

Acc No. OT 38

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

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

- If  $S_e$  and  $S_p$  be the spin of electron and proton, find  $\langle \hat{S}_e \cdot \hat{S}_p \rangle$  for hydrogen atom.
- Find the eigen value of  $\hat{J}_x$  for  $j=1$
- Parity operator  $\hat{\pi}$  is define as

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

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

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

- If  $V(r) = \frac{-e^2}{r}$ , using WKB approximation find the ground state energy of e in hydrogen atom.
- If  $Y_2^0(\theta, \phi) = \sqrt{\frac{5}{16\pi}}(3\cos^2\theta - 1)$ . Find expression for  $Y_2^1(\theta, \phi)$ .
- Prove that  $\gamma_\mu^+ = \gamma^0 \gamma_\mu \gamma^0$
- Define helicity operator.
- Prove that  $\gamma_\mu \gamma^\mu = 4$

(Turn Over)



2. a. If  $\hat{\pi} = \hat{p} - \frac{e\vec{A}}{c}$

4+4+2=10

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

- 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

$$\psi_{200} = \frac{1}{4\sqrt{2\pi}} \frac{1}{a_0^{3/2}} \left(2 - \frac{r}{a_0}\right) \exp\left(-\frac{r}{2a_0}\right)$$

$$\psi_{210} = \frac{1}{4\sqrt{2\pi}} \frac{1}{a_0^{3/2}} \frac{r}{a_0} \exp\left(-\frac{r}{2a_0}\right) \cos\theta$$

- b. If  $V(x) = \gamma|x|^a$  find the energy eigen value by WKB method. If  $a=2$  and  $a=\infty$ . What are the values?  
 c. Find out the ground state energy of a harmonic oscillator using the trial function  $\psi = e^{-ax^2}$

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**

$$a. f(t) = \cos\left(t - \frac{2\pi}{3}\right), \quad t \in \left[\frac{2\pi}{3}, \frac{4\pi}{3}\right]$$

$$= 0, \quad t \in \left[\frac{2\pi}{3}, \frac{4\pi}{3}\right]$$

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

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

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

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

$$\text{Solve: } (D^2 - 4DD' + 5D'^2)z = 0$$

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

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.

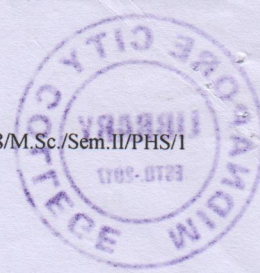
$$\frac{d^2 \psi}{dx^2} = f(x), \quad 0 \leq x \leq 1$$

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  $\phi$ .

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.

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

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

Then solve:  $(D^2 + 2DD' + D'^2)z = 2\text{Cos}y - x\text{Sin}y$

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

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

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