

# PhysicsByAaryan

CSIR NET . GATE . JEST . BARC - Physics

## CSIR NET Physics - June 2017 - Full Paper

Complete question paper with answer key

**75 questions . Answer key included**

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[www.physicsbyaaryan.com](http://www.physicsbyaaryan.com) . [www.csirnetphysics.com](http://www.csirnetphysics.com)

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**Q1. [June 2017] . 2.0 marks**

General Aptitude &gt; Basic Physics

CSIR NET	2017 June	2M
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An ant starts at the origin and moves along the  $y$ -axis and covers a distance  $l$ . This is its first stage in its journey. Every subsequent stage requires the ant to turn right and move a distance which is half of its previous stage. What would be its coordinates at the end of its 5<sup>th</sup> stage?

1.  $\left(\frac{3l}{8}, \frac{13l}{16}\right)$
2.  $\left(\frac{13l}{16}, \frac{3l}{8}\right)$
3.  $\left(\frac{13l}{8}, \frac{3l}{16}\right)$
4.  $\left(\frac{3l}{16}, \frac{13l}{8}\right)$

**Q2. [June 2017] . 2.0 marks**

General Aptitude &gt; Reasoning

CSIR NET	2017 June	2M
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In a group of siblings there are seven sisters and each sister has one brother. How many siblings are there in total?

1. 15
2. 14
3. 8
4. 7

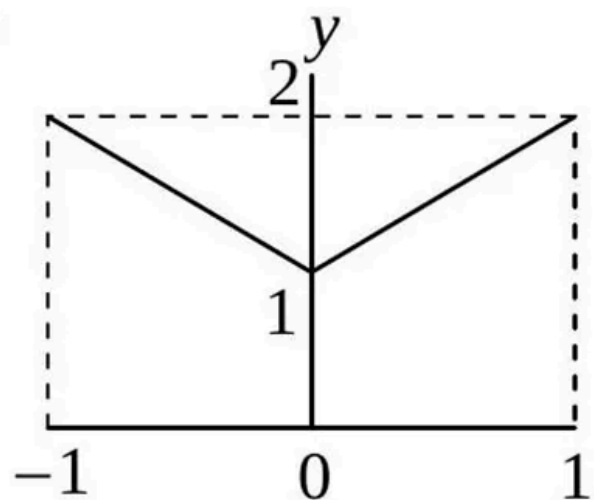
**Q3. [June 2017] . 2.0 marks**

General Aptitude &gt; Mathematical Analysis

CSIR NET	2017 June	2M
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What is the average value of  $y$  for the range of  $x$  shown in the following plot?

1. 0
2. 1
3. 1.5
4. 2



**Q4. [June 2017] . 2.0 marks**

General Aptitude &gt; Basic Physics

CSIR NET	2017 June	2M
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A bread contains 40% (by volume) edible matter and the remaining space is filled with air. If the density of edible matter is 2 g/cc, what will be the bulk density of the bread (in g/cc) ?

1. 0.4
2. 0.8
3. 1.2
4. 1.6

**Q5. [June 2017] . 2.0 marks**

General Aptitude &gt; Mathematical Analysis

CSIR NET	2017 June	2M
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A board has 8 rows and 8 columns. A move is defined as two steps along a column followed by one step along a row or vice-versa. What is the minimum number of moves needed to go from one corner to the diagonally opposite corner?

1. 5
2. 6
3. 7
4. 9

**Q6. [June 2017] . 2.0 marks**

General Aptitude &gt; Mathematical Analysis

CSIR NET	2017 June	2M
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A job interview is taking place with 21 male and 17 female candidates. Candidates are called randomly. What is the minimum number of candidates to be called to ensure that at least two males or two females have been interviewed?

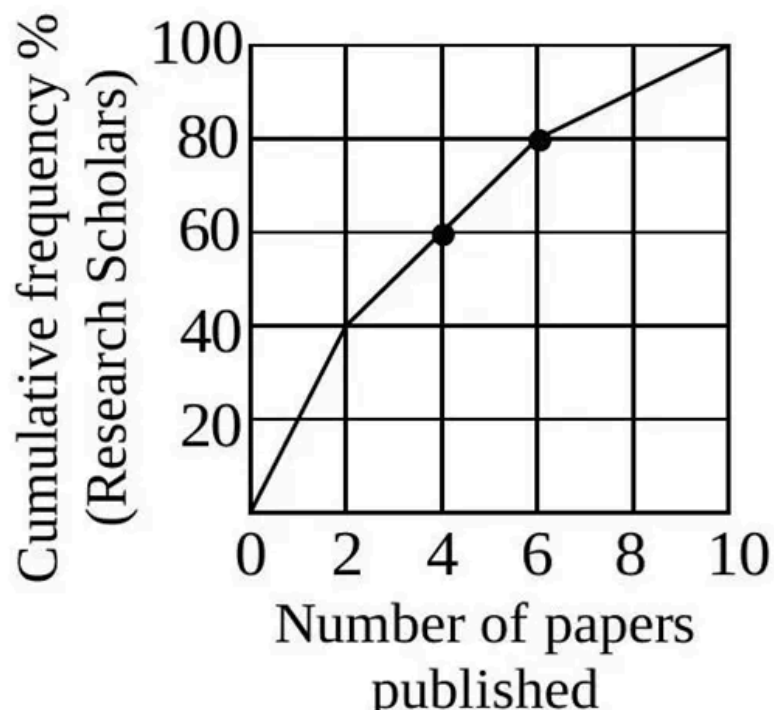
1. 17
2. 2
3. 3
4. 21

## Q7. [June 2017] . 2.0 marks

General Aptitude &gt; Data Analysis

CSIR NET	2017 June	2M
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The graph shows cumulative frequency % of research scholars and the number of papers published by them. Which of the following statements is true?



1. Majority of the scholars published more than 4 papers.
2. 60% of the scholars published at least 2 papers.
3. 80% of the scholars published at least 6 papers.
4. 30% of scholar's have not published any paper.

**Q8. [June 2017] . 2.0 marks**

General Aptitude &gt; Reasoning

CSIR NET	2017 June	2M
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A tells only lies on Monday, Tuesday and Wednesday and speaks only the truth for the rest of the week. B tells only lies on Thursday; Friday and Saturday and speaks only the truth for the rest of the week. If today both of them state that they have lied yesterday, what day is it today?

1. Monday
2. Thursday
3. Sunday
4. Tuesday

**Q9. [June 2017] . 2.0 marks**

General Aptitude &gt; Mathematical Analysis

CSIR NET	2017 June	2M
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A fair die was thrown three times and the outcome was repeatedly six. If the die is thrown again, what is the probability of getting six?

1.  $1/6$
2.  $1/216$
3.  $1/1296$
4. 1

**Q10. [June 2017] . 2.0 marks**

General Aptitude &gt; Reasoning

CSIR NET	2017 June	2M
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Which is the odd one out based on a divisibility test?

154,286,363,474,572,682

1. 474
2. 572
3. 682
4. 154

**Q11. [June 2017] . 2.0 marks**

General Aptitude &gt; Reasoning

CSIR NET	2017 June	2M
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My birthday is in January. What would be a sufficient number of questions with 'Yes/No' answers that will enable one to find my birth date?

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

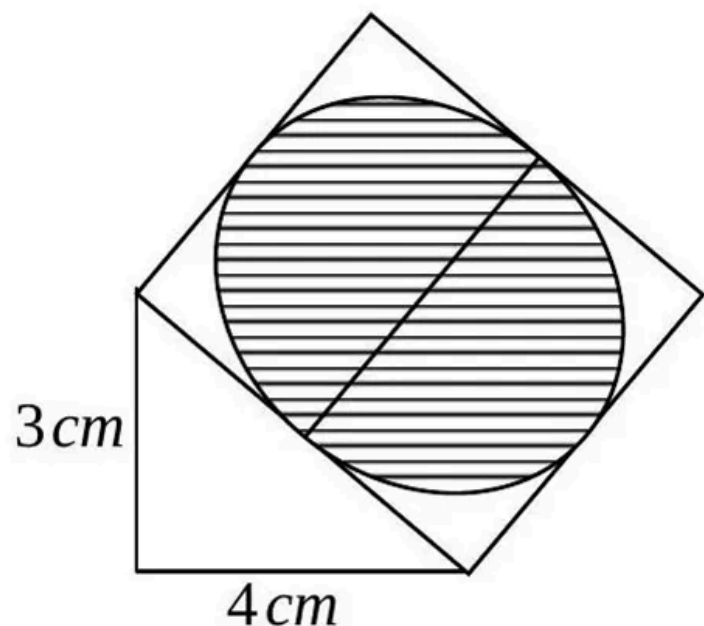
**Q12. [June 2017] . 2.0 marks**

General Aptitude &gt; Geometry

CSIR NET	2017 June	2M
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A square is drawn with one of its sides as the hypotenuse of a right-angled triangle as shown in the figure. What is the area of the shaded circle?

