PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

CSIR NET Physics - June 2020 - Full Paper

Complete question paper with answer key

75 questions . Answer key included

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Q1. [June 2020] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2020 June	2M

A couple lives in a house with their sons and daughters and no one else. The couple has four sons and each of the sons has exactly two sisters. How many persons live in that house?

1. 8
2. 10
3. 12
4. 14

Q2. [June 2020] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2020 June	2M

A bank pays interest to its depositors compounded yearly. If a deposit becomes Rs. 54,000/- at the end of 3^{rd} year and Rs. 64,800/- at the end of 6^{th} year, what is the principal invested in the deposit?

1. 40,000
2. 42,500
3. 45,000
4. 48,000

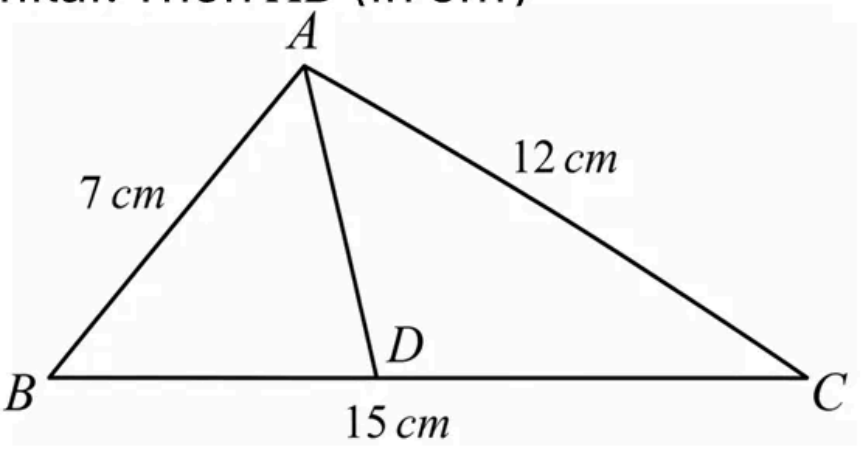
Q3. [June 2020] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2020 June	2M

In the following $\triangle ABC, AB = 7\ cm, BC = 15\ cm$ and $AC = 12\ cm$. D is a point on BC such that $\triangle ADC$ and $\triangle ABC$ are similar. Then AD (in cm) =

1. 5.6
2. 5.8
3. 6.1
4. 6.4



Q4. [June 2020] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2020 June	2M

Ten glass vases were to be packed one each in 10 boxes marked "Glass". Twelve brass vases were to be packed one each in 12 boxes marked "Brass". Four vases and boxes got mixed up. A customer orders 1 glass and 1 brass vase and is sent appropriately marked boxes. The chance that the customer does not get the ordered vases in correctly marked boxes is

1. $4/5$
2. $5/6$
3. $2/3$
4. $1/3$

Q5. [June 2020] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2020 June	2M

Anwara, Bharati, Colin and Tarun commute by different modes of transport namely, Cycle (C), Autorickshaw (A), Bus (B) and Train (T). The initials of the mode of transport and the name of the person match in exactly two cases. If Tarun travels by Train, and Colin rides neither an Autorickshaw nor a Bus, then

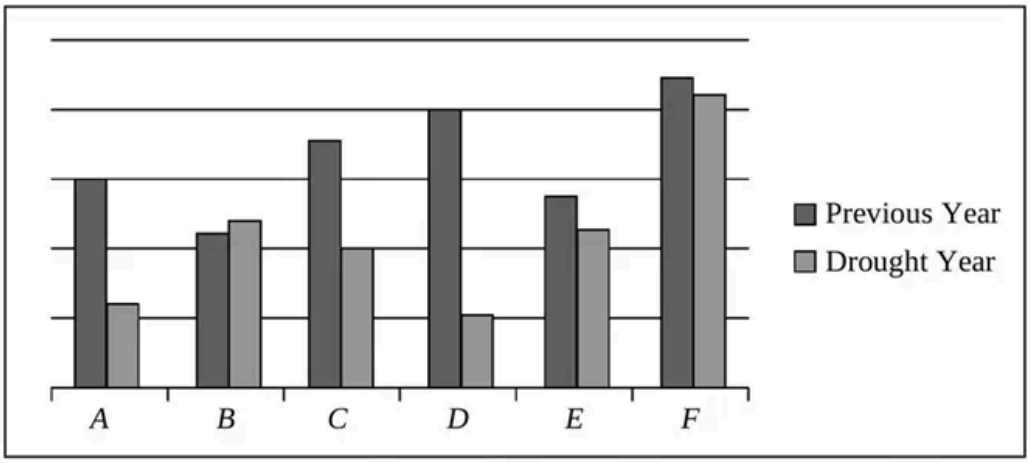
1. Anwara rides an Autorikshaw
2. Anwara rides a Bus
3. Bharati rides a Bus
4. Bharati rides a Cycle

Q6. [June 2020] . 2.0 marks

General Aptitude > Data Analysis

CSIR NET	2020 June	2M

Rice production in six states A, B, C, D, E and F in two consecutive years are shown in the diagram in linear scale.



Among the states that saw a fall in production in the drought year, the maximum and minimum relative fall was, respectively, in states,

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

Q7. [June 2020] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2020 June	2M

Based on the table, what is the maximum number of diamonds one can buy for Rs. 10 lakh?

Size (in carat)	Rate (Rs. Lakh per carat)	Number in stock
0.25	1	20
0.5	2	10
1	4	5
2	8	1

1. 20
2. 25
3. 30
4. 36

Q8. [June 2020] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2020 June	2M

For a disease, every infected person infects three others on the 5^{th} day and recovers. On an average, men and women are infected in the proportion $4:1$. The total number of women who were infected by the end of 35 days, is closest to

1. 972
2. 820
3. 656
4. 502

Q9. [June 2020] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2020 June	2M

The maximum tolerable exposure time for noise is given to be about 8 hours at 85 dB and 90 seconds at 110 dB. Assuming linear noise tolerance response of the ear, an increase of 3 dB in noise level in this range would reduce the exposure time by roughly

1. 45 min
2. 60 min
3. 90 min
4. 120 min

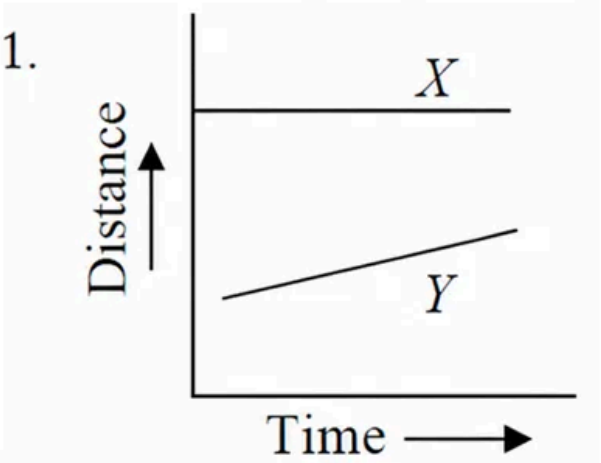
Q10. [June 2020] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2020 June	2M

Distance covered by cars, X and Y, with time is given below. Assuming constant acceleration for each car, which of the following graphs shows that X had higher acceleration than Y ?

1.



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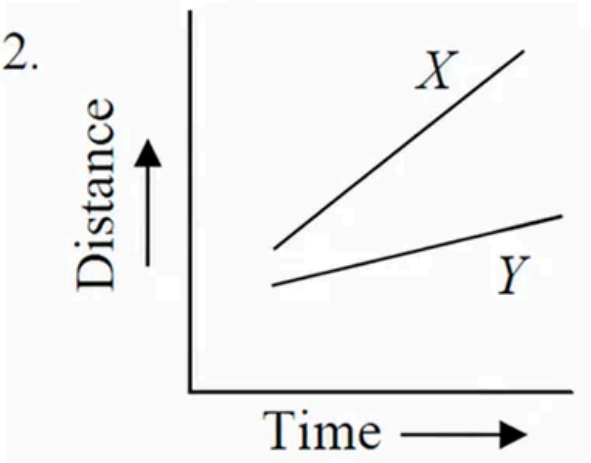

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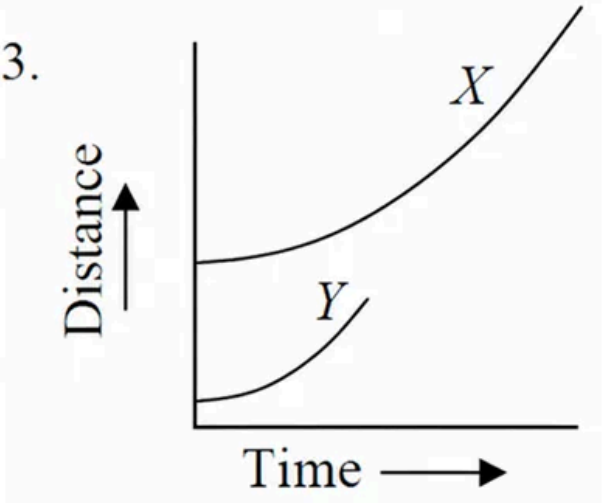
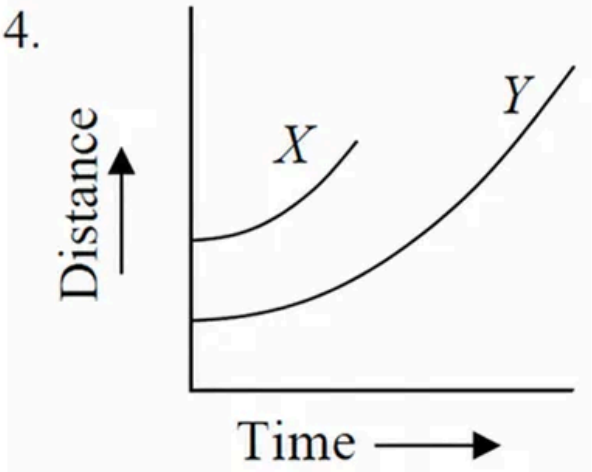


4.

