PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

CSIR NET Physics - June 2021 - Full Paper

Complete question paper with answer key

75 questions . Answer key included

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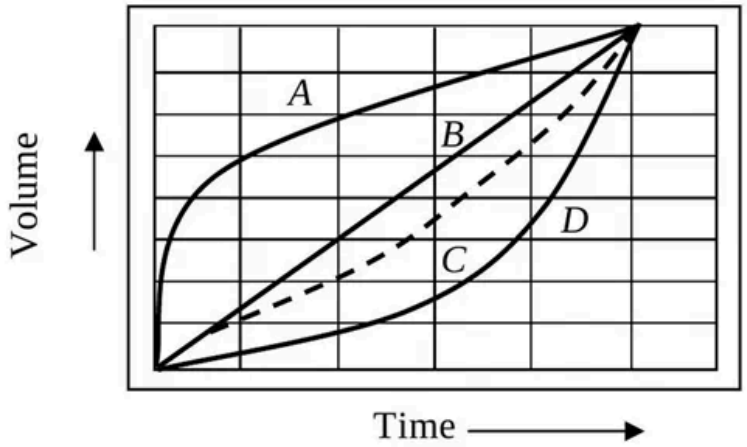
Q1. [June 2021] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2021 June	2M

An inverted cone is filled with water at a constant rate. The volume of water inside the cone as a function of times is represented the curve

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



Q2. [June 2021] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2021 June	2M

A spacecraft flies at a constant height R above a planet of radius R. At the instant the spacecraft is over the north-pole, the lowest latitude visible from the spacecraft is:

1. 0° (Equator)
2. 30°N
3. 45°N
4. 60°N

Q3. [June 2021] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2021 June	2M

An experiment consists of tossing a coin 20 times. Such an experiment is performed 50 times. The number of heads and the number of tails in each experiment are noted. What is the correlation coefficient between the two?

1. -1
2. $-20/50$
3. $20/50$
4. 1

Q4. [June 2021] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2021 June	2M

Which of these groups of numbers has the smallest mean?

Group A: 1,2,3,4,5,6,7,8,9

Group B: 1,2,3,4,6,6,7,8,9

Group C: 1,2,2,4,5,6,7,8,9

Group D: 1,3,3,4,5,6,7,9,9

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

Q5. [June 2021] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2021 June	2M

Identical balls are tightly arranged in the shape of an equilateral triangle with each side containing n balls. How many balls are there in the arrangement?

1. $n^2/2$
2. $n(n+1)/2$
3. $n(n-1)/2$
4. $(n+1)^2/2$

Q6. [June 2021] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2021 June	2M

A shopkeeper has a faulty pan balance with a zero offset. When an object is placed in the left plan it is balanced by a standard 100 g weight. When it is placed in the right pan it is balanced by a standard 80 g weight. What is the actual weight of the object?

1. 90 g
2. 88.88 g
3. 95 g
4. 85 g

Q7. [June 2021] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2021 June	2M

A and B start from the same point in opposite directions along a circular track simultaneously. Speed of B is $2/3^{rd}$ that of A. How many times will A and B cross each other before meeting at the starting point?

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

Q8. [June 2021] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2021 June	2M

Consider a solid cube of side 5 units. After painting, it is cut into cubes of 1 unit. Find the probability that a randomly chosen unit cube has only one side painted.

1. $56/125$
2. $36/125$
3. $44/125$
4. $54/125$

Q9. [June 2021] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2021 June	2M

How many integers in the set $\{1,2,3,\ldots\ldots,100\}$ have exactly 3 divisors?

1. 4
2. 12
3. 5
4. 9

Q10. [June 2021] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2021 June	2M

The arithmetic and geometric means of two numbers are 65 and 25, respectively. What are these two numbers?

1. 110, 20
2. 115,15
3. 120,10
4. 125,5

Q11. [June 2021] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2021 June	2M

Shyam spent half of his money and was left with as many as he had rupees before, but with half as many rupees as he had paise before. Which of the following is a possible amount of money he is left with?

1. 49 rupees and 98 paise
2. 49 rupees and 99 paise
3. 99 rupees and 99 paise
4. 99 rupees and 98 paise

Q12. [June 2021] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2021 June	2M

A cylindrical road roller having a diameter of 1.5 m moves at a speed of 3 km/h while levelling a road. How much length of the road will be leveled in 45 minutes?

1. 2.25 km
2. 0.375π km
3. 0.75π km
4. 1.5 km

Q13. [June 2021] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2021 June	2M

An intravenous fluid is given to a child of 7.5 kg, at the rate of 20 drop/minute. The prescribed dose of the fluid is 40 ml per kg of body weight. If the volume of a drop is 0.05 ml, how many hours are needed to complete the dose?

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

Q14. [June 2021] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2021 June	2M

A cousin is a non-sibling with a common ancestor. If there is exactly one pair of siblings in a group of 5 persons then the maximum possible number of pairs of cousins in the group is

1. 3
2. 6
3. 9
4. 10

Q15. [June 2021] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2021 June	2M

In a tournament with 8 teams, a win fetches 3 points and a draw, 1. After all teams have played three matches each, total number of points earned by all teams put together must lie between

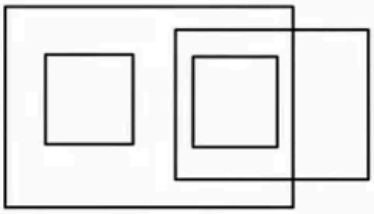
1. 24 and 36
2. 24 and 32
3. 12 and 24
4. 32 and 48

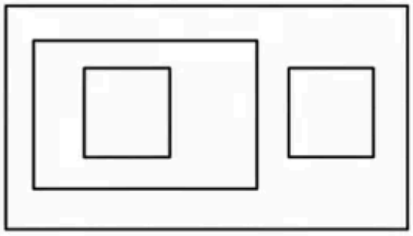
Q16. [June 2021] . 2.0 marks

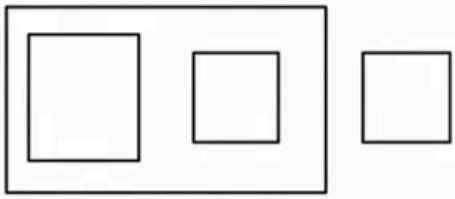
General Aptitude > Reasoning

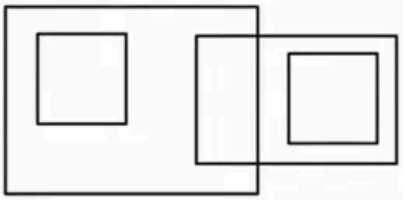
CSIR NET	2021 June	2M

An appropriate diagram to represent the relations between the categories KEYBOARD, HARDWARE, OPERATING SYSTEM and CPU is

1. 

2. 

3. 

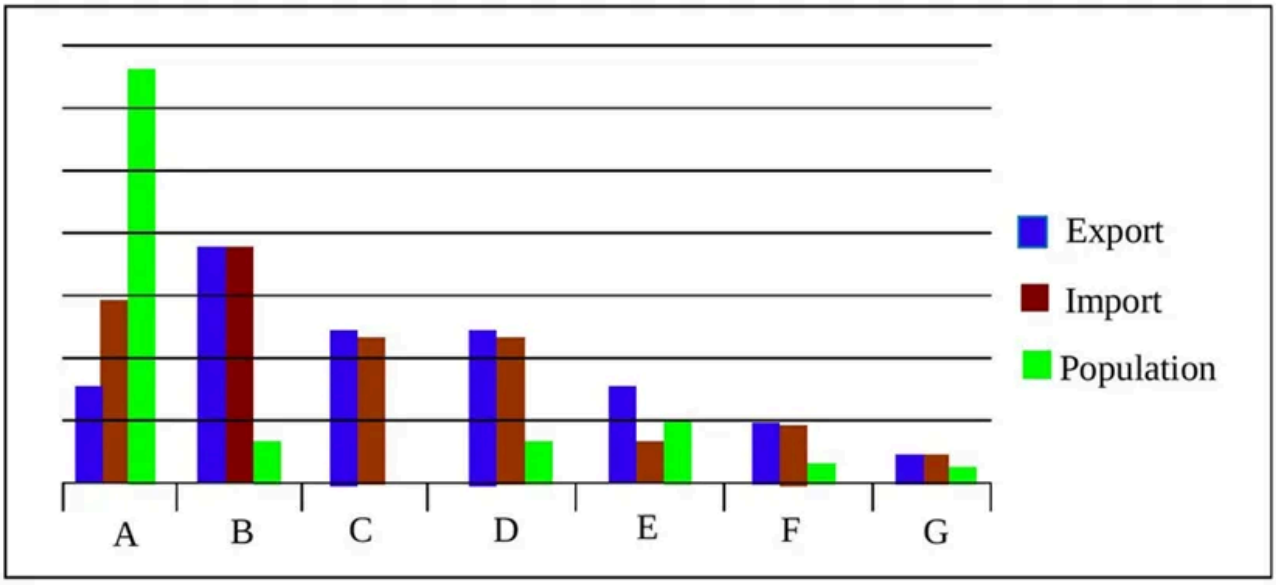
4. 