1.  $\frac{25\pi}{1} \text{ cm}^2$
2.  $\frac{25\pi}{2} \text{ cm}^2$
3.  $\frac{25\pi}{3} \text{ cm}^2$
4.  $\frac{25\pi}{4} \text{ cm}^2$



**Q13. [June 2017] . 2.0 marks**

General Aptitude &gt; Mathematical Analysis

CSIR NET	2017 June	2M
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What should be added to the product of the two numbers 983713 and 983719 to make it a perfect square?

1. 9
2. 13
3. 19
4. 27

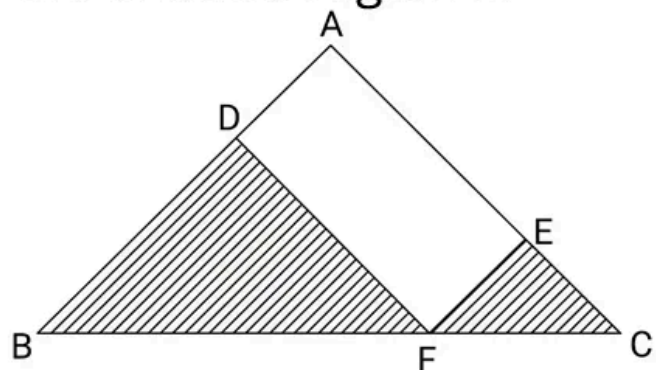
**Q14. [June 2017] . 2.0 marks**

General Aptitude &gt; Geometry

CSIR NET	2017 June	2M
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In  $\triangle ABC$ ,  $AB = AC$  and  $\angle BAC = 90^\circ$ ;  $EF \parallel AB$  and  $DF \parallel AC$ . The total area of the shaded region is

1.  $AF^2/2$
2.  $AF^2$
3.  $BC^2/2$
4.  $BC^2$



**Q15. [June 2017] . 2.0 marks**

General Aptitude &gt; Geometry

CSIR NET	2017 June	2M
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Consider a circle of radius  $r$ . Fit the largest possible square inside it and the largest possible circle inside the square. What is the radius of the innermost circle?

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

**Q16. [June 2017] . 2.0 marks**

General Aptitude &gt; Mathematical Analysis

CSIR NET	2017 June	2M
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In how many ways can you place  $N$  coins on a board with  $N$  rows and  $N$  columns such that every row and every column contains exactly one coin?

1.  $N$
2.  $N(N - 1)(N - 2) \dots 2 \times 1$
3.  $N^2$
4.  $N^N$

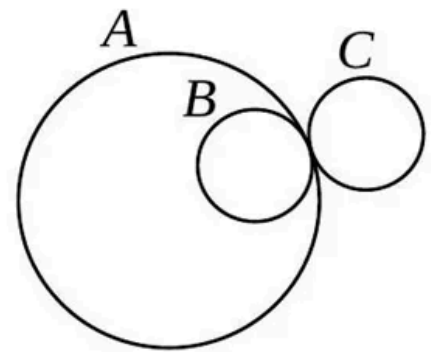
**Q17. [June 2017] . 2.0 marks**

General Aptitude &gt; Basic Physics

CSIR NET	2017 June	2M
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Two identical wheels  $B$  and  $C$  move on the periphery of circle  $A$ . Both start at the same point on  $A$  and return to it,  $B$  moving inside  $A$  and  $C$  outside it. Which is the correct statement?

1.  $B$  wears out  $\pi$  times  $C$
2.  $C$  wears out  $\pi$  times  $B$
3.  $B$  and  $C$  wear out about equally
4.  $C$  wears out two times  $B$

**Q18. [June 2017] . 2.0 marks**

General Aptitude &gt; Reasoning

CSIR NET	2017 June	2M
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Which of the following is the odd one out?

1. Isosceles triangle
2. Square
3. Regular hexagon
4. Rectangle

**Q19. [June 2017] . 2.0 marks**

General Aptitude &gt; Reasoning

CSIR NET	2017 June	2M
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Find the missing word:  $A, AB, \dots, ABBABAAB$

1.  $AABB$
2.  $ABAB$
3.  $ABBA$
4.  $BAAB$

**Q20. [June 2017] . 2.0 marks**

General Aptitude &gt; Basic Physics

CSIR NET	2017 June	2M
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A 100 m long train crosses a bridge 200 m long and 20 m wide bridge in 20 seconds. What is the speed of the train in km/hr ?

1. 45
2. 36
3. 54
4. 57.6

**Q21. [June 2017] . 3.5 marks**

Mathematical Physics &gt; Matrices and Linear Algebra

CSIR NET	2017 June	3.5M
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Which of the following can not be the eigenvalues of a real  $3 \times 3$  matrix

1.  $2i, 0, -2i$
2.  $1, 1, 1$
3.  $e^{i\theta}, e^{-i\theta}, 1$
4.  $i, 1, 0$

**Q22. [June 2017] . 3.5 marks**

Mathematical Physics &gt; Complex analysis

CSIR NET	2017 June	3.5M
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Let  $u(x, y) = e^{ax} \cos(by)$  be the real part of a function  $f(z) = u(x, y) + iv(x, y)$  of the complex variable  $z = x + iy$ , where  $a, b$  are real constants and  $a \neq 0$ . The function  $f(z)$  is complex analytic everywhere in the complex plane if and only if

1.  $b = 0$
2.  $b = \pm a$
3.  $b = \pm 2\pi a$
4.  $b = a \pm 2\pi$

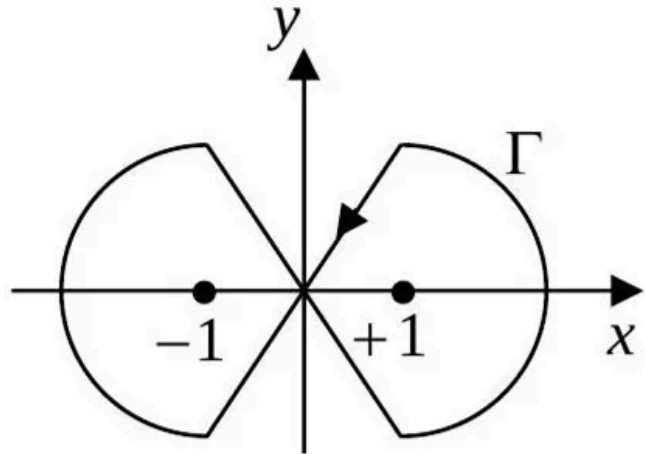
**Q23. [June 2017] . 3.5 marks**

Mathematical Physics > Complex analysis

CSIR NET	2017 June	3.5M
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The integral  $\oint_{\Gamma} \frac{ze^{i\pi z/2}}{z^2-1} dz$  along the closed contour  $\Gamma$  shown in the figure is

1. 0
2.  $2\pi$
3.  $-2\pi$
4.  $4\pi i$



**Q24. [June 2017] . 3.5 marks**

Mathematical Physics > Ordinary Differential Equations

CSIR NET	2017 June	3.5M
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The function  $y(x)$  satisfies the differential equation

$$x \frac{dy}{dx} + 2y = \frac{\cos \pi x}{x}. \text{ If } y(1) = 1, \text{ the value of } y(2) \text{ is}$$

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

**Q25. [June 2017] . 3.5 marks**

Mathematical Physics &gt; Probability

CSIR NET	2017 June	3.5M
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The random variable  $x$  ( $-\infty < x < \infty$ ) is distributed according to the normal distribution  $P(x) =$

$\frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}}$ . The probability density of the random variable  $y = x^2$  is

1.  $\frac{1}{\sqrt{2\pi\sigma^2 y}} e^{-y/2\sigma^2}, 0 \leq y < \infty$
2.  $\frac{1}{2\sqrt{2\pi\sigma^2 y}} e^{-y/2\sigma^2}, 0 \leq y < \infty$
3.  $\frac{1}{\sqrt{2\sigma^2}} e^{-y/2\sigma^2}, 0 \leq y < \infty$
4.  $\frac{1}{\sqrt{2\pi\sigma^2 y}} e^{-y/\sigma^2}, 0 \leq y < \infty$

**Q26. [June 2017] . 3.5 marks**

Classical Mechanics &gt; Lagrangian and Hamiltonian

CSIR NET	2017 June	3.5M
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The Hamiltonian for a system described by the generalised coordinate  $x$  and generalised momentum  $p$  is

$$H = \alpha x^2 p + \frac{p^2}{2(1 + 2\beta x)} + \frac{1}{2} \omega^2 x^2$$

where  $\alpha, \beta$  and  $\omega$  are constants. The corresponding Lagrangian is

