PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

CSIR NET Physics - June 2016 - Full Paper

Complete question paper with answer key

75 questions . Answer key included

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Q1. [June 2016] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2016 June	2M

An infinite number of identical circular discs each of radius $\frac{1}{2}$ are tightly packed such that the centres of the discs are at integer values of coordinates x and y. The ratio of the area of the uncovered patches to the total area is

1. $1-\pi/4$

2. $\pi/4$

3. $1-\pi$

4. π

Q2. [June 2016] . 2.0 marks
General Aptitude > Basic Physics

CSIR NET	2016 June	2M

It takes 5 days for a steamboat to travel from A to B along a river. It takes 7 days to return from B to A . How many days will it take for a raft to drift from A to B (all speeds stay constant)?

1. 13
2. 35
3. 6
4. 12

Q3. [June 2016] . 2.0 marks
General Aptitude > Reasoning

CSIR NET	2016 June	2M

"My friend Raju has more than 1000 books", said Ram. "Oh no, he has less than 1000 books", said Shyam. "Well, Raju certainly has at least one book", said Geeta. If only one of these statements is true, how many books does Raju have?

1. 1
2. 1000
3. 999
4. 1001

Q4. [June 2016] . 2.0 marks

General Aptitude > Reasoning

CSIR NET	2016 June	2M

Of the following, which is the odd one out?

1. Cone
2. Torus
3. Sphere
4. Ellipsoid

Q5. [June 2016] . 2.0 marks

General Aptitude > Mathematical Analysis

CSIR NET	2016 June	2M

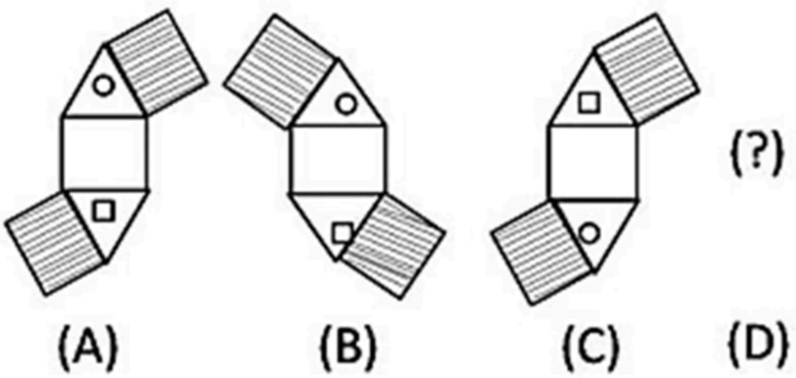
A student appearing for an exam is declared to have failed the exam if his/her score is less than half the median score. This implies

1. 1/4 of the students appearing for the exam always fail.
2. if a student scores less than $1/4$ of the maximum score, he/she always fails.
3. if a student scores more than $1/2$ of the maximum score, he/she always passes.
4. it is possible that no one fails.

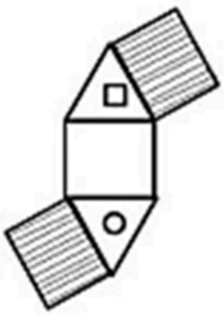
Q6. [June 2016] . 2.0 marks

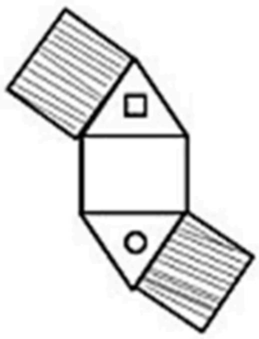
General Aptitude > Reasoning

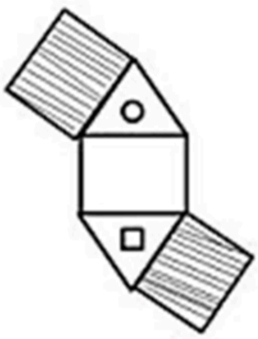
CSIR NET	2016 June	2M

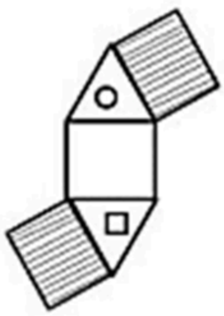


Find the next figure ‘D”

1. 

2. 

3. 

4. 

Q7. [June 2016] . 2.0 marks
General Aptitude > Mathematical Analysis

CSIR NET	2016 June	2M

N is a four digit number. If the leftmost digit is removed, the resulting three digit number is $1/9^{\text{th}}$ of N. How many such N are possible?

1. 10
2. 9
3. 8
4. 7

Q8. [June 2016] . 2.0 marks
General Aptitude > Geometry

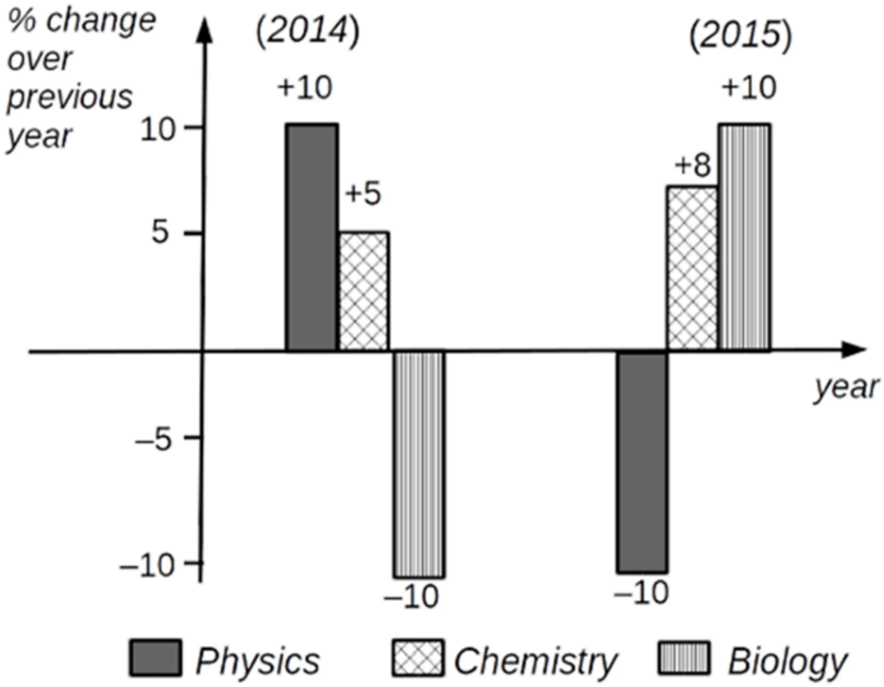
CSIR NET	2016 June	2M

AB and CD are two chords of a circle subtending 60° and 120° respectively at the same point on the circumference of the circle. Then AB: CD is

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

Q9. [June 2016] . 2.0 marks
General Aptitude > Data Analysis

CSIR NET	2016 June	2M



Which of the following inferences can be drawn from the above graph?

1. The total number of students qualifying in Physics in 2015 and 2014 is the same
2. The number of students qualifying in Biology in 2015 is less than that in 2013
3. The number of Chemistry students qualifying in 2015 must be more than the number of students who qualified in Biology in 2014
4. The number of students qualifying in Physics in 2015 is equal to the number of students in Biology that qualified in 2014

Q10. [June 2016] . 2.0 marks
General Aptitude > Reasoning

CSIR NET	2016 June	2M

What is the minimum number of moves required to transform figure 1 to figure 2? A move is defined as removing a coin and placing it such that it touches two other coins in its new position.

