# PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

# CSIR NET Physics - June 2022 - Full Paper

Complete question paper with answer key

**75 questions . Answer key included**

**www.physicsbyaaryan.com . www.csirnetphysics.com**
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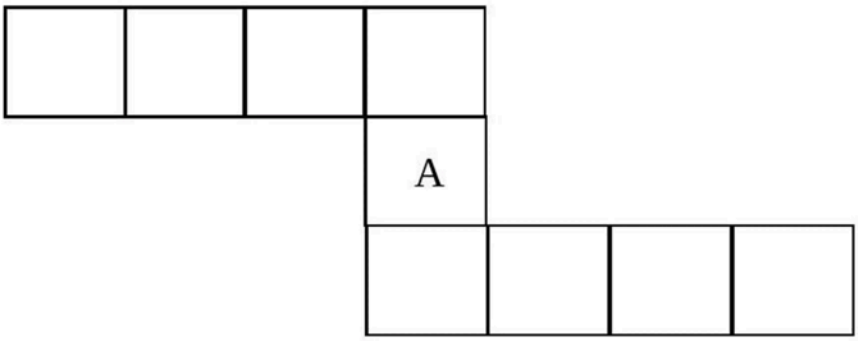
**Q1. [June 2022] . 2.0 marks**

General Aptitude > Reasoning

| CSIR NET | 2022 June | 2M |
|---|---|---|

The squares in the following sketch are filled with digits 1 to 9 , without any repetition, such that the numbers in the two horizontal rows add up to 20 each. What number appears in the square labelled A in the vertical column?

1. It cannot be ascertained in the absence of the sum of the numbers in the column
2. 3
3. 5
4. 7



**Q2. [June 2022] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2022 June | 2M |
|---|---|---|

Sections $A$, $B$, $C$ and $D$ of a class have 24, 27, 30 and 36 students, respectively. One section has boys and girls who are seated alternately in three rows, such that the first and the last positions in each row are occupied by boys. Which section could this be?

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

**Q3. [June 2022] . 2.0 marks**

General Aptitude > Reasoning

| CSIR NET | 2022 June | 2M |
|---|---|---|

In a round-robin tournament, after each team has played exactly four matches, the number of wins / losses of 6 participating teams are as follows

Which of the two teams have certainly NOT played with each other?

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

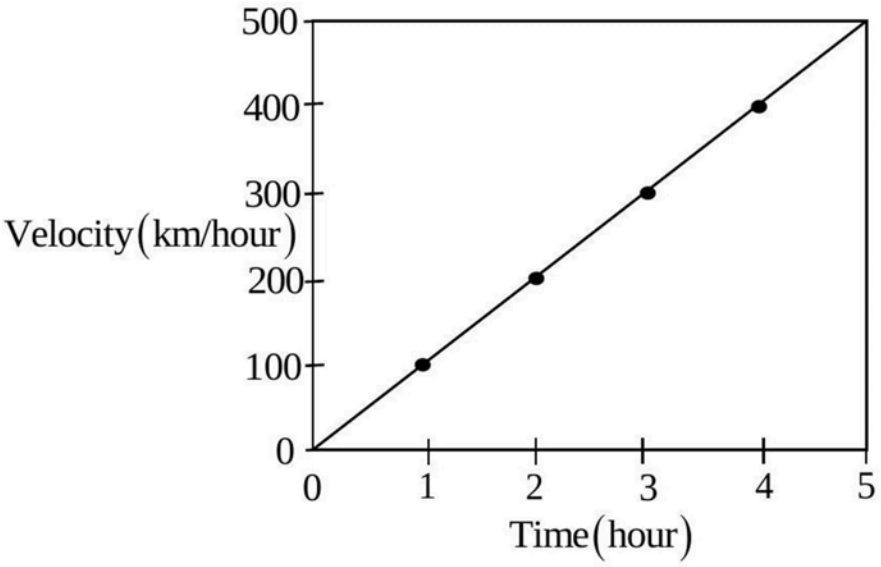
| Team | Win | Loss |
|---|---|---|
| $A$ | 4 | 0 |
| $B$ | 0 | 4 |
| $C$ | 3 | 1 |
| $D$ | 2 | 2 |
| $E$ | 0 | 4 |
| $F$ | 3 | 1 |

**Q4. [June 2022] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2022 June | 2M |
|---|---|---|

Given plot describes the motion of an object with time.




1. The object is moving with a constant velocity.
2. The object covers equal distance every hour.
3. The object is accelerating.
4. Velocity of the object doubles every hour.

**Q5. [June 2022] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2022 June | 2M |
|---|---|---|

If one letter each is drawn at random from the words CAUSE and EFFECT, the chance that they are the same is

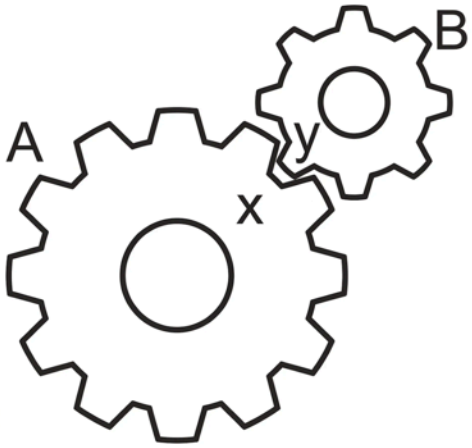
1. $1/30$
2. $1/11$
3. $1/10$
4. $2/11$

**Q6. [June 2022] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2022 June | 2M |
|---|---|---|

A vehicle has tyres of diameter 1 m connected by a shaft directly to gearwheel A which meshes with gearwheel B as shown in the diagram. A has 12 teeth and B has 8 . If points $x$ on A and $y$ on B are initially in contact, they will again be in contact after the vehicle has travelled a distance (in meters)




1. $2\pi$
2. $3\pi$
3. $4\pi$
4. $12\pi$

**Q7. [June 2022] . 2.0 marks**

General Aptitude > Reasoning

| CSIR NET | 2022 June | 2M |
|---|---|---|

A liar always lies and a non-liar, never. If in a group of $n$ persons seated around a roundtable everyone calls his/her left neighbor a liar, then

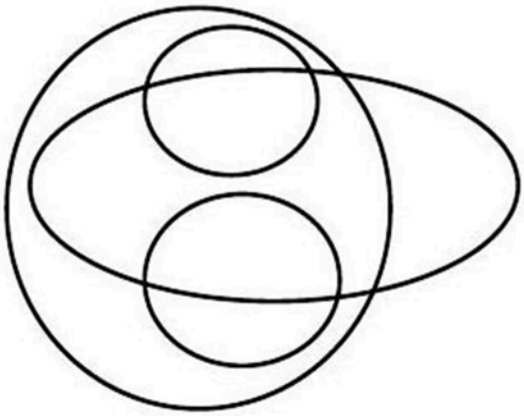
1. all are liars.
2. $n$ must be even and every alternate person is a liar
3. $n$ must be odd and every alternate person is a liar
4. $n$ must be a prime

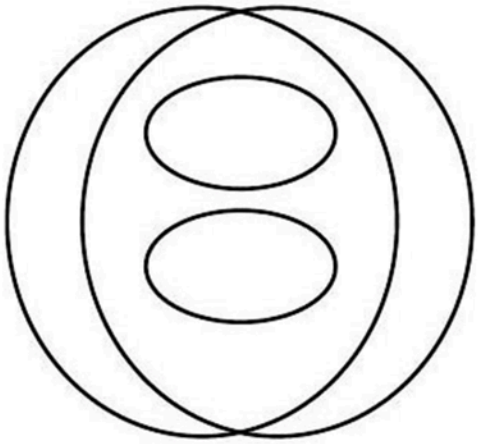
**Q8. [June 2022] . 2.0 marks**

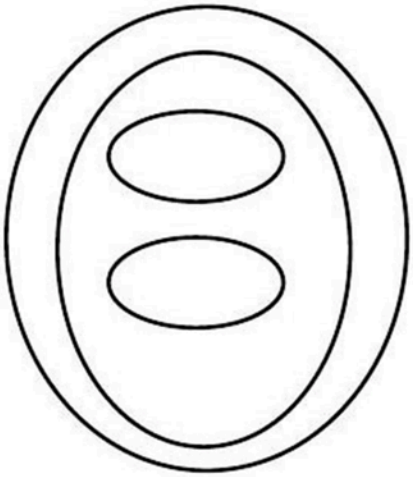
General Aptitude > Reasoning

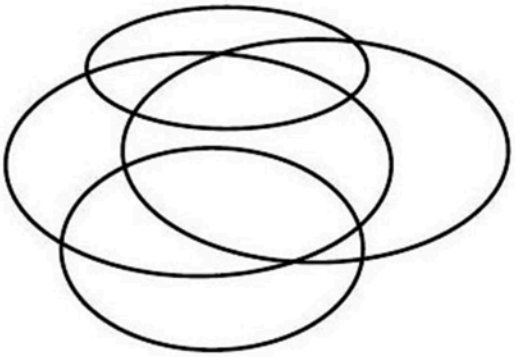
| CSIR NET | 2022 June | 2M |
|---|---|---|

The correct pictorial representation of the relations among the categories PLAYERS, FEMALE CRICKETERS, MALE FOOTBALLERS and GRADUATES is

1. 

2. 

3. 

4. 

**Q9. [June 2022] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2022 June | 2M |
|---|---|---|

What is the product of the number of capital letters and the number of small letters of the English alphabet in the following text?

A4;={c8%$56((+B/;,.H&r]]](u];#~K@>83<??/STvx%^(d)L:/<-N347)))2;:$+}E$###{w}`"..;/89

1. 17
2. 37
3. 53
4. 63

**Q10. [June 2022] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2022 June | 2M |
|---|---|---|

On a track of 200 m length, $S$ runs from the starting point and $R$ starts 20 m ahead of $S$ at the same time. Both reach the end of the track at the same time. $S$ runs at a uniform speed of $10\ \mathrm{m/s}$. If $R$ also runs at a uniform speed, what is $R$'s speed (in $\mathrm{m/s}$ )?

