PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

CSIR NET Physics - Dec 2015 - Full Paper

Complete question paper with answer key

75 questions . Answer key included

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Q1. [Dec 2015] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2015 Dec	2 M

In each of the following groups of words is a hidden number, based on which you should arrange them in descending order. Pick the correct answer:

E. Papers I Xeroxed

F. Wi-Fi veteran

G. Yourself ourselves

H. Breaks even

1. H, F, G, H
2. E, G, F, H
3. H, F, G, E
4. H, E, F, G

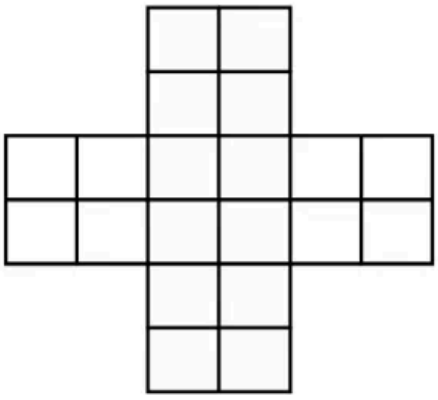
Q2. [Dec 2015] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2015 Dec	2 M

The number of squares in the figure is

1. 30
2. 29
3. 25
4. 20



Q3. [Dec 2015] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2015 Dec	2 M

A shopkeeper purchases a product for Rs. 100 and sells it making a profit of 10%. In these dealings the shopkeeper makes

1. No profit, no loss
2. Rs. 11
3. Re. 1
4. Rs. 20

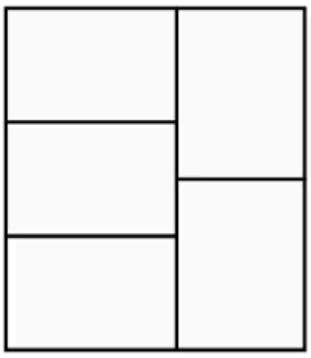
Q4. [Dec 2015] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2015 Dec	2 M

Five congruent rectangles are drawn inside a big rectangle pf perimeter 165 as shown. What is the perimeter of one of the five rectangles?

1. 37
2. 75
3. 15
4. 165



Q5. [Dec 2015] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2015 Dec	2 M

A person walks downhill at $10km/h$, uphill at $6km/h$ and on the plane at $7.5km/h$. If the person takes 3 hours to go from a place A to another place B, and 1 hour on the way back, the distance between A and B is

1. $15km$
2. 23.5 km
3. 16 km
4. Given data is insufficient to calculate distance.

Q6. [Dec 2015] . 2.0 marks

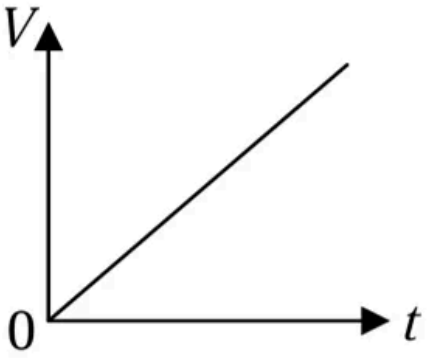
General Aptitude > Basic Physics

CSIR NET	2015 Dec	2 M

A vessel is partially filled with water. More water is added to it at a rate directly proportional to time

[i.e., $\frac{dV}{dt} \propto t$]. Which of the following graphs depicts correctly the variation of total volume V of water with time t ?

1.



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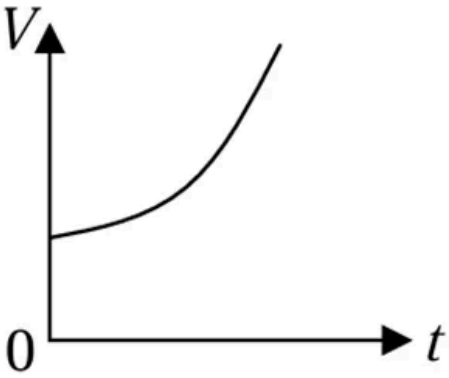

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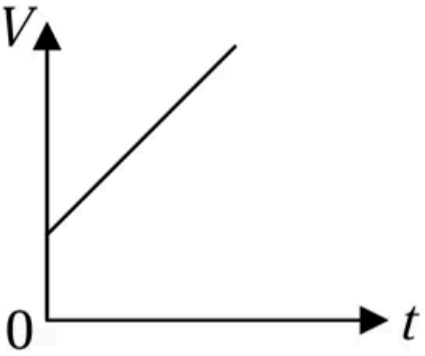

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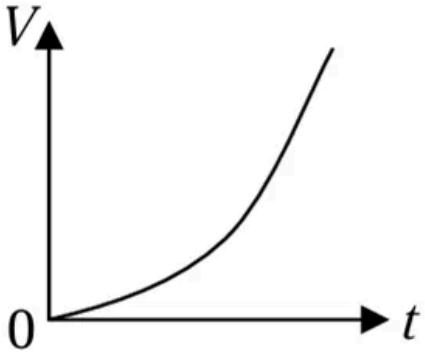


Q7. [Dec 2015] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2015 Dec	2 M

At one instant, the hour hand and the minute hand of a clock are one over the other in between the markings for 5 and 6 on the dial. At this instant, the tip of the minute hand

1. is closer to the marking for 6
2. is equidistant from the markings for 5 and 6
3. is closer to marking for 5
4. is equidistant from the markings for 11 and 12

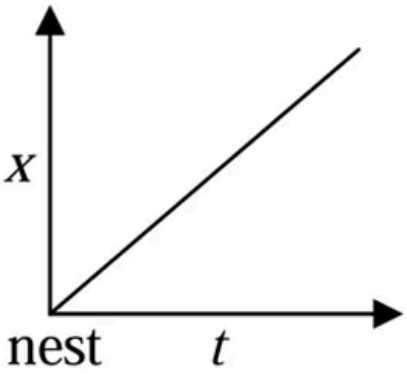
Q8. [Dec 2015] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2015 Dec	2 M

A bird leaves its nest and flies away. Its distance x from the nest is plotted as a function of time t. Which of the following plots cannot be right?

1.



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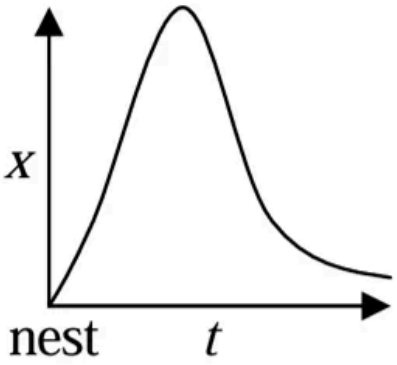
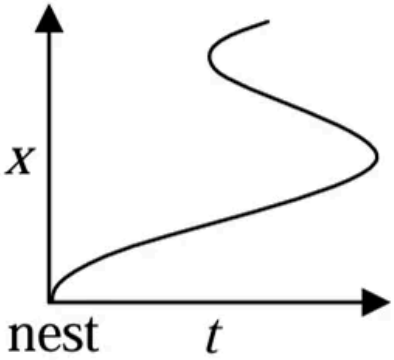
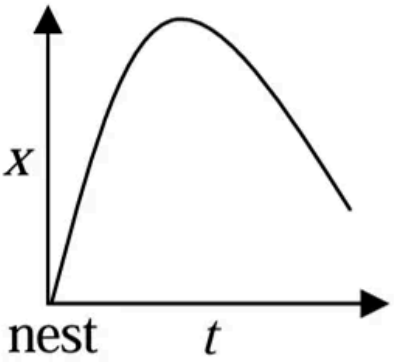


3.



4.



Q9. [Dec 2015] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2015 Dec	2 M

A cubical cardboard box made of $1cm$ thick card board has outer side of $29cm$. A tight-fitting cubical box of the same thickness is placed inside it, then another one inside it and so on. How many cubical boxes will be there in the entire set?

1. 29
2. 28
3. 15
4. 14

Q10. [Dec 2015] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2015 Dec	2 M

Secondary colours are made by a mixture of three primary colours, Red, Green and Blue, in different proportions; each of the primary colours comes in 8 possible levels. Grey corresponds to equal proportions of Red, Green and Blue. How many shades of grey exist ii this scheme?

