PUMDET-2019

Subject : Physics

(Booklet Number)

Duration : 90 Minutes **Full Marks : 100**

INSTRUCTIONS

1. All questions are of objective type having four answer options for each. Only one option is correct. Correct answer will carry full marks **2**. In case of incorrect answer or any combination of more than one answer, ½ mark will be deducted.

2. Questions must be answered on OMR sheet by darkening the appropriate bubble marked A, B, C or D.

3. Use only **Black/Blue ball point pen** to mark the answer by complete filling up of the respective bubbles.

4. Mark the answers only in the space provided. Do not make any stray mark on the OMR.

5. Write question booklet number and your roll number carefully in the specified locations of the **OMR**. Also fill appropriate bubbles.

6. Write your name (in block letter), name of the examination centre and put your full signature in appropriate boxes in the OMR.

7. The OMR is liable to become invalid if there is any mistake in filling the correct bubbles for question booklet number/roll number or if there is any discrepancy in the name/signature of the candidate, name of the examination centre. The OMR may also become invalid due to folding or putting stray marks on it or any damage to it. The consequence of such invalidation due to incorrect marking or careless handling by the candidate will be sole responsibility of candidate.

8. Candidates are not allowed to carry any written or printed material, calculator, pen, docu-pen, log table, wristwatch, any communication device like mobile phones etc. inside the examination hall. Any candidate found with such items will be **reported against** and his/her candidature will be summarily cancelled.

9. Rough work must be done on the question paper itself. Additional blank pages are given in the question paper for rough work.

10. Handover the OMR to the invigilator before leaving the Examination Hall.

CONFIDENTIAL

PHYSICS

1. Consider the set of triangles with a fixed base (PQ) and a fixed perimeter. The locus of the third vertex (R) is

   (A) An ellipse
   (B) A circle
   (C) A straight line
   (D) A hyperbola

2. Take the sequence of numbers 1, 1, 2, 3, 5, 8, 13, ..., t_n, ... Then, $\lim_{n \to \infty} \frac{t_{n+1}}{t_n} =$

   (A) $\frac{5}{3}$
   (B) $\frac{\sqrt{5}+2}{3}$
   (C) $\frac{\sqrt{5}+1}{1}$
   (D) $\left(\sqrt{\frac{2}{5}}\right)\pi$

3. The total length of the equiangular spiral $r = ae^{-k\theta}$ $(a > 0, k > 0)$ from $\theta = 0$ to $\theta = \infty$ is

   (A) $\frac{a}{k}$
   (B) $\sqrt{2}\,a$
   (C) $\frac{a}{k}\sqrt{1+\frac{1}{k^2}}$
   (D) $a\sqrt{1+\frac{1}{k^2}}$

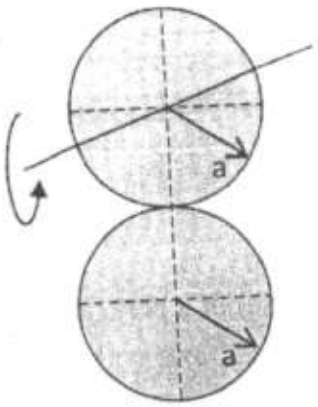
4. If m and n are positive integers, then $\int_0^1 x^{m-1}(1-x)^{n-1}\,dx =$

   (A) 0
   (B) 1
   (C) $\frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$
   (D) $\frac{\Gamma(m)}{\Gamma(n)}$

5. Consider two 2×2 matrices A and B such that $[A, B] \neq 0$. Then which of the following relations is true ?

   (A) $\mathrm{Tr}(AB) \neq \pm \mathrm{Tr}(BA)$
   (B) $\mathrm{Tr}(AB) = \mathrm{Tr}(BA)$
   (C) $AB + BA = 0$
   (D) $\mathrm{Tr}(AB) = -\mathrm{Tr}(BA)$

11.