1.  $\frac{1}{2} (\dot{x} - \alpha x^2)^2 (1 + 2\beta x) - \frac{1}{2} \omega^2 x^2$
2.  $\frac{1}{2(1+2\beta x)} \dot{x}^2 - \frac{1}{2} \omega^2 x^2 - \alpha x^2 \dot{x}$
3.  $\frac{1}{2} (\dot{x}^2 - \alpha^2 x)^2 (1 + 2\beta x) - \frac{1}{2} \omega^2 x^2$
4.  $\frac{1}{2(1+2\beta x)} \dot{x}^2 - \frac{1}{2} \omega^2 x^2 + \alpha x^2 \dot{x}$

**Q27. [June 2017] . 3.5 marks**

Classical Mechanics &gt; Special theory of relativity

CSIR NET	2017 June	3.5M
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An inertial observer sees two events  $E_1$  and  $E_2$  happening at the same location but  $6\mu\text{ s}$  apart in time. Another observer moving with a constant velocity  $v$  (with respect to the first one) sees the same events to be  $9\mu\text{ s}$  apart. The spatial distance between the events, as measured by the second observer, is approximately

1. 300 m
2. 1000 m
3. 2000 m
4. 2700 m

**Q28. [June 2017] . 3.5 marks**

Classical Mechanics &gt; Basic Mechanics

CSIR NET	2017 June	3.5M
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A ball weighing 100 gm , released from a height of 5 m , bounces perfectly elastically off a plate. The collision time between the ball and the plate is 0.5s . The average force on the plate is approximately

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

**Q29. [June 2017] . 3.5 marks**

Classical Mechanics &gt; Oscillations

CSIR NET	2017 June	3.5M
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A solid vertical rod, of length  $L$  and cross-sectional area  $A$ , is made of a material of Young's modulus  $Y$ . The rod is loaded with a mass  $M$ , and, as a result, extends by a small amount  $\Delta L$  in the equilibrium condition. The mass is then suddenly reduced to  $M/2$ . As a result, the rod will undergo longitudinal oscillation with an angular frequency

1.  $\sqrt{2YA/ML}$
2.  $\sqrt{YA/ML}$
3.  $\sqrt{2YA/M\Delta L}$
4.  $\sqrt{YA/M\Delta L}$

**Q30. [June 2017] . 3.5 marks**

Quantum Mechanics &gt; Quantum Harmonic Oscillator

CSIR NET	2017 June	3.5M
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If the root-mean-squared momentum of a particle in the ground state of a one-dimensional simple harmonic potential is  $p_0$ , then its root-mean-squared momentum in the first excited state is

1.  $p_0\sqrt{2}$
2.  $p_0\sqrt{3}$
3.  $p_0\sqrt{2/3}$
4.  $p_0\sqrt{3/2}$

**Q31. [June 2017] . 3.5 marks**

Quantum Mechanics &gt; Potential Well

CSIR NET	2017 June	3.5M
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Consider a potential barrier  $A$  of height  $V_0$  and width  $b$ , and another potential barrier  $B$  of height  $2V_0$  and the same width  $b$ . The ratio  $T_A/T_B$  of tunnelling probabilities  $T_A$  and  $T_B$ , through barriers  $A$  and  $B$  respectively, for a particle of energy  $V_0/100$  is best approximated by

1.  $\exp \left[ (\sqrt{1.99} - \sqrt{0.99}) \sqrt{8mV_0 b^2 / \hbar^2} \right]$
2.  $\exp \left[ (\sqrt{1.98} - \sqrt{0.98}) \sqrt{8mV_0 b^2 / \hbar^2} \right]$
3.  $\exp \left[ (\sqrt{2.99} - \sqrt{0.99}) \sqrt{8mV_0 b^2 / \hbar^2} \right]$
4.  $\exp \left[ (\sqrt{2.98} - \sqrt{0.98}) \sqrt{8mV_0 b^2 / \hbar^2} \right]$

**Q32. [June 2017] . 3.5 marks**

Quantum Mechanics &gt; Perturbation theory

CSIR NET	2017 June	3.5M
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A constant perturbation  $H'$  is applied to a system for time  $\Delta t$  (where  $H' \Delta t \ll \hbar$ ) leading to a transition from a state with energy  $E_i$  to another with energy  $E_f$ . If the time of application is doubled the probability of transition will be

1. Unchanged
2. Doubled
3. Quadrupled
4. Halved

**Q33. [June 2017] . 3.5 marks**

Mathematical Physics &gt; Vector Algebra and Vector Calculus

CSIR NET	2017 June	3.5M
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The two vectors  $\begin{pmatrix} a \\ 0 \end{pmatrix}$  and  $\begin{pmatrix} b \\ c \end{pmatrix}$  are orthonormal if

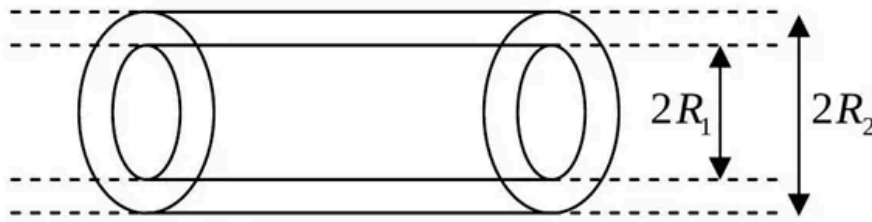
1.  $a = \pm 1, b = \pm 1/\sqrt{2}, c = \pm 1/\sqrt{2}$
2.  $a = \pm 1, b = \pm 1, c = 0$
3.  $a = \pm 1, b = 0, c = \pm 1$
4.  $a = \pm 1, b = \pm 1/2, c = 1/2$

## Q34. [June 2017] . 3.5 marks

Electromagnetism &gt; Electrostatics

CSIR NET	2017 June	3.5M
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Two long hollow co-axial conducting cylinders of radii  $R_1$  and  $R_2$  ( $R_1 < R_2$ ) are placed in vacuum as shown in the figure below.



The inner cylinder carries a charge  $+\lambda$  per unit length and the outer cylinder carries a charge  $-\lambda$  per unit length. The electrostatic energy per unit length of this system is

1.  $\frac{\lambda^2}{\pi\epsilon_0} \ln(R_2/R_1)$
2.  $\frac{\lambda^2}{4\pi\epsilon_0} (R_2^2/R_1^2)$
3.  $\frac{\lambda^2}{4\pi\epsilon_0} \ln(R_2/R_1)$
4.  $\frac{\lambda^2}{2\pi\epsilon_0} \ln(R_2/R_1)$

**Q35. [June 2017] . 3.5 marks**

Electromagnetism &gt; Magnetostatics

CSIR NET	2017 June	3.5M
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A set of  $N$  concentric circular loops of wire, each carrying a steady current  $I$  in the same direction, is arranged in a plane. The radius of the first loop is  $r_1 = a$  and the radius of the  $n^{\text{th}}$  loop is given by  $r_n = nr_{n-1}$ . The magnitude  $B$  of the magnetic field at the centre of the circles in the limit  $N \rightarrow \infty$ , is

1.  $\mu_0 I(e^2 - 1)/4\pi a$
2.  $\mu_0 I(e - 1)/\pi a$
3.  $I(e^2 - 1)/8a$
4.  $\mu_0 I(e - 1)/2a$

## Q36. [June 2017] . 3.5 marks

Electromagnetism &gt; EM Waves

CSIR NET	2017 June	3.5M
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An electromagnetic wave (of wavelength  $\lambda_0$  in free space) travels through an absorbing medium with dielectric permittivity given by  $\varepsilon = \varepsilon_R + i\varepsilon_I$  where  $\frac{\varepsilon_I}{\varepsilon_R} = \sqrt{3}$ . If the skin depth is  $\frac{\lambda_0}{4\pi}$ , the ratio of the amplitude of electric field  $E$  to that of the magnetic field  $B$ , in the medium (in ohms) is

1.  $120\pi$
2.  $377$
3.  $30\sqrt{2}\pi$
4.  $30\pi$

## Q37. [June 2017] . 3.5 marks

Electromagnetism &gt; Potential Formulation

CSIR NET	2017 June	3.5M
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The vector potential  $\vec{A} = ke^{-at}r\hat{r}$  (where  $a$  and  $k$  are constants) corresponding to an electromagnetic field is changed to  $\vec{A}' = -ke^{-at}r\hat{r}$ . This will be a gauge transformation if the corresponding change  $\phi' - \phi$  in the scalar potential is

1.  $akr^2e^{-at}$
2.  $2akr^2e^{-at}$
3.  $-akr^2e^{-at}$
4.  $-2akr^2e^{-at}$

**Q38. [June 2017] . 3.5 marks**

Thermodynamics &gt; Thermodynamic relations and maxwell equations

CSIR NET	2017 June	3.5M
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A thermodynamic function

$$G(T, P, N) = U - TS + PV$$

is given in terms of the internal energy  $U$ , temperature  $T$ , entropy  $S$ , pressure  $P$ , volume  $V$  and the number of particles  $N$ . Which of the following relations is true? (In the following  $\mu$  is the chemical potential.)