Q17. [June 2021] . 2.0 marks

General Aptitude > Data Analysis

CSIR NET	2021 June	2M

Trade figures populations in appropriate units in a certain year are given for 7 countries.



If countries are ranked according to the difference in their per capita exports over import, the best and worst ranking countries are respectively

1. C and A
2. A and E
3. C and B
4. A and F

Q18. [June 2021] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2021 June	2M

At least two among three persons A, B and C are truthful. If A calls B a liar and if B calls C a liar, then which of the following is FALSE?

1. A is truthful
2. B is truthful
3. C is truthful
4. At least one is a liar

Q19. [June 2021] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2021 June	2M

The maximum area of a right-angled triangle inscribed in a circle of radius r is

1. $2r^2$
2. $r^2/2$
3. $\sqrt{2}r^2$
4. r^2

Q20. [June 2021] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2021 June	2M

If we replace the mathematical operations in the expression $(11 + 4 - 2) \div 24 \times 6$ as given in the table: Then is new value is

Operation	+	-	×	÷
Replaced by	-	×	÷	+

1. $23/6$
2. 1
3. 18
4. 7

Q21. [June 2021] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2021 June	3.5M

A particle in one dimension executes oscillatory motion in a potential $V(x) = A|x|$, where $A > 0$ is a constant of appropriate dimension. If the time period T of its oscillation depends on the total energy E as E^a, then the value of a is

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

Q22. [June 2021] . 3.5 marks

Mathematical Physics > Ordinary Differential Equations

CSIR NET	2021 June	3.5M

The equation of motion of a one-dimensional forced harmonic oscillator in the presence of a dissipative force is described by $\frac{d^2x}{dt^2} + 10\frac{dx}{dt} + 16x = 6te^{-8t} + 4t^2e^{-2t}$. The general form of the particular solution, in terms of constants A, B etc., is

1. $t(At^2 + Bt + C)e^{-2t} + (Dt + E)e^{-8t}$
2. $(At^2 + Bt + C)e^{-2t} + (Dt + E)e^{-8t}$
3. $t(At^2 + Bt + C)e^{-2t} + t(Dt + E)e^{-8t}$
4. $(At^2 + Bt + C)e^{-2t} + t(Dt + E)e^{-8t}$

Q23. [June 2021] . 3.5 marks

Electromagnetism > Magetostatics

CSIR NET	2021 June	3.5M

The vector potential for an almost point like magnetic dipole located at the origin is $\vec{A} = \frac{\mu \sin\theta}{4\pi r^2}\hat{\phi}$ where (r, θ, ϕ) denote the spherical polar coordinates and $\hat{\phi}$ is the unit vector along $\hat{\phi}$. A particle of mass m and charge q, moving in the equatorial plane of the dipole, starts at time $= t = 0$ with an initial speed v_0 and an impact parameter b. Its instantaneous speed at the point of closest approach is

1. v_0
2. $0/0$
3. $v_0 + \frac{\mu q}{4\pi m b^2}$
4. $\sqrt{v_0^2 + \left(\frac{\mu q}{4\pi m b^2}\right)^2}$

Q24. [June 2021] . 3.5 marks

Classical Mechanics > Central forces

CSIR NET	2021 June	3.5M

A particle, thrown with a speed v from the earth's surface, attains a maximum height h (measured from the surface of the earth). If v is half the escape velocity and R denotes the radius of earth, then h/R is

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

Q25. [June 2021] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2021 June	3.5M

A particle of mass $1\ \mathrm{GeV}/c^2$ and its antiparticle, both moving with the same speed v, produce new particle x of mass $10\ \mathrm{GeV}/c^2$ in a head on collision. The minimum value of v required for this process is closest to

1. $0.83c$
2. $0.93c$
3. $0.98c$
4. $0.88c$

Q26. [June 2021] . 3.5 marks

Mathematical Physics > Basic Mathematics

CSIR NET	2021 June	3.5M

The volume of the region common to the interiors of two infinitely long cylinders defined by $x^2 + y^2 = 25$ and $x^2 + 4z^2 = 25$ is best approximated by

1. 225
2. 333
3. 423
4. 625

Q27. [June 2021] . 3.5 marks

Mathematical Physics > Vector Algebra and Vector Calculus

CSIR NET	2021 June	3.5M

The volume integral $I = \iiint_V \vec{A} \cdot (\vec{\nabla} \times \vec{A}) d^3x$ is over a region V bounded by a surface $\sum$ (an infinitesimal area element being $\hat{n}ds$, where $\hat{n}$ is the outward unit normal). If it changes to $I + \Delta I$ when the vector $\vec{A}$ is changed to $\vec{A} + \vec{\nabla}\Lambda$, then ΔI can be expressed as

1. $\iiint_V \vec{\nabla} \cdot (\vec{\nabla}\Lambda \times \vec{A}) d^3x$
2. $-\iiint_V \nabla^2 \Lambda d^3x$
3. $-\oiint_\Sigma (\vec{\nabla}\Lambda \times \vec{A}) \cdot \hat{n} ds$
4. $\oiint_\Sigma \vec{\nabla}\Lambda . \hat{n} ds$

Q28. [June 2021] . 3.5 marks

Mathematical Physics > Matrices and Linear Algebra

CSIR NET	2021 June	3.5M

A generic 3×3 real matrix A has eigenvalues 0,1 and 6, and I is the 3×3 identity matrix. The quantity/quantities that cannot be determined from this information is/are the

1. eigenvalue of $(\mathrm{I} + \mathrm{A})^{-1}$
2. eigenvalue of $\left(\mathrm{I} + \mathrm{A}^{\mathrm{T}}\mathrm{A}\right)$
3. determinant of $\mathrm{A}^{\mathrm{T}}\mathrm{A}$
4. rank of A

Q29. [June 2021] . 3.5 marks

Mathematical Physics > Probability

CSIR NET	2021 June	3.5M

A discrete random variable X takes a value from the set $\{-1,0,1,2\}$ with the corresponding probabilities $p(X) = 3/10,2/10,2/10$ and $3/10$, respectively. The probability distribution $q(Y) = (q(0), q(1), q(4))$ of the random variable $Y = X^2$ is

1. $\left(\frac{1}{5}, \frac{3}{5}, \frac{1}{5}\right)$
2. $\left(\frac{1}{5}, \frac{1}{2}, \frac{3}{10}\right)$
3. $\left(\frac{2}{5}, \frac{2}{5}, \frac{1}{5}\right)$
4. $\left(\frac{3}{10}, \frac{3}{10}, \frac{2}{5}\right)$

Q30. [June 2021] . 3.5 marks

Mathematical Physics > Tensors

CSIR NET	2021 June	3.5M

The components of the electric field, in a region of space devoid of any change or current sources, are given to be $E_i = a_i + \sum_{j=1,2,3} b_{ij} x_j$, where a_i and b_{ij} are constants independent of the coordinates. The number of independent components of the matrix b_{ij} is

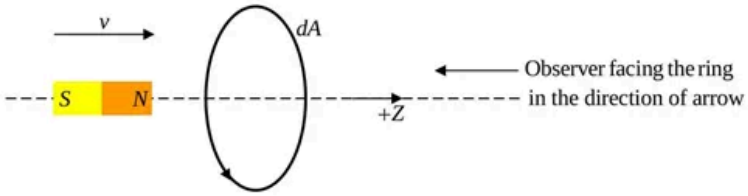
1. 5
2. 6
3. 3
4. 4

Q31. [June 2021] . 3.5 marks

Electromagnetism > Electrodynamics

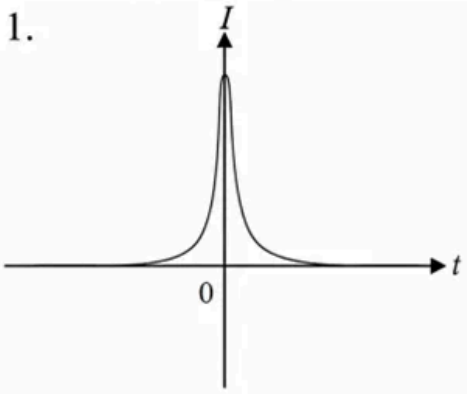
CSIR NET	2021 June	3.5M

A conducting wire in the shape of a circle lies on the (x, y)-plane with its centre at the origin. A bar magnet moves with a constant velocity towards the wire along the z-axis (as shown in the figure below).

