

PAPER – II
PHYSICAL SCIENCES

Note : Answer all the questions. Each question carries *two* (2) marks.

1. In Simpson's rule the error estimation by halving h is

- | | |
|----------------------------------|----------------------------------|
| 1) $\frac{1}{12}(J_{h/2} - j_h)$ | 2) $\frac{1}{15}(J_h - j_{h/2})$ |
| 3) $1(J_{h/2} + j_h)$ | 4) $\frac{1}{15}(J_{h/2} - j_h)$ |

2. Any three vectors, A, B, C are said to be linearly dependent if,

- | | |
|----------------|----------------|
| 1) $[ABC] = 1$ | 2) $[ABC] = 0$ |
| 3) $A = B + C$ | 4) $A + B = C$ |

3. If $\nabla \times B = \epsilon_0 \mu_0 \frac{\partial E}{\partial t}$ (Maxwell's equation), then $\frac{\partial}{\partial t} \nabla \times B$ is,

- | | |
|-------------------------------------|--|
| 1) 0 | 2) $\nabla \times \frac{\partial B}{\partial t}$ |
| 3) $-\frac{\partial B}{\partial t}$ | 4) $\frac{\partial B}{\partial t}$ |

4. If $y = 2x^3 - 3x^2 + 3x - 10$, then $\Delta^3 y$ is

- | | |
|-------|------|
| 1) 10 | 2) 8 |
| 3) 12 | 4) 3 |

5. Complex number $a + ib$ may be represented by 2×2 matrices, a, b are real,

- | | |
|--|---|
| 1) $\begin{pmatrix} a & b \\ -b & a \end{pmatrix}$ | 2) $\begin{pmatrix} a & -a \\ b & a \end{pmatrix}$ |
| 3) $\begin{pmatrix} a & -b \\ b & a \end{pmatrix}$ | 4) $\begin{pmatrix} a & -b \\ -b & a \end{pmatrix}$ |

6. An invariant is a tensor of order,

- | | |
|------|-------------|
| 1) 1 | 2) Zero |
| 3) 3 | 4) ∞ |

7. If one of the generalized coordinates is polar angle θ then $\frac{\partial H}{\partial \theta}$ represents

- | | |
|---------------------|-------------|
| 1) angular momentum | 2) momentum |
| 3) force | 4) torque |

8. The eikonal is

- 1) a measure of phase of the wave
- 2) a measure of amplitude of the wave
- 3) a measure of frequency of the wave
- 4) a measure of amplitude and frequency of the wave

9. The total power radiated by an electric dipole is

- | | |
|--|--|
| 1) $\frac{\mu_0 p_0^2 \omega^4}{12 \pi c}$ | 2) $\frac{\mu_0 p_0 \omega^4}{12 \pi c}$ |
| 3) $\frac{\mu_0 p_0^2 \omega}{12 \pi c}$ | 4) $\frac{\mu_0 p_0^2 \omega^4}{\pi c}$ |

10. In plasma

- | | |
|--|---|
| 1) $\mu \neq \mu_0$ and $\varepsilon \neq \varepsilon_0$ | 2) $\mu = \mu_0$ and $\varepsilon \neq \varepsilon_0$ |
| 3) $\mu \neq \mu_0$ and $\varepsilon = \varepsilon_0$ | 4) $\mu = \mu_0$ and $\varepsilon = \varepsilon_0$ |

11. The unit of $\nabla \times H$ is

- | | |
|------------------------------|-----------------------------|
| 1) ampere/meter | 2) weber/meter |
| 3) ampere/meter ² | 4) weber/meter ² |

12. The Faraday's law states that

- | | |
|----------------------------|----------------------------|
| 1) $e = -\frac{d\phi}{dt}$ | 2) $e = \frac{d\phi}{dt}$ |
| 3) $e = \frac{d\phi}{dx}$ | 4) $e = -\frac{d\phi}{dx}$ |

13. The direction of induced current can be found by

- | | |
|------------------|--------------------|
| 1) Faraday's law | 2) Lenz's law |
| 3) Laplace's law | 4) Kirchhoff's law |

