LOYOLA COLLEGE (AUTONOMOUS), CHENNAI – 600 034

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

FIFTH SEMESTER – **NOVEMBER 2023**

UPH 5603 – PROBLEM SOLVING SKILLS IN PHYSICS

Date: 16-11-2023   Dept. No.   Max. : 100 Marks
Time: 09:00 AM - 12:00 NOON

	SECTION A - K1 (CO1)			
	Answer ALL the Questions			**(10 x 1 = 10)**
1.	**MCQ**			
a)	The magnitude of electric field strength E such that an electron placed in it would experience an electrical force equal to its weight is given by			
	(1) mge	(2) mg/e	(3) e/mg	(4) eg/2m
b)	A satellite moves around the earth in a circular orbit of radius R centered at the earth. A second satellite moves in an elliptical orbit of major axis 8R, with the earth at one of the foci. If the former takes 1 day to complete a revolution, the latter would take			
	(1) 21.6 days	(2) 8 days	(3) 3 hours	(4) 1.1 hours
c)	Consider a Carnot's engine operating between temperatures of 600 K and 400 K. The engine performs 1000 J of work/cycle. The heat (In Joule) extracted per cycle from the high temperature reservoir is			
	(1) 1000 J	(2) 2000 J	(3) 3000 J	(4) 4000 J
d)	The wavelength of matter waves is independent of			
	(1) Mass	(2) Velocity	(3) Momentum	(4) Charge
e)	Time period of a simple pendulum in a free falling lift will be			
	(1) Finite	(2) Infinite	(3) Zero	(4) All of these
2.	**Fill in the blanks**			
a)	A charge q is situated at the centre of a cube. Electric flux through one of the faces of the cube is ………………………………………………..			
b)	If the root mean square velocity of hydrogen molecules exceeds their most probable speed by Δv, then the temperature is ……………………………			
c)	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 root mean square velocity, v_{rms} increase? ………………………………………………			
d)	Monochromatic light of frequency 6.0×10^{14} Hz is produced by a laser. The wavelength of the light is ………………………………………..			
e)	The damping force on an oscillator is directly proportional to the velocity. The unit of the constant of proportionality is………………………..			
	SECTION A - K2 (CO1)			
	Answer ALL the Questions			**(10 x 1 = 10)**
3.	**True or False**			
a)	Electric potential is a vector quantity.			
b)	A body of mass 2 kg is sliding with a constant velocity of 4 m/s on a frictionless horizontal table. The force required to keep the body moving with the same velocity is zero.			
c)	Mean kinetic energy per mole is $\frac{3}{2}kT$.			

d)	Concept of specific heat of solid was successfully explained by classical mechanics.
e)	In an electromagnetic wave, the electric and magnetic fields vectors are mutually perpendicular to each other.
4.	**Match the following**
a)	Magnetic flux - simple harmonic motion
b)	Impulse - reversible heat engine
c)	Carnot cycle - Planck's theory
d)	Black body radiation - change in velocity
e)	simple pendulum - Weber

SECTION B - K3 (CO2)

Answer any TWO of the following in 100 words each.   **(2 x 10 = 20)**

5.	A planet of mass m moves in the gravitational field of the sun of mass M. If the semi-major and semi-minor axis of the orbit are a and b respectively, find the angular momentum of the planet.
6.	The equation of state for one mole of a non- ideal gas is given by pV= A (1+B/V) where the coefficients A & B are temperature dependent. If the volume changes from V_1 to V_2 in an isothermal process, find the work done by the gas.
7.	(i) Calculate the wavelength associated with an electron subjected to a potential difference of 10 KV. (3) (ii) Apply Biot-Savart's law to obtain an expression for the magnetic field at the centre of a coil bent in the form of a square of side 2a carrying current I. (7)
8.	Evaluate the following commutators (i). $\left[\hat{L}_x, \hat{L}_y\right]$ and (ii). $\left[\hat{L}^2, \hat{L}_x\right]$ (6 + 4)

SECTION C – K4 (CO3)

Answer any TWO of the following in 100 words each.   **(2 x 10 = 20)**

9.	A planet's average density is the same as that of the earth but it has only one eighth of the mass of the Earth. If the acceleration due to gravity at the surface is g_p and g_e for the planet and Earth respectively. Find g_p/g_e.
10.	Two thermally insulated vessels 1 and 2 are filled with air and connected by a short tube equipped with valve. The Volumes of the vessels, the pressures and temperatures of air is then known (P1, V1, and T1) and (P2, V2, T2). What is the pressure established after the valve is opened?
11.	Calculate the expectation values of P & P^2 for the wave function $$\psi(x) = \begin{cases} \left(\frac{2}{L}\right)^{\frac{1}{2}} \sin\frac{\pi x}{L}, & 0 < x < L \\ 0 & for \quad x > L \end{cases}$$
12.	(i) A wire 2 m in length suspended vertically stretches by 10 mm when mass of 10 kg is attached to the lower end. Calculate the elastic potential energy gain of the wire. (6) (ii) Air streams horizontally past an air plane. The speed over the top surface is 60 m/s and that under the bottom surface is 45 m/s. The density of air is 1.293 kg/m3. Calculate the pressure difference in pressure. (4)

SECTION D – K5 (CO4)

Answer any ONE of the following in 250 words   **(1 x 20 = 20)**

13.	a) A particle of unit mass moves along X-axis under the influence of a potential, $V(x) = x(x-2)^2$. The particle is found to be in stable equilibrium at the point x =2. Find the time period of oscillation of the particle. (10)

	b) If Helmholtz free energy for radiation is given by $F = \frac{-8\pi^5 k^4 T^4 V}{45 h^3 c^3}$ i) What is its radiation pressure? ii) If S is the entropy of the system, then prove that Cv =3S. (10)
14.	(i)The wave function of the hydrogen atom for 1s state is $\psi(1s) = \frac{1}{\sqrt{\pi}}\left(\frac{1}{a_0}\right)^{\frac{3}{2}} e^{-\frac{r}{a_0}}$, Where $a_0 = \frac{\hbar^2}{me^2}$ is the Bohr radius. Calculate the expectation value of the potential energy of electron 1s state. (12) (ii) Calculate the zero-point energy of a system consisting of a mass of 1g connected to a fixed point by a spring which is stretched 1 cm, by a force of 0.1 N, the particle being constrained to moving only along X-axis (8)

<div align="center">SECTION E – K6 (CO5)</div>

Answer any ONE of the following in 250 words	**(1 x 20 = 20)**

15.	a) A cyclist weighing a total of 80 kg with the bicycle pedals at a speed of 10 m/s. She stops pedaling at an instant which is taken to be t = 0. Due to the velocity dependent frictional force, her velocity is found to vary as v(t) = 10 / (1+ t/30) m/s, where t is measured in seconds. When the velocity drops to 8 m/s, she starts pedalling again to maintain a constant speed. Find the energy expended by her in 1 minute at this (new) speed. (13) a) A syringe is used to exert 1.5 atmospheric pressure to release water horizontally. Find the speed of water immediately after ejection. (Take 1 atmospheric pressure = 10^5 Pascal, Density of water = $1000\ kg\ /\ m^3$). (7)
16.	(i)Four charges each equal to Q are placed at the four corners of a square and a charge q is placed at the centre of the square. Calculate the value of q If the system is in equilibrium. (10) (ii) In a region, the potential is represented by V (x, y, z) = 6x – 8xy – 8y + 6yz, where V is in volts and x, y, z is in meters. Calculate the electric force experienced by a charge of 2 coulomb situated at point (1, 1, 1). (10)

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