1. 9
2. 10
3. 12
4. 8

**Q11. [June 2022] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2022 June | 2M |
|---|---|---|

A plant grows by 10% of its height every three months. If the plant's height today is 1 m , its height after one year is the closest to

1. 1.10 m
2. 1.21 m
3. 1.33 m
4. 1.46 m

**Q12. [June 2022] . 2.0 marks**

General Aptitude > Basic Physics

| CSIR NET | 2022 June | 2M |
|---|---|---|

Starting from the top of a page and pointing downward, an ant moves according to the following commands

Start

↓

Repeat actions in curly brackets 3 times

Repeat actions in the box 4 times

Move forward 100 units

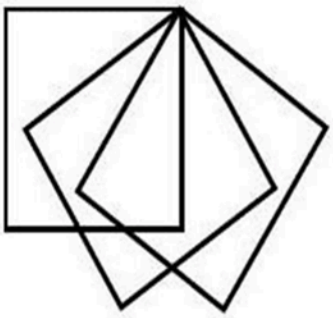
↓

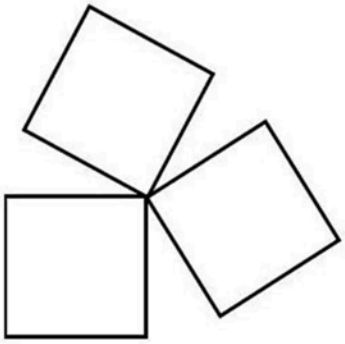
Turn right by 90 degrees

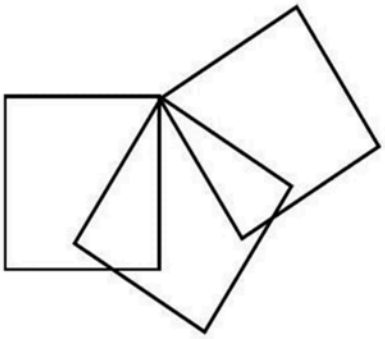
↓

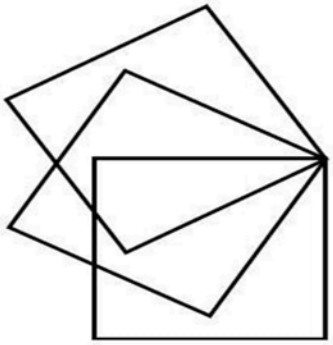
Turn left by 30 degrees

Of the following paths

A 

B 

C 

D 

Which is the correct path of the ant?

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

**Q13. [June 2022] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2022 June | 2M |
|---|---|---|

In a four-digit PIN, the third digit is the product of the first two digits and the fourth digit is zero. The number of such PINs is

1. 42
2. 41
3. 40
4. 39

**Q14. [June 2022] . 2.0 marks**

General Aptitude > Reasoning

| CSIR NET | 2022 June | 2M |
|---|---|---|

After 12:00:00 the hour hand and minute hand of a clock will be perpendicular to each other for the first time at

1. 12:16:21
2. 12: 15: 00
3. 13: 22: 21
4. 12: 48: 08

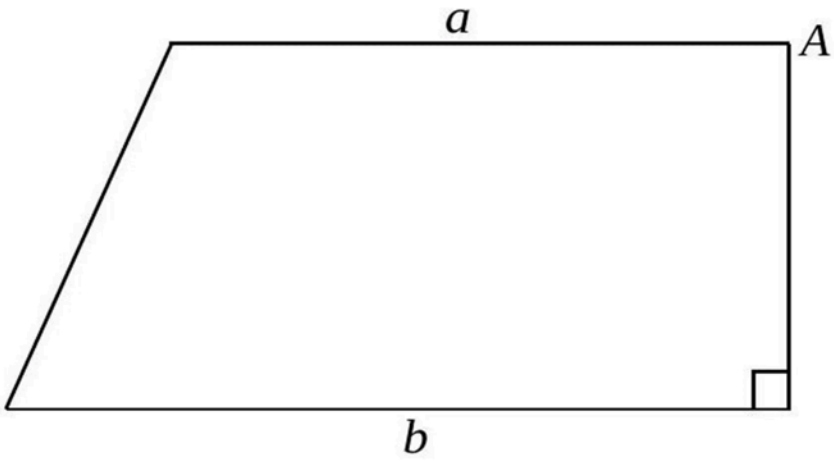
**Q15. [June 2022] . 2.0 marks**

General Aptitude > Geometry

| CSIR NET | 2022 June | 2M |
|---|---|---|

At what horizontal distance from $A$ should a vertical line be drawn so as to divide the area of the trapezium shown in the figure into two equal parts? ( $a$ and $b$ are lengths of the parallel sides.)

1. $(a+b)/4$
2. $(a+b)/3$
3. $(a+b)/2$
4. $(2a+b)/2$



**Q16. [June 2022] . 2.0 marks**

General Aptitude > Reasoning

| CSIR NET | 2022 June | 2M |
|---|---|---|

I have a brother who is 4 years elder to me, and a sister who was 5 years old when my brother was born. When my sister was born, my father was 24 years old. My mother was 27 years old when I was born. How old (in years) were my father and mother, respectively, when my brother was born?

1. 29 and 23
2. 27 and 25
3. 27 and 23
4. 29 and 25

**Q17. [June 2022] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2022 June | 2M |
|---|---|---|

A boy has kites of which all but 9 are red, all but 9 are yellow, all but 9 are green, and all but 9 are blue. How many kites does he have?

1. 12
2. 15
3. 9
4. 18

**Q18. [June 2022] . 2.0 marks**

General Aptitude > Mathematical Analysis

| CSIR NET | 2022 June | 2M |
|---|---|---|

Tokens numbered from 1 to 25 are mixed and one token is drawn randomly. What is the probability that the number on the token drawn is divisible either by 4 or by 6 ?

1. $8/25$
2. $10/25$
3. $9/25$
4. $12/25$

**Q19. [June 2022] . 2.0 marks**

General Aptitude > Geometry

| CSIR NET | 2022 June | 2M |
|---|---|---|

A beam of square cross-section is to be cut out of a wooden log. Assuming that the log is cylindrical, what approximately is the largest fraction of the wood by volume that can be fruitfully utilized as the beam?

1. 49%
2. 64%
3. 71%
4. 81%

**Q20. [June 2022] . 2.0 marks**

General Aptitude > Geometry

| CSIR NET | 2022 June | 2M |
|---|---|---|

How many rectangles are there in the given figure?

1. 6
2. 7
3. 8
4. 9

**Q21. [June 2022] . 3.5 marks**

Mathematical Physics > Gamma and beta functions

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

The value of the integral $\int_0^\infty dx e^{-x^{2m}}$, where $m$ is a positive integer, is

1. $\Gamma\left(\frac{m+1}{2m}\right)$
2. $\Gamma\left(\frac{m-1}{2m}\right)$
3. $\Gamma\left(\frac{2m+1}{2m}\right)$
4. $\Gamma\left(\frac{2m-1}{2m}\right)$

**Q22. [June 2022] . 3.5 marks**

Mathematical Physics > Complex analysis

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

At $z = 0$, the function $\frac{1}{z - \sin z}$ of a complex variable $z$ has

1. no singularity
2. a simple pole
3. a pole of order 2
4. a pole of order 3

**Q23. [June 2022] . 3.5 marks**

Mathematical Physics > Matrices and Linear Algebra

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

Two $n \times n$ invertible real matrices $A$ and $B$ satisfy the relation $(AB)^T = -(A^{-1}B)^{-1}$

If $B$ is orthogonal then $A$ must be

1. Lower triangular
2. Orthogonal
3. Symmetric
4. Antisymmetric

**Q24. [June 2022] . 3.5 marks**

Mathematical Physics > Basic Mathematics

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

The infinite series $\sum_{n=0}^{\infty}(n^2+3n+2)x^n$ evaluated at $x=\frac{1}{2}$, is

1. 16
2. 32
3. 8
4. 24

**Q25. [June 2022] . 3.5 marks**

Mathematical Physics > Complex analysis

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

If $z=i^{i^{i'}}$ (note that the exponent continues indefinitely), then a possible value of $\frac{1}{z}\ln z$ is

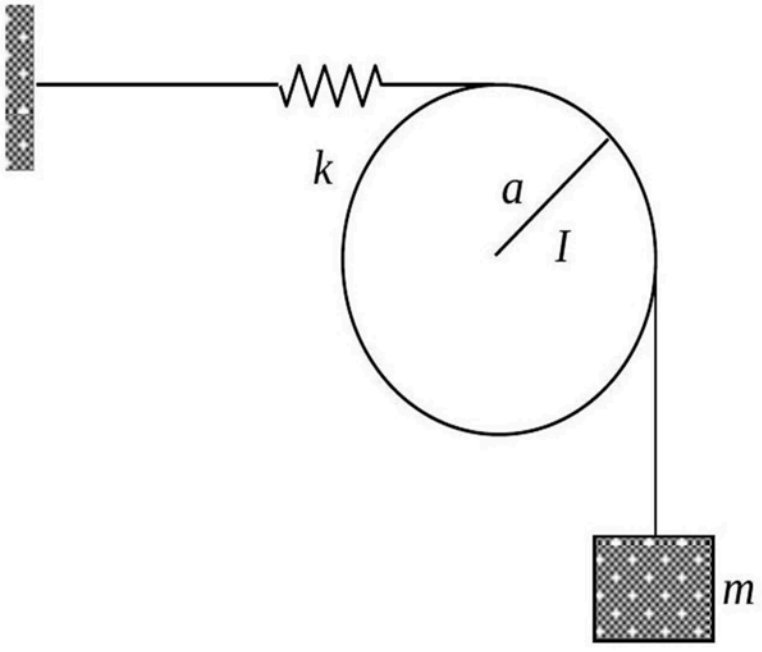
1. $2i\ln i$
2. $l\,n\,i$
3. $i\ln i$
4. $2\ln i$

**Q26. [June 2022] . 3.5 marks**

Classical Mechanics > Oscillations

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

A wire, connected to a massless spring of spring constant $k$ and a block of mass $m$, goes around a disc of radius $a$ and moment of inertia $I$, as shown in the figure. Assume that the spring remains horizontal, the pulley rotates freely and there is no slippage between the wire and the pulley. The angular frequency of small oscillations of the disc is




1. $\sqrt{\frac{2ka^2}{ma^2+I}}$
2. $\sqrt{\frac{ka^2}{ma^2+I}}$
3. $\sqrt{\frac{ka^2}{ma^2+2I}}$
4. $\sqrt{\frac{ka^2}{2ma^2+I}}$

**Q27. [June 2022] . 3.5 marks**

Classical Mechanics > Lagrangian and Hamiltonian

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

The Lagrangian of a system described by three generalized coordinates $q_1, q_2$ and $q_3$ is

$$L = \frac{1}{2}m(\dot{q}_1^2 + \dot{q}_2^2) + M\dot{q}_1\dot{q}_2 + k\dot{q}_1 q_3,$$

where $m, M$ and $k$ are positive constants. Then, as a function of time

1. two coordinates remain constant and one evolves linearly
2. one coordinate remains constant, one evolves linearly and the third evolves as a quadratic function
3. one coordinate evolves linearly and two evolve quadratically
4. all three evolve linearly

**Q28. [June 2022] . 3.5 marks**

Classical Mechanics > Central forces

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

The periods of oscillation of a simple pendulum at the sea level and at the top of a mountain of height 6 km are $T_1$ and $T_2$, respectively. If the radius of earth is approximately 6000 km, then $\frac{(T_2-T_1)}{T_1}$ is closest to

1. $-10^{-4}$
2. $-10^{-3}$
3. $10^{-4}$
4. $10^{-3}$

**Q29. [June 2022] . 3.5 marks**

Classical Mechanics > Special theory of relativity

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

A particle of rest mass $m$ is moving with a velocity $v\hat{k}$, with respect to an inertial frame $S$. The energy of the particle as measured by an observer $S'$, who is moving with a uniform velocity $u\hat{\imath}$ with respect to $S$ (in terms of $\gamma_u = 1/\sqrt{1-u^2/c^2}$ and $\gamma_v = 1/\sqrt{1-v^2/c^2}$ is

