

Test Booklet Code & No.

प्रश्नपत्रिका कोड व क्र.

A**Paper-II****PHYSICAL SCIENCE****Signature and Name of Invigilator**

Seat No.

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1. (Signature)

(In figures as in Admit Card)

(Name)

Seat No.

2. (Signature)

(In words)

(Name)

OMR Sheet No.

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(To be filled by the Candidate)

MAY - 32216**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 घ्याव्यात.
 - 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 घ्यावी. 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 वेळही 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/निळ करवा.
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 पटले अशी कोणतीही खूण केलेली आढळून आल्यास अथवा असभ्य भाषेचा वापर किंवा इतर गैरमागाचा अवलंब केल्यास विद्यार्थ्यांना 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.**
- कॅलक्युलेटर किंवा लॉग टेबल वापरण्यास परवानगी नाही.**
- चुकीच्या उत्तरासाठी गुण कपात केली जाणार नाही.**

MAY - 32216/II—A

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.

1. The value of the integral

$$\int_{-\infty}^{\infty} \frac{\sin^2 x}{x^2} dx$$

is :

(A) $\frac{\pi^2}{2}$

(B) 0

(C) $\frac{\pi^2}{9}$

(D) 2π

2. The Fourier transform of a Gaussian function is of the form :

(A) Exponential

(B) Lorentzian

(C) Gaussian

(D) Screened coulomb

3. The real part of $\log (3 + 4i)$ is :

(A) $\log 2$

(B) $\log 3$

(C) $\log 4$

(D) $\log 5$

4. Particular integral of the first order linear differential equation

$$\frac{dy}{dx} = x + y$$

is given by :

(A) $y(x) = -x - 1$

(B) $y(x) = x + 1$

(C) $y(x) = x - 1$

(D) $y(x) = -x + 1$

5. Eigenvalues of the matrix

$$\begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix}$$

are :

- (A) 1, -1
 (B) -1, -i
 (C) i, -i
 (D) 1 + i, 1 - i

6. $\nabla \left(\frac{1}{|\vec{r}|} \right)$ is given by :

- (A) $\frac{1}{r} \hat{r}$
 (B) $\frac{1}{r^3} (\hat{i} + \hat{j} + \hat{k})$
 (C) $\frac{\vec{r}}{r^3}$
 (D) $r(\hat{i} - \hat{j} - \hat{k})$

7. If a coin is tossed four times, what is the probability that two heads and two tails will result ?

- (A) $\frac{3}{8}$
 (B) $\frac{1}{2}$
 (C) $\frac{5}{8}$
 (D) $\frac{3}{4}$

8. Which of the following defines a conservative force ?

- (A) $\vec{\nabla} \cdot \vec{F} = 0$
 (B) $\vec{\nabla} \times \vec{F} = 0$
 (C) $\oint \vec{F} \cdot d\vec{r} = 0$
 (D) $\frac{d\vec{F}}{dt} = 0$

9. Consider the three vectors :

$$\vec{a} = \hat{i} + \hat{j} + \hat{k}$$

$$\vec{b} = \hat{i} - \hat{j} + \hat{k} \text{ and}$$

$$\vec{c} = \hat{i} - \hat{j} - \hat{k}$$

Which of the following statements is true ?

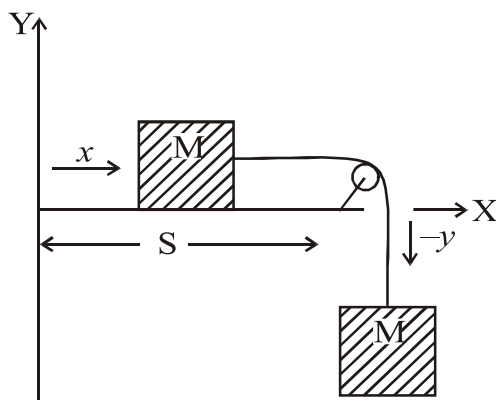
- (A) $\vec{a}, \vec{b}, \vec{c}$ are linearly independent
- (B) \vec{a}, \vec{b} are linearly dependent
- (C) \vec{b}, \vec{c} are at right angles to each other
- (D) \vec{a} and \vec{c} are parallel
10. The moment of inertia of a thin disc of radius R about an axis passing through its center and perpendicular to the plane of the disc is :
- (A) MR^2
- (B) $\frac{2}{3}MR^2$
- (C) $\frac{3}{2}MR^2$
- (D) $\frac{1}{2}MR^2$

11. A thin rigid rod of length ' l ' is moving inside a sphere of radius R ($R > l$) such that both of its ends are in contact with the inner surface of the sphere. The degree of freedom of the rod are :

