



'সমানো মন্ত্র: সমিতি: সমানী'

UNIVERSITY OF NORTH BENGAL
B.Sc. Honours 6th Semester Examination, 2022

DSE-P4-PHYSICS

Time Allotted: 2 Hours

Full Marks: 60

*The figures in the margin indicate full marks.
All symbols are of usual significance.*

**The question paper DSE4 contains Section-A, Section-B and Section-C.
Candidates are required to answer any *one* section from the *three* sections and they should mention it clearly on the Answer Book. Candidates should also ensure that the chosen section in the paper DSE4 is different from the chosen section in the paper DSE3.**

SECTION-A

NUCLEAR AND PARTICLE PHYSICS

GROUP-A

1. Answer any **four** questions from the following: 3×4 = 12
- (a) Draw the binding energy curve and explain it. 3
- (b) What do you mean by the neutrino hypothesis of Pauli? 3
- (c) State and explain the concept of the colour quantum number in quark model. 3
- (d) Give at least three differences between the shell model and the liquid drop model of atomic nuclei. 3
- (e) Show that the frequency of revolution of the ions in a cyclotron is independent of its speed and the radius of the path. 3
- (f) Why does a free neutron not decay into an electron and a proton? 3

GROUP-B

Answer any *four* questions from the following 6×4 = 24

2. Derive an expression for the coulomb energy of a spherical nucleus of mass number A , charge z , having an uniform charge density. Calculate the numerical value of the constant occurring in the coulomb energy term of the mass formula. 3+3=6
3. Check if the following reactions are allowed: 3+3=6
- (i) $\pi^- + p \rightarrow \Lambda^0 + \pi^0$
- (ii) $p + p^- \rightarrow 2\pi^+ + 2\pi^- + 2\pi^0$

4. Describe qualitatively how γ -rays interact with matter while passing through it. 6
5. What is Geiger-Nuttall rule? Explain 'straggling' of the range of α -particles. 2+2+2
A sample contains 4 mg of Bi^{210} . If the half-life is 5 days and the average energy of β -particles emitted is 0.34 MeV, at what rate does the sample emit energy?
6. (a) Calculate the Q -value for the reaction ${}^3\text{H} (d, n) {}^4\text{He}$. Give an expression for the neutron energy for this reaction in terms of deuteron energy, K_x and angle θ . 2+3
(b) Explain the differential cross-section of a nuclear reaction. 1
7. (a) What do you mean by resonance reaction? 1
(b) With the help of a diagram explain the principle of action of linear accelerator. 4+1
What is the main advantage of linear accelerators?

GROUP-C

Answer any *two* questions from the following

12×2 = 24

8. (a) State the main assumptions of the nuclear shell model. 4
(b) What are the experimental evidences that suggest the shell model? 5
(c) Using the shell model, find the total angular momentum and parity of the ground state of ${}_{16}^{33}\text{S}$ nucleus. 3
9. (a) Describe the structure of a GM-counter and explain its operation principle. 3+4
(b) What is meant by the 'dead time' of a GM-counter? 2
(c) A GM-counter has a 'dead time' 400 μs . What are the true counting rates when the observed rates are (i) 100 per minute, (ii) 1000 per minute. 3
- 10.(a) What is a Cherenkov detector? Show how the energy of a particle can be determined in a beam of mixed particles but having the same mass with the help of a Cherenkov detector. 2+4
(b) Describe the construction of an ionisation chamber with the help of a diagram. 4
(c) Explain the difference between ionisation chamber and GM-counter. 2
- 11.(a) What do you mean by the energy spectrum of β -particle? 2
(b) Derive an expression for the energy spectrum of β -particles emitted from a radioactive source. 7
(c) Find out an expression for the maximum energy of the β -particles in terms of atomic mass of the parent and daughter nuclei. 3

SECTION-B

ASTROPHYSICS AND ASTRONOMY

GROUP-A

1. Answer any *four* questions from the following: 3×4 = 12
- (a) What is luminosity of a star? 3
 - (b) Explain how to determine the distance in Parallax method. 3
 - (c) What is galaxy morphology? 3
 - (d) What do you mean by diurnal motion of the stars? 3
 - (e) Discuss the differences between Newtonian and Einstein's theory of gravitation. 3
 - (f) Explain Hubble's law of "distance-velocity" relation of a galaxy. 3

GROUP-B

Answer any *four* questions from the following 6×4 = 24

- 2. Describe the Hertzsprung-Russel diagram for the classification of stars. 6
- 3. Write down the properties of Galactic Nucleus. How does it differ from the around the galactic nucleus. 6
- 4. Describe the basic structure and properties of the Milky way galaxy. 6
- 5. What is Virial theorem in astrophysics? Write a brief note on 'Extra-solar planets'. 4+2
- 6. Describe the Nebular model to explain the origin of the solar system. 6
- 7. What is the source of solar energy? Discuss the properties of various layer of Sun. 2+4

GROUP-C

Answer any *two* questions from the following 12×2 = 24

- 8. Write down the process to determine the temperature and radius of a star. 6+6
- 9. Describe the nature of the milky way galaxy and its rotation curve. Write down your view on Dark matter. 4+4+4
- 10.(a) What is a Galaxy? Describe Hubble's classification of galaxies. 2+4
- (b) What is solar activity? Explain basics of solar magneto-hydrodynamics. 2+4