1.  $S = -\left.\frac{\partial G}{\partial T}\right|_{N,P}$

2.  $S = \left.\frac{\partial G}{\partial T}\right|_{N,P}$

3.  $V = -\left.\frac{\partial G}{\partial P}\right|_{N,T}$

4.  $\mu = -\left.\frac{\partial G}{\partial N}\right|_{P,T}$

**Q39. [June 2017] . 3.5 marks**

Thermodynamics &gt; Laws of thermodynamics

CSIR NET	2017 June	3.5M
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A box, separated by a movable wall, has two compartments filled by a monoatomic gas of  $\frac{C_P}{C_V} = \gamma$ . Initially the volumes of the two compartments are equal, but the pressures are  $3P_0$  and  $P_0$  respectively. When the wall is allowed to move, the final pressures in the two compartments become equal. The final pressure is

1.  $\left(\frac{2}{3}\right)^\gamma P_0$
2.  $3\left(\frac{2}{3}\right)^\gamma P_0$
3.  $\frac{1}{2}\left(1 + 3^{1/\gamma}\right)^\gamma P_0$
4.  $\left(\frac{3^{1/\gamma}}{1+3^{1/\gamma}}\right)^\gamma P_0$

**Q40. [June 2017] . 3.5 marks**

Statistical Mechanics &gt; Quantum Statistical Mechanics

CSIR NET	2017 June	3.5M
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A gas of photons inside a cavity of volume  $V$  is in equilibrium at temperature  $T$ . If the temperature of the cavity is changed to  $2T$ , the radiation pressure will change by a factor of

1. 2
2. 16
3. 8
4. 4

**Q41. [June 2017] . 3.5 marks**

Statistical Mechanics &gt; Microcanonical Ensemble

CSIR NET	2017 June	3.5M
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In a thermodynamic system in equilibrium, each molecule can exist in three possible states with probabilities  $1/2, 1/3$  and  $1/6$  respectively. The entropy per molecule is

1.  $k_B \ln 3$
2.  $\frac{1}{2} k_B \ln 2 + \frac{2}{3} k_B \ln 3$
3.  $\frac{2}{3} k_B \ln 2 + \frac{1}{2} k_B \ln 3$
4.  $\frac{1}{2} k_B \ln 2 + \frac{1}{6} k_B \ln 3$

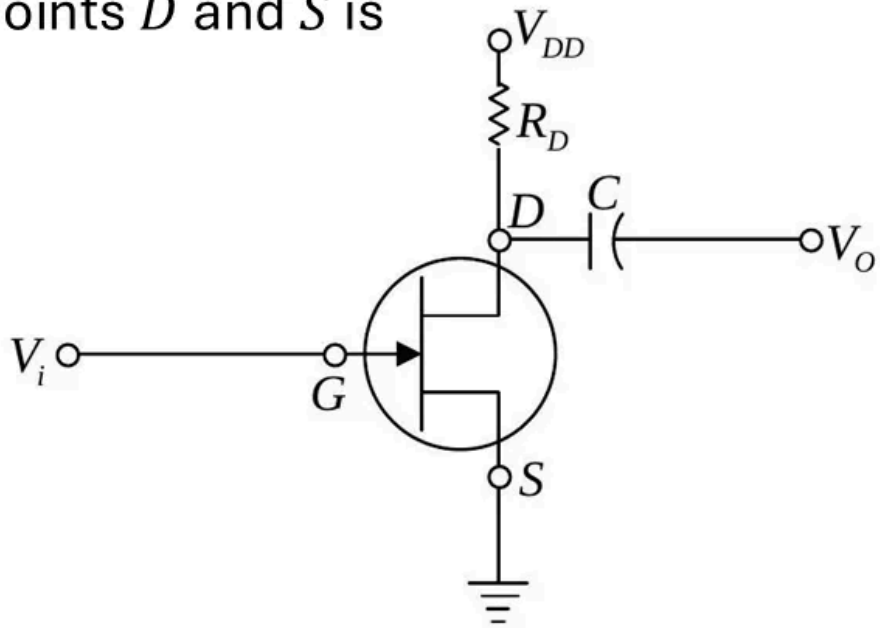
Q42. [June 2017] . 3.5 marks

Electronics &gt; FET

CSIR NET	2017 June	3.5M
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In the  $n$ -channel JFET shown in figure below,  $V_i = -2V$ ,  $C = 10pF$ ,  $V_{DD} = +16V$  and  $R_D = 2k\Omega$ . If the drain  $D$  - source  $S$  saturation current  $I_{DSS}$  is  $10mA$  and the pinch-off voltage  $V_P$  is  $-8V$ , then the voltage across points  $D$  and  $S$  is

1. 11.125 V
2. 10.375 V
3. 5.75 V
4. 4.75 V

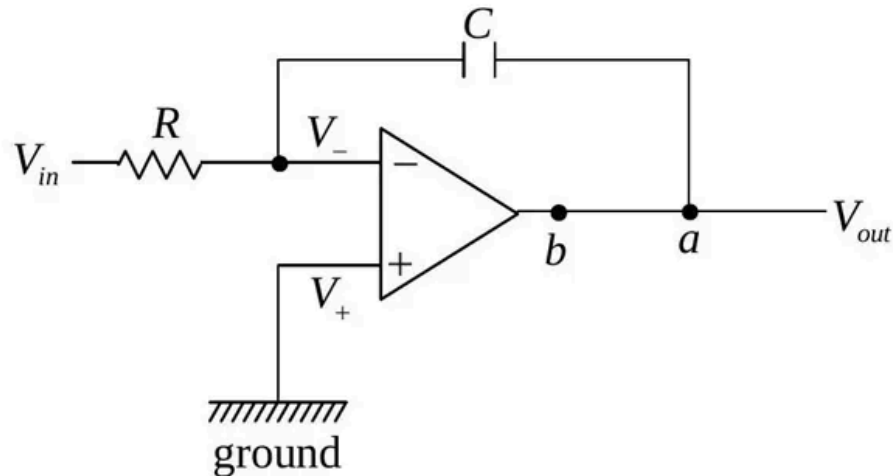


Q43. [June 2017] . 3.5 marks

Electronics &gt; OPAMP

CSIR NET	2017 June	3.5M
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The gain of the circuit given below is  $-\frac{1}{\omega RC}$ .



The modification in the circuit required to introduce a dc feedback is to add a resistor

1. between  $a$  and  $b$
2. between positive terminal of the op-amp and ground
3. in series with  $C$
4. parallel to  $C$

**Q44. [June 2017] . 3.5 marks**

Electronics &gt; Flip flops/Counters/Registers/microcontroller etc.

CSIR NET	2017 June	3.5M
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A  $2 \times 4$  decoder with an enable input can function as a

1.  $4 \times 1$  multiplexer
2.  $1 \times 4$  demultiplexer
3.  $4 \times 2$  encoder
4.  $4 \times 2$  priority encoder

**Q45. [June 2017] . 3.5 marks**

Electronics &gt; "Errors , curve fitting and data analysis"

CSIR NET	2017 June	3.5M
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The experimentally measured values of the variables  $x$  and  $y$  are  $2.00 \pm 0.05$  and  $3.00 \pm 0.02$  respectively. What is the error in the calculated value of  $z = 3y - 2x$  from the measurements?