1. $\gamma_u\gamma_v m(c^2 - uv)$
2. $\gamma_u\gamma_v mc^2$
3. $\frac{1}{2}(\gamma_u + \gamma_v)mc^2$
4. $\frac{1}{2}(\gamma_u + \gamma_v)m(c^2 - uv)$

**Q30. [June 2022] . 3.5 marks**

Electromagnetism > EM Waves

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

An electromagnetic wave is incident from vacuum normally on a planer surface of a nonmagnetic medium. If the amplitude of the electric field of the incident wave is $E_0$ and that of the transmitted wave is $2E_0/3$, then neglecting any loss, the refractive index of the medium is

1. 1.5
2. 2.0
3. 2.4
4. 2.7

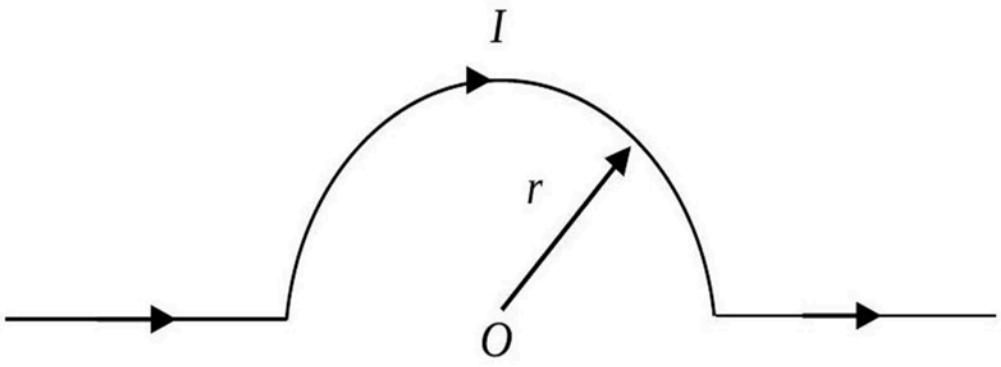
**Q31. [June 2022] . 3.5 marks**

Electromagnetism > Magetostatics

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

A part of an infinitely long wire, carrying a current $I$, is bent in a semi-circular arc of radius $r$ (as shown in the figure). The magnetic field at the centre $O$ of the arc is

1. $\frac{\mu_0 I}{4r}$
2. $\frac{\mu_0 I}{4\pi r}$
3. $\frac{\mu_0 I}{2r}$
4. $\frac{\mu_0 I}{2\pi r}$

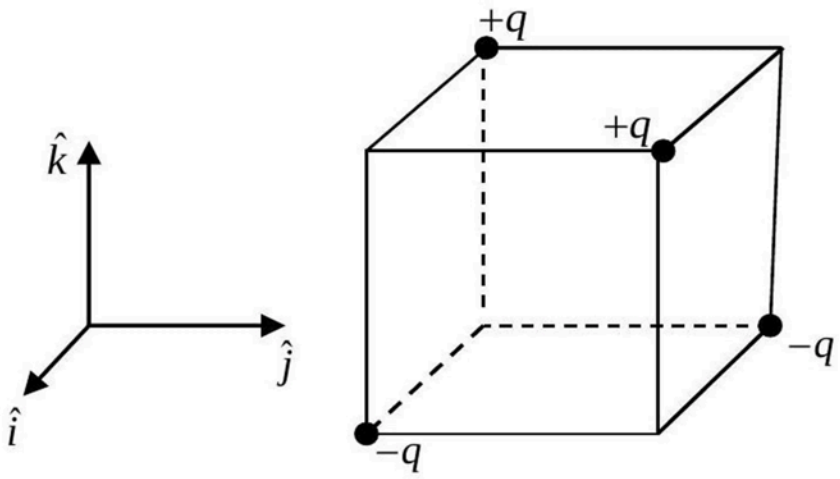


**Q32. [June 2022] . 3.5 marks**

Electromagnetism > Multipoles

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

Two positive and two negative charges of magnitude $q$ are placed on the alternate vertices of a cube of side $a$ (as shown in the figure).




The electric dipole moment of this charge configuration is

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

**Q33. [June 2022] . 3.5 marks**

Electromagnetism > Relativistic electromagnetism

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

The electric and magnetic fields in an inertial frame are $\vec{E} = 3a\hat{i} - 4\hat{j}$ and $\vec{B} = \frac{5a}{c}\hat{k}$, where $a$ is a constant. A massive charged particle is released from rest. The necessary and sufficient condition that there is an inertial frame, where the trajectory of the particle is a uniform-pitched helix, is

1. $1 < a < \sqrt{2}$
2. $-1 < a < 1$
3. $a^2 > 1$
4. $a^2 > 2$

**Q34. [June 2022] . 3.5 marks**

Quantum Mechanics > Basic Quantum Mechanics

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

If the expectation value of the momentum of a particle in one dimension is zero, then its (box-normalizable) wave function may be of the form

1. $\sin kx$
2. $e^{ikx} \sin kx$
3. $e^{ikx} \cos kx$
4. $\sin kx + e^{ikx} \cos kx$

**Q35. [June 2022] . 3.5 marks**

Quantum Mechanics > Basic Quantum Mechanics

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

In terms of a complete set of orthonormal basis kets $|n\rangle$, $n = 0, \pm 1, \pm 2, \ldots$, the Hamiltonian is

$$H = \sum_n (E|n\rangle\langle n| + \epsilon|n+1\rangle\langle n| + \epsilon|n\rangle\langle n+1|)$$

where E and $\in$ are constants. The state $|\varphi\rangle = \sum_n e^{in\varphi}|n\rangle$ is an eigenstate with energy

1. $E + \in cos\,\varphi$
2. $E - \in cos\,\varphi$
3. $E + 2 \in cos\,\varphi$
4. $E - 2 \in \cos\varphi$

**Q36. [June 2022] . 3.5 marks**

Quantum Mechanics > Basic Quantum Mechanics

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

The momentum space representation of the Schrodinger equation of a particle in a potential $V(\vec{r})$ is $\left(|\vec{p}|^2 + \beta\left(\nabla_p^2\right)^2\right)\psi(\vec{p},t) = i\hbar\frac{\partial}{\partial t}\psi(\vec{p},t)$ , where $\left(\nabla_p\right)_i = \frac{\partial}{\partial p_i}$, and $\beta$ is a constant. The potential is (in the following $V_0$ and $a$ are constants)

1. $V_0 e^{-r^2/a^2}$
2. $V_0 e^{-r^4/a^4}$
3. $V_0\left(\frac{r}{a}\right)^2$
4. $V_0\left(\frac{r}{a}\right)^4$

**Q37. [June 2022] . 3.5 marks**

Quantum Mechanics > Spin Angular momentum

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

Consider the Hamiltonian $H = AI + B\sigma_x + C\sigma_y$, where $A, B$ and $C$ are positive constants, $I$ is the $2 \times 2$ identity matrix and $\sigma_x, \sigma_y$ are Pauli matrices. If the normalized eigenvector corresponding to its largest energy eigenvalue is $\frac{1}{\sqrt{2}}\begin{pmatrix}1\\ y\end{pmatrix}$, then $y$ is

1. $\frac{B+iC}{\sqrt{B^2+C^2}}$
2. $\frac{A-iB}{\sqrt{A^2+B^2}}$
3. $\frac{A-iC}{\sqrt{A^2+C^2}}$
4. $\frac{B-iC}{\sqrt{B^2+C^2}}$

**Q38. [June 2022] . 3.5 marks**

Statistical Mechanics > Canonical Ensemble

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

If the average energy $\langle E \rangle_T$ of a quantum harmonic oscillator at a temperature $T$ is such that $\langle E \rangle_T = 2\langle E \rangle_{T \to 0}$, then $T$ satisfies

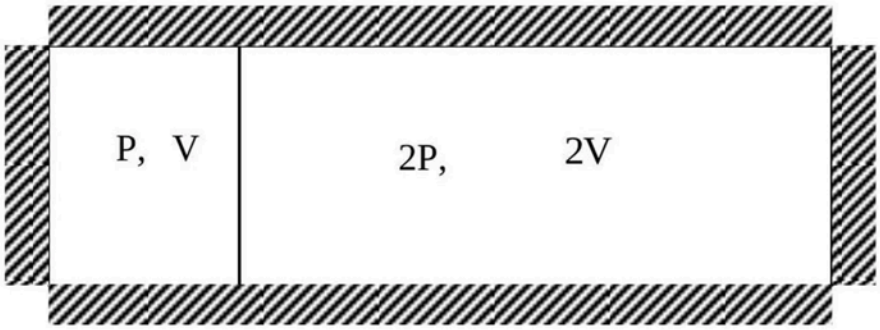
1. $coth\left(\frac{\hbar\omega}{k_B T}\right) = 2$
2. $coth\left(\frac{\hbar\omega}{2k_B T}\right) = 2$
3. $coth\left(\frac{\hbar\omega}{k_B T}\right) = 4$
4. $\coth\left(\frac{\hbar\omega}{2k_B T}\right) = 4$

**Q39. [June 2022] . 3.5 marks**

Thermodynamics > Laws of thermodynamics

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

A thermally isolated container, filled with an ideal gas at temperature $T$, is divided by a partition, which is clamped initially, as shown in the figure below.




The partition does not allow the gas in the two parts to mix. It is subsequently released and allowed to move freely with negligible friction. The final pressure at equilibrium is

1. $5P/3$
2. $5P/4$
3. $3P/5$
4. $4P/5$

**Q40. [June 2022] . 3.5 marks**

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

A walker takes steps, each of length $L$, randomly in the directions along east, west, north and south. After four steps its distance from the starting point is $d$. The probability that $d \leq 3L$ is

1. $63/64$
2. $59/64$
3. $57/64$
4. $55/64$

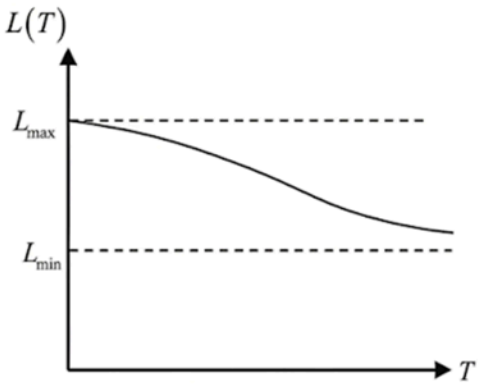
**Q41. [June 2022] . 3.5 marks**

Statistical Mechanics > Canonical Ensemble

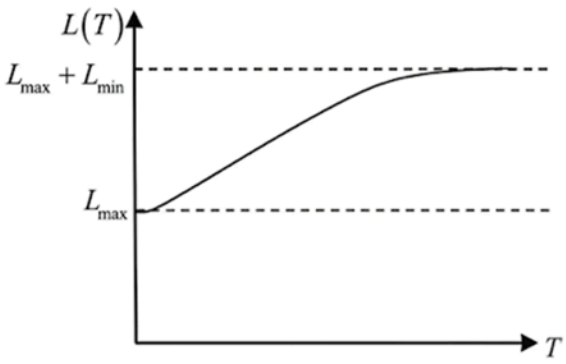
| CSIR NET | 2022 June | 3.5M |
|---|---|---|

An elastic rod has a low energy state of length $L_{max}$ and high energy state of length $L_{min}$. The best schematic representation of the temperature (T) dependence of the mean equilibrium length L(T) of the rod, is

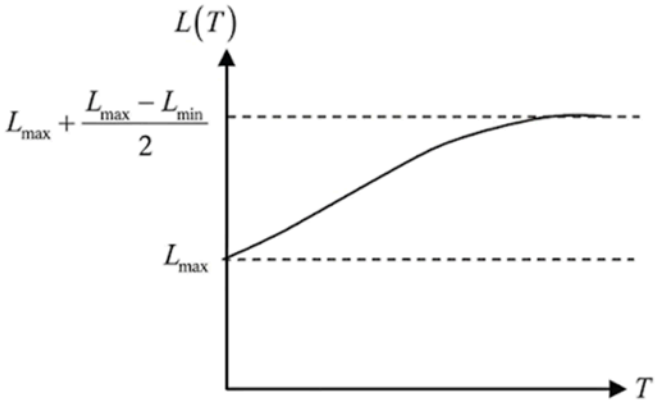
1.



