PG/IVS/PHS-402/15

M.Sc. 4th Semester Examination, 2015

PHYSICS

PAPER – PHS-402 (A + B)

Full Marks : 40

Time : 2 hours

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

PHS-402(A)

[*Marks* : 20]

Answer **Q.No. 1** and any **one** from the rest

1. Answer any *five* questions : 2 × 5

(*a*) Write down the Meson-theory of nuclear force.

(*b*) Find the ground state spin and parity of $_{13}Al^{27}$ according to shell model.

(*c*) What is the compound nucleus hypothesis of Bohr ? Write down the expression for cross section of nuclear reaction on the basis of this hypothesis.

(*d*) Classify neutron according to energy scale.

(*e*) Give an evidence of strong repulsive core at very short distance in case of nucleon -nucleon interaction.

(*f*) There is a spin-orbit term $\vec{L} \cdot \vec{S}$ in the nucleon-nucleon interaction. Explain – why there can not be a term like $\vec{r} \cdot \vec{L}$?

(*g*) The neutral pion has a life time $r\ 10^{-16}$s whereas the charged pions have life time $r\ 10^{-8}$s. How would you explain the large difference in the order of magnitude of life times ?

(*h*) Why are dineutron and diproton unbound but not deuteron ?

2. Using square well potential and appropriate boundary conditions find the wave function of the bound state of deuteron. Represent it graphically. Find the relation between range and depth of the potential. Comment on the excited *s*-states of deuteron. 5 + 1 + 2 + 2

3. (*a*) Derive and discuss the four factor formula for nuclear reactors.

(*b*) Define Fermi age and write down the Fermi-age equation.

(*c*) What do you mean by resonance particles ? Give examples.

(*d*) Using the $SU(3)$ symmetry sketch the Baryon octet in the Y-I_3 weight diagram.

3 + 2 + 2 + 3

PHS-402(B)

(*Qu. Field Theory*)

[*Marks* : 20]

Answer **Q.No. 1** and any **one** from the rest

1. Answer any *five* bits : 2×5

(*a*) Show that the stress energy tensor $T^{\mu\nu}$ for a scalar field ϕ satisfies the continuity equation

$$\partial_\mu T^{\mu\nu} = 0.$$

(*b*) Explain the time-ordered product of fields and show that the vacuum expectation value of a scalar field is one of the Green's function of the Klein Gordon operator i.e.

$$G_F(x' - x) = i \langle 0 | T \phi^+(x) \ \phi(x) | 0 \rangle.$$

(*c*) Draw the Feynman diagram for the process $B(k) \rightarrow e^-(p) + e^+(p')$ where the process results from the interaction Hamiltonian of the Yukawa interaction

$$\lambda t_I = g : \overline{\psi} \psi \phi : ;$$

where B refers to the quantum of the scalar field ϕ, e refers to the quantum of the fermionic field ψ, e^+ refers to the positron and k, p and p' are the four momentum of the particles.

(*d*) State and explain the Wick's theorem for a product of n-fields.

(*e*) Obtain the charge conjugation operator for a Dirac particle in an e.m. field satisfying the equation

$$(i\gamma^{\mu}\partial_{\mu} - e A_{\mu}(x))\,\psi(x) = 0.$$

(*f*) Show that the eigenvalues of the number operator for a Dirac field can be zero and unity.

(*g*) Explain charge and mass renormalization in QED.

2. (*a*) If $\alpha = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} - J^{\mu}A_{\mu}$ be Lagrangian density, find Maxwell's inhomogeneous equation of motion.

(*b*) If $J^{\mu} = 0$, show that

$$T^{00} = \frac{1}{2}\left(\vec{E}^2 + \vec{B}^2\right) + \vec{E} \cdot \vec{\nabla}\phi$$

under suitable gauge conditions.

(*c*) Find the value of

(*i*) $Tr\left[\not{a}\gamma^{\mu}\not{b}\gamma^{\nu}\right]$

(*ii*) $Tr\left[\left(\not{p}_1 + m_{\mu}\right)\gamma_{\lambda}\left(\not{p}_2 - m_{\mu}\right)\gamma_{\rho}\right]$

were m_{μ} is constant. 3 + 3 + 2 + 2

3. (*a*) For a Dirac field

$$\psi(x) = \int \frac{d^3p}{\sqrt{(2\pi)^3 2E_p}} \sum_{s=1,2} \left\{ b_s(\vec{p}) u^s(\vec{p}) e^{-ip.x} + d_s^{+}(\vec{p}) v^s(\vec{p}) e^{ip.x} \right\}$$

using suitable anticommutation relations show that

$$\left[\psi(t,\vec{x}),\ \psi^{+}(t,\vec{y})\right]_{+} = \delta^3(\vec{x} - \vec{y}).$$

(*b*) Prove that Noether charge

$$:Q:=q\int d^3p\sum_{s=1,2}\left[b_s^+(p)b_s(p)-d_s^+(p)d_s(p)\right]$$

(*c*) In GSW group $SU(2)_L \times U(1)$ how photon and neutral gauge boson fields arise ? Illustrate your answer by drawing Feynman diagram mediated by the photon and the weak neutral gauge boson. 4 + 3 + 3