

Test Booklet Code & Serial No.

प्रश्नपत्रिका कोड व क्रमांक

B

Paper-II

PHYSICAL SCIENCE

Signature and Name of Invigilator

Seat No.

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(In figures as in Admit Card)

1. (Signature)

(Name)

Seat No.

(In words)

2. (Signature)

(Name)

OMR Sheet No.

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(To be filled by the Candidate)

JAN - 32218

Time Allowed : 1¼ Hours]

[Maximum Marks : 100

Number of Pages in this Booklet : 16

Number of Questions in this Booklet : 50

Instructions for the Candidates

- Write your Seat No. and OMR Sheet No. in the space provided on the top of this page.
- This paper consists of **50** objective type questions. Each question will carry **two** marks. All questions of Paper-II will be compulsory, covering entire syllabus (including all electives, without options).
- At the commencement of examination, the question booklet will be given to the student. In the first 5 minutes, you are requested to open the booklet and compulsorily examine it as follows :
 - To have access to the Question Booklet, tear off the paper seal on the edge of this cover page. Do not accept a booklet without sticker-seal or open booklet.
 - Tally the number of pages and number of questions in the booklet with the information printed on the cover page. Faulty booklets due to missing pages/questions or questions repeated or not in serial order or any other discrepancy should not be accepted and correct booklet should be obtained from the invigilator within the period of 5 minutes. Afterwards, neither the Question Booklet will be replaced nor any extra time will be given. The same may please be noted.**
 - After this verification is over, the OMR Sheet Number should be entered on this Test Booklet.
- Each question has four alternative responses marked (A), (B), (C) and (D). You have to darken the circle as indicated below on the correct response against each item.
Example : where (C) is the correct response.

(A)	(B)	(C)	(D)
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- Your responses to the items are to be indicated in the **OMR Sheet given inside the Booklet only**. If you mark at any place other than in the circle in the OMR Sheet, it will not be evaluated.
- Read instructions given inside carefully.
- Rough Work is to be done at the end of this booklet.
- If you write your Name, Seat Number, Phone Number or put any mark on any part of the OMR Sheet, except for the space allotted for the relevant entries, which may disclose your identity, or use abusive language or employ any other unfair means, you will render yourself liable to disqualification.
- You have to return original OMR Sheet to the invigilator at the end of the examination compulsorily and must not carry it with you outside the Examination Hall. You are, however, allowed to carry the Test Booklet and duplicate copy of OMR Sheet on conclusion of examination.
- Use only Blue/Black Ball point pen.**
- Use of any calculator or log table, etc., is prohibited.**
- There is no negative marking for incorrect answers.**

विद्यार्थ्यांसाठी महत्वाच्या सूचना

- परिक्षार्थींनी आपला आसन क्रमांक या पृष्ठावरील वरच्या कोपऱ्यात लिहावा. तसेच आपणांस दिलेल्या उत्तरपत्रिकेचा क्रमांक त्याखाली लिहावा.
- सदर प्रश्नपत्रिकेत **50** बहुपर्यायी प्रश्न आहेत. प्रत्येक प्रश्नास **दोन** गुण आहेत. या प्रश्नपत्रिकेतील **सर्व** प्रश्न सोडविणे अनिवार्य आहे. सदरचे प्रश्न हे या विषयाच्या संपूर्ण अभ्यासक्रमावर आधारित आहेत.
- परीक्षा सुरू झाल्यावर विद्यार्थ्यांना प्रश्नपत्रिका दिली जाईल. सुरुवातीच्या 5 मिनीटांमध्ये आपण सदर प्रश्नपत्रिका उघडून खालील बाबी अवश्य तपासून पहाव्यात.
 - प्रश्नपत्रिका उघडण्यासाठी प्रश्नपत्रिकेवर लावलेले सील उघडावे. सील नसलेली किंवा सील उघडलेली प्रश्नपत्रिका स्विकारू नये.
 - पहिल्या पृष्ठावर नमूद केल्याप्रमाणे प्रश्नपत्रिकेची एकूण पृष्ठे तसेच प्रश्नपत्रिकेतील एकूण प्रश्नांची संख्या पडताळून पहावी. पृष्ठे कमी असलेली/कमी प्रश्न असलेली/प्रश्नांचा चुकीचा क्रम असलेली किंवा इतर त्रुटी असलेली सदोष प्रश्नपत्रिका सुरुवातीच्या 5 मिनिटातच पर्यवेक्षकाला परत देऊन दुसरी प्रश्नपत्रिका मागवून घ्यावी. त्यानंतर प्रश्नपत्रिका बदलून मिळणार नाही तसेच वेळी वाढवून मिळणार नाही याची कृपया विद्यार्थ्यांनी नोंद घ्यावी.
 - वरीलप्रमाणे सर्व पडताळून पहिल्यानंतरच प्रश्नपत्रिकेवर ओ.एम.आर. उत्तरपत्रिकेचा नंबर लिहावा.
- प्रत्येक प्रश्नासाठी (A), (B), (C) आणि (D) अशी चार विकल्प उत्तरे दिली आहेत. त्यातील योग्य उत्तराचा रकाना खाली दर्शविल्याप्रमाणे ठळकपणे काळ/निळ्या करावा.
उदा. : जर (C) हे योग्य उत्तर असेल तर.