1. 8^3
2. 8
3. 3^8
4. 8×3

Q11. [Dec 2015] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2015 Dec	2 M

The triangle formed by the lines $y = x, y = 1 - x$ and $x = 0$ in a two dimensional plane is
(x and y axes have the same scale)

1. isosceles and right-angled
2. isosceles but not right-angled
3. right-angled but not isosceles
4. neither isosceles nor right angled

Q12. [Dec 2015] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2015 Dec	2 M

There are two buckets A and B. Initially A has 2 liters of water and B is empty. At every hour 1 liter of water is transferred from A to B followed by returning $\frac{1}{2}$ liter back to A from B half an hour later. The earliest A will get empty is in:

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

Q13. [Dec 2015] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2015 Dec	2 M

Statement A: The following statement is true

Statement B: The preceding statement is false

Choose the correct inference from the following:

1. Statements A and B are always true
2. Statements A and B can be true if there is at least one statement between A and B
3. Statements A and B can be true if there are at least two statements between A and B
4. Statements A and B can never be true, independently

Q14. [Dec 2015] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2015 Dec	2 M

A car is moving at $60\ \mathrm{km/h}$. The instantaneous velocity of the upper most points of its wheels is

1. $60\ \mathrm{km/h}$ forward
2. $120 km/h$ forward
3. $60\ \mathrm{km/h}$ backward
4. $120\ \mathrm{km/h}$ backward

Q15. [Dec 2015] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2015 Dec	2 M

If $D + I + M = 1501$

$$C + I + V + I + L = 157$$
$$L + I + V + I + D = 557$$
$$C + I + V + I + C = 207$$

What is $V + I + M = ?$

1. Cannot be found
2. 1009
3. 1006
4. 509

Q16. [Dec 2015] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2015 Dec	2 M

A living cell has a protoplasm which is water based and demarcated by a lipid bilayer membrane. If a cell is pierced up to $\frac{1}{5}$ th of its diameter with a very sharp needle, after taking the needle out

1. no effect will be observed.
2. protoplasm will leak out from the hole made by the needle for a few minutes until the cell heals the wound.
3. protoplasm will keep on leaking out till the cell is dead.
4. the cell will burst like a balloon.

Q17. [Dec 2015] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2015 Dec	2 M

Density of a rice grain is $1.5 g/cc$ and bulk density of rice heap is $0.80 g/cc$. If a 1 litre container is completely filled with rice, what will be the approximate volume of pore space in the container?

1. $350 cc$
2. $465 cc$
3. $550 cc$
4. $665 cc$

Q18. [Dec 2015] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2015 Dec	2 M

A turtle starts swimming from a point A located on the circumference of a circular pond. After swimming for 4 meters in a straight line it hits point B on the circumference or the pond. From there it changes direction and swims for 3 meters in a straight line and arrives at point D diametrically opposite to point A. How far is point D from A ?

1. $3m$
2. $4m$
3. $7m$
4. $5m$

Q19. [Dec 2015] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2015 Dec	2 M

Four circles of unit radius each are drawn such that each one touches two others and their centres lie on the vertices of a square. The area of the region enclosed between the circles is

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

Q20. [Dec 2015] . 2.0 marks

General Aptitude > Basic Physics

CSIR NET	2015 Dec	2 M

A film projector and microscope give equal magnification. But a film projector is not used to see living cells because

1. a living cell cannot be placed in a film projector.
2. the viewer's eye is close to a microscope whereas it is far away from the projector's screen.
3. a microscope produces a virtual image whereas a projector produces a real image.
4. a microscope has greater resolving power than a projector.

Q21. [Dec 2015] . 3.5 marks

Quantum Mechanics > Scattering theory

CSIR NET	2015 Dec	3.5 M

In the scattering of some elementary particles, the scattering cross-section σ is found to depend on the total energy E and the fundamental constants h (Planck's constant) and c (the speed of light in vacuum). Using dimensional analysis, the dependence of σ on these quantities is given by

1. $\sqrt{\frac{hc}{E}}$
2. $\frac{hc}{E^{3/2}}$
3. $\left(\frac{hc}{E}\right)^2$
4. $\frac{hc}{E}$

Q22. [Dec 2015] . 3.5 marks

Mathematical Physics > Basic Mathematics

CSIR NET	2015 Dec	3.5 M

If $y = \frac{1}{\tanh(x)}$, then x is

1. $ln\left(\frac{y+1}{y-1}\right)$
2. $ln\left(\frac{y-1}{y+1}\right)$
3. $ln\sqrt{\frac{y-1}{y+1}}$
4. $\ln\sqrt{\frac{y+1}{y-1}}$

Q23. [Dec 2015] . 3.5 marks

Mathematical Physics > Complex analysis

CSIR NET	2015 Dec	3.5 M

The function $\frac{Z}{\sin \pi Z^2}$ of a complex variable Z has

1. a simple pole at 0 and poles of order 2 at $\pm\sqrt{n}$ for $n = 1,2,3 \ldots$
2. a simple pole at 0 and poles of order 2 at $\pm\sqrt{n}$ and $\pm i\sqrt{n}$ for $n = 1,2,3 \ldots$
3. poles of order 2 at $\pm\sqrt{n}, n = 0,1,2,3 \ldots$
4. poles of order 2 at $\pm n, n = 0,1,2,3 \ldots$

Q24. [Dec 2015] . 3.5 marks

Mathematical Physics > Fourier Transform

CSIR NET	2015 Dec	3.5 M

The Fourier transform of $f(x)$ is $\tilde{f}(k) = \int_{-\infty}^{+\infty} dx e^{ikx} f(x)$.

If $f(x) = \alpha\delta(x) + \beta\delta'(x) + \gamma\delta''(x)$, where $\delta(x)$ is the Dirac delta-function (and prime denotes derivative), what is $\tilde{f}(k)$?

1. $\alpha + i\beta k + i\gamma k^2$
2. $\alpha + \beta k - \gamma k^2$
3. $\alpha - i\beta k - \gamma k^2$
4. $i\alpha + \beta k - i\gamma k^2$

Q25. [Dec 2015] . 3.5 marks

Mathematical Physics > Ordinary Differential Equations

CSIR NET	2015 Dec	3.5 M

The solution of the differential equation $\frac{dx}{dt} = 2\sqrt{1-x^2}$, with initial condition $x = 0$ at $t = 0$ is

1. $x = \begin{cases} \sin 2t, & 0 \le t < \frac{\pi}{4} \\ \sinh 2t, & t \ge \frac{\pi}{4} \end{cases}$

2. $x = \begin{cases} \sin 2t, & 0 \le t < \frac{\pi}{2} \\ 1, & t \ge \frac{\pi}{2} \end{cases}$

3. $x = \begin{cases} \sin 2t, & 0 \le t < \frac{\pi}{4} \\ 1, & t \ge \frac{\pi}{4} \end{cases}$

4. $x = 1 - \cos 2t, t \ge 0$

Q26. [Dec 2015] . 3.5 marks

Classical Mechanics > Central forces

CSIR NET	2015 Dec	3.5 M

A particle moves in three dimensional space in a central potential $V(r) = kr^4$ where k is a constant. The angular frequency ω for a circular orbit depends on it radius R as

1. $\omega \propto R$
2. $\omega \propto R^{-1}$
3. $\omega \propto R^{1/4}$
4. $\omega \propto R^{-2/3}$

Q27. [Dec 2015] . 3.5 marks

Classical Mechanics > Rotation Motion

CSIR NET	2015 Dec	3.5 M

Two masses m each, are placed at the points $(x, y) = (a, a)$ and $(-a, -a)$ and two masses, $2m$ each, are placed at the points $(a, -a)$ and $(-a, a)$. The principal moments of inertia of the system are

1. $2m^2, 4ma^2$
2. $4ma^2, 8ma^2$
3. $4ma^2, 4ma^2$
4. $8ma^2, 8ma^2$

Q28. [Dec 2015] . 3.5 marks

Classical Mechanics > Oscillations

CSIR NET	2015 Dec	3.5 M

The Lagrangian of a system is given by

$$L = \frac{1}{2}m\dot{q}_1^2 + 2m\dot{q}_2^2 - k\left(\frac{5}{4}q_1^2 + 2q_2^2 - 2q_1q_2\right)$$

where m and k are positive constants. The frequencies of its normal modes are

1. $\sqrt{\frac{k}{2m}}, \sqrt{\frac{3k}{m}}$
2. $\sqrt{\frac{k}{2m}}\left(13 \pm \sqrt{73}\right)$
3. $\sqrt{\frac{5k}{2m}}, \sqrt{\frac{k}{m}}$
4. $\sqrt{\frac{k}{2m}}, \sqrt{\frac{6k}{m}}$

Q29. [Dec 2015] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2015 Dec	3.5 M

Consider a particle of mass m moving with a speed v. If T_R denotes the relativistic kinetic energy and T_N its non-relativistic approximation, then the value of $\frac{(T_R - T_N)}{T_R}$ for $v = 0.01c$, is

1. 1.25×10^{-5}
2. 5.0×10^{-5}
3. 7.5×10^{-5}
4. 1.0×10^{-4}

Q30. [Dec 2015] . 3.5 marks

Electromagnetism > Electrostatics

CSIR NET	2015 Dec	3.5 M

A hollow metallic sphere of radius a, which is kept at a potential V_0 has a charge Q at its centre.
The potential at a point outside the sphere, at a distance r from the centre, is

