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M. Phil/Ph.D/URS - EE - Jan.-Dec.-2017

SUBJECT : Physics

A

Sr. No. 10021

Time : **1¼ Hours** Max. Marks : **100** Total Questions : **100**

Roll No. (in figures)_____ (in words) _____

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1. The electrostatic potential $V(x, y)$ in free space in a region where the charge density ρ is zero is given by $V(x,y) = 4e^{2x} + f(x) - 3y^2$. Given that the x-component of the electric field, E_x and V are zero at the origin, $f(x)$ is :

(1) $3x^2 - 4e^{2x} + 8x$ (2) $3x^2 - 4e^{2x} + 16x$

(3) $4e^{2x} - 8$ (4) $3x^2 - 4e^{2x}$

2. Which of the following matrices is an element of the group SU(2) ?

(1) $\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$ (2) $\begin{bmatrix} \frac{1+i}{\sqrt{3}} & \frac{-1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} & \frac{1-i}{\sqrt{3}} \end{bmatrix}$

(3) $\begin{bmatrix} 2+i & i \\ 3 & 1+i \end{bmatrix}$ (4) $\begin{bmatrix} \frac{1}{2} & \frac{\sqrt{3}}{2} \\ \frac{\sqrt{3}}{2} & \frac{1}{2} \end{bmatrix}$

3. A cavity contains blackbody radiation in equilibrium at temperature T. The specific heat per unit volume of the photon gas in the cavity is of the form $C_v = \gamma T^3$ where γ is a constant. The cavity is expanded to twice its original volume and then allowed to equilibrate at the same temperature T. The new internal energy per unit volume is :

(1) $4\gamma T^4$ (2) $2\gamma T^4$

(3) $\gamma T^4/4$ (4) γT^4

4. A particle in one dimension moves under the influence of a potential $V(x) = ax^6$, where a is a real constant. For large n, the quantized energy level E_n depends on n as :

(1) $E_n \sim n^3$ (2) $E_n \sim n^{4/3}$ (3) $E_n \sim n^{6/5}$ (4) $E_n \sim n^{3/2}$

5. A beam of pions (π^+) is incident on a proton target, giving rise to the process $\pi^+ p \rightarrow n + \pi^+ + \pi^+$. Assuming that the decay proceeds through strong interactions, the total isospin I and its third component I_3 for the decay products, are :

(1) $I = 3/2,\ I_3 = 3/2$ (2) $I = 5/2,\ I_3 = 5/2$

(3) $I = 5/2,\ I_3 = 3/2$ (4) $I = 1/2,\ I_3 = -1/2$

6. The equation of the plane that is tangent to the surface $xyz = 8$ at the point $(1, 2, 4)$ is :

(1) $x + 2y + 4z = 12$ (2) $4x + 2y + z = 12$

(3) $x + 4y + 2z = 12$ (4) $x + y + z = 7$

7. Assume that the free energy of a magnetic system has an expansion in the order parameter M of the form $F(M, T) = a(T - T_c)\, M^2 + bM^4 + cM^6$, with a, b and $c > 0$. As the temperature is lowered below T_c, the system undergoes a phase transition. The behaviour of the order parameter just below the transition, where $(T - T_c)$ is very small, is best described by :

(1) $M \alpha (T_c - T)^{-1/2}$ (2) $M \alpha (T_c - T)^{1/2}$

(3) $M \alpha (T_c - T)$ (4) $M \alpha (T_c - T)^3$

8. The minimum energy of an electron (the rest mass of which is 0.5 MeV) that can emit Cherenkov radiation while passing through water (of refractive index 1.5) is approximately :

(1) 1.0 MeV (2) 3.0 MeV (3) 0.7 MeV (4) 0.5 MeV

9. Let $y(x)$ be a continuous real function in the range 0 and $2n$, satisfying the inhomogeneous differential equation : $\sin x d^2y/dx^2 + \cos x dy/dx = \delta(x - \pi/2)$. The value of dy/dx at the point $x = \pi/2$:

(1) is continuous (2) has a discontinuity of 3

(3) has a discontinuity of 1/3 (4) has a discontinuity of 1

10. A bag contains many balls, each with a number painted on it. There are exactly N balls which have the number N (namely one ball with 1, two balls with 2, and so on until N balls with N on them). An experiment consists of choosing a ball at random, noting the number on it and returning it to the bag. If the experiment is repeated a large number of times, the average value of the number will tend to :

(1) $(2N+1)/3$ (2) $N/2$ (3) $(N+1)/2$ (4) $N(N+1)/2$

11. Bose condensation occurs in liquid He^4 kept at ambient pressure at 2.17 K. At which temperature will Bose condensation occur in He^4 in gaseous state, the density of which is 1000 times smaller than that of liquid He^4 ? (Assume that it is a perfect Bose gas)

(1) 2.17 mK (2) 21.7 mK (3) 21.7 μK (4) 2.17 μK

12. The energy required to create a lattice vacancy in a crystal is equal to 1 eV. The ratio of the number densities of vacancies n (1200 K) / n (300 K), when the crystal is at equilibrium at 1200 K and 300 K, respectively is approximately :

(1) $e^{(-30)}$ (2) $e^{(-15)}$ (3) $e^{(15)}$ (4) $e^{(30)}$

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13. The minimum energy of a collection of 6 non-interacting electrons of spin –1/2 placed in a one dimensional infinite square well potential of width L is :

(1) $14\pi^2\hbar^2 / rnL^2$ (2) $91\pi^2\hbar^2 / rnL^2$

(3) $7\pi^2\hbar^2 / rnL^2$ (4) $3\pi^2\hbar^2 / rnL^2$

14. A function $f(x)$ obeys the differential equation $d^2 f / dx^2 - (3-2i)f = 0$ and satisfies the conditions $f(0) = 1$ and $f(x) \to 0$ as $x \to \infty$. The value $f(\pi)$ is :

(1) $\exp(2\pi)$ (2) $\exp(-2\pi)$ (3) $-\exp(-2\pi)$ (4) $-\exp(2\pi i)$

15. A magnetic field sensor based on the Hall effect is to be fabricated by implanting As into a Si film of thickness 1 μrn, The specifications require a magnetic field sensitivity of 500 mV/Tesla at an excitation current of 1 mA. The implantation dose is to be adjusted such that the average carrier density, after activation, is :

(1) $1.25 \times 10^{26} m^{-3}$ (2) $1.25 \times 10^{22} m^{-3}$

(3) $4.1 \times 10^{21} m^{-3}$ (4) $4.1 \times 10^{20} m^{-3}$

16. Consider a He-Ne laser cavity consisting of two mirrors of reflectivities $R_1 = 1$ and $R_2 = 0.98$. The mirrors are separated by a distance $d = 20$ cm and the medium in between has a refractive index $n_0 = 1$ and absorption coefficient $\alpha = 0$. The values of the separation between the modes δv and the width Δv_p of each mode of the laser cavity are :

(1) $\delta v = 75$ kHz, $\Delta v_p = 24$ kHz (2) $\delta v = 100$ kHz, $\Delta v_p = 100$ kHz

(3) $\delta v = 750$ MHz, $\Delta v_p = 2.4$ MHz (4) $\delta v = 2.4$ MHz, $\Delta v_p = 750$ MHz

17. In a basis in which the z-component S_z of the spin is diagonal, an electron is in a spin state $\psi = \begin{pmatrix} 1+i \\ \sqrt{2/3} \end{pmatrix}$. The probabilities that a measurement of S_z will yield the values $\hbar/2$ and $-\hbar/2$ are, respectively :

(1) 1/2 and 1/2 (2) 2/3 and 1/3

(3) 1/4 and 3/4 (4) 1/3 and 2/3

18. A muon (μ^-) from cosmic ray is trapped by a proton to form a hydrogen like atom. Given that a muon is approximately 200 times heavier than an electron, the longest wavelength of the spectral line (in the analogue of the Lyman series) of such an atom will be :

(1) 5.62 Å (2) 6.67 Å (3) 3.75 Å (4) 13.3 Å

19. A particle of mass m is at the stable equilibrium position of its potential energy $V(x) = ax - bx^3$ where a, b are positive constants. The minimum velocity that has to be imparted to the particle to render its motion unstable is :

(1) $(64a^3/9m^2b)^{1/4}$ (2) $(64a^3/27m^2b)^{1/4}$

(3) $(16a^3/27m^2b)^{1/4}$ (4) $(3a^3/64m^2b)^{1/4}$

20. Muons are produced through the annihilation of particle a and its antiparticle, namely the process $a + a \rightarrow \mu^+ + \mu^-$. A muon has a rest mass of 105 MeV/c^2 and its proper life time is 2 μs. If the center of mass energy of the collision is 2.1 GeV in the laboratory frame that coincides with the center-of-mass frame, then the fraction of muons that will decay before they reach a detector placed 6 km away from the interaction point is :

(1) e^{-1} (2) $1 - e^{-1}$ (3) $1 - e^{-2}$ (4) e^{-10}

21. The electronic energy levels in a hydrogen atom are given by En = $-13.6/n^2$ eV. If a selective excitation to the n = 100 level is to be made using a laser, the maximum allowed frequency line-width of the laser is approximately :

(1) 6.5 MHz (2) 6.5 GHz (3) 6.5 Hz (4) 6.5 kHz

22. Let A, B and C be functions of phase space variables (coordinates and momenta of a mechanical system). If {,} represents the Poisson bracket, the value of {A,{B,C}} – {{A,B},C} is given by :

(1) 0 (2) {B,{C,A}} (3) {A, {C,B}} (4) {{C,A},B}

23. Two monochromatic sources, L_1 and L_2 emit light at 600 and 700 run, respectively. If their frequency bandwidths are 10^{-1} and 10^{-3} GHz, respectively, then the ratio of line-width of L_1 and L_2 is approximately :

(1) 100 : 1 (2) 1 : 85 (3) 75 : 1 (4) 1 : 75

24. A child makes a random walk on a square lattice of lattice constant a taking a step in the north, east, south, or west directions with probabilities 0.255, 0.255, 0.245, and 0.245, respectively. After a large number of steps, N, the expected position of the child with respect to the starting point is at a distance :

(1) $\sqrt{2} \times 10^{-2}$ Na in the north-east direction

(2) $\sqrt{(2N)} \times 10^{-2}$ Na in the north-east direction

(3) $2\sqrt{2} \times 10^{-2}$ Na in the south-east direction

(4) 0

SEAL

25. A 4-variable switching function is given by $f = \Sigma(5,7,8,10,13,15)+d(0,1,2)$, where d is the do-not-care-condition. The minimized form of f in sum of products (SOP) form is :

(1) $\overline{AC}+\overline{BD}$ (2) $A\overline{B}+C\overline{D}$ (3) $AD+BC$ (4) $\overline{B}\,\overline{D}+BD$

26. A gas laser cavity has been designed to operate at $\lambda = 0.5$ μm with a cavity length of 1 m. With this set-up, the frequency is found to be larger than the desired frequency by 100 Hz. The change in the effective length of the cavity required to retune the laser is :

(1) -0.334×10^{-12} m (2) 0.334×10^{-12} m

(3) 0.167×10^{-12} m (4) -0.167×10^{-12} m

27. One gram of salt is dissolved in water that is filled to a height of 5 cm in a beaker of diameter 10 cm, The accuracy of length measurement is 0.01 cm while that of mass measurement is 0.01 mg. When measuring the concentration C, the fractional error $\Delta C/C$ is :

(1) 0.8% (2) 0.14% (3) 0.5% (4) 0.28%

28. The recently-discovered Higgs boson at the LHC experiment has a decay mode into a photon and a Z boson. If the rest masses of the Higgs and Z boson are 125 GeV/c^2 and 90 GeV/c^2 respectively, and the decaying Higgs particle is at rest, the energy of the photon will approximately be :

(1) $35\sqrt{3}$ GeV (2) 35 GeV (3) 30 GeV (4) 15 GeV

29. A canonical transformation relates the old coordinates (q, p) to the new ones (Q, P) by the relations $Q = q^2$ and $P = p/2q$. The corresponding time-independent generating function is :

(1) P/q^2 (2) q^2P (3) q^2/P (4) qP^2

30. Let x and p denote, respectively, the coordinate and momentum operators satisfying the canonical commutation relation $[x, p] = i$ in natural units $(\hbar = 1)$. Then the commutator $[x, pe^{-p}]$ is :

(1) $i(1-p)e^{-p}$ (2) $i(1-p^2)e^{-p}$ (3) $i(1-e^{-p})$ (4) ipe^{-p}

31. In a measurement of the viscous drag force experienced by spherical particles in a liquid, the force is found to be proportional to $V^{1/3}$ where V is the measured volume of each particle. If V is measured to be 30 mm^3, with an uncertainty of 2.7 mm^3, the resulting relative percentage uncertainty in the measured force is :

(1) 2.08 (2) 0.09 (3) 6 (4) 3

32. A plane electromagnetic wave incident normally on the surface of a material is partially reflected. Measurements on the standing wave in the region in front of the interface show that the ratio of the electric field amplitude at the maxima and the minima is 5. The ratio of the reflected intensity to the incident intensity is :

(1) 4/9 (2) 2/3 (3) 2/5 (4) 1/5

33. A computer cannot "boot" if it does not have the :

(1) Compiler (2) Loader

(3) Operating System (4) Assembler

34. Which of the following is ***not*** a function of the control unit ?

(1) Read Instructions (2) Execute Instructions

(3) Interpret Instructions (4) Direct Operations

35. A combination is made of two lenses of focal lengths f and f' in contact; the dispersive power of the materials of the lenses are ω and ω'. The combination is achromatic when :

(1) $\omega = \omega_0, \omega' = 2\omega_0, f' = 2f$ (2) $\omega = \omega_0, \omega' = 2\omega_0, f' = f/2$

(3) $\omega = \omega_0, \omega' = 2\omega_0, f' = -f/2$ (4) $\omega = \omega_0, \omega' = 2\omega_0, f' = -2f$

36. A monochromatic beam of light is used for the formation of fringes on a screen by illuminating the two slits in the Young's double slit experiment. When a thin film of mica is interposed in the path of one of the interfering beams :

(1) the fringe width increases

(2) the fringe width decreases

(3) the fringe pattern disappears

(4) the fringe width remains the same but the pattern shifts

37. The proper half life of some radio-isotopes is 5 μs. When these isotopes pass through a laboratory, their half life is observed to be 15 μs. The speed of the radio- isotopes is :

(1) $\frac{2\sqrt{2}}{3}c$ (2) $\frac{\sqrt{2}}{3}c$

(3) $\frac{3}{\sqrt{2}}c$ (4) $\frac{2}{3\sqrt{2}}c$

38. A slowly moving electron collides with a positron at rest and annihilates it producing two photons. If the rest mass of the electron or positron be m_0 then the frequency of each photon is :

(1) $2m_0c^2/h^2$ (2) m_0c^2/h^2 (3) m_0c^2/h (4) $2m_0c^2/h$

39. An α particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of :

(1) 1 Å (2) 10^{-10} cm (3) 10^{-12} cm (4) 10^{-16} cm

40. An X -ray photon of wavelength λ, and frequency ν collides with an electron and bounces off. If λ', and ν' are respectively the wavelength and frequency of the scattered photon, then :

(1) $\lambda' = \lambda; \nu' = \nu$ (2) $\lambda' < \lambda; \nu' > \nu$

(3) $\lambda' > \lambda; \nu' > \nu$ (4) $\lambda' > \lambda; \nu' < \nu$

41. In Foucaults rotating mirror experiment for determining the velocity of light, the distance between the rotating mirror and the convex lens is negligible when compared to the radius of curvature of the concave mirror. If the radius of curvature of the concave mirror is doubled, the image shift is :

(1) halved
(2) doubled
(3) zero
(4) independent of radius of curvature of concave mirror

42. A particle moving with a uniform acceleration along a straight line covers distances a and b in successive intervals of p and q seconds. The acceleration of the particle is :

(1) $\frac{pq(p+q)}{2(bp-aq)}$ (2) $\frac{bp-aq}{pq(p-q)}$ (3) $\frac{2(aq-bp)}{pq(p-q)}$ (4) $\frac{2(bp-aq)}{pq(p+q)}$

43. A uniform rod *'AB'* of mass m and length l is at rest on a smooth horizontal surface. An impulse p is applied to the end *'B'*. The time taken by the rod to twist through a right angle is :

(1) $\frac{2\pi ml}{p}$ (2) $\frac{\pi ml}{12p}$ (3) $\frac{2\pi p}{ml}$ (4) $\frac{\pi p}{ml}$

44. A rod of length *'l'* is hinged from one end. It is brought to a horizontal position and released. The angular velocity of the rod when it is in vertical position, is :

(1) $\sqrt{\frac{2g}{L}}$ (2) $\sqrt{\frac{3g}{L}}$ (3) $\sqrt{\frac{g}{2L}}$ (4) $\sqrt{\frac{g}{L}}$

45. A particle executes S.H.M. with an amplitude of 10 cm and frequency 2 Hz. At t = 0, the particle is at a point where potential energy and kinetic energy are same. The equation of displacement of the particle is :

(1) $0.1\cos\left\{4\pi l+\frac{\pi}{4}\right\}$ (2) $0.1\sin 4\pi l$

(3) $0.1\sin\left\{4\pi l+\frac{\pi}{4}\right\}$ (4) $0.1\sec\left\{4\pi l+\frac{\pi}{4}\right\}$

