A-51

ENTRANCE EXAMINATION, 2021

QUESTION PAPER BOOKLET

Ph.D. (PHYSICS)

Marks: 70

Time: 2.00 hrs.

Hall Ticket No.: [ ]

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

II. Read carefully the following instructions:

1. This Question paper has to parts: **PART - A** and **PART - B**.
2. **PART-A** consists of 20 objective type questions related to Research Methods.
3. **PART-B** consists of 20 objective type questions related to Physics.
4. All questions carry 1.75 marks each.
   There is no negative marking
5. Answers are to be marked on the OMR answer sheet following the instructions provided there upon. An example is shown below

100. (A) (B) (C) ●

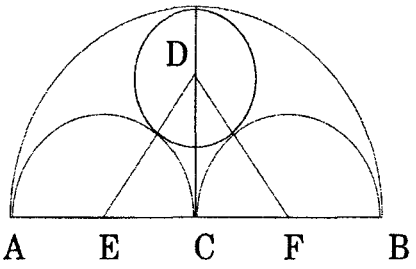
6. Non-programmable Calculators are permitted. Mobile phone based calculators are not permitted. Logarithmic tables are not allowed.
7. No additional sheets will be provided. Rough work can be done in the question paper itself/space provided at the end of the booklet.
8. Hand over the OMR answer sheet at the end of the examination to the invigilator.

This book contains 20 pages

III. Values of physical constants:
$c = 3 \times 10^8$ m/s; $h = 6.63 \times 10^{-34}$ J.s; $k_B = 1.38 \times 10^{-23}$ J/K
$e = 1.6 \times 10^{-19}$ C; $\mu_\circ = 4\pi \times 10^{-7}$ Henry/m; $\epsilon_\circ = 8.85 \times 10^{-12}$ Farad/m

SECTION - A

1. In the figure, shown below, AC = CB = R and E and F are mid points of AC and CB, respectively. The area of the triangle DEF is



A. $\frac{R^2}{16}$

B. $\frac{R^2}{4}$

C. $\frac{R^2}{3}$

D. $\frac{R^2}{6}$

2. A particle is moving along a straight line with a velocity proportional to $x^{\frac{1}{3}}$, where x is the displacement from the origin. Then, the displacement varies with time (t) as

A. $t^{\frac{3}{2}}$

B. $t^{\frac{2}{3}}$

C. $t^{-\frac{3}{2}}$

D. $t^{-\frac{2}{3}}$

3. In an experiment, a quantity O is measured 10 times, the resulting values are O_1, O_2, ...O_{10}, whose average is 10. The average of O_1+3, O_2+6, O_3+9,.....$O_{10}+30$ is

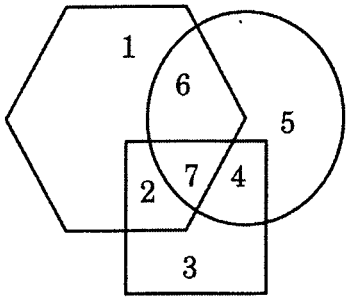
A. 26

B. 26.5

C. 43

D. 175

4. In the figure shown below, the hexagon represents the cricketers, the circle represents the football players and the square represents the hockey players. Different regions are denoted by numbers 1 to 7. The region representing those who play football and hockey but not cricket is



A. 7

B. 6

C. 4

D. 2

5. The opening price of a certain stock is Rs.120/- per share on day 1. The share price suffers a drop of 50% each on closing of day 1 and day 2, followed by a 100% rise on day 3. The opening share price on day 4 is

A. Rs. 120/-

B. Rs. 30/-

C. Rs. 40/-

D. Rs. 60/-

6. An investor subscribes to a cumulative saving scheme that returns 10% annual interest, with an annual payment of Rs.10,000/- at the begining of each year. The corpus generated at the end of 20 years is approximately