(A)	(B)	(C)	(D)
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- या प्रश्नपत्रिकेतील प्रश्नांची उत्तरे **ओ.एम.आर. उत्तरपत्रिकेतच दर्शवावीत**. इतर ठिकाणी लिहीलेली उत्तरे तपासली जाणार नाहीत.
- आत दिलेल्या सूचना काळजीपूर्वक वाचाव्यात.
- प्रश्नपत्रिकेच्या शेवटी जोडलेल्या कोऱ्या पानावरच कच्चे काम करावे.
- जर आपण ओ.एम.आर. वर नमूद केलेल्या ठिकाणा व्यतिरिक्त इतर कोठेही नाव, आसन क्रमांक, फोन नंबर किंवा ओळख पटेल अशी कोणतीही खूण केलेली आढळून आल्यास अथवा असभ्य भाषेचा वापर किंवा इतर गैरमार्गाचा अवलंब केल्यास विद्यार्थ्याला परीक्षेस अपात्र ठरविण्यात येईल.
- परीक्षा संपल्यानंतर विद्यार्थ्यांनी मूळ ओ.एम.आर. उत्तरपत्रिका पर्यवेक्षकांकडे परत करणे आवश्यक आहे. तथापी, प्रश्नपत्रिका व ओ.एम.आर. उत्तरपत्रिकेची द्वितीय प्रत आपल्याबरोबर नेण्यास विद्यार्थ्यांना परवानगी आहे.
- फक्त निळ्या किंवा काळ्या बॉल पेनचाच वापर करावा.**
- कॅल्क्युलेटर किंवा लॉग टेबल वापरण्यास परवानगी नाही.**
- चुकीच्या उत्तरासाठी गुण कपात केली जाणार नाही.**

JAN - 32218/II—B



JAN - 32218/II—B

Physical Science

Paper II

Time Allowed : 75 Minutes]

[Maximum Marks : 100

Note : This Paper contains **Fifty (50)** multiple choice questions. Each question carries **Two (2)** marks. Attempt *All* questions.

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|--|--|
| <p>1. A circular loop of radius r is placed in a magnetic field $\vec{B}(t) = B_0 e^{-\alpha t} \hat{z}$, B_0 is constant. If the loop is in xy plane, then the induced emf in the loop is :</p> <p>(A) Zero</p> <p>(B) $\pi r^2 \alpha B_0 e^{-\alpha t}$</p> <p>(C) $2\pi r B_0 e^{-\alpha t}$</p> <p>(D) $2\pi r \alpha B_0 e^{-\alpha t}$</p> | <p>3. Under the Lorentz gauge condition, the electric potential V, is related to magnetic vector potential $\vec{A}$ as :</p> <p>(A) $\vec{\nabla} \cdot \vec{A} + (1/\mu_0 \epsilon_0) \frac{\partial V}{\partial t} = 0$</p> <p>(B) $\vec{\nabla} \cdot \vec{A} + \mu_0 \epsilon_0 \frac{\partial V}{\partial t} = 0$</p> <p>(C) $-\vec{\nabla} \cdot \vec{A} - (1/\mu_0 \epsilon_0) \frac{\partial^2 V}{\partial t^2} = 0$</p> <p>(D) $\vec{\nabla} \cdot \vec{A} - \mu_0 \epsilon_0 \frac{\partial V}{\partial t} = 0$</p> |
| <p>2. Plane monochromatic electromagnetic wave is propagating through a conducting material of refractive index $n + ik$. The phase difference between the fields $\vec{E}$ and $\vec{B}$ associated with the wave is :</p> <p>(A) $\tan^{-1}(n)$</p> <p>(B) $\tan^{-1}(k)$</p> <p>(C) $\tan^{-1}(nk)$</p> <p>(D) $\tan^{-1}(n/k)$</p> | <p>4. A point charge 'q' having mass 'm' follows a circular trajectory of radius 'R' under the action of magnetic field $\vec{B}$. The magnitude of the angular momentum of the particle is :</p> <p>(A) Zero</p> <p>(B) $Bq^2 R^2$</p> <p>(C) $Bmq^2 R^2$</p> <p>(D) BqR^2</p> |