46. Equation of a plane wave is given by $\frac{4\sin\pi}{4}\left[2t+\frac{x}{8}\right]$. The phase difference at any instant of two particles 16 cm apart is :

(1) 60° (2) 90° (3) 30° (4) 120°

47. A thermally insulated piece of matter is heated under atmosphere by an electric current so that it receives electrical energy at a constant power P. This leads to an increase of the absolute temperature T of the metal with time t as $T = at^{1/4}$. The specific heat C_p in this case is :

(1) $\frac{4PT^3}{a^4}$ (2) $\frac{4PT^2}{a^3}$ (3) $4PT^2$ (4) $\frac{4PT^3}{a^3}$

48. Two identical containers A and B have frictionless pistons. Both contain same volume of ideal gas at same temperature. The gas in each cylinder is allowed to expand isothermally to double the initial volume. The mass of the gas in A is m_A and the mass of the gas in B is m_B. The changes in the pressure in A and B are ΔP and $1.5\,\Delta P$ respectively, then :

(1) $4m_A = 9m_B$ (2) $2m_A = 3m_B$ (3) $3m_A = 2m_B$ (4) $4m_A = 4m_B$

49. The moment of inertia I of a body at a temperature 'T' increases to $I+\Delta I$ as the temperature rises to $T+\Delta T$. If the coefficient of linear expansion of the material is 'α', then the ratio $\Delta I/I$ will be :

(1) $\Delta T/T$ (2) $2\Delta T/T$ (3) $\alpha\Delta T$ (4) $2\alpha\Delta T$

50. An electric dipole, made up of a positive and negative charge, each of 1 mC placed at a distance 2 cm apart is placed in an electric field of 10^5 N/C. The maximum torque exerted by the field on the dipole while it is turned from $\theta = 0°$ to $\theta = 180°$ is :

(1) 2×10^{-3} N-m (2) 3×10^{-3} N-m

(3) 4×10^{-3} N-m (4) 2.8×10^{-3} N-m

SEAL

51. If a charged particle moving in a magnetic field looses 4% of its kinetic energy, then the radius of curvature of its path will change by :

(1) 6% (2) 4% (3) 10% (4) 2%

52. The mutual inductance of coil and a solenoid, for a solenoid of length 50 cm and with 5000 turns of wire of radius 4 cm and a coil of 700 turns wound on middle of the solenoid is :

(1) 44.17 mH (2) 48.98 mH (3) 34.34 mH (4) 36.72 mH

53. A circular turn table has a block of ice placed at its centre. The system rotates with an angular speed ω about an axis passing through the centre of the table. If the ice melts, on its own, without any evaporation, the speed of rotation of the system :

(1) becomes zero

(2) remains constant at the same value ω

(3) increases to a value greater than ω

(4) decreases to a value less than ω

54. Out of various configurations of a transistor as an amplifier, which of following statement is ***not*** correct ?

(1) input resistance is least in CB mode

(2) output resistance is least in CC mode

(3) output resistance in CE mode is more than the CB mode

(4) voltage gain of CC mode is less than CE mode

55. A metallic surface has a threshold wavelength 5200 Å. This surface is irradiated by monochromatic light of wavelength 4500 Å. Which of the following statements is ***true*** ?

(1) The electrons are emitted from the surface having energy between 0 and infinity

(2) The electrons are emitted from the surface having energy between 0 and certain finite maximum value

(3) The electrons are emitted from the surface, all having certain finite energy

(4) No electron is emitted from the surface

56. The group and phase velocities in case of wave packets are equal if :

(1) phase velocity v_p is independent of the wavevector

(2) phase velocity v_p is independent of the wavevector and frequency

(3) phase velocity v_p is dependent on the wavevector

(4) None of these

57. The number of atoms in 100 gm of a f.c.c. crystal with density 10g cm^{-3} and cell edge 200 pm is :

(1) 3.2×10^{26} (2) 1.1×10^{26} (3) 5.0×10^{24} (4) 2.6×10^{25}

58. If a one dimensional harmonic oscillator is in the state :

$$\psi(x)=\frac{1}{\sqrt{14}}[3\psi_0(x)-2\psi_1(x)+3\psi_2(x)]$$

where $\psi_0(x), \psi_1(x)$ and $\psi_2(x)$ are the ground, first and second excited states respectively. The probability of finding the oscillator in the ground state is :

(1) 9/14 (2) 1/2 (3) $\frac{3}{\sqrt{14}}$ (4) 1

59. ECL circuits have higher fan-out due to their :

(1) high input impedance

(2) low output impedance

(3) high input impedance and low output impedance

(4) complementary outputs

60. In a TTL gate with passive pull-up, the collector current of the output transistor is 4 mA corresponding to LOW level output when it is not driving any other gate. Its fan-out is 10 and sinks 1.5 mA current corresponding to each load gate. The fan-out when two such gates are wire- ANDed will be :

(1) 5 (2) 7 (3) 10 (4) 20

61. The hexadecimal equivalent of the binary number 11101101111010 is :

(1) EDE8 (2) 3B7A (3) FB7A (4) 35572

62. The maximum positive and negative numbers which can be represented in two complements form using n bits are respectively :

(1) $+(2^{n-1}-1),-(2^{n-1}-1)$ (2) $+(2^{n-1}-1),-2^{n-1}$

(3) $+2^{n-1},-2^{n-1}$ (4) $+2^{n-1},-(2^{n-1}+1)$

63. A microprocessor without the interrupt facility :

(1) is best suited for a process control system

(2) is not useful for a process control system

(3) cannot be used for DMA operation

(4) cannot be interfaced with any I/O device

64. A body moves along x-axis with velocity v_x at position x. If the plot $v_x - x$ is an ellipse with major axis $2A$ and minor axis $2v_0$, the maximum acceleration has a modulus :

(1) v_0^2 / A (2) A / v_0^2 (3) $v_0 A$ (4) $v_0^2 / A^{1/2}$

65. A uniform rod AB of mass m and length l is at rest on a smooth horizontal surface. If an impulse 'p' is applied at the end B, then the time taken by the rod to turn through a right angle is :

(1) $2\pi ml/p$ (2) $2\pi p/ml$ (3) $\pi ml/12p$ (4) $\pi p/ml$

66. In a glass sphere, there is small bubble at 2×10^{-2} m from its centre. If the bubble is viewed along a diameter of the sphere from the side on which it lies, how far from the surface will it appear ? The radius of the sphere is 5×10^{-2} m and the refractive index of glass is 3/2.

(1) 2.5×10^{-2} m (2) 3.2×10^{-2} m

(3) 6.5×10^{-2} m (4) 0.2×10^{-2} m

67. The work function of a certain metain is 2.3 eV. If the light of wave number $2\times10^{6}\,m^{-1}$ falls on it, the kinetic energy of fastest and slowest ejected electrons will be respectively :

(1) 2.48 eV, 0.18 eV (2) 0.18 eV, zero

(3) 2.30 eV, 0.18 eV (4) 0.18 eV, 0.18 eV

68. Given $\log_e 2 = 0.69$, the approximate value of $\log_e 3$ by evaluating the $\int_2^3 dx/x$ by Simpson's rule with intervals is :

(1) 1.155 (2) 0.991 (3) 1.095 (4) 1.201

69. If $f(0) = 1$ and $f(1) = 2.72$, then the trapezoidal rule gives the approximate value of $\int_0^1 f(x)dx$ as :

(1) 3.72 (2) 1.86 (3) 1.72 (4) 0.86

70. Entropy of a thermodynamic system does not change when this system is used for :

(1) conduction of heat from a hot reservoir to a cold reservoir

(2) conversion of work into heat isothermally

(3) conversion of heat into internal energy isochorically

(4) conversion of heat into work, isobarically

71. An atom of mass M can be excited to a state of mass $M + \Delta$ by photon capture. The frequency of a photon which can cause this transition is :

(1) $\Delta c^2/2Mh$ (2) $\Delta c^2/M^2h$

(3) $\Delta c^2(\Delta + 2M)/2Mh$ (4) $\Delta^2c^2/2M^2h$

72. The associated change in wavelength resulting due to a collision of relativistic nature of a photon of wavelength λ with a free electron at rest is given as :

(1) $\lambda - \lambda' = \{h/m_0c\}\{1 - \cos\varphi\}$ (2) $\lambda - \lambda' = \{h/m_0c^2\}\{1 - \cos\varphi\}$

(3) $\lambda - \lambda' = \{h/m_0c\}\{1 - \cos^2\varphi\}$ (4) $\lambda - \lambda' = \{h^2/m_0c\}\{1 - \cos\varphi\}$

where φ is the angle of scattered photon with the direction of incident photon

73. According to Langevin's theory of diamagnetism, the induced magnetic moment per unit volume is proportional to :

(1) mass of the electron (2) radius of the orbit

(3) external magnetic field (4) none of these

74. Born's approximation can be used :

(1) only within very low energy limits

(2) only within high energy limits

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75. Which of the following statements is/are ***false*** ?

(i) Brownian motion offers an experimental test of the kinetic theory hypothesis.

(ii) Brownian movements are the motions of small particles that are bombarded by molecules of the fluid.

(iii) Brownian motion demonstrates the occurrence of random motion of the particles

(iv) The average kinetic energy of the particles in the Brownian motion is the same as that of the molecules of the fluid.

(1) None of the above (2) (i) only

(3) (ii) and (iii) only (4) (iii) and (iv) only

76. If a rigid body is rotating with an angular velocity ω about an instantaneous axis through a fixed point in the body, the angular momentum J about the same point :

(i) will always be in the direction of ω

(ii) may be in the direction of ω

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(2) $f(z)$ has many infinite poles

(3) $f(z)$ has non-isolated essential singularity at $z = 0$

(4) $f(z)$ has essential singularity at $z = 0$

78. The polynomial $2x^2 + x + 3$ in terms of legendre polynomial is :

(1) $1/3(4P_2 + 3P_1 + 11P_0)$ (2) $1/3(4P_2 - 3P_1 + 11P_0)$

(3) $1/3(4P_2 + 3P_1 - 11P_0)$ (4) $1/3(4P_2 - 3P_1 - 11P_0)$

79. A particle moving on a every long frictionless wire rotating at constant angular velocity about a horizontal axis is an example of :

(1) Only conservative system

(2) Rheonomic, holonomic and conservative system

(3) Only holonomic and conservative system

(4) Rheonomic, non-holonomic, non-conservative system

80. Which of the following statements is correct for the function $f(x) = x^4 - x^2$ in the $-\infty < x < \infty$?

(1) The plot of $f(x)$ vs x as two maxima and two minima

(2) The plot of $f(x)$ vs x as three extrima

(3) The plot of $f(x)$ vs x cuts the x-axis at four points

(4) No part of the plot of $f(x)$ vs x lies in the fourth quadrant

81. A system of four particles lie in x-y plane. Out of these, two particles each of mass m are located at (–1, 1) and (1, –1). The other two particles are located at (1, 1) and (–1, –1). The value of (x, y) component of the moment of inertia tensor of this system of particles is :

(1) 10 m (2) –2 m (3) –10 m (4) 2 m

82. The specified value of holding current for an SCR means that :

(1) The device will turn on when the anode current exceeds this value

(2) The device may be damaged when the anode current exceeds this value

(3) The device will turn off when the anode current falls below this value

(4) The gate current must be equal to or exceeds this value to turn the device on

83. If a sinusoidal voltage is applied to base of a biased n-p-n transistor and the resulting sinusoidal collector voltage is clipped near zero volt, the transistor is :

(1) Being driven into saturation (2) Being driven into active region

(3) Operating non-linearly (4) None of the above

84. A dynamic RAM cell holds 5 V to be refreshed every 20 m secs., such that the stored voltage does not fall below 0.5 V. If the cell has a constant current of 0.1 pA, the storage capacitance of the cell is :

(1) 4×10^{-15} F (2) 4×10^{-6} F (3) 4×10^{-9} F (4) 4×10^{-12} F

85. A 10 bit A/D converter is used to digitise an analog signal in the 0 to 5 V range. The maximum peak to peak ripple voltage that can be allowed in the dc supply voltage is :

(1) ~100 mV (2) ~25 mV (3) ~50 mV (4) ~5.0 mV

86. The value of radius of the Fermi sphere of a degenerate free electron gas at zero temperature, having N particles contained in volume V is given as :

(1) $(3\pi^2)^{1/3}(N/V)^{2/3}\hbar$ (2) $(3\pi^2)^{1/3}(N/V)^{1/6}\hbar$

(3) $(3\pi^2)^{1/3}(N/V)^{1/3}\hbar$ (4) $(3\pi^2)^{2/3}(N/V)^{1/3}\hbar$

87. According to the uncertainity relation, the minimum uncertainity in the velocity of an electron orbiting around the nucleus of radius r is :

(1) $\pi h/(2mr^2)$ (2) $2\pi hmr$ (3) $\dfrac{h}{2\pi mr}$ (4) $2hm/\pi r^2$

88. For a spherically symmetric probability cloud of an electron :

(1) Principal quantum number is zero

(2) Magnetic quantum number is zero

(3) Spin quantum number is zero

(4) Orbital quantum number is zero

89. The nucleus of the atom $_4Be^9$ consists of :

(1) 13 up quarks and 13 down quarks

(2) 14 up quarks and 14 down quarks

(3) 13 up quarks and 14 down quarks

(4) 14 up quarks and 13 down quarks

90. Out of the following reactions, which one violates the lepton number conservation :

(1) $e^+ + e^- \rightarrow \nu + \overline{\nu}$ (2) $e^- + n \rightarrow p + \nu$

(3) $e^- + p \rightarrow \nu + n$ (4) $\overline{\mu} \rightarrow e^- + \nu + \overline{\nu}$

91. The maximum change in energy of a p-electron due to precessional motion of its orbit in a magnetic field of 3×10^4 gauss is of the order :

(1) 2.8×10^{-8} erg (2) 2.8×10^{-16} erg

(3) 2.8×10^{-12} erg (4) 2.8×10^{-10} erg

92. From X-rays produced using cobalt (z = 27) as target, the observed X-ray spectrum contained a strong K_α line of wavelength 0.1785 nm and a weak K_α line of wavelength 0.1930 nm. The weak K_α line may be due to an impurity atom of atomic number :

(1) 26 (2) 25 (3) 30 (4) 28

93. In an ESR spectrometer operating at 9.302 GHz, the ESR spectrum of hydrogen atom yields two lines, one at 357.3 mT and the other at 306.6 mT. The hyperfine coupling constant of the hydrogen atom is :

(1) 0.507 mT (2) 357.3 mT

(3) 50.7 mT (4) 257.3 mT

94. In band spectrum of diatomic molecules, which one is ***not*** true :

(1) Formation of band does not occur in rotation vibration spectra

(2) The band head can occur toward the red end

(3) The band head can occur toward the violet end

(4) The band head must be formed at the transition between the same set of-rotational quantum number

95. A file server performs one of the following :

(1) manages file operations and is limited to one PC

(2) manages file operations and is shared on a network

(3) acts as a fat client and is shared on a network

(4) acts as a fat client and is limited to one PC

96. Object oriented programming relies on which of the following basic concepts ?

(1) Data abstraction, Inheritance, Polymorphism

(2) I/O, Inheritance, Polymorphism

(3) Data abstraction, Inheritance, Arrays

(4) Data abstraction, I/O, Inheritance

97. The stray wiring capacitance in an amplifier has an effect on :

(1) mid band frequencies (2) lower cut off frequency

(3) output resistance (4) upper cut off frequency

98. The plane of oscillation of a Foucault's pendulum rotates :

(1) 15° per hour at the equator (2) 15° per hour at the pole

(3) 7.5° per hour at the latitude 60° (4) 30° per hour at the latitude 60°

99. In a biprism experiment, if the wavelength of red light used is 6.5×10^{-7} m and that of green light is 5.2×10^{-7} m, the value of 'n' for which $(n+1)^{th}$ green bright band coincides with n^{th} red bright band for the same setting is given by :

(1) 2 (2) 3 (3) 4 (4) 1

100. Two Nicol prisms are first crossed and then one of them is rotated through 60°. The percentage of light transmitted is :

(1) 1.25 (2) 25.0 (3) 37.5 (4) 50.0

Total No. of Printed Pages : 17

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M. Phil/Ph.D/URS - EE - Jan.-Dec.-2017

SUBJECT : Physics

B

Sr. No. 10002

Time : **1¼ Hours** Max. Marks : **100** Total Questions : **100**

Roll No. (in figures)_____ (in words) _____

Name _____ Father's Name _____

Mother's Name _____ Date of Examination _____

_____ _____

(Signature of the Candidate) (Signature of the Invigilator)

CANDIDATES MUST READ THE FOLLOWING INFORMATION/INSTRUCTIONS BEFORE STARTING THE QUESTION PAPER.