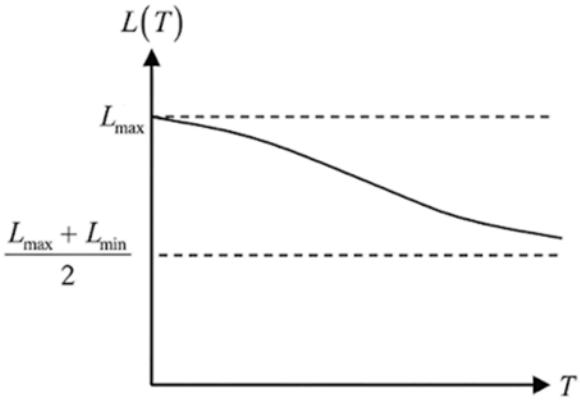

2.




3.




4.



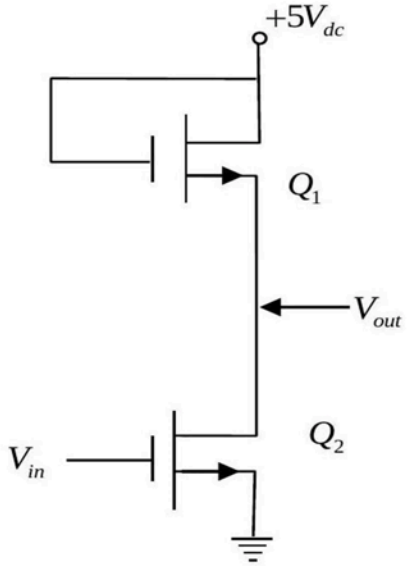
**Q42. [June 2022] . 3.5 marks**

Electronics > FET

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

The circuit containing two n-channel MOSFETs shown below, works as

1. a buffer
2. a non-inverting amplifier
3. an inverter
4. a rectifier



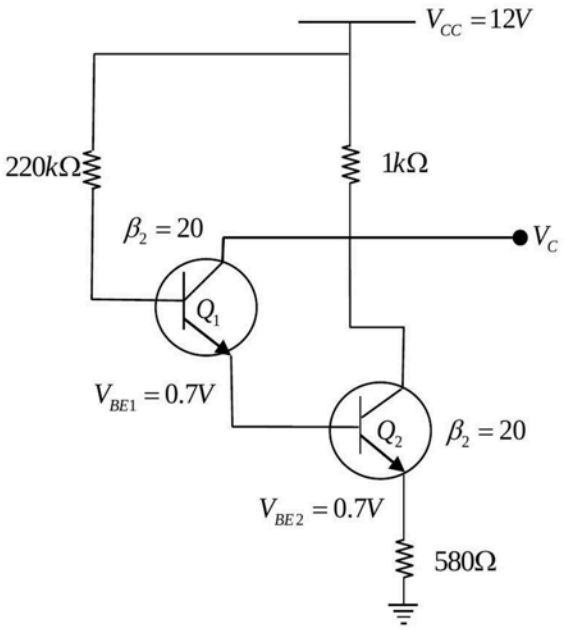
**Q43. [June 2022] . 3.5 marks**

Electronics > Transistors

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

The figure below shows a circuit with two transistors, $Q_1$ and $Q_2$, having current gains $\beta_1$ and $\beta_2$ respectively. The collector voltage $V_C$ will be closest to

1. 0.9 V
2. 2.2 V
3. 2.9 V
4. 4.2 V

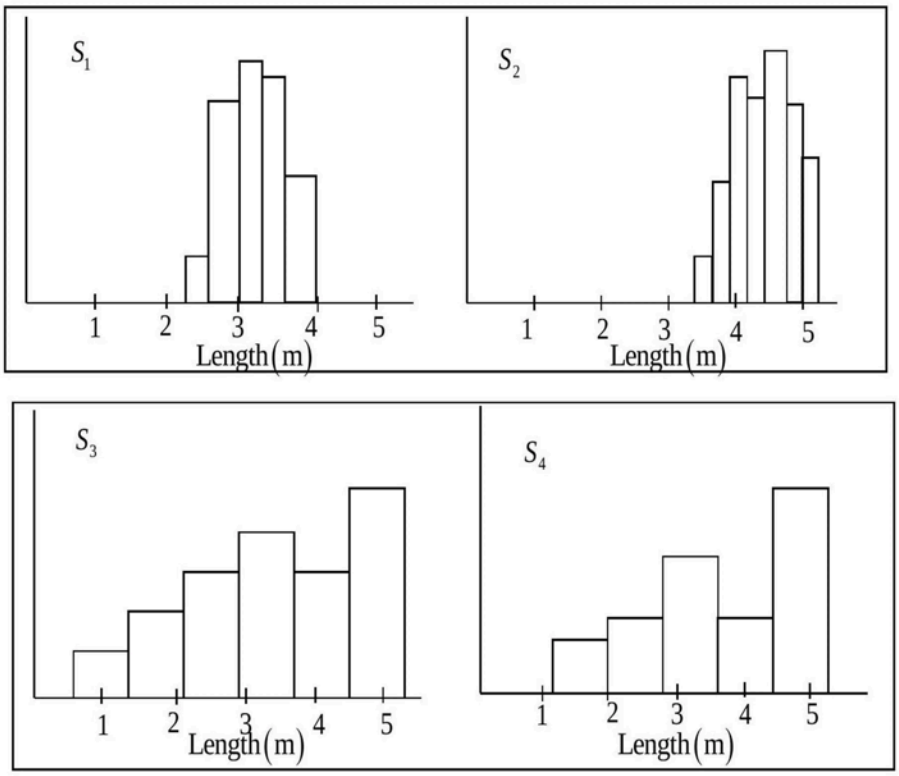


**Q44. [June 2022] . 3.5 marks**

Electronics > "Errors , curve fitting and data analysis"

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

Four students ($S_1, S_2, S_3$ and $S_4$) make multiple measurements on the length of a table. The binned data are plotted as histograms in the following figures.




If the length of the table, specified by the manufacturer, is $3m$ , the student whose measurements have the minimum systematic error, is

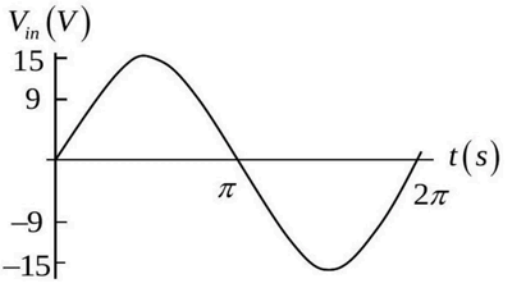
1. $S_2$
2. $S_1$
3. $S_4$
4. $S_3$

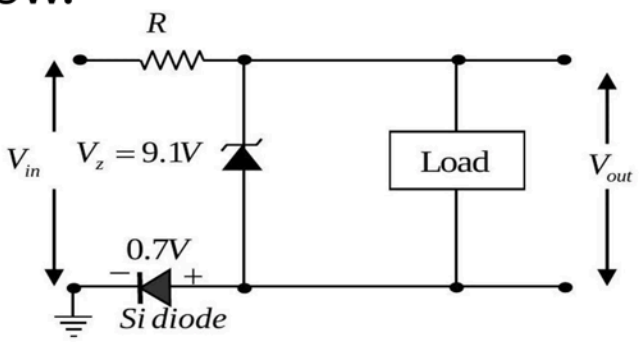
**Q45. [June 2022] . 3.5 marks**

Electronics > Diodes

| CSIR NET | 2022 June | 3.5M |
|---|---|---|

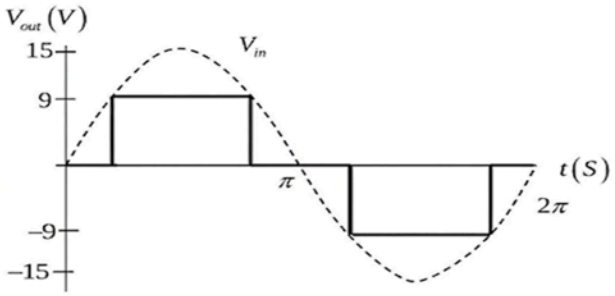
A high impedance load (network) is connected in the circuit as shown below.



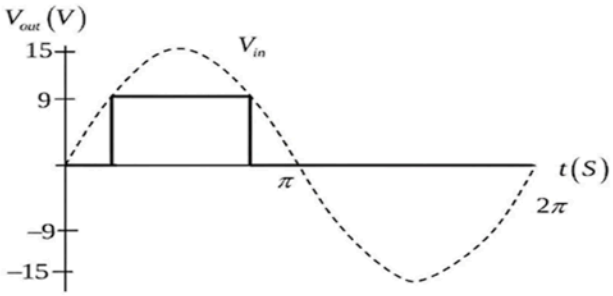




The forward voltage drop for silicon diode is 0.7 V and the Zener voltage is 9.10 V . If the input voltage ( $V_{in}$ ) is sine wave with an amplitude of 15 V (as shown in the figure above), which of the following waveform qualitatively describes the output voltage ($V_{out}$) across the load?

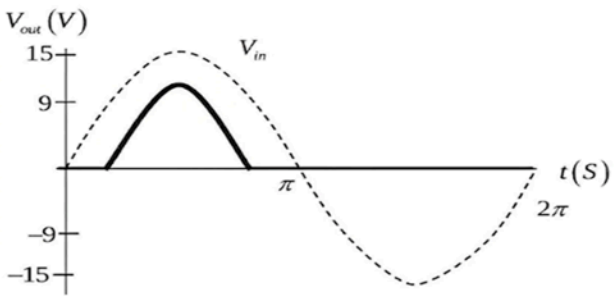
1.



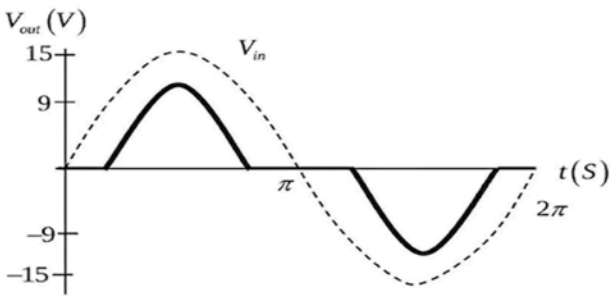

2.