A uniform lamina has the shape as shown. The time period of gravitational oscillations of the lamina about a horizontal axis passing through the centre C of the upper circle is

(A) $2\pi\sqrt{\frac{2a}{g}}$

(B) $2\pi\sqrt{\frac{5a}{2g}}$

(C) $2\pi\sqrt{\frac{3a}{2g}}$

(D) $2\pi\sqrt{\frac{5g}{2a}}$

12. Let $dW = 3x^2dx - 2ydy + f_3dz$.

If $W_{12} = \int_{P_1(x_1, y_1, z_1)}^{P_2(x_2, y_2, z_2)} dW$ is path independent, f_3 may be

(A) $x^3 - y^2$

(B) 1

(C) $y^2 - x^3$

(D) xyz

13. The equation of motion of a particle is $m\ddot{x} + k\left[\sum_{n=1}^{\infty}(-1)^{n-1}\frac{x^{2n-1}}{(2n-1)!}\right] = 0$. A possible functional form of the corresponding Lagrangian is

(A) $\frac{1}{2}m\dot{x}^2 - k\cos x$

(B) $\frac{1}{2}m\dot{x}^2 + \frac{1}{2}kx^2$

(C) $\frac{1}{2}m\dot{x}^2 + k\cos x$

(D) $\frac{1}{2}m\dot{x}^2 + ke^{-x^2}$

17. A short bar magnet, with dipole moment 'm', moves with uniform velocity 'v' along the axis of a short and narrow coil of radius 'a' and number of turns 'N'. If the dipole moment of the magnet is aligned along the axis, the e. m. f. induced in the coil when the centre of the bar magnet is at a distance 'r' from the coil is

(A) $\frac{1}{2}Nma^2.v.\frac{1}{r^3}$ (B) $\frac{3}{2}Nma^2.v.\frac{1}{r^4}$

(C) $\frac{1}{2}\mu_0 Nma^2.v.\frac{1}{r^3}$ (D) $\frac{3}{2}\mu_0 Nma^2.v.\frac{1}{r^4}$

18. Consider a circuit comprising of an AC source with output impedance $Z_S = R_S + jX_S$ and a load. For maximum power transfer to the load, its impedance (Z_L) must be

(A) $R_s + jX_s$ (B) R_s

(C) $R_s - jX_s$ (D) $\sqrt{R_s^2 + X_s^2}$

19. The 'virtual ground' point is realized for circuits using an OP-AMP when it is used in

(A) non-inverting amplifier configuration

(B) inverting amplifier configuration

(C) a differential amplifier

(D) an oscillator

20. What is the relation between h_{fe} and h_{fb} for a bipolar junction transistor (BJT)? [Symbols have their usual significances.]

(A) $h_{fe} = -\frac{h_{fb}}{1+h_{fb}}$ (B) $h_{fe} = -\frac{1}{1+h_{fb}}$

(C) $h_{fe} = \frac{h_{fb}}{1+h_{fb}}$ (D) $h_{fe} = \frac{h_{fb}}{1-h_{fb}}$

21. If V_{rms} be the root-mean-square input voltage to an ideal bridge rectifier, what is the DC component of the output voltage ?

(A) $\sqrt{2}V_{rms}$ (B) $2\sqrt{2}V_{rms}$

(C) $\frac{2\sqrt{2}V_{rms}}{\pi}$ (D) $\frac{\sqrt{2}V_{rms}}{\pi}$

26. The coherence length ℓ_c of a LASER beam is related to its monochromaticity $Q\left(=\frac{\omega_0}{\Delta\omega}\right)$ as

(A) $\ell_c = \frac{cQ}{\omega_0}$

(B) $\ell_c = \frac{c}{Q\omega_0}$

(C) $\ell_c = \frac{Q\omega_0}{c}$

(D) $\ell_c = \frac{c\omega_0}{Q}$

27. Consider a double-slit arrangement comprising of two identical narrow slits separated by a distance d. A parallel beam of light of wavelength λ is allowed fall normally on the arrangement and the resulting interference pattern is examined with a telescope. The intensity of light $I(\theta)$ at small angles (θ) with respect to the incident beam will be found to vary as

(A) $\sin^2\left(\frac{\pi d \sin\theta}{\lambda}\right)$

(B) $\cos^2\left(\frac{2\pi d \sin\theta}{\lambda}\right)$

(C) $\cos^2\left(\frac{\pi d \sin\theta}{\lambda}\right)$

(D) $1-\cos^2\left(\frac{\pi d \sin\theta}{\lambda}\right)$

28. A paraboloid of revolution is generated by rotating the parabola $y^2 = 4ax$ about the X-axis. If its inner surface is used as a reflector, what will be its focal length ?

(A) a

(B) 2a

(C) 4a

(D) $\frac{1}{2}a$

29. A plane transmission grating has m rulings/cm. A parallel beam of light (from a collimator) falls normally on the grating, covering a length of x cm. What will be the resolving power of the grating in the n^{th} order of diffraction ?