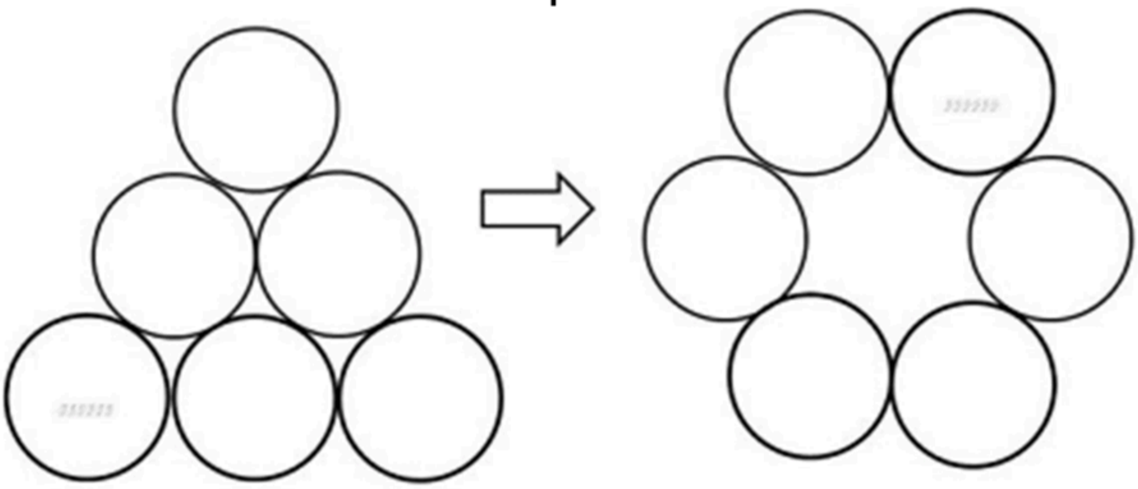


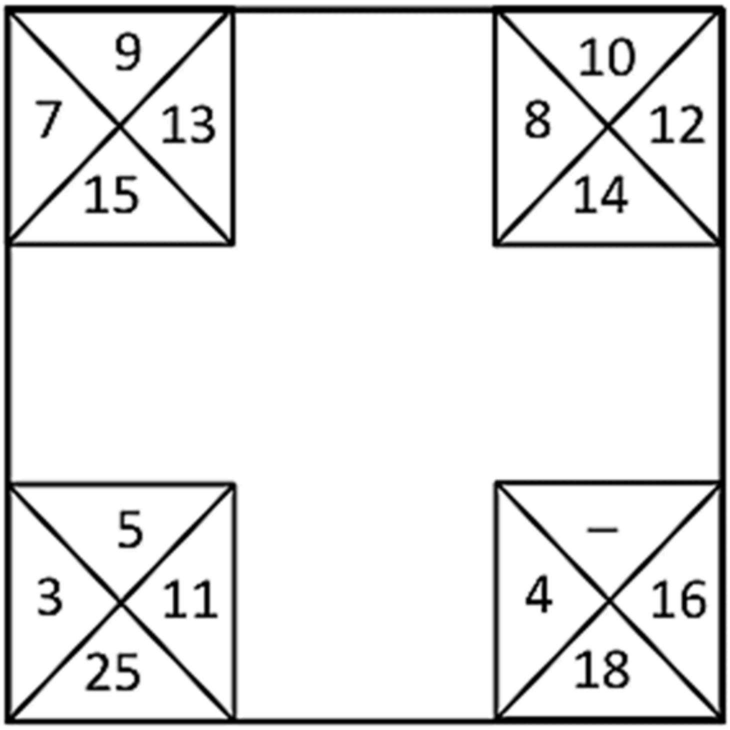
Fig - 1 Fig - 2

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

Q11. [June 2016] . 2.0 marks
General Aptitude > Reasoning

CSIR NET	2016 June	2M

The relationship among the numbers in each corner square is the same as that in the other corner squares. Find the missing number.



1. 10
2. 8
3. 6
4. 12

Q12. [June 2016] . 2.0 marks
General Aptitude > Mathematical Analysis

CSIR NET	2016 June	2M

Which of the following best approximates $\sin(0.5^\circ)$?

1. 0.5
2. $0.5 \times \frac{\pi}{90}$
3. $0.5 \times \frac{\pi}{180}$
4. $0.5 \times \frac{\pi}{360}$

Q13. [June 2016] . 2.0 marks
General Aptitude > Reasoning

CSIR NET	2016 June	2M

What comes next in the sequence?

1. 
2. 
3. 
4. 

Q14. [June 2016] . 2.0 marks
General Aptitude > Reasoning

CSIR NET	2016 June	2M

Which of the following statements is logically incorrect?

1. I always speak the truth
2. I occasionally lie
3. I occasionally speak the truth
4. I always lie

Q15. [June 2016] . 2.0 marks
General Aptitude > Reasoning

CSIR NET	2016 June	2M

How many times starting at 1:00 pm would the minute and hour hands of a clock make an angle of 40° with each other in the next 6 hours?

1. 6
2. 7
3. 11
4. 12

Q16. [June 2016] . 2.0 marks
General Aptitude > Basic Physics

CSIR NET	2016 June	2M

Brothers Santa and Chris walk to school from their house. The former takes 40 minutes while the latter, 30 minutes. One day Santa started 5 minutes earlier than Chris. In how many minutes would Chris overtake Santa?

1. 5
2. 15
3. 20
4. 25

Q17. [June 2016] . 2.0 marks
General Aptitude > Mathematical Analysis

CSIR NET	2016 June	2M

The set of numbers $(5,6,7,m,6,7,8,n)$ has an arithmetic mean of 6 and mode (most frequently occurring number) of 7 . Then $m \times n =$

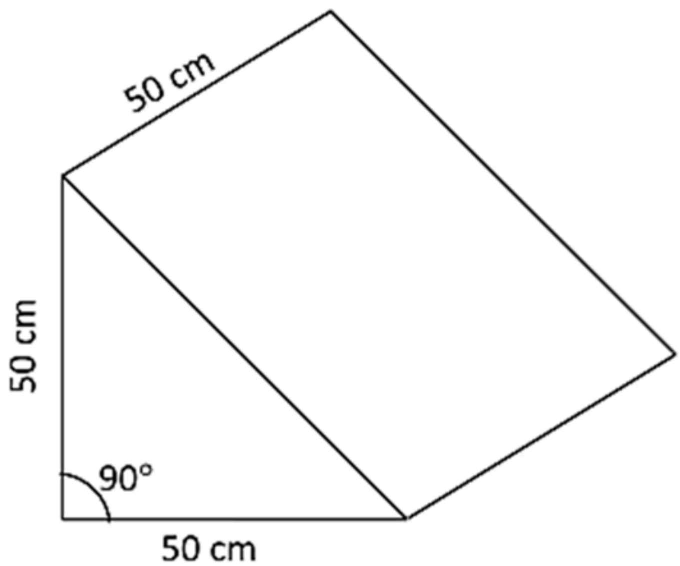
1. 18
2. 35
3. 28
4. 14

Q18. [June 2016] . 2.0 marks

General Aptitude > Geometry

CSIR NET	2016 June	2M

The diagram shows a block of marble having the shape of a triangular prism. What is the maximum number of slabs of $10 \times 10 \times 5\ \mathrm{cm}^3$ size that can be cut parallel to the face on which the block is resting?



1. 50
2. 100
3. 125
4. 250

Q19. [June 2016] . 2.0 marks
General Aptitude > Basic Physics

CSIR NET	2016 June	2M

A solid contains a spherical cavity. The cavity is filled with a liquid and includes a spherical bubble of gas. The radii of cavity and gas bubble are 2 mm and 1 mm , respectively. What proportion of the cavity is filled with liquid?

1. $\frac{1}{8}$
2. $\frac{3}{8}$
3. $\frac{5}{8}$
4. $\frac{7}{8}$

Q20. [June 2016] . 2.0 marks
General Aptitude > Reasoning

CSIR NET	2016 June	2M

Fill in the blank: F2, _____ , D8, C16, B32, A64.

1. C4
2. E4
3. C2
4. G16

Q21. [June 2016] . 3.5 marks

Mathematical Physics > Basic Mathematics

CSIR NET	2016 June	3.5M

The radius of convergence of the Taylor series expansion of the function $\frac{1}{\cosh(x)}$ around $x = 0$, is

1. ∞
2. π
3. $\frac{\pi}{2}$
4. 1

Q22. [June 2016] . 3.5 marks

Mathematical Physics > Complex analysis

CSIR NET	2016 June	3.5M

The value of the contour integral

$$\frac{1}{2\pi i}\oint_C \frac{e^{4z}-1}{\cosh(z)-2\sinh(z)}dz$$

around the unit circle C traversed in the anti-clockwise direction, is

1. 0
2. 2
3. $-8/\sqrt{3}$
4. $-\tanh\left(\frac{1}{2}\right)$

Q23. [June 2016] . 3.5 marks
Mathematical Physics > Fourier Series

CSIR NET	2016 June	3.5M

The Gauss hypergeometric function $F(a,b,c;z)$, defined by the Taylor series expansion around $z=0$ as $F(a,b,c;z) =$

$$\sum_{n=0}^{\infty} \frac{a(a+1)\cdots(a+n-1)b(b+1)\cdots(b+n-1)}{c(c+1)\cdots(c+n-1)n!} z^n,$$

satisfies the recursion relation

1. $\frac{d}{dz}F(a,b,c;z) = \frac{c}{ab}F(a-1,b-1,c-1;z)$
2. $\frac{d}{dz}F(a,b,c;z) = \frac{c}{ab}F(a+1,b+1,c+1;z)$
3. $\frac{d}{dz}F(a,b,c;z) = \frac{ab}{c}F(a-1,b-1,c-1;z)$
4. $\frac{d}{dz}F(a,b,c;z) = \frac{ab}{c}F(a+1,b+1,c+1;z)$

