Mid-West University

# Examinations Management Office

End Semester Examinations 2081

Master level/ M.Sc.(Physics)/ 3rd Semester | Full Marks: 37.5

Time: 3 hours | Pass Marks: 18.75

**Subject: Quantum Field Theory (PHY612)**

*Candidates are required to give their answer in their own words as far as Practicable. The figures in the margin indicate full marks.*

**Attempt all the questions:**

1. Derive the field equation for spin half particle and show that it is Lorentz invariant. Also, Discuss the concepts of particle and antiparticle with the help of Dirac hole by using Hemiltonian operator, $\hat{H} = \int d^3x \hat{\psi}^\dagger(x,t)(-i\vec{\alpha}.\vec{\nabla} + \beta m)\,\hat{\psi}(x,t)$. **[2+2+6]**
2. What do you understand about time evolution operator? Discuss about normal order product for bosonic and fermionic field operators? Also establish the relation between time order product and normal order product for many operators with statement of Wick's theorem. **[2+4+4]**

   **OR**

   Define Feynman propagator in QFT. Write importance of propagator in QFT. Show that Feynman propagator can be expressed as,

   $\Delta_F(x-y) = \int \frac{d^4P}{(2\pi)^4}\, e^{-iP.(x-y)} \frac{1}{(P^2-m^2+i\epsilon)}$, where symbol have usual.

   Then, show that function $\Delta_F(x-y)$ is a solution of inhomogeneous K.G. equation.
3. Discuss the system of interacting bosons. Show that system of interacting helium atoms at $T = 0K$ behaves as collection of elementary excitons corresponding to non-interacting quasi-particle (quanta) of momentum $\hbar k$ and energies $E(k)$,

   $E(k) = \left[\frac{2\bar{v}n\hbar^2k^2}{m} + \left(\frac{\hbar^2k^2}{2m}\right)^2\right]^{1/2}$ **[5]**
4. Derive covariant form of Klein Gordon Equation. Show that it is invariant under Lorentz transformation. **[5]**

   **OR**

   Discuss the quantization rule for Bosons and Fermions.
5. Define Lorentz gauge. Derive covariant form of Maxwell's equation. **[5]**
6. Define creation and annihilation operator. Also, show that, If $\hat{N} = \sum_i \hat{n}_i = \sum_i \hat{a}_i^\dagger \hat{a}_i$ then show that $\hat{a}_i^\dagger$ *and* $\hat{a}_i$ are creation and annihilation operator.

   **OR**

   Define Bosons and fermions. Write the expression for wave function for n- particles bosons and fermions. **[2.5]**

**The End**