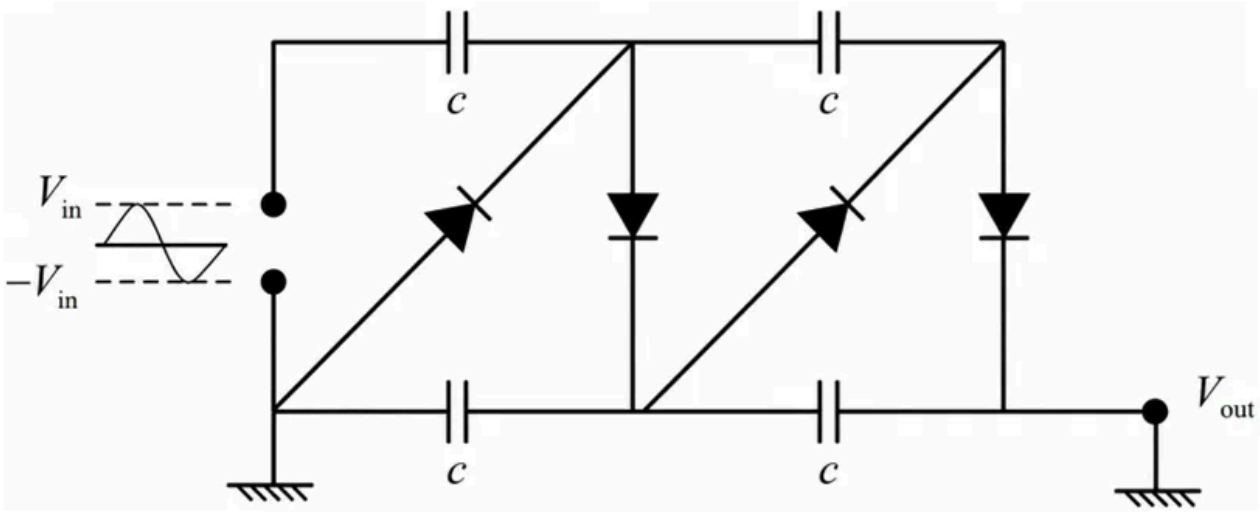
1. discrete with the spacing between the peaks being the same as the time period of the sampling signal
2. a sinusoidal wave with the same time period as the sampling signal
3. discrete with the spacing between the peaks being the same as the time period of the input signal
4. a sinusoidal wave with the same time period as the input signal

Q66. [June 2023] . 5.0 marks

Electronics > Diodes

CSIR NET	2023 June	5M

In the circuit shown below, four silicon diodes and four capacitors are connected to a sinusoidal voltage source of amplitude $V_{in} > 0.7\ V$ and frequency 1 kHz .



If the knee voltage for each of the diodes is 0.7 V and the resistances of the capacitors are negligible, the DC output voltage V_{out} after 2 seconds of starting the voltage source is closest to

1. $1.4\ V_{in} - 0.7\ V$
2. $4\ V_{in} - 2.8\ V$
3. $V_{in} - 0.7\ V$
4. $V_{in} - 2.8\ V$

Q67. [June 2023] . 5.0 marks

Atomic and Molecular Physics > Bohar Model and h-atom model

CSIR NET	2023 June	5M

The electron cloud (of the outermost electrons) of an ensemble of atoms of atomic number Z is described by a continuous charge density $\rho(r)$ that adjusts itself so that the electrons at the Fermi level have zero energy. If $V(r)$ is the local electrostatic potential, then $\rho(r)$ is

1. $\frac{e}{3\pi^2\hbar^3}[2m_e eV(\mathbf{r})]^{3/2}$
2. $\frac{Ze}{3\pi^2\hbar^3}[2m_e eV(\mathbf{r})]^{3/2}$
3. $\frac{e}{3\pi^2\hbar^3}[Zm_e eV(\mathbf{r})]^{3/2}$
4. $\frac{e}{3\pi^2\hbar^3}[m_e eV(\mathbf{r})]^{3/2}$

Q68. [June 2023] . 5.0 marks

Atomic and Molecular Physics > Zeeman effect

CSIR NET	2023 June	5M

The red line of wavelength 644 nm in the emission spectrum of Cd corresponds to a transition from the $^1D_2$ level to the $^1P_1$ level. In the presence of a weak magnetic field, this spectral line will split into (ignore hyperfine structure)

