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TEST BOOKLET

Sl. No. **3798**

Subject Code : 20

Subject : Physics

LECTURERS FOR NON-GOVT. AIDED COLLEGES OF ODISHA

Time Allowed : 2 Hours

Maximum Marks : 150

: INSTRUCTIONS TO CANDIDATES :

1. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS TEST BOOKLET CONTAINS 23 PAGES AND DOES NOT HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.
2. You have to enter your **Roll No.** on the Test Booklet in the Box provided alongside. **DO NOT** write anything else on the Test Booklet.

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3. The Test Booklet contains **100** questions. Each question comprises four answers. You have to select the correct answer which you want to mark (darken) on the **Answer Sheet (OMR Sheet)**. In any case choose **ONLY ONE** answer for each question. If more than one answer is darkened, it will be considered as wrong.
4. You have to mark (darken) all your answers only on the **OMR Answer Sheet using BLACK BALL POINT PEN** provided by the State Selection Board. You have to do rough work only in the space provided at the end of the Test Booklet. See instructions in the Answer Sheet.
5. All questions carry equal marks i.e. of one and half mark for each correct answer and each wrong answer will result in negative marking of **0.50** mark.
6. Before you proceed to mark (darken) the answers in the **OMR Answer Sheet** to the questions in the Test Booklet, you have to fill in some particulars in the Answer Sheet as per the instructions in your Admit Card.
7. On completion of the examination, you should hand over the **original Answer Sheet (OMR Sheet)** issued to you to the Invigilator before leaving the Examination Hall. You are allowed to take with you the candidate's copy (carbon copy) of the **OMR Answer Sheet** along with the Test Booklet for your reference.

SEAL

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IW-6/16

(Turn over)

2021

1. A one-dimensional coupled oscillator consists of two identical masses connected to three identical springs. The free ends of the springs are fixed to two parallel walls. It can move on a frictionless horizontal surface. Which of the following statements is true about the motion of a coupled oscillator, if it is in a normal mode ?
- (A) All parts of the oscillator is oscillating sinusoidally with the frequency of the mode.
- (B) All parts of the oscillator is oscillating with a linear combination of two frequencies of the normal modes.
- (C) One mass oscillates with the frequency of one mode, while the other oscillates with the frequency of the other mode.
- (D) The period of oscillation is a common period of the two modes.
2. Three vectors \vec{a} , \vec{b} and \vec{c} are defined as : $\vec{a} = x\hat{i} - y\hat{j} + z\hat{k}$, $\vec{b} = x\hat{i} + y\hat{j} - 2z\hat{k}$, $\vec{c} = x\hat{i} - y\hat{j} + \hat{k}$. Which of the following statements is true ?
- (A) \vec{a} and \vec{b} both may represent a magnetic field.
- (B) \vec{b} and \vec{c} both may represent a magnetic field.
- (C) \vec{a} and \vec{c} both may represent a magnetic field.
- (D) \vec{a} , \vec{b} and \vec{c} all may represent a magnetic field.
3. A particle of mass $m = 0.1$ kg is initially motionless on a frictionless surface. At time $t = 0$, an impulse is imparted to the block and it starts moving on the surface with a uniform acceleration $a = 10 \text{ m/s}^2$. What is the action S (in J-s) of the particle at a time $t = 1$ s ?
- (A) 2
- (B) 3
- (C) 4
- (D) 5

4. A particle of mass m and angular momentum L is moving in an attractive potential $U(r) = -\frac{\alpha}{r^2}$, where α is a positive constant of appropriate dimensions. It may reach the centre of force due to the potential $U(r)$, if:

(A) $\alpha < -\frac{L^2}{2m}$

(B) $\alpha = -\frac{L^2}{2m}$

(C) $\alpha > -\frac{L^2}{2m}$

(D) $\alpha < -\frac{L^2}{m}$

5. At time t , two electric charges are at a distance r . The distance between them is r' at time t' . The equations of motion allow a series of similar paths. If $t'/t = (r'/r)^\beta$, then $\beta =$

(A) $1/2$

(B) 1

(C) $3/2$

(D) 2

6. The components of a second rank tensor σ_{ij} for $i = 1, 2, 3$ are given as: $\sigma_{ij} = \psi\delta_{ij} + c(\partial_j v_i + \partial_i v_j)$, where c is a constant, ψ is a scalar field and v_i (for $i = 1, 2, 3$) are the components of a divergence free vector field \vec{v} .

