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ENTRANCE EXAMINATION, 2022

Question Paper Booklet: Ph. D. (Physics)

Time: 2 hours

Marks:70

Hall Ticket Number:

Instructions

1. Please enter your **Hall Ticket Number on Page 1 of this question paper and on the OMR sheet** without fail.

2. (a) This question paper has to two parts: Part-A and Part-B.

   (b) **Part-A** consists of 20 multiple-choice questions related to Research methods.

   (c) **Part-B** consists of 20 multiple-choice questions related to Physics.

   (d) Each questions carries **1.75** marks.

   (e) **There is negative marking of 0.50 marks for every wrong answer.** The marks obtained by a candidate in Part-A will be used for resolving tie cases.

   (f) Answers are to be marked on the OMR answer sheet following the instructions provided thereupon. An example is shown below:

   100 Ⓐ Ⓑ Ⓒ ●

   (g) Only non-scientific non-progammable calculators are permitted. Mobile phone based calculators are not permitted. Logarithmic tables are not allowed.

   (h) **Handover the OMR sheet at the end of the examination.**

3. Values of physical constants:

   $c = 3 \times 108 m/s; h = 6.63 \times 10^{-34} J - s; k_B = 1.38^{-23} J/K;$

   $e = 1.6^{-19} C; \mu_0 = 4\pi \times 10^{-7} Henry/m; \epsilon_0 = 8.85 \times 10^{-12} Farad/m;$

THIS BOOKET CONTAINS 16 PAGES

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Part-A

1. If $(a+b+c+d+e)^2 = 100$, then the maximum value of the product $a \times b \times c \times d \times e$ is

   (A) 32

   (B) 12

   (C) 48

   (D) 72

2. The maximum pressure exerted by a $3cm \times 4cm \times 5cm$ metal block of density ρ, when it presses on a surface with one of its faces is (in units of Ba)

   (A) $5\rho g$

   (B) $3\rho g$

   (C) $4\rho g$

   (D) $12\rho g$

3. Six people O, B, A, F, G and K are standing at the vertices of a regular hexagon. O is not adjacent to B or A. F is not adjacent to A or G. B and A are adjacent, and K is adjacent to F and A. The non-neighbour pair among the following is

   (A) A and K

   (B) B and G

   (C) F and K

   (D) O and K

4. If $\alpha = b^x, \beta = b^y$, and $\alpha^y \beta^x = b^2$, then

   (A) $x = y$

   (B) $x = 1/y$

   (C) $x = 2/y$

   (D) $x = 2y$

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5. Consider a set of numbers $S = \{l^2, l = 1, 2, \cdots 70\}$. The percentage of the numbers in S with their last digit as 1 is,

   (A) 10

   (B) 5

   (C) 20

   (D) 25

6. The number of intersection points of the two curves representing the functions $f(x) = 4x^2$ and $g(x) = 3x + 4$, are

   (A) 0

   (B) 1

   (C) 2

   (D) 3

7. The value of the integral $\int_{-3}^{3} dx\ x^3\ \delta(3x - 1)$ is,

   (A) $\frac{1}{3}$

   (B) $\frac{1}{9}$

   (C) $\frac{1}{27}$

   (D) $\frac{1}{81}$

8. Consider the matrix A given by, $A = \begin{bmatrix} 1 & 1 & 2 \\ 2 & 2 & 1 \\ 4 & 4 & 3 \end{bmatrix}$. Then, Det e^A is

   (A) e^2

   (B) 1

   (C)e^6

   (D) $e^5 - e^2$

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9. The time taken for heating one litre of water from 25°C to 75°C using a 200-watt heating element with 50% efficiency is approximately (in seconds),

   (A) 1000

   (B) 2000

   (C) 200

   (D) 100

10. The metal detectors, used at the entrance of shopping malls and airports, work based on

    (A) Hooke's law of elasticity

    (B) Einstein's formula for the photoelectric effect

    (C) Faraday's law of induction

    (D) Curie's law of magnetism

11. Wearing polaroid goggle glasses minimises the glare (low-angle scattering of light) when you drive a car on a sunny day. Which among the following is involved in this process?