A. Rs. 2.10 lakh

B. Rs. 3.15 lakh

C. Rs. 6.30 lakh

D. Rs. 4.20 lakh

7. A small number of cards have been lost from a complete pack of 52 cards. If the pack is distributed equally among four people, three cards remain. If the pack is distributed equally among three people, two cards remain and if the pack is distributed equally among five people, two cards remain. The number of cards in the pack is

   A. 51

   B. 44

   C. 47

   D. 46

8. The difference, the sum and the product of two numbers are in the ratio, 1 : 5 : 12. The product of the two numbers is

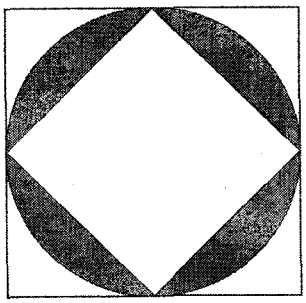
   A. 24

   B. 48

   C. 36

   D. 12

9. A cirlce is drawn inside a square board of side 2 units. Another square is drawn inside this circle as shown. If a small arrow is thrown and it hits the board, then the probability of hitting the shaded region is



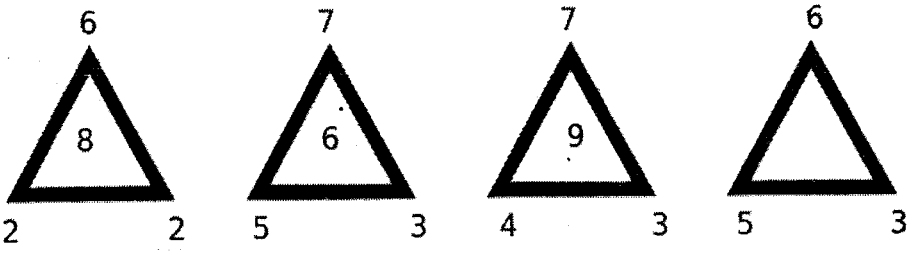
   A. $\frac{\pi}{4} - 1$

   B. $\frac{\pi}{2} + 1$

   C. $\frac{\pi}{4} + \frac{1}{2}$

   D. $\frac{\pi}{4} - \frac{1}{2}$

10. Which number should be placed in the empty triangle?



A. 8

B. 3

C. 2

D. 9

11. A student measures the height and the radius of a right circular cone to calculate its volume. The percentage error in measuring the radius and the height are 2% and 5%, respectively. The percentage error in the volume calculation is

A. 10%

B. 9%

C. 7%

D. 3%

12. A group of 12 students is seated around a table. The number of ways of selecting any two students who are not seated adjacent to each other is

A. 12

B. 54

C. 66

D. 78

13. Two ships leave a port at the same time. One goes 15 km/h in the north-east direction making 35° with respect to the east and other travels 20 km/h in the south-east direction making 55° with respect to the east. At the end of 2 hours the distance between the ships is

A. 10 km

B. 35 km

C. 50 km

D. 70 km

14. A student (of height 2.0 m) is walking with a constant velocity of 1 m/s, passes under a lamp post (of height 4.0 m) at a time $t = 0$. As she walks away from the lamp post her shadow moves ahead of her. The velocity of the edge of the shadow at time $t = 10$ s, is

    A. 2 m/s

    B. 1 m/s

    C. 3 m/s

    D. 4 m/s

15. Circle, square, triangle and cylinder are to be uniquely coded using ϕ and ψ. If the circle and the square are coded as $\phi\phi$ and $\phi\psi$ respectively, then the triangle and the cylinder can be coded respectively, as

