2023
M.Sc.
4th Semester Examination
PHYSICS
PAPER – PHS-402
Full Marks: 50
Time: 2 Hours
Paper code: 402.1 (Nuclear Physics-II)

Answer any two (02) from the following questions: 2×2 = 4

1. The bound state of deuteron can be expressed as $\Psi_0 = a\Psi(l=0) + b\Psi(l=2)$. Explain it.
2. What is neutron moderating ratio?
3. What are direct nuclear reactions? Give two examples.
4. Derive the spin and parity of Mg_{12}^{25} using single particle shell model.

Answer any two (02) from the following questions: 2×4 = 8

5. Discuss the compound nucleus hypothesis.
6. What is nuclear fusion? Discuss proton-proton cycle. (1+3)
7. Find the nature of the force in ^3S and ^1S levels of n-p system for Heisenberg and Wigner exchange force.
8. (a) Write down the classification of neutrons according to energy scale.
   (b) What are the sources of neutrons? (2+2)

Answer any one (01) from the following questions: 1×8 = 8

9. (a) Using square well potential and appropriate boundary conditions find the wave function of the bound state of deuteron. Show it graphically. Find the relation between range and depth of the potential. (3+1+2)

   (b) The slow neutron reaction with Indium the exit channels are $(n, n)$and (n, γ). Compare the cross-section of the two channels at resonance. 2

10. (a) What is nuclear reactor? What are the purposes of it? (1+2)
    (b) Discuss with schematic diagram, the basic elements of a nuclear reactor.5

(Turn Over)

Paper code: 402.2 (Quantum Field Theory)

Answer any two (02) from the following: **2×2=4**

1. (a) State and explain the Noether's theorem of symmetry.
   (b) Write down the Feynman diagram of the following term:
   $$\frac{(-i\delta m)^2}{8}\int d^4y_1 d^4y_2\, i\,\Delta_F(x_1-y_1) i\,\Delta_F(y_1-y_2)\, i\,\Delta_F(y_2-x_2)$$
   (c) Find $\boldsymbol{tr(\gamma^5\gamma^\mu\gamma^\nu)}$.
   (d) Show that vacuum expectation value of time ordered product of the odd numbers of field operators vanishes.

Answer any two (02) from the following: **2×4=8**

2. The Lagrangian density of a real 3-component scalar field is given by $\mathcal{L}=\frac{1}{2}\partial_\mu\varphi^T\partial^\mu\varphi-\frac{m^2}{2}\varphi^T\varphi$, Where $\varphi=\begin{pmatrix}\varphi_1\\ \varphi_2\\ \varphi_3\end{pmatrix}$ is an SO(3) triplet. Show that $\mathcal{L}$ has SO(3) symmetry. Find Noether currents. 2+2

3. Write down the Lagrangian density of the photon field and hence construct the Hamiltonian and momentum density of the field. [1+3]
4. State the Wick's theorem and prove it for three Bosonic operators.
5. Write down the free Dirac equations and hence construct the Lagrangian density of the Dirac field and show that this Lagrangian is not Hermitian. [1+1+2]

Answer any one (01) from the following: **1×8=8**

6. (a) Discuss quantization (momentum expansion) of the real scalar field.
(b) Construct the Lagrangian density for the complex scalar field. [5+3]

(Continued)

7. (a) Deduce the Feynman propagator for the Dirac field.
(b) For $\lambda\varphi^3$ theory, construct the Hamiltonian density and hence calculate the 1st order contribution of Hamiltonian density with Feynman diagram. [5+3]

(All the symbols have their usual meanings)

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Internal Assessment-10