- (A) Four
- (B) Three
- (C) Two
- (D) One

12. For a system shown in figure given below, the Lagrangian function is given by :

$$(V = 0, \text{ at } y = 0)$$



- (A) $L = M\dot{y}^2 + Mgy$
- (B) $L = \frac{1}{2}M\dot{y}^2 + Mgy$
- (C) $L = \frac{1}{2}M\dot{y}^2 - Mg(y - x)$
- (D) $L = M\dot{y}^2 + Mg(y - x)$

13. “Hamiltonian H is not equal to the total energy E (sum of kinetic and potential energies)” holds true for a system characterized with :
- (A) conservative forces and time-independent constraints
- (B) conservative forces and time-dependent constraints
- (C) dissipative forces and time-independent constraints
- (D) for every system irrespective of the nature of forces and constraints
14. A particle moves under the action of force $\vec{F} = -\frac{1}{r^n}\hat{r}$. The particle moves in a closed orbit, if :
- (A) $n = -1$ or $n = 2$
- (B) $n = 1$ or $n = -2$
- (C) $n = -1$ or $n = -2$
- (D) $n = 1$ or $n = 2$
15. Which of the following statements holds *true* for a freely rotating rigid body ?
- (A) $\vec{\omega}$ and $\frac{d\vec{L}}{dt}$ are perpendicular to each other
- (B) $\vec{\omega}$ and $\frac{d\vec{L}}{dt}$ are parallel to each other
- (C) $\vec{\omega}$ and $\frac{d\vec{L}}{dt}$ are antiparallel to each other
- (D) $\vec{\omega}$ and $\frac{d\vec{L}}{dt}$ do not have 0 specific relationship
16. A particle is at rest in a rotating frame of reference. The pseudoforce(s) acting on the particle is(are) :
- (A) None of these
- (B) Only the Coriolis force
- (C) Only the centrifugal force
- (D) Both the centrifugal and Coriolis forces

17. The electric field of an electromagnetic wave propagating in the free space is given by :

$$\vec{E}(r, t) = E_0 \hat{z} \cos [200\sqrt{3}\pi x - 200\pi y - \omega t]$$

Then the wave vector \vec{k} is given by :

(A) $200\frac{\sqrt{3}}{2}\pi\hat{x} - 200\pi\hat{y}$

(B) $400\pi\left[\frac{\sqrt{3}}{2}\hat{x} - \frac{1}{2}\hat{y}\right]$

(C) $200\sqrt{3}\pi\hat{x}$

(D) $-200\pi\hat{y}$

18. The Ampere's law in the case of free space takes the form :

(A) $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$

(B) $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \epsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t}$

(C) $\vec{\nabla} \times \vec{B} = \epsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t}$

(D) $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} - \epsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t}$

19. An electric charge +Q is placed at the center of a cube of sides 10 cm. The electric flux emanating from each of the face of the cube is :

(A) $\frac{Q}{\epsilon_0}$

(B) $\frac{Q}{10\epsilon_0}$

(C) $\frac{Q}{6\epsilon_0}$

(D) $\frac{10Q}{\epsilon_0}$

20. A field at certain point in the space is expressed as the potential function $V = 3x^2z - xy^3 + z$. Then the potential V at point (2, -1, 1) is :

(A) 15 V

(B) 13 V

(C) 0 V

(D) 8 V

21. The electric displacement vector at the interface of two dielectric media with unit normal vector \hat{n}_{12} from medium 1 to 2 and free surface charge density δ_s is given by :

(A) $\hat{n}_{12} \times (\vec{D}_2 + \vec{D}_1) = \delta_s / \epsilon_0$
 (B) $(\vec{D}_2 - \vec{D}_1) \times \hat{n}_{12} = \delta_s / \epsilon_0$
 (C) $(\vec{D}_2 - \vec{D}_1) \cdot \hat{n}_{12} = \delta_s / \epsilon_0$
 (D) $(\vec{D}_2 - \vec{D}_1) \cdot \hat{n}_{12} = \delta_s / \epsilon_0$

22. A plane polarized EM wave of frequency ω is incident at an angle θ in a rectangular wave guide of resonant frequency ω_{mn} . Then energy carried by the wave propagating inside the cavity will propagate with the group velocity of :

(A) $\frac{c}{\sqrt{1 - \left(\frac{\omega_{mn}}{\omega}\right)^2}}$
 (B) $c\sqrt{1 - \frac{\omega_{mn}}{\omega}}$
 (C) $\frac{c}{\sqrt{1 - \left(\frac{\omega_{mn}}{\omega}\right)^2}}$
 (D) $c\sqrt{1 - \left(\frac{\omega_{mn}}{\omega}\right)^2}$