    A. $\phi\phi$ and $\psi\phi$

    B. $\psi\psi$ and $\phi\phi$

    C. $\phi\psi$ and $\psi\psi$

    D. $\psi\psi$ and $\psi\phi$

16. If $x^2 + 3x + 1 = 0$, the value of $x^2 + (1/x^2)$ is equal to

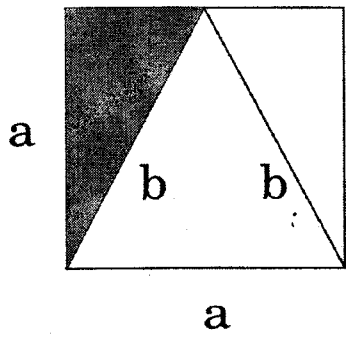
    A. 47

    B. 9

    C. 7

    D. 5

17. The area of the shaded region, in the square of side a, is



    A. $b^2/2$

    B. $b^2/3$

    C. $b^2/5$

    D. $ab/4$

18. There are trains from a suburban station that go eastward at every hour starting 00:00 hours, and westward at every hour starting 00:15 hours. A sales person goes to the station everyday at a random time and takes the first available train. The probabilities for the person to travel towards east and west, in that order, are

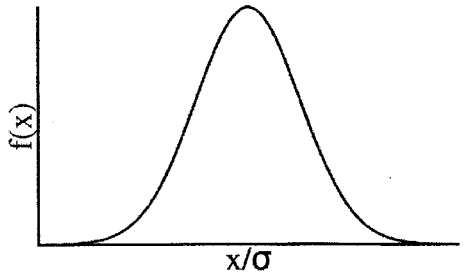
    A. 3/4, 1/4

    B. 0, 1

    C. 1/3, 2/3

    D. 1/2, 1/2

19. The full width at half maximum of the Gaussian function, $f(x) = Ce^{-(x^2/2\sigma^2)}$ is given by



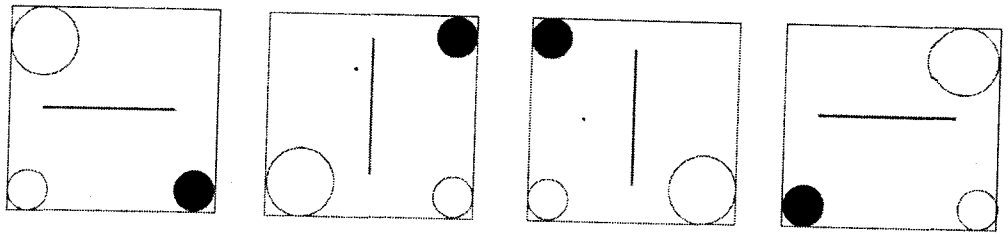
    A. σ

    B. $\sigma\sqrt{2\ln(2)}$

    C. 2σ

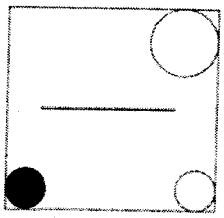
    D. $2\sigma\sqrt{2\ln(2)}$

20. The next figure in the given series is

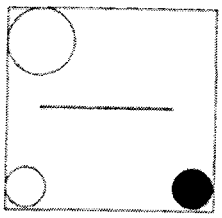


?

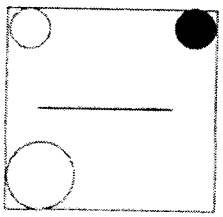
A.



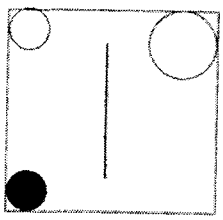
B.



C.



D.



SECTION - B

21. A three-dimensional cubic lattice is formed with 4 basis atoms per lattice site. The number of acoustic and optical branches for the phonon spectrum, respectively, are

A. 3 and 4

B. 4 and 3

C. 9 and 3

D. 3 and 9

22. Consider N atoms arranged in a simple cubic lattice. The energy of the configuration is due to the nearest-neighbour pair attractive potential energy $-\varepsilon$. The heat of the sublimation is the energy needed per atom to transform the solid phase to the gaseous phase, by knocking the atoms from the lattice. The heat of sublimation is given by

A. 6ε

B. 2ε

C. 3ε

D. 4ε

23. Consider a wave function $\psi(\vec{r}) = \frac{1}{\sqrt{3}}(\psi_{100}(\vec{r}) + \psi_{211}(\vec{r}) - \psi_{21-1}(\vec{r}))$, where ψ_{nlm} represents the hydrogen atom eigenfunction with the principal quantum number n, the angular momentum quantum number l, and the azimuthal quntum number m. The expectation value of $\hat{L}^2$ in this state (in units of $\hbar^2$) is given by