1. V_0
2. $\frac{Q}{4\pi\epsilon_0 r} + \frac{V_0 a}{r}$
3. $\frac{Q}{4\pi\epsilon_0 r} + \frac{V_0 a^2}{r^2}$
4. $\frac{V_0 a}{r}$

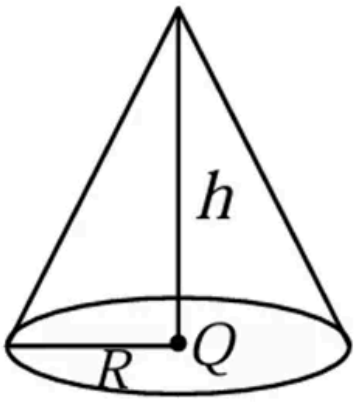
Q31. [Dec 2015] . 3.5 marks

Electromagnetism > Electrostatics

CSIR NET	2015 Dec	3.5 M

Consider a charge Q at the origin of 3 - dimensional coordinate system. The flux of the electric field through the curved surface of a cone that has a height h and a circular base of radius R (as shown in the figure) is

1. $\frac{Q}{\epsilon_0}$
2. $\frac{Q}{2\epsilon_0}$
3. $\frac{hQ}{R\epsilon_0}$
4. $\frac{QR}{2h\epsilon_0}$



Q32. [Dec 2015] . 3.5 marks

Electromagnetism > Potential Formulation

CSIR NET	2015 Dec	3.5 M

Given a uniform magnetic field $B = B_0\hat{k}$ (where B_0 is a constant), a possible choice for the magnetic vector potential A is

1. $B_0 y\hat{i}$
2. $-B_0 y\hat{i}$
3. $B_0(x\hat{j} + y\hat{i})$
4. $B_0(x\hat{i} + y\hat{j})$

Q33. [Dec 2015] . 3.5 marks

Optics > Polarization

CSIR NET	2015 Dec	3.5 M

A beam of unpolarized light in a medium with dielectric constant ϵ_1 is reflected from a plane interface formed with another medium of dielectric constant $\epsilon_2 = 3\epsilon_1$. The two media have identical magnetic permeability. If the angle of incidence is 60°, then the reflected light

1. is plane polarized perpendicular to the plane of incidence
2. is plane polarized parallel to the plane of incidence
3. is circularly polarized
4. has the same polarization as the incident light

Q34. [Dec 2015] . 3.5 marks

Quantum Mechanics > Basic Quantum Mechanics

CSIR NET	2015 Dec	3.5 M

A Hermitian operator $\bar{O}$ has two normalized eigenstates $|1\rangle$ and $|2\rangle$ with eigenvalues 1 and 2 , respectively. The two states

$|u\rangle = \cos\theta|1\rangle + \sin\theta|2\rangle$ and $|v\rangle = \cos\phi|1\rangle + \sin\phi|2\rangle$ are such that $\langle v|\hat{O}|v\rangle = 7/4$ and $\langle u \mid v\rangle = 0$. Which of the following are possible values of θ and ϕ ?

1. $\theta = -\frac{\pi}{6}$ and $\phi = \frac{\pi}{3}$
2. $\theta = \frac{\pi}{6}$ and $\phi = \frac{\pi}{3}$
3. $\theta = -\frac{\pi}{4}$ and $\phi = \frac{\pi}{4}$
4. $\theta = \frac{\pi}{3}$ and $\phi = -\frac{\pi}{6}$

Q35. [Dec 2015] . 3.5 marks

Quantum Mechanics > Variational Principle

CSIR NET	2015 Dec	3.5 M

The ground state energy of a particle of mass m in the potential $V(x) = V_0 \cosh\left(\frac{x}{L}\right)$, where L and V_0 are constants (with $V_0 \gg \frac{\hbar^2}{2ml^2}$) is approximately

1. $V_0 + \frac{\hbar}{L}\sqrt{\frac{2V_0}{m}}$
2. $V_0 + \frac{\hbar}{L}\sqrt{\frac{V_0}{m}}$
3. $V_0 + \frac{\hbar}{4L}\sqrt{\frac{V_0}{m}}$
4. $V_0 + \frac{\hbar}{2L}\sqrt{\frac{V_0}{m}}$

Q36. [Dec 2015] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2015 Dec	3.5 M

Let ψ_{nlm} denote the eigenstates of a hydrogen atom in the usual notation. The state

$$\frac{1}{5}[2\psi_{200} - 3\psi_{211} + \sqrt{7}\psi_{210} - \sqrt{5}\psi_{21-1}]$$

is an eigenstate of

1. L^2, but not of the Hamiltonian or L_z
2. the Hamiltonian, but not of L^2 or L_z
3. the Hamiltonian, L^2 and L_z
4. L^2 and L_z, but not of the Hamiltonian

Q37. [Dec 2015] . 3.5 marks

Quantum Mechanics > Spin Angular momentum

CSIR NET	2015 Dec	3.5 M

The Hamiltonian for a spin-$\frac{1}{2}$ particle at rest is given by $H = E_0(\sigma_z + \alpha\sigma_x)$, where σ_x and σ_z are Pauli spin matrices and E_0 and α are constants. The eigenvalues of this Hamiltonian are

1. $\pm E_0\sqrt{1+\alpha^2}$
2. $\pm E_0\sqrt{1-\alpha^2}$
3. E_0 (doubly degenerate)
4. $E_0\left(1 \pm \frac{1}{2}\alpha^2\right)$

Q38. [Dec 2015] . 3.5 marks

Thermodynamics > Carnot Cycle

CSIR NET	2015 Dec	3.5 M

The heat capacity of (the interior of a refrigerator is $4.2kJ/K$. The minimum' work that must be done to lower the internal temperature from $18^{\circ}C$ to $17^{\circ}C$ when the outside temperature is $27^{\circ}C$ will be

1. 2.20 kJ
2. 0.80 kJ
3. 0.30 kJ
4. 0.14 kJ

Q39. [Dec 2015] . 3.5 marks

Statistical Mechanics > Canonical Ensemble

CSIR NET	2015 Dec	3.5 M

For a system of independent non interacting one-dimensional oscillators, the value of the free energy per oscillator, in the limit $T \rightarrow 0$, is

1. $\frac{1}{2}\hbar\omega$
2. $\hbar\omega$
3. $\frac{3}{2}\hbar\omega$
4. 0

Q40. [Dec 2015] . 3.5 marks

Statistical Mechanics > Ising model

CSIR NET	2015 Dec	3.5 M

The partition function of a system of N Ising spins is $Z = \lambda_1^N + \lambda_2^N$ where λ_1 and λ_2 are functions of temperature, but are independent of N. If $\lambda_1 > \lambda_2$, the free energy per spin in the limit $N \to \infty$ is

1. $-k_B T \ln\left(\frac{\lambda_1}{\lambda_2}\right)$
2. $-k_B T \ln \lambda_2$
3. $-k_B T \ln(\lambda_1 \lambda_2)$
4. $-k_B T \ln \lambda_1$

Q41. [Dec 2015] . 3.5 marks

Statistical Mechanics > Canonical Ensemble

CSIR NET	2015 Dec	3.5 M

The Hamiltonian of a system of N non interacting spin $-\frac{1}{2}$ particles is $H = -\mu_0 B \sum_i S_i^z$, where $S_i^z = \pm 1$ are components of i^{th} spin along an external magnetic field B. At a temperature T such that $e^{\frac{\mu_0 B}{k_B T}} = 2$. the specific heat per particle is

1. $\frac{16}{25} k_B$
2. $\frac{8}{25} k_B ln\, 2$
3. $k_B (ln\, 2)^2$
4. $\frac{16}{25} k_B (\ln 2)^2$

Q42. [Dec 2015] . 3.5 marks

Electronics > Diodes

CSIR NET	2015 Dec	3.5 M

If the reverse bias voltage of a silicon varactor is increased by a factor of 2 , the corresponding transition capacitance