    (A) Mie scattering angle

    (B) Rayleigh scattering angle

    (C) Brewster angle of incidence

    (D) Total internal reflection

12. A business starts with an initial capital C. It suffers a loss of 50% at the end of the first year, followed by a gain of 50% at the end of the second year. At the end of the third year, the business stands with the initial capital C. The gain or the loss in the third year is,

    (A) 33.3 % loss

    (B) 33.3 % gain

    (C) 20 % gain

    (D) Zero gain or loss

13. During the summer days we feel uncomfortable due to high temperature (T) and relative humidity (RH). Another yardstick is the due point T_D, the temperature to which the air needs to be cooled to achieve 100% RH. Then,

    (A) you sweat more with higher T_D

    (B) you sweat less with higher T_D

    (C) RH is 50% if $T_D = T$

    (D) T is higher if RH is higher

14. Bragg peaks in x-ray diffraction off crystal lattices arise due to

    (A) the preferential distribution of orientations of different single crystals

    (B) the channeling of x-rays through voids of the crystal

    (C) the interference of the incoming and outgoing plane waves

    (D) the interference of the scattered waves from various crystal planes

15. In a tank of water, there are three red fish, four green fish and five blue fish. If someone takes out three fish randomly, the probability of getting one red, one green, and one blue fish is,

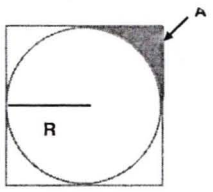
    (A) $\frac{1}{4}$

    (B) $\frac{1}{20}$

    (C) $\frac{3}{11}$

    (D) $\frac{2}{9}$

16. If a random aim is taken with an arrow at the square shown below, the probability of hitting the shaded area A shown in the figure is



(A) $(1 - \frac{\pi}{4})/4$

(B) $(1 - \frac{\pi}{4})/2$

(C) $(\frac{4}{\pi} - 1)/4$

(D) $(\frac{4}{\pi} - 1)/2$

17. A forced damped harmonic oscillator of natural frequency ω_0 and the damping coefficient γ is driven by an oscillatory force field, $F = F_0 \cos \omega t$. The phase lag in the position with respect to the driving field is

(A) $\tan^{-1} \frac{\omega^2}{\omega_0^2 - \omega^2}$

(B) $\tan^{-1} \frac{\gamma\omega}{\omega^2 - \omega_0^2}$

(C) $\tan^{-1} \frac{\omega^2}{\omega_0^2 + \omega^2}$

(D) $\tan^{-1} \frac{\gamma\omega}{\omega_0^2 + \omega^2}$

18. Three binary random variables x, y and z can take values 1 or -1 each. The cost function is $E = xy + yz + zx$. The probability for getting $E = -1$ is,

(A) 1/2

(B) 1/3

(C) 2/3

(D) 3/4

19. An X-polarised light propates through a quarter-wave plate oriented along X-direction. The transmitted light will be,

    (A) Circularly polarised

    (B) Elliptically polarised

    (C) X-polarised

    (D) Y-polarised

20. The number of ways in which N identical bosons can be distributed in three energy levels is

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

    (B) $(N+2)(N-1)/2$

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

    (D) $(N+2)N/2$

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Part-B

21. The value of the clockwise-closed contour integral $\frac{1}{2\pi}\oint dz \frac{\sin(i\pi z/2)}{z^2+1}$, for a contour with $|z-i|=1$ is

(A) 1/4

(B) 1/2

(C) 1

(D) 1/3

22. A 3×3 matrix B satisfies the equation $\alpha B + \beta B^2 = 0$. The sum of its eigenvalues is

(A) $-9\alpha/\beta$

(B) $-9\beta/\alpha$

(C) $-3\alpha/\beta$

(D) $-3\beta/\alpha$

23. The Lagrangian of a system is given by $L = \frac{1}{2}m(\alpha^2 + l^2\dot{\theta}^2) + mgl\cos\theta$, where α, l, m, g are constants. The Hamiltonian of the system is given by

(A) $\frac{p_\theta^2}{2ml^2} - \frac{m\alpha^2}{2} - mgl\cos\theta$

(B) $\frac{p_\theta^2}{ml^2} - \frac{m\alpha^2}{2} - mgl\cos\theta$

(C) $\frac{p_\theta^2}{2ml^2} - \frac{m\alpha^2}{2} + mgl\cos\theta$

(D) $\frac{p_\theta^2}{ml^2} - \frac{m\alpha^2}{2} + mgl\cos\theta$

24. Consider a planet in an elliptic orbit around the sun with energy E, the angular momentum $\vec{L}$, the momentum $\vec{P}$. Then,

(A) $\vec{L}$ and E are conserved, and $\vec{P}$ is not conserved

(B) $\vec{L}$ and $\vec{P}$ are conserved, and E not conserved

(C) $\vec{P}$ and E are conserved, and $\vec{L}$ is not conserved

(D) $\vec{P}, \vec{L}$ and E conserved

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25. A meson with charge +1 and strangeness -1 cannot exist according to the quark model because

(A) the s quark has strangeness +1

(B) the s quark has electric charge +1/2

(C) a quark of electric charge +4/3 does not exist

(D) an anti-quark of electric charge +4/3 does not exist

26. For a three-dimensional crystal lattice having N primitive unit cells with a basis of p atoms, the number of optical phonon branches is

