**2022/TDC/ODD/SEM/
PHSDSE–502T (A/B)/158**

TDC (CBCS) Odd Semester Exam., 2022

PHYSICS

(5th Semester)

Course No. : PHSDSE–502T

Full Marks : 70

Pass Marks : 28

Time : 3 hours

*The figures in the margin indicate full marks
for the questions*

Candidates have to answer *either* Option—A
or Option—B

OPTION—A

Course No. : PHSDSE–502T (A)

(Nuclear and Particle Physics)

UNIT—I

1. Answer any *four* questions : 1×4=4

   (a) What is the mathematical relationship between the radius and the atomic mass of a nucleus?

   (b) What is the energy of electron at rest?

J23/359 (*Turn Over*)

(2)

(c) Define nuclear magnetic dipole moment.

(d) What is electrical quadrupole moment of a nucleus?

(e) Define average binding energy of a nucleus.

2. Answer any *one* question : 2

(a) Why can electrons not be present inside the nucleus?

(b) Calculate the mass number of the nucleus whose radius is $4 \cdot 8 \times 10^{-15}$ m. (Given $r_0 = 1 \cdot 3$ fm)

3. Answer any *one* question : 8

(a) (i) Explain the significance of angular momentum quantum numbers in relation to individual nucleons. 4

(ii) Write a short note on parity of a nucleus. 4

(b) Draw the curve for binding energy per nucleon against mass number. Discuss the characteristics of this curve in detail.

UNIT—II

4. Answer any *four* questions : 1×4=4

(a) What is shell model?

(b) Define nuclear force.

(3)

(c) What are magic numbered nuclei?

(d) Name a parameter of a nucleus that is analogous to the heat energy within a liquid drop.

(e) On what factors does the stability of a nucleus depend?

5. Answer any *one* question : 2

(a) What are the basic similarities between a liquid drop and an atomic nucleus?

(b) Explain the salient features of nuclear force.

6. Answer any *one* question : 8

(a) Write Bethe-Weizsaecker semi-empirical mass formula explaining various terms in it.

(b) (i) What are the evidences in favour of shell model? 3

(i) Discuss meson theory of nuclear force in detail. 5

UNIT—III

7. Answer any *four* questions : 1×4=4

(a) What is meant by range of an α-particle?

(b) State Geiger-Nuttall law.

(c) What is β-decay?

(d) Define internal conversion.

(e) What do you mean by endoergic reaction?

8. Answer any *one* question :   2

(a) What is the difference between electron capture and positron emission?

(b) Explain conservation of mass-energy in nuclear reactions.

9. Answer any *one* question :   8

(a) What do you mean by range of α-particles? Give an account of experiments to determine the range of α-particles accurately.   2+6=8

(b) What do you mean by *Q*-value of a nuclear reaction? Discuss various conservation laws in nuclear reactions with illustrative examples.   1+7=8

UNIT—IV

10. Answer any *four* questions :   1×4=4

(a) In Compton effect, whether the energy of photon increases or decreases after scattering by an electron?

(b) What is proportional counter?

(c) What is the approximate collection time of electrons by the anode in the GM counter?

(d) Why can electrons not be accelerated to high energy in a cyclotron?

(e) What are the processes by which γ-radiation loses energy on passing through matter?

11. Answer any *one* question :   2

(a) Write down the difference between proportional counter and GM counter.

(b) What is Cerenkov radiation?

12. Answer any *one* question :   8

(a) (i) Explain how gamma rays are absorbed in matter while passing through it.   2

(ii) Discuss interaction of gamma rays with matter with special reference to Compton scattering, photo-elective effect and pair production.   6

(b) Describe the construction and action of a cyclotron. Discuss its limitations.   2+4+2=8

(6)

UNIT—V

13. Answer any *four* questions : 1×4=4

 (a) Which conservation law is applicable only in strong interaction?

 (b) Define strangeness quantum number.

 (c) Write the lepton numbers of electron and positron.

 (d) On the basis of what a particle is classified as hadron or lepton?

 (e) What are the electric charges of top and bottom quark?

14. Answer any *one* question : 2

 (a) Explain CPT theorem.

 (b) Draw the quark structures of the following :

  (i) Proton

  (ii) Neutron

15. Answer any *one* question : 8

 (a) (i) Explain the conservation laws, which govern the elementary particle reaction and decay. 5

  (ii) How are hadrons divided into more subgroups? 3

(Continued)

(7)

 (b) What is a charmed quark? Write down three generations of quarks and leptons. What do you mean by standard model? 2+3+3=8

OPTION—B

Course No. : PHSDSE–502T (B)

(**Advance Mathematical Physics**)

UNIT—I

1. Answer any *four* questions as directed : 1×4=4

 (a) Let a binary operation '∗' be defined on a set such that $a * b = b * a$ where a and b are elements of the set . The operation is commutative. (State true or false)

 (b) Define the term 'basis'.

 (c) What do you mean by dimension of a vector space.