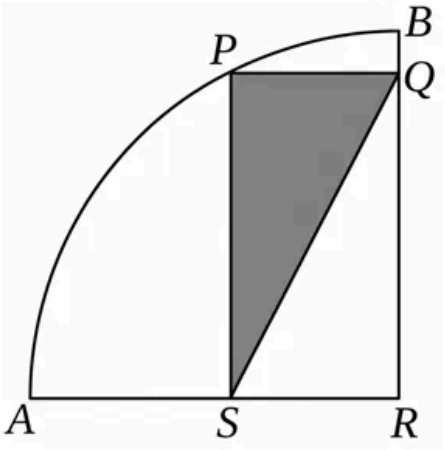


Q11. [June 2020] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2020 June	2M

PQRS is a rectangle inscribed in a quarter circle as shown. The area of shaded region is $24\,cm^2$ and $PQ = 6cm$. The area of the quarter circle is



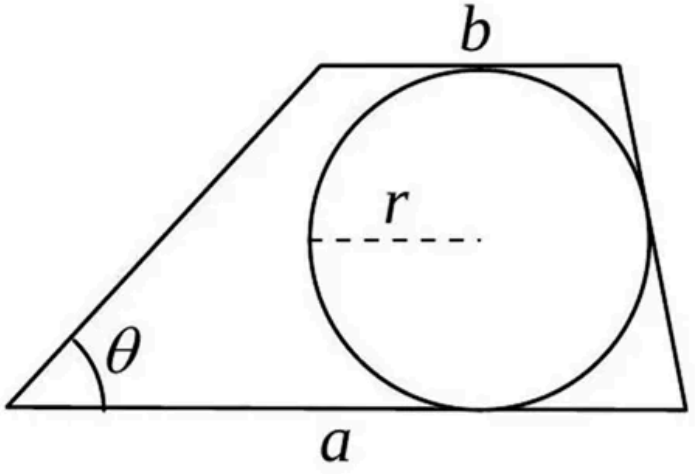
1. 36π
2. 25π
3. 13π
4. 48π

Q12. [June 2020] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2020 June	2M

Area of the trapezium as shown in the figure, is



1. $ab + r^2 \tan\theta$
2. $r(a+b)\cos\theta$
3. $2r(a+b)$
4. $r(a+b)$

Q13. [June 2020] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2020 June	2M

From an initially full bucket, water is dripping continuously from the bottom. The centre of mass of the bucket with water

1. remains stationary
2. moves upward all the way
3. moves downward all the way
4. moves downward first and then moves up

Q14. [June 2020] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2020 June	2M

Seven persons A, B, C, D, E, F and G are sitting in a row. E and B are sitting adjacent to each other. F is sitting between D and G. If C is sitting four places left of F, who among the following cannot be sitting at the centre?

1. G
2. B
3. D
4. F

Q15. [June 2020] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2020 June	2M

Starting from the same point at the same instant of time, three cyclists P, Q and R move on a circular path in the same direction with speeds 18, 27 and $36\ \mathrm{km/h}$, respectively. The circumference of the circular path is 5.4 km . After a lapse of how much time would they all meet at the starting point again?

1. 12 min
2. 24 min
3. 36 min
4. 48 min

Q16. [June 2020] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2020 June	2M

Supply of food to a community is reducing at a constant rate, as a result of which the population is dying out. Ignoring other factors, which of these statements can be made about the long-term trend for the population?

1. It will eventually die out completely
2. It will stabilise at a non-zero number
3. It will increase after reaching a minimum
4. It will fall and rise repeatedly

Q17. [June 2020] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2020 June	2M

A marksman had four successes in six attempts. What is the probability that he had three consecutive successes?

1. $9/15$
2. $12/15$
3. $13/15$
4. $6/15$

Q18. [June 2020] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2020 June	2M

The scores of the six students of Group A in an examination are 38, 45, 42, 58, 62 and 55. In the same examination, the scores of the six students of Group B of size 7 are 38, 41, 44, 46, 49 and 52, where one score is missing. If the arithmetic means of the scores of the two groups are same, then what is the missing score?

1. 80
2. 65
3. 63
4. 62

Q19. [June 2020] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2020 June	2M

A wire is bent into the shape of a square enclosing an area M. If the same wire is bent to form a circle, the area enclosed will be

1. $\frac{4\sqrt{2}M}{\pi}$
2. M
3. $\frac{4M}{\pi}$
4. $\frac{\pi M}{2\sqrt{2}}$

Q20. [June 2020] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2020 June	2M

In a flight of 600 km, an aircraft was slowed down due to bad weather. Its average speed for the trip was reduced by 200 km/h and the time of flight increased by 30 minutes. What was the scheduled duration of the flight?

1. 1 hour
2. 1 hour 30 minutes
3. 2 hours
4. 45 minutes

Q21. [June 2020] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2020 June	3.5M

A point mass m, is constrained to move on the inner surface of a paraboloid of revolution $x^2 + y^2 = az$ (where $a > 0$ is a constant). When it spirals down the surface, under the influence of gravity (along $-z$ direction), the angular speed about the z - axis is proportional to

1. 1 (independent of z)
2. Z
3. Z^{-1}
4. z^{-2}

Q22. [June 2020] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2020 June	3.5M

Two coupled oscillators in a potential $V(x,y) = \frac{1}{2}kx^2 + 2xy + \frac{1}{2}ky^2$ $(k > 2)$ can be decoupled into two independent harmonic oscillators (coordinates: x', y') by means of an appropriate transformation $\begin{pmatrix} x' \\ y' \end{pmatrix} = S \begin{pmatrix} x \\ y \end{pmatrix}$. The transformation matrix S is

1. $\begin{pmatrix} \frac{1}{\sqrt{2}} & 1 \\ 1 & -\frac{1}{\sqrt{2}} \end{pmatrix}$

2. $\begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{pmatrix}$

3. $\begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{pmatrix}$

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

Q23. [June 2020] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2020 June	3.5M

A heavy particle of rest mass M while moving along the positive z - direction, decays into two identical light particles with rest mass m (where $M > 2m$). The maximum value of the momentum that any one of the lighter particles can have in a direction perpendicular to the z direction, is

1. $\frac{1}{2}C\sqrt{M^2 - 4m^2}$
2. $\frac{1}{2}C\sqrt{M^2 - 2m^2}$
3. $C\sqrt{M^2 - 4m^2}$
4. $\frac{1}{2}MC$

Q24. [June 2020] . 3.5 marks

Classical Mechanics > Rotation Motion

CSIR NET	2020 June	3.5M

A frictionless horizontal circular table is spinning with a uniform angular velocity ω about the vertical axis through its centre. If a ball of radius a is placed on it at a distance r from the centre of the table, its linear velocity will be

1. $-r\omega\hat{r} + a\omega\hat{\theta}$
2. $r\omega\hat{r} + a\omega\hat{\theta}$
3. $a\omega\hat{r} + r\omega\hat{\theta}$
4. 0 (zero)

Q25. [June 2020] . 3.5 marks

Electronics > RLC Circuits

CSIR NET	2020 June	3.5M

An inductor L, a capacitor C and a resistor R are connected in series to an AC source, $V = V_0 \sin \omega t$. If the net current is found to depend only on R, then

1. $C = 0$
2. $L = 0$
3. $\omega = 1/\sqrt{LC}$
4. $\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$

Q26. [June 2020] . 3.5 marks

Electromagnetism > Electrostatics

CSIR NET	2020 June	3.5M

Three point charges q are placed at the corners of an equilateral triangle. Another point charge -Q is placed at the centroid of the triangle. If the force on each of the charges q vanishes, then the ratio Q/q is

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

Q27. [June 2020] . 3.5 marks

Electromagnetism > Magetostatics

CSIR NET	2020 June	3.5M

Three infinitely long wires, each carrying equal current are placed in the xy - plane along $x = 0, +d$ and $-d$. On the xy-plane, the magnetic field vanishes at

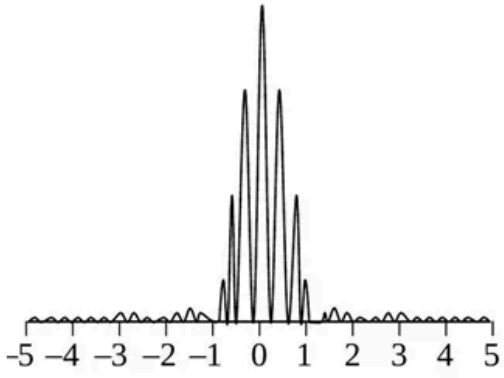
1. $x = \pm\frac{d}{2}$
2. $x = \pm d\left(1 + \frac{1}{\sqrt{3}}\right)$
3. $x = \pm d\left(1 - \frac{1}{\sqrt{3}}\right)$
4. $x = \pm\frac{d}{\sqrt{3}}$

Q28. [June 2020] . 3.5 marks

Optics > Interference and diffraction

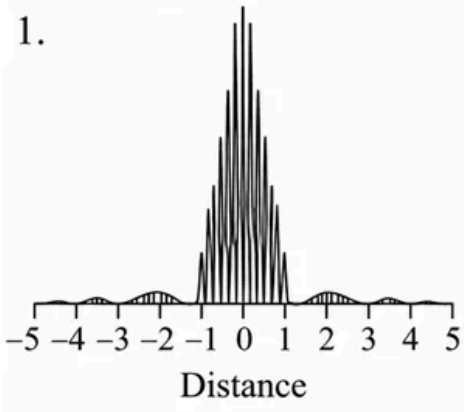
CSIR NET	2020 June	3.5M

The following figure shows the intensity of the interference pattern in the Young's double-slit experiment with two slits of equal width is observed on a distant screen.