(A) $3N - 3p$

(B) $3N - 3$

(C) $3p - 3$

(D) 3

27. Cosider the process $\gamma + p \rightarrow p + \pi^o$ with the proton at rest. In this process, the minimum energy of the photon is (in terms of the respective masses m_p, m_π of the proton and the pion and the speed of light c)

(A)$(\frac{m_p^2 - m_\pi^2}{2m_p})c^2$

(B) $(\frac{m_p^2 + m_\pi^2}{2m_p})c^2$

(C) $(\frac{m_\pi^2 + 2m_p m_\pi}{2m_p})c^2$

(D) $(\frac{m_p^2 + 2m_p m_\pi}{2m_p})c^2$

28. Consider a linear combination of $|n, l, m\rangle$ states of the hydrogen atom, given as $|\psi\rangle = a|210\rangle + b|2, 0.0\rangle + c|1, 0, 0\rangle$. For $a = b = c$, the expectation values of the energy (in terms of the ground state energy E_0), and L^2 (in terms of $\hbar^2$) are respectively

(A) $E_0/2, 2\hbar^2/3$

(B) $3E_0/4, \hbar^2/2$

(C) $4E_0/3, 4\hbar^2/3$

(D) $E_0/2, \hbar^2/2$

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29. Including a spin-orbit interaction term in the hydrogen atom, $H_{LS} = \frac{\lambda}{\hbar^2}\vec{L}\cdot\vec{S}$, the energy difference between the states with the total angular momentum $J = L + 1/2$ and $J = L - 1/2$ is

(A) $\lambda(L + 1/2)$

(B) $\lambda(L - 1/2)$

(C) λL

(D) $2\lambda L$

30. Consider the ground state for a free particle state (FP), a particle moving in a harmonic potential in one dimension (HO), an electron in a hydrogen atom (HA) . The ground state energies in the three cases are ordered in an increasing order as

(A) FP, HO, HA

(B) HA, HO, FP

(C) HO, HA, FP

(D) HA, FP, HO

31. Consider a system of N spin-1/2 particles in the presence of a magnetic field, at a temperature T. The entropy of the system $S(T)$ depends on the temperature. Then, $S(0)$ and $S(\infty)$, respectively (in terms of the Boltzmann constant k_B), are

(A) $0, \frac{1}{2}N$

(B) $N\log 2, 0$

(C) $0, N\log 2$

(D) $\frac{N}{2}\log 2, N\log 2$

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32. Consider a system of N atoms, each having an excited $S = 1$ triplet state of energy ϵ above the $S = 0$ singlet ground state. By applying a magnetic field $\vec{B} = B_0\hat{z}$, the Zeeman term perturbation is turned on given by $H_{Zeeman} = -\mu\vec{B}.\vec{S}/\hbar$, where μ is the effective magnetic moment. At hight temperatures, $k_BT >> \epsilon$, the magnetisation is

(A) 0

(B) $\frac{2\mu B}{k_BT}$

(C) $\frac{\mu^2 B}{2k_BT}$

(D) $\frac{\mu^2 B}{4k_BT}$

33. Consider two energy levels with energy $E = 0$ and $E = \Delta$ respectively, occupied by particles at a finite temperature T. The specific heat is (in terms of the Boltzmann constant k_B)

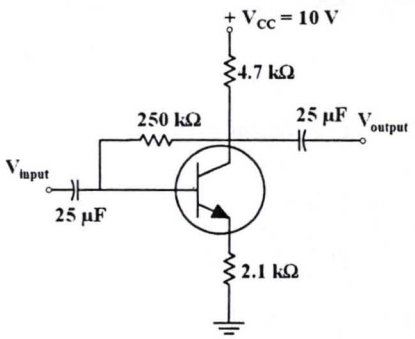
(A) $k_B(\frac{\Delta}{k_BT})^2 e^{-\Delta/k_BT}$

(B) $k_B(\frac{\Delta}{k_BT})^2 e^{-k_BT/\Delta}$

(C) $k_B(\frac{k_BT}{\Delta})^2 e^{-\Delta/k_BT}$

(D) $k_B(\frac{k_BT}{\Delta})^2 e^{-k_BT/\Delta}$

34. The operation point (I_{c_Q}, V_{CE_Q}) of the transistor shown in the circuit below, with β= 100, V_{BE}= 0.7 V, and V_{CC}= 10 V, is



(A) (1 mA, 5.0 V)

(B) (0.1 mA, 4.3 V)

(C) (1 mA, 3.2 V)

(D) (0.1 mA, 6.8 V)

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35. Using the Karnaugh map shown in the table, the reduced Boolean algebraic expression is

