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ENTRANCE EXAMINATION – 2017

QUESTION PAPER BOOKLET

Ph.D. (PHYSICS)

Marks: 80

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 two parts: **PART - A** and **PART - B**.
2. **PART-A** consists of 20 objective type questions related to Research Methodology.
3. **PART-B** consists of 20 objective type questions related to Physics.
4. All questions carry 2 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.



6. Only non-programmable scientific calculators are permitted. Mobile phone based calculators are not permitted. Logarithmic tables are not allowed.
7. Hand over the OMR sheet at the end of the examination.
8. Space is provided at the end of the question paper booklet itself for rough work. This booklet can be taken by the candidate at the end of the examination.

This book contains 19 pages

III. Values of physical constants:

$$c = 3 \times 10^8 \text{ m/s}; h = 6.63 \times 10^{-34} \text{ J.s}; k_B = 1.38 \times 10^{-23} \text{ J/K}$$

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

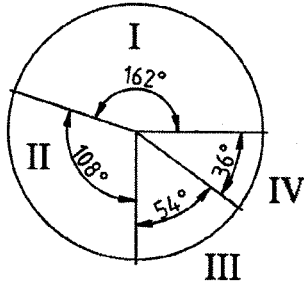
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Blank sheets are provided for rough work at the end of this booklet**

PART - A

1. Suppose $x^{x^{x^{\dots\infty}}} = 2$ and $x > 0$, what is x ?
 - A. 2.
 - B. $\sqrt{2}$.
 - C. e .
 - D. $\ln_{10} e$
2. A father said he has N sons and every son has $N - 1$ sisters. How many children does he have?
 - A. $2N + 1$.
 - B. $N(N - 1)$
 - C. $2N - 1$
 - D. $\frac{1}{2}N(N - 1)$
3. The graph of the function $y = f(x)$ is symmetrical about the line $x = 2$, then
 - A. $f(x + 2) = f(x - 2)$.
 - B. $f(2 + x) = f(2 - x)$.
 - C. $f(x) = f(-x)$.
 - D. $f(x) = -f(-x)$.
4. The domain of the function $f(x) = \sin^{-1}[\log_3(x/3)]$ is
 - A. $[1, 9]$.
 - B. $[-1, 9]$.
 - C. $[-9, 1]$.
 - D. $[-9, -1]$.
5. A man is paid Rs.50 for every day he works. He is fined Rs.10 for every day he is absent from work. Total payment he receives is Rs. 90 times the number of days he was absent. The number of days he was absent is ten days less than the number of days he worked. The number of days he worked and was absent respectively are
 - A. 20, 10
 - B. 25, 15
 - C. 30, 20
 - D. 10, 0

6. The coefficient of the middle term in the binomial expansion in powers of x of $(1 - \alpha x)^2$ and $(1 + \alpha x)^4$ is same if α equals to
- A. $\frac{1}{2}$.
 B. $\frac{1}{3}$.
 C. $-\frac{1}{3}$.
 D. $\frac{1}{6}$.
7. A father said, "In two years my boy will be twice as old as he was two years ago. And my girl in three years will be three times as she was three years ago". Who is older and by how much?
- A. Boy by 1 year.
 B. Girl by 1 year.
 C. Girl by 2 years.
 D. Both same age.
8. The total adults in a city is 10000. The various sections of them are indicated below in the circle

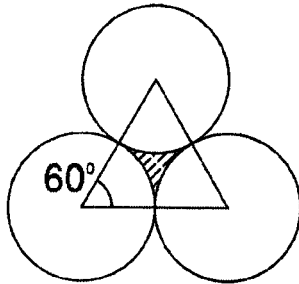


- I. Employees in public sector.
 II. Employees in private sector.
 III. Self employed.
 IV. Unemployed.

What percentage of the employed persons is self employed?