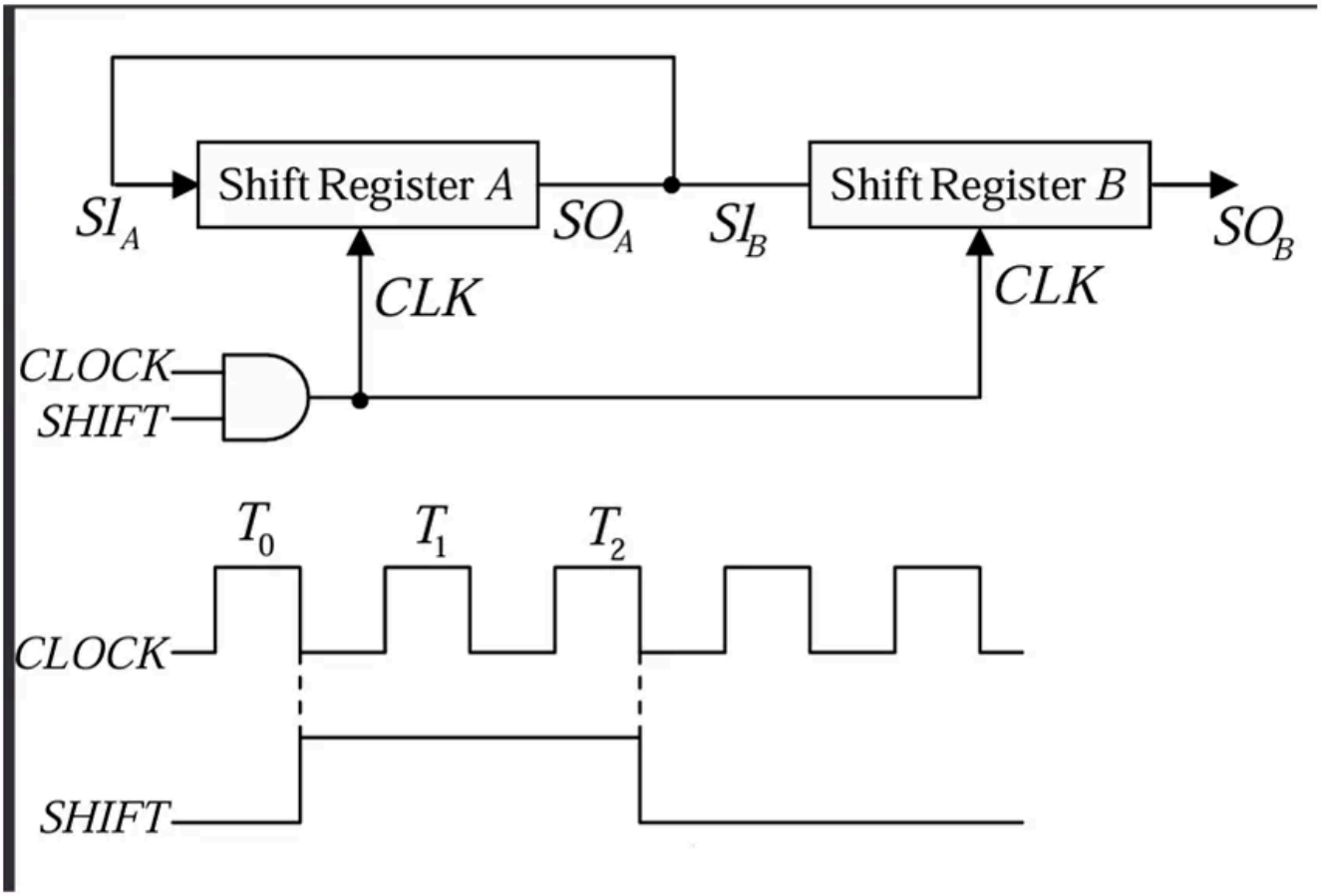
1. increases by a factor of $\sqrt{2}$
2. increase by a factor of 2
3. decreases h a factor of $\sqrt{2}$
4. decreases by a factor of 2

Q43. [Dec 2015] . 3.5 marks

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

CSIR NET	2015 Dec	3.5 M

In the schematic figure given below the initial values of 4 bit shift registers A and B are 1011 and 0010 respectively The values at SO_A. and SO_B after the pulse T_2 are respectively.



1. 1110 and 1001
2. 1101 and 1001
3. 1101 and 1100
4. 1110 and 1100

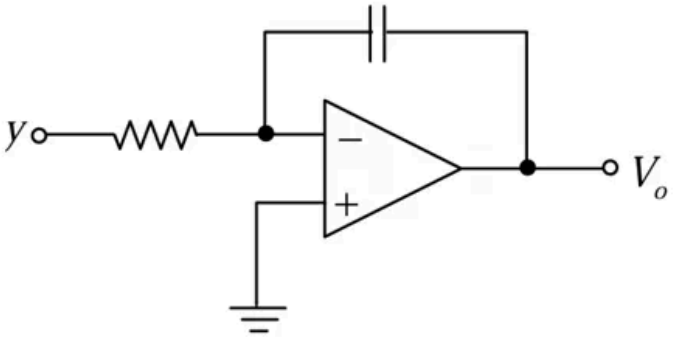
Q44. [Dec 2015] . 3.5 marks

Electronics > OPAMP

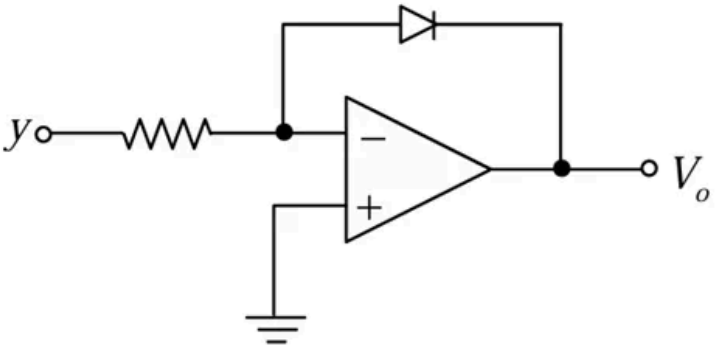
CSIR NET	2015 Dec	3.5 M

If the parameters y and x are related by $y = \log(x)$, then the circuit that can be used to produce an output voltage V_0 varying linearly with x is

1.



2.



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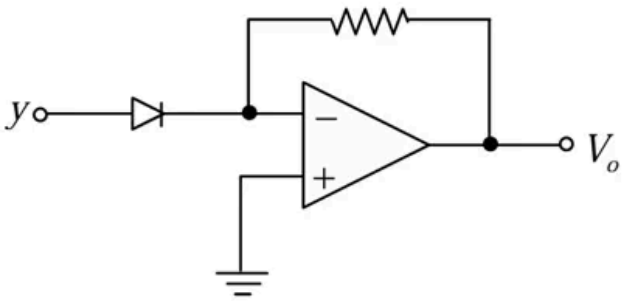
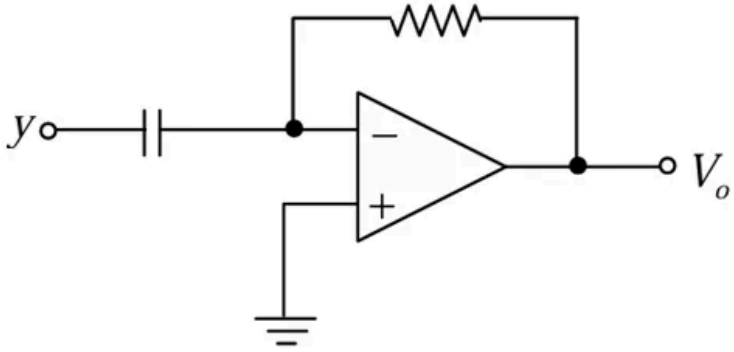


4.



Q45. [Dec 2015] . 3.5 marks

Electronics > "Errors , curve fitting and data analysis"

CSIR NET	2015 Dec	3.5 M

Two data sets A and B consist of 60 and 10 readings of a voltage measured using voltmeters of resolution of $1mV$ and $0.5mV$ respectively. The uncertainty in the mean voltage obtained from the data sets A and B are U_A and U_B, respectively. If the uncertainty of the mean of the combined data sets is U_{AB} then which of the following statements is correct?

1. $U_{AB} < U_A$ and $U_{AB} > U_B$
2. $U_{AB} < U_A$ and $U_{AB} < U_B$
3. $U_{AB} > U_A$ and $U_{AB} < U_B$
4. $U_{AB} > U_A$ and $U_{AB} > U_B$

Q46. [Dec 2015] . 5.0 marks

Mathematical Physics > Special Functions

CSIR NET	2015 Dec	5 M

The Hermite polynomial $H_n(x)$ satisfies the differential equation $\frac{d^2H_n}{dx^2} - 2x\frac{dH_n}{dx} + 2nH_n(x) = 0$

The corresponding generating function $G(t,x) = \sum_{n=0}^{\infty} \frac{1}{n!} H_n(x)t^n$ satisfies the equation

1. $\frac{\partial^2 G}{\partial x^2} - 2x\frac{\partial G}{\partial x} + 2t\frac{\partial G}{\partial t} = 0$
2. $\frac{\partial^2 G}{\partial x^2} - 2x\frac{\partial G}{\partial x} - 2t^2\frac{\partial G}{\partial t} = 0$
3. $\frac{\partial^2 G}{\partial x^2} - 2x\frac{\partial G}{\partial x} + 2\frac{\partial G}{\partial t} = 0$
4. $\frac{\partial^2 G}{\partial x^2} - 2x\frac{\partial G}{\partial x} + 2\frac{\partial^2 G}{\partial x \partial t} = 0$

