LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

B.Sc. DEGREE EXAMINATION – **PHYSICS**

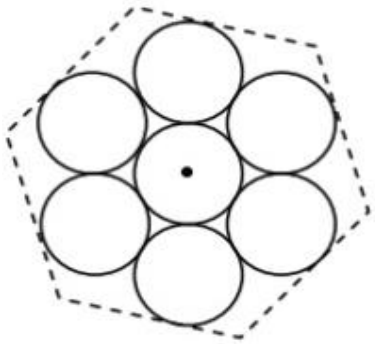
FIFTH SEMESTER – **NOVEMBER 2022**

UPH 5603 – PROBLEMS SOLVING SKILLS IN PHYSICS

Date: 30-11-2022 Dept. No. Max. : 100 Marks

Time: 09:00 AM - 12:00 NOON

PART - A

Q. No	**Answer all Questions** **(10 x 2 = 20 Marks)**
1	If a charge of 200 micro coulombs is placed at the origin, then the electric field produced at a distance of 10 mm is a) $18 \times 10^7\ NC^{-1}$ b) $9 \times 10^7\ NC^{-1}$ c) $3 \times 10^7\ NC^{-1}$ d) zero
2	If electrostatic potential $V = 3x^2y + 5$, then electric field $\vec{E}$ is (a)$-6xy\hat{\imath} - 3x^2\hat{\jmath}$ b) $-6xy\hat{\imath} + 3x^2\hat{\jmath}$ c) $6xy\hat{\imath} - 3x^2\hat{\jmath}$ d) -6xy$\hat{\imath}$
3	Temperature of an ideal gas is increased such that the most probable speed of molecules increases by a factor of 4. By what factor will the v_{rms} increase? a) 1 b) 2 c) 4 d) 16
4	In a heat engine based on Carnot's cycle heat is added to the working substance at constant a) Entropy b) Pressure c) Temperature d) Volume
5	During free expansion of an ideal gas under adiabatic condition, the internal energy of the gas a) Decreases b) Initially decreases & then increases c) Increases d) Remains constant
6	Gibbs free energy G in thermodynamics is defined as G = H – TS where, H is enthalpy, S is entropy and T is temperature In an isothermal, isobaric, reversible process G a) Remains constant but not zero b) Varies linearly c) Varies non-linearly d) Is zero
7	Seven uniform disks, each of mass m and radius r, are inscribed inside a regular hexagon as shown in the figure.  The moment of inertia of this system of seven disks, about an axis passing through the central disk and perpendicular to the plane of the disks is (a) $\frac{7}{2}mr^2$ b) $7mr^2$ c) $\frac{13}{2}mr^2$ d) $\frac{55}{2}mr^2$

8	If the wave function satisfies the following relation $\int_{-\infty}^{\infty} \Psi^* \Psi dx = 49$, then the value of normalization constant is (a) $\frac{1}{7}$ (b) 7 (c) $\frac{1}{49}$ (d) 49
9	If two physical quantities A and B are measured with error ΔA and ΔB, what is the error in the physical quantity Z=A+B (a) ΔA-ΔB (b) ΔA+ΔB (c) $\frac{\Delta A}{\Delta B}$ (d) ΔA× ΔB
10	A planet has average density same as that of the earth but it has only 1/8 th the mass of the earth. If acceleration due to gravity at the surface of the earth is g_e and g_p for the planet, the ratio $\frac{g_p}{g_e}$ is (a) ½ (b) 2 (c) ¼ (d) 4

PART – B

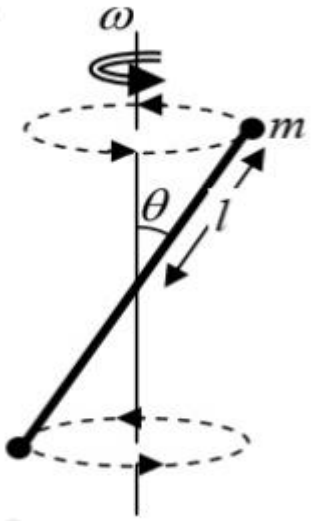
Answer any four Questions **(4 x 7.5 = 30 Marks)**