A. 4/3

B. 1/3

C. 2/3

D. 0

24. Consider two-dimensional vectors $V_1 = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $V_2 = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$. The eigenvalues of the matrix $\lambda_1 V_1 V_2^T + \lambda_2 V_2 V_1^T$ are

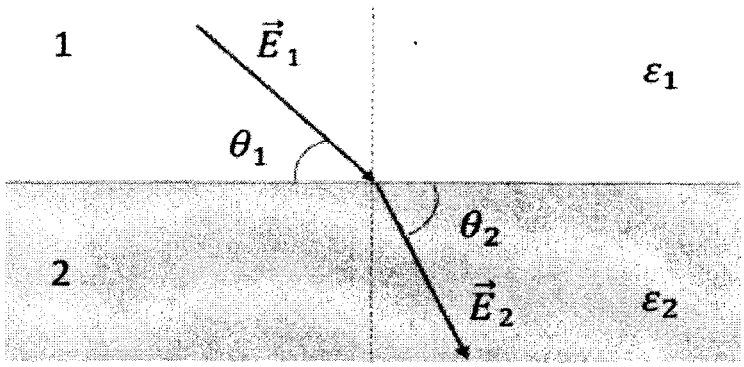
A. $\sqrt{\lambda_1}, \sqrt{\lambda_2}$

B. $\lambda_1\lambda_2, -\lambda_1\lambda_2$

C. $\lambda_1 + \lambda_2, \lambda_1 - \lambda_2$

D. $\sqrt{\lambda_1\lambda_2}, -\sqrt{\lambda_1\lambda_2}$

25. Two semi-infinite dielectric slabs 1 and 2, having dielectric constant ε_1 and ε_2, are joined as shown in the figure below. The electric fields $\vec{E}_1$ and $\vec{E}_2$ make angles θ_1 and θ_2 with respect to the dielectric interface. Then, which of the following relations is correct?



A. $\frac{\tan\theta_1}{\tan\theta_2} = \frac{\varepsilon_1}{\varepsilon_2}$

B. $\frac{\sin\theta_1}{\sin\theta_2} = \frac{\varepsilon_1}{\varepsilon_2}$

C. $\frac{\cos\theta_1}{\cos\theta_2} = \frac{\varepsilon_1}{\varepsilon_2}$

D. $\frac{\tan\theta_1}{\tan\theta_2} = \frac{\varepsilon_2}{\varepsilon_1}$

26. An electromagnetic wave in free space is described by $\vec{E}(x,y,z,t) = \hat{z}E_0 cos(kx - \sqrt{2}ky - \omega t)$. The direction of the Poynting vector is

A. $+\sqrt{2}\hat{y}$

B. $\sqrt{2}\hat{x} + \hat{y}$

C. $-\sqrt{2}\hat{y}$

D. $\hat{x} - \sqrt{2}\hat{y}$

27. A solid dielectric sphere of radius R is permanently polarised, such that the direction of polarization is radially outward, with a magnitude proportional to the distance from the centre i.e., $\vec{P} = \frac{1}{4}kr\hat{r}$, where k is a constant. The volume bound charge density of the sphere is given by

A. $\frac{-3k}{4}$

B. $\frac{-k}{4}$

C. $\frac{3k}{4}$

D. $\frac{k}{4}$

28. The degeneracy of a three-dimentional harmonic oscillator energy level of energy $\frac{9}{2}\hbar\omega$ is

A. 3

B. 8

C. 4

D. 10

29. For the system described by the Hamiltonian $H = \frac{1}{2}(P_x^2 + P_y^2 + P_z^2) + \frac{m^2\omega^2}{2}(ax^2 + by^2 + z^2)$ where $a \neq b$, $a \neq 1$, $b \neq 1$,