JAN - 32218/II—B

5. If 'A₁' and 'A₂' are the amplitudes of two electromagnetic waves (same frequency) coming from two slits in Young's double slit experiment, then the maximum intensity of interference fringe is :

- (A) A₁ + A₂
- (B) A₁² + A₂²
- (C) (A₁ + A₂)²
- (D) $\sqrt{A_1^2 + A_2^2}$

6. Given $[x_i, p_j] = i\hbar\delta_{ij}$, $i, j = 1, 2, 3$, $[x_1, p_1^3]$ is :

- (A) $(i\hbar)^3 p_1$
- (B) $i\hbar^2 p_1$
- (C) $3i\hbar p_1^2$
- (D) Zero

7. Which of the following is *not* an eigenstate of linear momentum operator px ?

- (A) Ae^{ikx}
- (B) Ae^{-ikx}
- (C) Ae^{-x}
- (D) $A \sin kx$

8. The electron in a hydrogen atom is in a superposition state described by the wave function

$$\psi(\vec{r}) = \frac{1}{6} [4\psi_{100}(\vec{r}) - 2\psi_{211}(\vec{r}) + \sqrt{6}\psi_{210}(\vec{r}) - \sqrt{10}\psi_{21-1}(\vec{r})],$$

where $\psi_{nem}(\vec{r})$ is a normalized eigenstate. The expectation value of L_z is :

- (A) $-\hbar/6$
- (B) $\hbar/6$
- (C) $6\hbar$
- (D) $-6\hbar$

JAN - 32218/II—B

9. Two coherent light sources of intensities I and $9I$ are used in an interference experiment. The resultant intensity at points where the waves from the two sources superpose with a phase difference zero is :

- (A) $16I$
- (B) $9I$
- (C) I
- (D) Zero

10. The number of distinct (n, l, m_l) states of hydrogen atom with $n = 3$ is :

- (A) 5
- (B) 9
- (C) 3
- (D) 2

11. The condition for two distinct quantum mechanical states, represented by wave functions $\psi_1(x)$ and $\psi_2(x)$ respectively, to be orthogonal is :

(A) $\int_{-\infty}^{\infty} \psi_1^*(x)\psi_2(x) dx = 1$

(B) $\int_{-\infty}^{\infty} \psi_1^*(x)\psi_2(x) dx = 0$

(C) $\int_{-\infty}^{\infty} \psi_1^*(x)\psi_2(x) dx = \infty$

(D) $\int_{-\infty}^{\infty} [\psi_1^*(x)\psi_2(x) + \psi_2^*(x)\psi_1(x)] dx = 1$

12. Addition of angular momentum states $\vec{j}_1 = 1/2$ and $\vec{j}_2 = 1/2$ will result in 4 states, of which number of linearly dependent states with magnetic quantum number $m = 0$ is :

- (A) Zero
- (B) 1
- (C) 2
- (D) 4

JAN - 32218/II—B

13. In the Born approximation, the effective cross-section of scattering depends :

- (A) Linearly on scattering angle θ
- (B) on $p \sin^2 \theta$
- (C) on $p \sin \theta/2$
- (D) only on the momentum p

14. A system consists of two indistinguishable fermions. Each particle can occupy only two energy levels $E_1 = \epsilon$ and $E_2 = 2\epsilon$. The canonical partition function is :