1. ***All questions are compulsory.***
2. The candidates ***must return*** the question booklet as well as OMR Answer-Sheet to the Invigilator concerned before leaving the Examination Hall, failing which a case of use of unfair-means/misbehaviour will be registered against him/her, in addition to lodging of an FIR with the police. Further the answer-sheet of such a candidate will not be evaluated.
3. In case there is any discrepancy in any question(s) in the Question Booklet, the same may be brought to the notice of the Controller of Examinations in writing **within two hours** after the test is over. No such complaint(s) will be entertained thereafter.
4. The candidate ***must not*** do any rough work or writing in the OMR Answer-Sheet. Rough work, if any, may be done in the question booklet itself. Answers ***must not*** be ticked in the question booklet.
5. ***There will be no negative marking. Each correct answer will be awarded one full mark. Cutting, erasing, overwriting and more than one answer in OMR Answer-Sheet will be treated as incorrect answer.***
6. Use only **Black** or **Blue Ball Point Pen** of good quality in the OMR Answer-Sheet.
7. *Before answering the questions, the candidates should ensure that they have been supplied correct and complete booklet. Complaints, if any, regarding misprinting etc. will not be entertained* **30** *minutes after starting of the examination.*

1. In Foucaults rotating mirror experiment for determining the velocity of light, the distance between the rotating mirror and the convex lens is negligible when compared to the radius of curvature of the concave mirror. If the radius of curvature of the concave mirror is doubled, the image shift is :

   (1) halved

   (2) doubled

   (3) zero

   (4) independent of radius of curvature of concave mirror

2. A particle moving with a uniform acceleration along a straight line covers distances a and b in successive intervals of p and q seconds. The acceleration of the particle is :

   (1) $\frac{pq(p+q)}{2(bp-aq)}$ (2) $\frac{bp-aq}{pq(p-q)}$ (3) $\frac{2(aq-bp)}{pq(p-q)}$ (4) $\frac{2(bp-aq)}{pq(p+q)}$

3. A uniform rod $'AB'$ of mass m and length l is at rest on a smooth horizontal surface. An impulse p is applied to the end $'B'$. The time taken by the rod to twist through a right angle is :

   (1) $\frac{2\pi ml}{p}$ (2) $\frac{\pi ml}{12p}$ (3) $\frac{2\pi p}{ml}$ (4) $\frac{\pi p}{ml}$

4. A rod of length $'l'$ is hinged from one end. It is brought to a horizontal position and released. The angular velocity of the rod when it is in vertical position, is :

   (1) $\sqrt{\frac{2g}{L}}$ (2) $\sqrt{\frac{3g}{L}}$ (3) $\sqrt{\frac{g}{2L}}$ (4) $\sqrt{\frac{g}{L}}$

5. A particle executes S.H.M. with an amplitude of 10 cm and frequency 2 Hz. At t = 0, the particle is at a point where potential energy and kinetic energy are same. The equation of displacement of the particle is :

   (1) $0.1\cos\left\{4\pi l+\frac{\pi}{4}\right\}$ (2) $0.1\sin 4\pi l$

   (3) $0.1\sin\left\{4\pi l+\frac{\pi}{4}\right\}$ (4) $0.1\sec\left\{4\pi l+\frac{\pi}{4}\right\}$

6. Equation of a plane wave is given by $\frac{4\sin\pi}{4}\left[2t+\frac{x}{8}\right]$. The phase difference at any instant of two particles 16 cm apart is :

   (1) 60° (2) 90° (3) 30° (4) 120°

7. A thermally insulated piece of matter is heated under atmosphere by an electric current so that it receives electrical energy at a constant power P. This leads to an increase of the absolute temperature T of the metal with time t as $T = at^{1/4}$. The specific heat C_p in this case is :

(1) $\frac{4PT^3}{a^4}$ (2) $\frac{4PT^2}{a^3}$ (3) $4PT^2$ (4) $\frac{4PT^3}{a^3}$

8. Two identical containers A and B have frictionless pistons. Both contain same volume of ideal gas at same temperature. The gas in each cylinder is allowed to expand isothermally to double the initial volume. The mass of the gas in A is m_A and the mass of the gas in B is m_B. The changes in the pressure in A and B are ΔP and $1.5\ \Delta P$ respectively, then :

(1) $4m_A = 9m_B$ (2) $2m_A = 3m_B$ (3) $3m_A = 2m_B$ (4) $4m_A = 4m_B$

9. The moment of inertia I of a body at a temperature 'T' increases to $I+\Delta I$ as the temperature rises to $T+\Delta T$. If the coefficient of linear expansion of the material is 'α', then the ratio $\Delta I/I$ will be :

(1) $\Delta T/T$ (2) $2\Delta T/T$ (3) $\alpha\Delta T$ (4) $2\alpha\Delta T$

10. An electric dipole, made up of a positive and negative charge, each of 1 mC placed at a distance 2 cm apart is placed in an electric field of 10^5 N/C. The maximum torque exerted by the field on the dipole while it is turned from $\theta = 0°$ to $\theta = 180°$ is :

(1) 2×10^{-3} N-m (2) 3×10^{-3} N-m

(3) 4×10^{-3} N-m (4) 2.8×10^{-3} N-m

11. An atom of mass M can be excited to a state of mass $M + \Delta$ by photon capture. The frequency of a photon which can cause this transition is :

(1) $\Delta c^2/2Mh$ (2) $\Delta c^2/M^2h$

(3) $\Delta c^2(\Delta + 2M)/2Mh$ (4) $\Delta^2c^2/2M^2h$

12. The associated change in wavelength resulting due to a collision of relativistic nature of a photon of wavelength λ with a free electron at rest is given as :

(1) $\lambda - \lambda' = \{h/m_0c\}\{1 - \cos\varphi\}$ (2) $\lambda - \lambda' = \{h/m_0c^2\}\{1 - \cos\varphi\}$

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where φ is the angle of scattered photon with the direction of incident photon

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15. Which of the following statements is/are ***false*** ?

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(ii) Brownian movements are the motions of small particles that are bombarded by molecules of the fluid.

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16. If a rigid body is rotating with an angular velocity ω about an instantaneous axis through a fixed point in the body, the angular momentum J about the same point :

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    (1) 2 (2) 3 (3) 4 (4) 1

30. Two Nicol prisms are first crossed and then one of them is rotated through 60°. The percentage of light transmitted is :
    (1) 1.25 (2) 25.0 (3) 37.5 (4) 50.0

31. The electrostatic potential $V(x, y)$ in free space in a region where the charge density ρ is zero is given by $V(x,y)=4e^{2x}+f(x)-3y^2$. Given that the x-component of the electric field, E_x and V are zero at the origin, $f(x)$ is :

(1) $3x^2-4e^{2x}+8x$ (2) $3x^2-4e^{2x}+16x$

(3) $4e^{2x}-8$ (4) $3x^2-4e^{2x}$

32. Which of the following matrices is an element of the group SU(2) ?

(1) $\begin{bmatrix}1 & 1\\ 0 & 1\end{bmatrix}$ (2) $\begin{bmatrix}\frac{1+i}{\sqrt{3}} & \frac{-1}{\sqrt{3}}\\ \frac{1}{\sqrt{3}} & \frac{1-i}{\sqrt{3}}\end{bmatrix}$

(3) $\begin{bmatrix}2+i & i\\ 3 & 1+i\end{bmatrix}$ (4) $\begin{bmatrix}\frac{1}{2} & \frac{\sqrt{3}}{2}\\ \frac{\sqrt{3}}{2} & \frac{1}{2}\end{bmatrix}$

33. A cavity contains blackbody radiation in equilibrium at temperature T. The specific heat per unit volume of the photon gas in the cavity is of the form $C_v = \gamma T^3$ where γ is a constant. The cavity is expanded to twice its original volume and then allowed to equilibrate at the same temperature T. The new internal energy per unit volume is :

(1) $4\gamma T^4$ (2) $2\gamma T^4$

(3) $\gamma T^4/4$ (4) γT^4

34. A particle in one dimension moves under the influence of a potential $V(x)=ax^6$, where a is a real constant. For large n, the quantized energy level E_n depends on n as :

(1) $E_n \sim n^3$ (2) $E_n \sim n^{4/3}$ (3) $E_n \sim n^{6/5}$ (4) $E_n \sim n^{3/2}$

35. A beam of pions (π^+) is incident on a proton target, giving rise to the process $\pi^+p\rightarrow n+\pi^+ +\pi^+$. Assuming that the decay proceeds through strong interactions, the total isospin I and its third component I_3 for the decay products, are :

(1) $I = 3/2,\ I_3 = 3/2$ (2) $I = 5/2,\ I_3 = 5/2$

(3) $I = 5/2,\ I_3 = 3/2$ (4) $I = 1/2,\ I_3 = -1/2$

36. The equation of the plane that is tangent to the surface $xyz = 8$ at the point (1, 2, 4) is :

(1) $x + 2y + 4z = 12$ (2) $4x + 2y + z = 12$

(3) $x + 4y + 2z = 12$ (4) $x + y + z = 7$

37. Assume that the free energy of a magnetic system has an expansion in the order parameter M of the form $F(M, T) = a(T - T_c) M^2 + bM^4 + cM^6$, with a, b and $c > 0$. As the temperature is lowered below T_c, the system undergoes a phase transition. The behaviour of the order parameter just below the transition, where $(T - T_c)$ is very small, is best described by :

(1) $M \alpha (T_c - T)^{-1/2}$ (2) $M \alpha (T_c - T)^{1/2}$

(3) $M \alpha (T_c - T)$ (4) $M \alpha (T_c - T)^3$

38. The minimum energy of an electron (the rest mass of which is 0.5 MeV) that can emit Cherenkov radiation while passing through water (of refractive index 1.5) is approximately :

(1) 1.0 MeV (2) 3.0 MeV (3) 0.7 MeV (4) 0.5 MeV

39. Let $y(x)$ be a continuous real function in the range 0 and $2n$, satisfying the inhomogeneous differential equation : $\sin x d^2y/dx^2 + \cos x dy/dx = \delta(x - \pi/2)$. The value of dy/dx at the point $x = \pi/2$:

(1) is continuous (2) has a discontinuity of 3

(3) has a discontinuity of 1/3 (4) has a discontinuity of 1

40. A bag contains many balls, each with a number painted on it. There are exactly N balls which have the number N (namely one ball with 1, two balls with 2, and so on until N balls with N on them). An experiment consists of choosing a ball at random, noting the number on it and returning it to the bag. If the experiment is repeated a large number of times, the average value of the number will tend to :

(1) $(2N+1)/3$ (2) $N/2$

(3) $(N+1)/2$ (4) $N(N+1)/2$

41. If a charged particle moving in a magnetic field looses 4% of its kinetic energy, then the radius of curvature of its path will change by :

(1) 6% (2) 4% (3) 10% (4) 2%

42. The mutual inductance of coil and a solenoid, for a solenoid of length 50 cm and with 5000 turns of wire of radius 4 cm and a coil of 700 turns wound on middle of the solenoid is :

(1) 44.17 mH (2) 48.98 mH

(3) 34.34 mH (4) 36.72 mH

43. A circular turn table has a block of ice placed at its centre. The system rotates with an angular speed ω about an axis passing through the centre of the table. If the ice melts, on its own, without any evaporation, the speed of rotation of the system :

(1) becomes zero

(2) remains constant at the same value ω

(3) increases to a value greater than ω

(4) decreases to a value less than ω

44. Out of various configurations of a transistor as an amplifier, which of following statement is ***not*** correct ?

(1) input resistance is least in CB mode

(2) output resistance is least in CC mode

(3) output resistance in CE mode is more than the CB mode

(4) voltage gain of CC mode is less than CE mode

45. A metallic surface has a threshold wavelength 5200 Å. This surface is irradiated by monochromatic light of wavelength 4500 Å. Which of the following statements is ***true*** ?

(1) The electrons are emitted from the surface having energy between 0 and infinity

(2) The electrons are emitted from the surface having energy between 0 and certain finite maximum value

(3) The electrons are emitted from the surface, all having certain finite energy

(4) No electron is emitted from the surface

46. The group and phase velocities in case of wave packets are equal if :

(1) phase velocity v_p is independent of the wavevector

(2) phase velocity v_p is independent of the wavevector and frequency

(3) phase velocity v_p is dependent on the wavevector

(4) None of these

47. The number of atoms in 100 gm of a f.c.c. crystal with density 10g cm^{-3} and cell edge 200 pm is :

(1) 3.2×10^{26} (2) 1.1×10^{26} (3) 5.0×10^{24} (4) 2.6×10^{25}

48. If a one dimensional harmonic oscillator is in the state :

$$\psi(x)=\frac{1}{\sqrt{14}}[3\psi_0(x)-2\psi_1(x)+3\psi_2(x)]$$

where $\psi_0(x)$, $\psi_1(x)$ and $\psi_2(x)$ are the ground, first and second excited states respectively. The probability of finding the oscillator in the ground state is :

(1) 9/14 (2) 1/2 (3) $\frac{3}{\sqrt{14}}$ (4) 1

49. ECL circuits have higher fan-out due to their :

(1) high input impedance

(2) low output impedance

(3) high input impedance and low output impedance

(4) complementary outputs

50. In a TTL gate with passive pull-up, the collector current of the output transistor is 4 mA corresponding to LOW level output when it is not driving any other gate. Its fan-out is 10 and sinks 1.5 mA current corresponding to each load gate. The fan-out when two such gates are wire- ANDed will be :

(1) 5 (2) 7 (3) 10 (4) 20

51. The hexadecimal equivalent of the binary number 11101101111010 is :

(1) EDE8 (2) 3B7A (3) FB7A (4) 35572

52. The maximum positive and negative numbers which can be represented in two complements form using n bits are respectively :

(1) $+(2^{n-1}-1),-(2^{n-1}-1)$ (2) $+(2^{n-1}-1),-2^{n-1}$

(3) $+2^{n-1},-2^{n-1}$ (4) $+2^{n-1},-(2^{n-1}+1)$

53. A microprocessor without the interrupt facility :

(1) is best suited for a process control system

(2) is not useful for a process control system

(3) cannot be used for DMA operation

(4) cannot be interfaced with any I/O device

54. A body moves along x-axis with velocity v_x at position x. If the plot $v_x - x$ is an ellipse with major axis $2A$ and minor axis $2v_0$, the maximum acceleration has a modulus :

(1) v_0^2 / A (2) A / v_0^2 (3) $v_0 A$ (4) $v_0^2 / A^{1/2}$

55. A uniform rod AB of mass m and length l is at rest on a smooth horizontal surface. If an impulse 'p' is applied at the end B, then the time taken by the rod to turn through a right angle is :

(1) $2\pi ml/p$ (2) $2\pi p/ml$ (3) $\pi ml/12p$ (4) $\pi p/ml$

56. In a glass sphere, there is small bubble at 2×10^{-2} m from its centre. If the bubble is viewed along a diameter of the sphere from the side on which it lies, how far from the surface will it appear ? The radius of the sphere is 5×10^{-2} m and the refractive index of glass is 3/2.

(1) 2.5×10^{-2} m (2) 3.2×10^{-2} m

(3) 6.5×10^{-2} m (4) 0.2×10^{-2} m

57. The work function of a certain metain is 2.3 eV. If the light of wave number $2\times10^{6}\,m^{-1}$ falls on it, the kinetic energy of fastest and slowest ejected electrons will be respectively :

(1) 2.48 eV, 0.18 eV (2) 0.18 eV, zero

(3) 2.30 eV, 0.18 eV (4) 0.18 eV, 0.18 eV

58. Given $\log_e 2 = 0.69$, the approximate value of $\log_e 3$ by evaluating the $\int_2^3 dx/x$ by Simpson's rule with intervals is :

(1) 1.155 (2) 0.991 (3) 1.095 (4) 1.201

59. If $f(0) = 1$ and $f(1) = 2.72$, then the trapezoidal rule gives the approximate value of $\int_0^1 f(x)dx$ as :

(1) 3.72 (2) 1.86 (3) 1.72 (4) 0.86

60. Entropy of a thermodynamic system does not change when this system is used for :

(1) conduction of heat from a hot reservoir to a cold reservoir

(2) conversion of work into heat isothermally

(3) conversion of heat into internal energy isochorically

(4) conversion of heat into work, isobarically

61. The electronic energy levels in a hydrogen atom are given by $En = -13.6/n^2$ eV. If a selective excitation to the n = 100 level is to be made using a laser, the maximum allowed frequency line-width of the laser is approximately :

(1) 6.5 MHz (2) 6.5 GHz (3) 6.5 Hz (4) 6.5 kHz

62. Let A, B and C be functions of phase space variables (coordinates and momenta of a mechanical system). If {,} represents the Poisson bracket, the value of {A,{B,C}} – {{A,B},C} is given by :

(1) 0 (2) {B,{C,A}} (3) {A, {C,B}} (4) {{C,A},B}

63. Two monochromatic sources, L_1 and L_2 emit light at 600 and 700 run, respectively. If their frequency bandwidths are 10^{-1} and 10^{-3} GHz, respectively, then the ratio of line-width of L_1 and L_2 is approximately :

(1) 100 : 1 (2) 1 : 85 (3) 75 : 1 (4) 1 : 75

64. A child makes a random walk on a square lattice of lattice constant a taking a step in the north, east, south, or west directions with probabilities 0.255, 0.255, 0.245, and 0.245, respectively. After a large number of steps, N, the expected position of the child with respect to the starting point is at a distance :

(1) $\sqrt{2} \times 10^{-2}$ Na in the north-east direction

(2) $\sqrt{(2N)} \times 10^{-2}$ Na in the north-east direction

(3) $2\sqrt{2} \times 10^{-2}$ Na in the south-east direction

(4) 0

65. A 4-variable switching function is given by $f = \Sigma(5,7,8,10,13,15)+d(0,1,2)$, where d is the do-not-care-condition. The minimized form of f in sum of products (SOP) form is :

(1) $\overline{A}\,\overline{C} + \overline{B}\,\overline{D}$ (2) $A\overline{B} + C\overline{D}$ (3) $AD + BC$ (4) $\overline{B}\,\overline{D} + BD$