If the separation between the slits is doubled and the width of each of the slits is halved, then the new interference pattern is best represented by

1.



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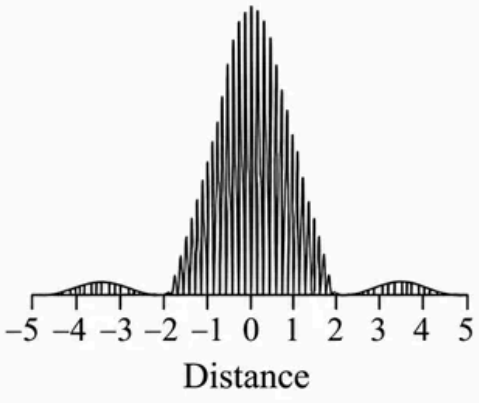

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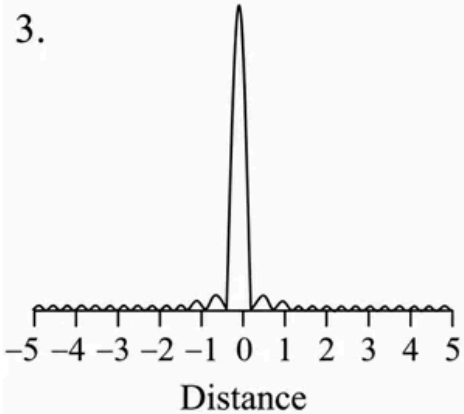
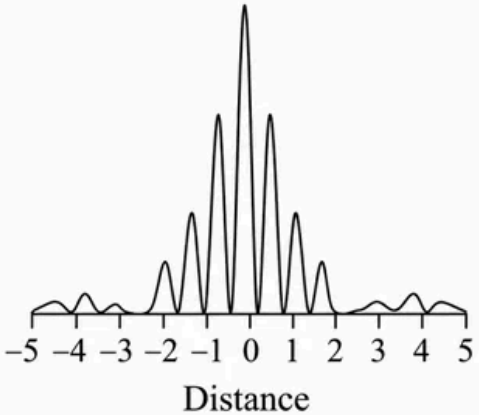


4.



Q29. [June 2020] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2020 June	3.5M

Let $\vec{E}(x, y, z, t) = \vec{E}_0 \cos(2x + 3y - \omega t)$, where ω is a constant, be the electric field of an electromagnetic wave travelling in vacuum. Which of the following vectors is a valid choice for $\vec{E}_0$?

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

Q30. [June 2020] . 3.5 marks

Mathematical Physics > Vector Algebra and Vector Calculus

CSIR NET	2020 June	3.5M

Two time dependent non-zero vectors $\vec{u}(t)$ and $\vec{v}(t)$, which are not initially parallel to each other, satisfy $\vec{u} \times \frac{d\vec{v}}{dt} - \vec{v} \times \frac{d\vec{u}}{dt} = 0$ at all time t. If the area of the parallelogram formed by $\vec{u}(t)$ and $\vec{v}(t)$ be $A(t)$ and the unit normal vector to it be $\hat{n}(t)$, then

1. $A(t)$ increases linearly with t, but $\hat{n}(t)$ is a constant
2. $A(t)$ increases linearly with t, and $\hat{n}(t)$ rotates about $\vec{u}(t) \times \vec{v}(t)$
3. $A(t)$ is a constant, but $\hat{n}(t)$ rotates about $\vec{u}(t) \times \vec{v}(t)$
4. $A(t)$ and $\hat{n}(t)$ are constants

Q31. [June 2020] . 3.5 marks

Mathematical Physics > Probability

CSIR NET	2020 June	3.5M

A basket consists of an infinite number of red and black balls in the proportion $p:(1-p)$. Three balls are drawn at random without replacement. The probability of their being two red and one black is a maximum for

1. $p = \frac{3}{4}$
2. $p = \frac{3}{5}$
3. $p = \frac{1}{2}$
4. $p = \frac{2}{3}$

Q32. [June 2020] . 3.5 marks

Mathematical Physics > Matrices and Linear Algebra

CSIR NET	2020 June	3.5M

The eigenvalues of the 3×3 matrix $M = \begin{pmatrix} a^2 & ab & ac \\ ab & b^2 & bc \\ ac & bc & c^2 \end{pmatrix}$ are

1. $a^2 + b^2 + c^2, 0, 0$
2. $b^2 + c^2, a^2, 0$
3. $a^2 + b^2, c^2, 0$
4. $a^2 + c^2, b^2, 0$

Q33. [June 2020] . 3.5 marks

Mathematical Physics > Complex analysis

CSIR NET	2020 June	3.5M

A function of a complex variable z is defined by the integral $f(z) = \oint_\Gamma \frac{w^2-2}{w-z} dw$, where Γ is a circular contour of radius 3, centred at origin, running counter-clockwise in the w - plane. The value of the function at $z = (2 - i)$ is

1. 0
2. $1 - 4i$
3. $8\pi + 2\pi i$
4. $-\frac{2}{\pi} - \frac{i}{2\pi}$

Q34. [June 2020] . 3.5 marks

Statistical Mechanics > Black Body Radiations

CSIR NET	2020 June	3.5M

The temperatures of two perfect black bodies A and B are $400K$ and $200K$, respectively. If the surface area of A is twice that of B, the ratio of total power emitted by A to that by B is

1. 4
2. 2
3. 32
4. 16

Q35. [June 2020] . 3.5 marks

Thermodynamics > Laws of thermodynamics

CSIR NET	2020 June	3.5M

Two ideal gases in a box are initially separated by a partition. Let N_1, V_1 and N_2, V_2 be the numbers of particles and volume occupied by the two systems. When the partition is removed, the pressure of the mixture at an equilibrium temperature T, is

1. $k_B T\left(\frac{N_1+N_2}{2(V_1+V_2)}\right)$
2. $k_B T\left(\frac{N_1+N_2}{V_1+V_2}\right)$
3. $k_B T\left(\frac{N_1}{V_1}+\frac{N_2}{V_2}\right)$
4. $\frac{1}{2}k_B T\left(\frac{N_1}{V_1}+\frac{N_2}{V_2}\right)$

Q36. [June 2020] . 3.5 marks

Statistical Mechanics > Canonical Ensemble

CSIR NET	2020 June	3.5M

An idealised atom has a non-degenerate ground state at zero energy and a g-fold degenerate excited state of energy E. In a non-interacting system of N such atoms, the population of the excited state may exceed that of the ground state above a temperature $T > \frac{E}{2k_B \ln 2}$. The minimum value of g for which this is possible is

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

Q37. [June 2020] . 3.5 marks

Thermodynamics > Kinetic theory of Gases

CSIR NET	2020 June	3.5M

The Hamiltonian of a system of N non-interacting particles, each of mass m, in one dimension is

$$H = \sum_{i=1}^{N} \left(\frac{p_i^2}{2m} + \frac{\lambda}{4} x_i^4 \right)$$

where $\lambda > 0$ is a constant and p_i and x_i are the momentum and position respectively of the i-th particle. The average internal energy of the system is

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

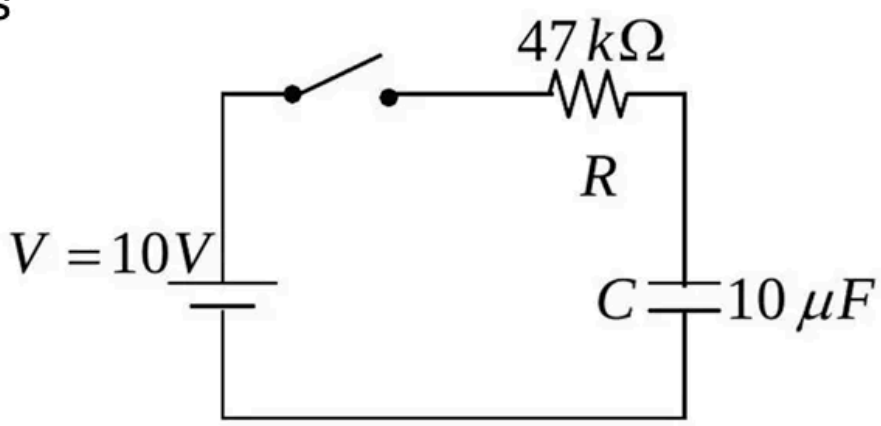
Q38. [June 2020] . 3.5 marks

Electronics > RLC Circuits

CSIR NET	2020 June	3.5M

A 10 V battery is connected in series to a resistor R and a capacitor C, as shown the figure. The initial charge on the capacitor is zero. The switch is turned on and the capacitor is allowed to charge to its full capacity. The total work done by the battery in this process is