1. 9 lines
2. 6 lines
3. 3 lines
4. 2 lines

Q69. [June 2023] . 5.0 marks

Atomic and Molecular Physics > Molecular physics

CSIR NET	2023 June	5M

Let the separation of the frequencies of the first Stokes and the first anti-Stokes lines in the pure rotational Raman Spectrum of the H_2 molecule be $\Delta v(H_2)$, while the corresponding quantity for D_2 is $\Delta v(D_2)$. The ratio $\Delta v(H_2)/\Delta v(D_2)$ is

1. 0.6
2. 1.2
3. 1
4. 2

Q70. [June 2023] . 5.0 marks

Statistical Mechanics > Quantum Statistical Mechanics

CSIR NET	2023 June	5M

The dispersion relation of electrons in three dimensions is $\epsilon(k) = \hbar v_F k$, where v_F is the Fermi velocity. If at low temperatures ($T \ll T_F$) the Fermi energy ϵ_F depends on the number density n as $\epsilon_F(n) \sim n^{\alpha}$, the value of α is

1. 1/3
2. 2/3
3. 1
4. 3/5

Q71. [June 2023] . 5.0 marks

Solid State Physics > Crystallography

CSIR NET	2023 June	5M

A lattice A consists of all points in three-dimensional space with coordinates (n_x, n_y, n_z) where n_x, n_y and n_z are integers with $n_x + n_y + n_z$ being odd integers. In another lattice B, $n_x + n_y + n_z$ are even integers. The lattices A and B are

1. both BCC
2. both FCC
3. BCC and FCC, respectively
4. FCC and BCC, respectively

Q72. [June 2023] . 5.0 marks

Statistical Mechanics > Canonical Ensemble

CSIR NET	2023 June	5M

Two electrons in thermal equilibrium at temperature $T = k_B/\beta$ can occupy two sites. The energy of the configuration in which they occupy the different sites is $J\mathbf{S}_1 \cdot \mathbf{S}_2$ (where $J > 0$ is a constant and $\mathbf{S}$ denotes the spin of an electron), while it is U if they are at the same site. If $U = 10J$, the probability for the system to be in the first excited state is

1. $e^{-3\beta J/4}/\left(3e^{\beta J/4} + e^{-3\beta J/4} + 2e^{-10\beta J}\right)$
2. $3e^{-\beta J/4}/\left(3e^{-\beta J/4} + e^{3\beta J/4} + 2e^{-10\beta J}\right)$
3. $e^{-\beta J/4}/\left(2e^{-\beta J/4} + 3e^{3\beta J/4} + 2e^{-10\beta J}\right)$
4. $3e^{-3\beta J/4}/\left(2e^{\beta J/4} + 3e^{-3\beta J/4} + 2e^{-10\beta J}\right)$

Q73. [June 2023] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2023 June	5M

The nucleus of $^{40}\mathrm{K}$ (of spin-parity 4^+ in the ground state) is unstable and decays to $^{40}\mathrm{Ar}$. The mass difference between these two nuclei is $\Delta \mathrm{Mc}^2 = 1504.4\,\mathrm{keV}$. The nucleus $^{40}\mathrm{Ar}$ has an excited state at 1460.8 keV with spinparity 2^+. The most probable decay mode of $^{40}\mathrm{K}$ is by

1. a β^+-decay to the 2^+ state of $^{40}\mathrm{Ar}$
2. an electron capture to the 2^+ state of $^{40}\mathrm{Ar}$
3. an electron capture to the ground state of $^{40}\mathrm{Ar}$
4. a β^+-decay to the ground state of $^{40}\mathrm{Ar}$

Q74. [June 2023] . 5.0 marks

Nuclear and Particle Physics > Nuclear forces and Scattering

CSIR NET	2023 June	5M

A neutral particle X^0 is produced in $\pi^- + p \rightarrow X^0 + n$ by s-wave scattering. The branching ratios of the decay of X^0 to $2\gamma, 3\pi$ and 2π are 0.38,0.30 and less than 10^{-3}, respectively. The quantum numbers J^{CP} of X^0 are

1. 0^{-+}
2. 0^{+-}
3. 1^{-+}
4. 1^{+-}

Q75. [June 2023] . 5.0 marks

Nuclear and Particle Physics > Collective model

CSIR NET	2023 June	5M

The energy (in keV) and spin-parity values $E(J^p)$ of the low lying excited states of a nucleus of mass number $A = 152$, are $122(2^+), 366(4^+), 707(6^+)$, and $1125(8^+)$. It may be inferred that these energy levels correspond to a

1. rotational spectrum of a deformed nucleus
2. rotational spectrum of a spherically symmetric nucleus
3. vibrational spectrum of a deformed nucleus
4. vibrational spectrum of a spherically symmetric nucleus

