



বিদ্যাসাগর বিশ্ববিদ্যালয়  
**VIDYASAGAR UNIVERSITY**  
**Question Paper**

**B.Sc. Honours Examinations 2021**

(Under CBCS Pattern)

**Semester - V**

**Subject : PHYSICS**

**Paper : DSE 2-T**

**Full Marks : 60**

**Time : 3 Hours**

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

*The figures in the margin indicate full marks.*

[ NUCLEAR & PARTICLE PHYSICS ]

(Theory)

Group-A

**A. Answer any *four* of the following questions :**

**12×4=48**

1. (i) What do you mean by parity of a nucleus?

(ii) The ground state spin  ${}^{41}_{20}\text{Ca}$  nuclide is  $7/2$ . If this nucleus is regarded as a rigid sphere with radius  $R = 1.4 A^{\frac{1}{3}} \text{ fm}$ , what would be the velocity of a point particle on the surface of this nucleus?

(iii) How do you distinguish various nuclear reaction mechanisms?

- (iv) Discuss two reactions :  $\pi^- + p \rightarrow \Sigma^+ + K^-$  and  $\Lambda^0 \rightarrow n + \gamma$ . [2+3+3+(2+2)]
2. (i) Describe the liquid drop model in case of nucleus.
- (ii) The  $Q$ -value of the reaction  $Ra^{226} \rightarrow Rn^{222} + He^4$  is  $4.88 \text{ MeV}$ . The radium nucleus is originally at rest. Calculate the K.E. of each disintegration product.
- (iii) If the nuclear force is charge independent and a neutron & a proton form a bound state, then why is there no bound state for two neutrons? What information is obtained from it?
- (iv) What is photoelectric effect? [4+4+(2+1)+1]
3. (i) Write the main features of binding-energy versus mass-number curve.
- (ii) Prove that the recoil energy of the nucleus undergoing electron capture type of  $\beta$ -decay is given by  $E_r = E^2 / 2Mc^2$ , where  $E$  is the total energy released in  $\beta$ -decay.
- (iii) In an absorption experiment with  $1.14 \text{ MeV}$   $\gamma$ -radiation from  $Zn^{65}$ , it is found that  $25 \text{ cm}$  thickness of  $Al$  reduce the beam intensity to  $2\%$ . Calculate the half-value thickness and the mass absorption coefficient for this radiation.
- (iv) Explain the differences between ionization chamber and Geiger-Muller counter. 2+4+3+3
4. (i) Establish the Gamow's theory for alpha decay.
- (ii) Explain the term 'mass-defect' and 'binding-energy' of nucleus.
- (iii) When  $F^{19}$  is bombarded with protons in  $(p,n)$  reaction, calculate the excitation energy of the compound nucleus that corresponds to the resonance with a proton energy of  $4.99 \text{ MeV}$ . 6+3+3
5. (i) Given that the  $K^-$  and  $\pi^-$ -mesons have zero spin, show that one of the weak processes  $K^+ \rightarrow \pi^+ + \pi^-$  and  $K^+ \rightarrow \pi^+ + \pi^+ + \pi^-$  must violate parity conservation.
- (ii) Determine the possible states of a deuteron if its angular momentum quantum number is 1.

- (iii) Write basic assumptions of nuclear shell model. Give experimental evidence in support of the nuclear shell structure.
- (iv) The nuclide  $Ba^{137}$  emits  $\gamma$ -ray photon of energy  $0.66 \text{ MeV}$  during an isomeric transition. Calculate the recoil kinetic energy of the nuclide in unit of  $eV$ .
- 3+2+(3+1)+3
6. (i) What is particle accelerator? Write a brief note on linear accelerator.
- (ii) An  $\alpha$ -particle of energy  $5 \text{ MeV}$  is scattered through angle  $180^\circ$  by an uranium nucleus. Calculate the distance of closest approach between the nucleus and the  $\alpha$ -particle.
- (iii) How do neutrino and antineutrino differ from photons, which also have no charge or rest mass? (1+5)+3+3
7. (i) The greatest binding-energy per nucleon occurs near  $Fe^{56}$  and it is much less for  $U^{238}$ . Explain this in terms of the semi-empirical nuclear binding energy.
- (ii) The Fermi gas model is a statistical model which pictures the nucleus as a degenerate gas of protons and neutrons. Using this model, show that the Fermi energy for the neutron gas is greater than that for the proton gas in case of a nucleus of  $N > Z$ .
- (iii) Derive Bethe-Bloch formula for 'stopping power' of heavy charged particles passing through a matter. 3+4+5
8. (i) For what elements should stable isobars exist for  $A = 169$  and  $A = 110$ ?
- (ii) The protons of energy  $7.5 \text{ MeV}$  are extracted from a cyclotron at a radius of  $0.51 \text{ m}$  by applying an electric field of  $5 \text{ MV/m}$  over an orbit arc of  $90^\circ$ . Calculate the equivalent reduction of magnetic field and the resulting change in orbit radius.
- (iii) Write a short note on 'direct nuclear reaction'. 4+4+4