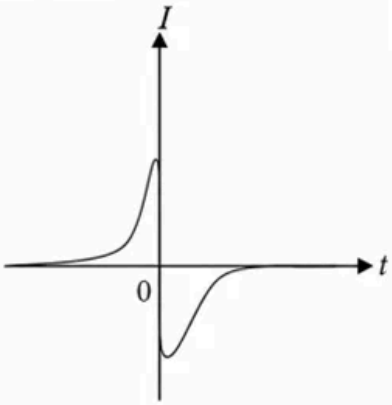


We take $t = 0$ to be the instant at which the midpoint of the magnet is at the centre of the wire loop and the induced current to be positive when it is counter-clockwise as viewed by the observer facing the loop and the incoming magnet. In these conventions, the best schematic representation of the induced current $I(t)$ as a function of t, is

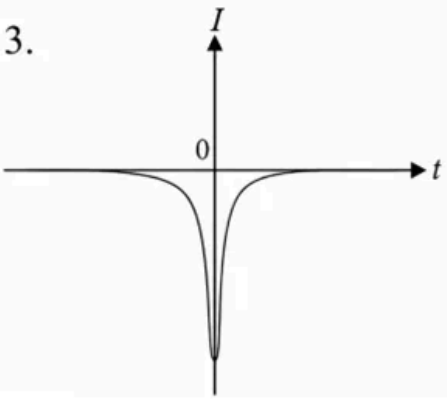
1.



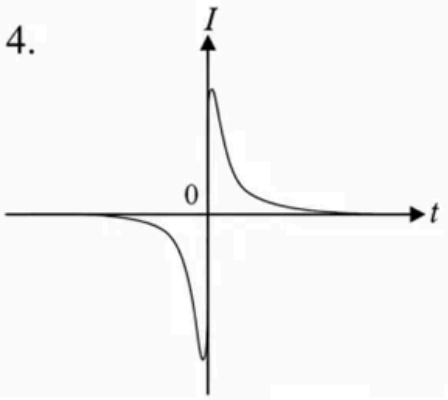
2.



3.



4.



Q32. [June 2021] . 3.5 marks

Electromagnetism > Magetostatics

CSIR NET	2021 June	3.5M

In an experiment to measure the charge to mass ratio e/m of the electron by Thomson's method, the values of the deflecting electric field and the accelerating potential are 6×10^6 N/C (newton per coulomb) and 150 V, respectively. The magnitude of the magnetic field that leads to zero deflection of the electron beam is closest to

1. 0.6 T
2. 1.2 T
3. 0.4 T
4. 0.8 T

Q33. [June 2021] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2021 June	3.5M

A monochromatic source emitting radiation with a certain frequency moves with a velocity v away from a stationary observer A. It is moving towards another observer B (also at rest) along a line joining the two. The frequencies of the radiation recorded by A and B are V_A and V_B, respectively. If the ratio $\frac{V_B}{V_A} = 7$, then the value of v/c is

1. $1/2$
2. $1/4$
3. 3/4
4. $\sqrt{3}/2$

Q34. [June 2021] . 3.5 marks

Quantum Mechanics > Pertubation theory

CSIR NET	2021 June	3.5M

The Hamiltonian of a particle of mass m in one-dimension is $H = \frac{1}{2m}p^2 + \lambda|x|^3$, where $\lambda > 0$ is a constant. If E_1 and E_2 respectively, denote the ground state energies of the particle for $\lambda = 1$ and $\lambda = 2$ (in appropriate units) the ratio E_2/E_1 is best approximated by

1. 1.260
2. 1.414
3. 1.516
4. 1.320

Q35. [June 2021] . 3.5 marks

Quantum Mechanics > Potential Well

CSIR NET	2021 June	3.5M

A particle of mass m is in a one dimensional infinite potential well of length L, extending from $x = 0$ to $x = L$. When it is in the energy Eigen-state labelled by $n, (n = 1,2,3,..)$ the probability of finding in the interval $0 \leq x \leq L/8$ is $1/8$. The minimum value of n for which this is possible is

1. 4
2. 2
3. 6
4. 8

Q36. [June 2021] . 3.5 marks

Quantum Mechanics > Basic Quantum Mechanics

CSIR NET	2021 June	3.5M

A two-state system evolves under the action of the Hamiltonian $H = E_0|A\rangle\langle A| + (E_0 + \Delta)|B\rangle\langle B|$, where $|A\rangle$ and $|B\rangle$ are its two orthonormal states. These states transform to one another under parity, i.e. $P|A\rangle = |B\rangle$ and $P|B\rangle = |A\rangle$. If at time $t = 0$ the system is in a state of definite parity $P = 1$, the earliest time t at which the probability of finding the system in a state of parity $P = -1$ is one is

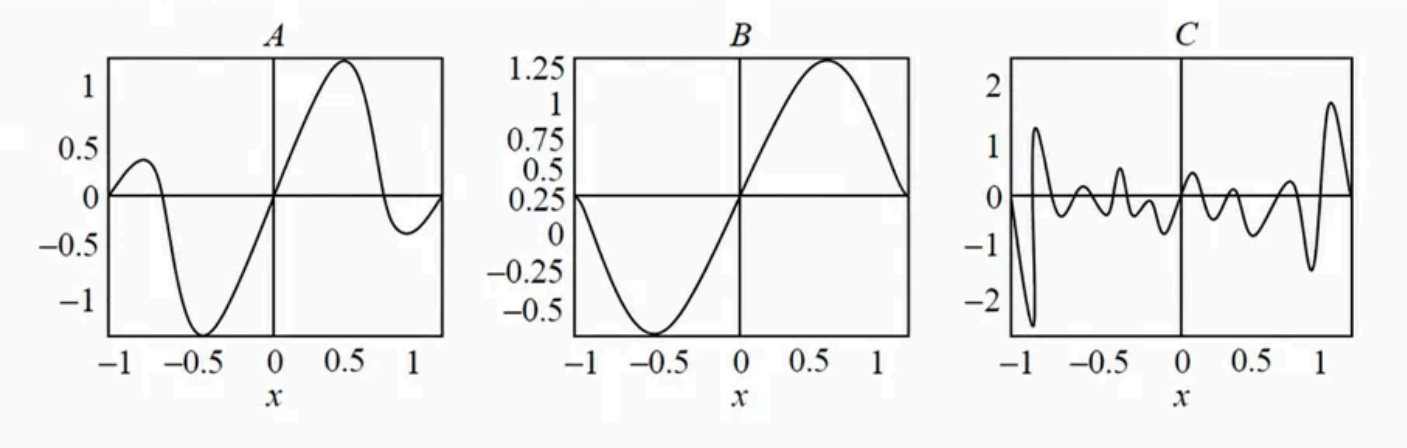
1. $\frac{\pi\hbar}{2\Delta}$
2. $\frac{\pi\hbar}{\Delta}$
3. $\frac{3\pi\hbar}{2\Delta}$
4. $\frac{2\pi\hbar}{\Delta}$

Q37. [June 2021] . 3.5 marks

Quantum Mechanics > Potential Well

CSIR NET	2021 June	3.5M

The figures below depict three different wave functions of a particle confined to a one dimensional box $-1 \leq x \leq 1$.



The wave functions that correspond to the maximum expectation values $|\langle x \rangle|$ (absolute value of the mean position) and $\langle x^2 \rangle$, respectively, are

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

Q38. [June 2021] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2021 June	3.5M

Which of the following two physical quantities cannot be measured simultaneously with arbitrary accuracy for the motion of a quantum particle in three dimensions?

1. square of the radial position and z-component of angular momentum (r^2 and L_z)
2. x-components of linear and angular momenta (p_x and L_x)
3. x-components of linear and angular momenta (p_x and L_x)
4. squares of the magnitudes of the linear and angular momenta (p^2 and L^2)

Q39. [June 2021] . 3.5 marks

Thermodynamics > Kinetic theory of Gases

CSIR NET	2021 June	3.5M

The ratio c_p/c_v of the specific heats at constant pressure and volume of a monatomic ideal gas in two dimensions is

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

Q40. [June 2021] . 3.5 marks

Statistical Mechanics > Black Body Radiations

CSIR NET	2021 June	3.5M

The volume and temperature of a spherical cavity filled with black body radiation are V and 300 K, respectively. If it expands adiabatically to a volume $2V$, its temperature will be closest to

1. 150 K
2. 300 K
3. 250 K
4. 240 K

Q41. [June 2021] . 3.5 marks

Solid State Physics > Lattice vibrations

CSIR NET	2021 June	3.5M

The total number of phonon modes in a solid of volume V is $\int_0^{\omega_D} g(\omega)d\omega = 3N$, is the number of primitive cells, ω_D is the Debye frequency and density of photon modes is $g(\omega) = AV\omega^2$ (with $A > 0$ a constant). If the density of the solid doubles in a phase transition, the Debye temperature θ_D will

1. increase by a factor of $2^{2/3}$
2. increase by a factor of $2^{1/3}$
3. decrease by a factor of $2^{2/3}$
4. decrease by a factor of $2^{1/3}$

Q42. [June 2021] . 3.5 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2021 June	3.5M

The position of a particle in one dimension changes in discrete steps. With each step it moves to the right, however, the length of the step is drawn from a uniform distribution from the interval $\left[\lambda - \frac{1}{2}w, \lambda + \frac{1}{2}w\right]$, where λ and w are positive constants. If X denotes the distance from the starting point after N steps, the standard deviation $\sqrt{\langle X^2 \rangle - \langle X \rangle^2}$ for large values of N is