66. A gas laser cavity has been designed to operate at $\lambda = 0.5$ μm with a cavity length of 1 m. With this set-up, the frequency is found to be larger than the desired frequency by 100 Hz. The change in the effective length of the cavity required to retune the laser is :

(1) -0.334×10^{-12} m (2) 0.334×10^{-12} m

(3) 0.167×10^{-12} m (4) -0.167×10^{-12} m

67. One gram of salt is dissolved in water that is filled to a height of 5 cm in a beaker of diameter 10 cm, The accuracy of length measurement is 0.01 cm while that of mass measurement is 0.01 mg. When measuring the concentration C, the fractional error $\Delta C/C$ is :

(1) 0.8% (2) 0.14% (3) 0.5% (4) 0.28%

68. The recently-discovered Higgs boson at the LHC experiment has a decay mode into a photon and a Z boson. If the rest masses of the Higgs and Z boson are 125 GeV/c^2 and 90 GeV/c^2 respectively, and the decaying Higgs particle is at rest, the energy of the photon will approximately be :

(1) $35\sqrt{3}$ GeV (2) 35 GeV (3) 30 GeV (4) 15 GeV

69. A canonical transformation relates the old coordinates (q, p) to the new ones (Q, P) by the relations $Q = q^2$ and $P = p/2q$. The corresponding time-independent generating function is :

(1) P/q^2 (2) q^2P (3) q^2/P (4) qP^2

70. Let x and p denote, respectively, the coordinate and momentum operators satisfying the canonical commutation relation $[x, p] = i$ in natural units $(\hbar = 1)$. Then the commutator $[x, pe^{-p}]$ is :

(1) $i(1-p)e^{-p}$ (2) $i(1-p^2)e^{-p}$ (3) $i(1-e^{-p})$ (4) ipe^{-p}

71. Bose condensation occurs in liquid He^4 kept at ambient pressure at 2.17 K. At which temperature will Bose condensation occur in He^4 in gaseous state, the density of which is 1000 times smaller than that of liquid He^4 ? (Assume that it is a perfect Bose gas)

(1) 2.17 mK (2) 21.7 mK (3) 21.7 μK (4) 2.17 μK

72. The energy required to create a lattice vacancy in a crystal is equal to 1 eV. The ratio of the number densities of vacancies n (1200 K) / n (300 K), when the crystal is at equilibrium at 1200 K and 300 K, respectively is approximately :

(1) $e^{(-30)}$ (2) $e^{(-15)}$ (3) $e^{(15)}$ (4) $e^{(30)}$

73. The minimum energy of a collection of 6 non-interacting electrons of spin –1/2 placed in a one dimensional infinite square well potential of width L is :

(1) $14\pi^2\hbar^2/rnL^2$ (2) $91\pi^2\hbar^2/rnL^2$

(3) $7\pi^2\hbar^2/rnL^2$ (4) $3\pi^2\hbar^2/rnL^2$

74. A function $f(x)$ obeys the differential equation $d^2f/dx^2 - (3-2i)f = 0$ and satisfies the conditions $f(0) = 1$ and $f(x) \to 0$ as $x \to \infty$. The value $f(\pi)$ is :

(1) $\exp(2\pi)$ (2) $\exp(-2\pi)$ (3) $-\exp(-2\pi)$ (4) $-\exp(2\pi i)$

75. A magnetic field sensor based on the Hall effect is to be fabricated by implanting As into a Si film of thickness 1 μrn, The specifications require a magnetic field sensitivity of 500 mV/Tesla at an excitation current of 1 mA. The implantation dose is to be adjusted such that the average carrier density, after activation, is :

(1) $1.25 \times 10^{26} m^{-3}$ (2) $1.25 \times 10^{22} m^{-3}$

(3) $4.1 \times 10^{21} m^{-3}$ (4) $4.1 \times 10^{20} m^{-3}$

76. Consider a He-Ne laser cavity consisting of two mirrors of reflectivities $R_1 = 1$ and $R_2 = 0.98$. The mirrors are separated by a distance $d = 20$ cm and the medium in between has a refractive index $n_0 = 1$ and absorption coefficient $\alpha = 0$. The values of the separation between the modes δv and the width Δv_p of each mode of the laser cavity are :

(1) $\delta v = 75$ kHz, $\Delta v_p = 24$ kHz (2) $\delta v = 100$ kHz, $\Delta v_p = 100$ kHz

(3) $\delta v = 750$ MHz, $\Delta v_p = 2.4$ MHz (4) $\delta v = 2.4$ MHz, $\Delta v_p = 750$ MHz

77. In a basis in which the z-component S_z of the spin is diagonal, an electron is in a spin state $\psi = \begin{pmatrix} 1+i \\ \sqrt{2/3} \end{pmatrix}$. The probabilities that a measurement of S_z will yield the values $\hbar/2$ and $-\hbar/2$ are, respectively :

(1) 1/2 and 1/2 (2) 2/3 and 1/3 (3) 1/4 and 3/4 (4) 1/3 and 2/3

78. A muon (μ^-) from cosmic ray is trapped by a proton to form a hydrogen like atom. Given that a muon is approximately 200 times heavier than an electron, the longest wavelength of the spectral line (in the analogue of the Lyman series) of such an atom will be :

(1) 5.62 Å (2) 6.67 Å (3) 3.75 Å (4) 13.3 Å

79. A particle of mass m is at the stable equilibrium position of its potential energy $V(x) = ax - bx^3$ where a, b are positive constants. The minimum velocity that has to be imparted to the particle to render its motion unstable is :

(1) $(64a^3/9m^2b)^{1/4}$ (2) $(64a^3/27m^2b)^{1/4}$

(3) $(16a^3/27m^2b)^{1/4}$ (4) $(3a^3/64m^2b)^{1/4}$

80. Muons are produced through the annihilation of particle a and its antiparticle, namely the process $a + a \rightarrow \mu^+ + \mu^-$. A muon has a rest mass of 105 MeV/c^2 and its proper life time is 2 μs. If the center of mass energy of the collision is 2.1 GeV in the laboratory frame that coincides with the center-of-mass frame, then the fraction of muons that will decay before they reach a detector placed 6 km away from the interaction point is :

(1) e^{-1} (2) $1 - e^{-1}$ (3) $1 - e^{-2}$ (4) e^{-10}

81. A system of four particles lie in x-y plane. Out of these, two particles each of mass m are located at (–1, 1) and (1, –1). The other two particles are located at (1, 1) and (–1, –1). The value of (x, y) component of the moment of inertia tensor of this system of particles is :

(1) 10 m (2) –2 m (3) –10 m (4) 2 m

82. The specified value of holding current for an SCR means that :

(1) The device will turn on when the anode current exceeds this value

(2) The device may be damaged when the anode current exceeds this value

(3) The device will turn off when the anode current falls below this value

(4) The gate current must be equal to or exceeds this value to turn the device on

83. If a sinusoidal voltage is applied to base of a biased n-p-n transistor and the resulting sinusoidal collector voltage is clipped near zero volt, the transistor is :

(1) Being driven into saturation (2) Being driven into active region

(3) Operating non-linearly (4) None of the above

84. A dynamic RAM cell holds 5 V to be refreshed every 20 m secs., such that the stored voltage does not fall below 0.5 V. If the cell has a constant current of 0.1 pA, the storage capacitance of the cell is :

(1) 4×10^{-15} F (2) 4×10^{-6} F (3) 4×10^{-9} F (4) 4×10^{-12} F

85. A 10 bit A/D converter is used to digitise an analog signal in the 0 to 5 V range. The maximum peak to peak ripple voltage that can be allowed in the dc supply voltage is :

(1) ~100 mV (2) ~25 mV (3) ~50 mV (4) ~5.0 mV

86. The value of radius of the Fermi sphere of a degenerate free electron gas at zero temperature, having N particles contained in volume V is given as :

(1) $(3\pi^2)^{1/3}(N/V)^{2/3}\hbar$ (2) $(3\pi^2)^{1/3}(N/V)^{1/6}\hbar$

(3) $(3\pi^2)^{1/3}(N/V)^{1/3}\hbar$ (4) $(3\pi^2)^{2/3}(N/V)^{1/3}\hbar$

87. According to the uncertainity relation, the minimum uncertainity in the velocity of an electron orbiting around the nucleus of radius r is :

(1) $\pi h/(2mr^2)$ (2) $2\pi hmr$ (3) $\dfrac{h}{2\pi mr}$ (4) $2hm/\pi r^2$

88. For a spherically symmetric probability cloud of an electron :

(1) Principal quantum number is zero

(2) Magnetic quantum number is zero

(3) Spin quantum number is zero

(4) Orbital quantum number is zero

89. The nucleus of the atom ${}_4Be^9$ consists of :

(1) 13 up quarks and 13 down quarks

(2) 14 up quarks and 14 down quarks

(3) 13 up quarks and 14 down quarks

(4) 14 up quarks and 13 down quarks

90. Out of the following reactions, which one violates the lepton number conservation :

(1) $e^+ + e^- \rightarrow \nu + \overline{\nu}$ (2) $e^- + n \rightarrow p + \nu$

(3) $e^- + p \rightarrow \nu + n$ (4) $\overline{\mu} \rightarrow e^- + \nu + \overline{\nu}$

91. In a measurement of the viscous drag force experienced by spherical particles in a liquid, the force is found to be proportional to $V^{1/3}$ where V is the measured volume of each particle. If V is measured to be 30 mm^3, with an uncertainty of 2.7 mm^3, the resulting relative percentage uncertainty in the measured force is :

(1) 2.08 (2) 0.09 (3) 6 (4) 3

92. A plane electromagnetic wave incident normally on the surface of a material is partially reflected. Measurements on the standing wave in the region in front of the interface show that the ratio of the electric field amplitude at the maxima and the minima is 5. The ratio of the reflected intensity to the incident intensity is :

(1) 4/9 (2) 2/3 (3) 2/5 (4) 1/5

93. A computer cannot "boot" if it does not have the :

(1) Compiler (2) Loader

(3) Operating System (4) Assembler

94. Which of the following is ***not*** a function of the control unit ?

(1) Read Instructions (2) Execute Instructions

(3) Interpret Instructions (4) Direct Operations

95. A combination is made of two lenses of focal lengths f and f' in contact; the dispersive power of the materials of the lenses are ω and ω'. The combination is achromatic when :

(1) $\omega = \omega_0, \omega' = 2\omega_0, f' = 2f$ (2) $\omega = \omega_0, \omega' = 2\omega_0, f' = f/2$

(3) $\omega = \omega_0, \omega' = 2\omega_0, f' = -f/2$ (4) $\omega = \omega_0, \omega' = 2\omega_0, f' = -2f$

96. A monochromatic beam of light is used for the formation of fringes on a screen by illuminating the two slits in the Young's double slit experiment. When a thin film of mica is interposed in the path of one of the interfering beams :

(1) the fringe width increases

(2) the fringe width decreases

(3) the fringe pattern disappears

(4) the fringe width remains the same but the pattern shifts

97. The proper half life of some radio-isotopes is 5 μs. When these isotopes pass through a laboratory, their half life is observed to be 15 μs. The speed of the radio- isotopes is :

(1) $\frac{2\sqrt{2}}{3}c$ (2) $\frac{\sqrt{2}}{3}c$

(3) $\frac{3}{\sqrt{2}}c$ (4) $\frac{2}{3\sqrt{2}}c$

98. A slowly moving electron collides with a positron at rest and annihilates it producing two photons. If the rest mass of the electron or positron be m_0 then the frequency of each photon is :

(1) $2m_0c^2/h^2$ (2) m_0c^2/h^2

(3) m_0c^2/h (4) $2m_0c^2/h$

99. An α particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of :

(1) 1 Å (2) 10^{-10} cm (3) 10^{-12} cm (4) 10^{-16} cm

100. An X -ray photon of wavelength λ, and frequency ν collides with an electron and bounces off. If λ', and ν' are respectively the wavelength and frequency of the scattered photon, then :

(1) $\lambda' = \lambda; \nu' = \nu$ (2) $\lambda' < \lambda; \nu' > \nu$

(3) $\lambda' > \lambda; \nu' > \nu$ (4) $\lambda' > \lambda; \nu' < \nu$

Total No. of Printed Pages : 17

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M. Phil/Ph.D/URS - EE - Jan.-Dec.-2017

SUBJECT : Physics

C

Sr. No. 10003

Time : **1¼ Hours** Max. Marks : **100** Total Questions : **100**

Roll No. (in figures)_____ (in words) _____

Name _____ Father's Name _____

Mother's Name _____ Date of Examination _____

_____ _____

(Signature of the Candidate) (Signature of the Invigilator)

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SEAL

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2. The candidates ***must return*** the question booklet as well as OMR Answer-Sheet to the Invigilator concerned before leaving the Examination Hall, failing which a case of use of unfair-means/misbehaviour will be registered against him/her, in addition to lodging of an FIR with the police. Further the answer-sheet of such a candidate will not be evaluated.
3. In case there is any discrepancy in any question(s) in the Question Booklet, the same may be brought to the notice of the Controller of Examinations in writing **within two hours** after the test is over. No such complaint(s) will be entertained thereafter.
4. The candidate ***must not*** do any rough work or writing in the OMR Answer-Sheet. Rough work, if any, may be done in the question booklet itself. Answers ***must not*** be ticked in the question booklet.
5. ***There will be no negative marking. Each correct answer will be awarded one full mark. Cutting, erasing, overwriting and more than one answer in OMR Answer-Sheet will be treated as incorrect answer.***
6. Use only **Black** or **Blue Ball Point Pen** of good quality in the OMR Answer-Sheet.
7. *Before answering the questions, the candidates should ensure that they have been supplied correct and complete booklet. Complaints, if any, regarding misprinting etc. will not be entertained* **30** *minutes after starting of the examination.*

1. The electronic energy levels in a hydrogen atom are given by $En = -13.6/n^2$ eV. If a selective excitation to the n = 100 level is to be made using a laser, the maximum allowed frequency line-width of the laser is approximately :

(1) 6.5 MHz (2) 6.5 GHz (3) 6.5 Hz (4) 6.5 kHz

2. Let A, B and C be functions of phase space variables (coordinates and momenta of a mechanical system). If {,} represents the Poisson bracket, the value of {A,{B,C}} – {{A,B},C} is given by :

(1) 0 (2) {B,{C,A}} (3) {A, {C,B}} (4) {{C,A},B}

3. Two monochromatic sources, L_1 and L_2 emit light at 600 and 700 run, respectively. If their frequency bandwidths are 10^{-1} and 10^{-3} GHz, respectively, then the ratio of line-width of L_1 and L_2 is approximately :

(1) 100 : 1 (2) 1 : 85 (3) 75 : 1 (4) 1 : 75

4. A child makes a random walk on a square lattice of lattice constant a taking a step in the north, east, south, or west directions with probabilities 0.255, 0.255, 0.245, and 0.245, respectively. After a large number of steps, N, the expected position of the child with respect to the starting point is at a distance :

(1) $\sqrt{2} \times 10^{-2}$ Na in the north-east direction
(2) $\sqrt{(2N)} \times 10^{-2}$ Na in the north-east direction
(3) $2\sqrt{2} \times 10^{-2}$ Na in the south-east direction
(4) 0

5. A 4-variable switching function is given by $f = \Sigma(5,7,8,10,13,15)+d(0,1,2)$, where d is the do-not-care-condition. The minimized form of f in sum of products (SOP) form is :

(1) $\overline{A}\overline{C} + \overline{B}\overline{D}$ (2) $A\overline{B} + C\overline{D}$ (3) $AD + BC$ (4) $\overline{B}\overline{D} + BD$

6. A gas laser cavity has been designed to operate at $\lambda = 0.5$ μm with a cavity length of 1 m. With this set-up, the frequency is found to be larger than the desired frequency by 100 Hz. The change in the effective length of the cavity required to retune the laser is :

(1) -0.334×10^{-12} m (2) 0.334×10^{-12} m
(3) 0.167×10^{-12} m (4) -0.167×10^{-12} m

7. One gram of salt is dissolved in water that is filled to a height of 5 cm in a beaker of diameter 10 cm, The accuracy of length measurement is 0.01 cm while that of mass measurement is 0.01 mg. When measuring the concentration C, the fractional error $\Delta C/C$ is :

(1) 0.8% (2) 0.14% (3) 0.5% (4) 0.28%

8. The recently-discovered Higgs boson at the LHC experiment has a decay mode into a photon and a Z boson. If the rest masses of the Higgs and Z boson are 125 GeV/c^2 and 90 GeV/c^2 respectively, and the decaying Higgs particle is at rest, the energy of the photon will approximately be :
(1) $35\sqrt{3}$ GeV (2) 35 GeV (3) 30 GeV (4) 15 GeV

9. A canonical transformation relates the old coordinates (q, p) to the new ones (Q, P) by the relations $Q = q^2$ and $P = p/2q$. The corresponding time-independent generating function is :
(1) P/q^2 (2) q^2P (3) q^2/P (4) qP^2

10. Let x and p denote, respectively, the coordinate and momentum operators satisfying the canonical commutation relation $[x, p] = i$ in natural units $(\hbar = 1)$. Then the commutator $[x, pe^{-p}]$ is :
(1) $i(1-p)e^{-p}$ (2) $i(1-p^2)e^{-p}$ (3) $i(1-e^{-p})$ (4) ipe^{-p}

11. If a charged particle moving in a magnetic field looses 4% of its kinetic energy, then the radius of curvature of its path will change by :
(1) 6% (2) 4% (3) 10% (4) 2%