1. 0.12
2. 0.05
3. 0.03
4. 0.07

## Q46. [June 2017] . 5.0 marks

Mathematical Physics &gt; Green Function

CSIR NET	2017 June	5M
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The Green's function satisfying

$$\frac{d^2}{dx^2} g(x, x_0) = \delta(x - x_0)$$

with the boundary conditions  $g(-L, x_0) = 0 = g(L, x_0)$ , is

$$1. \begin{cases} \frac{1}{2L} (x_0 - L)(x + L), & -L \leq x < x_0 \\ \frac{1}{2L} (x_0 + L)(x - L), & x_0 \leq x \leq L \end{cases}$$

$$2. \begin{cases} \frac{1}{2L} (x_0 + L)(x + L), & -L \leq x < x_0 \\ \frac{1}{2L} (x_0 - L)(x - L), & x_0 \leq x \leq L \end{cases}$$

$$3. \begin{cases} \frac{1}{2L} (L - x_0)(x + L), & -L \leq x < x_0 \\ \frac{1}{2L} (x_0 + L)(L - x), & x_0 \leq x \leq L \end{cases}$$

$$4. \frac{1}{2L} (x - L)(x + L), -L \leq x \leq L$$

**Q47. [June 2017] . 5.0 marks**

Mathematical Physics &gt; Matrices and Linear Algebra

CSIR NET	2017 June	5M
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Let  $\sigma_x, \sigma_y, \sigma_z$  be the Pauli matrices and

$$x'\sigma_x + y'\sigma_y + z'\sigma_z = \exp\left(\frac{i\theta\sigma_z}{2}\right) \times [x\sigma_x + y\sigma_y + z\sigma_z] \exp\left(-\frac{i\theta\sigma_z}{2}\right).$$

Then the coordinates are related as follows

$$1. \begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

$$2. \begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

$$3. \begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} \cos\frac{\theta}{2} & \sin\frac{\theta}{2} & 0 \\ -\sin\frac{\theta}{2} & \cos\frac{\theta}{2} & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

$$4. \begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = \begin{pmatrix} \cos\frac{\theta}{2} & -\sin\frac{\theta}{2} & 0 \\ \sin\frac{\theta}{2} & \cos\frac{\theta}{2} & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

**Q48. [June 2017] . 5.0 marks**

Mathematical Physics &gt; Numerical Methods

CSIR NET	2017 June	5M
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The interval  $[0,1]$  is divided into  $2n$  parts of equal length to calculate the integral  $\int_0^1 e^{i2\pi x} dx$  using Simpson's  $\frac{1}{3}$  rule. What is the minimum value of  $n$  for the result to be exact?

1.  $\infty$
2. 2
3. 3
4. 4

## Q49. [June 2017] . 5.0 marks

Mathematical Physics &gt; Group Theory

CSIR NET	2017 June	5M
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Which of the following sets of  $3 \times 3$  matrices (in which  $a$  and  $b$  are real numbers) forms a group under matrix multiplication?

1.  $\left\{ \begin{pmatrix} 1 & 0 & a \\ 0 & 1 & 0 \\ b & 0 & 1 \end{pmatrix}; a, b \in \mathbb{R} \right\}$

2.  $\left\{ \begin{pmatrix} 1 & a & 0 \\ 0 & 1 & b \\ 0 & 0 & 1 \end{pmatrix}; a, b \in \mathbb{R} \right\}$

3.  $\left\{ \begin{pmatrix} 1 & 0 & a \\ 0 & 1 & b \\ 0 & 0 & 1 \end{pmatrix}; a, b \in \mathbb{R} \right\}$

4.  $\left\{ \begin{pmatrix} 1 & a & 0 \\ b & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}; a, b \in \mathbb{R} \right\}$

**Q50. [June 2017] . 5.0 marks**

Classical Mechanics &gt; Lagrangian and Hamiltonian

CSIR NET	2017 June	5M
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The Lagrangian of a free relativistic particle (in one dimension) of mass  $m$  is given by  $L = -m\sqrt{1 - \dot{x}^2}$  where  $\dot{x} = dx/dt$ . If such a particle is acted upon by a constant force in the direction of its motion, the phase space trajectories obtained from the corresponding Hamiltonian are

1. Ellipses
2. Cycloids
3. Hyperbolas
4. Parabolas

**Q51. [June 2017] . 5.0 marks**

Classical Mechanics &gt; Canonical transformations

CSIR NET	2017 June	5M
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A Hamiltonian system is described by the canonical coordinate  $q$  and canonical momentum  $p$ . A new coordinate  $Q$  is defined as  $Q(t) = q(t + \tau) + p(t + \tau)$ , where  $t$  is the time and  $\tau$  is a constant, that is, the new coordinate is a combination of the old coordinate and momentum at a shifted time. The new canonical momentum  $P(t)$  can be expressed as

1.  $p(t + \tau) - q(t + \tau)$
2.  $p(t + \tau) - q(t - \tau)$
3.  $\frac{1}{2} [p(t - \tau) - q(t + \tau)]$
4.  $\frac{1}{2} [p(t + \tau) - q(t + \tau)]$

**Q52. [June 2017] . 5.0 marks**

Classical Mechanics &gt; Lagrangian and Hamiltonian

CSIR NET	2017 June	5M
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The energy of a one-dimensional system, governed by the Lagrangian

$$L = \frac{1}{2} m \dot{x}^2 - \frac{1}{2} k x^{2n}$$

where  $k$  and  $n$  are two positive constants, is  $E_0$ . The time period of oscillation  $\tau$  satisfies

1.  $\tau \propto k^{-\frac{1}{n}}$
2.  $\tau \propto k^{-\frac{1}{2n}} E_0^{\frac{1-n}{2n}}$
3.  $\tau \propto k^{-\frac{1}{2n}} E_0^{\frac{n-2}{2n}}$
4.  $\tau \propto k^{-\frac{1}{n}} E_0^{\frac{1+n}{2n}}$

**Q53. [June 2017] . 5.0 marks**

Electromagnetism &gt; Radiations

CSIR NET	2017 June	5M
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An electron is decelerated at a constant rate starting from an initial velocity  $u$  (where  $u \ll c$ ) to  $u/2$  during which it travels a distance  $s$ . The amount of energy lost to radiation is

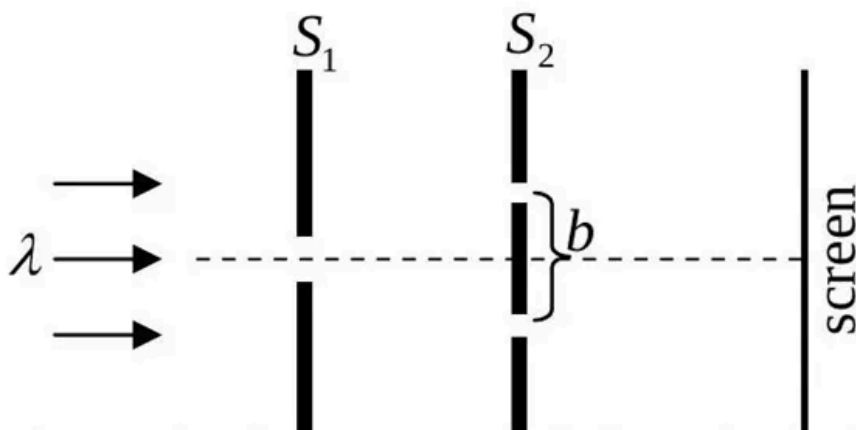
1.  $\frac{\mu_0 e^2 u^2}{3\pi m c^2 s}$
2.  $\frac{\mu_0 e^2 u^2}{6\pi m c^2 s}$
3.  $\frac{\mu_0 e^2 u}{8\pi m c s}$
4.  $\frac{\mu_0 e^2 u}{16\pi m c s}$

## Q54. [June 2017] . 5.0 marks

Optics &gt; Interference and diffraction

CSIR NET	2017 June	5M
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The figure below describes the arrangement of slits and screens in a Young's double slit experiment. The width of the slit in  $S_1$  is  $a$  and the slits in  $S_2$  are of negligible width.



If the wavelength of the light is  $\lambda$ , the  $d$  for which the screen would be dark is

1.  $b\sqrt{\left(\frac{a}{\lambda}\right)^2 - 1}$
2.  $\frac{b}{2}\sqrt{\left(\frac{a}{\lambda}\right)^2 - 1}$
3.  $\frac{a}{2}\left(\frac{b}{\lambda}\right)^2$
4.  $\frac{ab}{\lambda}$

**Q55. [June 2017] . 5.0 marks**

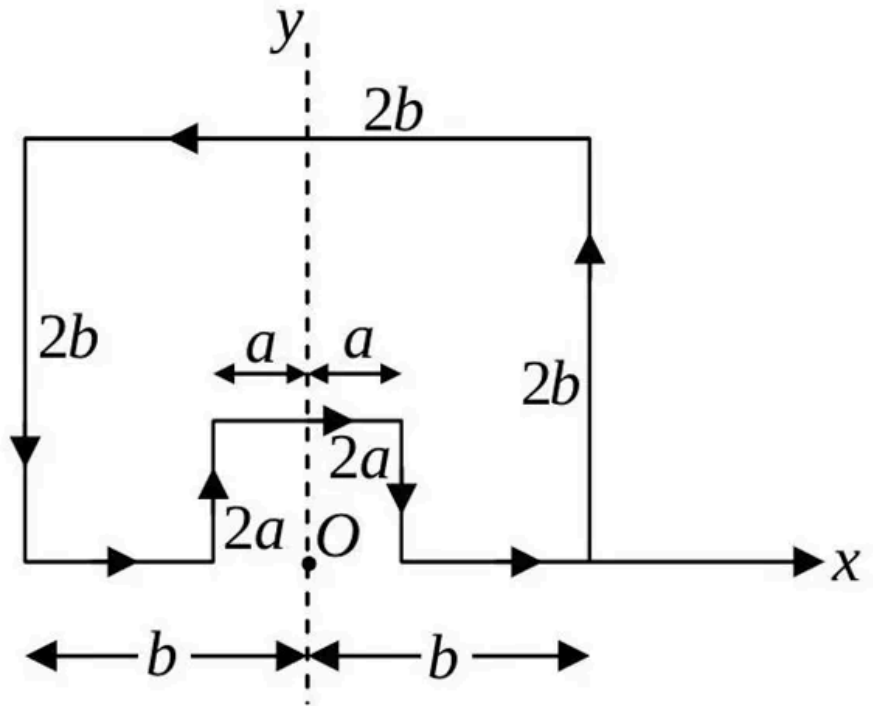
Electromagnetism > Magnetostatics

CSIR NET	2017 June	5M
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A constant current  $I$  is flowing in a piece of wire that is bent into a loop as shown in the figure.