Answer Key

75 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	General Aptitude	Mathematical Analysis	**2**
Q2	General Aptitude	Mathematical Analysis	**1**
Q3	General Aptitude	Basic Physics	**4**
Q4	General Aptitude	Mathematical Analysis	**3**
Q5	General Aptitude	Basic Physics	**4**
Q6	General Aptitude	Mathematical Analysis	**4**
Q7	General Aptitude	Geometry	**1**
Q8	General Aptitude	Reasoning	**1**
Q9	General Aptitude	Mathematical Analysis	**1**
Q10	General Aptitude	Data Analysis	**1**
Q11	General Aptitude	Mathematical Analysis	**4**
Q12	General Aptitude	Mathematical Analysis	**2**
Q13	General Aptitude	Reasoning	**1**
Q14	General Aptitude	Mathematical Analysis	**3**
Q15	General Aptitude	Geometry	**2**
Q16	General Aptitude	Geometry	**2**
Q17	General Aptitude	Basic Physics	**2**
Q18	General Aptitude	Basic Physics	**4**
Q19	General Aptitude	Mathematical Analysis	**2**
Q20	General Aptitude	Reasoning	**2**
Q21	Mathematical Physics	Basic Mathematics	**3**
Q22	Mathematical Physics	Probability	**4**
Q23	Mathematical Physics	Complex analysis	**1**
Q24	Mathematical Physics	Matrices and Linear Algebra	**3**
Q25	Classical Mechanics	Lagrangian and Hamiltonian	**1**
Q26	Classical Mechanics	Central forces	**1**
Q27	Classical Mechanics	Lagrangian and Hamiltonian	**4**
Q28	Classical Mechanics	Rotation Motion	**3**
Q29	Classical Mechanics	Central forces	**4**
Q30	Electromagnetism	EM Waves	**2**
Q31	Electromagnetism	Electrodynamics	**4**
Q32	Electromagnetism	Electrostatics	**1**
Q33	Optics	Polarization	**3**
Q34	Quantum Mechanics	Quantum Harmonic Oscillator	**4**
Q35	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**
Q36	Quantum Mechanics	Pertubation theory	**3**
Q37	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q38	Statistical Mechanics	Microcanonical Ensemble	**1**
Q39	Statistical Mechanics	Microstates and Macrostates	**2**
Q40	Statistical Mechanics	Quantum Statistical Mechanics	**1**

Answer Key (cont.)

Q. No	Subject	Topic	Answer
Q41	Statistical Mechanics	Microstates and Macrostates	**4**
Q42	Electronics	"Errors , curve fitting and data analysis"	**1**
Q43	Electronics	Digital Electronics	**2**
Q44	Electronics	Instruments	**2**
Q45	Electronics	OPAMP	**3**
Q46	Mathematical Physics	Probability	**1**
Q47	Mathematical Physics	Numerical Methods	**3**
Q48	Mathematical Physics	Dirac Delta Function	**1**
Q49	Mathematical Physics	Special Functions	**4**
Q50	Mathematical Physics	Matrices and Linear Algebra	**4**
Q51	Classical Mechanics	Oscillations	**1**
Q52	Classical Mechanics	Canonical transformations	**3**
Q53	Electromagnetism	Relativistic electromagnetism	**1**
Q54	Electromagnetism	Electrodynamics	**1**
Q55	Electromagnetism	EM Waves	**1**
Q56	Optics	Interference and diffraction	**1**
Q57	Quantum Mechanics	Basic Quantum Mechanics	**2**
Q58	Quantum Mechanics	Two particle System	**3**
Q59	Quantum Mechanics	Scattering theory	**2**
Q60	Quantum Mechanics	Pertubation theory	**4**
Q61	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**3**
Q62	Statistical Mechanics	Ising model	**1**
Q63	Thermodynamics	Phase transitions	**3**
Q64	Solid State Physics	Hall effect	**2**
Q65	Electronics	Instruments	**1**
Q66	Electronics	Diodes	**2**
Q67	Atomic and Molecular Physics	Bohar Model and h-atom model	**1**
Q68	Atomic and Molecular Physics	Zeeman effect	**3**
Q69	Atomic and Molecular Physics	Molecular physics	**4**
Q70	Statistical Mechanics	Quantum Statistical Mechanics	**1**
Q71	Solid State Physics	Crystallography	**2**
Q72	Statistical Mechanics	Canonical Ensemble	**2**
Q73	Nuclear and Particle Physics	Radioactivity	**2**
Q74	Nuclear and Particle Physics	Nuclear forces and Scattering	**2**
Q75	Nuclear and Particle Physics	Collective model	**1**

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