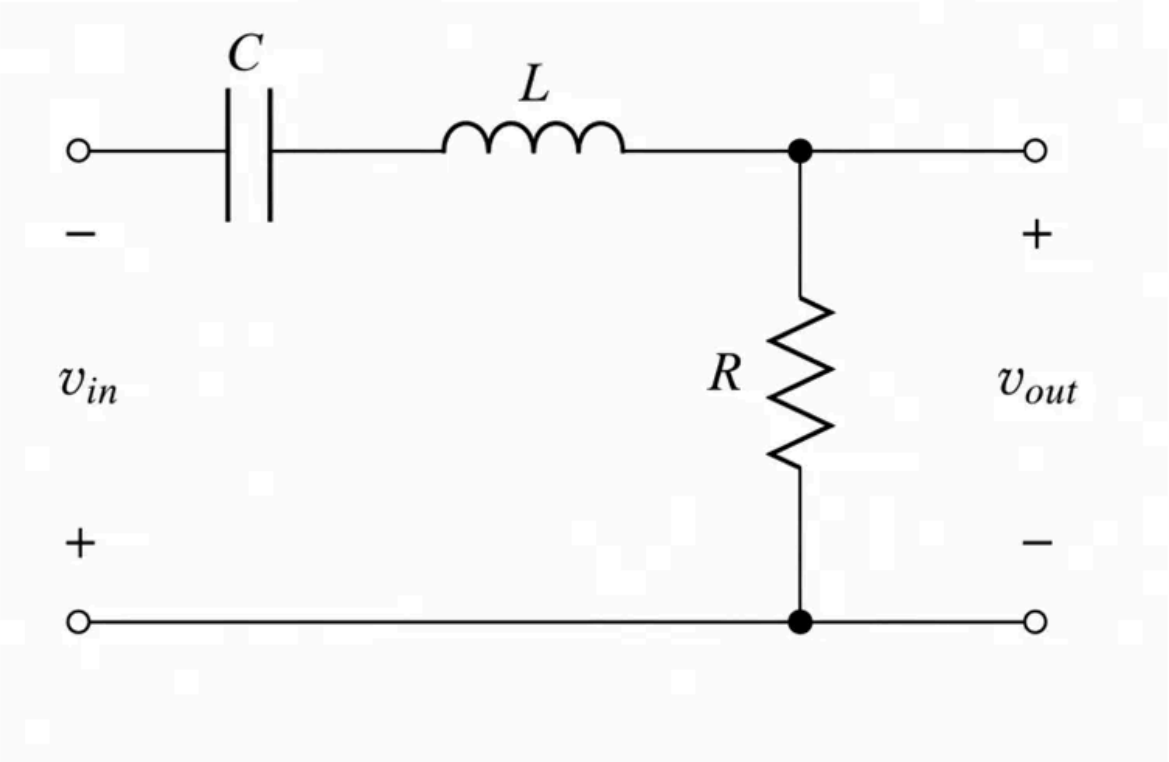
1. $\frac{\lambda}{2} \times \sqrt{N}$
2. $\frac{\lambda}{2} \times \sqrt{\frac{N}{3}}$
3. $\frac{w}{2} \times \sqrt{N}$
4. $\frac{w}{2} \times \sqrt{\frac{N}{3}}$

Q43. [June 2021] . 3.5 marks

Electronics > RLC Circuits

CSIR NET	2021 June	3.5M

In the LCR circuit shown below, the resistance $R = 0.05\ \Omega$, the inductance $L = 1\ H$ and the capacitance $C = 0.04\ F$.



If the input v_{in} is a square wave of angular frequency1rad/s, the output v_{out} is best approximated by a

1. Square wave of angular frequency 1rad/s
2. Sine wave of angular frequency 1rad/s
3. Square wave of angular frequency 5 rad/s
4. Sine wave of angular frequency 5 rad/s

Q44. [June 2021] . 3.5 marks

Electronics > "Errors , curve fitting and data analysis"

CSIR NET	2021 June	3.5M

In an experiment, the velocity of a non-relativistic neutron is determined by measuring the time (~ 50 ns) it takes to travel from the source to the detector kept at a distance L. Assume that the error in the measurement of L is negligibly small. If we want to estimate the kinetic energy T of the neutron to within 5% accuracy, i.e., $|\delta T/T| \leq 0.05$, the maximum permissible error $|\delta T|$ in measuring the time of flight is nearest to

1. 1.75 ns
2. 0.75 ns
3. 2.25 ns
4. 1.25 ns

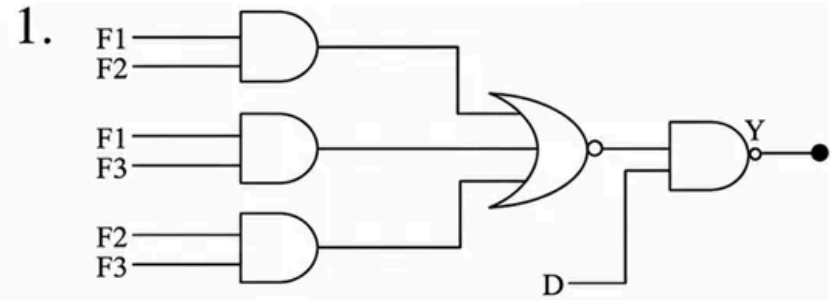
Q45. [June 2021] . 3.5 marks

Electronics > Digital Electronics

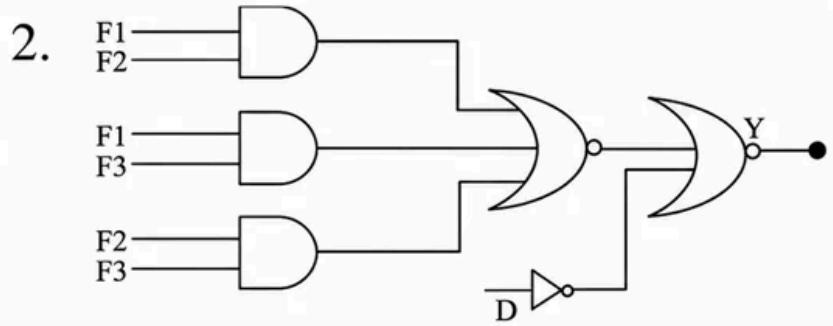
CSIR NET	2021 June	3.5M

The door of an X-ray machine room is fitted with a sensor D (0 is open and 1 is closed). It is also equipped with three fire sensors F_1, F_2 and F_3 (each is 0 when disabled and 1 when enabled). The X-ray machine can operate only if the door is closed and at least 2 fire sensors are enabled. The logic circuit to ensure that the machine can be operated is

1.



2.



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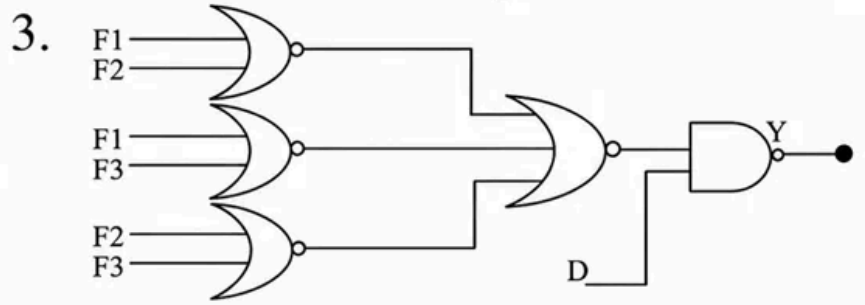

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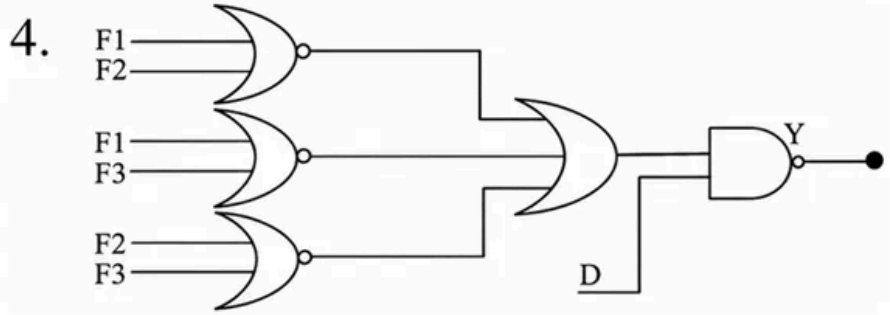


Q46. [June 2021] . 5.0 marks

Mathematical Physics > Fourier Transform

CSIR NET	2021 June	5M

If we use the Fourier transform

$$\phi(x,y) = \int e^{ikx}\phi_k(y)dk$$

to solve the partial differential equation

$$-\frac{\partial^2\phi(x,y)}{\partial y^2} - \frac{1}{y^2}\frac{\partial^2\phi(x,y)}{\partial x^2} + \frac{m^2}{y^2}\phi(x,y) = 0$$

in the half-plane $\{(x,y): -\infty < x < \infty, 0 < y < \infty\}$ the Fourier modes $\phi_k(y)$ depend on y as y^α and y^β. The value of α and β are