The value of $\partial_j \sigma_{ij}$ is:

(A) $\partial_i \psi + c\partial_j \partial_j v_i$

(B) $\partial_i \psi$

(C) $\partial_i \psi + 2c\partial_j \partial_j v_i$

(D) $c\partial_j \partial_j v_i$

7. If $P_n(x)$ is the Legendre polynomial of degree n , then $\left[\frac{d}{dx} P_n(x) \right]_{x=1}$ is

equal to:

(A) $n(n+1)$

(B) $n(n+1)/2$

(C) $n(n+1)/4$

(D) $n(n+1)/n!$

8. If $H_n(x)$ is Hermite polynomial of order n , then which of the following relations is correct?

(A) $|H_n(x)| \geq |H_n(ix)|/2$

(B) $|H_n(x)| \geq |H_n(ix)|$

(C) $|H_n(x)| \leq |H_n(ix)|/2$

(D) $|H_n(x)| \leq |H_n(ix)|$

9. The value of the integral

$$I = \int - (x^2 + y^2) dx dy \text{ is :}$$

- (A) π
- (B) $\pi / 4$
- (C) $\pi / 2$
- (D) $\pi / \sqrt{2}$

10. A 2π periodic function $f(x)$ on the interval $[-\pi, \pi]$ is defined as :

$$f(x) = \begin{cases} 0, & \text{if } -\pi \leq x \leq 0 \\ 1, & \text{if } 0 \leq x \leq \pi \end{cases} \text{ If the}$$

function $f(x)$ is expanded in Fourier series given by $f(x) =$

$$\frac{a_0}{2} + \sum a_n \cos nx + b_n \sin nx, \text{ then}$$

which of the following statements is true ?

(A) $a_0 = 1, a_n = 0, b_n = \frac{1 - (-1)^n}{n\pi}$

(B) $a_0 = 1, a_n = 0, b_n = \frac{1 + (-1)^n}{n\pi}$

(C) $a_0 = 1, a_n = 0, b_n = \frac{1}{n\pi}$

(D) $a_0 = 1, a_n = 0, b_n = -\frac{1}{n\pi}$

11. A one-dimensional coupled oscillator consists of two identical blocks, each of mass m , and three identical

massless springs, each of spring constant k . The free ends of the last two springs are connected to two parallel walls. The blocks can move along a straight line on a frictionless horizontal surface. The frequencies of normal modes are :

(A) $\sqrt{k/m}$ and $\sqrt{2k/m}$

(B) $\sqrt{k/m}$ and $\sqrt{(\sqrt{2}+1)k/m}$

(C) $\sqrt{(\sqrt{2}+1)k/m}$ and $\sqrt{3k/m}$

(D) $\sqrt{k/m}$ and $\sqrt{3k/m}$

12. The Hamiltonian of a system with one degree of freedom is given as :

$$H(x, p) = \frac{p^2}{2m} - m\gamma x. \text{ The Poisson}$$

bracket $[[x, H], H]_{x,p}$ is equal to :

(A) γ

(B) 0

(C) 1

(D) 2γ

13. The Lagrangian of a system with one degree of freedom is $L(q, \dot{q}) = \frac{\dot{q}^2}{8} - \frac{q^2}{16}$. The expression for the Hamiltonian $H(q, p)$ for the system is :

(A) $H(q, p) = \frac{p^2}{2} + \frac{q^2}{16}$

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

(C) $H(q, p) = p^2 + \frac{q^2}{16}$

(D) $H(q, p) = 2p^2 + \frac{q^2}{16}$

14. The Hamiltonian H of an oscillator is given as : $H(q, p) = \frac{1}{2}(p^2 + q^2)$.

Consider coordinate transformations in the phase space of the system from (q, p) to (Q, P) in the form $p = \psi(P) \cos(Q)$ and $q = \psi(P) \sin Q$.

The form of the function $\psi(P)$, which makes the transformation canonical

is :

(A) $\psi(P) = \sqrt{P}$

(B) $\psi(P) = \sqrt{P/2}$

(C) $\psi(P) = \sqrt{2P}$

(D) $\psi(P) = 2\sqrt{P}$

15. The curve $y(x)$ with $y(0) = 0$ and $y(1) = 1$ that gives the minimum value

for the integral $J = \int_0^1 \frac{y'^2}{x^3} dx$ is :

(A) $y(x) = x^2$

(B) $y(x) = x^3$

(C) $y(x) = x^4$

(D) $y(x) = (x^2 + x^4)/2$

16. Using the value of the Gamma function $\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$, the value of the

integral $I = \int_0^\infty \sqrt{z} e^{-z^3} dz$ is :