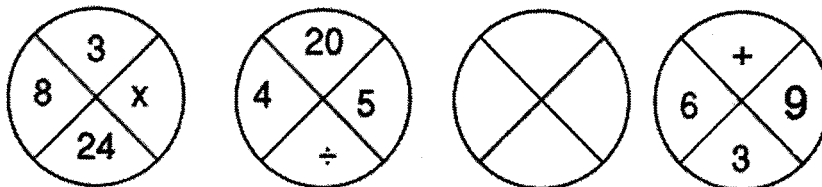
- A. 15%.
 B. 16.67%.
 C. 18%.
 D. 18.6%.
9. What number should come next in the series 14, 28, 20, 40, 32, 64, ...?
- A. 52.
 B. 56.
 C. 96.
 D. 128.

10. Three circles of unit radius each, are drawn such that each one touches the other two and their centres lie on the vertices of an equilateral triangle. The area of the region enclosed between the circles (shaded region in figure below) is



- A. $\sqrt{3} - \frac{\pi}{2}$.
- B. $\frac{\sqrt{3}}{4} - \frac{\pi}{2}$.
- C. $\frac{\sqrt{3}}{2} - \pi$.
- D. $\sqrt{3} - \frac{\pi}{4}$.

11. Find the missing pattern



- A.
- B.
- C.
- D.

12. The statements: All flowers are trees. No fruit is tree.
 Conclusions: (a) No fruit is flower.
 (b) some trees are flowers.

- A. Only conclusion (a) follows.
- B. Only conclusion (b) follows.
- C. Both (a) and (b) follows.
- D. Neither (a) nor (b) follows.

16. A girl goes on a bicycle to meet her friend from home. Starting from her home, she cycles 100 m in east direction. Then she turns left and cycles 40 m. She turns left again and cycles 130 m and reaches her friend's house. The straight distance and direction from her house to her friend's house will be
- A. 50 m to North West.
 - B. 50 m to South East.
 - C. 25 m to North East.
 - D. 25 m to North West.
17. A faulty computer keyboard replaces every letter pressed with another. Typing 'RAMESH' produces 'PYKCQF' and typing 'BACK' produces 'ZYAI'. Which of the following would give an output 'BGPYA' ?
- A. FERMI
 - B. DIRAC
 - C. RAMAN
 - D. CURIE
18. We need to determine who is the youngest among Alice, Bob and Eve, based on the following two statements.
- I. Alice is one year younger to Bob.
 - II. Bob's age is average of ages of Alice and Eve.
- Which of the following is then true?
- A. Statement I alone is sufficient to determine who is the youngest.
 - B. Statement II alone is sufficient to determine who is the youngest.
 - C. Both statements I and II are sufficient to determine who is the youngest.
 - D. Both statements I and II are insufficient to determine who is the youngest.
19. Two statements are given : (i) Every minister is a student. (ii) Every student is inexperienced.
- It is followed by two conclusions : (a) Every minister is inexperienced
(b) Some inexperienced are students.
- A. Only conclusion (a) follows.
 - B. Only conclusion (b) follows.
 - C. Either conclusion (a) or (b) follows.
 - D. Both conclusions (a) and (b) follow.

20. Which word comes next ? RED, BLUE, GREEN,

- A. GRAY
- B. WHITE
- C. VIOLET
- D. BLACK

PART - B

21. If Lagrangian $L = q\dot{q}$, then the equation of motion is

- A. $\ddot{q} = 0$.
- B. $\dot{q} = 0$.
- C. $q = 0$.
- D. There is no equation of motion.

22. If Lagrangian $L = \left(\frac{dq}{dt}\right)^2 - \frac{k}{2}q^2(t)$, among the following which is a constant of motion?

- A. $\frac{1}{2}\left(\frac{dq}{dt}\right)^2 + kq^2(t)$.
- B. $\left(\frac{dq}{dt}\right)^2 + \frac{k}{2}q^2(t)$.
- C. $\left(\frac{dq}{dt}\right)^2 + kq^2(t)$.
- D. No constant of motion.