1. $\frac{1}{2} + \sqrt{1 + 4(k^2 + m^2)}$ and $\frac{1}{2} - \sqrt{1 + 4(k^2 + m^2)}$
2. $1 + \sqrt{1 + 4(k^2 + m^2)}$ and $1 - \sqrt{1 + 4(k^2 + m^2)}$
3. $\frac{1}{2} + \frac{1}{2}\sqrt{1 + 4(k^2 + m^2)}$ and $\frac{1}{2} - \frac{1}{2}\sqrt{1 + 4(k^2 + m^2)}$
4. $1 + \frac{1}{2}\sqrt{1 + 4(k^2 + m^2)}$ and $1 - \frac{1}{2}\sqrt{1 + 4(k^2 + m^2)}$

Q47. [June 2021] . 5.0 marks

Mathematical Physics > Numerical Methods

CSIR NET	2021 June	5M

The Newton-Raphson method is to be used to determine the reciprocal of the number $x = 4$. If we start with the initial guess 0.20 then after the first iteration the reciprocal is

1. 0.23
2. 0.24
3. 0.25
4. 0.26

Q48. [June 2021] . 5.0 marks

Mathematical Physics > Special Functions

CSIR NET	2021 June	5M

The Legendre polynomials $P_n(x), n = 0,1,2, \ldots$, satisfying the orthogonality condition $\int_{-1}^{1} P_n(x) p_m(x) dx = \frac{2}{2n+1}\delta_{nm}$ on the interval $[-1, +1]$, may be defined by the Rodrigues formula $P_n(x) = \frac{1}{2^n n!}\frac{d^n}{dx^n}(x^2 - 1)^n$. The value of the definite integral $\int_{-1}^{1}(4 + 2x - 3x^2 + 4x^3)P_3(x)dx$ is

1. 3/5
2. 11/15
3. 23/32
4. 16/35

Q49. [June 2021] . 5.0 marks

Classical Mechanics > Oscillations

CSIR NET	2021 June	5M

A particle of mass m moves in a potential that is $V = \frac{1}{2}m(\omega_1^2 x^2 + \omega_2^2 y^2 + \omega_3^2 z^2)$ in the coordinates of a non-inertial frame F. The frame F is rotating with respect to an inertial frame with an angular velocity $\hat{k}\Omega$, where $\hat{k}$ it is the unit vector along their common z-axis. The motion of the particle is unstable for all angular frequencies satisfying

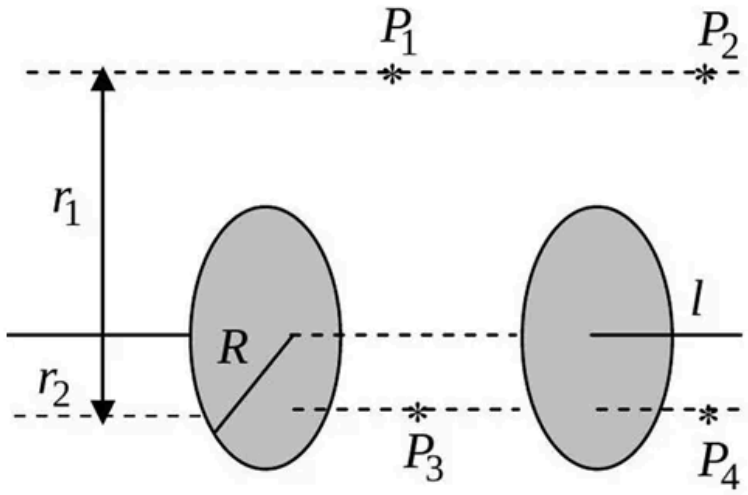
1. $(\Omega^2 - \omega_1^2)(\Omega^2 - \omega_2^2) > 0$
2. $(\Omega^2 - \omega_1^2)(\Omega^2 - \omega_2^2) < 0$
3. $(\Omega^2 - (\omega_1 + \omega_2)^2)(\Omega^2 - |\omega_1 - \omega_2|^2) > 0$
4. $(\Omega^2 - (\omega_1 + \omega_2)^2)(\Omega^2 - |\omega_1 - \omega_2|^2) < 0$

Q50. [June 2021] . 5.0 marks

Electromagnetism > Electrodynamics

CSIR NET	2021 June	5M

The figure below shows an ideal capacitor consisting of two parallel circular plates of radius R. Points P_1 and P_2 are at a transverse distance, $r_1 > R$ from the line joining the centers of the plates, while points P_3 and P_4 are at a transverse distance $r_2 < R$.



It $B(x)$ denotes the magnitude of the magnetic fields at these points, which of the following holds while the capacitor is charging?

1. $B(P_1) < B(P_2)$ and $B(P_3) < B(P_4)$
2. $B(P_1) > B(P_2)$ and $B(P_3) > B(P_4)$
3. $B(P_1) = B(P_2)$ and $B(P_3) < B(P_4)$
4. $B(P_1) = B(P_2)$ and $B(P_3) > B(P_4)$

Q51. [June 2021] . 5.0 marks

Electromagnetism > Electrodynamics

CSIR NET	2021 June	5M

A perfectly conducting fluid of permittivity ε and permeability μ flows with a uniform velocity $\vec{v}$ in the presence of time dependent electric and magnetic fields $\vec{E}$ and $\vec{B}$, respectively, if there is a finite current density in the fluid, then

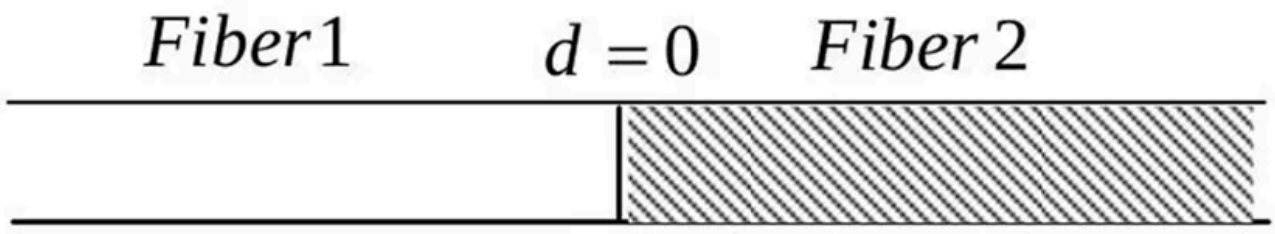
1. $\vec{\nabla} \times (\vec{v} \times \vec{B}) = \frac{\partial \vec{B}}{\partial t}$
2. $\vec{\nabla} \times (\vec{v} \times \vec{B}) = -\frac{\partial \vec{B}}{\partial t}$
3. $\vec{\nabla} \times (\vec{v} \times \vec{B}) = \sqrt{\varepsilon\mu}\frac{\partial \vec{E}}{\partial t}$
4. $\vec{\nabla} \times (\vec{v} \times \vec{B}) = -\sqrt{\varepsilon\mu}\frac{\partial \vec{E}}{\partial t}$

Q52. [June 2021] . 5.0 marks

Electromagnetism > Waveguides

CSIR NET	2021 June	5M

A laser beam propagates from fiber 1 to fiber 2 in a cavity made up of two optical fibers (as shown in the figure). The loss factor of fiber 2 is $10\ \mathrm{dB/km}$.



If $\mathrm{E_2(d)}$ denotes the magnitude of the electric field in fiber 2 at a distance d from the interface, the ratio $\mathrm{E_2(0)/E_2(d)}$ for $\mathrm{d = 10km}$, is

1. 10^2
2. 10^3
3. 10^5
4. 10^7

Q53. [June 2021] . 5.0 marks

Classical Mechanics > Central forces

CSIR NET	2021 June	5M

A particle in two dimensions is found to trace an orbit $r(\theta) = r_0\theta^2$. If it is moving under the influence of a central potential $V(r) = c_1 r^{-a} + c_2 r^{-b}$, where r_0, c_1 and c_2 are constants of appropriate dimensions, the values of a and b, respectively, are

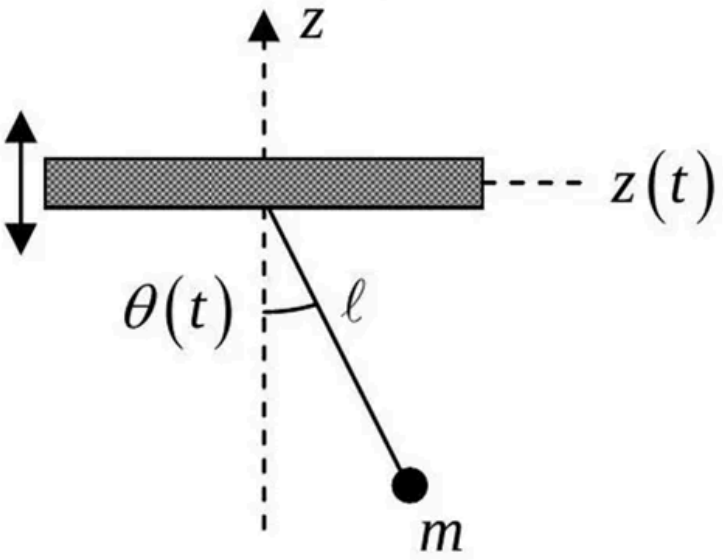
1. 2 and 4
2. 2 and 3
3. 3 and 4
4. 1 and 3

Q54. [June 2021] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2021 June	5M

The fulcrum of a simple pendulum (consisting of a particle of mass m attached to the support by a massless string of length ℓ) oscillates vertically as $\sin z(t) = a\sin \omega t$, where ω is a constant. The pendulum moves in a vertical plane and $\theta(t)$ denotes its angular position with respect to the z-axis.



