Test Booklet No.
प्रश्नपत्रिका क्र. **F**

Paper-II
PHYSICS

Signature and Name of Invigilator

1. (Signature) .....

   (Name) .....

2. (Signature) .....

   (Name) .....

Seat No. | | | | | | |

(In figures as in Admit Card)

Seat No. .....

(In words)

OMR Sheet No. | | | | | | |

(To be filled by the Candidate)

DEC - 32213

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

1. Write your Seat No. and OMR Sheet No. in the space provided on the top of this page.
2. 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).
3. 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 :
   (*i*) 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.
   (*ii*) **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.**
   (*iii*) After this verification is over, the OMR Sheet Number should be entered on this Test Booklet.
4. 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) ● (D)
5. 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.
6. Read instructions given inside carefully.
7. Rough Work is to be done at the end of this booklet.
8. 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.
9. 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.
10. **Use only Blue/Black Ball point pen.**
11. **Use of any calculator or log table, etc., is prohibited.**
12. **There is no negative marking for incorrect answers.**

विद्यार्थ्यांसाठी महत्त्वाच्या सूचना

1. परिक्षार्थींनी आपला आसन क्रमांक या पृष्ठावरील वरच्या कोपऱ्यात लिहावा. तसेच आपणांस दिलेल्या उत्तरपत्रिकेचा क्रमांक त्याखाली लिहावा.
2. सदर प्रश्नपत्रिकेत **50** बहुपर्याय प्रश्न आहेत. प्रत्येक प्रश्नास **दोन** गुण आहेत. या प्रश्नपत्रिकेतील **सर्व** प्रश्न सोडविणे अनिवार्य आहे. सदरचे प्रश्न हे या विषयाच्या संपूर्ण अभ्यासक्रमावर आधारित आहेत.
3. परीक्षा सुरू झाल्यावर विद्यार्थ्याला प्रश्नपत्रिका दिली जाईल. सुरुवातीच्या 5 मिनीटांमध्ये आपण सदर प्रश्नपत्रिका उघडून खालील बाबी अवश्य तपासून पहाव्यात.
   (*i*) प्रश्नपत्रिका उघडण्यासाठी प्रश्नपत्रिकेवर लावलेले सील उघडावे. सील नसलेली किंवा सील उघडलेली प्रश्नपत्रिका स्विकारू नये.
   (*ii*) **पहिल्या पृष्ठावर नमूद केल्याप्रमाणे प्रश्नपत्रिकेची एकूण पृष्ठे तसेच प्रश्नपत्रिकेतील एकूण प्रश्नांची संख्या पडताळून पहावी. पृष्ठे कमी असलेली/कमी प्रश्न असलेली/प्रश्नांचा चूकीचा 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.**
   (*iii*) वरीलप्रमाणे सर्व पडताळून पहिल्यानंतरच प्रश्नपत्रिकेवर ओ.एम.आर. उत्तरपत्रिकेचा नंबर लिहावा.
4. प्रत्येक प्रश्नासाठी (A), (B), (C) आणि (D) अशी चार विकल्प उत्तरे दिली आहेत. त्यातील योग्य उत्तराचा रकाना खाली दर्शविल्याप्रमाणे ठळकपणे काळा/निळा करावा.
   उदा. : जर (C) हे योग्य उत्तर असेल तर.
   (A) (B) ● (D)
5. या प्रश्नपत्रिकेतील प्रश्नांची उत्तरे **ओ.एम.आर. उत्तरपत्रिकेतच दर्शवावीत.** इतर ठिकाणी लिहीलेली उत्तरे तपासली जाणार नाहीत.
6. आत दिलेल्या सूचना काळजीपूर्वक वाचाव्यात.
7. प्रश्नपत्रिकेच्या शेवटी जोडलेल्या कोऱ्या पानावरच कच्चे काम करावे.
8. जर आपण ओ.एम.आर. वर नमूद केलेल्या ठिकाणा व्यतिरीक्त 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.
9. परीक्षा संपल्यानंतर विद्यार्थ्याने मूळ ओ.एम.आर. उत्तरपत्रिका पर्यवेक्षकांकडे परत करणे आवश्यक आहे. तथापी, प्रश्नपत्रिका व ओ.एम.आर. उत्तरपत्रिकेची द्वितीय प्रत आपल्याबरोबर नेण्यास विद्यार्थ्यांना परवानगी आहे.
10. **फक्त निळ्या किंवा काळ्या बॉल पेनचाच वापर करावा.**
11. **कॅलक्युलेटर किंवा लॉग टेबल वापरण्यास परवानगी नाही.**
12. **चुकीच्या उत्तरासाठी गुण कपात केली जाणार नाही.**

Physics
Paper II

Time Allowed : 75 Minutes] **[Maximum Marks : 100**

Note : This paper contains **Fifty (50)** multiple choice questions, each carrying **Two (2)** marks. Attempt *All* questions.