 (d) Give one example of infinite-dimensional vector space.

 (e) Give one example of basis vectors in three dimensions.

(Turn Over)

(8)

2. Answer any *one* question :   2

  (a) Define binary operation.

  (b) Explain the term 'equivalence relation'.

3. Answer any *one* question :   8

  (a)   (i) Discuss axioms of vector space.   4

      (ii) Prove that the set of real numbers $\mathbb{R}$ together with regular addition (+) and multiplication (×) is a field.   4

  (b)   (i) Discuss group axioms.   4

      (ii) Show that the vectors $\vec{X} = \dfrac{1}{\sqrt{2}}(\hat{i} + \hat{j})$,

$\vec{Y} = \dfrac{1}{\sqrt{2}}(\hat{i} - \hat{j})$ and $\vec{Z} = \hat{k}$ are linearly independent in $\mathbb{R}^3$.   4

UNIT—II

4. Answer any *four* questions as directed :   1×4=4

  (a) When is a matrix said to be orthogonal?

  (b) What is the relation between trace and determinant of a square matrix?

  (c) Give an example of a 2×2 orthogonal matrix.

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(9)

  (d) If one of the eigenvalues of a matrix is zero, then it must be a null matrix.   (State true or false)

  (e) If X and Y are two column matrices, then what is inner product of these two?

5. Answer any *one* question :   2

  (a) If U is an $n \times n$ unitary matrix, then how many real independent parameters are required to describe it?

  (b) Show that a real orthogonal matrix is also an unitary matrix.

6. Answer any *one* question :   8

  (a) State and prove Cayley-Hamilton theorem.

  (b) How do you diagonalize a matrix? Discuss the steps involved in it.

UNIT—III

7. Answer any *four* questions as directed :   1×4=4

  (a) What is the name of the group formed by Pauli spin matrices?

  (b) Identity element remains the same for a group and its subgroups.   (State true or false)

  (c) When is a group said to be Abelian?

J23/359   (Turn Over)

(10)

(d) Cyclic groups are Abelian groups.
(State true or false)

(e) What is order of a group?

8. Answer any *one* question : 2

(a) Give definition of subgroup.

(b) What do you mean by matrix multiplication table?

9. Answer any *one* question : 8

(a) State and prove Lagrange's theorem.

(b) Prove that the group of order 3 is cyclic. Show using matrix table that ω (cube root of unity) can be the generator of the group under multiplication. 4+4=8

UNIT—IV

10. Answer any *four* questions : 1×4=4

(a) What do you mean by Einstein's summation convention?

(b) What are the direction cosines of the vector $\vec{A} = \hat{i} + 2\hat{j} + 3\hat{k}$?

(c) State true or false :

$$x^{\mu} x_{\mu} = x^{\nu} x_{\nu}$$

(d) Define rank of a tensor.

(e) When is a rank 2 tensor said to be symmetric?

(11)

11. Answer any *one* question : 2

(a) Find the number of independent parameters in $g_{\mu\nu}$ if it is a symmetric tensor.

(b) Define covariant vector and give its properties.

12. Answer any *one* question : 8

(a) (i) Prove that $F^{\mu\nu} g_{\mu\nu} = 0$ where $F^{\mu\nu}$ and $g_{\mu\nu}$ are rank 2 anti-symmetric and symmetric tensors. 4

(ii) Prove that addition of two covariant vectors is also a vector. Is it true if one of them is contravariant? 4

(b) (i) Evaluate δ^{μ}_{μ} and $\delta^{\mu\nu}\delta_{\mu\nu}$ for four dimensions. 4

(ii) Show that the expression $A(i, j, k)$ is a tensor, if its inner product with an arbitrary tensor B^{ji}_{k} is a tensor. 4

UNIT—V

13. Answer any *four* questions as directed : 1×4=4

(a) Give signature of metric tensor in Minkowski space-time.

(b) What is Levi-Civita symbol in three dimensions?

(c) What is the metric tensor for flat space-time in spherical polar coordinate system?

(d) Metric tensor can be used to raise or lower an index of a tensor. (State true or false)

(e) State true or false :

$$\delta^{ij}\varepsilon_{ijk} = 3$$

2

14. Answer any *one* question :

(a) Find metric tensor for cylindrical coordinate system.

(b) Find inverse metric tensor in Cartesian coordinate system.

8

15. Answer any *one* question :

(a) (i) State and explain quotient law of tensors.

4

(ii) Show that $\varepsilon_{\mu\nu\rho\sigma}F^{\mu\nu}$ is also a rank 2 anti-symmetric tensor if $F^{\mu\nu}$ is a rank 2 anti-symmetric tensor.

4

(b) (i) Prove that

$$\varepsilon_{ijk}\varepsilon_{lmk} = \begin{vmatrix} \delta_{il} & \delta_{im} \\ \delta_{jl} & \delta_{jm} \end{vmatrix}$$

4

(ii) If all the components of a tensor are zero in one frame, then prove that it is zero in all other frames.

4

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