The magnitude of the magnetic field at the point  $O$  is

1.  $\frac{\mu_0 I}{4\pi\sqrt{5}} \ln\left(\frac{a}{b}\right)$
2.  $\frac{\mu_0 I}{4\pi\sqrt{5}} \left(\frac{1}{a} - \frac{1}{b}\right)$
3.  $\frac{\mu_0 I}{4\pi\sqrt{5}} \left(\frac{1}{a}\right)$
4.  $\frac{\mu_0 I}{4\pi\sqrt{5}} \left(\frac{1}{b}\right)$



## Q56. [June 2017] . 5.0 marks

Quantum Mechanics &gt; Scattering theory

CSIR NET	2017 June	5M
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Consider the potential

$$V(\vec{r}) = \sum_i V_0 a^3 \delta^{(3)}(\vec{r} - \vec{r}_i)$$

where  $\vec{r}_i$  are the position vectors of the vertices of a cube of length  $a$  centered at the origin and  $V_0$  is a constant. If  $V_0 a^2 \ll \frac{\hbar^2}{m}$ , the total scattering cross-section, in the low-energy limit, is

1.  $16a^2 \left( \frac{mV_0 a^2}{\hbar^2} \right)$
2.  $\frac{16a^2}{\pi^2} \left( \frac{mV_0 a^2}{\hbar^2} \right)^2$
3.  $\frac{64a^2}{\pi} \left( \frac{mV_0 a^2}{\hbar^2} \right)^2$
4.  $\frac{64a^2}{\pi^2} \left( \frac{mV_0 a^2}{\hbar^2} \right)$

**Q57. [June 2017] . 5.0 marks**

Quantum Mechanics &gt; Perturbation theory

CSIR NET	2017 June	5M
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The Coulomb potential  $V(r) = -e^2/r$  of a hydrogen atom is perturbed by adding  $H' = bx^2$  (where  $b$  is a constant) to the Hamiltonian. The first order correction to the ground state energy is

(The ground state wavefunction is  $\psi_0 = \frac{1}{\sqrt{\pi a_0^3}} e^{-r/a_0}$  )

1.  $2ba_0^2$
2.  $ba_0^2$
3.  $ba_0^2/2$
4.  $\sqrt{2}ba_0^2$

**Q58. [June 2017] . 5.0 marks**

Quantum Mechanics &gt; Variational Principle

CSIR NET	2017 June	5M
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Using the trial function

$$\psi(x) = \begin{cases} A(a^2 - x^2), & -a < x < a \\ 0 & \text{otherwise} \end{cases}$$

the ground state energy of a one-dimensional harmonic oscillator is

1.  $\hbar\omega$
2.  $\sqrt{\frac{5}{14}}\hbar\omega$
3.  $\frac{1}{2}\hbar\omega$
4.  $\sqrt{\frac{5}{7}}\hbar\omega$

**Q59. [June 2017] . 5.0 marks**

Quantum Mechanics &gt; Perturbation theory

CSIR NET	2017 June	5M
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In the usual notation  $|n l m\rangle$  for the states of a hydrogen like atom, consider the spontaneous transitions  $|210\rangle \rightarrow |100\rangle$  and  $|310\rangle \rightarrow |100\rangle$ . If  $t_1$  and  $t_2$  are the lifetimes of the first and second decaying states respectively, then the ratio  $\frac{t_1}{t_2}$  is proportional to

1.  $\left(\frac{32}{27}\right)^3$
2.  $\left(\frac{27}{32}\right)^3$
3.  $\left(\frac{2}{3}\right)^3$
4.  $\left(\frac{3}{2}\right)^3$

**Q60. [June 2017] . 5.0 marks**

Mathematical Physics &gt; Probability

CSIR NET	2017 June	5M
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A random variable  $n$  obeys Poisson statistics. The probability of finding  $n = 0$  is  $10^{-6}$ . The expectation value of  $n$  is nearest to

1. 14
2.  $10^6$
3.  $e$
4.  $10^2$

**Q61. [June 2017] . 5.0 marks**

Statistical Mechanics &gt; Quantum Statistical Mechanics

CSIR NET	2017 June	5M
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The single particle energy levels of a non-interacting three-dimensional isotropic system, labelled by momentum  $k$ , are proportional to  $k^3$ . The ratio  $\bar{P}/\epsilon$  of the average pressure  $\bar{P}$  to the energy density  $\epsilon$  at a fixed temperature, is

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

**Q62. [June 2017] . 5.0 marks**

Statistical Mechanics &gt; Ising model

CSIR NET	2017 June	5M
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The Hamiltonian for three Ising spins  $S_0, S_1$  and  $S_2$ , taking values  $\pm 1$ , is  $H = -JS_0(S_1 + S_2)$

If the system is in equilibrium at temperature  $T$ , the average energy of the system, in terms of  $\beta = (k_B T)^{-1}$ , is

1.  $-\frac{1+\cosh(2\beta J)}{2\beta\sinh(2\beta J)}$
2.  $-2J[1 + \cosh(2\beta J)]$
3.  $-2/\beta$
4.  $-2J\frac{\sinh(2\beta J)}{1+\cosh(2\beta J)}$

## Q63. [June 2017] . 5.0 marks

Electronics &gt; Diodes

CSIR NET	2017 June	5M
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Let  $I_0$  be the saturation current,  $\eta$  the ideality factor and  $v_F$  and  $v_R$  the forward and reverse potentials respectively, for a diode. The ratio  $R_R/R_F$  of its reverse and forward resistances  $R_R$  and  $R_F$ , respectively, varies as (In the following  $k_B$  is the Boltzmann constant,  $T$  is the absolute temperature and  $q$  is the charge.)