- (A) $Z = e^{-\beta\epsilon} + e^{-2\beta\epsilon}$
- (B) $Z = e^{-3\beta\epsilon}$
- (C) $Z = 3e^{-\beta\epsilon}$
- (D) $Z = e^{-\beta\epsilon} + 2e^{-2\beta\epsilon}$

15. Consider 5 independent magnetic moments. Each moment has only two directions $+m$ and $-m$. Hamiltonian of such system is given by

$x = \sum_{i=1}^5 m_i$. If the total magnetization of the system is equal to m , the entropy is equal to :

- (A) $k \ln(10)$
- (B) Zero
- (C) $k \ln(20)$
- (D) $k \ln(5)$

16. Let $\mathcal{F}(T, l)$ be the tension in a rubber band of length l , T being the absolute temperature. Let F denote Helmholtz free energy and S the entropy. Then :

- (A) $\left. \frac{\partial F}{\partial l} \right|_T = S, \left. \frac{\partial F}{\partial T} \right|_l = f$
- (B) $\left. \frac{\partial F}{\partial l} \right|_T = f, \left. \frac{\partial F}{\partial T} \right|_l = -S$
- (C) $\left. \frac{\partial F}{\partial l} \right|_T = Sl, \left. \frac{\partial F}{\partial T} \right|_l = fl$
- (D) $\left. \frac{\partial F}{\partial l} \right|_T = 0, \left. \frac{\partial F}{\partial T} \right|_l = f$

JAN - 32218/II—B

17. An insulated chamber is divided into two halves of volume. The left half contains an ideal gas at temperature T_0 and the right half is evacuated. A small hole is opened between the two halves, allowing the gas to flow through and the system comes to equilibrium. No heat is exchanged with walls. What is the final temperature of the system :
- (A) $2T_0$
- (B) $\frac{3}{2}T_0$
- (C) T_0
- (D) $\frac{1}{2}T_0$
18. Consider a mixture of equal number of non-interacting single atomic gas and diatomic gas. The internal energy per particle is given by :
- (A) $2kT$
- (B) $4kT$
- (C) $\frac{3}{2}kT$
- (D) $\frac{5}{2}kT$
19. Consider an ensemble of systems having only two energy levels having energies 0 and ϵ respectively. The average energy of the system at temperature T is :
- (A) $\frac{\epsilon}{e^{-\epsilon/kT} + 1}$
- (B) $\frac{\epsilon}{e^{\epsilon/kT} + 1}$
- (C) $\frac{\epsilon}{e^{-\epsilon/kT} - 1}$
- (D) $\frac{\epsilon}{e^{\epsilon/kT} - 1}$
20. What play the role of thermodynamic potential in micro-canonical ensemble ?
- (A) Entropy
- (B) Enthalpy
- (C) Gibbs potential
- (D) Internal energy

JAN - 32218/II—B

21. For a metal $C_V = \alpha T + \beta T^3$ at low temperatures. The entropy is :
- (A) $\alpha + 3\beta T^2$
 (B) $\alpha T + 3\beta T^2$
 (C) $\alpha T + \frac{\beta T^3}{3}$
 (D) $\alpha + \frac{\beta T^3}{3}$
22. In which of the following detectors P-N junction diode is used ?
- (A) G.M. Counter
 (B) Scintillation detector
 (C) Surface Barrier detector
 (D) Proportional counter
23. The X-rays emitted by a target consist of continuous range of wavelengths superimposed by characteristic X-rays named K_α , K_β etc. It is found that :
- (A) K_α has high intensity and lower wavelength compared to that of K_β .
 (B) K_α has low intensity and lower wavelength as compared to that of K_β .
 (C) K_α has high intensity and higher wavelength compared to that of K_β .
 (D) K_α has lower intensity and higher wavelength compared to that of K_β .
24. Air Ballast valve in a rotary pump is used for :
- (A) Reducing the noise
 (B) Removing the condensable vapors
 (C) Reducing the back streaming
 (D) Increasing the ultimate vacuum to 10^{-5} Torr
25. A signal of one μV is buried under 1V RMS noise. Which of the following devices is suitable to detect it ?
- (A) High gain linear amplifier
 (B) Band pass filter
 (C) Notch filter
 (D) Phase sensitive amplifier