11	(a) If two events are separated by spatial interval of 9×10^9 m but occurs simultaneously,calculate the time interval of these two with respect to a frame which travels at a speed $0.8c$. **(3.5 Marks)** (b) A satellite of mass m_s revolving in a circular orbit of radius r_s around earth of mass M has total energy E. Calculate the angular momentum of satellite in terms of the given quantities. **(4 Marks)**
12	(a) The state of the quantum particle moving in the infinite square well potential is given by $\Psi = 5\varphi_1 + 2\varphi_2 - 3i\varphi_3$. If energy is measured in this state, then calculate (a) the probability of getting E_1, E_2 and E_3 (b) the expectation of value of energy. **(4 Marks)** (b) For a given matrix $A = \begin{pmatrix} 1 & -i \\ i & -1 \end{pmatrix}$ (a) verify that A is Hermitian (b) calculate the eigen values of A. **(3.5 Marks)**
13	(a) Plot the following functions: (i) $\ln x$ (ii) e^{-x^2} (iii) $\cos hx$ **(3 Marks)** (b) A physical quantity Q is expressed as $Q = \frac{A^2B+C}{\sqrt{D}}$ with appropriate dimensions. The relative error of A, B, C and D respectively 0.1,0.03,0.5 and 0.3. Calculate the percentage of relative error of Q. **(4.5 Marks)**
14	2 kg of water is heated from 0 ℃ to 100 ℃ and converted to steam completely. Calculate the change in entropy of water in this process. (Specific heat of water is 4186 J/kg/K and Latent heat of vaporization is 2230 J/Kg).
15	The internal energy U of a system is given by **$U = bs^3/VN$**, where b is constant and the other symbols have their usual meaning. a) Calculate the temperature of the system b) Calculate the pressure of the system
16	An electromagnetic wave represented by $\vec{E} = E_0 sin\,(50 \times 10^{-8}\, z - 10t)\, \hat{y}$ travels in an unknown medium. Determine the medium.

PART – C

Answer any four Question **(4 x 12.5 = 50 Marks)**

17 A thin massless rod of length $2l$ has equal point masses m attached to its end (see figure).



The rod is rotating about an axis passing through its center making an angle θ with it. Calculate the magnitude of the rate of change of angular momentum $\left|\frac{d\vec{L}}{dt}\right|$

18 The wave function of the electron in one dimension is given by

$$\Psi(x) = \begin{cases} 0 & for\ x < 0 \\ 2\sqrt{3}\, e^{-x}(1 - e^{-x}) & for\ x \geq 0 \end{cases}$$

Calculate the ratio between $\langle x \rangle$ and most probable value x_m

19 A square loop of wire with sides of length L lies in the first quadrant of the XY plane with one corner at the origin. In the region there is a non-uniform time dependent magnetic field $\vec{B}(y,t) = B_0\, \mathrm{K y^3 t^2} \hat{k}$ where k is a constant. Find the magnitude of the induced emf in the loop.

20 a) A long solenoid of radius a and n turns per unit length carries a time dependent current $I(t) = I_0 \cos \omega t$ in the $\hat{\phi}$ direction. Find the magnitude of electric field at a distance r from the axis (both inside and outside) the solenoid. **(8 Marks)**

b) Calculate the Poynting vector for the following case

$\vec{E} = E_0\, sin\, sin\, (kz + \omega t)\, \hat{\jmath}$ and $\vec{B} = \frac{kE_0}{\omega} sin\, sin\, (kz + \omega t)\, \hat{\imath}$ **(4.5 Marks)**

21 A sample of ideal gas has pressure P_0, volume V_0 and temperature T_0. It isothermally expands to twice its original volume. It is then compressed at constant pressure to have original volume V_0. Finally the gas is heated at constant volume to get the original temperature.

a) Draw the VT diagram for the process.
b) Calculate the heat absorbed in the process.

22 (a) Plot the following functions. (i) $x \sin x$ (ii) $x^4 - x^2$ (iii) $\tanh x$ (iv) $\ln(\ln x)$ (v) xe^{-x^2} **(10 Marks)**

(b) A student wants to determine the acceleration due to gravity by simple pendulum experiment. The length of pendulum $1 \pm 0.01\ m$ and time period of the pendulum $2 \pm 0.01\ s$. Calculate acceleration due to gravity and the error involved in it. **(2.5 Marks)**

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