12. The mutual inductance of coil and a solenoid, for a solenoid of length 50 cm and with 5000 turns of wire of radius 4 cm and a coil of 700 turns wound on middle of the solenoid is :
(1) 44.17 mH (2) 48.98 mH (3) 34.34 mH (4) 36.72 mH

13. A circular turn table has a block of ice placed at its centre. The system rotates with an angular speed ω about an axis passing through the centre of the table. If the ice melts, on its own, without any evaporation, the speed of rotation of the system :
(1) becomes zero
(2) remains constant at the same value ω
(3) increases to a value greater than ω
(4) decreases to a value less than ω

14. Out of various configurations of a transistor as an amplifier, which of following statement is ***not*** correct ?
(1) input resistance is least in CB mode
(2) output resistance is least in CC mode
(3) output resistance in CE mode is more than the CB mode
(4) voltage gain of CC mode is less than CE mode

15. A metallic surface has a threshold wavelength 5200 Å. This surface is irradiated by monochromatic light of wavelength 4500 Å. Which of the following statements is *true* ?
    (1) The electrons are emitted from the surface having energy between 0 and infinity
    (2) The electrons are emitted from the surface having energy between 0 and certain finite maximum value
    (3) The electrons are emitted from the surface, all having certain finite energy
    (4) No electron is emitted from the surface

16. The group and phase velocities in case of wave packets are equal if :
    (1) phase velocity v_p is independent of the wavevector
    (2) phase velocity v_p is independent of the wavevector and frequency
    (3) phase velocity v_p is dependent on the wavevector
    (4) None of these

17. The number of atoms in 100 gm of a f.c.c. crystal with density 10g cm^{-3} and cell edge 200 pm is :
    (1) 3.2×10^{26} (2) 1.1×10^{26} (3) 5.0×10^{24} (4) 2.6×10^{25}

18. If a one dimensional harmonic oscillator is in the state :
$$\psi(x)=\frac{1}{\sqrt{14}}[3\psi_0(x)-2\psi_1(x)+3\psi_2(x)]$$
    where $\psi_0(x)$, $\psi_1(x)$ and $\psi_2(x)$ are the ground, first and second excited states respectively. The probability of finding the oscillator in the ground state is :
    (1) 9/14 (2) 1/2 (3) $\frac{3}{\sqrt{14}}$ (4) 1

19. ECL circuits have higher fan-out due to their :
    (1) high input impedance
    (2) low output impedance
    (3) high input impedance and low output impedance
    (4) complementary outputs

20. In a TTL gate with passive pull-up, the collector current of the output transistor is 4 mA corresponding to LOW level output when it is not driving any other gate. Its fan-out is 10 and sinks 1.5 mA current corresponding to each load gate. The fan-out when two such gates are wire- ANDed will be :
    (1) 5 (2) 7 (3) 10 (4) 20

21. A system of four particles lie in x-y plane. Out of these, two particles each of mass m are located at (–1, 1) and (1, –1). The other two particles are located at (1, 1) and (–1, –1). The value of (x, y) component of the moment of inertia tensor of this system of particles is :

(1) 10 m (2) –2 m (3) –10 m (4) 2 m

22. The specified value of holding current for an SCR means that :

(1) The device will turn on when the anode current exceeds this value

(2) The device may be damaged when the anode current exceeds this value

(3) The device will turn off when the anode current falls below this value

(4) The gate current must be equal to or exceeds this value to turn the device on

23. If a sinusoidal voltage is applied to base of a biased n-p-n transistor and the resulting sinusoidal collector voltage is clipped near zero volt, the transistor is :

(1) Being driven into saturation (2) Being driven into active region

(3) Operating non-linearly (4) None of the above

24. A dynamic RAM cell holds 5 V to be refreshed every 20 m secs., such that the stored voltage does not fall below 0.5 V. If the cell has a constant current of 0.1 pA, the storage capacitance of the cell is :

(1) 4×10^{-15} F (2) 4×10^{-6} F (3) 4×10^{-9} F (4) 4×10^{-12} F

25. A 10 bit A/D converter is used to digitise an analog signal in the 0 to 5 V range. The maximum peak to peak ripple voltage that can be allowed in the dc supply voltage is :

(1) ~100 mV (2) ~25 mV (3) ~50 mV (4) ~5.0 mV

26. The value of radius of the Fermi sphere of a degenerate free electron gas at zero temperature, having N particles contained in volume V is given as :

(1) $(3\pi^2)^{1/3}(N/V)^{2/3}\hbar$ (2) $(3\pi^2)^{1/3}(N/V)^{1/6}\hbar$

(3) $(3\pi^2)^{1/3}(N/V)^{1/3}\hbar$ (4) $(3\pi^2)^{2/3}(N/V)^{1/3}\hbar$

27. According to the uncertainity relation, the minimum uncertainity in the velocity of an electron orbiting around the nucleus of radius r is :

(1) $\pi h/(2mr^2)$ (2) $2\pi hmr$ (3) $\dfrac{h}{2\pi mr}$ (4) $2hm/\pi r^2$

28. For a spherically symmetric probability cloud of an electron :

(1) Principal quantum number is zero

(2) Magnetic quantum number is zero

(3) Spin quantum number is zero

(4) Orbital quantum number is zero

29. The nucleus of the atom $_4Be^9$ consists of :

(1) 13 up quarks and 13 down quarks

(2) 14 up quarks and 14 down quarks

(3) 13 up quarks and 14 down quarks

(4) 14 up quarks and 13 down quarks

30. Out of the following reactions, which one violates the lepton number conservation :

(1) $e^+ + e^- \rightarrow \nu + \overline{\nu}$ (2) $e^- + n \rightarrow p + \nu$

(3) $e^- + p \rightarrow \nu + n$ (4) $\overline{\mu} \rightarrow e^- + \nu + \overline{\nu}$

31. An atom of mass M can be excited to a state of mass M + Δ by photon capture. The frequency of a photon which can cause this transition is :

(1) $\Delta c^2/2Mh$ (2) $\Delta c^2/M^2h$

(3) $\Delta c^2(\Delta + 2M)/2Mh$ (4) $\Delta^2c^2/2M^2h$

32. The associated change in wavelength resulting due to a collision of relativistic nature of a photon of wavelength λ with a free electron at rest is given as :

(1) $\lambda - \lambda' = \{h/m_0c\}\{1 - \cos\varphi\}$ (2) $\lambda - \lambda' = \{h/m_0c^2\}\{1 - \cos\varphi\}$

(3) $\lambda - \lambda' = \{h/m_0c\}\{1 - \cos^2\varphi\}$ (4) $\lambda - \lambda' = \{h^2/m_0c\}\{1 - \cos\varphi\}$

where φ is the angle of scattered photon with the direction of incident photon

33. According to Langevin's theory of diamagnetism, the induced magnetic moment per unit volume is proportional to :

(1) mass of the electron (2) radius of the orbit

(3) external magnetic field (4) none of these

34. Born's approximation can be used :

(1) only within very low energy limits

(2) only within high energy limits

(3) in very low as well as in high energy limits

(4) none of these

35. Which of the following statements is/are ***false*** ?

(i) Brownian motion offers an experimental test of the kinetic theory hypothesis.

(ii) Brownian movements are the motions of small particles that are bombarded by molecules of the fluid.

(iii) Brownian motion demonstrates the occurrence of random motion of the particles.

(iv) The average kinetic energy of the particles in the Brownian motion is the same as that of the molecules of the fluid.

(1) None of the above (2) (i) only

(3) (ii) and (iii) only (4) (iii) and (iv) only

36. If a rigid body is rotating with an angular velocity ω about an instantaneous axis through a fixed point in the body, the angular momentum J about the same point :

(i) will always be in the direction of ω

(ii) may be in the direction of ω

(iii) may have different direction to that of ω

(1) i and ii (2) ii and iii

(3) i and iii (4) none of these

37. If $f(z) = 1/(1-z)^2 \tan(1/z)$, then the wrong statement is :

(1) $f(z)$ has poles at $z = 0$ and $z = 1$

(2) $f(z)$ has many infinite poles

(3) $f(z)$ has non-isolated essential singularity at $z = 0$

(4) $f(z)$ has essential singularity at $z = 0$

38. The polynomial $2x^2 + x + 3$ in terms of legendre polynomial is :

(1) $1/3(4P_2 + 3P_1 + 11P_0)$ (2) $1/3(4P_2 - 3P_1 + 11P_0)$

(3) $1/3(4P_2 + 3P_1 - 11P_0)$ (4) $1/3(4P_2 - 3P_1 - 11P_0)$

39. A particle moving on a every long frictionless wire rotating at constant angular velocity about a horizontal axis is an example of :

(1) Only conservative system

(2) Rheonomic, holonomic and conservative system

(3) Only holonomic and conservative system

(4) Rheonomic, non-holonomic, non-conservative system

40. Which of the following statements is correct for the function $f(x) = x^4 - x^2$ in the $-\infty < x < \infty$?

(1) The plot of $f(x)$ vs x as two maxima and two minima

(2) The plot of $f(x)$ vs x as three extrima

(3) The plot of $f(x)$ vs x cuts the x-axis at four points

(4) No part of the plot of $f(x)$ vs x lies in the fourth quadrant

41. The electrostatic potential $V(x, y)$ in free space in a region where the charge density ρ is zero is given by $V(x,y) = 4e^{2x} + f(x) - 3y^2$. Given that the x-component of the electric field, E_x and V are zero at the origin, $f(x)$ is :

(1) $3x^2 - 4e^{2x} + 8x$ (2) $3x^2 - 4e^{2x} + 16x$

(3) $4e^{2x} - 8$ (4) $3x^2 - 4e^{2x}$

42. Which of the following matrices is an element of the group SU(2) ?

(1) $\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$ (2) $\begin{bmatrix} \frac{1+i}{\sqrt{3}} & \frac{-1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} & \frac{1-i}{\sqrt{3}} \end{bmatrix}$

(3) $\begin{bmatrix} 2+i & i \\ 3 & 1+i \end{bmatrix}$ (4) $\begin{bmatrix} \frac{1}{2} & \frac{\sqrt{3}}{2} \\ \frac{\sqrt{3}}{2} & \frac{1}{2} \end{bmatrix}$

43. A cavity contains blackbody radiation in equilibrium at temperature T. The specific heat per unit volume of the photon gas in the cavity is of the form $C_v = \gamma T^3$ where γ is a constant. The cavity is expanded to twice its original volume and then allowed to equilibrate at the same temperature T. The new internal energy per unit volume is :

(1) $4\gamma T^4$ (2) $2\gamma T^4$ (3) $\gamma T^4/4$ (4) γT^4

44. A particle in one dimension moves under the influence of a potential $V(x) = ax^6$, where a is a real constant. For large n, the quantized energy level E_n depends on n as :

(1) $E_n \sim n^3$ (2) $E_n \sim n^{4/3}$

(3) $E_n \sim n^{6/5}$ (4) $E_n \sim n^{3/2}$

45. A beam of pions (π^+) is incident on a proton target, giving rise to the process $\pi^+ p \rightarrow n + \pi^+ + \pi^+$. Assuming that the decay proceeds through strong interactions, the total isospin I and its third component I_3 for the decay products, are :

(1) $I = 3/2,\ I_3 = 3/2$ (2) $I = 5/2,\ I_3 = 5/2$

(3) $I = 5/2,\ I_3 = 3/2$ (4) $I = 1/2,\ I_3 = -1/2$

46. The equation of the plane that is tangent to the surface $xyz = 8$ at the point (1, 2, 4) is :

(1) $x + 2y + 4z = 12$ (2) $4x + 2y + z = 12$

(3) $x + 4y + 2z = 12$ (4) $x + y + z = 7$

47. Assume that the free energy of a magnetic system has an expansion in the order parameter M of the form $F(M, T) = a(T - T_c)\, M^2 + bM^4 + cM^6$, with a, b and $c > 0$. As the temperature is lowered below T_c, the system undergoes a phase transition. The behaviour of the order parameter just below the transition, where $(T - T_c)$ is very small, is best described by :

(1) $M \alpha (T_c - T)^{-1/2}$ (2) $M \alpha (T_c - T)^{1/2}$

(3) $M \alpha (T_c - T)$ (4) $M \alpha (T_c - T)^3$

48. The minimum energy of an electron (the rest mass of which is 0.5 MeV) that can emit Cherenkov radiation while passing through water (of refractive index 1.5) is approximately :

(1) 1.0 MeV (2) 3.0 MeV

(3) 0.7 MeV (4) 0.5 MeV

49. Let $y(x)$ be a continuous real function in the range 0 and $2n$, satisfying the inhomogeneous differential equation : $\sin x d^2y/dx^2 + \cos x dy/dx = \delta(x - \pi/2)$. The value of dy/dx at the point $x = \pi/2$:

(1) is continuous (2) has a discontinuity of 3

(3) has a discontinuity of 1/3 (4) has a discontinuity of 1

50. A bag contains many balls, each with a number painted on it. There are exactly N balls which have the number N (namely one ball with 1, two balls with 2, and so on until N balls with N on them). An experiment consists of choosing a ball at random, noting the number on it and returning it to the bag. If the experiment is repeated a large number of times, the average value of the number will tend to :

(1) $(2N+1)/3$ (2) $N/2$ (3) $(N+1)/2$ (4) $N(N+1)/2$

51. In a measurement of the viscous drag force experienced by spherical particles in a liquid, the force is found to be proportional to $V^{1/3}$ where V is the measured volume of each particle. If V is measured to be 30 mm^3, with an uncertainty of 2.7 mm^3, the resulting relative percentage uncertainty in the measured force is :

(1) 2.08 (2) 0.09 (3) 6 (4) 3

52. A plane electromagnetic wave incident normally on the surface of a material is partially reflected. Measurements on the standing wave in the region in front of the interface show that the ratio of the electric field amplitude at the maxima and the minima is 5. The ratio of the reflected intensity to the incident intensity is :

(1) 4/9 (2) 2/3 (3) 2/5 (4) 1/5

53. A computer cannot "boot" if it does not have the :

(1) Compiler (2) Loader

(3) Operating System (4) Assembler

54. Which of the following is ***not*** a function of the control unit ?

(1) Read Instructions (2) Execute Instructions

(3) Interpret Instructions (4) Direct Operations

55. A combination is made of two lenses of focal lengths f and f' in contact; the dispersive power of the materials of the lenses are ω and ω'. The combination is achromatic when :

(1) $\omega = \omega_0, \omega' = 2\omega_0, f' = 2f$ (2) $\omega = \omega_0, \omega' = 2\omega_0, f' = f/2$

(3) $\omega = \omega_0, \omega' = 2\omega_0, f' = -f/2$ (4) $\omega = \omega_0, \omega' = 2\omega_0, f' = -2f$

56. A monochromatic beam of light is used for the formation of fringes on a screen by illuminating the two slits in the Young's double slit experiment. When a thin film of mica is interposed in the path of one of the interfering beams :

(1) the fringe width increases

(2) the fringe width decreases

(3) the fringe pattern disappears

(4) the fringe width remains the same but the pattern shifts

57. The proper half life of some radio-isotopes is 5 μs. When these isotopes pass through a laboratory, their half life is observed to be 15 μs. The speed of the radio- isotopes is :

(1) $\frac{2\sqrt{2}}{3}c$ (2) $\frac{\sqrt{2}}{3}c$

(3) $\frac{3}{\sqrt{2}}c$ (4) $\frac{2}{3\sqrt{2}}c$

58. A slowly moving electron collides with a positron at rest and annihilates it producing two photons. If the rest mass of the electron or positron be m_0 then the frequency of each photon is :

(1) $2m_0c^2/h^2$ (2) m_0c^2/h^2

(3) m_0c^2/h (4) $2m_0c^2/h$

59. An α particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of :

(1) 1 Å (2) 10^{-10} cm (3) 10^{-12} cm (4) 10^{-16} cm

60. An X -ray photon of wavelength λ, and frequency ν collides with an electron and bounces off. If λ', and ν' are respectively the wavelength and frequency of the scattered photon, then :

(1) $\lambda' = \lambda; \nu' = \nu$ (2) $\lambda' < \lambda; \nu' > \nu$

(3) $\lambda' > \lambda; \nu' > \nu$ (4) $\lambda' > \lambda; \nu' < \nu$

61. Bose condensation occurs in liquid He^4 kept at ambient pressure at 2.17 K. At which temperature will Bose condensation occur in He^4 in gaseous state, the density of which is 1000 times smaller than that of liquid He^4 ? (Assume that it is a perfect Bose gas)

(1) 2.17 mK (2) 21.7 mK (3) 21.7 μK (4) 2.17 μK

62. The energy required to create a lattice vacancy in a crystal is equal to 1 eV. The ratio of the number densities of vacancies n (1200 K) / n (300 K), when the crystal is at equilibrium at 1200 K and 300 K, respectively is approximately :

(1) $e^{(-30)}$ (2) $e^{(-15)}$ (3) $e^{(15)}$ (4) $e^{(30)}$

63. The minimum energy of a collection of 6 non-interacting electrons of spin $-1/2$ placed in a one dimensional infinite square well potential of width L is :

(1) $14\pi^2\hbar^2 / rnL^2$ (2) $91\pi^2\hbar^2 / rnL^2$

(3) $7\pi^2\hbar^2 / rnL^2$ (4) $3\pi^2\hbar^2 / rnL^2$

64. A function $f(x)$ obeys the differential equation $d^2f / dx^2 - (3-2i)f = 0$ and satisfies the conditions $f(0) = 1$ and $f(x) \to 0$ as $x \to \infty$. The value $f(\pi)$ is :