1. 10^{-3} J
2. 2×10^{-3} J
3. 5×10^{-4} J
4. 47×10^{-2}J

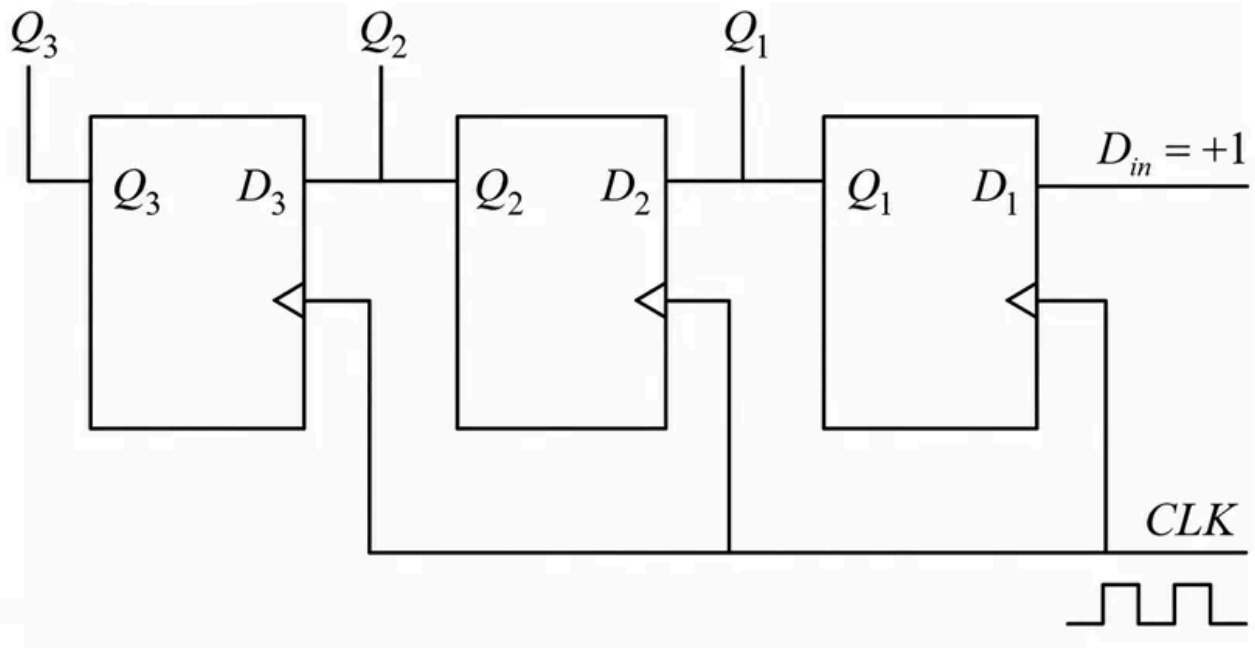


Q39. [June 2020] . 3.5 marks

Electronics > Flip flops/Counters/Registers/microcontroller etc.

CSIR NET	2020 June	3.5M

In the 3 -bit register shown below, Q_1 and Q_3 are the least and the most significant bits of the output, respectively.



If Q_1, Q_2 and Q_3 are set to zero initially, then the output after the arrival of the second falling clock (CLK) edge is

1. 001
2. 100
3. 011
4. 110

Q40. [June 2020] . 3.5 marks

Electronics > Digital Electronics

CSIR NET	2020 June	3.5M

The Boolean equation $Y = \bar{A}BC + \bar{A}B\bar{C} + A\bar{B}\bar{C} + A\bar{B}C$ is to be implemented using only two-input NAND gates. The minimum number of gates required is

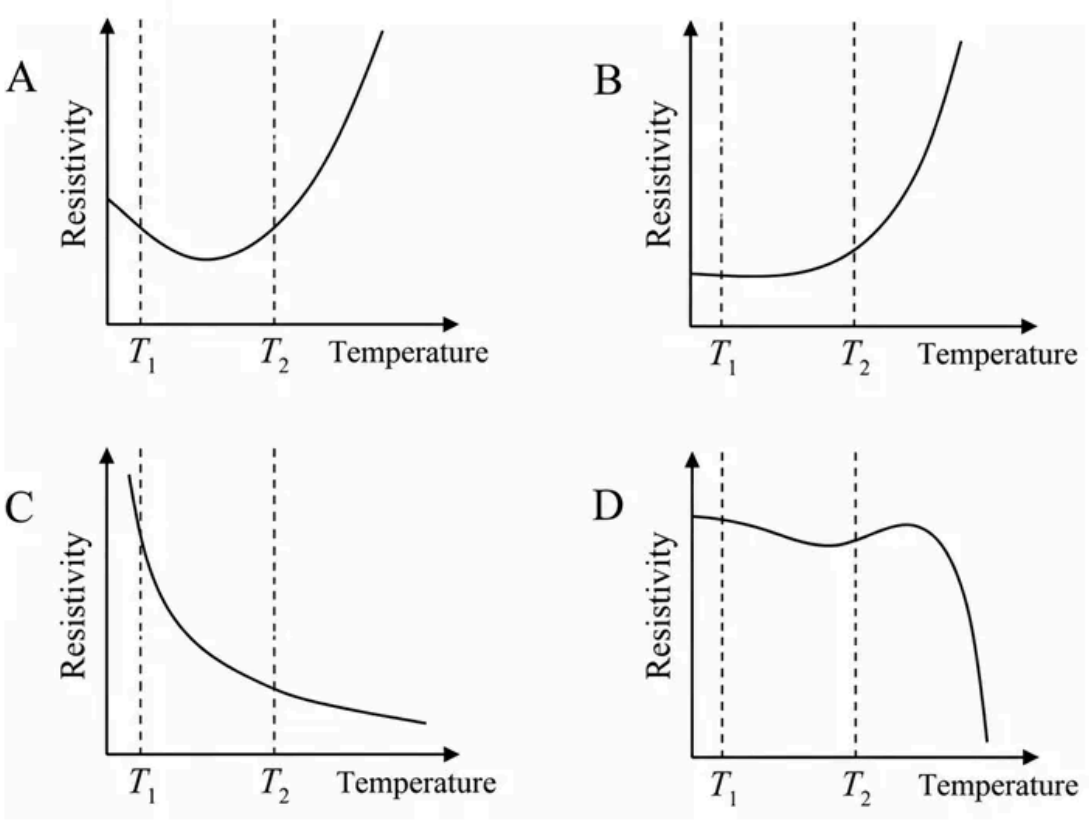
1. 3
2. 4
3. 5
4. 6

Q41. [June 2020] . 3.5 marks

Electronics > Instruments

CSIR NET	2020 June	3.5M

The temperature variation of the resistivity of four materials are shown in the following graphs.



The material that would make the most sensitive temperature sensor, when used at temperatures between T_1 and T_2, is

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

Q42. [June 2020] . 3.5 marks

Quantum Mechanics > Basic Quantum Mechanics

CSIR NET	2020 June	3.5M

Let $|n\rangle$ denote the energy eigenstates of a particle in a one-dimensional simple harmonic potential $V(x) = \frac{1}{2}m\omega^2x^2$. If the particle is initially prepared in the state $|\psi(t=0)\rangle = \sqrt{\frac{1}{2}}(|0\rangle + |1\rangle)$, the minimum time after which the oscillator will be found in the same state is

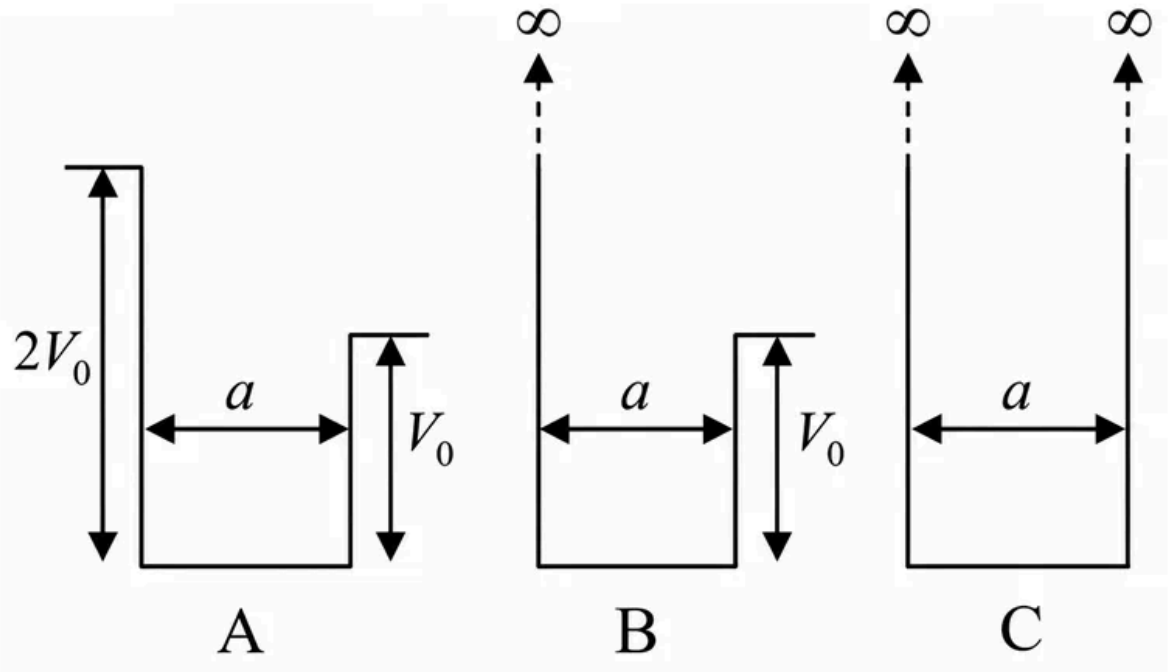
1. $3\pi/(2\omega)$
2. π/ω
3. $\pi/(2\omega)$
4. $2\pi/\omega$

Q43. [June 2020] . 3.5 marks

Quantum Mechanics > Pertubation theory

CSIR NET	2020 June	3.5M

For the one dimensional potential wells A, B and C, as shown in the figure, let E_A, E_B and E_C denote the ground sate energies of a particle, respectively.