23. Among the following which is $[\hat{p}_x, f(\hat{x})]$?

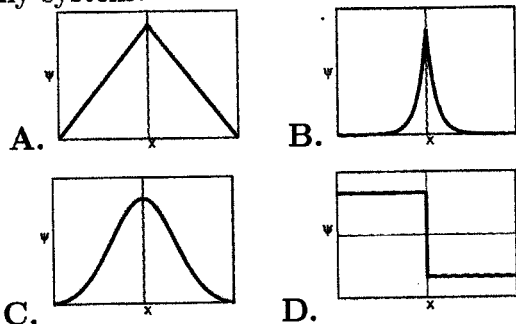
- A. $-i\hbar(df/dx)$.
- B. $+i\hbar(df/dx)$.
- C. $+i\hbar(df/dp)$.
- D. $-i\hbar(df/dp)$.

24. A two level unperturbed system is governed by the Hamiltonian $H_0 = E_0 \begin{bmatrix} 2 & 0 \\ 0 & 4 \end{bmatrix}$.

A perturbation $H' = \epsilon \begin{bmatrix} a & b \\ c & d \end{bmatrix}$ is applied. The first order correction to the lowest unperturbed energy is:

- A. $a\epsilon$.
- B. $b\epsilon$.
- C. $c\epsilon$.
- D. $d\epsilon$.

25. Among the following graphs, which one cannot represent a wavefunction $\psi(x)$ for any system?



26. The sky appears blue because the small dielectric particles in the atmosphere,

- A. absorb all the other colors except blue.
- B. scatter light more strongly at higher frequencies.
- C. scatter light more strongly at lower frequencies.
- D. scatter light multiple times, which coherently interfere.

27. Given that the probability P_r of finding a system of canonical ensemble in the energy E_r at a temperature T is $P_r = C \exp -(E_r/kT)$, then C is called

- A. Partition function.
- B. Inverse of Partition function.
- C. Log of Partition function.
- D. Free energy.

28. An electron, with rest mass $m_0 = 0.5MeV/c^2$ is accelerated through a potential difference of 2×10^6 V. The relativistic velocity of the electron is

- A. $v = 2\sqrt{2}c$.
- B. $v = \frac{2\sqrt{6}}{5}c$.
- C. $v = \frac{3}{2}c$.
- D. $v = \frac{c}{2}$.

29. When X-rays of wavelength λ is used, the angle corresponding to the first order Bragg reflection from (111) plane of a simple cubic crystal is 30° . The inter-atomic spacing of the crystal is,

- A. $\lambda/\sqrt{3}$
- B. $\sqrt{3}\lambda$
- C. $\lambda/\sqrt{2}$
- D. $\sqrt{3}\lambda/2$

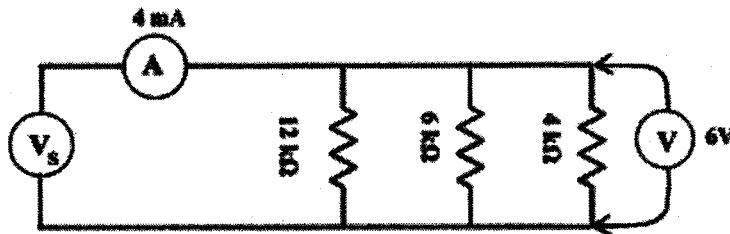
30. The dipole moment of a thin charged rod bearing charge density $\rho(x, y, z) = Az\delta(x)\delta(y)$ for $z \in (-a, a)$, where A is a constant, is

- A. $\frac{2}{3}Aa^3\hat{z}$.
- B. $\frac{1}{12}Aa^3\hat{z}$
- C. $\frac{1}{6}Aa^3\hat{z}$.
- D. $\frac{1}{3}Aa^3\hat{z}$.

31. A magnetic field is given by the expression $\mathbf{B}(x, y, z) = Axz\hat{x} + Byz\hat{y} + C\hat{z}$, where A, B and C are constants. What is the relationship between A and B ?