3.




4.



**Q46. [June 2022] . 5.0 marks**

Mathematical Physics > Probability

| CSIR NET | 2022 June | 5M |
|---|---|---|

A bucket contains 6 red and 4 blue balls. A ball is taken out of the bucket at random and two balls of the same colour are put back. This step is repeated once more. The probability that the numbers of red and blue balls are equal at the end, is

1. $4/11$
2. $2/11$
3. $1/4$
4. $3/4$

**Q47. [June 2022] . 5.0 marks**

Mathematical Physics > Complex analysis

| CSIR NET | 2022 June | 5M |
|---|---|---|

The value of the integral $\int_{-\infty}^{\infty} \frac{\cos \alpha x}{x^2+1} dx$, for $\alpha > 0$, is

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

**Q48. [June 2022] . 5.0 marks**

Mathematical Physics > Laplace transform

| CSIR NET | 2022 June | 5M |
|---|---|---|

The Laplace transform $L[f](y)$ of the function

$$f(x) = \begin{cases} 1 \text{ for } 2n \leq x \leq 2n+1 \\ 0 \text{ for } 2n+1 \leq x \leq 2n+2 \end{cases}, n = 0,1,2, \ldots \text{ is}$$

1. $\frac{e^{-y}(e^{-y}+1)}{y(e^{-2y}+1)}$
2. $\frac{e^{y}-e^{-y}}{y}$
3. $\frac{e^{y}+e^{-y}}{y}$
4. $\frac{e^{y}(e^{y}-1)}{y(e^{2y}-1)}$

**Q49. [June 2022] . 5.0 marks**

Mathematical Physics > Matrices and Linear Algebra

| CSIR NET | 2022 June | 5M |
|---|---|---|

The matrix corresponding to the differential operator $\left(1+\frac{d}{dx}\right)$ in the space of polynomials of degree at most two, in the basis spanned by $f_1 = 1,\ f_2 = x$ and $f_3 = x^2$, is

1. $\begin{pmatrix} 1 & 1 & 0 \\ 0 & 1 & 2 \\ 0 & 0 & 1 \end{pmatrix}$
2. $\begin{pmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 0 & 2 & 1 \end{pmatrix}$
3. $\begin{pmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 0 & 0 & 2 \end{pmatrix}$
4. $\begin{pmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 0 & 1 & 2 \end{pmatrix}$

**Q50. [June 2022] . 5.0 marks**

Classical Mechanics > Oscillations

| CSIR NET | 2022 June | 5M |
|---|---|---|

The Lagrangian of system of two particles is

$$L = \frac{1}{2}\dot{x}_1^2 + 2\dot{x}_2^2 - \frac{1}{2}(x_1^2 + x_2^2 + x_1 x_2).$$

The normal frequencies are best approximated by

1. 1.2 and 0.7
2. 1.5 and 0.5
3. 1.7 and 0.5
4. 1.0 and 0.4

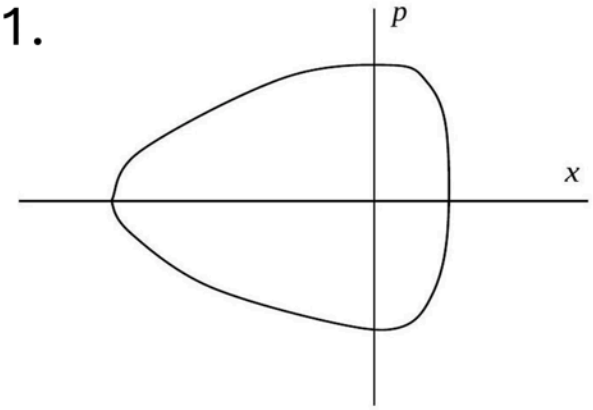
**Q51. [June 2022] . 5.0 marks**

Classical Mechanics > Phase space diagrams

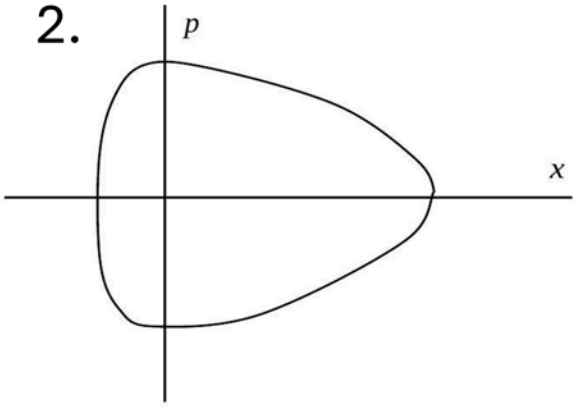
| CSIR NET | 2022 June | 5M |
|---|---|---|

The Lagrangian of a particle in one dimension is $L = \frac{m}{2}\dot{x}^2 - ax^2 - V_0 e^{-10x}$ where $a$ and $V_0$ are positive constants. The best qualitative representation of a trajectory in the phase space is

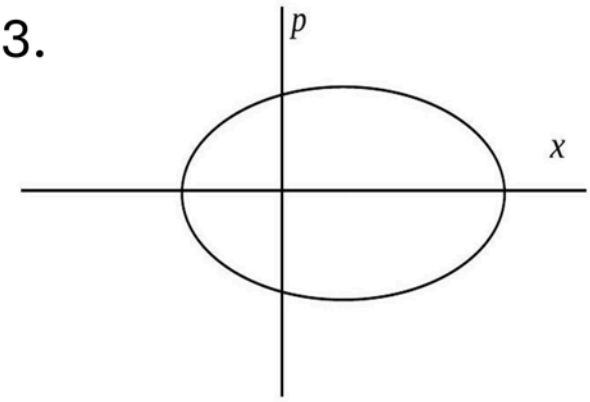
1.



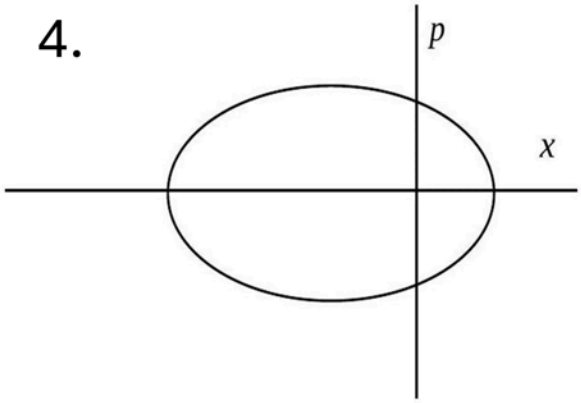

2.




3.




4.



**Q52. [June 2022] . 5.0 marks**

Classical Mechanics > Rotation Motion

| CSIR NET | 2022 June | 5M |
|---|---|---|

Earth may be assumed to be an axially symmetric freely rotating rigid body. The ratio of the principal moments of inertia about the axis of symmetry and an axis perpendicular to it is 33:32. If $T_0$ is the time taken by earth to make one rotation around its axis of symmetry, then the time period of precession is closest to

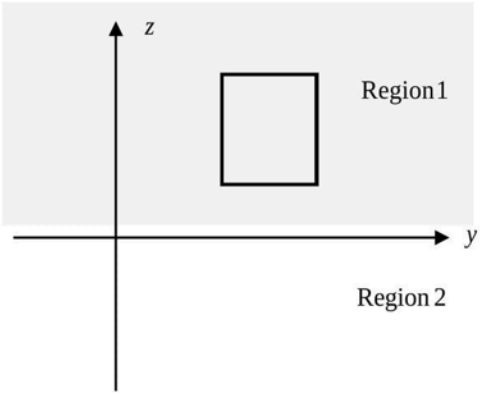
1. $33T_0$
2. $33T_0/2$
3. $32T_0$
4. $16T_0$

**Q53. [June 2022] . 5.0 marks**

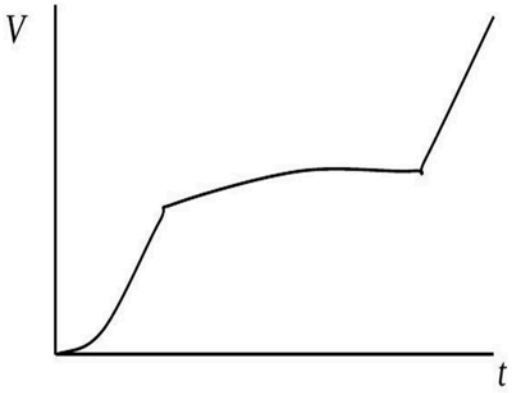
Electromagnetism > Electrodynamics

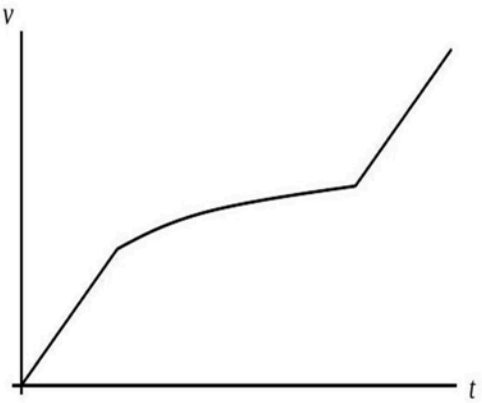
| CSIR NET | 2022 June | 5M |
|---|---|---|

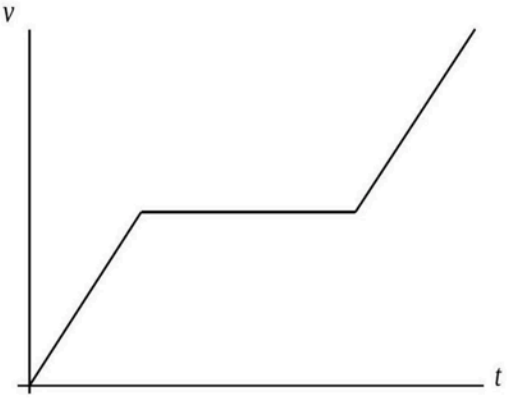
A square conducting loop in the $yz$-plane, falls downward under gravity along the negative $z$-axis. Region 1 , defined by $z > 0$ has a uniform magnetic field $\vec{B} = B_0\hat{i}$ while region 2 (defined by $z < 0$) has no magnetic field.

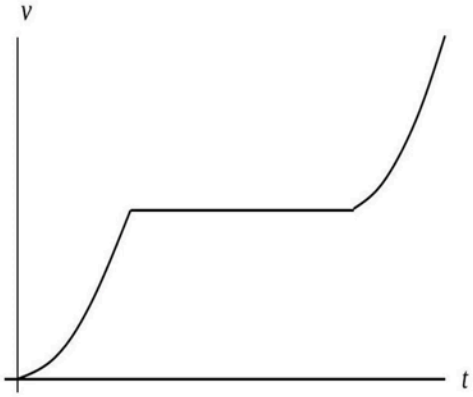



The time dependence of the speed $v(t)$ of the loop, as it starts to fall from well within the region 1 and passes into the region 2, is best represented by

1.