14. When separation between two charges increases, the electric potential energy of charges
- 1) increases
 - 2) decreases
 - 3) remains the same
 - 4) may increase or decrease
15. According to Lenz's law, if magnetic flux decreases, the induced current produces
- 1) an aiding flux
 - 2) an opposing flux
 - 3) no flux
 - 4) either (2) or (3)
16. What does the "normal dispersion" describe
- 1) Lower frequencies are absorbed more strongly
 - 2) Higher frequencies are absorbed more strongly
 - 3) Lower frequencies are refracted more strongly
 - 4) Higher frequencies are refracted more strongly
17. The commutation $[\hat{H}, \hat{p}_x]$ is equal to
- 1) $\left[\frac{\hat{p}_x^2}{2m}, \hat{p}_x \right]$
 - 2) $[\hat{V}(x), \hat{p}_x]$
 - 3) $[\hat{p}_x^2, \hat{p}_x]$
 - 4) $[\hat{V}(x), \hat{p}_x^2]$
18. Velocity of molecules based on Maxwell's law of distribution is
- 1) greater than the mean velocity
 - 2) equal to root mean square velocity
 - 3) less than the root mean square velocity
 - 4) equal to the mean velocity
19. The number of ways in which N identical Bosons can be distributed in two energy levels is
- 1) $\frac{N}{2}$
 - 2) $N + 1$
 - 3) N
 - 4) $2N$
20. Mean total energy of a classical three dimensional harmonic oscillator in equilibrium with a heat reservoir at temperature T is
- 1) $k_B T$
 - 2) $4k_B T$
 - 3) $2k_B T$
 - 4) $3k_B T$

- 21.** The JFET is
- 1) a unipolar device
 - 2) a voltage-controlled device
 - 3) a current-controlled device
 - 4) Both (1) and (2)
- 22.** An approximate value of π is given by $X_1 = 3.1428571$ and its true value is given by 3.1415926. The absolute error value is
- 1) -0.0012645
 - 2) 0.0012645
 - 3) -0.000402
 - 4) 0.000402
- 23.** The first Brillouin zone for a FCC structure is
- 1) Cube
 - 2) Hexagon
 - 3) Rhombic dodecahedron
 - 4) Truncated octahedron
- 24.** An ideal amplifier should have
- 1) high input current
 - 2) zero offset
 - 3) high output impedance
 - 4) moderate gain
- 25.** The spin orbit energy is observed from the precession of the spin axis of the electron, one of the parts of which arises from electromagnetic origin is called as,
- 1) Thomas precession
 - 2) Partial precession
 - 3) Larmor precession
 - 4) Dirac precession
- 26.** Invariance of the Lagrangian under time displacement implies
- 1) Conservation of energy
 - 2) Conservation of mass
 - 3) Conservation of linear momentum
 - 4) Conservation of angular momentum
- 27.** The cut of frequency of the rectangular waveguide is
- 1) $c\pi\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$
 - 2) $c\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$
 - 3) $\pi\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$
 - 4) $2\pi\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$

42. $\nabla \times V$ in terms of volume integral is,

1) $\lim_{\int d\tau \rightarrow 0} \frac{\int d\sigma \times V}{\int d\tau}$

2) $\lim_{\int d\tau \rightarrow 0} \frac{\int V \cdot d\sigma}{\int d\tau}$

3) $\lim_{\int d\sigma \rightarrow 0} \frac{\int d\tau \times V}{\int d\sigma}$

4) $\lim_{\int d\sigma \rightarrow 0} \frac{\int V \cdot d\tau}{\int d\sigma}$

43. The rank of matrix $\begin{bmatrix} a & -1 & 0 \\ 0 & a & -1 \\ -1 & 0 & a \end{bmatrix}$ is 2 for a equal to

1) 3

2) 1

3) 2

4) 4

44. In Frobenius method, for indicial equation root $K = 1$, the recurrence relation takes the form,

1) $\frac{a_0}{w} \sin wx$

2) $\frac{a_0}{w} \cos wx$

3) $a_0 \sin wx$

4) $a_0 \cos wx$

45. The conditions sufficient but not necessary for a Fourier series

1) $f(x)$ have only finite number of finite distinct in the interval $[-\pi, \pi]$

2) $f(x)$ have only finite number of finite distinct in the interval $[0, 2\pi]$

3) $f(x)$ have only finite number of finite distinct in the interval $[-\infty, \infty]$

4) $f(x)$ have only finite number of finite distinct in the interval $[0, \pi]$

46. Using Stoke's theorem $\int_c \phi dx + \psi dy$ is

1) $\int_c \frac{\partial \phi}{\partial x} - \frac{\partial \psi}{\partial y} dx dy$

2) $\int_c \frac{\partial \psi}{\partial x} + \frac{\partial \psi}{\partial y} dx dy$

3) $\int_c \frac{\partial \phi}{\partial x} + \frac{\partial \psi}{\partial y} dx dy$

4) $\int_c \frac{\partial \psi}{\partial x} - \frac{\partial \phi}{\partial y} dx dy$