Q24. [June 2016] . 3.5 marks
Mathematical Physics > Probability

CSIR NET	2016 June	3.5M

Let X and Y be two independent random variables, each of which follow a normal distribution with the same standard deviation σ, but with means $+\mu$ and $-\mu$, respectively. Then the sum $X+Y$ follows a

1. distribution with two peaks at $\pm\mu$ and mean 0 and standard deviation $\sigma\sqrt{2}$
2. normal distribution with mean 0 and standard deviation 2σ
3. distribution with two peaks at $\pm\mu$ and mean 0 and standard deviation 2σ
4. normal distribution with mean 0 and standard deviation $\sigma\sqrt{2}$

Q25. [June 2016] . 3.5 marks

Electronics > "Errors , curve fitting and data analysis"

CSIR NET	2016 June	3.5M

Using dimensional analysis, Planck defined a characteristic temperature T_P from powers of the gravitational constant G, Planck's constant h, Boltzmann constant k_B and the speed of light c in vacuum. The expression for T_P is proportional to

1. $\sqrt{\frac{hc^5}{k_B^2 G}}$

2. $\sqrt{\frac{hc^3}{k_B^2 G}}$

3. $\sqrt{\frac{G}{hc^4 k_B^2}}$

4. $\sqrt{\frac{hk_B^2}{Gc^3}}$

Q26. [June 2016] . 3.5 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2016 June	3.5M

Let (x, t) and (x', t') be the coordinate systems used by the observers O and O', respectively. Observer O' moves with a velocity $v = \beta c$ along their common positive x-axis. If $x_+ = x + ct$ and $x_- = x - ct$ are the linear combinations of the coordinates, the Lorentz transformation relating O and O' takes the form

1. $x'_+ = \frac{x_- - \beta x_+}{\sqrt{1-\beta^2}}$ and $x'_- = \frac{x_+ - \beta x_-}{\sqrt{1-\beta^2}}$,

2. $x'_+ = \sqrt{\frac{1+\beta}{1-\beta}}\, x_+$ and $x'_- = \sqrt{\frac{1-\beta}{1+\beta}}\, x_-$

3. $x'_+ = \frac{x_+ - \beta x_-}{\sqrt{1-\beta^2}}$ and $x'_- = \frac{x_- - \beta x_+}{\sqrt{1-\beta^2}}$,

4. $x'_+ = \sqrt{\frac{1-\beta}{1+\beta}}\, x_+$ and $x'_- = \sqrt{\frac{1+\beta}{1-\beta}}\, x_-$

Q27. [June 2016] . 3.5 marks

Classical Mechanics > Basic Mechanics

CSIR NET	2016 June	3.5M

A ball of mass m, initially at rest, is dropped from a height of 5 meters. If the coefficient of restitution is 0.9 , the speed of the ball just before it hits the floor the second time is approximately (take $g = 9.8 \mathrm{~m/s^2}$)

1. $9.80 \mathrm{~m/s}$
2. $9.10 \mathrm{~m/s}$
3. $8.91 \mathrm{~m/s}$
4. $7.02 \mathrm{~m/s}$

Q28. [June 2016] . 3.5 marks
Electromagnetism > Electrostatics

CSIR NET	2016 June	3.5M

Four equal charges of $+Q$ each are kept at the vertices of a square of side R. A particle of mass m and charge $+Q$ is placed in the plane of the square at a short distance $a(\ll R)$ from the centre. If the motion of the particle is confined to the plane, it will undergo small oscillations with an angular frequency

1. $\sqrt{\dfrac{Q^2}{2\pi\epsilon_0 R^3 m}}$

2. $\sqrt{\dfrac{Q^2}{\pi\epsilon_0 R^3 m}}$

3. $\sqrt{\dfrac{\sqrt{2}Q^2}{\pi\epsilon_0 R^3 m}}$

4. $\sqrt{\dfrac{Q^2}{4\pi\epsilon_0 R^3 m}}$

Q29. [June 2016] . 3.5 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2016 June	3.5M

The Hamiltonian of a system with generalized coordinate and momentum (q, p) is $H = p^2 q^2$. A solution of the Hamiltonian equation of motion is (in the following A and B are constants)

1. $p = Be^{-2At}, q = \frac{A}{B} e^{2At}$

2. $p = Ae^{-2At}, q = \frac{A}{B} e^{-2At}$

3. $p = Ae^{At}, q = \frac{A}{B} e^{-At}$

4. $p = 2Ae^{-A^2 t}, q = \frac{A}{B} e^{A^2 t}$

Q30. [June 2016] . 3.5 marks

Electromagnetism > Capacitors

CSIR NET	2016 June	3.5M

Two parallel plate capacitors, separated by distances x and $1.1x$ respectively, have a dielectric material of dielectric constant 3.0 inserted between the plates, and are connected to a battery of voltage V. The difference in charge on the second capacitor compared to the first is

1. +66%
2. $+20\%$
3. -3.3%
4. -10%

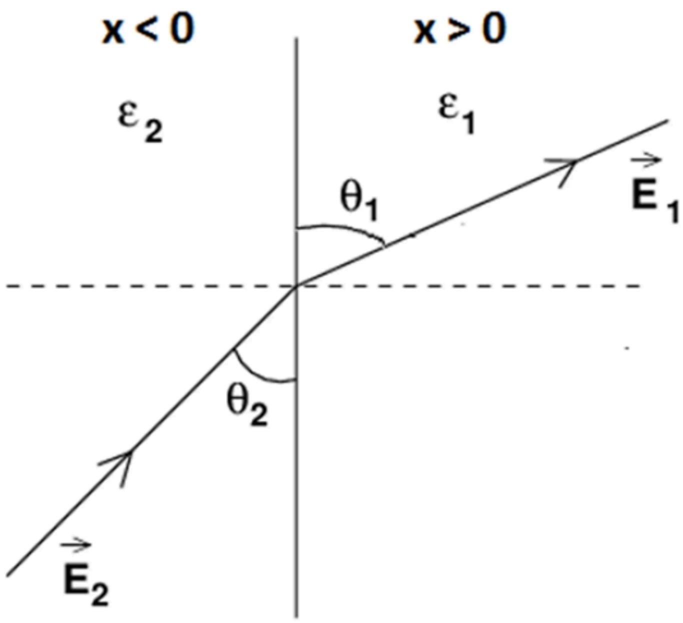
Q31. [June 2016] . 3.5 marks

Electromagnetism > Electric field in matter

CSIR NET	2016 June	3.5M

The half space regions $x > 0$ and $x < 0$ are filled with dielectric media of dielectric constants ϵ_1 and ϵ_2 respectively. There is a uniform electric field in each part. In the right half, the electric field makes an angle θ_1 to the interface. The corresponding angle θ_2 in the left half satisfies

1. $\epsilon_1 \sin\theta_2 = \epsilon_2 \sin\theta_1$
2. $\epsilon_1 \tan\theta_2 = \epsilon_2 \tan\theta_1$
3. $\epsilon_1 \tan\theta_1 = \epsilon_2 \tan\theta_2$
4. $\epsilon_1 \sin\theta_1 = \epsilon_2 \sin\theta_2$



Q32. [June 2016] . 3.5 marks

Electromagnetism > EM Waves

CSIR NET	2016 June	3.5M

The x - and z-components of a static magnetic field in a region are $B_x = B_0(x^2 - y^2)$ and $B_z = 0$, respectively. Which of the following solutions for its y component is consistent with the Maxwell equations?

1. $B_y = B_0 xy$
2. $B_y = -2B_0 xy$
3. $B_y = -B_0(x^2 - y^2)$
4. $B_y = B_0\left(\frac{1}{3}x^3 - xy^2\right)$

Q33. [June 2016] . 3.5 marks

Electromagnetism > Electrodynamics

CSIR NET	2016 June	3.5M

A magnetic field $\boldsymbol{B}$ is $B\hat{z}$ in the region $x > 0$ and zero elsewhere. A rectangular loop, in the xy-plane, of sides l (along the x direction) and h (along the y-direction) is inserted into the $x > 0$ region from the $x < 0$ region at a constant velocity $\boldsymbol{v} = v\hat{x}$. Which of the following values of l and h will generate the largest EMF?