23. A plane polarized electromagnetic wave is incident normally on an interface separating two dielectrics with intrinsic impedance equal to z_1 and z_2 . The reflection and transmission (Fresnel's) coefficients (R and T), respectively, are given as :

(A) $\frac{2z_2}{z_1 + z_2}$ and $\frac{z_2 - z_1}{z_1 + z_2}$
 (B) $\frac{z_2 - z_1}{z_1 + z_2}$ and $\frac{z_2}{z_1 + z_2}$
 (C) $\frac{z_2 - z_1}{z_1 + z_2}$ and $\frac{2z_2}{z_1 + z_2}$
 (D) $\frac{2z_2}{z_1 + z_2}$ and $\frac{z_1 + z_2}{z_1 - z_2}$

24. If the divergence of a vector potential at a point $(\vec{\nabla} \cdot \vec{A})$ in the fluid is non-zero and takes positive value, then which of the following is correct ?

- (A) The fluid is expanding
 (B) The fluid density is decreasing with time
 (C) The point acts as a source of fluid
 (D) Statements (A), (B) and (C) all are correct

25. The electric field of an electromagnetic wave is described by the relation :

$$\vec{E}(r, t) = (\hat{e}_1 E_1 + \hat{e}_2 E_2) \cdot e^{i(\vec{k} \cdot \vec{r} - \omega t)}$$

where \hat{e}_1 and \hat{e}_2 are two mutually orthogonal unit vectors both perpendicular to \vec{k} ; E_1 and E_2 are the electric field components along the two directions. What type of polarization state does this wave represent ?

- (A) Plane polarized
- (B) Left circularly polarized
- (C) Right circularly polarized
- (D) Elliptically polarized

26. A harmonic oscillator is perturbed by a perturbation potential αx^3 . The ground state energy of the oscillator to a first order in perturbation is :

- (A) $\hbar \frac{\omega}{2}$
- (B) $\hbar \frac{\omega}{2} + \alpha$
- (C) $\frac{3}{2} \hbar \omega + \alpha$
- (D) $\frac{\hbar \omega}{2} + \alpha^3$

27. The value of operator $\vec{r} \cdot \vec{p} - \vec{p} \cdot \vec{r}$ in quantum mechanics is :

- (A) $i\hbar$
- (B) zero
- (C) $3 i\hbar$
- (D) $\left(\frac{\partial}{\partial x} + \frac{\partial}{\partial y} + \frac{\partial}{\partial z} \right)$

28. a and a^+ are annihilation and creation operators for one dimensional harmonic oscillator. Then $aa^+a^+a|n\rangle$ equals :
- (A) $n^2|n\rangle$
 (B) $(n+1)^2|n\rangle$
 (C) $n(n+1)|n\rangle$
 (D) $\sqrt{n(n+1)}|n\rangle$
29. The ground state energy shift due to a non-zero perturbing potential is zero in first order perturbation. Which of the following is *correct* ?
- (A) $\Delta E > 0$ in second order perturbation
 (B) $\Delta E = 0$ in second order perturbation
 (C) $\Delta E < 0$ in second order perturbation
 (D) $\Delta E = 0$ in all orders of perturbation
30. The parity of wave function ψ is associated with which of the following transformation ?
- (A) Space inversion
 (B) Space translation
 (C) Space rotation
 (D) Space exchange of two particles
31. What is the degeneracy of the third excited state for a particle in 3-dimensional isotropic Harmonic oscillator potential. (Ground state is not an excited state) :
- (A) 10
 (B) 6
 (C) 4
 (D) 3

32. The eigenvalues of a Hermitian operator must be :

- (A) Real
- (B) Complex
- (C) Positive
- (D) Negative

33. In quantum mechanics three-dimensional normalized wave function $\psi(r)$ of a particle :

- (A) is dimensionless
- (B) has dimension of (energy \times time)
- (C) has dimension of energy
- (D) has dimension of (length)^{-3/2}

34. Particles with energy $E > V_0$ are incident from side with negative x , on step potential $V = 0$ for $x < 0$ and $V = V_0$ for $x > 0$.