Q47. [Dec 2015] . 5.0 marks

Mathematical Physics > Fourier Transform

CSIR NET	2015 Dec	5 M

A function $f(x)$ satisfies the differential equation

$$\frac{d^2f}{dx^2} - \omega^2 f = -\delta(x-a)$$

where ω is positive. The Fourier transform $\tilde{f}(k) = f\int_{-\infty}^{+\infty} dx e^{ikx} f(x)$ of f, and the solution of the equation are, respectively,

1. $\frac{e^{ika}}{k^2+\omega^2}$ and $\frac{1}{2\omega}\left(e^{-\omega|x-a|} + e^{\omega|x-a|}\right)$

2. $\frac{e^{ika}}{k^2+\omega^2}$ and $\frac{1}{2\omega} e^{-\omega|x-a|}$

3. $\frac{e^{ika}}{k^2-\omega^2}$ and $\frac{1}{2\omega}\left(e^{-i\omega|x-a|} + e^{i\omega|x-a|}\right)$

4. $\frac{e^{ika}}{k^2-\omega^2}$ and $\frac{1}{2i\omega}\left(e^{-\omega|x-a|} - e^{i\omega|x-a|}\right)$

Q48. [Dec 2015] . 5.0 marks

Classical Mechanics > Oscillations

CSIR NET	2015 Dec	5 M

For a dynamical system governed by the equation $\frac{dx}{dt} = 2\sqrt{1-x^2}$, with $|x| \leq 1$

1. $x = -1$ and $x = 1$ are both unstable fixed points
2. $x = -1$ and $x = 1$ are both stable fixed points
3. $x = -1$ is an unstable fixed point and $x = 1$ is a stable fixed points
4. $x = -1$ is a stable fixed point and $x = 1$ is a unstable fixed points

Q49. [Dec 2015] . 5.0 marks

Mathematical Physics > Numerical Methods

CSIR NET	2015 Dec	5 M

The value of the integral $\int_0^8 \frac{1}{x^2+5} dx$, valuated using Simpson's $\frac{1}{3}$ rule with $h = 2$ is

1. 0.565
2. 0.620
3. 0.698
4. 0.736

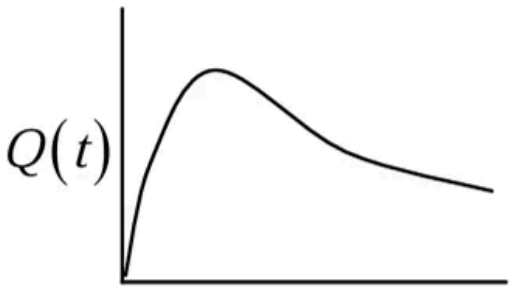
Q50. [Dec 2015] . 5.0 marks

Classical Mechanics > Canonical transformations

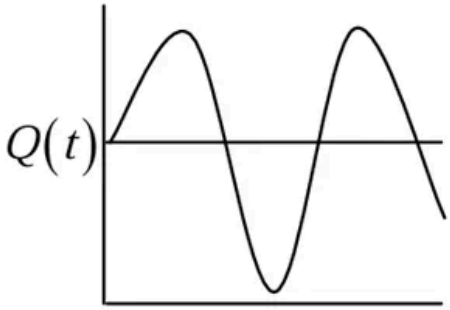
CSIR NET	2015 Dec	5 M

A canonical transformation $(p, q) \rightarrow (P, Q)$ is performed on the Hamiltonian $H = \frac{1}{2mp^2} + \frac{1}{2}m\omega^2 q^2$ via the generating function $F = \frac{1}{2}m\omega q^2 \cot Q$. If $Q(0) = 0$, which of the following graphs shows schematically the dependence of $Q(t)$ on t ?

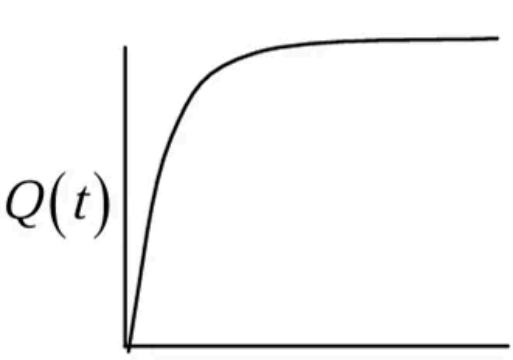
1.



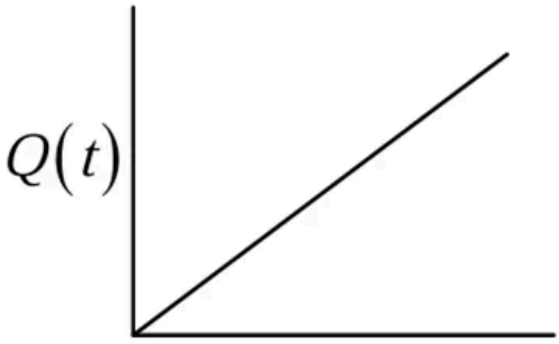
2.



3.



4.



Q51. [Dec 2015] . 5.0 marks

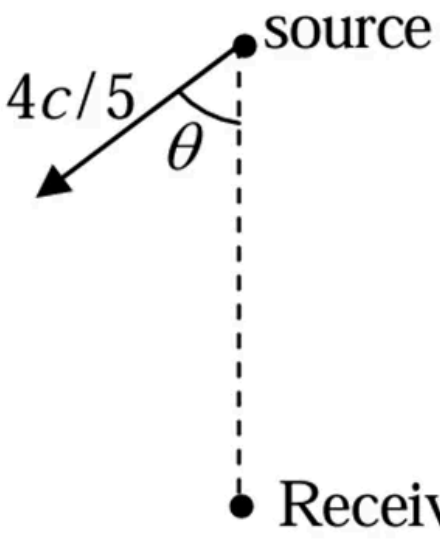
Classical Mechanics > Special theory of relativity

CSIR NET	2015 Dec	5 M

A distant source, emitting radiation of frequency ω moves with a velocity $\frac{4c}{5}$ in a certain direction with respect to a receiver (as shown in the figure). The upper cut-off frequency of the receiver is $\frac{3\omega}{2}$. Let θ the angle as shown. For the receiver to detect the radiation, θ should at least be

Receiver

1. $\cos^{-1}\left(\frac{1}{2}\right)$
2. $\cos^{-1}\left(\frac{3}{4}\right)$
3. $\cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$
4. $\cos^{-1}\left(\sqrt{\frac{2}{3}}\right)$



Q52. [Dec 2015] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2015 Dec	5 M

The Lagrangian of a particle moving in a plane s given in Cartesian coordinates as

$$L = \dot{x}\dot{y} - x^2 - y^2$$

In polar coordinates the expression for the canonical momentum p_r (conjugate to the radial coordinate r) is

1. $\dot{r}sin\,\theta + r\dot{\theta}cos\,\theta$
2. $\dot{r}cos\,\theta + r\dot{\theta}sin\,\theta$
3. $2\dot{r}cos\,\theta - r\dot{\theta}sin\,2\,\theta$
4. $\dot{r}\sin 2\theta + r\dot{\theta}\cos 2\theta$

Q53. [Dec 2015] . 5.0 marks

Electromagnetism > Magetostatics

CSIR NET	2015 Dec	5 M

A small magnetic needle is kept at $(0,0)$ with its moment along the x-axis. Another small magnetic needle is at the point $(1,1)$ and is free to rotate in the xy - plane. In equilibrium the angle θ between their magnetic moments is such that

1. $tan\,\theta = \frac{1}{3}$
2. $tan\,\theta = 0$
3. $tan\,\theta = 3$
4. $\tan\theta = 1$

Q54. [Dec 2015] . 5.0 marks

Electromagnetism > Radiations

CSIR NET	2015 Dec	5 M

A dipole of moment $\vec{p}$, oscillating at frequency ω, radiates spherical waves. The vector potential at large distance is

$$\vec{A}(\vec{r}) = \frac{\mu_0}{4\pi} i\omega \frac{e^{ikr}}{r} \vec{p}$$

To order $\left(\frac{1}{r}\right)$ the magnetic field $\vec{B}$ at a point $\vec{r} = r\hat{n}$ is

1. $-\frac{\mu_0}{4\pi}\frac{\omega^2}{C}(\hat{n}\cdot\vec{p})\hat{n}\frac{e^{ikr}}{r}$
2. $-\frac{\mu_0}{4\pi}\frac{\omega^2}{C}(\hat{n}\times\vec{p})\frac{e^{ikr}}{r}$
3. $-\frac{\mu_0}{4\pi}\omega^2 k(\hat{n}\cdot\vec{p})\vec{p}\frac{e^{ikr}}{r}$
4. $-\frac{\pi_0}{4\pi}\frac{\omega^2}{C}\vec{p}\frac{e^{ikr}}{r}$

Q55. [Dec 2015] . 5.0 marks

Electromagnetism > Plasma

CSIR NET	2015 Dec	5 M

The frequency dependent dielectric constant of a material is given by

$$\varepsilon(\omega) = 1 + \frac{A}{\omega_0^2 - \omega^2 - i\omega\gamma}$$

where A is a positive constant, ω_0 the resonant frequency and γ the damping coefficient. For an electromagnetic wave of angular frequency $\omega \ll \omega_0$ which of the following is true? (Assume that $\frac{\gamma}{\omega_0} \ll 1$).