JAN - 32218/II—B

26. Steady state response of an electric circuit is generally tested by giving following waveform at the input :
- (A) Sinusoidal
- (B) Square
- (C) Triangular
- (D) Swatooth
27. An inductance 'L', resistance 'R' and capacitance 'C' are connected in series to resonate to frequency " f_s ". When they are connected in parallel, the resonance frequency is " f_p ".
- (A) $f_p < f_s$
- (B) $f_p > f_s$
- (C) $f_p = f_s$
- (D) There is no relation between the two
28. Frequency Bandwidth of CRO is decided by :
- (A) Horizontal amplifier
- (B) Vertical amplifier
- (C) Delay line
- (D) Triggering circuit
29. Resolving power of a 2 cm^2 site grating having a rulings of 600 l/mm in order one is approximately :
- (A) 10
- (B) 10^2
- (C) 10^3
- (D) 10^4
30. A dual slope digital voltmeter has a gate time of 400 ms reflecting the measurement cycle. The frequency bandwidth of this instrument is :
- (A) 2.5 Hz
- (B) 1.25 Hz
- (C) 0.8 Hz
- (D) 0.6 Hz

JAN - 32218/II—B

31. Value of $\oint_c \frac{dz}{(z+2)}$, $c : |z| = 1$

is :

(A) πi

(B) zero

(C) $2\pi i$

(D) $-2\pi i$

32. The inverse Fourier transform of

$e^{-|k|}$ is :

(A) $\frac{1}{\pi} \frac{1}{1+x^2}$

(B) e^{-x^2}

(C) $e^{-|x|}$

(D) $\frac{1}{1+x}$

33. Two unbiased dice are thrown. The probability that both dice show the same number is :

(A) $\frac{1}{3}$

(B) $\frac{11}{36}$

(C) $\frac{1}{6}$

(D) $\frac{1}{36}$

34. Eigen values of a nilpotent matrix

A, i.e., a matrix satisfying $A^K = 0$

for some integer K are :

(A) Real and distinct

(B) Zero

(C) Purely imaginary

(D) Real and negative

JAN - 32218/II—B

35. Residue of $\cot(z)$ at $z = 0$ is :

- (A) $\frac{1}{2}$
 (B) 0
 (C) 2
 (D) 1

36. Trace of a 3×3 matrix is 6. Two of its eigen values are 1 and 2. The third eigen value is :

- (A) 1
 (B) 2
 (C) 3
 (D) 6

37. $\frac{d^2 f}{dx^2} + 2 \operatorname{sech}^2 x f - f = 0$.

One of the solution is :

- (A) $\operatorname{sech} x$
 (B) $\operatorname{sech}^2 x$
 (C) $\tanh x$
 (D) $\operatorname{sech}^3 x$

38. The average of function $f(x) = \sin x$ in the interval 0 to π is :

- (A) $1/2$
 (B) $2/\pi$
 (C) $1/\pi$
 (D) $4/\pi$

39. If $r^2 = x^2 + y^2 + z^2$, $\operatorname{grad} r^n$ is :

- (A) 0
 (B) $r^{n-1} \vec{r}$
 (C) $nr^{n-2} \vec{r}$
 (D) $n(n-2)r^n \vec{r}$

40. A simple pendulum of mass m and length l oscillates with a frequency ω_0 . A piece breaks off from the pendulum and the mass is reduced to $m/2$. The frequency of oscillation ω then becomes :

- (A) $\omega = 2\omega_0$
 (B) $\omega = \omega_0/2$
 (C) $\omega = \omega_0$
 (D) $\omega_0 = \sqrt{2}\omega_0$