2.



3.



4.


**Q54. [June 2022] . 5.0 marks**

Electromagnetism > Electrostatics

| CSIR NET | 2022 June | 5M |
|---|---|---|

Two small metallic objects are embedded in a weakly conducting medium of conductivity $\sigma$ and dielectric constant $\in$. A battery connected between them leads to a potential difference $V_0$. It is subsequently disconnected at time $t = 0$. The potential difference at a later time $t$ is

1. $V_0 e^{-\frac{t\sigma}{4\epsilon}}$
2. $V_0 e^{-\frac{t\sigma}{2\epsilon}}$
3. $V_0 e^{-\frac{3t\sigma}{4\epsilon}}$
4. $V_0 e^{-\frac{t\sigma}{\epsilon}}$

**Q55. [June 2022] . 5.0 marks**

Electromagnetism > Magnetism in matter

| CSIR NET | 2022 June | 5M |
|---|---|---|

A stationary magnetic dipole $\vec{m} = m\hat{k}$ is placed above an infinite surface ( $z = 0$ ) carrying a uniform surface current density $\vec{\kappa} = k\hat{i}$. The torque of the dipole is

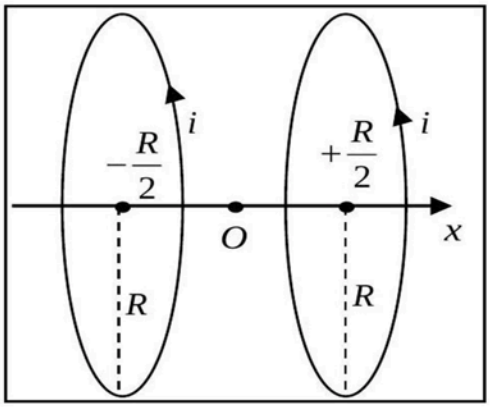
1. $\frac{\mu_0}{2} mk\hat{i}$
2. $-\frac{\mu_0}{2} mk\hat{i}$
3. $\frac{\mu_0}{2} mk\hat{j}$
4. $-\frac{\mu_0}{2} mk\hat{j}$

**Q56. [June 2022] . 5.0 marks**

Electromagnetism > Magetostatics

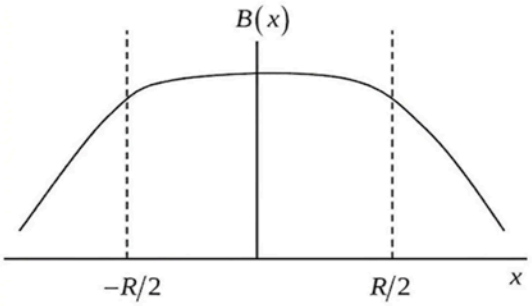
| CSIR NET | 2022 June | 5M |
|---|---|---|

Two parallel conducting rings, both of radius $R$, are separated by a distance $R$. The planes of the rings are perpendicular to the line joining their centres, which is taken to be the $x$-axis.

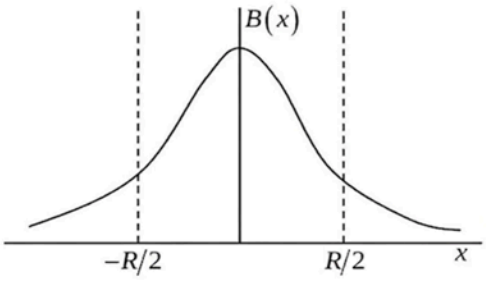



If both the rings carry the same current $i$ along the same direction, the magnitude of the magnetic field along the $x$-axis is best represented by

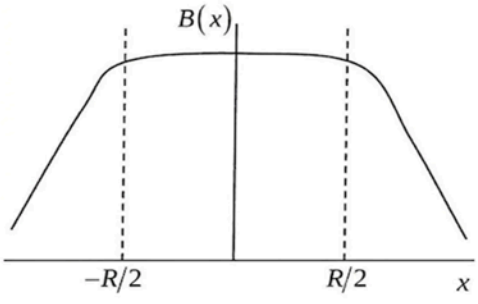
1.



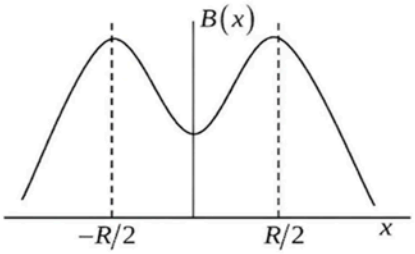

2.




3.




4.



**Q57. [June 2022] . 5.0 marks**

Quantum Mechanics > Pertubation theory

| CSIR NET | 2022 June | 5M |
|---|---|---|

At time $t = 0$, a particle is in the ground state of the Hamiltonian $H(t) = \frac{p^2}{2m} + \frac{1}{2}m\omega^2x^2 + \lambda x \sin\frac{\omega t}{2}$ where $\lambda, \omega$ and $m$ are positive constants. To $O(\lambda^2)$, the probability that at $t = \frac{2\pi}{\omega}$, the particle would be in the first excited state of $H(t = 0)$ is

1. $\frac{9\lambda^2}{16m\hbar\omega^3}$
2. $\frac{9\lambda^2}{8m\hbar\omega^3}$
3. $\frac{16\lambda^2}{9m\hbar\omega^3}$
4. $\frac{8\lambda^2}{9m\hbar\omega^3}$

**Q58. [June 2022] . 5.0 marks**

Quantum Mechanics > Pertubation theory

| CSIR NET | 2022 June | 5M |
|---|---|---|

To first order in perturbation theory, the energy of the ground state of the Hamiltonian

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2 + \frac{\hbar\omega}{\sqrt{512}}\exp\left[-\frac{m\omega}{\hbar}x^2\right]$$

(treating the third term of the Hamiltonian as a perturbation) is

1. $\frac{15}{32}\hbar\omega$
2. $\frac{17}{32}\hbar\omega$
3. $\frac{19}{32}\hbar\omega$
4. $\frac{21}{32}\hbar\omega$

**Q59. [June 2022] . 5.0 marks**

Quantum Mechanics > Potential Well

| CSIR NET | 2022 June | 5M |
|---|---|---|

The energy/energies $E$ of the bound state(s) of a particle of mass $m$ in one dimension in the potential $V(x) = \begin{cases} \infty, & x \leq 0 \\ -V_0, & 0 < x < a \\ 0, & x \geq a \end{cases}$ (where $V_0 > 0$) is/are determined by

1. $\cot^2\left(a\sqrt{\frac{2m(E+V_0)}{\hbar^2}}\right) = \frac{E-V_0}{E}$
2. $\tan^2\left(a\sqrt{\frac{2m(E+V_0)}{\hbar^2}}\right) = -\frac{E}{E+V_0}$
3. $\cot^2\left(a\sqrt{\frac{2m(E+V_0)}{\hbar^2}}\right) = -\frac{E}{E+V_0}$
4. $\tan^2\left(a\sqrt{\frac{2m(E+V_0)}{\hbar^2}}\right) = \frac{E-V_0}{E}$

**Q60. [June 2022] . 5.0 marks**

Statistical Mechanics > Canonical Ensemble

| CSIR NET | 2022 June | 5M |
|---|---|---|

The energy levels of a system, which is in equilibrium at temperature $T = 1/(k_B\beta)$, are $0, \in$ and $2 \in$. If two identical bosons occupy these energy levels, the probability of the total energy being $3 \in$, is

1. $\frac{e^{-3\beta\epsilon}}{1+e^{-\beta\epsilon}+e^{-2\beta\epsilon}+e^{-3\beta\epsilon}+e^{-4\beta\epsilon}}$
2. $\frac{e^{-3\beta\epsilon}}{1+2e^{-\beta\epsilon}+2e^{-2\beta\epsilon}+e^{-3\beta\epsilon}+e^{-4\beta\epsilon}}$
3. $\frac{e^{-3\beta\epsilon}}{e^{-\beta\epsilon}+2e^{-2\beta\epsilon}+e^{-3\beta\epsilon}+e^{-4\beta\epsilon}}$
4. $\frac{e^{-3\beta\epsilon}}{1+e^{-\beta\epsilon}+2e^{-2\beta\epsilon}+e^{-3\beta\epsilon}+e^{-4\beta\epsilon}}$

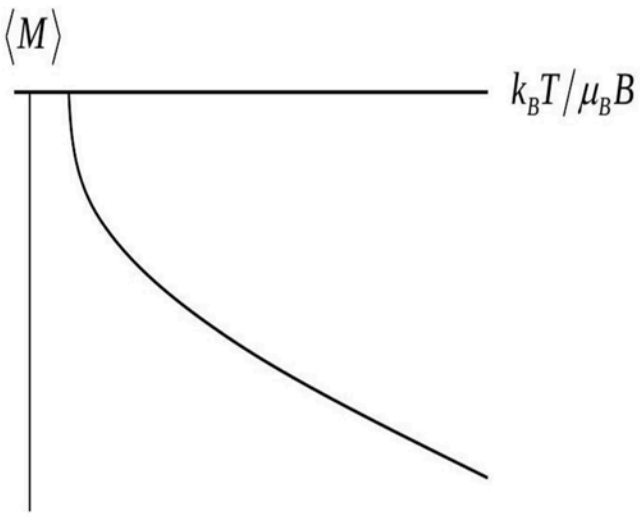
**Q61. [June 2022] . 5.0 marks**

Statistical Mechanics > Canonical Ensemble

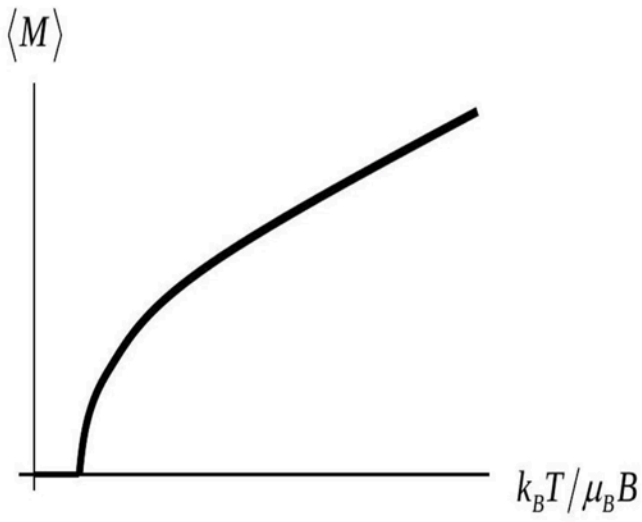
| CSIR NET | 2022 June | 5M |
|---|---|---|

A paramagnetic salt with magnetic moment per ion $\mu_{\pm} = \pm\mu_B$ (where $\mu_B$ is the Bohr magneton) is in thermal equilibrium at temperature $T$ in a constant magnetic field $B$. The average magnetic moment $\langle M \rangle$, as a function of $\frac{k_B T}{\mu_B B}$, is best represented by

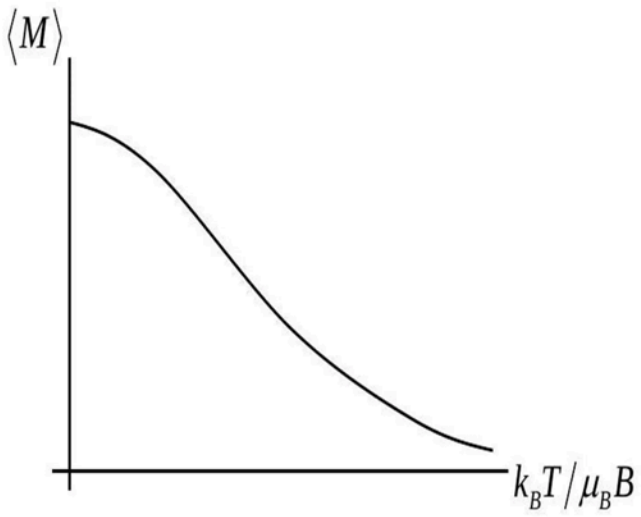
1.