1. There is negligible absorption of the wave
2. The wave propagation is highly dispersive
3. There is strong absorption of the electromagnetic wave
4. The group velocity and the phase velocity will have opposite sign

Q56. [Dec 2015] . 5.0 marks

Quantum Mechanics > Pertubation theory

CSIR NET	2015 Dec	5 M

A hydrogen atom is subjected to the perturbation

$$V_{\text{pert}}(r) = \epsilon \cos\frac{2r}{a_0}$$

where a_0 is the Bohr radius. The change in the ground state energy to first order in ϵ

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

Q57. [Dec 2015] . 5.0 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2015 Dec	5 M

A positron is suddenly absorbed by the nucleus of a tritium (${}^{3}_{1}H$) atom to turn the latter into a He^{+}ion. If the electron in the tritium atom was initially in the ground state, the probability that the resulting He^{+}ion will be in its ground state is

1. 1
2. $\frac{8}{9}$
3. $\frac{128}{243}$
4. $\frac{512}{729}$

Q58. [Dec 2015] . 5.0 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2015 Dec	5 M

The product of the uncertainties $(\Delta L_x)(\Delta L_y)$ for a particle in the state $a|1,1\rangle + b|1,-1\rangle$ where $|l,m\rangle$ denotes an eigenstate of L^2 and L_z will be a minimum for

1. $a = \pm ib$
2. $a = 0$ and $b = 1$
3. $a = \frac{\sqrt{3}}{2}$ and $b = \frac{1}{2}$
4. $a = \pm b$

Q59. [Dec 2015] . 5.0 marks

Quantum Mechanics > Variational Principle

CSIR NET	2015 Dec	5 M

The ground state energy of a particle in potential $V(x) = g|x|$, estimated using the trail wavefunction

$$\psi(x) = \begin{cases} \sqrt{\frac{c}{a^5}}(a^2 - x^2), & x < |a| \\ 0, & x \geq |a| \end{cases}$$

(where g and c are constants) is

1. $\frac{15}{16}\left(\frac{\hbar^2 g^2}{m}\right)^{1/3}$
2. $\frac{5}{6}\left(\frac{\hbar^2 g^2}{m}\right)^{1/3}$
3. $\frac{3}{4}\left(\frac{\hbar^2 g^2}{m}\right)^{1/3}$
4. $\frac{7}{8}\left(\frac{\hbar^2 g^2}{m}\right)^{1/3}$

Q60. [Dec 2015] . 5.0 marks

Statistical Mechanics > Canonical Ensemble

CSIR NET	2015 Dec	5 M

An ensemble of non-interacting spin $-\frac{1}{2}$ particles is in contact with a heat bath at temperature T and is subjected to an external magnetic field. Each particle can be in one of the two quantum states of energies $\pm\epsilon_0$. If the mean energy per particle is $-\epsilon_0/2$, then the free energy per particle is

1. $-2\,\epsilon_0\,\frac{\ln(4/\sqrt{3})}{\ln 3}$

2. $-\epsilon_0\,ln(3/2)$

3. $-2\,\epsilon_0\,ln\,2$

4. $-\epsilon_0\,\frac{\ln 2}{\ln 3}$

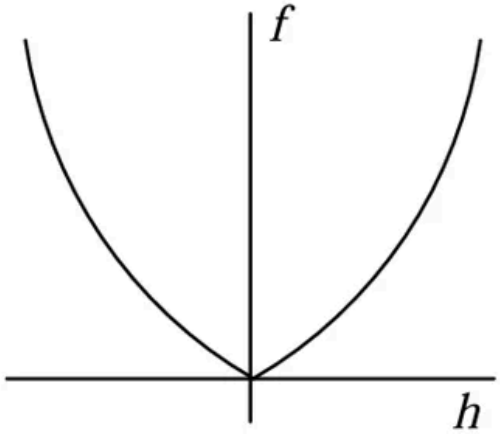
Q61. [Dec 2015] . 5.0 marks

Thermodynamics > Phase transitions

CSIR NET	2015 Dec	5 M

Which of the following graphs shows the qualitative dependence of the free energy $f(h,T)$ of a ferromagnet in an external magnetic field h, and at a fixed temperature $T < T_C$, where T_C is the critical temperature?

1.



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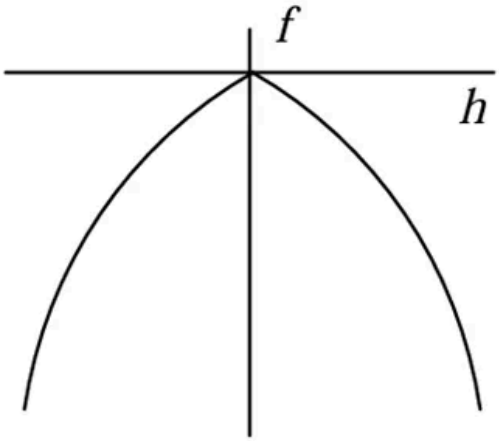

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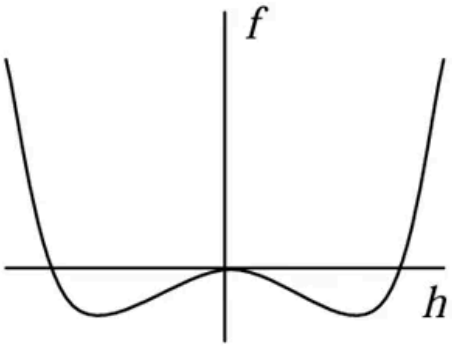
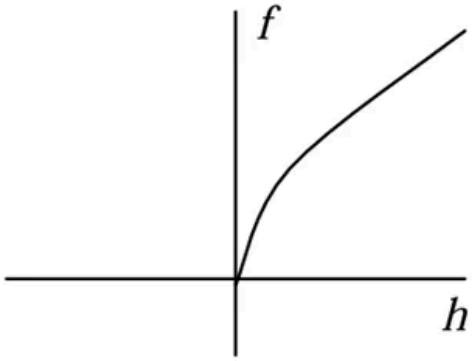


4.



Q62. [Dec 2015] . 5.0 marks

Statistical Mechanics > Random Walk/Brownian motion/Diffusion

CSIR NET	2015 Dec	5 M

Consider a random walker on a square lattice. At each step the walker moves to a nearest neighbour site with equal probability for each of the four sites. The walker starts at the origin and takes 3 steps. The probability that during this walk no site is visited more than one is

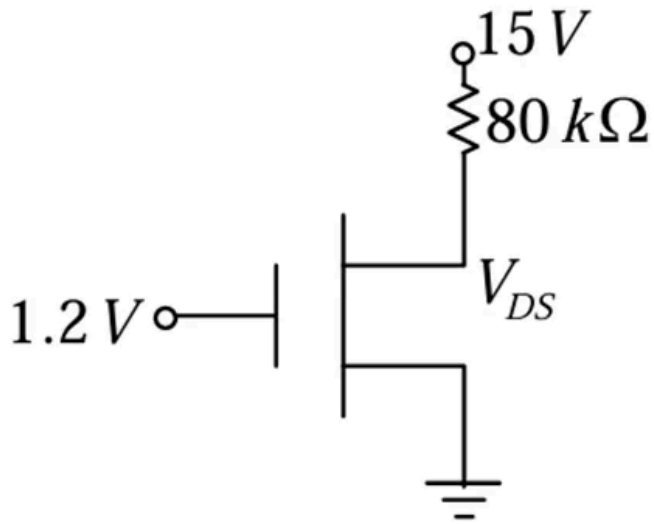
1. $12/27$
2. $27/64$
3. $3/8$
4. $9/16$

Q63. [Dec 2015] . 5.0 marks

Electronics > FET

CSIR NET	2015 Dec	5 M

Consider an n - MOSFET with the following parameters: current drive strength $K = 60\mu A/V^2$, breakdown voltage $BV_{DS} = 10$ V, ratio of effective gate width to the channel length $\frac{W}{L} = 5$ and threshold voltage $V_{\text{th}} = 0.5$ V. In the circuit given below, this n-MOSFET is operating in the