A. the energy, all components of the linear momentum and all components of the angular momentum are conserved.

B. the energy and the z-component of the angular momentum are conserved.

C. only the energy is conserved.

D. only the z component of the angular momentum is conserved.

30. For the complex function $f(z) = \frac{1}{1+e^{\frac{1}{z}}}$,

A. $z = 0$ is an isolated singular point

B. $z = \frac{1}{(2n+1)i\pi}$, $n = 0, \pm 1, \pm 2$ are isolated singular points

C. $z = 0$ and $z = \frac{1}{(2n+1)i\pi}$, $n = 0, \pm 1, \pm 2$ are isolated singular points

D. neither $z = 0$ nor $z = \frac{1}{(2n+1)i\pi}$, $n = 0, \pm 1, \pm 2$ are isolated singular points

31. The correct ordering of the numerical methods, according to their rate of convergence, from the lowest to the highest speed is

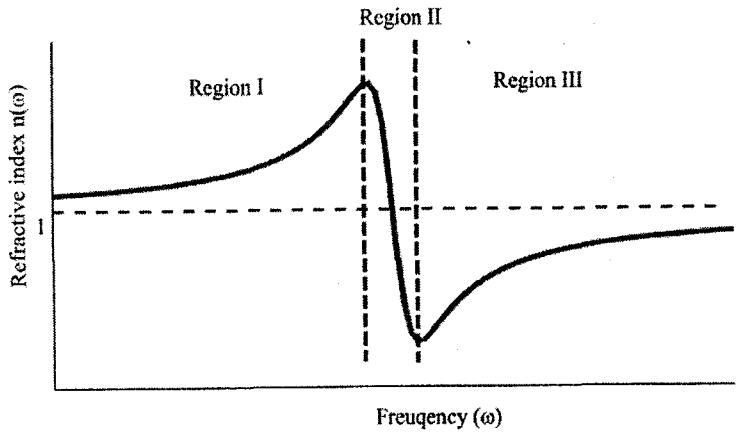
A. bisection, Newton-Raphson and secant

B. bisection, secant and Newton-Raphson

C. Newton-Raphson, bisection and secant

D. secant, Newton-Raphson and bisection

32. Refractive index of a medium as a function of frequency is shown below. The correct statement among the following is



A. Region I and II have normal dispersion; Region III has anomalous dispersion

B. I and II are off-resonance regions; III is resonance region

C. in Region I, the phase velocity $v < c$ and in Region III, $v > c$

D. in Region I, $v > c$ and in Region III, $v < c$

33. The interplanar spacing for a BCC (body centered cubic) crystal corresponding to (100) planes is d_{100}, and for (111) planes is d_{111}. The ratio, d_{100}:d_{111} is

A. $1 : \frac{1}{\sqrt{3}}$

B. $1 : 3$

C. $1 : \frac{2}{\sqrt{3}}$

D. $2 : \frac{1}{\sqrt{3}}$

34. Consider N non-interacting Ising spins ($S_i = \pm 1$) in a magnetic field B. The partition function can be expanded at high temperature ($k_B T > \mu_B B$) in powers of the inverse temperature and is written as $Z = a_0 + a_1(\frac{\mu_B B}{k_B T}) + a_2(\frac{\mu_B B}{k_B T})^2 + \ldots$
The constant a_1 is given by

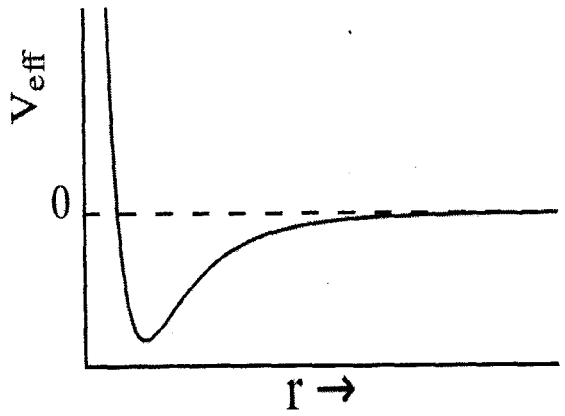
A. 1

B. N

C. 0

D. $\frac{1}{2}$

35. The graph below represents the effective potential (V_{eff}), in the Kepler problem, as a function of the radial coordinate r. If the energy of the particle is equal to the minimum possible value of the effective potential, then its orbit is