1. $l = 8, h = 3$
2. $l = 4, h = 6$
3. $l = 6, h = 4$
4. $l = 12, h = 2$

Q34. [June 2016] . 3.5 marks
Quantum Mechanics > Potential Well

CSIR NET	2016 June	3.5M

The state of a particle of mass m in a one-dimensional rigid box in the interval 0 to L is given by the normalised wavefunction

$\psi(x) = \sqrt{\frac{2}{L}}\left(\frac{3}{5}\sin\left(\frac{2\pi x}{L}\right) + \frac{4}{5}\sin\left(\frac{4\pi x}{L}\right)\right)$. If its energy is measured, the possible outcomes and the average value of energy are, respectively

1. $\frac{h^2}{2mL^2}, \frac{2h^2}{mL^2}$ and $\frac{73}{50}\frac{h^2}{mL^2}$
2. $\frac{h^2}{8mL^2}, \frac{h^2}{2mL^2}$ and $\frac{19}{40}\frac{h^2}{mL^2}$
3. $\frac{h^2}{2mL^2}, \frac{2h^2}{mL^2}$ and $\frac{19}{10}\frac{h^2}{mL^2}$
4. $\frac{h^2}{8mL^2}, \frac{2h^2}{mL^2}$ and $\frac{73}{200}\frac{h^2}{mL^2}$

Q35. [June 2016] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2016 June	3.5M

If $\hat{L}_x, \hat{L}_y$ and $\hat{L}_z$ are the components of the angular momentum operator in three dimensions, the commutator $[\hat{L}_x, \hat{L}_x\hat{L}_y\hat{L}_z]$ may be simplified to

1. $i\hbar L_x(\hat{L}_z^2 - \hat{L}_y^2)$
2. $i\hbar \hat{L}_z\hat{L}_y\hat{L}_x$
3. $i\hbar L_x(2\hat{L}_z^2 - \hat{L}_y^2)$
4. 0

Q36. [June 2016] . 3.5 marks

Quantum Mechanics > Orbital angular Momentum and Hydrogen atom

CSIR NET	2016 June	3.5M

Suppose that the Coulomb potential of the hydrogen atom is changed by adding an inverse-square term such that the total potential is $V(\vec{r}) = -\frac{Ze^2}{r} + \frac{g}{r^2}$, where g is a constant. The energy eigenvalues E_{nlm} in the modified potential

1. depend on n and l, but not on m
2. depend on n but not on l and m
3. depend on n and m, but not on l
4. depend explicitly on all three quantum numbers n, l and m

Q37. [June 2016] . 3.5 marks
Quantum Mechanics > Basic Quantum Mechanics

CSIR NET	2016 June	3.5M

The eigenstates corresponding to eigenvalues E_1 and E_2 of a time-independent Hamiltonian are $|1\rangle$ and $|2\rangle$ respectively. If at $t=0$, the system is in a state $|\psi(t=0)\rangle = \sin\theta|1\rangle + \cos\theta|2\rangle$ the value of $\langle\psi(t) \mid \psi(t)\rangle$ at time t will be

1. 1

2. $\left(E_1\sin^2\theta + E_2\cos^2\theta\right)/\sqrt{E_1^2 + E_2^2}$

3. $e^{iE_1t/\hbar}\sin\theta + e^{iE_2t/\hbar}\cos\theta$

4. $e^{-iE_1t/\hbar}\sin^2\theta + e^{-iE_2t/\hbar}\cos^2\theta$

Q38. [June 2016] . 3.5 marks
Thermodynamics > Kinetic theory of Gases

CSIR NET	2016 June	3.5M

The specific heat per molecule of a gas of diatomic molecules at high temperatures is

1. $8k_B$

2. $3.5k_B$

3. $4.5k_B$

4. $3k_B$

Q39. [June 2016] . 3.5 marks

Thermodynamics > Laws of thermodynamics

CSIR NET	2016 June	3.5M

When an ideal monatomic gas is expanded adiabatically from an initial volume V_0 to $3V_0$, its temperature changes from T_0 to T. Then the ratio T/T_0 is

1. $\frac{1}{3}$

2. $\left(\frac{1}{3}\right)^{2/3}$

3. $\left(\frac{1}{3}\right)^{1/3}$

4. 3

Q40. [June 2016] . 3.5 marks

Thermodynamics > Kinetic theory of Gases

CSIR NET	2016 June	3.5M

A box of volume V containing N molecules of an ideal gas, is divided by a wall with a hole into two compartments. If the volume of the smaller compartment is $V/3$, the variance of the number of particles in it, is

1. $N/3$
2. $2N/9$
3. $\sqrt{N}$
4. $\sqrt{N}/3$

Q41. [June 2016] . 3.5 marks
Statistical Mechanics > Canonical Ensemble

CSIR NET	2016 June	3.5M

A gas of non-relativistic classical particles in one dimension is subjected to a potential $V(x) = \alpha|x|$ (where α is a constant). The partition function is

$(\beta = \frac{1}{k_B T})$

1. $\sqrt{\frac{4m\pi}{\beta^3\alpha^2h^2}}$

2. $\sqrt{\frac{2m\pi}{\beta^3\alpha^2h^2}}$

3. $\sqrt{\frac{8m\pi}{\beta^3\alpha^2h^2}}$

4. $\sqrt{\frac{3m\pi}{\beta^3\alpha^2h^2}}$

Q42. [June 2016] . 3.5 marks
Electronics > Basic Electronics

CSIR NET	2016 June	3.5M

The dependence of current I on the voltage V of a certain device is given by

$$I = I_0 \left(1 - \frac{V}{V_0}\right)^2$$

where I_0 and V_0 are constants. In an experiment the current I is measured as the voltage V applied across the device is increased. The parameters V_0 and $\sqrt{I_0}$ can be graphically determined as

1. the slope and the y-intercept of the $I - V^2$ graph
2. the negative of the ratio of the y-intercept and the slope, and the y-intercept of the $I - V^2$ graph
3. the slope and the y-intercept of the $\sqrt{I} - V$ graph
4. the negative of the ratio of the y-intercept and the slope, and the y-intercept of the $\sqrt{I} - V$ graph

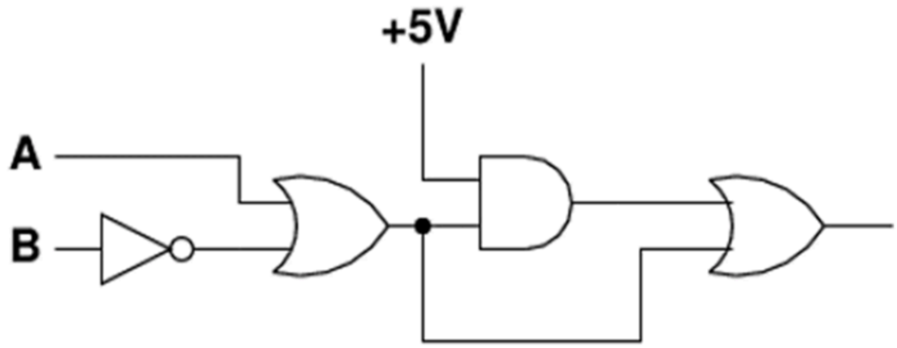
Q43. [June 2016] . 3.5 marks

Electronics > Digital Electronics

CSIR NET	2016 June	3.5M

In the schematic figure given below, assume that the propagation delay of each logic gate is t_{gate}.