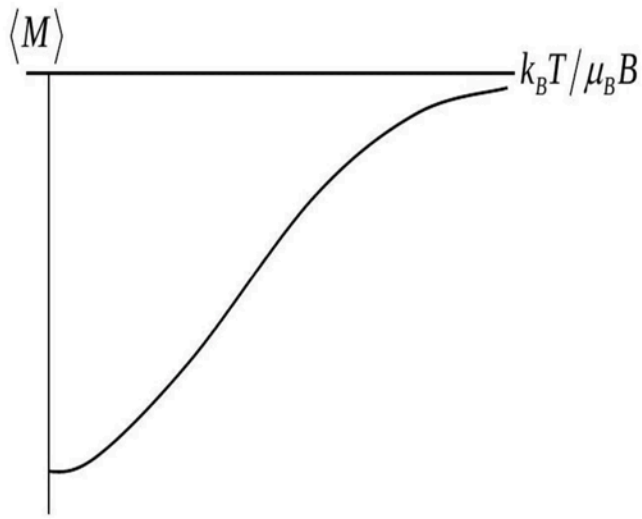

2.




3.




4.



**Q62. [June 2022] . 5.0 marks**

Statistical Mechanics > Quantum Statistical Mechanics

| CSIR NET | 2022 June | 5M |
|---|---|---|

A system of $N$ non-interacting particles in one-dimension, each of which is in a potential $V(x) = gx^6$ where $g > 0$ is a constant and $x$ denotes the displacement of the particle from its equilibrium position. In thermal equilibrium, the heat capacity at constant volume is

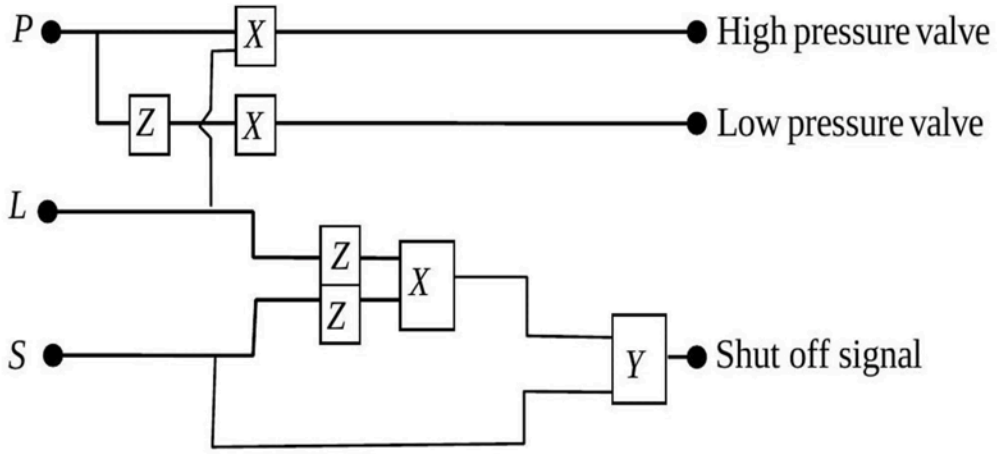
1. $\frac{7}{6}Nk_B$
2. $\frac{4}{3}Nk_B$
3. $\frac{3}{2}Nk_B$
4. $\frac{2}{3}Nk_B$

**Q63. [June 2022] . 5.0 marks**

Electronics > Digital Electronics

| CSIR NET | 2022 June | 5M |
|---|---|---|

A liquid oxygen cylinder system is fitted with a level-sensor (L) and a pressure-sensor (P), as shown in the figure below. The output of L and P are set to logic high ( $S = 1$ ) when the measured values exceed the respective preset threshold values. The system can be shut off either by an operator by setting the input S to high, or when the level of oxygen in the tank falls below the threshold value




The logic gates X, Y and Z , respectively, are

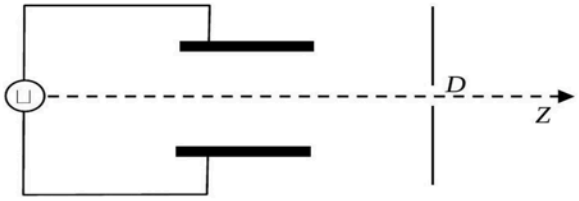
1. OR, AND and NOT
2. AND, OR and NOT
3. NAND, OR and NOT
4. NOR, AND and NOT

**Q64. [June 2022] . 5.0 marks**

Optics > Interference and diffraction

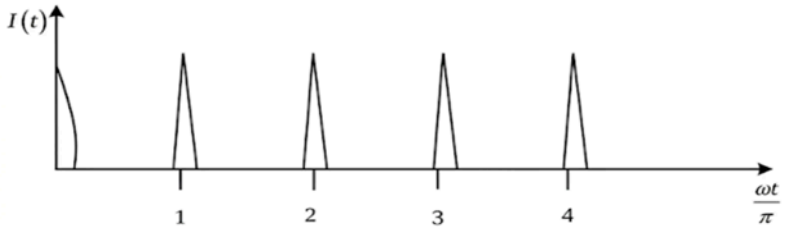
| CSIR NET | 2022 June | 5M |
|---|---|---|

A high frequency voltage signal $V_i = V_m \sin \omega t$ is applied to a parallel plate deflector as shown in the figure.

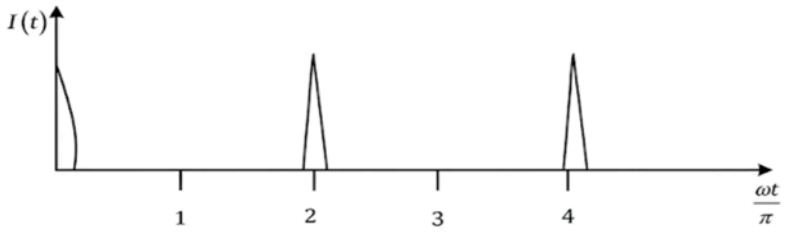



An electron beam is passing through the deflector along the central line. The best qualitative representation of the intensity $I(t)$ of the beam after it goes through the narrow circular aperture $D$, is

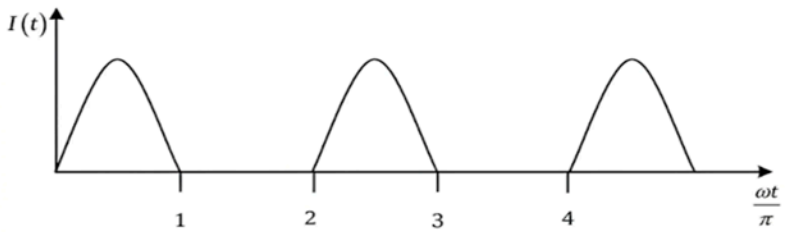
**1.**



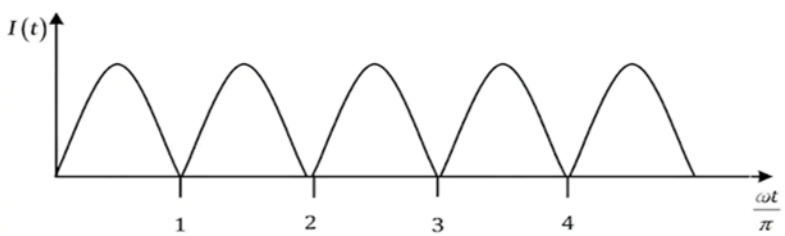

**2.**




**3.**




**4.**



**Q65. [June 2022] . 5.0 marks**

Electronics > OPAMP

| CSIR NET | 2022 June | 5M |
|---|---|---|

An amplifier with a voltage gain of 40 dB without feedback is used in an electronic circuit. A negative feedback with a fraction $1/40$ is connected to the input of this amplifier. The net gain of the amplifier in the circuit is closest to

1. 40 dB
2. 37 dB
3. 29 dB
4. 20 dB

**Q66. [June 2022] . 5.0 marks**

Electronics > Instruments

| CSIR NET | 2022 June | 5M |
|---|---|---|

A receiver operating at $27^{\circ}\mathrm{C}$ has an input resistance of $100\Omega$. The input thermal noise voltage for this receiver with a bandwidth of 100 kHz is closest to

1. 0.4 nV
2. 0.6 pV
3. 40 mV
4. $0.4\ \mu\mathrm{V}$

**Q67. [June 2022] . 5.0 marks**

Atomic and Molecular Physics > Molecular physics

| CSIR NET | 2022 June | 5M |
|---|---|---|

The Raman rotational-vibrational spectrum of nitrogen molecules is observed using an incident radiation of wavenumber $12500\,\mathrm{cm}^{-1}$. In the first shift band, the wavenumbers of the observed lines (in $\mathrm{cm}^{-1}$ ) are 10150, 10158, 10170, 10182 and 10190. The values of vibrational frequency and rotational constant (in $\mathrm{cm}^{-1}$ ), respectively, are

1. 2330 and 2
2. 2350 and 2
3. 2350 and 3
4. 2330 and 3

**Q68. [June 2022] . 5.0 marks**

Atomic and Molecular Physics > "LS, JJ and other interactions"

| CSIR NET | 2022 June | 5M |
|---|---|---|

The electronic configuration of $^{12}C$ is $1s^2 2s^2 2p^2$. Including $LS$ coupling, the correct ordering of its energies is

1. $E(^3P_2) < E(^3P_1) < E(^3P_0) < E(^1D_2)$
2. $E(^3P_0) < E(^3P_1) < E(^3P_2) < E(^1D_2)$
3. $E(^1D_2) < E(^3P_2) < E(^3P_1) < E(^3P_0)$
4. $E(^3P_1) < E(^3P_0) < E(^3P_2) < E(^1D_2)$

**Q69. [June 2022] . 5.0 marks**

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

| CSIR NET | 2022 June | 5M |
|---|---|---|

In the absorption spectrum of H-atom, the frequency of transition from the ground state to the first excited state is $v_H$. The corresponding frequency for a bound state of a positively charged muon $(\mu^+)$ and an electron is $v_\mu$. Using $m_\mu = 10^{-28}$ kg, $m_e = 10^{-30}$ kg and $m_p \gg m_e, m_\mu$, the value of $(v_\mu - v_H)/v_H$ is