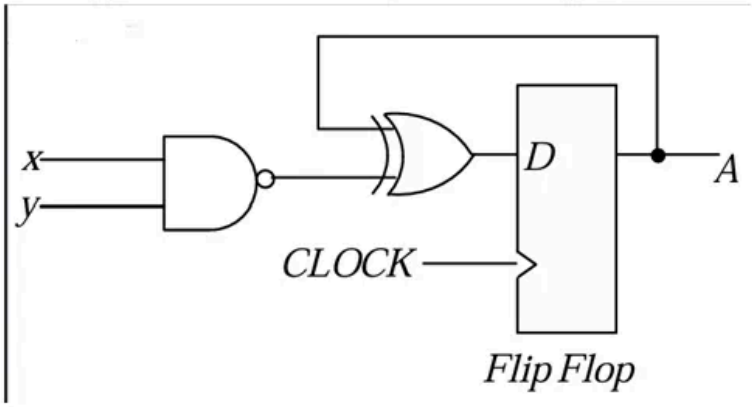
1. ohmic region
2. cut-off region
3. saturation region
4. breakdown

Q64. [Dec 2015] . 5.0 marks

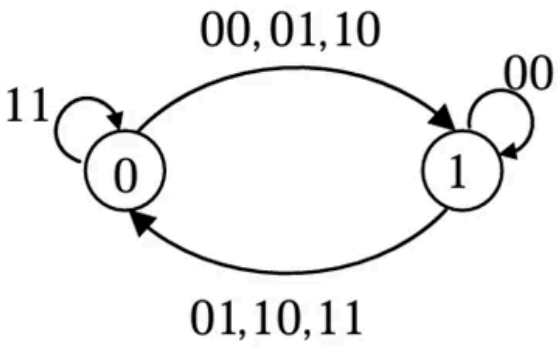
Electronics > Flip flops/Counters/Registers/microcontroller etc.

CSIR NET	2015 Dec	5 M

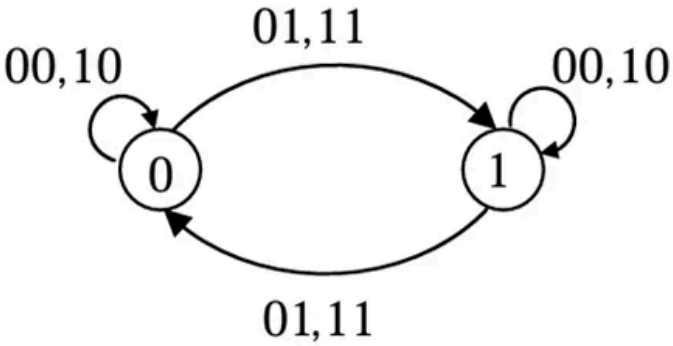
The state diagram corresponding to the following circuit is



1.



2.



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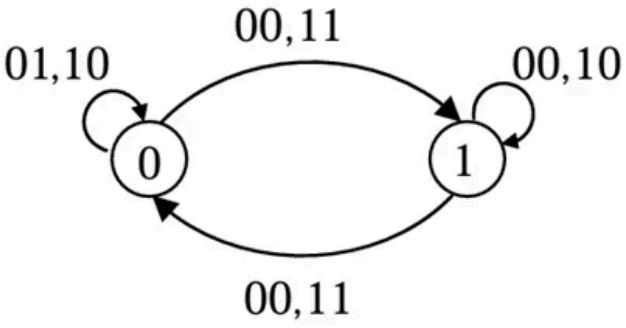
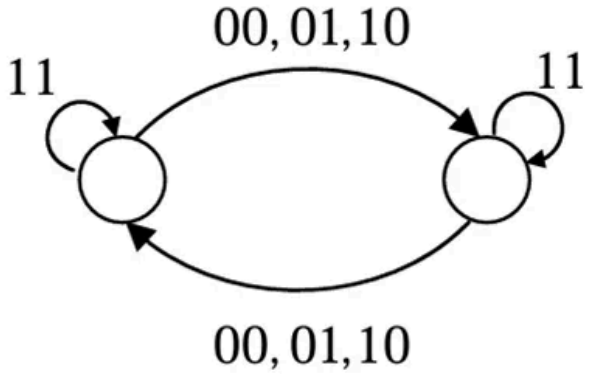


4.

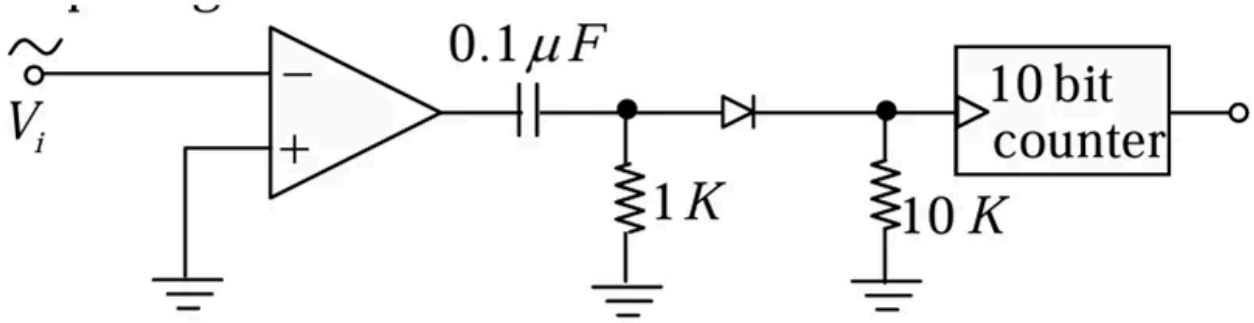


Q65. [Dec 2015] . 5.0 marks

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

CSIR NET	2015 Dec	5 M

A sinusoidal signal of peak to peak amplitude 1 V and unknown time period is input to the following circuit for 5 seconds duration. If the counter measures a value $(3E8)_H$ in hexadecimal then the time period of the input signal is



1. $2.5ms$
2. $4ms$
3. 10 ms
4. $5ms$

Q66. [Dec 2015] . 5.0 marks

Solid State Physics > Xray diffraction

CSIR NET	2015 Dec	5 M

The first order diffraction peak of a crystalline solid occurs at a scattering angle of 30^0 when the diffraction pattern is recorded using an x-ray beam of wavelength $0.15nm$. If the error in measurements of the wavelength and the angle are $0.01nm$ and 1^0 respectively, then the error in calculating the inter-planar spacing will approximately be

1. $1.1 \times 10^{-2}\ nm$
2. $1.3 \times 10^{-4} nm$
3. $2.5 \times 10^{-2} nm$
4. 2.0×10^{-3} nm

Q67. [Dec 2015] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2015 Dec	5 M

The dispersion relation of electrons in a 3 -dimensional lattice in the tight binding approximation is given by,

$$\varepsilon_k = \alpha\cos k_x a + \beta\cos k_y a + \gamma\cos k_z a$$

where a is the lattice constant and α, β, γ are constants with dimension of energy. The effective mass tensor at the corner of the first Brillouin zone $\left(\frac{\pi}{a}, \frac{\pi}{a}, \frac{\pi}{a}\right)$ is

1. $\frac{\hbar^2}{a^2}\begin{pmatrix} -\frac{1}{\alpha} & 0 & 0 \\ 0 & -\frac{1}{\beta} & 0 \\ 0 & 0 & \frac{1}{\gamma} \end{pmatrix}$

2. $\frac{\hbar^2}{a^2}\begin{pmatrix} -\frac{1}{\alpha} & 0 & 0 \\ 0 & -\frac{1}{\beta} & 0 \\ 0 & 0 & -\frac{1}{\gamma} \end{pmatrix}$

3. $\frac{\hbar^2}{a^2}\begin{pmatrix} \frac{1}{\alpha} & 0 & 0 \\ 0 & \frac{1}{\beta} & 0 \\ 0 & 0 & \frac{1}{\gamma} \end{pmatrix}$

4. $\frac{\hbar^2}{a^2}\begin{pmatrix} \frac{1}{\alpha} & 0 & 0 \\ 0 & \frac{1}{\beta} & 0 \\ 0 & 0 & -\frac{1}{\gamma} \end{pmatrix}$

Q68. [Dec 2015] . 5.0 marks

Solid State Physics > Free electron theory

CSIR NET	2015 Dec	5 M

A thin metal film of dimension $2mm \times 2mm$ contains 4×10^{12} electrons. The magnitude of the Fermi wavevector of the system, in the free electron approximation, is

1. $2\sqrt{\pi} \times 10^{7}\ \mathrm{cm}^{-1}$
2. $\sqrt{2\pi} \times 10^{7}\ \mathrm{cm}^{-1}$
3. $\sqrt{\pi} \times 10^{7}\ \mathrm{cm}^{-1}$
4. $2\pi \times 10^{7}\ \mathrm{cm}^{-1}$

Q69. [Dec 2015] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2015 Dec	5 M

For an electron moving through a one-dimensional periodic lattice of periodicity a, which of the following corresponds to an energy eigenfunction consistent with Bloch's theorem?