The correct ordering of the energies is

1. $E_C > E_B > E_A$
2. $E_A > E_B > E_C$
3. $E_B > E_C > E_A$
4. $E_B > E_A > E_C$

Q44. [June 2020] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2020 June	3.5M

An angular momentum eigenstate $|j, 0\rangle$ is rotated by an infinitesimally small angle ε about the positive y-axis in the counter clockwise direction. The rotated state, to order ε (upto a normalisation constant), is

1. $|j, 0\rangle - \frac{\varepsilon}{2}\sqrt{j(j+1)}(|j, 1\rangle + |j, -1\rangle)$
2. $|j, 0\rangle - \frac{\varepsilon}{2}\sqrt{j(j+1)}(|j, 1\rangle - |j, -1\rangle)$
3. $|j, 0\rangle - \frac{\varepsilon}{2}\sqrt{j(j-1)}(|j, 1\rangle - |j, -1\rangle)$
4. $|j, 0\rangle - \frac{\varepsilon}{2}\sqrt{j(j+1)}|j, 1\rangle - \frac{\varepsilon}{2}\sqrt{j(j-1)}|j, -1\rangle$

Q45. [June 2020] . 3.5 marks

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

CSIR NET	2020 June	3.5M

The wavelength of the first Balmer line of hydrogen is $656\ \text{nm}$. The wavelength of the corresponding line for a hydrogenic atom with $Z = 6$ and nuclear mass of $19.92 \times 10^{-27}\ \text{kg}$ is

1. 18.2 nm
2. 109.3 nm
3. 143.5 nm
4. 393.6 nm

Q46. [June 2020] . 5.0 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2020 June	5M

The state of an electron in a hydrogen atom is

$$|\psi\rangle = \frac{1}{\sqrt{6}}|1,0,0\rangle + \frac{1}{\sqrt{3}}|2,1,0\rangle + \frac{1}{\sqrt{2}}|3,1,-1\rangle$$

where $|n,l,m\rangle$ denotes common eigenstates of $\hat{H}$, $\hat{L}^2$ and $\hat{L}_z$ operators in the standard notation.

In a measurement of $\hat{L}_z$ for the electron in this state, the result is recorded to be 0 . Subsequently a measurement of energy is performed. The probability that the result is E_2 (the energy of the $n = 2$ state) is

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

Q47. [June 2020] . 5.0 marks

Quantum Mechanics > Scattering theory

CSIR NET	2020 June	5M

A particle with incoming wave vector $\vec{k}$, after being scattered by the potential $V(r) = \frac{C}{r^2}$, goes out with wave vector $\vec{k}'$. The differential scattering cross-section, calculated in the first Born approximation, depends on $q = |\vec{k} - \vec{k}'|$, as

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

Q48. [June 2020] . 5.0 marks

Quantum Mechanics > Pertubation theory

CSIR NET	2020 June	5M

A quantum particle in a one-dimensional infinite potential well, with boundaries at 0 and a, is perturbed by adding $H' = \in \delta\left(x - \frac{a}{2}\right)$ to the initial Hamiltonian. The correction to the energies of the ground and the first excited states (to first order in $\in$) are respectively

1. 0 and 0
2. $2 \in/a$ and 0
3. 0 and $2 \in/a$
4. $2 \in/a$ and $2 \in/a$

Q49. [June 2020] . 5.0 marks

Statistical Mechanics > Microstates and Macrostates

CSIR NET	2020 June	5M

Spin $\frac{1}{2}$ fermions of mass m and $4m$ are in a harmonic potential $V(x) = \frac{1}{2}kx^2$. Which configuration of 4 such particles has the lowest value of the ground state energy?

1. 4 particles of mass m
2. 4 particles of mass $4m$
3. 1 particle of mass m and 3 particles of mass $4m$
4. 2 particles of mass m and 2 particles of mass $4m$

Q50. [June 2020] . 5.0 marks

Classical Mechanics > Basic Mechanics

CSIR NET	2020 June	5M

Falling drops of rain break up and coalesce with each other and finally achieve an approximately spherical shape in the steady state. The radius of such a drop scales with the surface tension σ as

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

Q51. [June 2020] . 5.0 marks

Classical Mechanics > Basic Mechanics

CSIR NET	2020 June	5M

The velocity $v(x)$ of a particle moving in one dimension is given by $v(x) = v_0 \sin\left(\frac{\pi x}{x_0}\right)$, where v_0 and x_0 are positive constants of appropriate dimensions. If the particle is initially at $x/x_0 = \in$, where $|\in| \ll 1$, then, in the long time, it

1. Executes an oscillatory motion around $x = 0$
2. Tends towards $x = 0$
3. Tends towards $x = x_0$
4. Executes an oscillatory motion around $x = x_0$

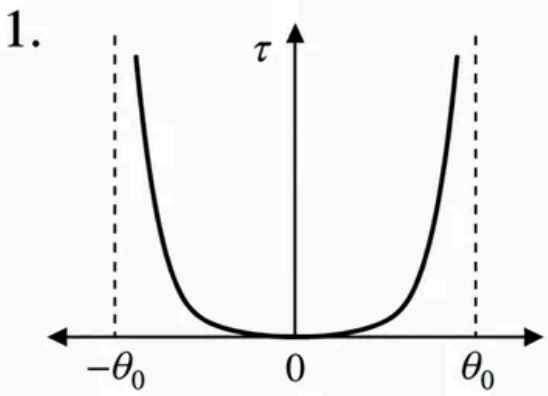
Q52. [June 2020] . 5.0 marks

Classical Mechanics > Oscillations

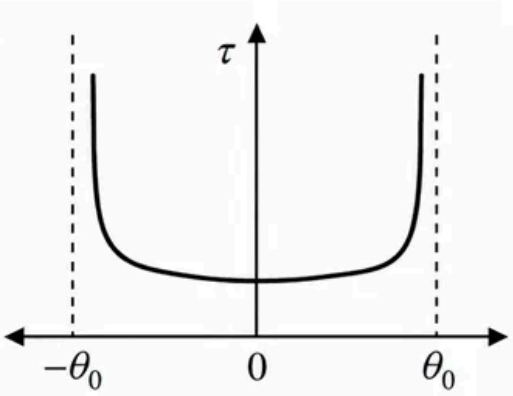
CSIR NET	2020 June	5M

A pendulum executes small oscillations between angles $+\theta_0$ and $-\theta_0$. If $\tau(\theta)d\theta$ is the time spent between θ and $\theta + d\theta$, then $\tau(\theta)$ is best represented by

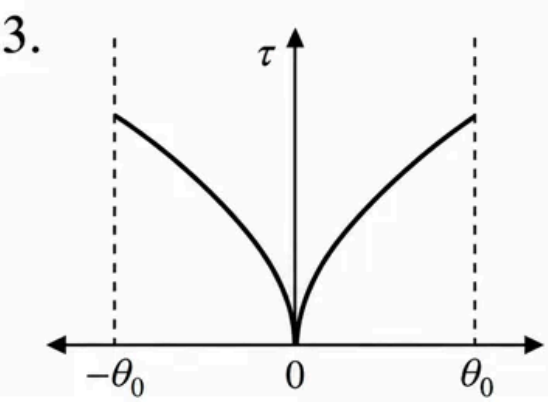
1.



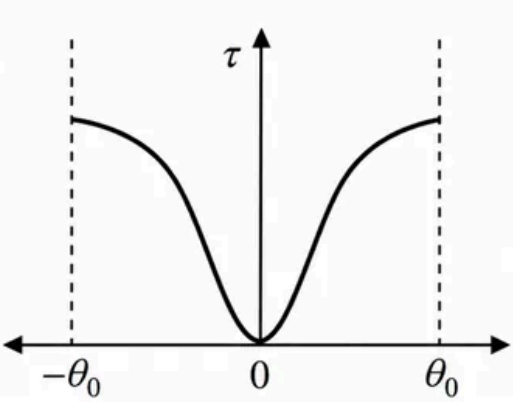
2.



3.



4.

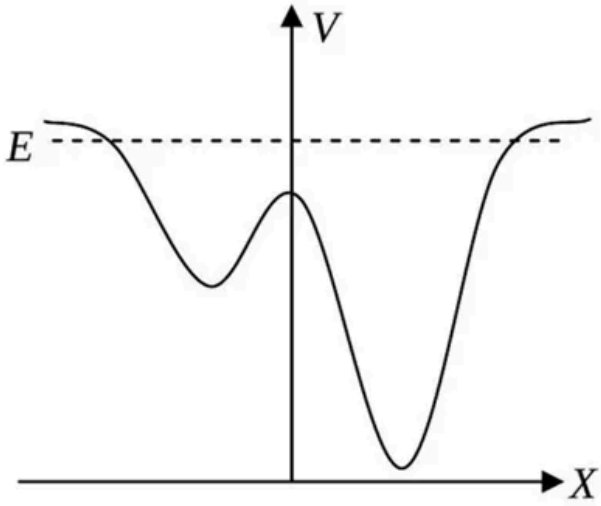


Q53. [June 2020] . 5.0 marks

Classical Mechanics > Phase space diagrams

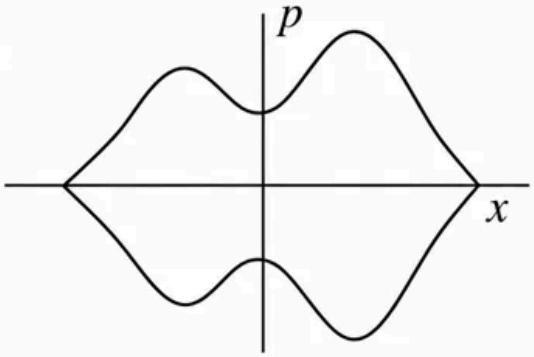
CSIR NET	2020 June	5M

Consider a particle with total energy E moving in one dimension in a potential $V(x)$ as shown in the figure below.

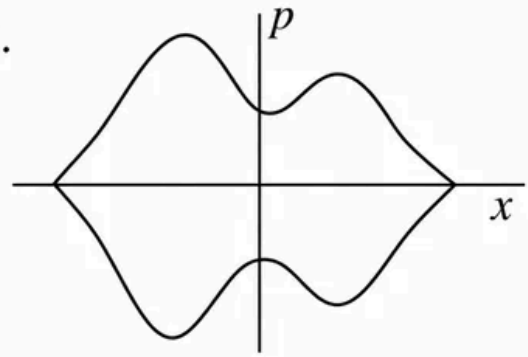


Which of the following figures best represents the orbit of the particle in the phase space?