1. 0.001
2. -0.001
3. -0.01
4. 0.01

**Q70. [June 2022] . 5.0 marks**

Statistical Mechanics > Canonical Ensemble

| CSIR NET | 2022 June | 5M |
|---|---|---|

The energies of a two-level system are $\pm E$. Consider an ensemble of such non-interacting systems at a temperature $T$. At low temperatures, the leading term in the specific heat depends on $T$ as

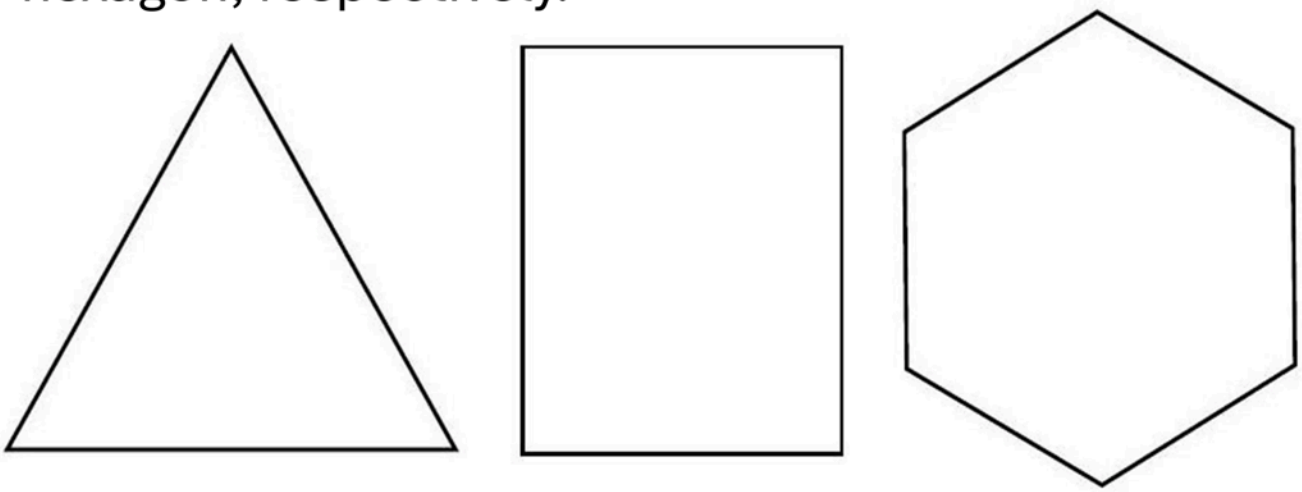
1. $\frac{1}{T^2} e^{-E/k_B T}$
2. $\frac{1}{T^2} e^{-2E/k_B T}$
3. $T^2 e^{-E/k_B T}$
4. $T^2 e^{-2E/k_B T}$

**Q71. [June 2022] . 5.0 marks**

Solid State Physics > Crystallography

| CSIR NET | 2022 June | 5M |
|---|---|---|

The Figures (i), (ii) and (iii) below represent an equilateral triangle, a rectangle and a regular hexagon, respectively.



(i) (ii) (iii)

Which of these can be primitive unit cells of a Bravais lattice in two dimensions?

1. only (i) and (iii) but not (ii)
2. only (i) and (ii) but not (iii)
3. only (ii) and (iii) but not (i)
4. All of them

**Q72. [June 2022] . 5.0 marks**

Quantum Mechanics > Spin Angular momentum

| CSIR NET | 2022 June | 5M |
|---|---|---|

The Hamiltonian for a spin-1/2 particle in a magnetic field $\vec{B} = B_0\hat{k}$ is given by $H = \lambda\vec{S}\cdot\vec{B}$, where $\vec{S}$ is its spin (in units of $\hbar$ ) and $\lambda$ is a constant. If the average spins density is $\langle\vec{S}\rangle$ for an ensemble of such non-interacting particles, then $\frac{d}{dt}\langle S_x\rangle$

1. $\frac{\lambda}{\hbar}B_0\langle S_x\rangle$
2. $\frac{\lambda}{\hbar}B_0\langle S_y\rangle$
3. $-\frac{\lambda}{\hbar}B_0\langle S_x\rangle$
4. $-\frac{\lambda}{\hbar}B_0\langle S_y\rangle$

**Q73. [June 2022] . 5.0 marks**

Nuclear and Particle Physics > Nuclear forces and Scattering

| CSIR NET | 2022 June | 5M |
|---|---|---|

The tensor component of the nuclear force may be inferred from the fact that deuteron nucleus ${}_1^2H$

1. has only one bound state with total spin $S = 1$
2. has a non-zero electric quadrupole moment in its ground state
3. is stable while triton ${}_1^3\mathrm{H}$ is unstable
4. is the only two nucleon bound state

**Q74. [June 2022] . 5.0 marks**

Nuclear and Particle Physics > Nuclear forces and Scattering

| CSIR NET | 2022 June | 5M |
|---|---|---|

The elastic scattering process $\pi^- p \rightarrow \pi^- p$ may be treated as a hard-sphere scattering. The mass of $\pi^-$, $m_\pi \cong \frac{1}{6} m_p$, where $m_p \cong 938\mathrm{MeV/c^2}$ is the mass of the proton. The total scattering cross-section is closet to

1. 0.01 milli-barn
2. 1 milli-barn
3. 0.1 barn
4. 10 barn

**Q75. [June 2022] . 5.0 marks**

Nuclear and Particle Physics > Particle Detectors and accelerators

| CSIR NET | 2022 June | 5M |
|---|---|---|

Thermal neutrons may be detected most efficiently by a

1. $^{6}\mathrm{Li}$ loaded plastic scintillator
2. Geiger-Muller counter
3. inorganic scintillator $\mathrm{CaF_2}$
4. silicon detector

# Answer Key

75 questions . Subject and topic for quick revision

| Q. No | Subject | Topic | Answer |
|---|---|---|---|
| Q1 | General Aptitude | Reasoning | **3** |
| Q2 | General Aptitude | Mathematical Analysis | **2** |
| Q3 | General Aptitude | Reasoning | **4** |
| Q4 | General Aptitude | Basic Physics | **3** |
| Q5 | General Aptitude | Mathematical Analysis | **3** |
| Q6 | General Aptitude | Basic Physics | **1** |
| Q7 | General Aptitude | Reasoning | **2** |
| Q8 | General Aptitude | Reasoning | **1** |
| Q9 | General Aptitude | Mathematical Analysis | **4** |
| Q10 | General Aptitude | Mathematical Analysis | **1** |
| Q11 | General Aptitude | Mathematical Analysis | **4** |
| Q12 | General Aptitude | Basic Physics | **1** |
| Q13 | General Aptitude | Mathematical Analysis | **1** |
| Q14 | General Aptitude | Reasoning | **1** |
| Q15 | General Aptitude | Geometry | **1** |
| Q16 | General Aptitude | Reasoning | **1** |
| Q17 | General Aptitude | Mathematical Analysis | **1** |
| Q18 | General Aptitude | Mathematical Analysis | **1** |
| Q19 | General Aptitude | Geometry | **2** |
| Q20 | General Aptitude | Geometry | **3** |
| Q21 | Mathematical Physics | Gamma and beta functions | **3** |
| Q22 | Mathematical Physics | Complex analysis | **4** |
| Q23 | Mathematical Physics | Matrices and Linear Algebra | **4** |
| Q24 | Mathematical Physics | Basic Mathematics | **1** |
| Q25 | Mathematical Physics | Complex analysis | **2** |
| Q26 | Classical Mechanics | Oscillations | **2** |
| Q27 | Classical Mechanics | Lagrangian and Hamiltonian | **1** |
| Q28 | Classical Mechanics | Central forces | **4** |
| Q29 | Classical Mechanics | Special theory of relativity | **2** |
| Q30 | Electromagnetism | EM Waves | **2** |
| Q31 | Electromagnetism | Magetostatics | **1** |
| Q32 | Electromagnetism | Multipoles | **2** |
| Q33 | Electromagnetism | Relativistic electromagnetism | **3** |
| Q34 | Quantum Mechanics | Basic Quantum Mechanics | **1** |
| Q35 | Quantum Mechanics | Basic Quantum Mechanics | **3** |
| Q36 | Quantum Mechanics | Basic Quantum Mechanics | **4** |
| Q37 | Quantum Mechanics | Spin Angular momentum | **1** |
| Q38 | Statistical Mechanics | Canonical Ensemble | **2** |
| Q39 | Thermodynamics | Laws of thermodynamics | **1** |
| Q40 | Statistical Mechanics | Random Walk/Brownian motion/Diffusion | **4** |

# Answer Key (cont.)

| Q. No | Subject | Topic | Answer |
|---|---|---|---|
| Q41 | Statistical Mechanics | Canonical Ensemble | **4** |
| Q42 | Electronics | FET | **3** |
| Q43 | Electronics | Transistors | **2** |
| Q44 | Electronics | "Errors , curve fitting and data analysis" | **2** |
| Q45 | Electronics | Diodes | **3** |
| Q46 | Mathematical Physics | Probability | **2** |
| Q47 | Mathematical Physics | Complex analysis | **2** |
| Q48 | Mathematical Physics | Laplace transform | **4** |
| Q49 | Mathematical Physics | Matrices and Linear Algebra | **1** |
| Q50 | Classical Mechanics | Oscillations | **4** |
| Q51 | Classical Mechanics | Phase space diagrams | **None** |
| Q52 | Classical Mechanics | Rotation Motion | **3** |
| Q53 | Electromagnetism | Electrodynamics | **2** |
| Q54 | Electromagnetism | Electrostatics | **4** |
| Q55 | Electromagnetism | Magnetism in matter | **1** |
| Q56 | Electromagnetism | Magetostatics | **1** |
| Q57 | Quantum Mechanics | Pertubation theory | **4** |
| Q58 | Quantum Mechanics | Pertubation theory | **2** |
| Q59 | Quantum Mechanics | Potential Well | **3** |
| Q60 | Statistical Mechanics | Canonical Ensemble | **4** |
| Q61 | Statistical Mechanics | Canonical Ensemble | **3** |
| Q62 | Statistical Mechanics | Quantum Statistical Mechanics | **4** |
| Q63 | Electronics | Digital Electronics | **None** |
| Q64 | Optics | Interference and diffraction | **1** |
| Q65 | Electronics | OPAMP | **3** |
| Q66 | Electronics | Instruments | **4** |
| Q67 | Atomic and Molecular Physics | Molecular physics | **1** |
| Q68 | Atomic and Molecular Physics | "LS, JJ and other interactions" | **2** |
| Q69 | Atomic and Molecular Physics | Bohar Model and h-atom model | **3** |
| Q70 | Statistical Mechanics | Canonical Ensemble | **2** |
| Q71 | Solid State Physics | Crystallography | **3** |
| Q72 | Quantum Mechanics | Spin Angular momentum | **4** |
| Q73 | Nuclear and Particle Physics | Nuclear forces and Scattering | **2** |
| Q74 | Nuclear and Particle Physics | Nuclear forces and Scattering | **3** |
| Q75 | Nuclear and Particle Physics | Particle Detectors and accelerators | **1** |

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