A. unstable and circular

B. stable and circular

C. stable and elliptical

D. unstable and elliptical

36. The number of vibrational modes of CO_2 and SO_2 molecules, respectively, are

A. 4, 3

B. 4, 4

C. 3, 4

D. 3, 3

37. Given that the mass of the deuteron is m_D= 1875.61 MeV and the masses of the proton and the neutron are m_p= 938.28 MeV and m_n= 939.57 MeV. The binding energy of the deuteron is (c = 1)

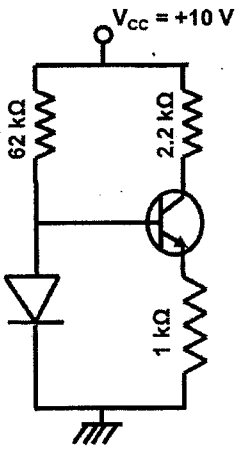
A. 2.24 MeV

B. 937.33 MeV

C. 936.04 MeV

D. 1.29 MeV

38. The transistor and the diode shown in figure below are made of Si. The transistor operates in the



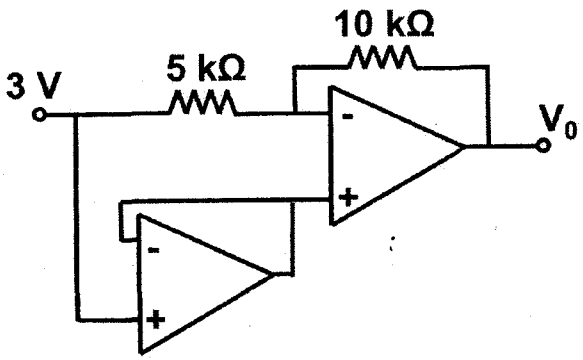
A. saturation region

B. active region

C. cut-off region

D. reverse active region

39. The output voltage (V_0), of the operational amplifier based circuit shown in figure below, is



A. +3 V

B. 0 V

C. −3 V

D. −6 V

40. Consider a periodic function $f(x)$ with a period L such that $f(x+L) = f(x)$. The function has a Fourier series expansion given by $f(x) = a_0 + \sum_1^\infty b_n sin(\frac{2n\pi x}{L}) + \sum_1^\infty c_n cos(\frac{2n\pi x}{L})$. If $f(x) = L_1 cos^3(\frac{2\pi x}{L})$, the non zero coefficients in the expansion are

A. b_1, b_3

B. c_1, c_3

C. a_0, b_1, c_1

D. a_0, b_3, c_3

University of Hyderabad
Entrance Examinations - 2021

School/Department/Centre :School of Physics
Course/Subject : PhD Physics (Code No A-51)

Q.No.	Answer	Q.No.	Answer	Q.No.	Answer	Q.No.	Answer
1	C	26	D	51		76	
2	A	27	A	52		77	
3	B	28	D	53		78	
4	C	29	C	54		79	
5	D	30	B	55		80	
6	C	31	B	56		81	
7	C	32	C	57		82	
8	A	33	A	58		83	
9	D	34	C	59		84	
10	B	35	B	60		85	
11	B	36	A	61		86	
12	B	37	A	62		87	
13	C	38	C	63		88	
14	A	39	A	64		89	
15	D	40	B	65		90	
16	C	41		66		91	
17	C	42		67		92	
18	A	43		68		93	
19	D	44		69		94	
20	B	45		70		95	
21	D	46		71		96	
22	C	47		72		97	
23	A	48		73		98	
24	D	49		74		99	
25	D	50		75		100	

Note/Remarks : Total questions 40

Signature
School/Department/Centre