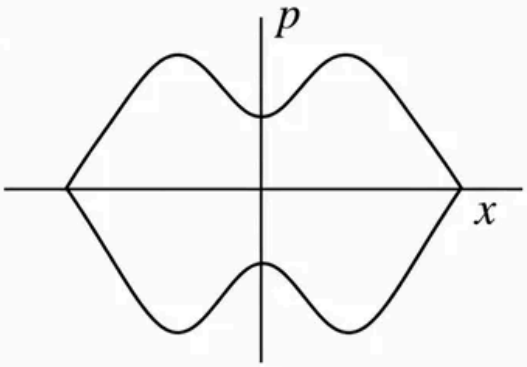
1.



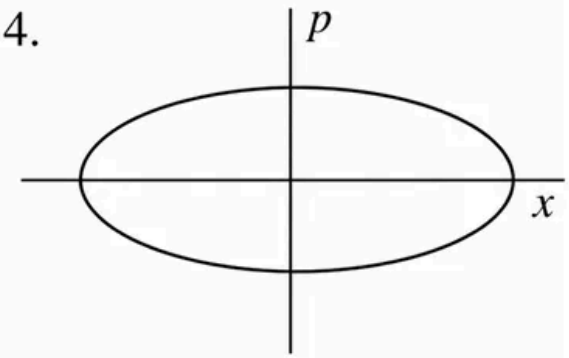
2.



3.



4.



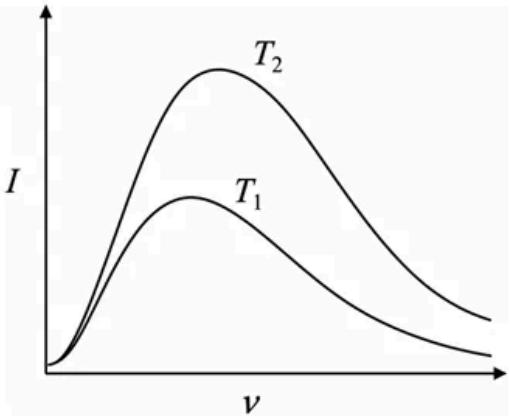
Q54. [June 2020] . 5.0 marks

Statistical Mechanics > Black Body Radiations

CSIR NET	2020 June	5M

The energy density I of a black body radiation at temperature T is given by the Planck's distribution function $I(v,T) = \frac{8\pi v^2}{c^3}\frac{hv}{\left(e^{\frac{hv}{k_B T}}-1\right)}$, where v is the frequency. The function $I(v,T)$ for two different temperatures T_1 and T_2 are shown below. If the two curves coincide when $I(v,T)v^a$ is plotted against v^b/T, then the values of a and b are, respectively,

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



Q55. [June 2020] . 5.0 marks

Statistical Mechanics > Microcanonical Ensemble

CSIR NET	2020 June	5M

For an ideal gas consisting of N distinguishable particles in a volume V, the probability of finding exactly 2 particles in a volume $\delta V \ll V$, in the limit $N, V \to \infty$, is

1. $2N\delta V/V$
2. $(N\delta V/V)^2$
3. $\frac{(N\delta V)^2}{2V^2} e^{-N\delta V/V}$
4. $\left(\frac{\delta V}{V}\right)^2 e^{-N\delta V/V}$

Q56. [June 2020] . 5.0 marks

Statistical Mechanics > Ising model

CSIR NET	2020 June	5M

The Hamiltonian of a system of 3 spins is $H = J(S_1S_2 + S_2S_3)$, where $S_i = \pm 1$ for $i = 1,2,3$. Its canonical partition function, at temperature T, is

1. $2\left(2\sinh\frac{J}{k_BT}\right)^2$
2. $2\left(2\cosh\frac{J}{k_BT}\right)^2$
3. $2\left(2\cosh\frac{J}{k_BT}\right)$
4. $2\left(2\cosh\frac{J}{k_BT}\right)^3$

Q57. [June 2020] . 5.0 marks

Solid State Physics > Free electron theory

CSIR NET	2020 June	5M

A certain two-dimensional solid crystallises to a square monoatomic lattice with lattice constant a. Each atom can contribute an integer number of free conduction electrons. The minimum number of electrons each atom must contribute such that the free electron Fermi circle at zero temperature encloses the first Brillouin zone completely, is

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

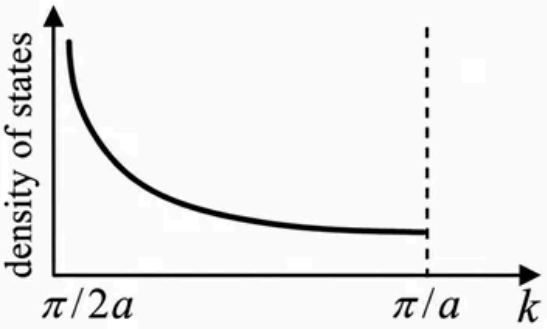
Q58. [June 2020] . 5.0 marks

Solid State Physics > Tight binding model

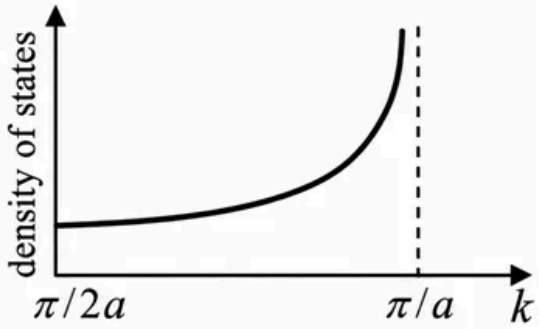
CSIR NET	2020 June	5M

A tight binding model of electrons in one dimension has the dispersion relation $\varepsilon(k) = -2t(1 - \cos ka)$, where $t > 0$, a is the lattice constant and $-\frac{\pi}{a} < k < \frac{\pi}{a}$. Which of the following figures best represents the density of states over the range $\frac{\pi}{2a} \leq k < \frac{\pi}{a}$?

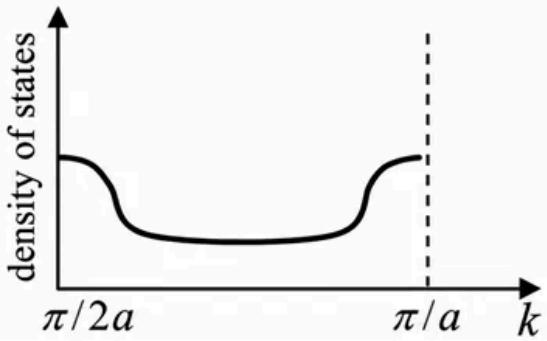
1.



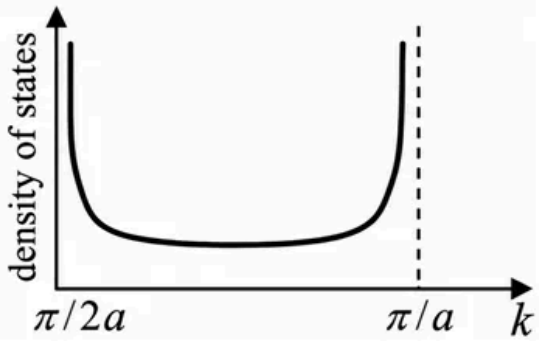
2.



3.



4.



Q59. [June 2020] . 5.0 marks

Solid State Physics > Crystallography

CSIR NET	2020 June	5M

A lattice is defined by the unit vectors $\vec{a}_1 = a\hat{i}, \vec{a}_2 = -\frac{a}{2}\hat{i} + \frac{a\sqrt{3}}{2}\hat{j}$ and $\vec{a}_3 = a\hat{k}$, where $a > 0$ is a constant. The spacing between the (100) planes of the lattice is

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

Q60. [June 2020] . 5.0 marks

Electromagnetism > EM Waves

CSIR NET	2020 June	5M

A spacecraft of mass $m = 1000\,kg$ has a fully reflecting sail that is oriented perpendicular to the direction of the sun. The sun radiates $10^{26}\,W$ and has a mass $M = 10^{30}\,kg$. Ignoring the effect of the planets, for the gravitational pull of the sun to balance the radiation pressure on the sail, the area of the sail will be

1. $10^2 m^2$
2. $10^4 m^2$
3. $10^8\ m^2$
4. $10^6\ m^2$

Q61. [June 2020] . 5.0 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2020 June	5M

The electric field due to a uniformly charged infinite line along the z - axis, as observed in the rest frame S of the line charge, is $\vec{E}(\vec{r}) = \frac{\lambda}{2\pi\epsilon_0}\frac{x\hat{i}+y\hat{j}}{(x^2+y^2)}$. In a frame M moving with a constant speed v with respect to S along the z - direction, the electric field $\vec{E}'$ is (in the following $\beta = v/c$ and $\gamma = 1/\sqrt{1-\beta^2}$)

