MCC/18/M.Sc./Sem.II/PHS/1

Second Semester Examination-2018

M.Sc. PHYSICS

Paper Code: PHS-201

Full Marks : 40 **Time: 2 Hours**

Use Separate scripts for Group A & Group B

Group A

(Quantum Mechanics-II)

Answer Question no 1 and any One from the rest.

1. **Answer any five bits:** **2×5=10**

   a. If S_e and S_p be the spin of electron and proton, find $\langle \hat{S}_e.\hat{S}_p \rangle$ for hydrogen atom.

   b. Find the eigen value of $\hat{J}_x$ for j=1

   c. Parity operator $\hat{\pi}$ is define as

   $$\hat{\pi}|\vec{r}\rangle = |-\vec{r}\rangle.$$

   and $P_+ = \frac{1}{2}\left(I + \hat{\pi}\right)$

   Prove that $\hat{\pi}P_- = \frac{1}{2}\left(I - \hat{\pi}\right)$

   d. If $V(r) = \frac{-e^2}{r}$, using WKB approximation find the ground state energy of e in hydrogen atom.

   e. If $Y_2^o(\theta,\varphi) = \sqrt{\frac{5}{16\pi}}\left(3\cos^2\theta - 1\right)$. Find expression for $Y_2^1(\theta,\varphi)$.

   f. Prove that $\gamma_\mu^+ = \gamma^0\gamma_\mu\gamma^0$

   g. Define helicity operator.

   h. Prove that $\gamma_\mu\gamma^\mu = 4$

(Turn Over)

Sec. 2017-18

2\. a. If $\hat{\pi} = \hat{p} - \frac{e\vec{A}}{C}$ **4+4+2=10**

Prove that $\left(\hat{\sigma}.\hat{\pi}\right)\left(\hat{\sigma}.\hat{\pi}\right) = \left(\hat{p} - \frac{e\vec{A}}{c}\right)^2 - \frac{e\hbar}{c}\hat{\sigma}.\vec{B}$.

b. Find an expression of Dirac Hamiltonian of e in a central potential in radial form only.

c. Explain Lamb Shift.

3\. a. Find out the effect of a constant electric field in the n=2 state of hydrogen atom. The perturbation due to the field is given as H^1=eEZ. Given

$$\psi_{200} = \frac{1}{4\sqrt{2\pi}} \frac{1}{a_o^{3/2}} \left(2 - r/a_o\right) \exp\left(-r/2a_o\right)$$

$$\psi_{210} = \frac{1}{4\sqrt{2\pi}} \frac{1}{a_o^{3/2}} \frac{r}{a_o} \exp\left(-r/2a_o\right) \cos\theta$$

b. If $V(x) = \gamma |x|^a$ find the energy eigen value by WKB method. If a=2 and a=∞. What are the values?

c. Find out the ground state energy of a harmonic oscillator using the trial function $\psi = e^{-ar^2}$ **4+4+2=10**

Group B

(Methods of Mathematical Physics-II)

Answer Question no 1 and any One from the rest.

1. Answer any five bits: **2×5=10**

a. $f(t) = \text{Cos}\left(t - \frac{2\pi}{3}\right),\ t \rangle \frac{2\pi}{3}$

$= 0 \qquad\qquad , \ t \langle \frac{2\pi}{3}$

Find $\hat{L}\{f(t)\}$.

b. $g(t) = \int_0^t \frac{\text{Sin}\tau}{\tau} d\tau$

Find $\hat{L}\, g(t)$.

c. If $D = \frac{d}{dx},\ D' = \frac{d}{dy}$

Solve: $\left(D^2 - 4DD' + 5D'^2\right)z = 0$

d. If $f(r) = Ae^{-}\frac{r^2}{2a^2}$

Find the fourier transformer of f(r).

e. Find the Green's function in terms of eigen value and eigen function of operator $\hat{L}$ for the differential equation.

$$\frac{d^2\psi}{dx^2} = f(x), \qquad 0 \le x \le 1$$

With the boundary conditions

$$\psi(0) = 0 = \psi(1)$$

(Turn Over)

f. $A = \begin{pmatrix} a & b \\ c & d \end{pmatrix}$

Find the group element in SU(2).

g. Find the character of rotational group (SUG) with angular momentum $l\hbar$ and rotation angle ϕ.

h. Prove that group of order two is always cyclic.

2. a. Find the classes of D_3 group.

b. Find the integral equation to the boundary value problem.

$$y''(x) + \lambda y(x) = 0; \quad y(0) = y(1) = 0$$ 5+5

3. a. If $D = \frac{\partial}{\partial x}, \quad D' = \frac{\partial}{\partial y}$

Then solve: $(D^2 + 2DD' + D'^2)z = 2Cosy - xSiny$

b. Solve the following equation for X(t).

$$X(t) = t^2 + \int_0^t Sin(t-u)X(u)du.$$ 5+5

*****