1. $\psi(x) = A \exp\left(i\left[\frac{\pi X}{a} + cos\left(\frac{\pi X}{2a}\right)\right]\right)$
2. $\psi(x) = A \exp\left(i\left[\frac{\pi x}{a} + cos\left(\frac{2\pi x}{a}\right)\right]\right)$
3. $\psi(x) = A \exp\left(i\left[\frac{2\pi x}{a} + i\cosh\left(\frac{2\pi x}{a}\right)\right]\right)$
4. $\psi(x) = A\exp\left(i\left[\frac{\pi x}{a} + i\left|\frac{\pi x}{2a}\right|\right]\right)$

Q70. [Dec 2015] . 5.0 marks

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

CSIR NET	2015 Dec	5 M

The LS configurations of the ground state of $^{12}\mathrm{Mg}$, $^{13}\mathrm{Al}$, $^{17}\mathrm{Cl}$ and $^{18}\mathrm{Ar}$ are, respectively,

1. $^3S_1$, $^2P_{1/2}$, $^2P_{1/2}$ and $^1S_0$
2. $^3S_1$, $^2P_{3/2}$, $^2P_{3/2}$ and $^3S_1$
3. $^1S_0$, $^2P_{1/2}$, $^2P_{3/2}$ and $^1S_0$
4. $^1S_0$, $^2P_{3/2}$, $^2P_{1/2}$ and $^3S_1$

Q71. [Dec 2015] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2015 Dec	5 M

For a two level system, the population of atoms in the upper and lower levels are 3×10^{18} and , respectively. If the coefficient of stimulated emission is $3.0 \times 10^5\ \mathrm{m}^3/W - s^3$ and the energy density is $9.0\ \mathrm{J}/m^3 - Hz$, the rate of stimulated emission will be

1. $6.3 \times 10^{16}\ \mathrm{s}^{-1}$
2. $4.1 \times 10^{16}\ \mathrm{s}^{-1}$
3. $2.7 \times 10^{16}\ \mathrm{s}^{-1}$
4. $1.8 \times 10^{16}\ \mathrm{s}^{-1}$

Q72. [Dec 2015] . 5.0 marks

Atomic and Molecular Physics > Molecular physics

CSIR NET	2015 Dec	5 M

The first ionization potential of K is 4.34 eV , the electron affinity of CI is 3.82 eV and the equilibrium separation of KCI is $0.3nm$. The required to dissociate

a KCI molecule into a K and a CI atom is

1. 8.62 eV
2. 8.16 eV
3. 4.28 eV
4. 4.14 eV

Q73. [Dec 2015] . 5.0 marks

Nuclear and Particle Physics > Particle physics

CSIR NET	2015 Dec	5 M

Consider the following processes involving free particles

(i) $\bar{n} \rightarrow \bar{p} + e^{+} + \bar{\nu}_e$

(ii) $\bar{p} + n \rightarrow \pi^{-}$

(iii) $p + n \rightarrow \pi^{+} + \pi^{0} + \pi^{0}$

(iv) $p + \bar{\nu}_e \rightarrow n + e^{+}$

Which of the following statements is true?

1. Process (i) obeys all conservation laws
2. Process (ii) conserves baryon number, but violates energy-momentum conservation
3. process (iii) is not allowed by strong interaction but is allowed by weak interactions
4. Process (iv) conserves baryon number, but violates lepton number conservation

Q74. [Dec 2015] . 5.0 marks

Nuclear and Particle Physics > Shell model

CSIR NET	2015 Dec	5 M

The electric quadrupole moment of an odd proton nucleus is $\frac{(2j-1)}{2(j+1)}\langle r^2\rangle$, where j is the total angular momentum. Given that $R_0 = 1.2\text{fm}$, what is the value in barn, of the quadrupole moment of the ^{27}Al nucleus in the shell model?

1. 0.043
2. 0.023
3. 0.915
4. 0

Q75. [Dec 2015] . 5.0 marks

Nuclear and Particle Physics > Liquid drop Model

CSIR NET	2015 Dec	5 M

Of the nuclei of mass number $A = 125$, the binding energy calculated from the liquid drop model (given that the coefficients for the Coulomb and the asymmetry energy are $a_c = 0.7\text{MeV}$ and $a_{sym} = 22.5\text{MeV}$ respectively) is a maximum for

1. $^{125}_{54}\text{Xe}$
2. $^{124}_{53}\text{I}$
3. $^{125}_{52}\text{Te}$
4. $^{125}_{51}\text{Sb}$

Answer Key

75 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	General Aptitude	Reasoning	**4**
Q2	General Aptitude	Reasoning	**2**
Q3	General Aptitude	Mathematical Analysis	**2**
Q4	General Aptitude	Geometry	**2**
Q5	General Aptitude	Basic Physics	**1**
Q6	General Aptitude	Basic Physics	**2**
Q7	General Aptitude	Reasoning	**3**
Q8	General Aptitude	Basic Physics	**3**
Q9	General Aptitude	Geometry	**4**
Q10	General Aptitude	Mathematical Analysis	**2**
Q11	General Aptitude	Geometry	**1**
Q12	General Aptitude	Reasoning	**3**
Q13	General Aptitude	Reasoning	**3**
Q14	General Aptitude	Basic Physics	**2**
Q15	General Aptitude	Mathematical Analysis	**3**
Q16	General Aptitude	Basic Physics	**1**
Q17	General Aptitude	Basic Physics	**2**
Q18	General Aptitude	Basic Physics	**4**
Q19	General Aptitude	Geometry	**4**
Q20	General Aptitude	Basic Physics	**4**
Q21	Quantum Mechanics	Scattering theory	**3**
Q22	Mathematical Physics	Basic Mathematics	**4**
Q23	Mathematical Physics	Complex analysis	**2**
Q24	Mathematical Physics	Fourier Transform	**3**
Q25	Mathematical Physics	Ordinary Differential Equations	**3**
Q26	Classical Mechanics	Central forces	**1**
Q27	Classical Mechanics	Rotation Motion	**2**
Q28	Classical Mechanics	Oscillations	**1**
Q29	Classical Mechanics	Special theory of relativity	**3**
Q30	Electromagnetism	Electrostatics	**4**
Q31	Electromagnetism	Electrostatics	**2**
Q32	Electromagnetism	Potential Formulation	**2**
Q33	Optics	Polarization	**1**
Q34	Quantum Mechanics	Basic Quantum Mechanics	**1**
Q35	Quantum Mechanics	Variational Principle	**4**
Q36	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**2**
Q37	Quantum Mechanics	Spin Angular momentum	**1**
Q38	Thermodynamics	Carnot Cycle	**4**
Q39	Statistical Mechanics	Canonical Ensemble	**1**
Q40	Statistical Mechanics	Ising model	**4**

Answer Key (cont.)

Q. No	Subject	Topic	Answer
Q41	Statistical Mechanics	Canonical Ensemble	**4**
Q42	Electronics	Diodes	**3**
Q43	Electronics	Flip flops/Counters/Registers/microcontroller etc.	**4**
Q44	Electronics	OPAMP	**3**
Q45	Electronics	"Errors , curve fitting and data analysis"	**2**
Q46	Mathematical Physics	Special Functions	**1**
Q47	Mathematical Physics	Fourier Transform	**2**
Q48	Classical Mechanics	Oscillations	**3**
Q49	Mathematical Physics	Numerical Methods	**1**
Q50	Classical Mechanics	Canonical transformations	**4**
Q51	Classical Mechanics	Special theory of relativity	**2**
Q52	Classical Mechanics	Lagrangian and Hamiltonian	**4**
Q53	Electromagnetism	Magetostatics	**3**
Q54	Electromagnetism	Radiations	**2**
Q55	Electromagnetism	Plasma	**1**
Q56	Quantum Mechanics	Pertubation theory	**4**
Q57	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**
Q58	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**4**
Q59	Quantum Mechanics	Variational Principle	**1**
Q60	Statistical Mechanics	Canonical Ensemble	**1**
Q61	Thermodynamics	Phase transitions	**2**
Q62	Statistical Mechanics	Random Walk/Brownian motion/Diffusion	**4**
Q63	Electronics	FET	**3**
Q64	Electronics	Flip flops/Counters/Registers/microcontroller etc.	**4**
Q65	Electronics	Flip flops/Counters/Registers/microcontroller etc.	**4**
Q66	Solid State Physics	Xray diffraction	**1**
Q67	Solid State Physics	Tight binding model	**3**
Q68	Solid State Physics	Free electron theory	**2**
Q69	Solid State Physics	Tight binding model	**2**
Q70	Atomic and Molecular Physics	"LS, JJ and other interactions"	**3**
Q71	Atomic and Molecular Physics	Lasers	**3**
Q72	Atomic and Molecular Physics	Molecular physics	**3**
Q73	Nuclear and Particle Physics	Particle physics	**2**
Q74	Nuclear and Particle Physics	Shell model	**1**
Q75	Nuclear and Particle Physics	Liquid drop Model	**3**

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