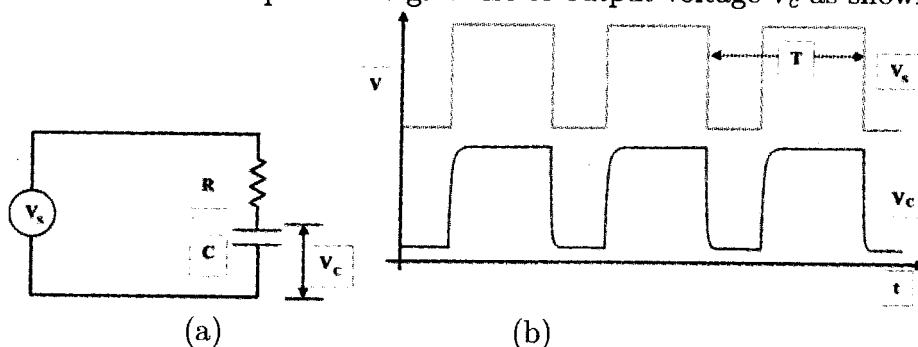
- A. $A = B$.
- B. $A = -B$.
- C. $AB = 1$.
- D. A and B are uncorrelated.

32. Based on the voltmeter and ammeter readings shown in the figure below, which of the following statements are correct, given source voltage $V_s = 6V$?



- A. Both ammeter and voltmeter is showing the correct reading.
- B. Ammeter is showing correct reading and voltmeter is showing incorrect reading.
- C. Ammeter is showing incorrect reading and voltmeter is showing correct reading.
- D. Both ammeter and voltmeter is showing incorrect reading.

33. The figure (a) below shows a series RC circuit with $R = 1 \text{ k}\Omega$. The input voltage (V_i) is a unipolar square wave with time period 50 ms, duty cycle 60% and $V_{pp} = 10\text{V}$. The output voltage is measured across the capacitor. What should be the value of the capacitor to give rise to output voltage V_c as shown in Figure (b)



- A. $C = 6\mu\text{F}$.
 B. $C = 20\mu\text{F}$.
 C. $C = 0.1\mu\text{F}$.
 D. $C = 10\mu\text{F}$.
34. If $A^2 = I$, what is $\exp(i\alpha A)$ where α is real, A is a $n \times n$ matrix and I is identity matrix.
- A. $I \cos \alpha + iA \sin \alpha$
 B. $I \sin \alpha + iA \cos \alpha$
 C. $I \cos \alpha - iA \sin \alpha$
 D. $I \cos \alpha - iA \sin \alpha$
35. For $f(z) = (z^2 + 5z + 3)/[(z - 1)(z + 2)^2]$, the sum of residues of all the poles is
- A. 1
 B. 2
 C. 0
 D. -1
36. Consider the following four processes
- (i) $n \rightarrow p + e^- + \nu_e$.
 (ii) $\Lambda^0 \rightarrow p^+ + \pi^-$.
 (iii) $\pi^+ \rightarrow \mu^+ + \nu_\mu$.
 (iv) $\mu^+ \rightarrow e^+ + \gamma$.

- which of the above is/are forbidden?
- A. only (iv).
 - B. (i), (iii) and (iv).
 - C. (iii) and (iv).
 - D. (i) and (iv).
37. A student measures acceleration due to gravity (g), by measuring the time for a stone to fall from a height (h) above the ground, using $h = \frac{1}{2}gt^2$. After making several measurements he/she finds that $t = 1.6 \pm 0.1\text{sec}$ and $h = 14.08 \pm 0.09\text{m}$. The percentage of error in the measurement of g is:
- A. 12.5%
 - B. 13.1%
 - C. 14.5%
 - D. 15.2%
38. The ratio of nuclear radii of ${}_{13}^{27}\text{Al}$ and ${}_{4}^8\text{Be}$ nuclei is
- A. 1
 - B. $1/2$
 - C. $3/2$
 - D. 2
39. In n-type and p-type semiconductors, the Fermi levels lie
- A. in the middle of the bandgap for both p-type and n-type.
 - B. close to the valance band for n-type and close to the conduction band for p-type.
 - C. close to the conduction band for n-type and close the to valance band for p-type.
 - D. close to the valance band for both p-type and n-type.
40. The Poisson bracket between the z component of the angular momentum (L_z) and x , i.e., $\{L_z, x\}$ is
- A. $+z$
 - B. $-z$
 - C. $+y$
 - D. $-y$