(1) $\exp(2\pi)$ (2) $\exp(-2\pi)$ (3) $-\exp(-2\pi)$ (4) $-\exp(2\pi i)$

65. A magnetic field sensor based on the Hall effect is to be fabricated by implanting As into a Si film of thickness 1 μrn, The specifications require a magnetic field sensitivity of 500 mV/Tesla at an excitation current of 1 mA. The implantation dose is to be adjusted such that the average carrier density, after activation, is :

(1) $1.25 \times 10^{26}\text{m}^{-3}$ (2) $1.25 \times 10^{22}\text{m}^{-3}$

(3) $4.1 \times 10^{21}\text{m}^{-3}$ (4) $4.1 \times 10^{20}\text{m}^{-3}$

66. Consider a He-Ne laser cavity consisting of two mirrors of reflectivities $R_1 = 1$ and $R_2 = 0.98$. The mirrors are separated by a distance $d = 20$ cm and the medium in between has a refractive index $n_0 = 1$ and absorption coefficient $\alpha = 0$. The values of the separation between the modes δv and the width Δv_p of each mode of the laser cavity are :

(1) $\delta v = 75$ kHz, $\Delta v_p = 24$ kHz (2) $\delta v = 100$ kHz, $\Delta v_p = 100$ kHz

(3) $\delta v = 750$ MHz, $\Delta v_p = 2.4$ MHz (4) $\delta v = 2.4$ MHz, $\Delta v_p = 750$ MHz

67. In a basis in which the z-component S_z of the spin is diagonal, an electron is in a spin state $\psi = \begin{pmatrix} 1+i \\ \sqrt{2/3} \end{pmatrix}$. The probabilities that a measurement of S_z will yield the values $\hbar/2$ and $-\hbar/2$ are, respectively :

(1) 1/2 and 1/2 (2) 2/3 and 1/3

(3) 1/4 and 3/4 (4) 1/3 and 2/3

68. A muon (μ^-) from cosmic ray is trapped by a proton to form a hydrogen like atom. Given that a muon is approximately 200 times heavier than an electron, the longest wavelength of the spectral line (in the analogue of the Lyman series) of such an atom will be :

(1) 5.62 Å (2) 6.67 Å (3) 3.75 Å (4) 13.3 Å

69. A particle of mass m is at the stable equilibrium position of its potential energy $V(x) = ax - bx^3$ where a, b are positive constants. The minimum velocity that has to be imparted to the particle to render its motion unstable is :

(1) $(64a^3/9m^2b)^{1/4}$ (2) $(64a^3/27m^2b)^{1/4}$

(3) $(16a^3/27m^2b)^{1/4}$ (4) $(3a^3/64m^2b)^{1/4}$

70. Muons are produced through the annihilation of particle a and its antiparticle, namely the process $a + a \rightarrow \mu^+ + \mu^-$. A muon has a rest mass of 105 MeV/c^2 and its proper life time is 2 μs. If the center of mass energy of the collision is 2.1 GeV in the laboratory frame that coincides with the center-of-mass frame, then the fraction of muons that will decay before they reach a detector placed 6 km away from the interaction point is :

(1) e^{-1} (2) $1 - e^{-1}$ (3) $1 - e^{-2}$ (4) e^{-10}

71. In Foucaults rotating mirror experiment for determining the velocity of light, the distance between the rotating mirror and the convex lens is negligible when compared to the radius of curvature of the concave mirror. If the radius of curvature of the concave mirror is doubled, the image shift is :

(1) halved
(2) doubled
(3) zero
(4) independent of radius of curvature of concave mirror

72. A particle moving with a uniform acceleration along a straight line covers distances a and b in successive intervals of p and q seconds. The acceleration of the particle is :

(1) $\frac{pq(p+q)}{2(bp-aq)}$ (2) $\frac{bp-aq}{pq(p-q)}$ (3) $\frac{2(aq-bp)}{pq(p-q)}$ (4) $\frac{2(bp-aq)}{pq(p+q)}$

73. A uniform rod 'AB' of mass m and length l is at rest on a smooth horizontal surface. An impulse p is applied to the end 'B'. The time taken by the rod to twist through a right angle is :

(1) $\frac{2\pi ml}{p}$ (2) $\frac{\pi ml}{12p}$ (3) $\frac{2\pi p}{ml}$ (4) $\frac{\pi p}{ml}$

74. A rod of length '*l*' is hinged from one end. It is brought to a horizontal position and released. The angular velocity of the rod when it is in vertical position, is :

(1) $\sqrt{\frac{2g}{L}}$ (2) $\sqrt{\frac{3g}{L}}$ (3) $\sqrt{\frac{g}{2L}}$ (4) $\sqrt{\frac{g}{L}}$

75. A particle executes S.H.M. with an amplitude of 10 cm and frequency 2 Hz. At t = 0, the particle is at a point where potential energy and kinetic energy are same. The equation of displacement of the particle is :

(1) $0.1\cos\left\{4\pi l+\frac{\pi}{4}\right\}$ (2) $0.1\sin 4\pi l$

(3) $0.1\sin\left\{4\pi l+\frac{\pi}{4}\right\}$ (4) $0.1\sec\left\{4\pi l+\frac{\pi}{4}\right\}$

76. Equation of a plane wave is given by $\frac{4\sin\pi}{4}\left[2t+\frac{x}{8}\right]$. The phase difference at any instant of two particles 16 cm apart is :

(1) 60° (2) 90° (3) 30° (4) 120°

77. A thermally insulated piece of matter is heated under atmosphere by an electric current so that it receives electrical energy at a constant power P. This leads to an increase of the absolute temperature T of the metal with time t as $T = at^{1/4}$. The specific heat C_p in this case is :

(1) $\frac{4PT^3}{a^4}$ (2) $\frac{4PT^2}{a^3}$ (3) $4PT^2$ (4) $\frac{4PT^3}{a^3}$

78. Two identical containers A and B have frictionless pistons. Both contain same volume of ideal gas at same temperature. The gas in each cylinder is allowed to expand isothermally to double the initial volume. The mass of the gas in A is m_A and the mass of the gas in B is m_B. The changes in the pressure in A and B are ΔP and $1.5\ \Delta P$ respectively, then :

(1) $4m_A = 9m_B$ (2) $2m_A = 3m_B$ (3) $3m_A = 2m_B$ (4) $4m_A = 4m_B$

79. The moment of inertia I of a body at a temperature 'T' increases to $I+\Delta I$ as the temperature rises to $T+\Delta T$. If the coefficient of linear expansion of the material is 'α', then the ratio $\Delta I/I$ will be :

(1) $\Delta T/T$ (2) $2\Delta T/T$ (3) $\alpha\Delta T$ (4) $2\alpha\Delta T$

80. An electric dipole, made up of a positive and negative charge, each of 1 mC placed at a distance 2 cm apart is placed in an electric field of 10^5 N/C. The maximum torque exerted by the field on the dipole while it is turned from $\theta = 0°$ to $\theta = 180°$ is :

(1) 2×10^{-3} N-m (2) 3×10^{-3} N-m

(3) 4×10^{-3} N-m (4) 2.8×10^{-3} N-m

81. The maximum change in energy of a p-electron due to precessional motion of its orbit in a magnetic field of 3×10^4 gauss is of the order :

(1) 2.8×10^{-8} erg (2) 2.8×10^{-16} erg

(3) 2.8×10^{-12} erg (4) 2.8×10^{-10} erg

82. From X-rays produced using cobalt (z = 27) as target, the observed X-ray spectrum contained a strong K_α line of wavelength 0.1785 nm and a weak K_α line of wavelength 0.1930 nm. The weak K_α line may be due to an impurity atom of atomic number :

(1) 26 (2) 25 (3) 30 (4) 28

83. In an ESR spectrometer operating at 9.302 GHz, the ESR spectrum of hydrogen atom yields two lines, one at 357.3 mT and the other at 306.6 mT. The hyperfine coupling constant of the hydrogen atom is :

(1) 0.507 mT (2) 357.3 mT

(3) 50.7 mT (4) 257.3 mT

84. In band spectrum of diatomic molecules, which one is ***not*** true :

(1) Formation of band does not occur in rotation vibration spectra

(2) The band head can occur toward the red end

(3) The band head can occur toward the violet end

(4) The band head must be formed at the transition between the same set of-rotational quantum number

85. A file server performs one of the following :

(1) manages file operations and is limited to one PC

(2) manages file operations and is shared on a network

(3) acts as a fat client and is shared on a network

(4) acts as a fat client and is limited to one PC

86. Object oriented programming relies on which of the following basic concepts ?

(1) Data abstraction, Inheritance, Polymorphism

(2) I/O, Inheritance, Polymorphism

(3) Data abstraction, Inheritance, Arrays

(4) Data abstraction, I/O, Inheritance

87. The stray wiring capacitance in an amplifier has an effect on :

(1) mid band frequencies (2) lower cut off frequency

(3) output resistance (4) upper cut off frequency

88. The plane of oscillation of a Foucault's pendulum rotates :

(1) 15° per hour at the equator (2) 15° per hour at the pole

(3) 7.5° per hour at the latitude 60° (4) 30° per hour at the latitude 60°

89. In a biprism experiment, if the wavelength of red light used is 6.5×10^{-7} m and that of green light is 5.2×10^{-7} m, the value of 'n' for which $(n+1)^{th}$ green bright band coincides with n^{th} red bright band for the same setting is given by :

(1) 2 (2) 3 (3) 4 (4) 1

90. Two Nicol prisms are first crossed and then one of them is rotated through 60°. The percentage of light transmitted is :

(1) 1.25 (2) 25.0 (3) 37.5 (4) 50.0

91. The hexadecimal equivalent of the binary number 11101101111010 is :

(1) EDE8 (2) 3B7A (3) FB7A (4) 35572

92. The maximum positive and negative numbers which can be represented in two complements form using n bits are respectively :

(1) $+(2^{n-1}-1),-(2^{n-1}-1)$ (2) $+(2^{n-1}-1),-2^{n-1}$

(3) $+2^{n-1},-2^{n-1}$ (4) $+2^{n-1},-(2^{n-1}+1)$

93. A microprocessor without the interrupt facility :

(1) is best suited for a process control system

(2) is not useful for a process control system

(3) cannot be used for DMA operation

(4) cannot be interfaced with any I/O device

94. A body moves along x-axis with velocity v_x at position x. If the plot $v_x - x$ is an ellipse with major axis $2A$ and minor axis $2v_0$, the maximum acceleration has a modulus :

(1) v_0^2 / A (2) A / v_0^2 (3) $v_0 A$ (4) $v_0^2 / A^{1/2}$

95. A uniform rod AB of mass m and length l is at rest on a smooth horizontal surface. If an impulse 'p' is applied at the end B, then the time taken by the rod to turn through a right angle is :

(1) $2\pi ml/p$ (2) $2\pi p/ml$ (3) $\pi ml/12p$ (4) $\pi p/ml$

96. In a glass sphere, there is small bubble at 2×10^{-2} m from its centre. If the bubble is viewed along a diameter of the sphere from the side on which it lies, how far from the surface will it appear ? The radius of the sphere is 5×10^{-2} m and the refractive index of glass is 3/2.

(1) 2.5×10^{-2} m (2) 3.2×10^{-2} m

(3) 6.5×10^{-2} m (4) 0.2×10^{-2} m

97. The work function of a certain metain is 2.3 eV. If the light of wave number $2\times10^6\ m^{-1}$ falls on it, the kinetic energy of fastest and slowest ejected electrons will be respectively :

(1) 2.48 eV, 0.18 eV (2) 0.18 eV, zero

(3) 2.30 eV, 0.18 eV (4) 0.18 eV, 0.18 eV

98. Given $\log_e 2 = 0.69$, the approximate value of $\log_e 3$ by evaluating the $\int_2^3 dx/x$ by Simpson's rule with intervals is :

(1) 1.155 (2) 0.991 (3) 1.095 (4) 1.201

99. If $f(0) = 1$ and $f(1) = 2.72$, then the trapezoidal rule gives the approximate value of $\int_0^1 f(x)dx$ as :

(1) 3.72 (2) 1.86 (3) 1.72 (4) 0.86

100. Entropy of a thermodynamic system does not change when this system is used for :

(1) conduction of heat from a hot reservoir to a cold reservoir

(2) conversion of work into heat isothermally

(3) conversion of heat into internal energy isochorically

(4) conversion of heat into work, isobarically

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M. Phil/Ph.D/URS - EE - Jan.-Dec.-2017

SUBJECT : Physics

D

Sr. No. 10024

Time : **1¼ Hours** Max. Marks : **100** Total Questions : **100**

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3. In case there is any discrepancy in any question(s) in the Question Booklet, the same may be brought to the notice of the Controller of Examinations in writing **within two hours** after the test is over. No such complaint(s) will be entertained thereafter.
4. The candidate ***must not*** do any rough work or writing in the OMR Answer-Sheet. Rough work, if any, may be done in the question booklet itself. Answers ***must not*** be ticked in the question booklet.
5. ***There will be no negative marking. Each correct answer will be awarded one full mark. Cutting, erasing, overwriting and more than one answer in OMR Answer-Sheet will be treated as incorrect answer.***
6. Use only **Black** or **Blue Ball Point Pen** of good quality in the OMR Answer-Sheet.
7. *Before answering the questions, the candidates should ensure that they have been supplied correct and complete booklet. Complaints, if any, regarding misprinting etc. will not be entertained* **30** *minutes after starting of the examination.*

1. The maximum change in energy of a p-electron due to precessional motion of its orbit in a magnetic field of 3×10^4 gauss is of the order :

   (1) 2.8×10^{-8} erg (2) 2.8×10^{-16} erg

   (3) 2.8×10^{-12} erg (4) 2.8×10^{-10} erg

2. From X-rays produced using cobalt (z = 27) as target, the observed X-ray spectrum contained a strong K_α line of wavelength 0.1785 nm and a weak K_α line of wavelength 0.1930 nm. The weak K_α line may be due to an impurity atom of atomic number :

   (1) 26 (2) 25 (3) 30 (4) 28

3. In an ESR spectrometer operating at 9.302 GHz, the ESR spectrum of hydrogen atom yields two lines, one at 357.3 mT and the other at 306.6 mT. The hyperfine coupling constant of the hydrogen atom is :

   (1) 0.507 mT (2) 357.3 mT

   (3) 50.7 mT (4) 257.3 mT

4. In band spectrum of diatomic molecules, which one is *not* true :

   (1) Formation of band does not occur in rotation vibration spectra

   (2) The band head can occur toward the red end

   (3) The band head can occur toward the violet end

   (4) The band head must be formed at the transition between the same set of-rotational quantum number

5. A file server performs one of the following :

   (1) manages file operations and is limited to one PC

   (2) manages file operations and is shared on a network

   (3) acts as a fat client and is shared on a network

   (4) acts as a fat client and is limited to one PC

6. Object oriented programming relies on which of the following basic concepts ?

   (1) Data abstraction, Inheritance, Polymorphism

   (2) I/O, Inheritance, Polymorphism

   (3) Data abstraction, Inheritance, Arrays

   (4) Data abstraction, I/O, Inheritance

7. The stray wiring capacitance in an amplifier has an effect on :
   (1) mid band frequencies (2) lower cut off frequency
   (3) output resistance (4) upper cut off frequency

8. The plane of oscillation of a Foucault's pendulum rotates :
   (1) 15° per hour at the equator (2) 15° per hour at the pole
   (3) 7.5° per hour at the latitude 60° (4) 30° per hour at the latitude 60°

9. In a biprism experiment, if the wavelength of red light used is 6.5×10^{-7} m and that of green light is 5.2×10^{-7} m, the value of 'n' for which $(n+1)^{th}$ green bright band coincides with n^{th} red bright band for the same setting is given by :
   (1) 2 (2) 3 (3) 4 (4) 1

10. Two Nicol prisms are first crossed and then one of them is rotated through 60°. The percentage of light transmitted is :
   (1) 1.25 (2) 25.0 (3) 37.5 (4) 50.0

11. In a measurement of the viscous drag force experienced by spherical particles in a liquid, the force is found to be proportional to $V^{1/3}$ where V is the measured volume of each particle. If V is measured to be 30 mm^3, with an uncertainty of 2.7 mm^3, the resulting relative percentage uncertainty in the measured force is :
   (1) 2.08 (2) 0.09 (3) 6 (4) 3

12. A plane electromagnetic wave incident normally on the surface of a material is partially reflected. Measurements on the standing wave in the region in front of the interface show that the ratio of the electric field amplitude at the maxima and the minima is 5. The ratio of the reflected intensity to the incident intensity is :
   (1) 4/9 (2) 2/3 (3) 2/5 (4) 1/5

13. A computer cannot "boot" if it does not have the :
   (1) Compiler (2) Loader
   (3) Operating System (4) Assembler

14. Which of the following is ***not*** a function of the control unit ?
   (1) Read Instructions (2) Execute Instructions
   (3) Interpret Instructions (4) Direct Operations

15. A combination is made of two lenses of focal lengths f and f' in contact; the dispersive power of the materials of the lenses are ω and ω'. The combination is achromatic when :

(1) $\omega = \omega_0, \omega' = 2\omega_0, f' = 2f$ (2) $\omega = \omega_0, \omega' = 2\omega_0, f' = f/2$