(A) $\sqrt{\pi}/3$

(B) $\sqrt{\pi}/2$

(C) $\sqrt{\pi}$

(D) $2\sqrt{\pi}$

17. The Laplace transform of a function

$f(t) = \sin hbt$ is :

(A) $\frac{s}{s^2 - b^2}$

(B) $\frac{b}{s^2 - b^2}$

(C) $\frac{s}{s^2 + b^2}$

(D) $\frac{b}{s^2 + b^2}$

18. A surface integral $I = \iint \vec{F} \cdot d\vec{s}$ is defined on a sphere $x^2 + y^2 + z^2 = 9$.

If $\vec{F} = 2x\hat{i} + y\hat{j} + 2z\hat{k}$, then the value of the integral I is :

- (A) 180π
- (B) 150π
- (C) 120π
- (D) 90π

19. The value of the integral

$$I = \int_{-\infty}^{\infty} \frac{1}{1+x^4} dx \text{ is :}$$

- (A) 2π
- (B) $\sqrt{2}\pi$
- (C) π
- (D) $\pi/\sqrt{2}$

20. The dimensionality of the phase variables of a coplanar double pendulum is :

- (A) 1
- (B) 2
- (C) 3
- (D) 4

21. Among the options given below, which one is **not** a scalar quantity ?

- (A) Charge density
- (B) Current density
- (C) Potential energy
- (D) Electromagnetic energy density

22. A Faraday cage is usually useful to shield :

- (A) Any static electric field as well as electromagnetic radiation
- (B) Any static magnetic field as well as electromagnetic radiation
- (C) Only static electric and static magnetic field
- (D) Only electromagnetic radiation

23. Capacitance of a parallel plate capacitor is :

- (A) Inversely proportional to the area of the plates
- (B) Proportional to the separation between two plates
- (C) Proportional to the area of the plates as well as the separation between plates
- (D) Proportional to the area of plates but inversely proportional to the separation

24. Which of the following statement is **not** true ?
- (A) Any charged particle moving at a non-zero velocity produces a magnetic field
 - (B) Any current carrying wire produces a magnetic field
 - (C) Force on a charged particle is non-zero if the particle moves along the magnetic field direction
 - (D) A changing magnetic flux across a conducting wire loop induces an electric field along the conducting wire and hence it generates a current
25. A rheostat :
- (A) Can be used in high voltage and / or high power dc circuits
 - (B) Is ideal for tuning a radio receiver
 - (C) Is better than a potentiometer for low-power audio
 - (D) Offers the advantage of having no inductance
26. A current loop has magnetic moment μ . The torque, τ , in a magnetic field B is given by :
- (A) $\tau = \mu \times B$
 - (B) $\tau = \mu \cdot B$
 - (C) $\tau = 0$
 - (D) $\tau = \mu / B$
27. Which of the following should be minimized in an RF transmission line ?
- (A) The load impedance
 - (B) The load resistance
 - (C) The line loss
 - (D) The transmitter power
28. At the Brewster's angle, the angle between the reflected and refracted rays is :
- (A) 45°
 - (B) 90°
 - (C) 180°
 - (D) 0°
29. Suppose a transformer has a primary-to-secondary turns ratio of exactly 9 : 1. The ac voltage at the primary is 117 V rms. What is the voltage across the secondary ?
- (A) 1053 V
 - (B) 13V
 - (C) 351V
 - (D) 39V

30. From a point source the intensity of the light is proportional to the :
- Distance from the source
 - Square of the distance from the source
 - Inverse square of the distance from the source
 - Inverse of the distance from the source
31. Vector potential, $A_x = -Hy$, $A_y = 0$ and $A_z = 0$ ($H = \text{const}$), will describe a :
- Uniform magnetic field
 - Non-uniform magnetic field
 - Magnetic field along y-direction
 - Magnetic field along x-direction
32. A 10 eV electron is circulating in a plane at right angles to a uniform field of magnetic induction of 1.0 gauss (1.0×10^{-4} weber / m^2). Radius of its orbit is approximately :
- 18 mm
 - 1.3 m
 - 11 cm
 - 5.6 mm
33. Hamiltonian for a non-relativistic particle of mass m and charge q moving in an electromagnetic field with scalar potential ϕ and vector potential A is (p is the momentum and c is the speed of light) :
- $p^2 / (2m) + q\phi$
 - $p^2 / (2m) + q\phi + q^2 A^2 / (2mc^2)$
 - $(p - qA / c)^2 / (2m) + q\phi$
 - $p^2 / (2m) + q^2 A^2 / (2mc^2)$
34. Two electrons leave a radioactive sample in opposite directions each having a speed of $0.67c$ ($c = \text{speed of light}$) with respect to the sample. The relative speed of one electron to the other is :
- c
 - $1.34c$
 - $0.67c$
 - $0.92c$
35. In Rayleigh scattering the cross section is proportional to (λ : wavelength of light) :
- λ^2
 - λ
 - λ^{-1}
 - λ^{-4}