47. In $f(z) = u + iv$, u, v are harmonic then both these u, v satisfy,

1) Cauchy condition

2) Laplace's equation

3) Helmholtz equation

4) Demoiivre's theorem

48. The variance for a discrete random variable X with probabilities P_i at $X = u_i$,

1) $\sigma^2 = \sum_j (x_j - \langle X \rangle)^2 P_j$

2) $\sigma^2 = \sum_j (x_j - \langle X \rangle) P_j$

3) $\sigma^2 = \sum_j (x_j - \langle X^2 \rangle) P_j$

4) $\sigma^2 = \sum_j (x_j^2 - \langle X \rangle)^2 P_j$

49. Which is true for phase space?

1) $6N$ dimension space

2) Each particle contributes 1 D for each position and 1 D for momentum coordinate

3) There is only one possible path in phase space

4) $2N$ dimension space

50. An xyz co-ordinate system, initially coinciding with an inertial frame xyz , rotates with an angular velocity $\vec{\omega} = 2\hat{i} + 2t^2\hat{j} + (2t + 4)\hat{k}$ where $t = \text{time}$. The position vector of a particle at time t in xyz system is given by

$$\vec{r} = (t^2 + 1)\hat{i} + 3t\hat{j} + 2t^3\hat{k}$$

Its apparent velocity at time $t = 1$ sec.

1) $V' = 2\hat{i} + 6\hat{j} + 4\hat{k}$

2) $V' = 2\hat{i} - 6\hat{j} + 12\hat{k}$

3) $V' = 2\hat{i} + 3\hat{j} + 6\hat{k}$

4) $V' = 2\hat{i} + 6\hat{j} - 4\hat{k}$

51. Which of the following statement is not true about fast top?

1) The amplitude of nutation is small

2) Nutation is sinusoidal

3) Frequency of nutation is small

4) Precession is slow

52. Curve joining two points along which a particle falling from rest under the influence of gravity travels from higher to the lower point in the minimum time is called

1) brachistochrone

2) geodesics

3) minimum surface of revolution

4) variation

53. Hamilton's canonical equations of motion are

- 1) $\dot{q}_i = \frac{\partial H}{\partial p_i}$ and $\dot{p}_i = \frac{\partial H}{\partial q_i}$ 2) $\dot{q}_i = \frac{\partial H}{\partial p_i}$ and $\dot{p}_i = -\frac{\partial H}{\partial q_i}$
3) $q_i = \frac{\partial H}{\partial p_i}$ and $p_i = \frac{\partial H}{\partial \dot{q}_i}$ 4) $q_i = \frac{\partial H}{\partial \dot{p}_i}$ and $p_i = -\frac{\partial H}{\partial \dot{q}_i}$

54. An electrostatic field is said to be conservative when

- 1) the divergence of the field is equal to zero
2) the curl of the field is equal to zero
3) the divergence of the field is unity
4) the curl of the field is unity

55. For static electric and magnetic fields in an inhomogeneous source free medium, which of the following represents the correct form of two of Maxwell's equation?

- 1) $\nabla \cdot E = 0, \nabla \times B = 0$ 2) $\nabla \times E = 0, \nabla \cdot B = 0$
3) $\nabla \times E = 0, \nabla \times B = 0$ 4) $\nabla \cdot E = 0, \nabla \cdot B = 0$

56. Which expression describes electromagnetic field energy flow?

- 1) $\frac{1}{2}(E \cdot D + B \cdot H)$ 2) $E \times H$
3) $E \times D$ 4) $E \cdot D$

57. Polarization of dielectric material is given by

- 1) $P = \epsilon_r E$ 2) $P = (\epsilon_r - 1)E$
3) $P = \epsilon_0(\epsilon_r - 1)E$ 4) $P = \epsilon_0(\epsilon_r - 1)$

58. In material media the velocity of electromagnetic wave depends on the frequency. This phenomenon is known as

- 1) diffraction 2) dispersion
3) reflection 4) impedance

59. Which of the following statements correctly represents the relation between phase velocity and group velocity for a non-relativistic free particle?