(3) $\omega = \omega_0, \omega' = 2\omega_0, f' = -f/2$ (4) $\omega = \omega_0, \omega' = 2\omega_0, f' = -2f$

16. A monochromatic beam of light is used for the formation of fringes on a screen by illuminating the two slits in the Young's double slit experiment. When a thin film of mica is interposed in the path of one of the interfering beams :

(1) the fringe width increases

(2) the fringe width decreases

(3) the fringe pattern disappears

(4) the fringe width remains the same but the pattern shifts

17. The proper half life of some radio-isotopes is 5 μs. When these isotopes pass through a laboratory, their half life is observed to be 15 μs. The speed of the radio- isotopes is :

(1) $\frac{2\sqrt{2}}{3}c$ (2) $\frac{\sqrt{2}}{3}c$

(3) $\frac{3}{\sqrt{2}}c$ (4) $\frac{2}{3\sqrt{2}}c$

18. A slowly moving electron collides with a positron at rest and annihilates it producing two photons. If the rest mass of the electron or positron be m_0 then the frequency of each photon is :

(1) $2m_0c^2/h^2$ (2) m_0c^2/h^2 (3) m_0c^2/h (4) $2m_0c^2/h$

19. An α particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of :

(1) 1 Å (2) 10^{-10} cm (3) 10^{-12} cm (4) 10^{-16} cm

20. An X -ray photon of wavelength λ, and frequency ν collides with an electron and bounces off. If λ', and ν' are respectively the wavelength and frequency of the scattered photon, then :

(1) $\lambda' = \lambda; \nu' = \nu$ (2) $\lambda' < \lambda; \nu' > \nu$

(3) $\lambda' > \lambda; \nu' > \nu$ (4) $\lambda' > \lambda; \nu' < \nu$

21. An atom of mass M can be excited to a state of mass $M + \Delta$ by photon capture. The frequency of a photon which can cause this transition is :

(1) $\Delta c^2/2Mh$ (2) $\Delta c^2/M^2h$

(3) $\Delta c^2(\Delta + 2M)/2Mh$ (4) $\Delta^2c^2/2M^2h$

22. The associated change in wavelength resulting due to a collision of relativistic nature of a photon of wavelength λ with a free electron at rest is given as :

(1) $\lambda - \lambda' = \{h/m_0c\}\{1 - \cos\varphi\}$ (2) $\lambda - \lambda' = \{h/m_0c^2\}\{1 - \cos\varphi\}$

(3) $\lambda - \lambda' = \{h/m_0c\}\{1 - \cos^2\varphi\}$ (4) $\lambda - \lambda' = \{h^2/m_0c\}\{1 - \cos\varphi\}$

where φ is the angle of scattered photon with the direction of incident photon

23. According to Langevin's theory of diamagnetism, the induced magnetic moment per unit volume is proportional to :

(1) mass of the electron (2) radius of the orbit

(3) external magnetic field (4) none of these

24. Born's approximation can be used :

(1) only within very low energy limits

(2) only within high energy limits

(3) in very low as well as in high energy limits

(4) none of these

25. Which of the following statements is/are ***false*** ?

(i) Brownian motion offers an experimental test of the kinetic theory hypothesis.

(ii) Brownian movements are the motions of small particles that are bombarded by molecules of the fluid.

(iii) Brownian motion demonstrates the occurrence of random motion of the particles.

(iv) The average kinetic energy of the particles in the Brownian motion is the same as that of the molecules of the fluid.

(1) None of the above (2) (i) only

(3) (ii) and (iii) only (4) (iii) and (iv) only

26. If a rigid body is rotating with an angular velocity ω about an instantaneous axis through a fixed point in the body, the angular momentum J about the same point :

(i) will always be in the direction of ω

(ii) may be in the direction of ω

(iii) may have different direction to that of ω

(1) i and ii (2) ii and iii

(3) i and iii (4) none of these

27. If $f(z) = 1/(1-z)^2 \tan(1/z)$, then the wrong statement is :

(1) $f(z)$ has poles at $z = 0$ and $z = 1$

(2) $f(z)$ has many infinite poles

(3) $f(z)$ has non-isolated essential singularity at $z = 0$

(4) $f(z)$ has essential singularity at $z = 0$

28. The polynomial $2x^2 + x + 3$ in terms of legendre polynomial is :

(1) $1/3(4P_2 + 3P_1 + 11P_0)$ (2) $1/3(4P_2 - 3P_1 - 11P_0)$

(3) $1/3(4P_2 + 3P_1 - 11P_0)$ (4) $1/3(4P_2 - 3P_1 - 11P_0)$

29. A particle moving on a every long frictionless wire rotating at constant angular velocity about a horizontal axis is an example of :

(1) Only conservative system

(2) Rheonomic, holonomic and conservative system

(3) Only holonomic and conservative system

(4) Rheonomic, non-holonomic, non-conservative system

30. Which of the following statements is correct for the function $f(x) = x^4 - x^2$ in the $-\infty < x < \infty$?

(1) The plot of $f(x)$ vs x as two maxima and two minima

(2) The plot of $f(x)$ vs x as three extrima

(3) The plot of $f(x)$ vs x cuts the x-axis at four points

(4) No part of the plot of $f(x)$ vs x lies in the fourth quadrant

31. The electronic energy levels in a hydrogen atom are given by $En = -13.6/n^2$ eV. If a selective excitation to the n = 100 level is to be made using a laser, the maximum allowed frequency line-width of the laser is approximately :

(1) 6.5 MHz (2) 6.5 GHz (3) 6.5 Hz (4) 6.5 kHz

32. Let A, B and C be functions of phase space variables (coordinates and momenta of a mechanical system). If {,} represents the Poisson bracket, the value of {A,{B,C}} - {{A,B},C} is given by :

(1) 0 (2) {B,{C,A}} (3) {A, {C,B}} (4) {{C,A},B}

33. Two monochromatic sources, L_1 and L_2 emit light at 600 and 700 run, respectively. If their frequency bandwidths are 10^{-1} and 10^{-3} GHz, respectively, then the ratio of line-width of L_1 and L_2 is approximately :

(1) 100 : 1 (2) 1 : 85 (3) 75 : 1 (4) 1 : 75

34. A child makes a random walk on a square lattice of lattice constant a taking a step in the north, east, south, or west directions with probabilities 0.255, 0.255, 0.245, and 0.245, respectively. After a large number of steps, N, the expected position of the child with respect to the starting point is at a distance :

(1) $\sqrt{2} \times 10^{-2}$ Na in the north-east direction

(2) $\sqrt{(2N)} \times 10^{-2}$ Na in the north-east direction

(3) $2\sqrt{2} \times 10^{-2}$ Na in the south-east direction

(4) 0

35. A 4-variable switching function is given by $f = \Sigma(5,7,8,10,13,15)+d(0,1,2)$, where d is the do- not-care-condition. The minimized form of f in sum of products (SOP) form is :

(1) $\overline{A}\,\overline{C} + \overline{B}\,\overline{D}$ (2) $A\overline{B} + C\overline{D}$ (3) $AD + BC$ (4) $\overline{B}\,\overline{D} + BD$

36. A gas laser cavity has been designed to operate at $\lambda = 0.5$ μm with a cavity length of 1 m. With this set-up, the frequency is found to be larger than the desired frequency by 100 Hz. The change in the effective length of the cavity required to retune the laser is :

(1) -0.334×10^{-12} m (2) 0.334×10^{-12} m

(3) 0.167×10^{-12} m (4) -0.167×10^{-12} m

37. One gram of salt is dissolved in water that is filled to a height of 5 cm in a beaker of diameter 10 cm, The accuracy of length measurement is 0.01 cm while that of mass measurement is 0.01 mg. When measuring the concentration C, the fractional error $\Delta C/C$ is :

(1) 0.8% (2) 0.14% (3) 0.5% (4) 0.28%

38. The recently-discovered Higgs boson at the LHC experiment has a decay mode into a photon and a Z boson. If the rest masses of the Higgs and Z boson are 125 GeV/c^2 and 90 GeV/c^2 respectively, and the decaying Higgs particle is at rest, the energy of the photon will approximately be :

(1) $35\sqrt{3}$ GeV (2) 35 GeV (3) 30 GeV (4) 15 GeV

39. A canonical transformation relates the old coordinates (q, p) to the new ones (Q, P) by the relations $Q = q^2$ and $P = p/2q$. The corresponding time-independent generating function is :

(1) P/q^2 (2) q^2P (3) q^2/P (4) qP^2

40. Let x and p denote, respectively, the coordinate and momentum operators satisfying the canonical commutation relation $[x, p] = i$ in natural units $(\hbar = 1)$. Then the commutator $[x, pe^{-p}]$ is :

(1) $i(1-p)e^{-p}$ (2) $i(1-p^2)e^{-p}$ (3) $i(1-e^{-p})$ (4) ipe^{-p}

41. The hexadecimal equivalent of the binary number 11101101111010 is :

(1) EDE8 (2) 3B7A (3) FB7A (4) 35572

42. The maximum positive and negative numbers which can be represented in two complements form using n bits are respectively :

(1) $+(2^{n-1}-1), -(2^{n-1}-1)$ (2) $+(2^{n-1}-1), -2^{n-1}$

(3) $+2^{n-1}, -2^{n-1}$ (4) $+2^{n-1}, -(2^{n-1}+1)$

43. A microprocessor without the interrupt facility :

(1) is best suited for a process control system

(2) is not useful for a process control system

(3) cannot be used for DMA operation

(4) cannot be interfaced with any I/O device

44. A body moves along x-axis with velocity v_x at position x. If the plot $v_x - x$ is an ellipse with major axis $2A$ and minor axis $2v_0$, the maximum acceleration has a modulus :

(1) v_0^2/A (2) A/v_0^2 (3) $v_0 A$ (4) $v_0^2/A^{1/2}$

45. A uniform rod AB of mass m and length l is at rest on a smooth horizontal surface. If an impulse 'p' is applied at the end B, then the time taken by the rod to turn through a right angle is :

(1) $2\pi ml/p$ (2) $2\pi p/ml$ (3) $\pi ml/12p$ (4) $\pi p/ml$

46. In a glass sphere, there is small bubble at 2×10^{-2} m from its centre. If the bubble is viewed along a diameter of the sphere from the side on which it lies, how far from the surface will it appear ? The radius of the sphere is 5×10^{-2} m and the refractive index of glass is 3/2.

(1) 2.5×10^{-2} m (2) 3.2×10^{-2} m (3) 6.5×10^{-2} m (4) 0.2×10^{-2} m

47. The work function of a certain metain is 2.3 eV. If the light of wave number $2\times10^{6}\,m^{-1}$ falls on it, the kinetic energy of fastest and slowest ejected electrons will be respectively :

(1) 2.48 eV, 0.18 eV (2) 0.18 eV, zero

(3) 2.30 eV, 0.18 eV (4) 0.18 eV, 0.18 eV

48. Given $\log_e 2 = 0.69$, the approximate value of $\log_e 3$ by evaluating the $\int_2^3 dx/x$ by Simpson's rule with intervals is :

(1) 1.155 (2) 0.991 (3) 1.095 (4) 1.201

49. If $f(0) = 1$ and $f(1) = 2.72$, then the trapezoidal rule gives the approximate value of $\int_0^1 f(x)dx$ as :

(1) 3.72 (2) 1.86 (3) 1.72 (4) 0.86

50. Entropy of a thermodynamic system does not change when this system is used for :

(1) conduction of heat from a hot reservoir to a cold reservoir

(2) conversion of work into heat isothermally

(3) conversion of heat into internal energy isochorically

(4) conversion of heat into work, isobarically

51. A system of four particles lie in x-y plane. Out of these, two particles each of mass m are located at (–1, 1) and (1, –1). The other two particles are located at (1, 1) and (–1, –1). The value of (x, y) component of the moment of inertia tensor of this system of particles is :

(1) 10 m (2) –2 m (3) –10 m (4) 2 m

52. The specified value of holding current for an SCR means that :

(1) The device will turn on when the anode current exceeds this value

(2) The device may be damaged when the anode current exceeds this value

(3) The device will turn off when the anode current falls below this value

(4) The gate current must be equal to or exceeds this value to turn the device on

53. If a sinusoidal voltage is applied to base of a biased n-p-n transistor and the resulting sinusoidal collector voltage is clipped near zero volt, the transistor is :

(1) Being driven into saturation
(2) Being driven into active region
(3) Operating non-linearly
(4) None of the above

54. A dynamic RAM cell holds 5 V to be refreshed every 20 m secs., such that the stored voltage does not fall below 0.5 V. If the cell has a constant current of 0.1 pA, the storage capacitance of the cell is :

(1) 4×10^{-15} F (2) 4×10^{-6} F (3) 4×10^{-9} F (4) 4×10^{-12} F

55. A 10 bit A/D converter is used to digitise an analog signal in the 0 to 5 V range. The maximum peak to peak ripple voltage that can be allowed in the dc supply voltage is :

(1) ~100 mV (2) ~25 mV (3) ~50 mV (4) ~5.0 mV

56. The value of radius of the Fermi sphere of a degenerate free electron gas at zero temperature, having N particles contained in volume V is given as :

(1) $(3\pi^2)^{1/3}(N/V)^{2/3}\hbar$
(2) $(3\pi^2)^{1/3}(N/V)^{1/6}\hbar$
(3) $(3\pi^2)^{1/3}(N/V)^{1/3}\hbar$
(4) $(3\pi^2)^{2/3}(N/V)^{1/3}\hbar$

57. According to the uncertainity relation, the minimum uncertainity in the velocity of an electron orbiting around the nucleus of radius r is :

(1) $\pi h/(2mr^2)$ (2) $2\pi hmr$ (3) $\dfrac{h}{2\pi mr}$ (4) $2hm/\pi r^2$

58. For a spherically symmetric probability cloud of an electron :

(1) Principal quantum number is zero
(2) Magnetic quantum number is zero
(3) Spin quantum number is zero
(4) Orbital quantum number is zero

59. The nucleus of the atom ${}_4Be^9$ consists of :

(1) 13 up quarks and 13 down quarks
(2) 14 up quarks and 14 down quarks
(3) 13 up quarks and 14 down quarks
(4) 14 up quarks and 13 down quarks

60. Out of the following reactions, which one violates the lepton number conservation :

(1) $e^+ + e^- \rightarrow \nu + \overline{\nu}$ (2) $e^- + n \rightarrow p + \nu$

(3) $e^- + p \rightarrow \nu + n$ (4) $\overline{\mu} \rightarrow e^- + \nu + \overline{\nu}$

61. In Foucaults rotating mirror experiment for determining the velocity of light, the distance between the rotating mirror and the convex lens is negligible when compared to the radius of curvature of the concave mirror. If the radius of curvature of the concave mirror is doubled, the image shift is :

(1) halved

(2) doubled

(3) zero

(4) independent of radius of curvature of concave mirror

62. A particle moving with a uniform acceleration along a straight line covers distances a and b in successive intervals of p and q seconds. The acceleration of the particle is :

(1) $\frac{pq(p+q)}{2(bp-aq)}$ (2) $\frac{bp-aq}{pq(p-q)}$

(3) $\frac{2(aq-bp)}{pq(p-q)}$ (4) $\frac{2(bp-aq)}{pq(p+q)}$

63. A uniform rod 'AB' of mass m and length l is at rest on a smooth horizontal surface. An impulse p is applied to the end 'B'. The time taken by the rod to twist through a right angle is :

(1) $\frac{2\pi ml}{p}$ (2) $\frac{\pi ml}{12p}$ (3) $\frac{2\pi p}{ml}$ (4) $\frac{\pi p}{ml}$

64. A rod of length 'l' is hinged from one end. It is brought to a horizontal position and released. The angular velocity of the rod when it is in vertical position, is :

(1) $\sqrt{\frac{2g}{L}}$ (2) $\sqrt{\frac{3g}{L}}$ (3) $\sqrt{\frac{g}{2L}}$ (4) $\sqrt{\frac{g}{L}}$

65. A particle executes S.H.M. with an amplitude of 10 cm and frequency 2 Hz. At t = 0, the particle is at a point where potential energy and kinetic energy are same. The equation of displacement of the particle is :

(1) $0.1\cos\left\{4\pi l + \frac{\pi}{4}\right\}$ (2) $0.1\sin 4\pi l$

(3) $0.1\sin\left\{4\pi l + \frac{\pi}{4}\right\}$ (4) $0.1\sec\left\{4\pi l + \frac{\pi}{4}\right\}$

66. Equation of a plane wave is given by $\frac{4\sin\pi}{4}\left[2t+\frac{x}{8}\right]$. The phase difference at any instant of two particles 16 cm apart is :

(1) 60° (2) 90° (3) 30° (4) 120°

67. A thermally insulated piece of matter is heated under atmosphere by an electric current so that it receives electrical energy at a constant power P. This leads to an increase of the absolute temperature T of the metal with time t as $T = at^{1/4}$. The specific heat C_p in this case is :

(1) $\frac{4PT^3}{a^4}$ (2) $\frac{4PT^2}{a^3}$ (3) $4PT^2$ (4) $\frac{4PT^3}{a^3}$

68. Two identical containers A and B have frictionless pistons. Both contain same volume of ideal gas at same temperature. The gas in each cylinder is allowed to expand isothermally to double the initial volume. The mass of the gas in A is m_A and the mass of the gas in B is m_B. The changes in the pressure in A and B are ΔP and $1.5\ \Delta P$ respectively, then :

