PSG COLLEGE OF ARTS & SCIENCE
(AUTONOMOUS)
MSc DEGREE EXAMINATION MAY 2024
(Fourth Semester)

Branch – PHYSICS

PROBLEMS IN CORE PHYSICS

Time: Three Hours   Maximum: 50 Marks

SECTION-A (5 Marks)
Answer ALL questions

ALL questions carry EQUAL marks   (5 x 1 = 5)

1   A particle of mass m moves along a straight line and attached towards a point on this line with a force proportional to a distance x from the point. The Lagrangian of the system is

    (i) $\frac{1}{2} mv^2 + \frac{1}{2} kx^2$ (ii) $\frac{1}{2} mv^2 - \frac{1}{2} kr^2$

    (iii) $\frac{1}{2}mv^2 + 1kx^2$ (iv) $mv^2 + \frac{1}{2} kx^2$

2   The eigen values of the matrix $M = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ are

    (i)   0,0   (ii) 1,0

    (iii) 1,-1   (iv) 1,1

3   The de-Broglie wavelength of an electron accelerated to a potential difference of V volts is

    (i) $\frac{\sqrt{150}}{V}$ Å   (ii) $\frac{h}{\sqrt{2mE}}$Å

    (iii) $\frac{h}{\sqrt{2mKT}}$Å   (iv) $\frac{h\sqrt{150}}{meV}$ Å

4   Under equilibrium condition, the thermodynamic variable associated with black body radiation at temperature T which reduces to zero is

    (i) Entropy   (ii) Helmholtz free energy

    (iii) Gibb's free energy   (iv) Pressure

5   The strokes line in the Rotational Raman spectrum is produced when the quantum number J changes by

    (i) -2   (ii) -1

    (iii) 1   (iv) 2

SECTION - B (15 Marks)
Answer ALL Questions

ALL Questions Carry EQUAL Marks   (5 x 3 = 15)

6   a Find the rate of change of $\phi = x^2y+yz$ at (1, 2, -1) in the direction of $\vec{i}+2\vec{j}+3\vec{k}$.

OR

    b Rob throws a ball vertically in the air with an initial velocity 3.5m/s. What is the maximum height of the ball?

7   a Find the rank of matrix $\begin{bmatrix} 1 & 1 & -1 \\ 3 & -2 & 3 \\ 2 & -3 & 4 \end{bmatrix}$

OR

    b $H^0 = \begin{bmatrix} 5 & 0 & 0 \\ 0 & 5 & 0 \\ 0 & 0 & 2 \end{bmatrix}$, $H^1 = \lambda \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & -1 \\ 1 & -1 & 1 \end{bmatrix}$, Find the energy eigen values up to First order.

8 a An e^- & e^+ at rest producing three photons after annihilating. Find the energy of III photon if energy of 2 of the photon are 0.2 Mev & 0.3 Mev.

OR

b An eigen function of the operator d^2/dx^2 is $\Psi = e^{2x}$. Find the corresponding eigen value.

9 a After the detonation of an atom bomb, the spherical ball of gas found be of 15m radius at a temperature 3×10^5 k. Give the adiabatic expansion coefficient $v = 5/2$. What will be the radius of the ball when its temperature reduces to 3×10^3k?

OR

b A body at 200°C undergoes a reversible isothermal process. The heat energy removed in the process is 7875 J. Determine the change in entropy of a body.

10 a Find the velocity of e^- in 3rd orbit of hydrogen.

OR

b An electron and positron are separated by distance r. What is ratio of gravitational force to electric forces acting between particles detected in bubble chamber?

SECTION -C (30 Marks)
Answer ALL questions
ALL questions carry EQUAL Marks   (5 x 6 = 30)

11 a If $V = xy - x^2y + y^2z^2$. Find the value of div grad v.

OR

b Convert the Lagrangian.
   i. $L = 1/2\ m(\dot{x}^2 + \dot{y}^2 + \dot{z}^2) - V(x)$
   ii. $L = 1/2\ m(\dot{p}^2 + p^2\dot{\phi}^2 + \dot{z}^2) - V(x)$
   iii. $L = 1/2\ m(\dot{r}^2 + r^2\dot{\theta}^2 + r^2\sin^2\theta\dot{\phi}^2) - V(x)$

12 a $A = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 3 & -1 \\ 0 & -1 & 3 \end{bmatrix}$, calculate eigen vectors and eigen values.

OR

b Consider a 2D harmonic oscillator $H = b\hat{x}\hat{y}$. Find ground state energy of the system. Find the 1st excited state energy.

13 a Find the de Broglie wavelength associated with
   i. A 46 gm golf ball with velocity 36 m/s.
   ii. an electron with a velocity 10^7 m/s.
      which of these two-show wave character and why?

OR

b The angular frequency of the surface wave in a liquid is given by

$W = \sqrt{gk + tk^3}/\rho$. If g = acceleration due to gravity, ρ = density of liquid, T = surface tension. Find the phase and group velocity if,
   i.   surface wave has very large wavelength
   ii.   surface wave has very small wavelength.

14 a A lump of steel of mass 30kg at 427°C is dropped in 100kg oil at 27°C. The specific heats of steel and oil id 0.5 KJ/kg^{-k} and 3.0 KJ/kg^{-k} respectively. Calculate the entropy change of steel, oil, universe.

OR

b There are 10 identical particles each of mass m to be accommodated in a cubical box of side L. What is the lowest energy of the system, if the particles obey i) BE and ii) FD statistics.

15 a Evaluate the values of j for the e^- configuration 4p 4d and show the splitting under j-j coupling.

OR

b An electron and its antiparticle are annihilated after collision. How much energy will be obtained.

Z-Z-Z   END