If $\ell \frac{d^2\theta}{dt^2} + \sin\theta(g - f(t)) = 0$ (where g is the acceleration due to gravity) describes the equation of motion of the mass, then f(t) is

1. $a\omega^2 \cos \omega t$
2. $a\omega^2 \sin \omega t$
3. $-a\omega^2 \cos \omega t$
4. $-a\omega^2 \sin \omega t$

Q55. [June 2021] . 5.0 marks

Classical Mechanics > Central forces

CSIR NET	2021 June	5M

A satellite of mass m orbits around earth in an elliptic trajectory of semi-major axis a. At a radial distance $r = r_0$, measured from the centre of the earth, the kinetic energy is equal to half the magnitude of the total energy. If M denotes the mass of the earth and the total energy is $-\frac{GMm}{2a}$, the value of r_0/a is nearest to

1. 1.33
2. 1.48
3. 1.25
4. 1.67

Q56. [June 2021] . 5.0 marks

Quantum Mechanics > Pertubation theory

CSIR NET	2021 June	5M

A particle of mass m in one dimension is in the ground state of a simple harmonic oscillator described by a Hamiltonian $H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2$ in the standard notation. An impulsive force at time to $t = 0$ suddenly imparts a momentum $p_0 = \sqrt{\hbar m\omega}$ to it. The probability that the particle remains in the original ground state is

1. e^{-2}
2. $e^{-3/2}$
3. e^{-1}
4. $e^{-1/2}$

Q57. [June 2021] . 5.0 marks

Quantum Mechanics > Pertubation theory

CSIR NET	2021 June	5M

The energies of a two-state quantum system are E_0 and $E_0 + \alpha\hbar$, (where $\alpha > 0$ is a constant) and the corresponding normalized state vectors are $|0\rangle$ and $|1\rangle$, respectively. At time $t = 0$, when the system is in the state $|0\rangle$, the potential is altered by a time independent term V such that $\langle 1|V|0\rangle = \hbar\alpha/10$. The transition probability to the state $|1\rangle$ at times $t \ll 1/\alpha$, is

1. $\alpha^2 t^2/25$
2. $\alpha^2 t^2/50$
3. $\alpha^2 t^2/100$
4. $\alpha^2 t^2/200$

Q58. [June 2021] . 5.0 marks

Quantum Mechanics > Scattering theory

CSIR NET	2021 June	5M

In an elastic scattering process at an energy E, the phase shifts satisfy $\delta_0 \approx 30^\circ, \delta_1 \approx 10^\circ$, while the other phase shifts are zero. The polar angle at which the differential cross section peaks is closest to

1. 20°
2. 10°
3. 0°
4. 30°

Q59. [June 2021] . 5.0 marks

Quantum Mechanics > Basic Quantum Mechanics

CSIR NET	2021 June	5M

The unnormalized wave function of a particle in one dimension in an infinite square well with walls at $x = 0$ and $x = a$, is $\psi(x) = x(a - x)$. If $\psi(x)$ is expanded as a linear combination of the energy eigenfunctions, $\int_0^a |\psi(x)|^2 dx$ is proportional to the infinite series

(You may use $\int_0^a t\sin t dt = -a\cos a + \sin a$ and $\int_0^a t^2 \sin t dt = -2 - (a^2 - 2)\cos a + 2a\sin a)$

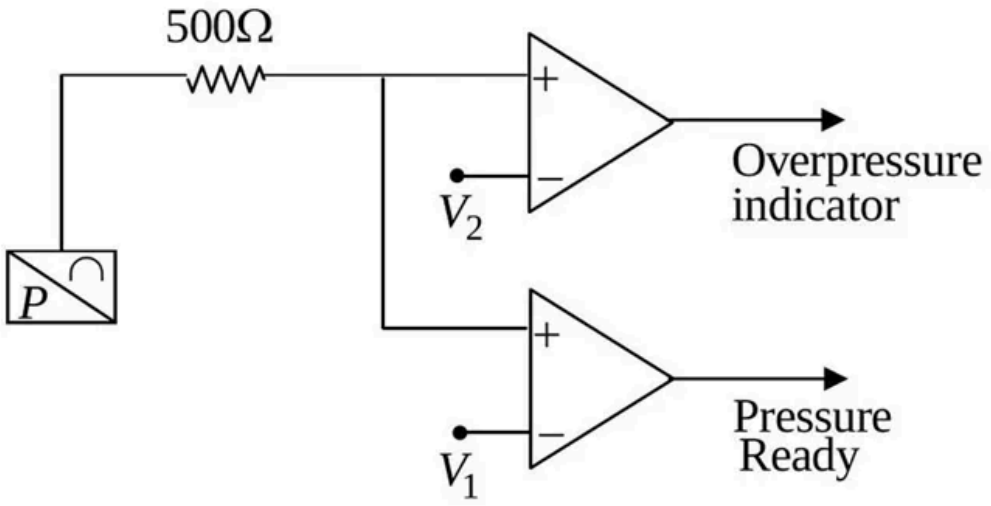
1. $\sum_{n=1}^{\infty}(2n-1)^{-6}$
2. $\sum_{n=1}^{\infty}(2n-1)^{-4}$
3. $\sum_{n=1}^{\infty}(2n-1)^{-2}$
4. $\sum_{n=1}^{\infty}(2n-1)^{-8}$

Q60. [June 2021] . 5.0 marks

Electronics > Instruments

CSIR NET	2021 June	5M

The pressure of a gas in a vessel needs be maintained between 1.5 bar to 2.5 bar in an experiment. The vessel is fitted with a pressure transducer that generates $4\ mA$ to $20\ mA$ current for pressure in the range 1 bar to 5 bar. The current output of the transducer has a linear dependence on the pressure.



The reference voltages V_1 and V_2 in the comparators in the circuit (shown in figure above) suitable for the desired operating conditions are respectively

1. 2 V and 10 V
2. 2 V and 5 V
3. 3 V and 10 V
4. 3 V and 5 V

Q61. [June 2021] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2021 June	5M

The nuclei of ^{137}Cs decay by the emission of β-particles with a half-life of 30.08 years. The activity (in units of disintegrations per second or Bq) of a 1mg source of ^{137}Cs, prepared on January 1, 1980, as measured on January 1, 2021 is closest to

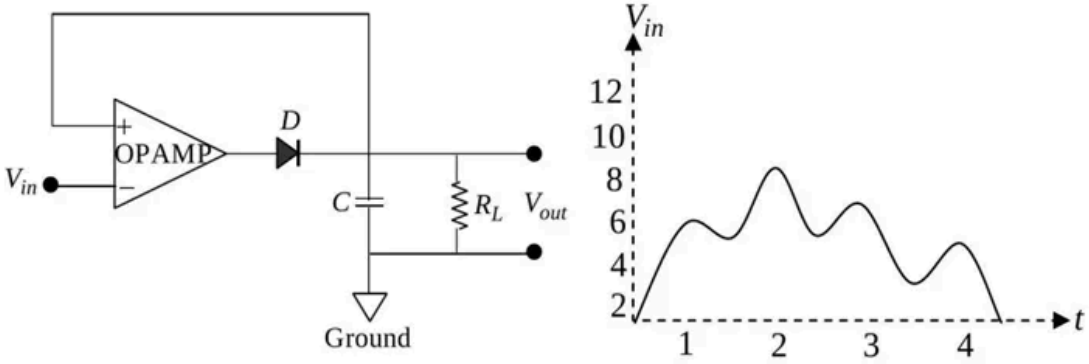
1. 1.79×10^{16}
2. 1.79×10^{9}
3. 1.24×10^{16}
4. 1.24×10^{9}

Q62. [June 2021] . 5.0 marks

Electronics > Instruments

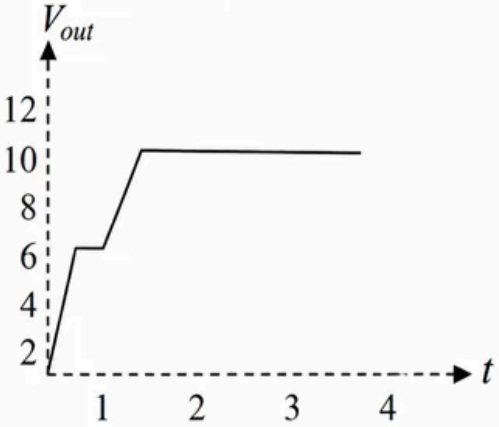
CSIR NET	2021 June	5M

In the following circuit the input voltage V_{in} is such that $|V_{in}| < |V_{sat}|$ where V_{sat} is the saturation voltage of the op-amp (Assume that the diode is an ideal one and $R_L C$ is much larger than the duration of the measurement.)