The propagation delay of the circuit will be maximum when the logic inputs A and B make the transition



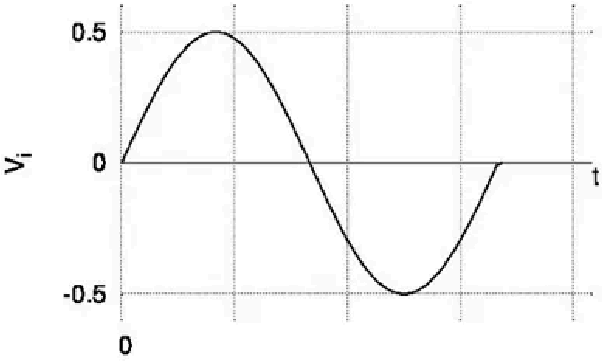
1. $(0,1) \to (1,1)$
2. $(1,1) \to (0,1)$
3. $(0,0) \to (1,1)$
4. $(0,0) \to (0,1)$

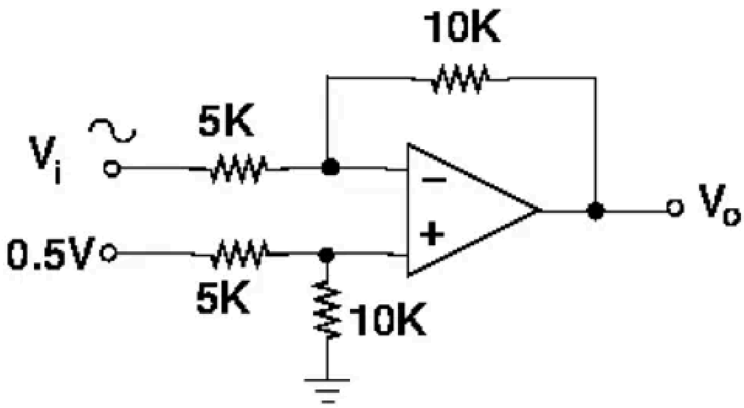
Q44. [June 2016] . 3.5 marks

Electronics > OPAMP

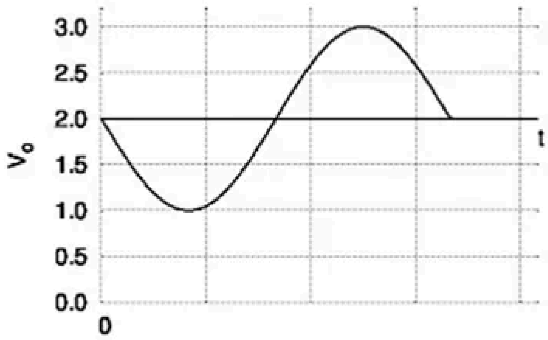
CSIR NET	2016 June	3.5M

Given the input voltage V_i, which of the following waveforms correctly represents the output voltage V_0 in the circuit shown below?

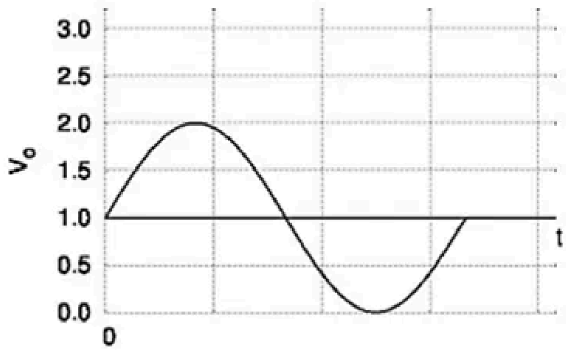




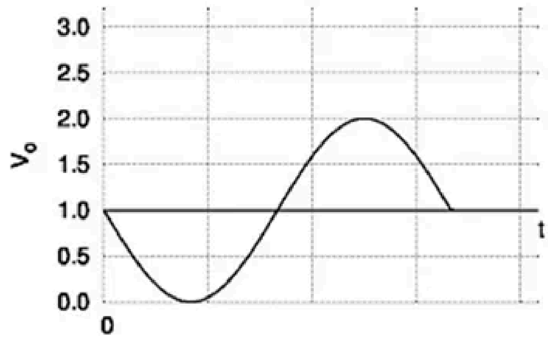
1.



3.



2.



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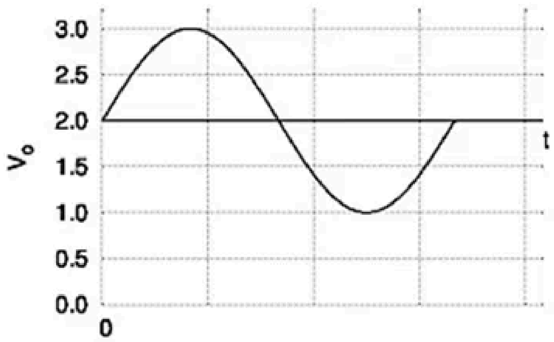


Q45. [June 2016] . 3.5 marks

Electronics > Diodes

CSIR NET	2016 June	3.5M

The intensity distribution of a red LED on an absorbing layer of material is a Gaussian centred at the wavelength $\lambda_0 = 660\,\mathrm{nm}$ and width 20 nm . If the absorption coefficient varies with wavelength as $\alpha_0 - K(\lambda - \lambda_0)$, where α_0 and K are positive constants, the light emerging from the absorber will be

1. blue shifted retaining the Gaussian intensity distribution
2. blue shifted with an asymmetric intensity distribution
3. red shifted retaining the Gaussian intensity distribution
4. red shifted with an asymmetric intensity distribution

Q46. [June 2016] . 5.0 marks

Mathematical Physics > Fourier Transform

CSIR NET	2016 June	5M

What is the Fourier transform $\int dx e^{ikx} f(x)$ of

$$f(x) = \delta(x) + \sum_{n=1}^{\infty} \frac{d^n}{dx^n}\delta(x)$$

where $\delta(x)$ is the Dirac delta-function?

1. $\frac{1}{1-ik}$
2. $\frac{1}{1+ik}$
3. $\frac{1}{k+i}$
4. $\frac{1}{k-i}$

Q47. [June 2016] . 5.0 marks

Mathematical Physics > Integral Equations

CSIR NET	2016 June	5M

The integral equation

$$\phi(x,t) = \lambda \int dx' dt'$$

$$\int \frac{d\omega dk}{(2\pi)^2} \frac{e^{-ik(x-x')+i\omega(t-t')}}{\omega^2 - k^2 - m^2 + i\epsilon} \phi^3(x',t')$$

is equivalent to the differential equation

1. $\left(\frac{\partial^2}{\partial t^2} + \frac{\partial^2}{\partial x^2} - m^2 + i\epsilon\right)\phi(x,t) = -\frac{1}{6}\lambda\phi^3(x,t)$

2. $\left(\frac{\partial^2}{\partial t^2} - \frac{\partial^2}{\partial x^2} + m^2 - i\epsilon\right)\phi(x,t) = \lambda\phi^2(x,t)$

3. $\left(\frac{\partial^2}{\partial t^2} - \frac{\partial^2}{\partial x^2} + m^2 - i\epsilon\right)\phi(x,t) = -3\lambda\phi^2(x,t)$

4. $\left(\frac{\partial^2}{\partial t^2} - \frac{\partial^2}{\partial x^2} + m^2 - i\epsilon\right)\phi(x,t) = -\lambda\phi^3(x,t)$

Q48. [June 2016] . 5.0 marks
Mathematical Physics > Group Theory

CSIR NET	2016 June	5M

A part of the group multiplication table for a six element group $G = \{e, a, b, c, d, f\}$ is shown below. (In the following e is the identity element of G.)

	e	a	b	c	d	f
e	e	a	b	c	d	f
a	a	b	e	d		
b	b	e	x	f	y	z
c	c					
d	d					
f	f					

The entries x, y and z should be

1. $x = a, y = d$ and $z = c$
2. $x = c, y = a$ and $z = d$
3. $x = c, y = d$ and $z = a$
4. $x = a, y = c$ and $z = d$

Q49. [June 2016] . 5.0 marks

Mathematical Physics > Numerical Methods

CSIR NET	2016 June	5M

In finding the roots of the polynomial $f(x) = 3x^3 - 4x - 5$ using the iterative Newton-Raphson method, the initial guess is taken to be $x = 2$. In the next iteration its value is nearest to

1. 1.671
2. 1.656
3. 1.559
4. 1.551

Q50. [June 2016] . 5.0 marks

Classical Mechanics > Special theory of relativity

CSIR NET	2016 June	5M

For a particle of energy E and momentum $\boldsymbol{p}$ (in a frame F), the rapidity y is defined as

$y=\frac{1}{2}\ln\left(\frac{E+p_3c}{E-p_3c}\right)$. In a frame F' moving with velocity $\boldsymbol{v}=(0,0,\beta c)$ with respect to F , the rapidity y' will be