(1) $4m_A = 9m_B$ (2) $2m_A = 3m_B$ (3) $3m_A = 2m_B$ (4) $4m_A = 4m_B$

69. The moment of inertia I of a body at a temperature 'T' increases to $I+\Delta I$ as the temperature rises to $T+\Delta T$. If the coefficient of linear expansion of the material is 'α', then the ratio $\Delta I/I$ will be :

(1) $\Delta T/T$ (2) $2\Delta T/T$ (3) $\alpha\Delta T$ (4) $2\alpha\Delta T$

70. An electric dipole, made up of a positive and negative charge, each of 1 mC placed at a distance 2 cm apart is placed in an electric field of 10^5 N/C. The maximum torque exerted by the field on the dipole while it is turned from $\theta = 0°$ to $\theta = 180°$ is :

(1) 2×10^{-3} N-m (2) 3×10^{-3} N-m

(3) 4×10^{-3} N-m (4) 2.8×10^{-3} N-m

71. If a charged particle moving in a magnetic field looses 4% of its kinetic energy, then the radius of curvature of its path will change by :

(1) 6% (2) 4% (3) 10% (4) 2%

72. The mutual inductance of coil and a solenoid, for a solenoid of length 50 cm and with 5000 turns of wire of radius 4 cm and a coil of 700 turns wound on middle of the solenoid is :

(1) 44.17 mH (2) 48.98 mH (3) 34.34 mH (4) 36.72 mH

73. A circular turn table has a block of ice placed at its centre. The system rotates with an angular speed ω about an axis passing through the centre of the table. If the ice melts, on its own, without any evaporation, the speed of rotation of the system :
(1) becomes zero
(2) remains constant at the same value ω
(3) increases to a value greater than ω
(4) decreases to a value less than ω

74. Out of various configurations of a transistor as an amplifier, which of following statement is ***not*** correct ?
(1) input resistance is least in CB mode
(2) output resistance is least in CC mode
(3) output resistance in CE mode is more than the CB mode
(4) voltage gain of CC mode is less than CE mode

75. A metallic surface has a threshold wavelength 5200 Å. This surface is irradiated by monochromatic light of wavelength 4500 Å. Which of the following statements is ***true*** ?
(1) The electrons are emitted from the surface having energy between 0 and infinity
(2) The electrons are emitted from the surface having energy between 0 and certain finite maximum value
(3) The electrons are emitted from the surface, all having certain finite energy
(4) No electron is emitted from the surface

76. The group and phase velocities in case of wave packets are equal if :
(1) phase velocity v_p is independent of the wavevector
(2) phase velocity v_p is independent of the wavevector and frequency
(3) phase velocity v_p is dependent on the wavevector
(4) None of these

77. The number of atoms in 100 gm of a f.c.c. crystal with density 10g cm^{-3} and cell edge 200 pm is :
(1) 3.2×10^{26} (2) 1.1×10^{26} (3) 5.0×10^{24} (4) 2.6×10^{25}

78. If a one dimensional harmonic oscillator is in the state :

$$\psi(x)=\frac{1}{\sqrt{14}}[3\psi_0(x)-2\psi_1(x)+3\psi_2(x)]$$

where $\psi_0(x)$, $\psi_1(x)$ and $\psi_2(x)$ are the ground, first and second excited states respectively. The probability of finding the oscillator in the ground state is :

(1) 9/14 (2) 1/2 (3) $\frac{3}{\sqrt{14}}$ (4) 1

79. ECL circuits have higher fan-out due to their :

(1) high input impedance

(2) low output impedance

(3) high input impedance and low output impedance

(4) complementary outputs

80. In a TTL gate with passive pull-up, the collector current of the output transistor is 4 mA corresponding to LOW level output when it is not driving any other gate. Its fan-out is 10 and sinks 1.5 mA current corresponding to each load gate. The fan-out when two such gates are wire- ANDed will be :

(1) 5 (2) 7 (3) 10 (4) 20

81. The electrostatic potential $V(x, y)$ in free space in a region where the charge density ρ is zero is given by $V(x,y)=4e^{2x}+f(x)-3y^2$. Given that the x-component of the electric field, E_x and V are zero at the origin, $f(x)$ is :

(1) $3x^2-4e^{2x}+8x$ (2) $3x^2-4e^{2x}+16x$

(3) $4e^{2x}-8$ (4) $3x^2-4e^{2x}$

82. Which of the following matrices is an element of the group SU(2) ?

(1) $\begin{bmatrix}1 & 1\\ 0 & 1\end{bmatrix}$ (2) $\begin{bmatrix}\frac{1+i}{\sqrt{3}} & \frac{-1}{\sqrt{3}}\\ \frac{1}{\sqrt{3}} & \frac{1-i}{\sqrt{3}}\end{bmatrix}$

(3) $\begin{bmatrix}2+i & i\\ 3 & 1+i\end{bmatrix}$ (4) $\begin{bmatrix}\frac{1}{2} & \frac{\sqrt{3}}{2}\\ \frac{\sqrt{3}}{2} & \frac{1}{2}\end{bmatrix}$

83. A cavity contains blackbody radiation in equilibrium at temperature T. The specific heat per unit volume of the photon gas in the cavity is of the form $C_v = \gamma T^3$ where γ is a constant. The cavity is expanded to twice its original volume and then allowed to equilibrate at the same temperature T. The new internal energy per unit volume is :

(1) $4\gamma T^4$ (2) $2\gamma T^4$

(3) $\gamma T^4/4$ (4) γT^4

84. A particle in one dimension moves under the influence of a potential $V(x) = ax^6$, where a is a real constant. For large n, the quantized energy level E_n depends on n as :

(1) $E_n \sim n^3$ (2) $E_n \sim n^{4/3}$

(3) $E_n \sim n^{6/5}$ (4) $E_n \sim n^{3/2}$

85. A beam of pions (π^+) is incident on a proton target, giving rise to the process $\pi^+ p \rightarrow n + \pi^+ + \pi^+$. Assuming that the decay proceeds through strong interactions, the total isospin I and its third component I_3 for the decay products, are :

(1) $I = 3/2,\ I_3 = 3/2$ (2) $I = 5/2,\ I_3 = 5/2$

(3) $I = 5/2, I_3 = 3/2$ (4) $I = 1/2, I_3 = -1/2$

86. The equation of the plane that is tangent to the surface $xyz = 8$ at the point (1, 2, 4) is :

(1) $x + 2y + 4z = 12$ (2) $4x + 2y + z = 12$

(3) $x + 4y + 2z = 12$ (4) $x + y + z = 7$

87. Assume that the free energy of a magnetic system has an expansion in the order parameter M of the form $F(M, T) = a(T - T_c) M^2 + bM^4 + cM^6$, with a, b and $c > 0$. As the temperature is lowered below T_c, the system undergoes a phase transition. The behaviour of the order parameter just below the transition, where $(T - T_c)$ is very small, is best described by :

(1) $M \alpha (T_c - T)^{-1/2}$ (2) $M \alpha (T_c - T)^{1/2}$

(3) $M \alpha (T_c - T)$ (4) $M \alpha (T_c - T)^3$

88. The minimum energy of an electron (the rest mass of which is 0.5 MeV) that can emit Cherenkov radiation while passing through water (of refractive index 1.5) is approximately :

(1) 1.0 MeV (2) 3.0 MeV

(3) 0.7 MeV (4) 0.5 MeV

89. Let $y(x)$ be a continuous real function in the range 0 and $2n$, satisfying the inhomogeneous differential equation : $\sin x d^2y/dx^2 + \cos x dy/dx = \delta(x - \pi/2)$. The value of dy/dx at the point $x = \pi/2$:

(1) is continuous
(2) has a discontinuity of 3
(3) has a discontinuity of 1/3
(4) has a discontinuity of 1

90. A bag contains many balls, each with a number painted on it. There are exactly N balls which have the number N (namely one ball with 1, two balls with 2, and so on until N balls with N on them). An experiment consists of choosing a ball at random, noting the number on it and returning it to the bag. If the experiment is repeated a large number of times, the average value of the number will tend to :

(1) $(2N+1)/3$ (2) $N/2$ (3) $(N+1)/2$ (4) $N(N+1)/2$

91. Bose condensation occurs in liquid He^4 kept at ambient pressure at 2.17 K. At which temperature will Bose condensation occur in He^4 in gaseous state, the density of which is 1000 times smaller than that of liquid He^4 ? (Assume that it is a perfect Bose gas)

(1) 2.17 mK (2) 21.7 mK (3) 21.7 μK (4) 2.17 μK

92. The energy required to create a lattice vacancy in a crystal is equal to 1 eV. The ratio of the number densities of vacancies n (1200 K) / n (300 K), when the crystal is at equilibrium at 1200 K and 300 K, respectively is approximately :

(1) $e^{(-30)}$ (2) $e^{(-15)}$ (3) $e^{(15)}$ (4) $e^{(30)}$

93. The minimum energy of a collection of 6 non-interacting electrons of spin $-1/2$ placed in a one dimensional infinite square well potential of width L is :

(1) $14\pi^2\hbar^2/rnL^2$ (2) $91\pi^2\hbar^2/rnL^2$ (3) $7\pi^2\hbar^2/rnL^2$ (4) $3\pi^2\hbar^2/rnL^2$

94. A function $f(x)$ obeys the differential equation $d^2f/dx^2 - (3-2i)f = 0$ and satisfies the conditions $f(0) = 1$ and $f(x) \to 0$ as $x \to \infty$. The value $f(\pi)$ is :

(1) $\exp(2\pi)$ (2) $\exp(-2\pi)$ (3) $-\exp(-2\pi)$ (4) $-\exp(2\pi i)$

95. A magnetic field sensor based on the Hall effect is to be fabricated by implanting As into a Si film of thickness 1 μrn, The specifications require a magnetic field sensitivity of 500 mV/Tesla at an excitation current of 1 mA. The implantation dose is to be adjusted such that the average carrier density, after activation, is :

(1) $1.25 \times 10^{26} m^{-3}$
(2) $1.25 \times 10^{22} m^{-3}$
(3) $4.1 \times 10^{21} m^{-3}$
(4) $4.1 \times 10^{20} m^{-3}$

96. Consider a He-Ne laser cavity consisting of two mirrors of reflectivities $R_1 = 1$ and $R_2 = 0.98$. The mirrors are separated by a distance $d = 20$ cm and the medium in between has a refractive index $n_0 = 1$ and absorption coefficient $\alpha = 0$. The values of the separation between the modes δv and the width Δv_p of each mode of the laser cavity are :

(1) $\delta v = 75$ kHz, $\Delta v_p = 24$ kHz (2) $\delta v = 100$ kHz, $\Delta v_p = 100$ kHz

(3) $\delta v = 750$ MHz, $\Delta v_p = 2.4$ MHz (4) $\delta v = 2.4$ MHz, $\Delta v_p = 750$ MHz

97. In a basis in which the z-component S_z of the spin is diagonal, an electron is in a spin state $\psi = \begin{pmatrix} \frac{1+i}{\sqrt{2/3}} \end{pmatrix}$. The probabilities that a measurement of S_z will yield the values $\hbar/2$ and $-\hbar/2$ are, respectively :

(1) 1/2 and 1/2 (2) 2/3 and 1/3

(3) 1/4 and 3/4 (4) 1/3 and 2/3

98. A muon (μ^-) from cosmic ray is trapped by a proton to form a hydrogen like atom. Given that a muon is approximately 200 times heavier than an electron, the longest wavelength of the spectral line (in the analogue of the Lyman series) of such an atom will be :

(1) 5.62 Å (2) 6.67 Å (3) 3.75 Å (4) 13.3 Å

99. A particle of mass m is at the stable equilibrium position of its potential energy $V(x) = ax - bx^3$ where a, b are positive constants. The minimum velocity that has to be imparted to the particle to render its motion unstable is :

(1) $(64a^3/9m^2b)^{1/4}$ (2) $(64a^3/27m^2b)^{1/4}$

(3) $(16a^3/27m^2b)^{1/4}$ (4) $(3a^3/64m^2b)^{1/4}$

100. Muons are produced through the annihilation of particle a and its antiparticle, namely the process $a + a \rightarrow \mu^+ + \mu^-$. A muon has a rest mass of 105 MeV/c^2 and its proper life time is 2 μs. If the center of mass energy of the collision is 2.1 GeV in the laboratory frame that coincides with the center-of-mass frame, then the fraction of muons that will decay before they reach a detector placed 6 km away from the interaction point is :

(1) e^{-1} (2) $1 - e^{-1}$ (3) $1 - e^{-2}$ (4) e^{-10}

SET : A

1. 4	16. 3	31. 3	46. 2	61. 2	76. 2	91. 2
2. 2	17. 4	32. 1	47. 1	62. 2	77. 3	92. 1
3. 3	18. 2	33. 3	48. 3	63. 2	78. 1	93. 3
4. 4	19. 2	34. 4	49. 4	64. 1	79. 2	94. 4
5. 3	20. 2	35. 4	50. 1	65. 3	80. 2	95. 2
6. 2	21. 2	36. 4	51. 4	66. 1	81. 2	96. 3
7. 2	22. 4	37. 1	52. 1	67. 2	82. 3	97. 4
8. 3	23. 3	38. 3	53. 4	68. 3	83. 1	98. 2
9. 4	24. 1	39. 3	54. 3	69. 2	84. 1	99. 3
10. 1	25. 4	40. 4	55. 2	70. 2	85. 2	100. 4
11. 2	26. 4	41. 2	56. 1	71. 3	86. 1	
12. 4	27. 4	42. 3	57. 3	72. 1	87. 3	
13. 1	28. 3	43. 2	58. 1	73. 3	88. 4	
14. 3	29. 2	44. 2	59. 3	74. 2	89. 3	
15. 2	30. 1	45. 3	60. 2	75. 2	90. 2	

SET : B

1. 2	16. 2	31. 4	46. 1	61. 2	76. 3	91. 3
2. 3	17. 3	32. 2	47. 3	62. 4	77. 4	92. 1
3. 2	18. 1	33. 3	48. 1	63. 3	78. 2	93. 3
4. 2	19. 2	34. 4	49. 3	64. 1	79. 2	94. 4
5. 3	20. 2	35. 3	50. 2	65. 4	80. 2	95. 4
6. 2	21. 2	36. 2	51. 2	66. 4	81. 2	96. 4
7. 1	22. 1	37. 2	52. 2	67. 4	82. 3	97. 1
8. 3	23. 3	38. 3	53. 2	68. 3	83. 1	98. 3
9. 4	24. 4	39. 4	54. 1	69. 2	84. 1	99. 3
10. 1	25. 2	40. 1	55. 3	70. 1	85. 2	100. 4
11. 3	26. 3	41. 4	56. 1	71. 2	86. 1	
12. 1	27. 4	42. 1	57. 2	72. 4	87. 3	
13. 3	28. 2	43. 4	58. 3	73. 1	88. 4	
14. 2	29. 3	44. 3	59. 2	74. 3	89. 3	
15. 2	30. 4	45. 2	60. 2	75. 2	90. 2	

SET : C

1. 2	16. 1	31. 3	46. 2	61. 2	76. 2	91. 2
2. 4	17. 3	32. 1	47. 2	62. 4	77. 1	92. 2
3. 3	18. 1	33. 3	48. 3	63. 1	78. 3	93. 2
4. 1	19. 3	34. 2	49. 4	64. 3	79. 4	94. 1
5. 4	20. 2	35. 2	50. 1	65. 2	80. 1	95. 3
6. 4	21. 2	36. 2	51. 3	66. 3	81. 2	96. 1
7. 4	22. 3	37. 3	52. 1	67. 4	82. 1	97. 2
8. 3	23. 1	38. 1	53. 3	68. 2	83. 3	98. 3
9. 2	24. 1	39. 2	54. 4	69. 2	84. 4	99. 2
10. 1	25. 2	40. 2	55. 4	70. 2	85. 2	100. 2
11. 4	26. 1	41. 4	56. 4	71. 2	86. 3	
12. 1	27. 3	42. 2	57. 1	72. 3	87. 4	
13. 4	28. 4	43. 3	58. 3	73. 2	88. 2	
14. 3	29. 3	44. 4	59. 3	74. 2	89. 3	
15. 2	30. 2	45. 3	60. 4	75. 3	90. 4	

SET : D

1. 2	16. 4	31. 2	46. 1	61. 2	76. 1	91. 2
2. 1	17. 1	32. 4	47. 2	62. 3	77. 3	92. 4
3. 3	18. 3	33. 3	48. 3	63. 2	78. 1	93. 1
4. 4	19. 3	34. 1	49. 2	64. 2	79. 3	94. 3
5. 2	20. 4	35. 4	50. 2	65. 3	80. 2	95. 2
6. 3	21. 3	36. 4	51. 2	66. 2	81. 4	96. 3
7. 4	22. 1	37. 4	52. 3	67. 1	82. 2	97. 4
8. 2	23. 3	38. 3	53. 1	68. 3	83. 3	98. 2
9. 3	24. 2	39. 2	54. 1	69. 4	84. 4	99. 2
10. 4	25. 2	40. 1	55. 2	70. 1	85. 3	100. 2
11. 3	26. 2	41. 2	56. 1	71. 4	86. 2	
12. 1	27. 3	42. 2	57. 3	72. 1	87. 2	
13. 3	28. 1	43. 2	58. 4	73. 4	88. 3	
14. 4	29. 2	44. 1	59. 3	74. 3	89. 4	
15. 4	30. 2	45. 3	60. 2	75. 2	90. 1	