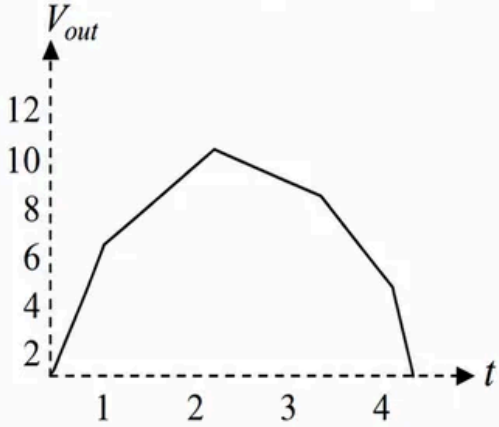


For the input voltage as shown in the figure above the output voltage V_{out} is best represented by

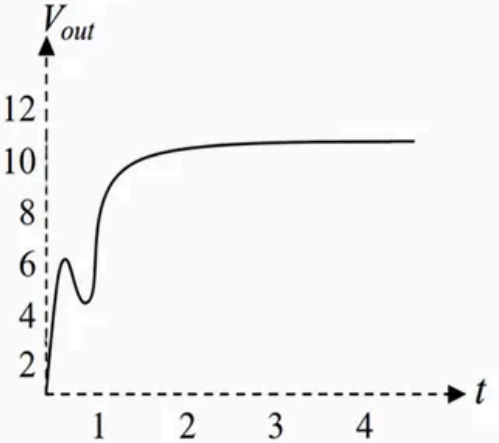
1.



2.



3.



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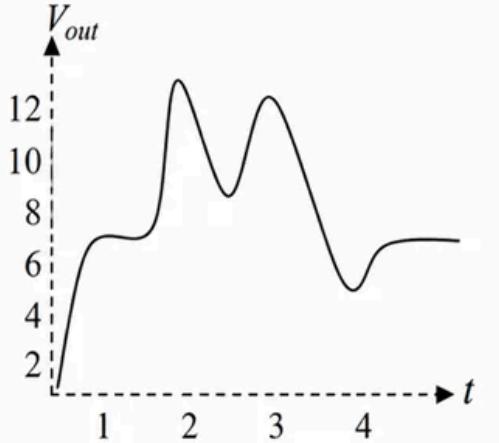
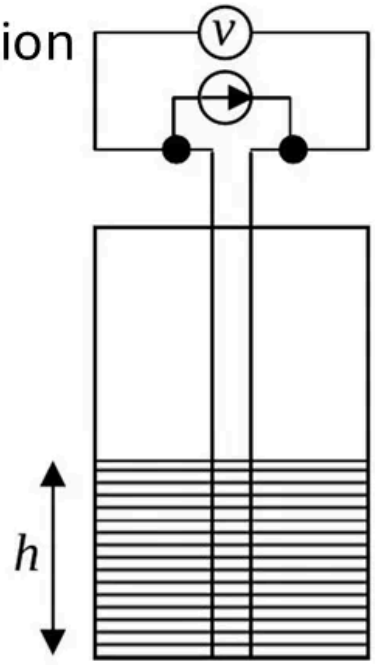


Q63. [June 2021] . 5.0 marks

Solid State Physics > Superconductivity

CSIR NET	2021 June	5M

To measure the height h of a column of liquid helium in a container, a constant current I is sent through an NbTi wire of length l, as shown in the figure. The normal state resistance of the NbTi wire is R. If the superconducting transition temperature of NbTi is $\approx 10K$, then the measured voltage $V(h)$ is best described by the expression



1. $IR\left(\frac{1}{2}-\frac{2h}{l}\right)$
2. $IR\left(1-\frac{h}{l}\right)$
3. $IR\left(\frac{1}{2}-\frac{h}{l}\right)$
4. $IR\left(1-\frac{2h}{l}\right)$

Q64. [June 2021] . 5.0 marks

Statistical Mechanics > Canonical Ensemble

CSIR NET	2021 June	5M

The energy levels of a non-degenerate quantum system are $\epsilon_n = nE_0$, where E_0 is a constant and $n = 1,2,3, \ldots$. At a temperature T, the free energy F can be expressed in terms of the average energy E by

1. $E_0 + k_B T \ln \frac{E}{E_0}$
2. $E_0 + 2k_B T \ln \frac{E}{E_0}$
3. $E_0 - k_B T \ln \frac{E}{E_0}$
4. $E_0 - 2k_B T \ln \frac{E}{E_0}$

Q65. [June 2021] . 5.0 marks

Statistical Mechanics > Canonical Ensemble

CSIR NET	2021 June	5M

A polymer, made up of N monomers, is in thermal equilibrium at temperature T. Each monomer could be of length a or 2a. The first contributes zero energy, while the second one contributes $\in$. The average length (in units of Na) of the polymer at temperature $T = \in/k_B$ is

1. $\frac{5+e}{4+e}$
2. $\frac{4+e}{3+e}$
3. $\frac{3+e}{2+e}$
4. $\frac{2+e}{1+e}$

Q66. [June 2021] . 5.0 marks

Statistical Mechanics > Microcanonical Ensemble

CSIR NET	2021 June	5M

Balls of ten different colours labeled by $a = 1,2, \ldots, 10$ are to be distributed among different coloured boxes. A ball can only go in a box of the same colour, and each box can contain at most one ball. Let n_a and N_a denote respectively, the numbers of balls and boxes of colour a. Assuming that $N_a \gg n_a \gg 1$, the total entropy (in units of the Boltzmann constant) can be best approximated by

1. $\sum_a (N_a \ln N_a + n_a \ln n_a - (N_a - n_a)\ln(N_a - n_a)$
2. $\sum_a \left(N_a \ln N_a - n_a \ln n_a + (N_a - n_a)\ln(N_a - n_a)\right)$
3. $\sum_a \left(N_a \ln N_a - n_a \ln n_a + (N_a - n_a)\ln(N_a - n_a)\right)$
4. $\sum_a \left(N_a \ln N_a + n_a \ln n_a + (N_a - n_a)\ln(N_a - n_a)\right)$

Q67. [June 2021] . 5.0 marks

Statistical Mechanics > Quantum Statistical Mechanics

CSIR NET	2021 June	5M

The dispersion relation of a gas of non-interacting bosons in d dimensions $E(k) = ak^s$ where a and s are positive constants, Bose-Einstein condensation will occur for all values of

1. $d > s$
2. $d + 2 > s > d - 2$
3. $s > 2$ independent of d
4. $d > 2$ independent of s

Q68. [June 2021] . 5.0 marks

Solid State Physics > Superconductivity

CSIR NET	2021 June	5M

Lead is superconducting below 7 K and has a critical magnetic field 800×10^{-4} tesla close to 0 K . At 2 K the critical current that flows through a long lead wire of radius 5 mm is closest to

1. 1760 A
2. 1670 A
3. 1950 A
4. 1840 A

Q69. [June 2021] . 5.0 marks

Solid State Physics > Xray diffraction

CSIR NET	2021 June	5M

Potassium chloride forms an FCC lattice, in which K and Cl occupy alternating sites. The density of KCl is $1.98\ \mathrm{g/cm^3}$ and the atomic weights of K and Cl are 39.1 and 35.5, respectively. The angles of incidence (in degrees) for which Bragg peaks will appear when X ray of wavelength 0.4 nm is shone on a KCl crystal are

1. 18.5,39.4 and 72.2
2. 19.5 and 41.9
3. 12.5, 25.7, 40.5 and 60.0
4. 13.5, 27.8, 44.5 and 69.0

Q70. [June 2021] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2021 June	5M

In the reaction $p + n \rightarrow p + K^+ + X$ mediated by strong interaction, the baryon number B, strangeness S and the third component of isospin I_3 of the particle X are, respectively

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

Q71. [June 2021] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2021 June	5M

A ^{60}Co nucleus β-decays from its ground state with $J^P = 5^+$ to a state of ^{60}Ni with $J^P = 4^+$. From the angular momentum selection rules, the allowed values of the orbital angular momentum L and the total spin S of the electron-antineutrino pair are

1. $L = 0$ and $S = 1$
2. $L = 1$ and $S = 0$
3. $L = 0$ and $S = 0$
4. $L = 1$ and $S = 1$

Q72. [June 2021] . 5.0 marks

Nuclear and Particle Physics > Radioactivity

CSIR NET	2021 June	5M

The Q-value of the α-decay of $^{232}\mathrm{Th}$ to the ground state of $^{228}\mathrm{Ra}$ in $4082\ \mathrm{keV}$. The maximum possible kinetic energy of the α-particle is closest to