1. $y' = y+\frac{1}{2}\ln(1-\beta^2)$

2. $y' = y-\frac{1}{2}\ln\left(\frac{1+\beta}{1-\beta}\right)$

3. $y' = y+\ln\left(\frac{1+\beta}{1-\beta}\right)$

4. $y' = y+2\ln\left(\frac{1+\beta}{1-\beta}\right)$

Q51. [June 2016] . 5.0 marks

Classical Mechanics > Canonical transformations

CSIR NET	2016 June	5M

A canonical transformation $(q, p) \to (Q, P)$ is made through the generating function $F(q, P) = q^2 P$ on the Hamiltonian

$$H(q, p) = \frac{p^2}{2\alpha q^2} + \frac{\beta}{4} q^4$$

where α and β are constants. The equations of motion for (Q, P) are

1. $\dot{Q} = P/\alpha$ and $\dot{P} = -\beta Q$
2. $\dot{Q} = 4P/\alpha$ and $\dot{P} = -\beta Q/2$
3. $\dot{Q} = P/\alpha$ and $\dot{P} = -\frac{2P^2}{Q} - \beta Q$
4. $\dot{Q} = 2P/\alpha$ and $\dot{P} = -\beta Q$

Q52. [June 2016] . 5.0 marks

Classical Mechanics > Lagrangian and Hamiltonian

CSIR NET	2016 June	5M

The Lagrangian of a system moving in three dimensions is

$$L = \frac{1}{2}m\dot{x}_1^2 + m\left(\dot{x}_2^2 + \dot{x}_3^2\right) - \frac{1}{2}kx_1^2 - \frac{1}{2}k(x_2 + x_3)^2$$

The independent constant(s) of motion is/are

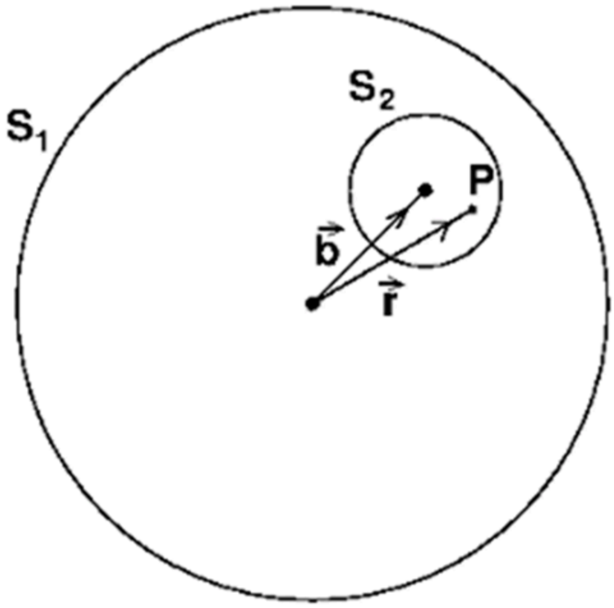
1. energy alone
2. only energy, one component of the linear momentum and one component of the angular momentum.
3. only energy and one component of the linear momentum
4. only energy and one component of the angular momentum

Q53. [June 2016] . 5.0 marks
Electromagnetism > Electrostatics

CSIR NET	2016 June	5M

Consider a sphere S_1 of radius R which carries a uniform charge of density ρ. A smaller sphere S_2 of radius $a < R/2$ is cut out and removed from it. The centres of the two spheres are separated by the vector $\vec{b} = \hat{n}R/2$, as shown in the figure.

The electric field at a point P inside S_2 is



1. $\frac{\rho R}{3\varepsilon_0}\hat{n}$
2. $\frac{\rho R}{3\varepsilon_0 a}(\vec{r} - \hat{n}a)$
3. $\frac{\rho R}{6\varepsilon_0}\hat{n}$
4. $\frac{\rho a}{3\varepsilon_0 R}\vec{r}$

Q54. [June 2016] . 5.0 marks

Electromagnetism > Relativistic electromagnetism

CSIR NET	2016 June	5M

The values of the electric and magnetic fields in a particular reference frame (in Gaussian units) are $\boldsymbol{E} = 3\hat{x} + 4\hat{y}$ and $\boldsymbol{B} = 3\hat{z}$, respectively. An inertial observer moving with respect to this frame measures the magnitude of the electric field to be $|\boldsymbol{E}'| = 4$. The magnitude of the magnetic field $|\boldsymbol{B}'|$ measured by him is

1. 5

2. 9

3. 0

4. 1

Q55. [June 2016] . 5.0 marks

Electromagnetism > Magetostatics

CSIR NET	2016 June	5M

A loop of radius a, carrying a current I, is placed in a uniform magnetic field $\boldsymbol{B}$. If the normal to the loop is denoted by $\hat{n}$, the force $\boldsymbol{F}$ and the torque $\boldsymbol{T}$ on the loop are

1. $\boldsymbol{F} = 0$ and $\boldsymbol{T} = \pi a^2 I \hat{n} \times \boldsymbol{B}$

2. $\boldsymbol{F} = \frac{\mu_0}{4\pi} \boldsymbol{I} \times \boldsymbol{B}$ and $\boldsymbol{T} = 0$

3. $\boldsymbol{F} = \frac{\mu_0}{4\pi} \boldsymbol{I} \times \boldsymbol{B}$ and $\boldsymbol{T} = I\hat{n} \times \boldsymbol{B}$

4. $\boldsymbol{F} = 0$ and $\boldsymbol{T} = \frac{1}{\mu_0 \varepsilon_0} I\boldsymbol{B}$

Q56. [June 2016] . 5.0 marks
Electromagnetism > Waveguides

CSIR NET	2016 June	5M

A waveguide has a square cross-section of side $2a$. For the TM modes of wavevector k, the transverse electromagnetic modes are obtained in terms of a function $\psi(x,y)$ which obeys the equation

$$\left[\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\left(\frac{\omega^2}{c^2}-k^2\right)\right]\psi(x,y)=0$$

with the boundary condition

$\psi(\pm a, y)=\psi(x,\pm a)=0$. The frequency ω of the lowest mode is given by

1. $\omega^2=c^2\left(k^2+\frac{4\pi^2}{a^2}\right)$

2. $\omega^2=c^2\left(k^2+\frac{\pi^2}{a^2}\right)$

3. $\omega^2=c^2\left(k^2+\frac{\pi^2}{2a^2}\right)$

4. $\omega^2=c^2\left(k^2+\frac{\pi^2}{4a^2}\right)$

Q57. [June 2016] . 5.0 marks

Quantum Mechanics > Pertubation theory

CSIR NET	2016 June	5M

Consider a particle of mass m in a potential $V(x) = \frac{1}{2}m\omega^2x^2 + g\cos kx$. The change in the ground state energy, compared to the simple harmonic potential $\frac{1}{2}m\omega^2x^2$, to first order in g is

1. $g\exp\left(-\frac{k^2\hbar}{2m\omega}\right)$
2. $g\exp\left(\frac{k^2\hbar}{2m\omega}\right)$
3. $g\exp\left(-\frac{2k^2\hbar}{m\omega}\right)$
4. $g\exp\left(-\frac{k^2\hbar}{4m\omega}\right)$

Q58. [June 2016] . 5.0 marks

Quantum Mechanics > WKB Approximation

CSIR NET	2016 June	5M

The energy levels for a particle of mass m in the potential $V(x) = \alpha|x|$, determined in the WKB approximation

$$\sqrt{2m}\int_a^b \sqrt{E - V(x)}dx = \left(n + \frac{1}{2}\right)\hbar\pi$$

(where a, b are the turning points and $n = 0,1,2 \cdots$), are

1. $E_n = \left[\frac{\hbar\pi\alpha}{4\sqrt{m}}\left(n + \frac{1}{2}\right)\right]^{2/3}$

2. $E_n = \left[\frac{3\hbar\pi\alpha}{4\sqrt{2m}}\left(n + \frac{1}{2}\right)\right]^{2/3}$

3. $E_n = \left[\frac{3\hbar\pi\alpha}{4\sqrt{m}}\left(n + \frac{1}{2}\right)\right]^{2/3}$

4. $E_n = \left[\frac{\hbar\pi\alpha}{4\sqrt{2m}}\left(n + \frac{1}{2}\right)\right]^{2/3}$

Q59. [June 2016] . 5.0 marks

Quantum Mechanics > Dirac delta potential

CSIR NET	2016 June	5M

A particle of mass m moves in one dimension under the influence of the potential $V(x) = -\alpha\delta(x)$, where α is a positive constant. The uncertainty in the product $(\Delta x)(\Delta p)$ in its ground state is

1. $2\hbar$

2. $\hbar/2$

3. $\hbar/\sqrt{2}$

4. $\sqrt{2}\hbar$

Q60. [June 2016] . 5.0 marks
Quantum Mechanics > Variational Principle

CSIR NET	2016 June	5M

The ground state energy of a particle of mass m in the potential $V(x) = \frac{\hbar^2\beta}{6m}x^4$, estimated using the normalized trial wavefunction

$\psi(x) = \left(\frac{\alpha}{\pi}\right)^{1/4} e^{-\alpha x^2/2}$, is

[Use $\sqrt{\frac{\alpha}{\pi}}\int_{-\infty}^{\infty} dx x^2 e^{-\alpha x^2} = \frac{1}{2\alpha}$

and $\sqrt{\frac{\alpha}{\pi}}\int_{-\infty}^{\infty} dx x^4 e^{-\alpha x^2} = \frac{3}{4\alpha^2}$].