1. Five data points can be exactly fitted by using a polynomial of order :
   (A) Five
   (B) Four
   (C) Three
   (D) Two

2. A person is confined to move in equal steps of 1 m in 1 minute along a straight line. He takes each step either to his left or to his right with equal probability (random walk in one-dimension).
   What is the probability that the person is at his starting point after 5 minutes ?
   (A) Zero
   (B) $\frac{1}{2}$
   (C) $\frac{1}{8}$
   (D) $\frac{1}{32}$

3. $\vec{r}$ is the position vector of any point on the surface of a cube of side L. The surface integral $\iint_s \vec{r} \cdot d\vec{s}$ is :
   (A) 0
   (B) ∞
   (C) $3L^2$
   (D) $3L^3$

4. A (3×3) matrix has unequal eigenvalues a, b and c and its determinant is D. If $a = -1$, $b = 2$ and D = 4, what is the value of c ?
   (A) 1
   (B) –1
   (C) –2
   (D) 0

5. A matrix M is of the form :
$$M = \begin{bmatrix} 0 & a \\ -a^* & 0 \end{bmatrix}$$
   If the det M = 1, the most general value of a is :
   (A) $\cos\theta$
   (B) $\sin\theta$
   (C) $\exp(i\theta)$
   (D) $\cosh\theta$
   where θ is a real parameter.

6. The solution of the differential equation :

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

is :

(A) $y = e^{x}$

(B) $y = x^{-1}$

(C) $y = e^{-x}$

(D) $y = x + 1$

7. $f(t) = e^{-at^2}$ is a Gaussian function. Its Fourier transform is :

(A) Gaussian

(B) Polynomial

(C) Trigonometric

(D) Lorentzian

8. $f(z) = \frac{1}{z^2 + 1}$, the contour integral of $f(z)$ over a contour C comprising the real axis from –2 to +2 and a semicircle in the upper half of the complex plane with centre at origin and radius 2 is given by :

(A) 0

(B) π

(C) $-\pi$

(D) 1

9. The complex function $f(z) = z$ is singular at :

(A) $z = \infty$

(B) $z = 0$

(C) $z = 1$

(D) $z = i$

10. Consider an electric charge 'q' moving at velocity , in an otherwise charge-free region containing both an electric field $\bar{E}$, and a magnetic field $\bar{B}$, which may depend upon time and position. Which of the following statements is *incorrect* ?

(A) The charge experiences a force $\bar{F} = q(\bar{v} \times \bar{B})$

(B) The force can be derived from a potential $U = q\phi - q(\bar{A} \cdot \bar{v}) + q(\bar{A} \cdot \bar{v})\, v^2$ with $\bar{A}$ as the vector potential

(C) The Hamiltonian of the system is :

$$H = \frac{1}{2m}(\bar{p} - q\bar{A})^2 + q\phi$$

where ϕ is the scalar potential

(D) The equations of motion are unaltered by gauge transformations

11. Consider a central force of the form $\bar{F} = -kr^n$. The values of 'n' that result in closed orbits are :

(A) $n = -2$ and $n = 1$

(B) $n = 2, 4, 6, ...$

(C) $n = 1, 3, 5, 7, ...$

(D) $n = -1, \ n = +2$

12. A satellite is moving in an elliptical orbit. If v_1 and v_2 are its maximum and minimum speeds respectively, then the eccentricity of the ellipse is :