1. 4082 keV
2. 4050 keV
3. 4035 keV
4. 4012 keV

Q73. [June 2021] . 5.0 marks

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

CSIR NET	2021 June	5M

The $|3,0,0\rangle$ state in the standard notation $|\mathrm{n},\mathrm{l},\mathrm{m}\rangle$ of the H-atom in the non-relativistic theory decays to the state $|1,0,0\rangle$ via two dipole transition. The transition route and the corresponding probability are

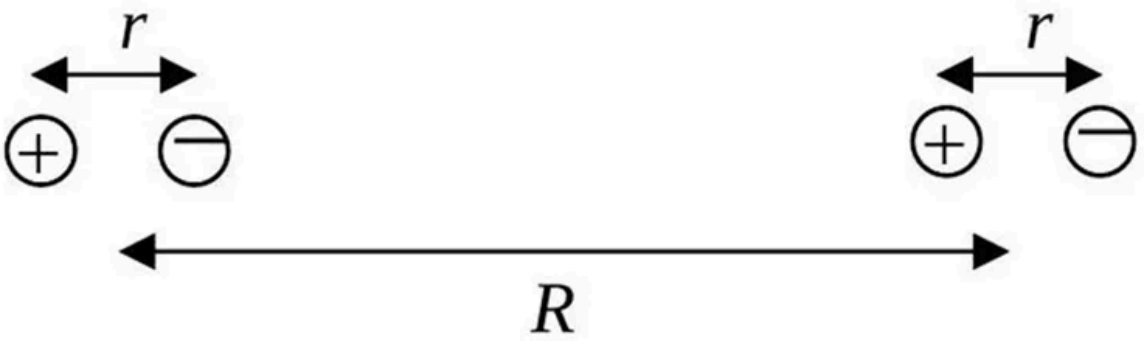
1. $|3,0,0\rangle \rightarrow |2,1,-1\rangle \rightarrow |1,0,0\rangle$ and 1/4
2. $|3,0,0\rangle \rightarrow |2,1,1\rangle \rightarrow |1,0,0\rangle$ and 1/4
3. $|3,0,0\rangle \rightarrow |2,1,0\rangle \rightarrow |1,0,0\rangle$ and $1/3$
4. $|3,0,0\rangle \rightarrow |2,1,0\rangle \rightarrow |1,0,0\rangle$ and $2/3$

Q74. [June 2021] . 5.0 marks

Electromagnetism > Electrostatics

CSIR NET	2021 June	5M

A linear diatomic molecule consists of two identical small electric dipoles with an equilibrium separation R, which is assumed to be a constant. Each dipole has charges $\pm q$ of mass m separated by r when the molecule is at equilibrium. Each dipole can execute simple harmonic motion of angular frequency ω.



Recall that the interaction potential between two dipoles of moments $\vec{p}_1$ and $\vec{p}_2$, separated by $\vec{R}_{12} = R_{12}\hat{n}$ is $(\vec{p}_1 \cdot \vec{p}_2 - 3(\vec{p}_1 \cdot \hat{n})(\vec{p}_2 \cdot \hat{n})/(4\pi \in_0 R_{12}^3)$. Assume that $R \gg r$ and let $\Omega^2 = \frac{q^2}{4\pi\epsilon_0 m R^3}$. The angular frequencies of small oscillations of the diatomic molecule are

1. $\sqrt{\omega^2 + \Omega^2}$ and $\sqrt{\omega^2 - \Omega^2}$
2. $\sqrt{\omega^2 + 3\Omega^2}$ and $\sqrt{\omega^2 - 3\Omega^2}$
3. $\sqrt{\omega^2 + 4\Omega^2}$ and $\sqrt{\omega^2 - 4\Omega^2}$
4. $\sqrt{\omega^2 + 2\Omega^2}$ and $\sqrt{\omega^2 - 2\Omega^2}$

Q75. [June 2021] . 5.0 marks

Atomic and Molecular Physics > Doppler broadening

CSIR NET	2021 June	5M

Diffuse hydrogen gas within a galaxy may be assumed to follow a Maxwell distribution at temperature $10^6\,\mathrm{K}$, while the temperature appropriate for the H gas in the inter-galactic space, following the same distribution, may be taken to be $10^4\,\mathrm{K}$. The ratio of thermal broadening $\Delta\nu_{\mathrm{G}}/\Delta\nu_{\mathrm{IG}}$ of the Lyman- α line from the H-atoms within the galaxy to that from the intergalactic space is closest to

1. 100
2. 1/100
3. 10
4. 1/10

Answer Key

75 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	General Aptitude	Basic Physics	**2**
Q2	General Aptitude	Basic Physics	**2**
Q3	General Aptitude	Mathematical Analysis	**1**
Q4	General Aptitude	Mathematical Analysis	**3**
Q5	General Aptitude	Mathematical Analysis	**2**
Q6	General Aptitude	Mathematical Analysis	**1**
Q7	General Aptitude	Basic Physics	**4**
Q8	General Aptitude	Mathematical Analysis	**4**
Q9	General Aptitude	Mathematical Analysis	**1**
Q10	General Aptitude	Mathematical Analysis	**4**
Q11	General Aptitude	Reasoning	**2**
Q12	General Aptitude	Basic Physics	**1**
Q13	General Aptitude	Basic Physics	**4**
Q14	General Aptitude	Mathematical Analysis	**3**
Q15	General Aptitude	Reasoning	**1**
Q16	General Aptitude	Reasoning	**3**
Q17	General Aptitude	Data Analysis	**1**
Q18	General Aptitude	Reasoning	**2**
Q19	General Aptitude	Geometry	**4**
Q20	General Aptitude	Reasoning	**4**
Q21	Classical Mechanics	Oscillations	**2**
Q22	Mathematical Physics	Ordinary Differential Equations	**3**
Q23	Electromagnetism	Magetostatics	**1**
Q24	Classical Mechanics	Central forces	**2**
Q25	Classical Mechanics	Special theory of relativity	**3**
Q26	Mathematical Physics	Basic Mathematics	**2**
Q27	Mathematical Physics	Vector Algebra and Vector Calculus	**3**
Q28	Mathematical Physics	Matrices and Linear Algebra	**2**
Q29	Mathematical Physics	Probability	**2**
Q30	Mathematical Physics	Tensors	**1**
Q31	Electromagnetism	Electrodynamics	**4**
Q32	Electromagnetism	Magetostatics	**4**
Q33	Classical Mechanics	Special theory of relativity	**3**
Q34	Quantum Mechanics	Pertubation theory	**4**
Q35	Quantum Mechanics	Potential Well	**1**
Q36	Quantum Mechanics	Basic Quantum Mechanics	**2**
Q37	Quantum Mechanics	Potential Well	**1**
Q38	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**3**
Q39	Thermodynamics	Kinetic theory of Gases	**2**
Q40	Statistical Mechanics	Black Body Radiations	**4**

Answer Key (cont.)

Q. No	Subject	Topic	Answer
Q41	Solid State Physics	Lattice vibrations	**2**
Q42	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**4**
Q43	Electronics	RLC Circuits	**4**
Q44	Electronics	"Errors , curve fitting and data analysis"	**4**
Q45	Electronics	Digital Electronics	**2**
Q46	Mathematical Physics	Fourier Transform	**3**
Q47	Mathematical Physics	Numerical Methods	**2**
Q48	Mathematical Physics	Special Functions	**4**
Q49	Classical Mechanics	Oscillations	**2**
Q50	Electromagnetism	Electrodynamics	**3**
Q51	Electromagnetism	Electrodynamics	**1**
Q52	Electromagnetism	Waveguides	**3**
Q53	Classical Mechanics	Central forces	**2**
Q54	Classical Mechanics	Lagrangian and Hamiltonian	**None**
Q55	Classical Mechanics	Central forces	**1**
Q56	Quantum Mechanics	Pertubation theory	**4**
Q57	Quantum Mechanics	Pertubation theory	**3**
Q58	Quantum Mechanics	Scattering theory	**3**
Q59	Quantum Mechanics	Basic Quantum Mechanics	**1**
Q60	Electronics	Instruments	**4**
Q61	Nuclear and Particle Physics	Radioactivity	**4**
Q62	Electronics	Instruments	**1**
Q63	Solid State Physics	Superconductivity	**4**
Q64	Statistical Mechanics	Canonical Ensemble	**3**
Q65	Statistical Mechanics	Canonical Ensemble	**4**
Q66	Statistical Mechanics	Microcanonical Ensemble	**2**
Q67	Statistical Mechanics	Quantum Statistical Mechanics	**1**
Q68	Solid State Physics	Superconductivity	**4**
Q69	Solid State Physics	Xray diffraction	**1**
Q70	Nuclear and Particle Physics	Particle physics	**2**
Q71	Nuclear and Particle Physics	Radioactivity	**1**
Q72	Nuclear and Particle Physics	Radioactivity	**4**
Q73	Atomic and Molecular Physics	Bohar Model and h-atom model	**3**
Q74	Electromagnetism	Electrostatics	**3**
Q75	Atomic and Molecular Physics	Doppler broadening	**3**

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