- 1) The phase velocity is equal to the group velocity
2) The phase velocity is not equal to the group velocity
3) The phase velocity is half of the group velocity
4) The phase velocity is equal to twice the group velocity

60. The phenomenon of propagation of a particle through a region where the energy of the particle is lower than the potential energy of the region is called as,

- | | |
|---------------------|--------------------------------|
| 1) Compton effect | 2) Photoelectric effect |
| 3) Tunneling effect | 4) Black body radiation effect |

61. The ground state energy of a particle in a cubic box with side a is :

- | | |
|-----------------------------------|-----------------------------------|
| 1) $\frac{\pi^2 \hbar^2}{2ma^2}$ | 2) $\frac{3\pi^2 \hbar^2}{2ma^2}$ |
| 3) $\frac{5\pi^2 \hbar^2}{8ma^2}$ | 4) $\frac{\pi^2 \hbar^2}{8ma^2}$ |

62. The commutation relation of $[L_+, L_-]$ is

- | | |
|-----------------|------------------------|
| 1) $\hbar L_+$ | 2) $\pm \hbar L_{\pm}$ |
| 3) $2\hbar L_z$ | 4) $\hbar L_z$ |

63. A *bra* and a *ket* vectors are said to be orthogonal if their scalar product is

- | | |
|--------|----------|
| 1) one | 2) zero |
| 3) two | 4) three |

64. The eigen value of the operator \hat{J}^2 is :

- | | |
|--------------------|--------------------|
| 1) $j(j+1)\hbar$ | 2) $j(j-1)\hbar^2$ |
| 3) $j(j+1)\hbar^2$ | 4) $(j+1)\hbar^2$ |

65. From the partial wave analysis, the inelastic scattering cross section by a spherically symmetric potential with the loss of flux is

- | |
|---|
| 1) $\sigma = \frac{\pi}{k} \sum_{l=0}^{\infty} (2l+1)(1 - \eta_l^2(k))$ |
| 2) $\sigma = \frac{\pi}{k} \sum_{l=0}^{\infty} (2l+1)^2 (1 - \eta_l^2(k))$ |
| 3) $\sigma = \frac{\pi}{k^2} \sum_{l=0}^{\infty} (2l+1)(1 - \eta_l^2(k))$ |
| 4) $\sigma = \frac{\pi^2}{k^2} \sum_{l=0}^{\infty} (2l-1)(1 - \eta_l^2(k))$ |

66. The Fermi-Golden rule of transition probability of a perturbed system with density of states $\rho(k)$ and perturbed Hamiltonian H'

- 1) $\frac{2\pi}{\hbar} \rho(k) |\langle k | H' | m \rangle|^2$ 2) $\frac{2\pi^2}{\hbar^2} \rho(k) |\langle k | H' | m \rangle|^2$
3) $\frac{\pi}{\hbar} \rho^2(k) |\langle k | H' | m \rangle|^2$ 4) $\frac{\pi^2}{\hbar^2} \rho^2(k) |\langle k | H' | m \rangle|^2$

67. Radiation is contained in a volume V and has pressure P and total energy E . Justify the correct value of PV

- 1) $\frac{1}{4} E$ 2) $\frac{3}{4} E$
3) $\frac{4}{3} E$ 4) $\frac{1}{3} E$

68. The potential energy of the molecules of ideal gas is

- 1) equal to the internal energy 2) zero
3) equal to kinetic energy 4) equal to the external work

69. The volume of a cell in six dimensional phase space is

- 1) h 2) h^6
3) h^3 4) h^2

70. The pressure of a gas filled vessel is P . If the masses of all the molecules of the gas are halved, their speed become doubled, what is the new pressure?

- 1) $3P$ 2) $2P$
3) $5P$ 4) P

71. In a silicon p - n junction diode, a forward voltage of 0.1 V is applied, the current that flows through the device is of the order of

- 1) 10^{-15} A 2) 10^{-3} A
3) 10^{-12} A 4) 10^2 A

72. At cut off, the JFET channel is

- 1) as its widest point
- 2) completely closed by the depletion region
- 3) extremely narrow
- 4) reverse biased

73. A portion of the output that provides circuit stabilization is considered to be

- 1) negative feedback
- 2) distortion
- 3) open loop
- 4) positive feedback

74. Given a parallel resonance circuit with $Q = 40$, $f = 440$ Hz, and the admittance of $500 \mu \text{ mho}$ at resonance, the resistance of the circuit is

- 1) 100Ω
- 2) 2Ω
- 3) 300Ω
- 4) $4 \text{ M}\Omega$

75. A certain op-amp has bias currents of $50 \mu \text{ A}$ and $49.3 \mu \text{ A}$. The input offset current is

- 1) 700 nA
- 2) $99.3 \mu \text{ A}$
- 3) $49.7 \mu \text{ A}$
- 4) $99 \mu \text{ A}$