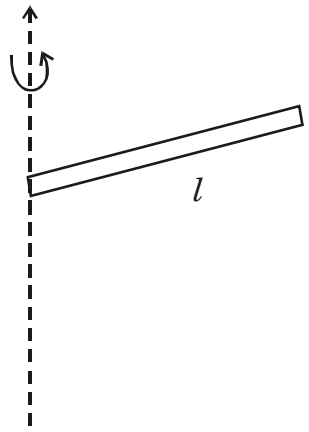
(A) $\frac{v_1}{v_2}$

(B) $\frac{v_2}{v_1}$

(C) $\frac{v_1 - v_2}{v_1 + v_2}$

(D) $\frac{v_1 + v_2}{v_1 - v_2}$

13. The momentum of inertia I of a rigid rod of length l about an axis passing through one of its ends is :



(A) $\frac{Ml^2}{3}$

(B) $\frac{1}{12} Ml^2$

(C) $\frac{1}{4} Ml^2$

(D) $\frac{4}{3} Ml^2$

14. Consider a body falling under the action of gravitational force F = $-mg$. If the effect of air resistance is included by including a frictional force $F_v = -bv$ and $v_0 = 0$, then the velocity of the falling body is given by :

(A) $v = \frac{-mg}{b}$

(B) $v = -mgt + b$

(C)

(D) $v = \frac{-mg}{b} e^{\frac{-bt}{m}} + \frac{bt}{m}$

15. Due to Coriolis force :

(A) In northern hemisphere, right banks of the rivers are raised to a slightly higher level than the left banks

(B) In southern hemisphere, right banks of the rivers are raised to a slightly higher level than the left banks

(C) In northern hemisphere left banks are raised to a slightly higher level than the right banks

(D) The river banks are of equal height in both the northern and southern hemisphere

[Right and left are defined with respect to direction of river flow]

16. If Lagrangian of n-particles system involves potential V(r), which is isotropic in nature, then :

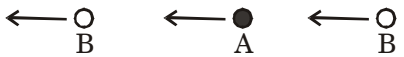
(A) The linear momenta of the n-particles are constants of motion

(B) The angular momenta of the n-particles are constants of motion

(C) The angular momenta of the n-particles are not constants of motion

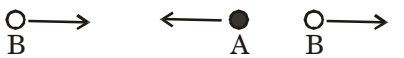
(D) The energy of the system depends on the angular momenta alone

17. A triatomic linear molecule AB_2 is performing small oscillations. The atomic displacements in symmetric stretching mode are :

(A) 

(B) 

(C) 

(D) 

18. A sphere of radius 'a' has a volume charge density $\rho(r) = A r^{½}$, where 'A' is a constant and r is the distance from the centre of the sphere. The electric field magnitude at a distance $r < a$ from the centre varies with r as :

(A) $r^{\frac{-1}{2}}$

(B) $r^{\frac{1}{2}}$

(C) $r^{\frac{3}{2}}$

(D) r^{-2}

19. A point charge of magnitude 'q' is at a distance 'd' from grounded conducting infinite plane. The electrostatic energy stored in the system is ..... .

(A) 0

(B) $\frac{-q^2}{4\pi \in_0 d}$

(C) $\frac{-q^2}{8\pi \in_0 d}$

(D) $\frac{-q^2}{16\pi \in_0 d}$

20. At a point at a distance r from the uniformly charged infinite plane, the magnitude of the electric field is ..... .

(A) 0

(B) inversely proportional to r

(C) inversely proportional to r^2

(D) independent of r

21. A particle enters uniform constant magnetic field region with its initial velocity parallel to the field direction. Which of the following statements about its velocity is *correct* ?

(A) There is change only in magnitude

(B) There is change only in direction

(C) There is change in both magnitude and direction

(D) There is no change

22. Which of the following represents Coulomb gauge condition ?

(A) $\nabla \cdot \bar{A} = 0$

(B) $\nabla \times \bar{A} = \bar{0}$

(C) $\nabla \cdot \bar{A} = -\epsilon_0 \mu_0 \frac{\partial \phi}{\partial t}$

(D) $\nabla \times \bar{A} = \bar{B}$

23. Current 'I' flows through a circular wire loop of radius 'a'. The radius of the wire is 'r'. The volume current density at a point in the wire is ..... .

(A) 0

(B) $\frac{I}{\pi a^2}$

(C) $\frac{I}{\pi r^2}$

(D) $\frac{I}{(2\pi a)(\pi r^2)}$

24. Which of the following relations describes the conservative character of electrostatic field $\bar{E}$?

(A) $\nabla . \bar{E} = \frac{\rho}{\epsilon_0}$

(B) $\nabla \times \bar{E} = \bar{0}$

(C) $\nabla \cdot \bar{J} + \frac{\partial \rho}{\partial t} = 0$

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

25. An electromagnetic wave is propagating with speed 'c'. The associated electric and magnetic fields share the energy of this electromagnetic wave in the ratio ..... .