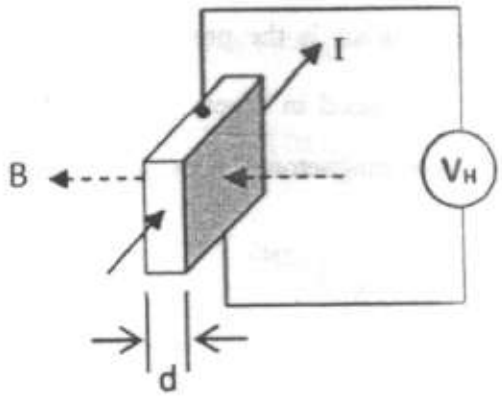
(A) n.m

(B) n.x

(C) n.m.x

(D) $\frac{n.m.x}{2}$

34.



In the diagram shown above, B represents magnetic field, I stands for current, d is thickness of the semiconductor wafer. If R_H be the Hall coefficient of the wafer, V_H is

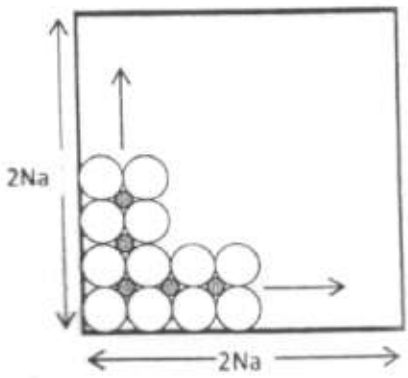
(A) $\frac{BId}{R_H}$

(B) $\frac{BI}{R_H d}$

(C) $\frac{R_H BI}{d}$

(D) $\frac{Bd}{R_H I}$

35.



A square tray (shown above) is filled up with white discs (diameter 2a) which touch each other and grey discs which fit tightly in the space between the larger discs. What is the packing fraction in the limit $N \to \infty$?

(A) $(\sqrt{2}-1)\frac{\pi}{4}$

(B) $\frac{\pi}{4}\left[1+(\sqrt{2}-1)^2\right]$

(C) $\sqrt{\frac{3}{2}}\cdot\frac{\pi}{4}$

(D) $\frac{\pi}{6}\left[1+(\sqrt{2}-1)^2\right]$

39. The internal energy (U) of a system comprising of N identical particles can be expressed in terms of its canonical partition function Z and temperature T as

(A) $U = NkT^2 \frac{\partial}{\partial T}(\ell n\, Z)$

(B) $U = NkT\, \ell n\, Z$

(C) $U = NkT^3 \frac{\partial^2}{\partial T^2}(\ell n\, Z)$

(D) $U = Nk \frac{\partial}{\partial T}(T^2\, \ell n\, Z)$

40. One of Maxwell's equations in thermodynamics is

(A) $\left(\frac{\partial V}{\partial P}\right)_S = -\left(\frac{\partial T}{\partial S}\right)_P$

(B) $\left(\frac{\partial P}{\partial V}\right)_T = \left(\frac{\partial S}{\partial T}\right)_V$

(C) $\left(\frac{\partial P}{\partial T}\right)_S = \left(\frac{\partial S}{\partial V}\right)_P$

(D) $\left(\frac{\partial P}{\partial T}\right)_V = \left(\frac{\partial S}{\partial V}\right)_T$

41. Which pair of variables remains unchanged during a first order phase transition ?

(A) P, V

(B) G, T

(C) G, S

(D) F, T

42. The boiling point (temperature) of water

(A) increases with pressure

(B) decreases with pressure

(C) does not change with pressure

(D) is an oscillatory function of pressure

46. What is the number of independent vibrational modes of a CO_2 molecule ?

(A) 4 (B) 3

(C) 5 (D) 2

47. Which, among the following, is a 'doubly magic' nucleus ?

(A) ${}^{12}_{6}C$ (B) ${}^{20}_{10}Ne$

(C) ${}^{206}_{82}Pb$ (D) ${}^{208}_{82}Pb$

48. The observed criterion for the stability of a nucleus ${}^{A}_{Z}X$ against spontaneous fission is

(A) $A < 255$ (B) $\frac{Z^2}{A} < 35$

(C) $\frac{Z^2}{A} \geq 35$ (D) $A < 2Z$

49. The quark composition of the hadron Ω^- is

(A) sss (B) ddd

(C) dds (D) dss

50. The charge Q (in units of e) of a hadron is related to the third component of its isospin, I_3 and hypercharge Y as

(A) $Q = I_3$ (B) $Q = I_3 + Y$

(C) $Q = I_3 + \frac{Y}{2}$ (D) $Q = I_3 - \frac{Y}{2}$