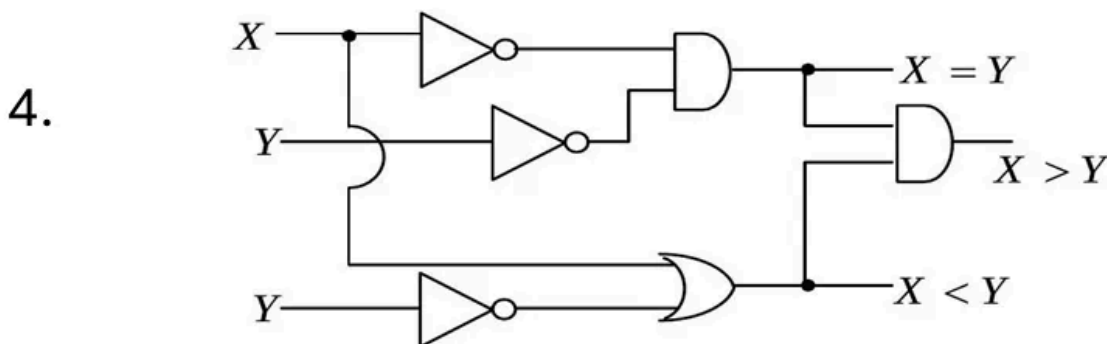
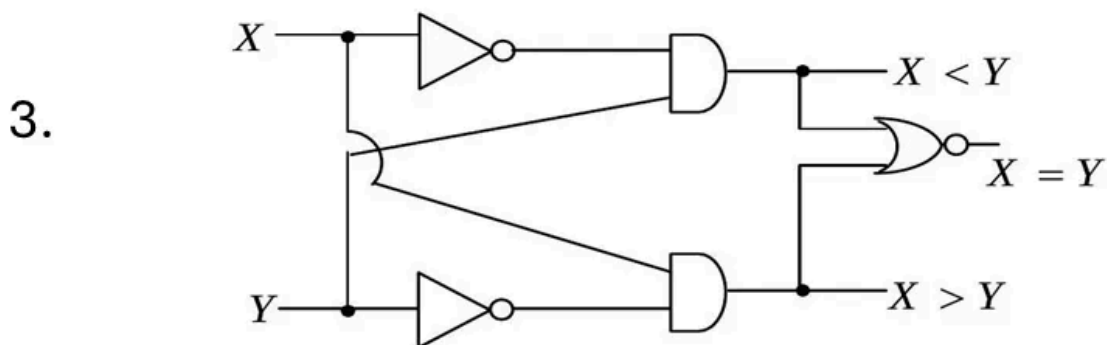
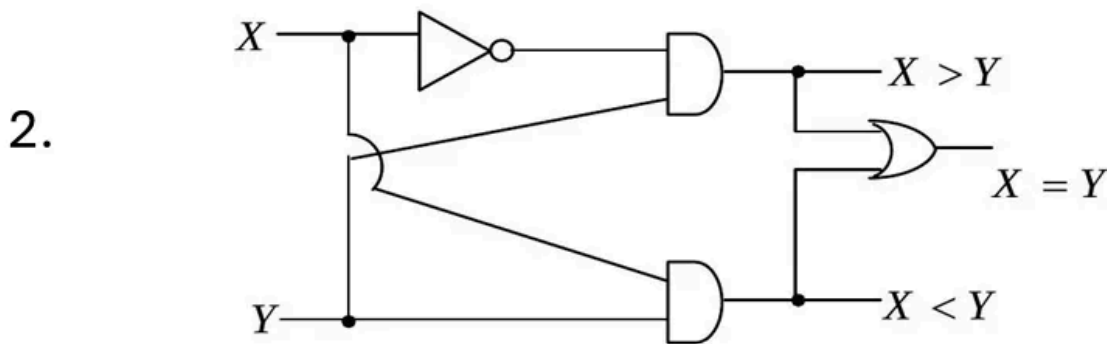
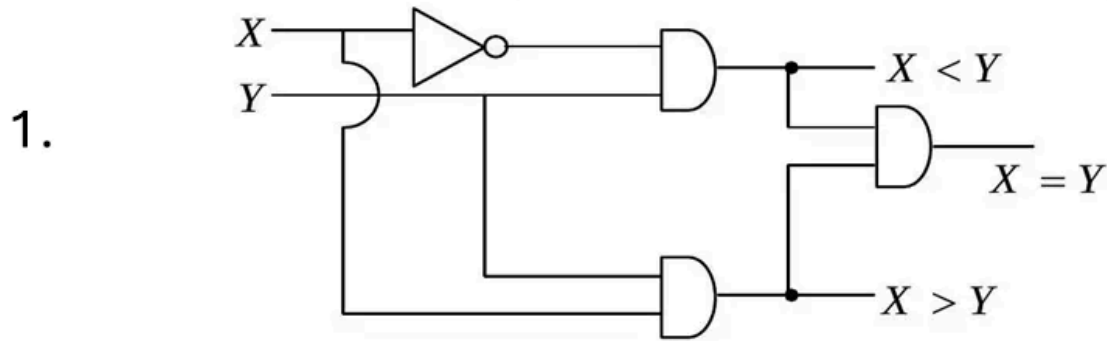
1.  $\frac{v_R}{v_F} \exp\left(\frac{qv_F}{\eta k_B T}\right)$
2.  $\frac{v_F}{v_R} \exp\left(\frac{qv_F}{\eta k_B T}\right)$
3.  $\frac{v_R}{v_F} \exp\left(-\frac{qv_F}{\eta k_B T}\right)$
4.  $\frac{v_F}{v_R} \exp\left(-\frac{qv_F}{\eta k_B T}\right)$

**Q64. [June 2017] . 5.0 marks**

Electronics > Digital Electronics

CSIR NET	2017 June	5M
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In the figures below,  $X$  and  $Y$  are one bit inputs. The circuit which corresponds to a one bit comparator is



**Q65. [June 2017] . 5.0 marks**

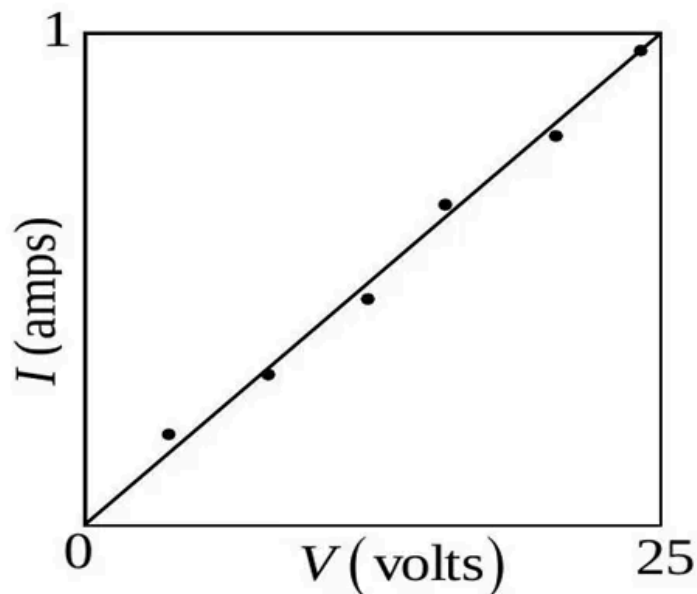
Electronics &gt; "Errors , curve fitting and data analysis"

CSIR NET

2017 June

5M

Both the data points and a linear fit to the current vs voltage of a resistor are shown in the graph below.



If the error in the slope is  $1.255 \times 10^{-3} \Omega^{-1}$ , then the value of resistance estimated from the graph is

1.  $(0.04 \pm 0.8) \Omega$
2.  $(25.0 \pm 0.8) \Omega$
3.  $(25 \pm 1.25) \Omega$
4.  $(25 \pm 0.0125) \Omega$

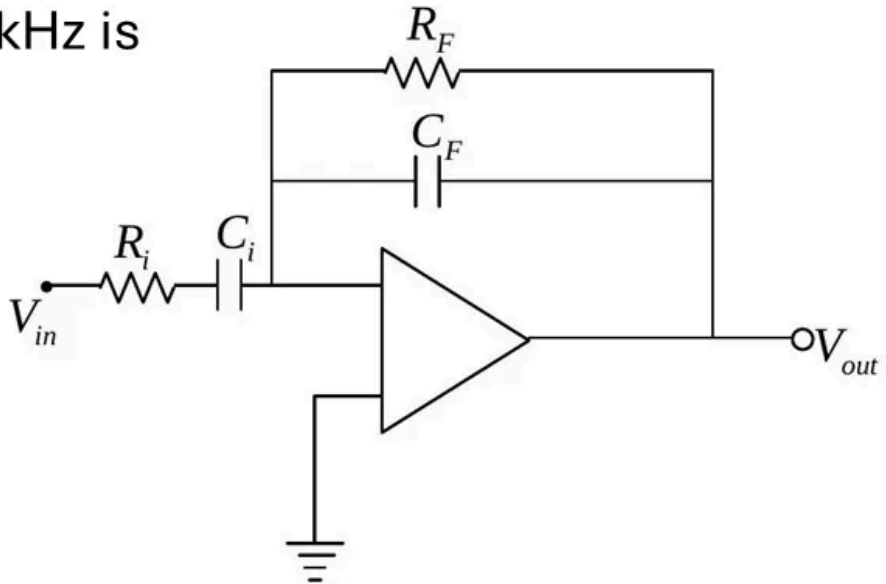
Q66. [June 2017] . 5.0 marks

Electronics &gt; OPAMP

CSIR NET	2017 June	5M
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In the following operational amplifier circuit  $C_{in} = 10nF$ ,  $R_{in} = 20k\Omega$ ,  $R_F = 200k\Omega$  and  $C_F = 100pF$ . The magnitude of the gain at a input signal frequency of 16 kHz is

1. 67
2. 0.15
3. 0.3
4. 3.5



Q67. [June 2017] . 5.0 marks

Atomic and Molecular Physics &gt; Zeeman effect

CSIR NET	2017 June	5M
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An atomic spectral line is observed to split into nine components due to Zeeman shift. If the upper state of the atom is  $^3D_2$  then the lower state will be

1.  $^3F_2$
2.  $^3F_1$
3.  $^3P_1$
4.  $^3P_2$

**Q68. [June 2017] . 5.0 marks**

Atomic and Molecular Physics &gt; Lasers

CSIR NET	2017 June	5M
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If the coefficient of stimulated emission for a particular transition is  $2.1 \times 10^{19} \text{ m}^3 \text{ W}^{-1} \text{ s}^{-3}$  and the emitted photon is at wavelength  $3000 \text{ \AA}$ , then the lifetime of the excited state is approximately