(A) 1 : 1

(B) c : 1

(C) 1 : c

(D) 1 : c^2

26. If $[x, p] = i\hbar$, the value of $[x^3, p]$ is :

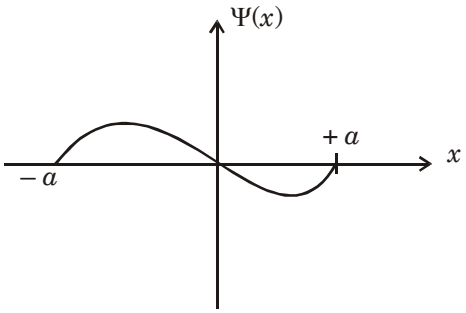
(A) $2\, i\hbar x^2$

(B) $-2\, i\hbar x^2$

(C) $3\, i\hbar x^2$

(D) $-3\, i\hbar x^2$

27.



The figure shows one of the possible energy eigen functions $\Psi(x)$ for a particle in infinite square well potential V = 0 for $|x| < a$ and V = ∞ for $|x| > a$. If the energy eigen-value of this state is 2 eV, what is the energy eigen-value of the particle in the ground state ?

(A) 0 eV

(B) $\frac{1}{\sqrt{2}}$ eV

(C) $\frac{1}{2}$ eV

(D) 1 eV

28. Which of the following is an eigen function of L_z ?

(A) $\cos\phi$

(B) $\sin\phi$

(C) $\cos^2\phi$

(D) $e^{2i\phi}$

29. Consider a particle of mass m moving in the potential,

$$V(x) = \infty \text{ for } x \le 0$$
$$= \frac{1}{2} m\omega^2 x^2 \text{ for } x > 0$$

The ground state wave function $\Psi_0(x)$ of the particle is given by :

(A) $\psi_0(x) = N_0 x\, e^{-\alpha x^2}$

(B) $\psi_0(x) = N_0\, e^{-\alpha x^2}$

(C) $\psi_0(x) = N_0 x\, e^{+\alpha x^2}$

(D) $\psi_0(x) = N_0\, e^{+\alpha x^2}$

30. The Pauli matrices :

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \quad \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix},$$

$$\sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}.$$

(A) Anticommute
(B) Commute
(C) Neither commute nor anti-commute
(D) Commute as well as anti-commute

31. A system, with an unperturbed Hamiltonian H_0 is subject to a perturbation $\hat{H}_1$ where :

$$\hat{H}_0 = E_0 \begin{pmatrix} 15 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & 3 \end{pmatrix}$$

and $$\hat{H}_1 = \frac{E_0}{100} \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$

The eigenvalue of the non-degenerate state upto first order in perturbation is given by :

(A) $\left(15 + \frac{1}{100}\right) E_0$

(B) $\frac{1}{100} E_0$

(C) $15\, E_0$

(D) $\left(3 + \frac{1}{100}\right) E_0$

32. What is the degeneracy of the third excited state of a particle in 3-dimensional isotropic harmonic oscillator potential ?

(*Note* : The ground state is not an excited state.)

(A) 10

(B) 6

(C) 4

(D) 3

33. In scattering theory, the Born approximation and partial wave analysis are usually used for :

(A) Both approximations are used for low energy scattering

(B) Born approximation for high energy and partial wave analysis for low energy scattering

(C) Both approximations are used for high energy scattering

(D) Born approximation for low energy and partial wave analysis for high energy scattering

34. Consider a system of three non-interacting identical spin ½ particles that are in the same spin states $|s, m_s> \equiv |½, ½>$ and confined to move in a one-dimensional infinite potential well of length a, V(X) = 0 for $0 < x < a$ and V(X) = ∞ for other values of x. The ground state energy E of the system is given by :

(A) $E = \frac{3\pi^2\hbar^2}{2ma^2}$

(B) $E = \frac{5\pi^2\hbar^2}{2ma^2}$

(C) $E = \frac{7\pi^2\hbar^2}{ma^2}$

(D) $E = \frac{5\pi^2\hbar^2}{ma^2}$

35. The Gibbs' free energy 'G' of a system maintained at a temperature 'T' satisfies the following relation with the pressure 'P', the volume 'V', the internal energy 'U' and the entropy 'S' of the system :