1. $\frac{3}{2m}\hbar^2\beta^{1/3}$
2. $\frac{8}{3m}\hbar^2\beta^{1/3}$
3. $\frac{2}{3m}\hbar^2\beta^{1/3}$
4. $\frac{3}{8m}\hbar^2\beta^{1/3}$

Q61. [June 2016] . 5.0 marks

Quantum Mechanics > Basic Quantum Mechanics

CSIR NET	2016 June	5M

Consider a gas of Cs atoms at a number density of 10^{12} atoms/cc. When the typical inter-particle distance is equal to the thermal de Broglie wavelength of the particles, the temperature of the gas is nearest to (Take the mass of a Cs atom to be 22.7×10^{-26} kg.)

1. 1×10^{-9} K
2. 7×10^{-5} K
3. 1×10^{-3} K
4. 2×10^{-8} K

Q62. [June 2016] . 5.0 marks
Statistical Mechanics > Canonical Ensemble

CSIR NET	2016 June	5M

The internal energy $E(T)$ of a system at a fixed volume is found to depend on the temperature T as $E(T) = aT^2 + bT^4$. Then the entropy $S(T)$, as a function of temperature, is

1. $\frac{1}{2}aT^2 + \frac{1}{4}bT^4$
2. $2aT^2 + 4bT^4$
3. $2aT + \frac{4}{3}bT^3$
4. $2aT + 2bT^3$

Q63. [June 2016] . 5.0 marks
Nuclear and Particle Physics > Radioactivity

CSIR NET	2016 June	5M

A radioactive element X decays to Y, which in turn decays to a stable element Z. The decay constant from X to Y is λ_1, and that from Y to Z is λ_2. If, to begin with, there are only N_0 atoms of X, at short times $\left(t \ll 1/\lambda_1\right.$ as well as $\left.1/\lambda_2\right)$ the number of atoms of Z will be

1. $\frac{1}{2}\lambda_1\lambda_2 N_0 t^2$
2. $\frac{\lambda_1\lambda_2}{2(\lambda_1+\lambda_2)} N_0 t$
3. $(\lambda_1+\lambda_2)^2 N_0 t^2$
4. $(\lambda_1+\lambda_2) N_0 t$

Q64. [June 2016] . 5.0 marks
Electronics > Instruments

CSIR NET	2016 June	5M

Two completely overlapping semi-circular parallel plates comprise a capacitive transducer. One of the plates is rotated by an angle of 10° relative to their common centre. Ignoring edge effects, the ratio, $I_n : I_o$, of sensitivity of the transducer in the new configuration with respect to the original one, is

1. $8:9$
2. 11:12
3. 17:18
4. $35:36$

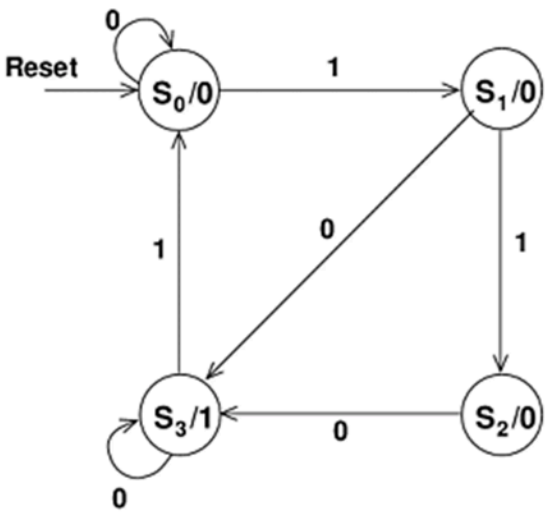
Q65. [June 2016] . 5.0 marks

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

CSIR NET	2016 June	5M

The state diagram that detects three or more consecutive 1's in a serial bit stream is

1.



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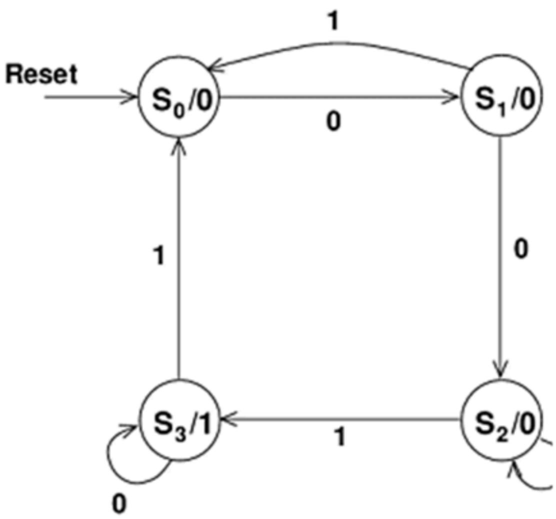

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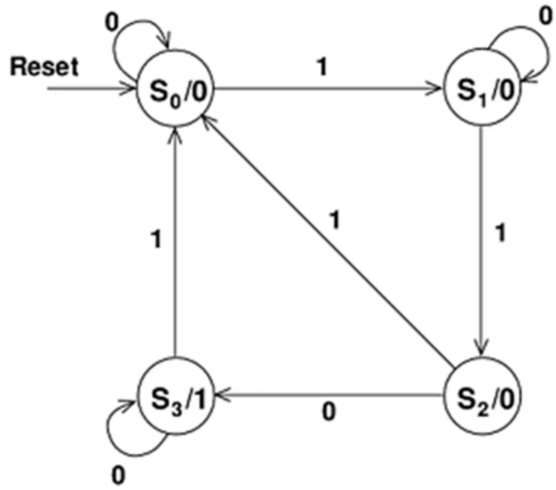

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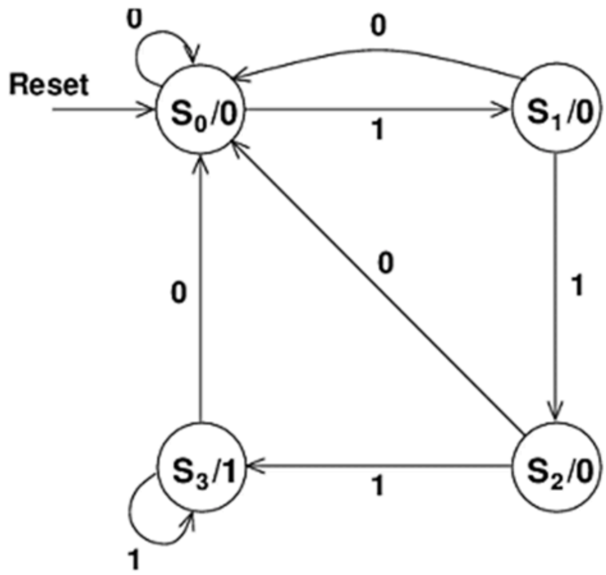

Q66. [June 2016] . 5.0 marks

Electronics > "Errors , curve fitting and data analysis"

CSIR NET	2016 June	5M

The decay constants f_p of the heavy pseudo-scalar mesons, in the heavy quark limit, are related to their masses m_p by the relation $f_p = \frac{a}{\sqrt{m_p}}$, where a is an empirical parameter to be determined. The values $m_p = 6400 \pm 160\text{MeV}$ and $f_p = 180 \pm$ 15 MeV correspond to uncorrelated measurements of a meson. The error on the estimate of a is

1. $175(\text{MeV})^{3/2}$

2. $900(\text{MeV})^{3/2}$

3. $1200(\text{MeV})^{3/2}$

4. $2400(\text{MeV})^{3/2}$

Q67. [June 2016] . 5.0 marks

Statistical Mechanics > Quantum Statistical Mechanics

CSIR NET	2016 June	5M

Consider electrons in graphene, which is a planar monatomic layer of carbon atoms. If the dispersion relation of the electrons is taken to be $\varepsilon(k) = ck$ (where c is constant) over the entire k-space, then the Fermi energy ε_F depends on the number density of electrons ρ as