36. Field due to an electric dipole for large distance r from the dipole is proportional to (approximately) :
- (A) r^{-1}
 (B) r^{-3}
 (C) r^{-2}
 (D) r^{-4}
37. For a uniform electric field \vec{E} :
- (A) $\nabla \times \vec{E} = 0$ and $\nabla \cdot \vec{E} \neq 0$
 (B) $\nabla \times \vec{E} \neq 0$ and $\nabla \cdot \vec{E} \neq 0$
 (C) $\nabla \times \vec{E} \neq 0$ and $\nabla \cdot \vec{E} = 0$
 (D) $\nabla \times \vec{E} = 0$ and $\nabla \cdot \vec{E} = 0$
38. For a vector potential \vec{A} and scalar potential ϕ , a valid gauge transformation with a scalar function λ :
- (A) $\vec{A}' = \vec{A} + \nabla\lambda$ and $\phi' = \phi - \partial\lambda/\partial t$
 (B) $\vec{A}' = \vec{A} + \nabla\lambda$ and $\phi' = \phi + \partial\lambda/\partial t$
 (C) $\vec{A}' = \vec{A} - \nabla\lambda$ and $\phi' = \phi - \partial\lambda/\partial t$
 (D) $\vec{A}' = \vec{A} + 2\nabla\lambda$ and $\phi' = \phi - \partial\lambda/\partial t$
39. For an electric dipole radiator the total radiated power is proportional to :
- (A) ω^3
 (B) ω^4
 (C) ω^2
 (D) ω
40. When an LCR series circuit driven with an AC voltage is compared to a forced horizontal spring-mass oscillator with a viscous damping (proportional to velocity), then :
- (A) R is equivalent to the spring and L is equivalent to the mass
 (B) R is equivalent to the mass and L is equivalent to the spring
 (C) C is equivalent to the mass and R is equivalent to the spring
 (D) L is equivalent to the mass and C is equivalent to the spring
41. Energy eigenvalue (E_n), where n denotes the level of excited state for a particle in a box is proportional to :
- (A) n^2
 (B) n^{-2}
 (C) n
 (D) n^{-1}
42. The three Pauli spin matrices satisfy the relation $\sigma_x \sigma_y \sigma_z =$
- (A) $i\hbar I$
 (B) $-i\hbar I$
 (C) iI
 (D) $\frac{3}{2}I$
- where I is the 2×2 unit matrix.

43. If the radial wave functions of the Hydrogen atom are $R_{nl}(r)$, the number of radial nodes in $R_{52}(r)$ is :
- (A) 3
(B) 2
(C) 7
(D) 4
44. If a hydrogen atom has its electron in the $n = 4$ state. The minimum energy needed to ionise it is :
- (A) 13.6 eV
(B) 3.4 eV
(C) 0.85 eV
(D) 0.25 eV
45. The energy levels are equi-spaced in which of the following one dimensional potential ?
- (A) Harmonic oscillator
(B) Particle in a box
(C) Finite potential well
(D) Infinite potential well
46. If L_x , L_y and L_z are the x, y and z-components of the orbital angular momentum operator and $L^2 = L_x^2 + L_y^2 + L_z^2$, then the value of $[L^2, L_z]$ is :
- (A) Zero
(B) $2i L_z$
(C) $-2i L_z$
(D) $i L_z$
47. For a particle of mass m in a one-dimensional box of side L , the energy levels are :
- (A) Directly proportional to m and directly proportional to L^2
(B) Directly proportional to m and inversely proportional to L^2
(C) Inversely proportional to m and inversely proportional to L^2
(D) Inversely proportional to m and directly proportional to L^2
48. A particle limited to x-axis has the wave function $\psi(x) = a x$, between $x = 0$ and $x = 1$, where a is a constant. The value of $\psi(x)$ is zero otherwise. The expectation value of $\langle x \rangle$ is :
- (A) $\frac{a^2}{8}$
(B) $\frac{a^2}{4}$
(C) $\frac{a^2}{2}$
(D) a^2