RS / PQ	00	01	11	10
00	1	1	0	0
01	0	0	0	0
11	1	0	0	0
10	1	1	0	0

(A) $\bar{Q}\bar{R}+\bar{P}\bar{R}\bar{S}$

(B) $QR+P\bar{R}S$

(C) $\bar{Q}R+P\bar{R}S$

(D) $\bar{Q}\bar{R}+P\bar{R}\bar{S}$

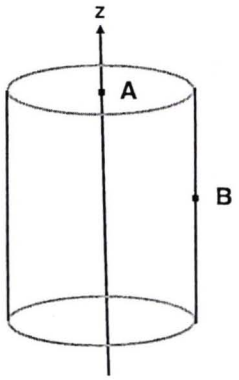
36. Consider a very long cylinder (with its cylindrical axis along z-direction as shown in the figure) with a frozen-in dielectric polarization, $\vec{P} = P_0\hat{z}$. You can take the length of the cylinder is far greater than the radius. The electric field at the point A (in the middle of upper circular surface just inside), and the electric field at the point B (in the middle of curved surface just inside) are resepectively

(A) $-P_0/\epsilon_0,\ P_0/\epsilon_0$

(B) $-P_0/\epsilon_0,\ 0$

(C) $P_0/\epsilon_0,\ -P_0/\epsilon_0$

(D) $0,\ -P_0/\epsilon_0$



37. Coaxial superposition of right-handed and left-handed circular polarised waves of equal amplitudes, with an initial phase difference of δ, is

(A) linearly polarized with $\vec{E}$ at an angle $\delta/2$ with x-axis

(B) linearly polarized with $\vec{E}$ at an angle δ with x-axis

(C) right-handed elliptically polarised

(D) left-handed elliptically polarised

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38. Ti:Sapphire laser source of 700 mm is incident on a sample. The output radiation has a spectral signature of 835 nm, due to a vibrational state. If Nd:YAG laser of 1060 mm is incident on the same sample, the wavelength of the spectral signature of the output radiation approximately is

(A) 1230 nm

(B) 1554 nm

(C) 1142 nm

(D) 1366 nm

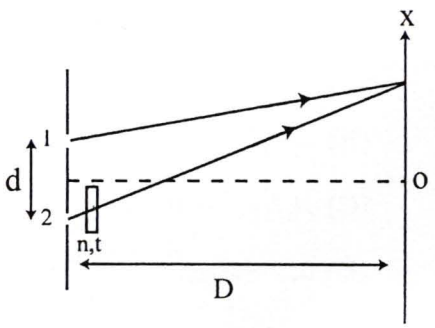
39. Consider Young's double-slit experiment illuminated by a quasi-monochromatic source to form interference fringes of width β on the screen. Placing a transparent sheet of thickness (t) and of refractive index (n), as shown in the figure, will shift the fringes by

(A) $\frac{1}{D}(n-1)t$

(B) $-\frac{\beta}{\lambda}(n-1)t$

(C) $\frac{2\beta}{\lambda}(n-1)t$

(D) $\frac{\lambda}{\beta}(n-1)t$



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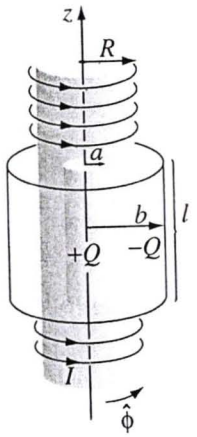
40. Consider a long solenoid with radius R and N turns per unit length, carrying a current $I(t)$ that varies slowly with time t. Coaxial with the solenoid are two long cylindrical shells of length l as shown in the figure. One shell with a radius a is inside the solenoid, carrying a charge $+Q$ uniformly distributed over its surface. The second shell with radius $b << l$ is outside the solenoid that carries a uniform charge $-Q$. The torque on the inner cylinder, and the change in in its angular momentum from time $t = 0$ to time t, are



(A) $-\frac{1}{2}\mu_0 NQb^2\dot{I}\hat{z}$, $\frac{1}{2}\mu_0 NIQb^2\hat{z}$

(B) $\frac{1}{2}\mu_0 NQa^2\dot{I}\hat{z}$, $-\frac{1}{2}\mu_0 NIQa^2\hat{z}$

(C) $-\frac{1}{2}\mu_0 NQa^2\dot{I}\hat{z}$, $\frac{1}{2}\mu_0 NIQa^2\hat{z}$

(D) $\frac{1}{2}\mu_0 NQb^2\dot{I}\hat{z}$, $-\frac{1}{2}\mu_0 NIQb^2\hat{z}$

University of Hyderabad
Entrance Examination-2022

School of Physics. Ph. D (Physics) (Code: B-4)

Q. No.	Answer	Q. No.	Anwer
1	A	21	B
2	A	22	C
3	D	23	A
4	B	24	A
5	C	25	D
6	C	26	C
7	D	27	C
8	C	28	A
9	B	29	A
10	C	30	D
11	C	31	C
12	B	32	C
13	A	33	A
14	D	34	C
15	C	35	D
16	A	36	B
17	B	37	A
18	D	38	A
19	C	39	B
20	C	40	C