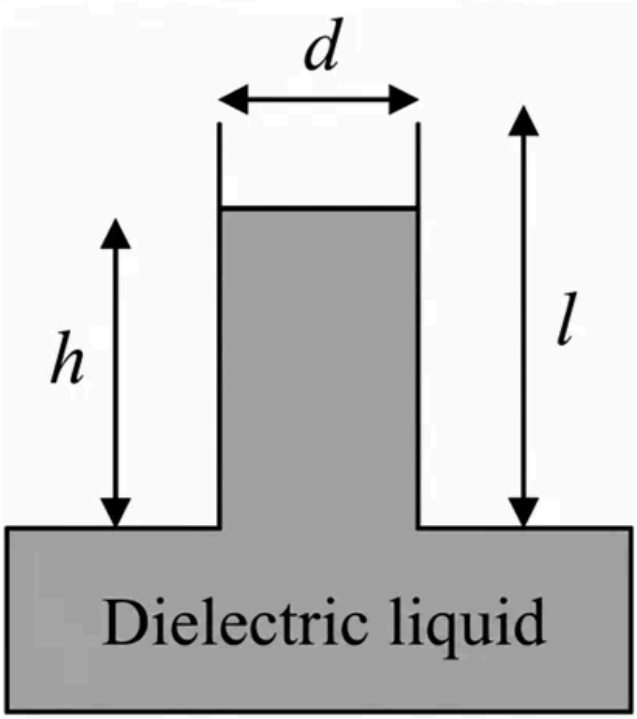
1. $E'_x = E_x$ and $E'_y = E_y$
2. $E'_x = \beta\gamma E_x$ and $E'_y = \beta\gamma E_y$
3. $E'_x = E_x/\gamma$ and $E'_y = E_y/\gamma$
4. $E'_x = \gamma E_x$ and $E'_y = \gamma E_y$

Q62. [June 2020] . 5.0 marks

Electromagnetism > Capacitors

CSIR NET	2020 June	5M

A parallel plate capacitor with rectangular plates of length l, breadth b and plate separation d, is held vertically on the surface of a dielectric liquid of dielectric constant κ and density ρ as shown in the figure. The length and breadth are large enough for edge effects to be neglected. The plates of the capacitor are kept at a constant voltage difference V. Ignoring effects of surface tension, the height h upto which the liquid level rises inside the capacitor, is



1. $\frac{V^2\varepsilon_0(\kappa-1)}{\rho g b d}$
2. $\frac{V^2\varepsilon_0(\kappa-1)}{2\rho g b^2}$
3. $\frac{V^2\varepsilon_0(\kappa-1)}{2\rho g d^2}$
4. $\frac{V^2\varepsilon_0(\kappa-1)}{\rho g d^2}$

Q63. [June 2020] . 5.0 marks

Mathematical Physics > Numerical Methods

CSIR NET	2020 June	5M

Using the following values of x and f(x) the integral $I = \int_0^{1.5} f(x)dx$, evaluated by the Trapezoidal rule, is 5/16. The value of a is

x	0	0.5	1.0	1.5
f(x)	1	a	0	−5/4

1. 3/4
2. 3/2
3. 7/4
4. 19/24

Q64. [June 2020] . 5.0 marks

Mathematical Physics > Green Function

CSIR NET	2020 June	5M

The Green's function for the differential equation $\frac{d^2x}{dt^2} + x = f(t)$, satisfying the initial conditions $x(0) = \frac{dx}{dt}(0) = 0$ is

$$G(t,\tau) = \begin{cases} 0 & \text{for} \quad 0 < t < \tau \\ \sin(t-\tau) & \text{for} \quad t > \tau \end{cases}$$

The solution of the differential equation when the source $f(t) = \theta(t)$ (the Heaviside step function) is

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

Q65. [June 2020] . 5.0 marks

Mathematical Physics > Ordinary Differential Equations

CSIR NET	2020 June	5M

The solution of the differential equation $\left(\frac{dy}{dx}\right)^2 - \frac{d^2y}{dx^2} = e^y$, with the boundary conditions $y(0) = 0$ and $y'(0) = -1$, is

1. $-\ln\left(\frac{x^2}{2} + x + 1\right)$
2. $-x\ln(e + x)$
3. $-xe^{-x^2}$
4. $-x(x + 1)e^{-x}$

Q66. [June 2020] . 5.0 marks

Atomic and Molecular Physics > Angular momentum in Atomic Physics

CSIR NET	2020 June	5M

If we take the nuclear spin I into account, the total angular momentum is $\vec{\mathrm{F}} = \vec{\mathrm{L}} + \vec{\mathrm{S}} + \vec{\mathrm{I}}$, where $\vec{\mathrm{L}}$ and $\vec{\mathrm{S}}$ are the orbital and spin angular momenta of the electron. The Hamiltonian of the hydrogen atom is corrected by the additional interaction $\lambda\vec{\mathrm{I}} \cdot (\vec{\mathrm{L}} + \vec{\mathrm{S}})$, where $\lambda > 0$ is a constant. The total angular momentum quantum number F of the p - orbital state with the lowest energy is

1. 0
2. 1
3. 1/2
4. 3/2

Q67. [June 2020] . 5.0 marks

Atomic and Molecular Physics > Molecular physics

CSIR NET	2020 June	5M

The absorption lines arising from pure rotational effects of HCl are observed at $83.03\ \text{cm}^{-1}$, $103.73\ \text{cm}^{-1}$, $124.30\ \text{cm}^{-1}$, $145.03\ \text{cm}^{-1}$ and $165.51\ \text{cm}^{-1}$. The moment of inertia of the HCl molecule is (take $\frac{\hbar}{2\pi c} = 5.6 \times 10^{-44}\ \text{kg} - \text{m}$)

1. $1.1 \times 10^{-48}\ \text{kg} - \text{m}^2$
2. $2.8 \times 10^{-47}\ \text{kg} - \text{m}^2$
3. $2.8 \times 10^{-48}\ \text{kg} - \text{m}^2$
4. $1.1 \times 10^{-42}\ \text{kg} - \text{m}^2$

Q68. [June 2020] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2020 June	5M

The energies of the 3 lowest states of an atom are $E_0 = -14\,eV, E_1 = -9\,eV$ and $E_2 = -7\,eV$. The Einstein coefficients are $A_{10} = 3 \times 10^8\,s^{-1}$, $A_{20} = 1.2 \times 10^8\,s^{-1}$ and $A_{21} = 8 \times 10^7 s^{-1}$. If a large number of atoms are in the energy level E_2, the mean radiative lifetime of this excited state is

1. $8.3 \times 10^{-9}\,s$
2. $1 \times 10^{-8}\,s$
3. $0.5 \times 10^{-8}\,s$
4. $1.2 \times 10^{-8}\,s$

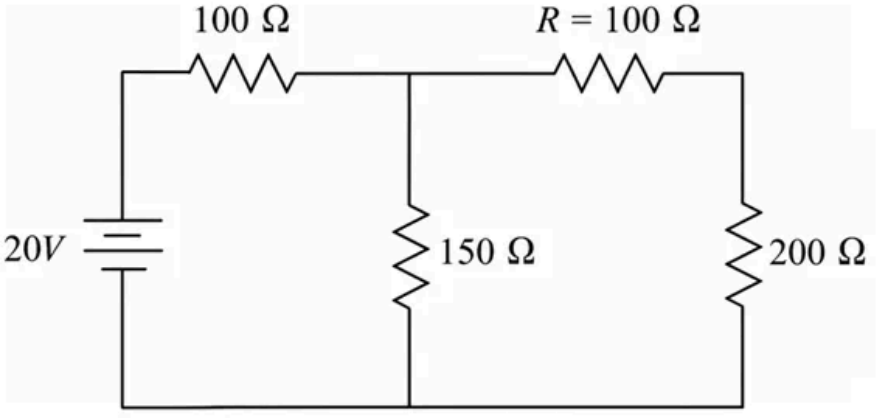
Q69. [June 2020] . 5.0 marks

Electronics > Instruments

CSIR NET	2020 June	5M

Two voltmeters A and B with internal resistances 2 MΩ and 0.1 kΩ are used to measure the voltage drops V_A and V_B, respectively, across the resistor R in the circuit shown below. The ratio V_A/V_B is

1. 0.58
2. 1.73
3. 1
4. 2

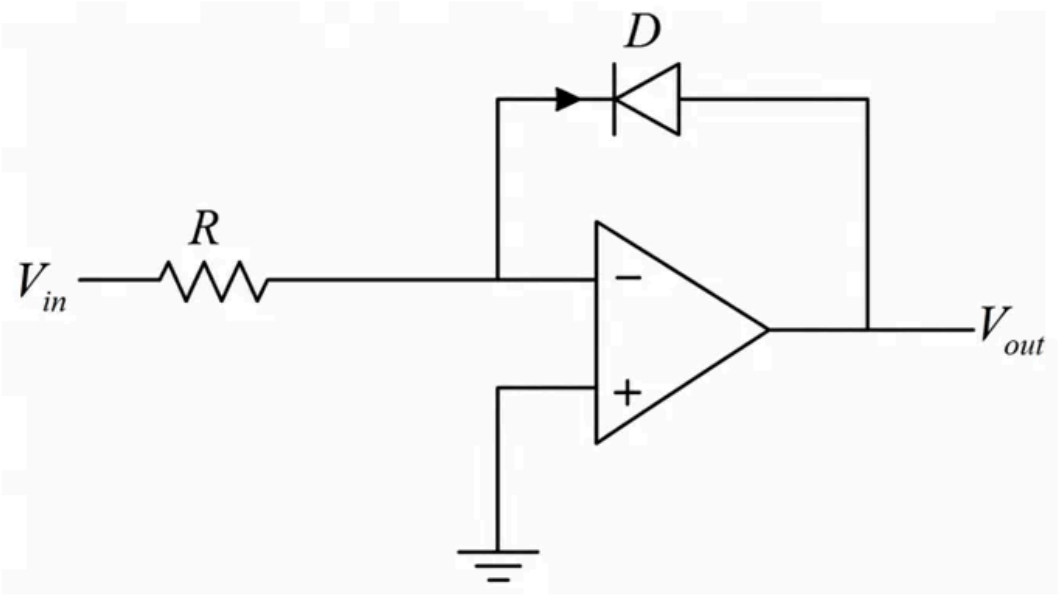


Q70. [June 2020] . 5.0 marks

Electronics > OPAMP

CSIR NET	2020 June	5M

The $I-V$ characteristics of the diode D in the circuit below is given by $I = I_s\left(e^{\frac{qV}{k_BT}} - 1\right)$ where I_s is the reverse saturation current, V is the voltage across the diode and T is the absolute temperature.