1. $\varepsilon_F \propto \rho^{1/2}$
2. $\varepsilon_F \propto \rho$
3. $\varepsilon_F \propto \rho^{2/3}$
4. $\varepsilon_F \propto \rho^{1/3}$

Q68. [June 2016] . 5.0 marks

Solid State Physics > Lattice vibrations

CSIR NET	2016 June	5M

Suppose the frequency of phonons in a onedimensional chain of atoms is proportional to the wavevector. If n is the number density of atoms and c is the speed of the phonons, then the Debye frequency is

1. $2\pi cn$

2. $\sqrt{2}\pi cn$

3. $\sqrt{3}\pi cn$

4. $\pi cn/2$

Q69. [June 2016] . 5.0 marks

Solid State Physics > Tight binding model

CSIR NET	2016 June	5M

The band energy of an electron in a crystal for a particular k-direction has the form

$\varepsilon(k) = A - B\cos 2ka$, where A and B are positive constants and $0 < ka < \pi$. The electron has a hole-like behaviour over the following range of k :

1. $\frac{\pi}{4} < ka < \frac{3\pi}{4}$
2. $\frac{\pi}{2} < ka < \pi$
3. $0 < ka < \frac{\pi}{4}$
4. $\frac{\pi}{2} < ka < \frac{3\pi}{4}$

Q70. [June 2016] . 5.0 marks

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

CSIR NET	2016 June	5M

The ground state electronic configuration of $^{22}\mathrm{Ti}$ is $[\mathrm{Ar}]3d^2 4s^2$. Which state, in the standard spectroscopic notations, is not possible in this configuration?

1. $^1F_3$
2. $^1S_0$
3. $^1D_2$
4. $^3P_0$

Q71. [June 2016] . 5.0 marks

Atomic and Molecular Physics > Zeeman effect

CSIR NET	2016 June	5M

In a normal Zeeman effect experiment using a magnetic field of strength 0.3 T , the splitting between the components of a 660 nm spectral line is

1. 12 pm
2. 10 pm
3. 3.8 pm
4. 6 pm

Q72. [June 2016] . 5.0 marks

Atomic and Molecular Physics > Lasers

CSIR NET	2016 June	5M

The separation between the energy levels of a two-level atom is 2 eV . Suppose that 4×10^{20} atoms are in the ground state and 7×10^{20} atoms are pumped into the excited state just before lasing starts. How much energy will be released in a single laser pulse?

1. 24.6 J

2. 22.4 J

3. 98 J

4. 48 J

Q73. [June 2016] . 5.0 marks
Nuclear and Particle Physics > Radioactivity

CSIR NET	2016 June	5M

In the large hadron collider (LHC), two equal energy proton beams traverse in opposite directions along a circular path of length 27 km . If the total centre of mass energy of a proton-proton pair is 14 TeV , which of the following is the best approximation for the proper time taken by a proton to traverse the entire path?

1. 12 ns
2. $1.2\mu s$
3. 1.2 ns
4. $0.12\mu s$

Q74. [June 2016] . 5.0 marks
Nuclear and Particle Physics > Liquid drop Model

CSIR NET	2016 June	5M

Let E_S denote the contribution of the surface energy per nucleon in the liquid drop model. The ratio $E_S\left({}^{27}_{13}\mathrm{Al}\right) : E_S\left({}^{64}_{30}\mathrm{Zn}\right)$ is

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

Q75. [June 2016] . 5.0 marks
Nuclear and Particle Physics > Shell model

CSIR NET	2016 June	5M

According to the shell model, the nuclear magnetic moment of the ${}^{27}_{13}\mathrm{Al}$ nucleus is (Given that for a proton $g_l = 1, g_s = 5.586$, and for a neutron

$g_l = 0, g_s = -3.826$.)

1. $-1.913\mu_N$
2. $14.414\mu_N$
3. $4.793\mu_N$
4. 0

Answer Key

75 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	General Aptitude	Geometry	**1**
Q2	General Aptitude	Basic Physics	**2**
Q3	General Aptitude	Reasoning	**2**
Q4	General Aptitude	Reasoning	**1 or 2**
Q5	General Aptitude	Mathematical Analysis	**4**
Q6	General Aptitude	Reasoning	**2**
Q7	General Aptitude	Mathematical Analysis	**4**
Q8	General Aptitude	Geometry	**3**
Q9	General Aptitude	Data Analysis	**2**
Q10	General Aptitude	Reasoning	**2**
Q11	General Aptitude	Reasoning	**3**
Q12	General Aptitude	Mathematical Analysis	**3**
Q13	General Aptitude	Reasoning	**3**
Q14	General Aptitude	Reasoning	**4**
Q15	General Aptitude	Reasoning	**3**
Q16	General Aptitude	Basic Physics	**2**
Q17	General Aptitude	Mathematical Analysis	**4**
Q18	General Aptitude	Geometry	**2**
Q19	General Aptitude	Basic Physics	**4**
Q20	General Aptitude	Reasoning	**2**
Q21	Mathematical Physics	Basic Mathematics	**3**
Q22	Mathematical Physics	Complex analysis	**3**
Q23	Mathematical Physics	Fourier Series	**4**
Q24	Mathematical Physics	Probability	**4**
Q25	Electronics	"Errors , curve fitting and data analysis"	**1**
Q26	Classical Mechanics	Special theory of relativity	**4**
Q27	Classical Mechanics	Basic Mechanics	**3**
Q28	Electromagnetism	Electrostatics	**3**
Q29	Classical Mechanics	Lagrangian and Hamiltonian	**1**
Q30	Electromagnetism	Capacitors	**4**
Q31	Electromagnetism	Electric field in matter	**3**
Q32	Electromagnetism	EM Waves	**2**
Q33	Electromagnetism	Electrodynamics	**2**
Q34	Quantum Mechanics	Potential Well	**1**
Q35	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q36	Quantum Mechanics	Orbital angular Momentum and Hydrogen atom	**1**
Q37	Quantum Mechanics	Basic Quantum Mechanics	**1**
Q38	Thermodynamics	Kinetic theory of Gases	**2**
Q39	Thermodynamics	Laws of thermodynamics	**2**
Q40	Thermodynamics	Kinetic theory of Gases	**2**

Answer Key (cont.)

Q. No	Subject	Topic	Answer
Q41	Statistical Mechanics	Canonical Ensemble	**3**
Q42	Electronics	Basic Electronics	**4**
Q43	Electronics	Digital Electronics	**4**
Q44	Electronics	OPAMP	**2**
Q45	Electronics	Diodes	**4**
Q46	Mathematical Physics	Fourier Transform	**2**
Q47	Mathematical Physics	Integral Equations	**4**
Q48	Mathematical Physics	Group Theory	**4**
Q49	Mathematical Physics	Numerical Methods	**2**
Q50	Classical Mechanics	Special theory of relativity	**2**
Q51	Classical Mechanics	Canonical transformations	**2**
Q52	Classical Mechanics	Lagrangian and Hamiltonian	**2**
Q53	Electromagnetism	Electrostatics	**3**
Q54	Electromagnetism	Relativistic electromagnetism	**3**
Q55	Electromagnetism	Magetostatics	**1**
Q56	Electromagnetism	Waveguides	**3**
Q57	Quantum Mechanics	Pertubation theory	**4**
Q58	Quantum Mechanics	WKB Approximation	**2**
Q59	Quantum Mechanics	Dirac delta potential	**3**
Q60	Quantum Mechanics	Variational Principle	**4**
Q61	Quantum Mechanics	Basic Quantum Mechanics	**4**
Q62	Statistical Mechanics	Canonical Ensemble	**3**
Q63	Nuclear and Particle Physics	Radioactivity	**1**
Q64	Electronics	Instruments	**3**
Q65	Electronics	Flip flops/Counters/Registers/microcontroller etc.	**4**
Q66	Electronics	"Errors , curve fitting and data analysis"	**3**
Q67	Statistical Mechanics	Quantum Statistical Mechanics	**1**
Q68	Solid State Physics	Lattice vibrations	**1**
Q69	Solid State Physics	Tight binding model	**1**
Q70	Atomic and Molecular Physics	"LS, JJ and other interactions"	**1**
Q71	Atomic and Molecular Physics	Zeeman effect	**4**
Q72	Atomic and Molecular Physics	Lasers	**4**
Q73	Nuclear and Particle Physics	Radioactivity	**1**
Q74	Nuclear and Particle Physics	Liquid drop Model	**2**
Q75	Nuclear and Particle Physics	Shell model	**3**

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