1.  $20 \text{ ns}$
2.  $40 \text{ ns}$
3.  $80 \text{ ns}$
4.  $100 \text{ ns}$

**Q69. [June 2017] . 5.0 marks**

Atomic and Molecular Physics &gt; Xray and alkali spectra

CSIR NET	2017 June	5M
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If the binding energies of the electron in the  $K$  and  $L$  shells of silver atom are  $25.4 \text{ keV}$  and  $3.34 \text{ keV}$ , respectively, then the kinetic energy of the Auger electron will be approximately

1.  $22 \text{ keV}$
2.  $9.3 \text{ keV}$
3.  $10.5 \text{ keV}$
4.  $18.7 \text{ keV}$

**Q70. [June 2017] . 5.0 marks**

Solid State Physics &gt; Semiconductor Physics

CSIR NET	2017 June	5M
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The energy gap and lattice constant of an indirect band gap semiconductor are  $1.875 \text{ eV}$  and  $0.52 \text{ nm}$ , respectively. For simplicity take the dielectric constant of the material to be unity. When it is excited by broadband radiation, an electron initially in the valence band at  $k = 0$  makes a transition to the conduction band. The wavevector of the electron in the conduction band, in terms of the wavevector  $k_{\text{max}}$  at the edge of the Brillouin zone, after the transition is closest to

1.  $k_{\text{max}} / 10$
2.  $k_{\text{max}} / 100$
3.  $k_{\text{max}} / 1000$
4. 0

**Q71. [June 2017] . 5.0 marks**

Solid State Physics &gt; Semiconductor Physics

CSIR NET	2017 June	5M
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The electrical conductivity of copper is approximately 95% of the electrical conductivity of silver, while the electron density in silver is approximately 70% of the electron density in copper. In Drude's model, the approximate ratio  $\tau_{Cu}/\tau_{Ag}$  of the mean collision time in copper ( $\tau_{Cu}$ ) to the mean collision time in silver ( $\tau_{Ag}$ ) is

1. 0.44
2. 1.50
3. 0.33
4. 0.66

**Q72. [June 2017] . 5.0 marks**

Electromagnetism &gt; Electrostatics

CSIR NET	2017 June	5M
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The charge distribution inside a material of conductivity  $\sigma$  and permittivity  $\epsilon$  at initial time  $t = 0$  is  $\rho(r, 0) = \rho_0$ , a constant. At subsequent times  $\rho(r, t)$  is given by

1.  $\rho_0 \exp\left(-\frac{\sigma t}{\epsilon}\right)$
2.  $\frac{1}{2}\rho_0 \left[1 + \exp\left(\frac{\sigma t}{\epsilon}\right)\right]$
3.  $\frac{\rho_0}{\left[1 - \exp\left(\frac{\sigma t}{\epsilon}\right)\right]}$
4.  $\rho_0 \cosh \frac{\sigma t}{\epsilon}$

**Q73. [June 2017] . 5.0 marks**

Nuclear and Particle Physics &gt; Radioactivity

CSIR NET	2017 June	5M
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If in a spontaneous  $\alpha$  - decay of  ${}_{92}^{232}\text{U}$  at rest, the total energy released in the reaction is  $Q$ , then the energy carried by the  $\alpha$ -particle is

1.  $57Q/58$
2.  $Q/57$
3.  $Q/58$
4.  $23Q/58$

**Q74. [June 2017] . 5.0 marks**

Nuclear and Particle Physics &gt; Nuclear forces and Scattering

CSIR NET	2017 June	5M
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The range of the nuclear force between two nucleons due to the exchange of pions is 1.40 fm . If the mass of pion is  $140\text{MeV}/c^2$  and the mass of the rho-meson is  $770\text{MeV}/c^2$ , then the range of the force due to exchange of rho-mesons is

1. 1.40 fm
2. 7.70 fm
3. 0.25 fm
4. 0.18 fm

**Q75. [June 2017] . 5.0 marks**

Nuclear and Particle Physics &gt; Particle physics

CSIR NET	2017 June	5M
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A baryon  $X$  decays by strong interaction as  $X \rightarrow \Sigma^+ + \pi^- + \pi^0$ , where  $\Sigma^+$  is a member of the isotriplet  $(\Sigma^+, \Sigma^0, \Sigma^-)$ . The third component  $I_3$  of the isospin of  $X$  is

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

## Answer Key

75 questions . Subject and topic for quick revision

Q. No	Subject	Topic	Answer
Q1	General Aptitude	Basic Physics	1
Q2	General Aptitude	Reasoning	3
Q3	General Aptitude	Mathematical Analysis	3
Q4	General Aptitude	Basic Physics	2
Q5	General Aptitude	Mathematical Analysis	2
Q6	General Aptitude	Mathematical Analysis	3
Q7	General Aptitude	Data Analysis	2
Q8	General Aptitude	Reasoning	2
Q9	General Aptitude	Mathematical Analysis	1
Q10	General Aptitude	Reasoning	1 or 4
Q11	General Aptitude	Reasoning	3
Q12	General Aptitude	Geometry	4
Q13	General Aptitude	Mathematical Analysis	1
Q14	General Aptitude	Geometry	1
Q15	General Aptitude	Geometry	1
Q16	General Aptitude	Mathematical Analysis	2
Q17	General Aptitude	Basic Physics	3
Q18	General Aptitude	Reasoning	1
Q19	General Aptitude	Reasoning	3
Q20	General Aptitude	Basic Physics	3
Q21	Mathematical Physics	Matrices and Linear Algebra	4
Q22	Mathematical Physics	Complex analysis	2
Q23	Mathematical Physics	Complex analysis	3
Q24	Mathematical Physics	Ordinary Differential Equations	4
Q25	Mathematical Physics	Probability	1
Q26	Classical Mechanics	Lagrangian and Hamiltonian	1
Q27	Classical Mechanics	Special theory of relativity	3
Q28	Classical Mechanics	Basic Mechanics	3
Q29	Classical Mechanics	Oscillations	1
Q30	Quantum Mechanics	Quantum Harmonic Oscillator	2
Q31	Quantum Mechanics	Potential Well	1
Q32	Quantum Mechanics	Perturbation theory	None
Q33	Mathematical Physics	Vector Algebra and Vector Calculus	3
Q34	Electromagnetism	Electrostatics	3
Q35	Electromagnetism	Magnetostatics	4
Q36	Electromagnetism	EM Waves	4
Q37	Electromagnetism	Potential Formulation	3
Q38	Thermodynamics	Thermodynamic relations and maxwell equations	1
Q39	Thermodynamics	Laws of thermodynamics	None
Q40	Statistical Mechanics	Quantum Statistical Mechanics	2

## Answer Key (cont.)

Q. No	Subject	Topic	Answer
Q41	Statistical Mechanics	Microcanonical Ensemble	3
Q42	Electronics	FET	4
Q43	Electronics	OPAMP	4
Q44	Electronics	Flip flops/Counters/Registers/microcontroller etc.	2
Q45	Electronics	"Errors , curve fitting and data analysis"	1
Q46	Mathematical Physics	Green Function	1
Q47	Mathematical Physics	Matrices and Linear Algebra	2
Q48	Mathematical Physics	Numerical Methods	2
Q49	Mathematical Physics	Group Theory	3
Q50	Classical Mechanics	Lagrangian and Hamiltonian	3
Q51	Classical Mechanics	Canonical transformations	4
Q52	Classical Mechanics	Lagrangian and Hamiltonian	2
Q53	Electromagnetism	Radiations	None
Q54	Optics	Interference and diffraction	2
Q55	Electromagnetism	Magetostatics	2
Q56	Quantum Mechanics	Scattering theory	3
Q57	Quantum Mechanics	Pertubation theory	2
Q58	Quantum Mechanics	Variational Principle	2
Q59	Quantum Mechanics	Pertubation theory	1
Q60	Mathematical Physics	Probability	1
Q61	Statistical Mechanics	Quantum Statistical Mechanics	3
Q62	Statistical Mechanics	Ising model	4
Q63	Electronics	Diodes	1
Q64	Electronics	Digital Electronics	3
Q65	Electronics	"Errors , curve fitting and data analysis"	2
Q66	Electronics	OPAMP	4
Q67	Atomic and Molecular Physics	Zeeman effect	3
Q68	Atomic and Molecular Physics	Lasers	3
Q69	Atomic and Molecular Physics	Xray and alkali spectra	4
Q70	Solid State Physics	Semiconductor Physics	3
Q71	Solid State Physics	Semiconductor Physics	4
Q72	Electromagnetism	Electrostatics	1
Q73	Nuclear and Particle Physics	Radioactivity	1
Q74	Nuclear and Particle Physics	Nuclear forces and Scattering	3
Q75	Nuclear and Particle Physics	Particle physics	1

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