If the input voltage is V_{in}, then the output voltage V_{out} is

1. $I_S R \ln\left(\frac{qV_{in}}{k_BT} + 1\right)$
2. $\frac{1}{q} k_B T \ln\left(\frac{q(V_{in}+I_S R)}{k_BT}\right)$
3. $\frac{1}{q} k_B T \ln\left(\frac{V_{in}}{I_S R} + 1\right)$
4. $-\frac{1}{q} k_B T \ln\left(\frac{V_{in}}{I_S R} + 1\right)$

Q71. [June 2020] . 5.0 marks

Electronics > Instruments

CSIR NET	2020 June	5M

A rod pivoted at one end is rotating clockwise 25 times a second in a plane. A video camera which records at a rate of 30 frames per second is used to film the motion. To someone watching the video, the apparent motion of the rod will seem to be

1. 10 rotations per second in the clockwise direction
2. 10 rotations per second in the anticlockwise direction
3. 5 rotations per second in the clockwise direction
4. 5 rotations per second in the anticlockwise direction

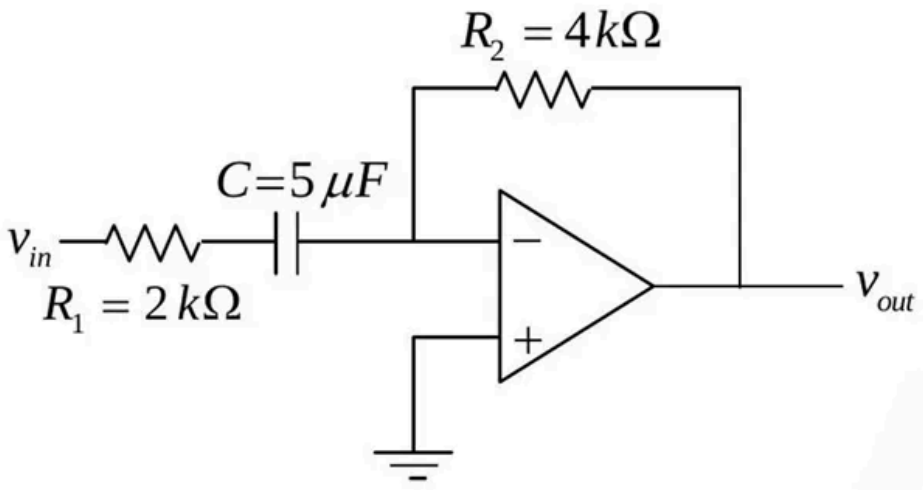
Q72. [June 2020] . 5.0 marks

Electronics > OPAMP

CSIR NET	2020 June	5M

In the circuit shown below, the gain of the op-amp in the middle of its bandwidth is 10^5. A sinusoidal voltage with angular frequency $\omega = 100\,\text{rad/s}$ is applied to the input of the op-amp. The phase difference between the input and the output voltage is

1. $5\pi/4$
2. $3\pi/4$
3. $\pi/2$
4. π



Q73. [June 2020] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2020 June	5M

Charged pions π^- decay to muons μ^- and anti-muon neutrinos $\vec{\nu}_\mu$; $\pi^- \rightarrow \mu^- + \vec{\nu}_\mu$. Take the rest masses of a muon and a pion to be 105 MeV and 140 MeV, respectively. The probability that the measurement of the muon spin along the direction of its momentum is positive, is closest to

1. 0.5
2. 0.75
3. 1
4. 0

Q74. [June 2020] . 5.0 marks

Nuclear and Particle Physics > Liquid drop Model

CSIR NET	2020 June	5M

The binding energy B of a nucleus is approximated by the formula $B = a_1A - a_2A^{2/3} - a_3Z^2A^{-1/3} - a_4(A-2Z)^2A^{-1}$, where Z is the atomic number and A is the mass number of the nucleus. If $\frac{a_4}{a_2} \simeq 30$. The atomic number Z for naturally stable isobars (constant value of A) is

1. $\frac{30A}{60+A^{2/3}}$
2. $\frac{30A}{30+A^{2/3}}$
3. $\frac{60A}{120+A^{2/3}}$
4. $\frac{120A}{60+A^{2/3}}$

Q75. [June 2020] . 5.0 marks

Nuclear and Particle Physics > Shell model

CSIR NET	2020 June	5M

The magnetic moments of a proton and a neutron are $2.792\ \mu_N$ and $-1.913\ \mu_N$, where μ_N is the nucleon magnetic moment. The values of the magnetic moments of the mirror nuclei $^{19}_{9}F_{10}$ and $^{19}_{10}Ne_{9}$, respectively, in the Shell model, are closest to

1. $23.652\ \mu_N$ and $-18.873\ \mu_N$
2. $26.283\ \mu_N$ and $-16.983\ \mu_N$
3. $-2.628\ \mu_N$ and $1.887\ \mu_N$
4. $2.628\ \mu_N$ and $-1.887\ \mu_N$

Answer Key

75 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	General Aptitude	Reasoning	**1**
Q2	General Aptitude	Mathematical Analysis	**3**
Q3	General Aptitude	Geometry	**1**
Q4	General Aptitude	Mathematical Analysis	**4**
Q5	General Aptitude	Reasoning	**2**
Q6	General Aptitude	Data Analysis	**1**
Q7	General Aptitude	Mathematical Analysis	**2**
Q8	General Aptitude	Mathematical Analysis	**3**
Q9	General Aptitude	Basic Physics	**2**
Q10	General Aptitude	Basic Physics	**4**
Q11	General Aptitude	Geometry	**2**
Q12	General Aptitude	Geometry	**4**
Q13	General Aptitude	Basic Physics	**4**
Q14	General Aptitude	Reasoning	**4**
Q15	General Aptitude	Basic Physics	**3**
Q16	General Aptitude	Reasoning	**1**
Q17	General Aptitude	Mathematical Analysis	**1**
Q18	General Aptitude	Mathematical Analysis	**1**
Q19	General Aptitude	Geometry	**3**
Q20	General Aptitude	Basic Physics	**1**
Q21	Classical Mechanics	Lagrangian and Hamiltonian	**3**
Q22	Classical Mechanics	Oscillations	**2**
Q23	Classical Mechanics	Special theory of relativity	**1**
Q24	Classical Mechanics	Rotation Motion	**4**
Q25	Electronics	RLC Circuits	**3**
Q26	Electromagnetism	Electrostatics	**2**
Q27	Electromagnetism	Magetostatics	**4**
Q28	Optics	Interference and diffraction	**2**
Q29	Electromagnetism	EM Waves	**4**
Q30	Mathematical Physics	Vector Algebra and Vector Calculus	**4**
Q31	Mathematical Physics	Probability	**4**
Q32	Mathematical Physics	Matrices and Linear Algebra	**1**
Q33	Mathematical Physics	Complex analysis	**3**
Q34	Statistical Mechanics	Black Body Radiations	**3**
Q35	Thermodynamics	Laws of thermodynamics	**2**
Q36	Statistical Mechanics	Canonical Ensemble	**2**
Q37	Thermodynamics	Kinetic theory of Gases	**2**
Q38	Electronics	RLC Circuits	**1**
Q39	Electronics	Flip flops/Counters/Registers/microcontroller etc.	**3**
Q40	Electronics	Digital Electronics	**2**

Answer Key (cont.)

Q. No	Subject	Topic	Answer
Q41	Electronics	Instruments	**3**
Q42	Quantum Mechanics	Basic Quantum Mechanics	**4**
Q43	Quantum Mechanics	Pertubation theory	**1**
Q44	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**2**
Q45	Atomic and Molecular Physics	Bohar Model and h-atom model	**1**
Q46	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**3**
Q47	Quantum Mechanics	Scattering theory	**1**
Q48	Quantum Mechanics	Pertubation theory	**2**
Q49	Statistical Mechanics	Microstates and Macrostates	**4**
Q50	Classical Mechanics	Basic Mechanics	**1**
Q51	Classical Mechanics	Basic Mechanics	**3**
Q52	Classical Mechanics	Oscillations	**2**
Q53	Classical Mechanics	Phase space diagrams	**1**
Q54	Statistical Mechanics	Black Body Radiations	**4**
Q55	Statistical Mechanics	Microcanonical Ensemble	**3**
Q56	Statistical Mechanics	Ising model	**2**
Q57	Solid State Physics	Free electron theory	**3**
Q58	Solid State Physics	Tight binding model	**2**
Q59	Solid State Physics	Crystallography	**1**
Q60	Electromagnetism	EM Waves	**4**
Q61	Electromagnetism	Relativistic electromagnetism	**4**
Q62	Electromagnetism	Capacitors	**3**
Q63	Mathematical Physics	Numerical Methods	**1**
Q64	Mathematical Physics	Green Function	**3**
Q65	Mathematical Physics	Ordinary Differential Equations	**1**
Q66	Atomic and Molecular Physics	Angular momentum in Atomic Physics	**2**
Q67	Atomic and Molecular Physics	Molecular physics	**2**
Q68	Atomic and Molecular Physics	Lasers	**3**
Q69	Electronics	Instruments	**2**
Q70	Electronics	OPAMP	**3**
Q71	Electronics	Instruments	**4**
Q72	Electronics	OPAMP	**1**
Q73	Nuclear and Particle Physics	Particle physics	**3**
Q74	Nuclear and Particle Physics	Liquid drop Model	**3**
Q75	Nuclear and Particle Physics	Shell model	**4**

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