- 11.(a) Derive the expression for Jeans mass. Write down the physical origin of Jeans mass. 5+2
- (b) What do you mean by main sequence stars? Explain briefly. 5

SECTION-C

ADVANCED MATHEMATICAL PHYSICS-II

GROUP-A

1. Answer any **four** questions from the following: 3×4 = 12
- (a) Define Hamiltonian. Give its physical significance.
- (b) Prove that every cyclic group is abelian.
- (c) What do you mean by “equal a priori probability”? If the letters in the word ‘mathematics’ are arranged at random, find the probability that the word formed contains the word ‘math’.
- (d) Find the value of C in the following normalized discrete distribution function $f(x)$.

$$f(x) = C \frac{3^x}{x!} e^{-3} ; \quad 0 \leq x \leq \infty$$

- (e) If $a = (1, 2, 3, 4)$, then show that the set of $\{a, a^2, a^3, a^4\}$ forms a cyclic group.
- (f) Using Poisson bracket, show that the transformation

$$Q = (e^{-2q} - p^2)^{1/2} ; \quad P = \cos^{-1}(pe^q)$$

is canonical, where symbols have their usual meaning.

GROUP-B

Answer any four questions from the following

6×4 = 24

2. (a) State and explain Hamilton’s principle. 2
- (b) Deduce Lagrange’s equation of motion for conservative systems from Hamilton’s principle. 4
3. (a) Show that the transformation $P = \frac{1}{2}(p^2 + q^2)$ and $Q = \tan^{-1} \frac{q}{p}$ is canonical. 3
- (b) The coordinates and momenta x_i, p_i ($i=1, 2, 3$) of a particle satisfy the canonical Poisson bracket relations $[x_i, p_i] = \delta_{ij}$. If $c_1 = x_2 p_3 + x_3 p_2$ and $c_2 = x_1 p_2 - x_2 p_1$, are constants of motion, and if $c_3 = x_1 p_3 + x_3 p_1$, then prove that $[c_2, c_3] = c_1$ and $[c_3, c_1] = -c_2$. 3

4. (a) Prove that real numbers or complex numbers with the binary operation '+' form groups. But the natural numbers with the operation '+' are not a group. 3
 (b) Explain isomorphism and homomorphism with example. 3
5. (a) If G is a group and H is a subgroup of index 2 in G , show that H is a normal subgroup of G . 3
 (b) Consider $G = S_3$, the symmetric group of three numbers 1, 2, 3, then show that the subgroup $H = \{I, (1, 2, 3), (1, 3, 2)\}$ is a normal subgroup of G but the subgroup $K = \{I, (1, 2)\}$ is not a normal subgroup of G . 3
6. (a) Find the mean and variance of a standard binomial distribution. 2+2
 (b) Using Poisson distribution, find the probability that the ace of spades will be drawn from a pack of well shuffled cards at least once in 104 consecutive trials. 2
7. (a) Four boxes contain balls in the following configuration. 4

5 Red	6 Red	7 Red	2 Red
5 Black	4 Black	3 Black	8 Black

One of the boxes is selected at random and a ball is drawn from it. If the ball drawn is black, find the probability that it is drawn from the second box.

- (b) An urn contains 20 black marbles and 10 red marbles. What is the probability of drawing two marbles of the same colour? 2

GROUP-C

Answer any *two* questions from the following

12×2 = 24

8. (a) Show that the given matrices form a group 6

$$I = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}, \quad A = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \quad B = \begin{pmatrix} 0 & -1 \\ -1 & 0 \end{pmatrix}, \quad C = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix}$$
- (b) Show that the set of all n th roots of unity form a finite abelian group G of order n under multiplication. 4
 (c) Show that the group of order 2 and 3 are always cyclic. 2
9. (a) Write down the Gaussian probability distribution function for non-zero mean. 2
 (b) Normalize the distribution function. 3
 (c) Calculate the mean, variance and standard deviation of the distribution. 4
 (d) A box contains three coins— two regular coins and one fake two-headed coin. If you pick a coin at random and toss it and get heads, what is the probability that it is the two-headed coin? 3

- 10.(a) A bead of mass m slides on a circular frictionless wire of radius r . If the wire itself rotates with angular velocity ω about a vertical diameter, find the Lagrangian and obtain the equation of motion. 4
- (b) Define generalized momentum and generalized force. 2
- (c) Show that generalized momentum corresponding to a cyclic coordinate is conserved. 3
- (d) Show that the shortest distance between two points in a plane is a straight line. 3
- 11.(a) Discuss the limit at which binomial distribution becomes Poisson distribution. Derive the Poisson distribution explicitly from binomial distribution. 1+4
- (b) In the last 10 bilateral India vs. Australia matches, India won 8 times and Australia won 2 times. Find the probability of the event such that India will win 6 matches in the next 20 matches. 2
- (c) Find the curve connecting the points (x_1, y_1) and (x_2, y_2) which when rotated about the x -axis gives a minimum surface. 5

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