The wave function is given by :

$$\begin{aligned}\psi(x) &= Ae^{ik_1x} + Be^{-ik_1x} \quad x < 0 \\ &= Ce^{ik_2x} + De^{-ik_2x} \quad x > 0\end{aligned}$$

Then :

- (A) Reflection coefficient $R = 0$
- (B) Transmission coefficient

$$T = \frac{C^*C}{A^*A}$$

- (C) Transmission coefficient

$$T = \frac{C^*C + D^*D}{A^*A + B^*B}$$

- (D) Reflection coefficient = $\frac{B^*B}{A^*A}$

35. A constant volume ideal gas thermometer is in thermal equilibrium with a system A at temperature T_A and measures a pressure p_A . When the same thermometer is brought in thermal equilibrium with another system B, the measured pressure is $2p_A$. The temperature of the system B is :
- (A) T_A
 (B) $T_A/2$
 (C) $2T_A$
 (D) $T_A/\sqrt{2}$
36. Consider a process in which the volume of the system remains constant and the system is in thermal equilibrium with a heat reservoir at temperature T. Such a process is called :
- (A) isothermal
 (B) isobaric isothermal
 (C) isochoric adiabatic
 (D) isochoric isothermal
37. A Carnot engine operates between 600 K and 300 K with ideal gas as working medium. Its maximum efficiency will be :
- (A) 0.5
 (B) 0.8
 (C) 1.2
 (D) 1
38. A gaseous sytem of volume V is at pressure p and temperature T. A small change ΔV is made in the volume. If ΔQ is the change in the heat content of the system, the change Δu in the internal energy is given by :
- (A) $\Delta u = p\Delta V + \Delta Q$
 (B) $\Delta u = p\Delta V - \Delta Q$
 (C) $\Delta u = -p\Delta V + \Delta Q$
 (D) $\Delta u = -p\Delta V - \Delta Q$

39. The chemical potential, in the classical limit is :

- (A) zero
- (B) negative
- (C) positive
- (D) complex quantity

40. The partition function z_{ij} of two independent systems i and j in thermal equilibrium with a reservoir at temperature T is given by :

- (A) $z_{ij} = z_i \times z_j$
- (B) $z_{ij} = z_i + z_j$
- (C) $z_{ij} = z_i^{z_j}$
- (D) $z_{ij} = z_i/z_j$

41. Considering the Maxwell-Boltzmann distribution of speeds of molecules, the root mean square speed of a molecular of mass m , at temperature T is :

- (A) $\sqrt{\frac{3kT}{m}}$
- (B) $\sqrt{\frac{8kT}{\pi m}}$
- (C) 0
- (D) $\sqrt{\frac{2kT}{m}}$

42. The number of distinct arrangements of 6 Bosons placed in 3 energy states are :

- (A) 84
- (B) 28
- (C) 56
- (D) 3^6

43. TTL output of the function generator is :
- (A) Triangular wave
 - (B) Sine wave
 - (C) Square wave
 - (D) Triangular, sine and square waves
44. In an experiment, the voltage across a $10\text{ k}\Omega$ resistor is applied to CRO. The screen shows a sinusoidal signal of total vertical occupancy 3 cm and total horizontal occupancy of 2 cm. The front-panel controls of V/div and time/div are on 2 V/div and 2 ms/div respectively. Calculate the rms value of the voltage across the resistor :
- (A) +3 V
 - (B) -2.1213 V
 - (C) +2.1213 V
 - (D) -3 V
45. When two rotary pumps are connected in parallel to a vacuum chamber, the ultimate pressure can be achieved is closest to :
- (A) 1×10^{-3} torr
 - (B) 0.1×10^{-3} torr
 - (C) 1×10^{-5} torr
 - (D) 1×10^{-6} torr
46. Noise due to several amplifiers connected in series is :
- (A) Additive
 - (B) Subtractive
 - (C) Multiplicative
 - (D) Logarithmic

47. In which counter for the detection of the thermal neutrons boron is introduced in the form of BF_3 ?
- (A) Ionisation chamber
(B) Proportional counter
(C) G.M. counter
(D) Scintillation counter
48. In the Millikan's experiments, an oil drop carries four electronic charges and has a mass of 1.8×10^{-12} g. It is held almost at rest between two horizontal charged plates. 1.8 cm apart. What voltage must there be between the two charged plates ?
- (A) 250 V
(B) 300 V
(C) 496 V
(D) 500 V
49. Metallic sodium has a bcc structure. Its X-ray diffraction pattern does not contain lines corresponding to Bragg plane :
- (A) (1 1 0)
(B) (2 2 2)
(C) (2 0 0)
(D) (2, 2, 1)
50. The movable mirror of Michelson's interferometer is moved through a distance of 0.02603 mm. The number of fringes shifted across the cross-wire of a eyepiece of the telescope, if a wavelength of light 5200 \AA used is :
- (A) 100
(B) 200
(C) 300
(D) 400

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ROUGH WORK