76. A skew symmetric tensor of second order has non-zero component equal to,

- 1) $n(n-1)$
- 2) $n(n+1)$
- 3) $\frac{1}{2}n(n-1)$
- 4) $\frac{1}{2}n(n+1)$

77. Which of the following equation is related to simple pendulum?

- 1) $\ddot{\theta} + \frac{g}{l} \sin \theta = 0$
- 2) $m\ddot{x} + kx = 0, m\ddot{y} + ky = 0$
- 3) $\ddot{\theta} + \frac{mgl}{I} \sin \theta = 0$
- 4) $\ddot{\theta} + \frac{g}{l} \cos \theta = 0$

78. Which one of the following equation describes the D'Alembert's principle?

- 1) $\frac{d}{dt} \left(\frac{\partial L}{\partial \dot{q}_j} \right) - \frac{\partial L}{\partial q_j} = 0$
- 2) $\sum P_j q_j - L$
- 3) $\delta \int_{t_1}^{t_2} L dt = 0$
- 4) $\sum (\vec{F}_i - \vec{P}_i) \cdot \delta \vec{r}_i = 0$

90. A type of crystallographic defect in which an anionic vacancy in a crystal is filled by one or more unpaired electrons is called
- 1) C-center
 - 2) M-center
 - 3) F-center
 - 4) M_A center
91. The field mediator of weak interaction is
- 1) Gluons
 - 2) Photons
 - 3) Gravitons
 - 4) Z^0 bosons
92. The reaction $\pi^- + p \rightarrow \Lambda^0 + \pi^0$ is forbidden because of
- 1) Law of baryon number conservation
 - 2) Law of strangeness conservation
 - 3) Law of charge conservation
 - 4) Law of hypercharge conservation
93. A spin $-\frac{1}{2}$ negatively charged particle has spin gyromagnetic ratio $g = -2$ (something like an electron, but with a different mass). If its magnetic moment is $\mu_z = \pm 4.5 \times 10^{-26} J/T$, what is its mass?
- 1) $1.88 \times 10^{-28} \text{ kg}$
 - 2) $2.88 \times 10^{-28} \text{ kg}$
 - 3) $1.88 \times 10^{-24} \text{ kg}$
 - 4) $1.68 \times 10^{-28} \text{ kg}$
94. Consider three Ising spins at the vertices of a triangle which interact with each other with a ferromagnetic Ising interaction of strength J . The partition function of the system at temperature T is given by ($\beta = \frac{1}{k_B T}$)
- 1) $2e^{3\beta J} + 6e^{-\beta J}$
 - 2) $2e^{-3\beta J} + 6e^{\beta J}$
 - 3) $2e^{3\beta J} + 3e^{-\beta J}$
 - 4) $4e^{3\beta J} + 6e^{-\beta J}$
95. Two nuclear states have magnetic moments that differ by one nuclear magneton. When $B = 0.1$ tesla, the populations of the two levels are in the ratio 1 : 2. What is the temperature?
- 1) $5.3 \times 10^{-5} \text{ K}$
 - 2) $5.3 \times 10^{-6} \text{ K}$
 - 3) $8.3 \times 10^{-6} \text{ K}$
 - 4) $2.3 \times 10^{-6} \text{ K}$

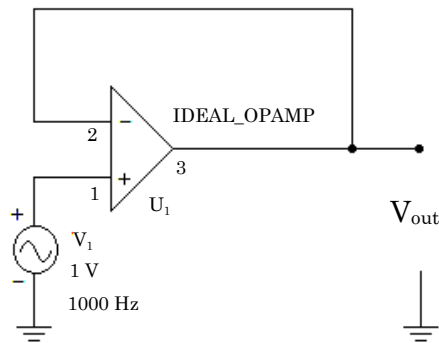
96. The mean variation of a χ^2 distribution with 8 degrees of freedom are

- 1) 4, 8
- 2) 8, 16
- 3) 16, 8
- 4) 8, 4

97. An LVDT

- 1) Exhibit linear characteristics up to a displacement of ± 5 mm
- 2) Has a linearity of 0.05%
- 3) Has an infinite resolution and a high sensitivity which is of the order of 40 V/mm
- 4) All of the above

98. What is the output wave form of the following circuit?



- 1) Sine wave
- 2) Square wave
- 3) Saw tooth wave
- 4) Triangle wave

99. The Lamb shift is due to the interaction of electron with

- 1) its own surrounding electric field
- 2) its own surrounding magnetic field
- 3) its own spin magnetic momentum
- 4) All of the above

100. If v' and v'' are the vibrational constants in the upper and lower vibrational states, the wave number of bands in a sequence

- 1) Increase with v'
- 2) decrease with v'
- 3) increase with v''
- 4) do not change

ROUGH WORK

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