(A) G = PV – TS

(B) G = U + PV – TS

(C) G = U – PV + TS

(D) S = $-k_B \ln G$

36. A gas chamber has a volume of 0.1 m^3 and is filled with helium gas at a pressure of 5×10^6 Pa. Another chamber has a volume of 0.15 m^3 and is filled with helium gas at a pressure of 6×10^6 Pa. A tap connecting the two chambers is then opened. Assuming that helium is a monatomic ideal gas and the walls of the chambers to be adiabatic and rigid, the final pressure of the system will be :

(A) 5.5×10^6 Pa

(B) 5.6×10^6 Pa

(C) 5.4×10^6 Pa

(D) 5×10^6 Pa

37. Consider a system of N non-interacting atoms, each having an orbital angular momentum J = 2. A constant magnetic field H is applied along the z-axis. The total number of microstates of the system is :

(A) 5^N

(B) N^5

(C) 2N

(D) 5N

38. Two identical indistinguishable particles are to be distributed over three energy states. The number of ways of distribution for Fermi gas and Bose gas, respectively, will be :

(A) 1, 3

(B) 6, 3

(C) 3, 6

(D) 1, 6

39. The critical temperature T_C for the Bose-Einstein condensation depends on the density 'n' of the gas as :

(A) $n^{1/3}$

(B) $n^{2/3}$

(C) n

(D) $n^{4/3}$

40. The Fermi wave-vector K_F of an ideal gas of N molecules enclosed in a volume V at T = 0°K, obeys the relation :

(A) $K_F = (\text{const}) \left(\frac{N}{V}\right)^{1/3}$

(B) $K_F^2 = (\text{const}) (N/V)$

(C) $K_F = (\text{const}) \left(\frac{N}{V}\right)^{1/2}$

(D) $K_F^2 = (\text{const}) \left(\frac{N}{V}\right)$

41. Consider a paramagnetic salt with N magnetic ions each with spin $\frac{1}{2}$. At T = 0, in the presence of an external magnetic field H :

(A) All the spins will be parallel to H

(B) All the spins will be antiparallel to H

(C) Half of the spins will be parallel to H and half of them antiparallel to H

(D) The spins will be randomly oriented

42. The Stefan-Boltzmann law for the radiation of energy from a black body is given by $\bar{u} \propto T^x$, where $\bar{u}$ is the energy density and T is the temperature of the black body. Here x is given by :

(A)

(B)

(C)

(D)

43. Surface barrier detector (SBD) is used for the detection of ..... .

(A) Alpha particles

(B) Beta particles

(C) Gamma radiation

(D) Neutron

44. A well directed white beam of X-rays is incident on a single crystal. The transmission beam will show :

(A) spots arranged in a regular pattern

(B) a ring pattern

(C) a random distribution of spots

(D) extended lines

45. In a Q-meter, a distributed capacitance of coil is measured by changing the capacitance of a tuning capacitor. The values of tuning capacitors are C_1 and C_2 for resonant frequencies f_1 and $2f_1$ respectively. The value of distributed capacitance is :

(A)

(B) $\frac{C_1 - 2C_2}{3}$

(C) $\frac{C_1 - 4C_2}{3}$

(D) $\frac{C_1 - 3C_2}{2}$

46. Lasing transition in He – Ne laser giving red light occurs in the following levels :

(A) $3d \rightarrow 2p$

(B)

(C)

(D)

47. The noise generated from the movement of charge carriers as they cross the *p-n* junction or arrive at electrode surface is :

(A) thermal noise

(B) flicker noise

(C) shot noise

(D) environmental noise

48. The body-centered cell of a crystal has two atoms of the same kind located at (0, 0, 0) and (½, ½, ½). Its crystal structure factor F in terms of atomic scattering factor f when $(h + k + l)$ is even is :

(A) $F = 2f$

(B) $F = 0$

(C) $F = f$

(D) $F = 4f$

49. The vapour diffusion pump works in the following region of air flow :

(A) molecular flow

(B) turbulent flow

(C) lamellar flow

(D) viscous flow

50. When the phase difference between the voltage applied to the X and Y plates of CRO is equal to 180°, the shape of the Lissajous figure observed on the screen of CRO is :

(A) A straight line with a positive slope

(B) A straight line with a negative slope

(C) Ellipse

(D) Circle

ROUGH WORK

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