JAN - 32218/II—B

41. A propagating wave is reflected at a barrier. The phase of the wave changes in the act of reflection by :
- (A) $\pi/2$
- (B) zero
- (C) π
- (D) $-\pi/2$
42. Two particles of mass m_1 and m_2 and charge q_1 and q_2 respectively are constrained to move in a straight line along x -axis. The Lagrangian of the system (in esu) is :
- (A) $\frac{1}{2} m_1 \dot{x}_1^2 + \frac{1}{2} m_2 \dot{x}_2^2 + q_1 q_2 / |x_1 - x_2|$
- (B) $\frac{1}{2} m_1 \dot{x}_1^2 + \frac{1}{2} m_2 \dot{x}_2^2 - q_1 q_2 / |x_1 - x_2|$
- (C) $-\frac{1}{2} m_1 \dot{x}_1^2 - \frac{1}{2} m_2 \dot{x}_2^2 - q_1 q_2 / |x_1 - x_2|$
- (D) $-\frac{1}{2} m_1 \dot{x}_1^2 - \frac{1}{2} m_2 \dot{x}_2^2 + q_1 q_2 / |x_1 - x_2|$
43. Time-order of two events can be changed by making a Lorentz transformation only if they occur in :
- (A) Time-like region
- (B) Space-like region
- (C) Light-like region
- (D) Speed of light can be exceeded
44. A satellite is moving around the earth in a circular orbit at a height of $2R$, from the earth surface. R is the radius of the earth. The speed of satellite is :
- (A) $gR/3$
- (B) $(gR/2)^{1/2}$
- (C) $(gR/3)^{1/2}$
- (D) $gR/2$

JAN - 32218/II—B

45. Virial theorem is expressed as

$$\left\langle \sum_{\alpha} p_{\alpha} \cdot \dot{\gamma}_{\alpha} \right\rangle = - \left\langle \sum_{\alpha} \dot{p}_{\alpha} \cdot \gamma_{\alpha} \right\rangle$$

The theorem is valid, if :

(A) γ_{α} is bounded (remain finite over all values of time)

(B) p_{α} is bounded

(C) both γ_{α} and p_{α} are bounded

(D) γ_{α} is unbounded

46. Electron and positron annihilate and produce a single photon only when :

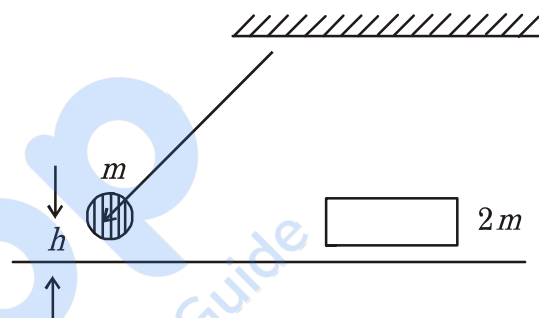
(A) Electron and positron are at rest

(B) Electron is at rest

(C) Positron is at rest

(D) At least one particle is in a bound state

47. As shown in the figure a ball of mass m suspended by an inextensible massless string is released from height h and collides elastically when it is at its lowest point with a block of mass $2m$ at rest on a frictionless surface. After the collision the ball will rise to a total height equal to :



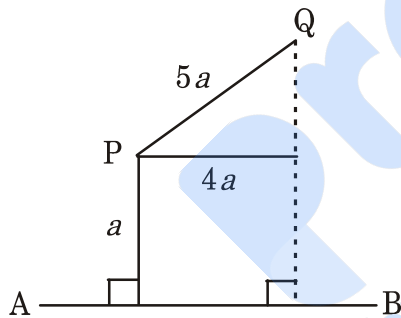
- (A) $h/9$
(B) $h/8$
(C) $h/3$
(D) $2h/3$

48. Uniformly charged solid sphere of radius R has a volume charge density ρ . The strength of electric field, at a distance r , ($r > R$), from its centre is :

- (A) $\frac{\rho r^3}{3 \epsilon_0 R^2}$
(B) $\frac{\rho R^3}{3 \epsilon_0 r^2}$
(C) $\frac{\rho R^3}{3 \epsilon_0 r}$
(D) $\frac{\rho r^3}{3 \epsilon_0 R}$

JAN - 32218/II—B

49. Consider the figure shown. AB is an infinite, uniform line charge distribution ' λ '. P and Q are two points as shown in the figure. The ratio of strength of electric fields at P and Q; *i.e.*, E_P/E_Q is :



(fig. not to the scale)

- (A) 3 : 1
(B) 1 : 3
(C) 4 : 1
(D) 1 : 4

50. Points P and Q are at a distance of 10 cm and 20 cm respectively from the ideal magnetic dipole. The ratio of magnitude of vector potential at point P to that at point Q is :

- (A) 4
(B) 8
(C) $1/4$
(D) $1/8$

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