**Group-B**

**B. Answer any six of the following questions :**

**2×6=12**

9. Why are the most stable nuclei found in the region near  $A = 60$ ?
  10. What do you mean by Kurie plot for  $\beta$ -decay?
  11. Find the minimum energy of an electron (rest-mass  $0.5 \text{ MeV}$ ) that can emit Cherenkov radiation while passing through water (*r.i.* 1.5).
  12. Write main differences between cyclotron and Synchrotron.
  13. How do you account for the saturation of binding energy of a nucleus?
  14. Write the main differences between compound and direct nuclear reactions.
  15. Define the terms : strangeness and charm in particle physics.
  16. Write the basic principle of 'Scintillation Counters'.
  17. How is quenching achieved in GM-counter?
  18. Calculate the magnetic moment and electric quadrupole moment of  $Mg^{225}$  nuclide.
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OR

[ ASTRONOMY AND ASTROPHYSICS ]

(Theory)

Group-A

A. Answer any *four* of the following questions : 12×4=48

1. (a) Define apparent magnitude and absolute magnitude of a celestial object. 2+2  
(b) A star at a distance 4 pc has an apparent magnitude 2. What is its absolute magnitude? Given the fact that the Sun has a luminosity  $3.6 \times 10^{26} W$  and has an absolute magnitude of about 5. Find the luminosity of the star. 1+2  
(c) Explain Chandrasekhar mass limit. 3  
(d) What is meant by gravitational condensation? 2
2. (a) State mass-luminosity relation. 2  
(b) What is HR diagram? Write down its physical significance. Hence state the mathematical relation between luminosity of a star with its surface temperature. 2+2+1  
(c) Define radiation pressure. Show that the pressure due to isotropic radiation  $P = \frac{U}{3}$ . 1+4
3. (a) Write down the conservation laws of stellar structure. 2  
(b) Discuss the importance of Saha equation in stellar structure calculation. 4  
(c) Derive the following equation of the stellar structure regarding heat flux is carried outward by radiative transfer  $\frac{dT}{dr} = -\frac{3}{4ca_B} \frac{\chi\rho}{T^3} \frac{L(r)}{4\pi r^2}$ .  
Where symbols have usual meaning. 6
4. (a) The gravitational field at a point inside or near the galaxy is expected to be directed towards the galactic centre. How is this gravitational field balanced,

- to ensure that there is not a general fall of everything towards the galactic center? 2
- (b) Derive the expression of Oort A and B constants related to differential galactic rotation. 6
- (c) What is LSR frame of reference? 2
- (d) Explain the term 'Strömgren sphere'. 2
5. (a) State Hubble's law. 2
- (b) What do you mean by spiral galaxies and elliptical galaxies? 2+2
- (c) Write down de Vaucouleurs law related to surface brightness with the distance from the center of the elliptical galaxies. Hence define effective radius. Write down the relation between surface brightness and distance for spiral galaxies. 2+1+1
- (d) How are planetary rings formed? 2
6. (a) What do you mean by galactic cannibalism? 1
- (b) Distinguish between galactic cannibalism and galactic merger. 2
- (c) From where the gas in the galaxy cluster came and why is it so hot? 2
- (d) What is ram pressure? Can it force the interstellar medium of a galaxy? 2
- (e) Estimate the typical time a galaxy would take to cross a cluster of galaxies and the relaxation time. A cluster of galaxies is clearly not a relaxed system, but it has to be virialized for the virial theorem to be applicable. Do you think that typical galaxy clusters are virialized? 3+2
7. (a) The interstellar medium in the galactic disk diminishes the luminosity of stars by about 1.5 magnitude per kpc. Show that this implies that the brightness of stars fall off with distance  $r$  in the galactic disk as  $\frac{\exp(-\alpha r)}{r^2}$ . Find the value of  $\alpha$ . 4
- (b) Define apparent solar time and mean solar time. 2

- (c) Why does mean-solar-time differ from apparent-solar-time? 2
- (d) The Sun has a rotation period of about 27 days. If the Sun collapsed to become a white dwarf conserving its angular momentum, what would be the expected rotation period? What would be the rotation period if the Sun collapsed to become a neutron star? 2+2
8. (a) Give the main characteristics of the spectral classification of stars? 3
- (b) Define open star clusters and globular clusters. 2+2
- (c) If the Sun was producing its energy by slow contraction as suggested by Helmholtz and Kelvin, estimate the amount by which the radius of the Sun has to decrease every year to produce observed luminosity? 3
- (d) Explain binary star. 2

**Group-B**

**B. Answer any six of the following questions : 2×6=12**

- (i) Define the term 'Celestial Sphere'.
- (ii) What is meant by spectroscopic parallax?
- (iii) Write down the advantages of radio telescope over optical telescope?
- (iv) What is 'Olbers Paradox'?
- (v) What are quasi-stellar objects?
- (vi) What do you mean by extra-solar planet? Do extra-solar planets exist?
- (vii) Define superluminal motion. What causes it?
- (viii) Why do we try to build bigger and bigger telescopes?
- (ix) What do you mean by 'neutron drip'?
- (x) How does 'cosmic distance ladder' work?
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OR

[ PHYSICS OF EARTH ]

(Theory)

Group-A

A. Answer any *four* of the following questions : 12×4=48

1. (a) What is an earthquake? What causes earthquakes? 1+3
- (b) Define hypocenter and epicentre of earthquake. 2
- (c) What are Seismic waves? Write down their characteristics. 2+3
- (d) Can Scientist predict earthquakes? 1
2. (a) What is the Cryosphere? What are the main components of the cryosphere? 1+2
- (b) How are valley glaciers likely to respond to global warming? 2
- (c) Define ice sheet. Write down difference between ice sheet and ice shelf. 1+2
- (d) What do you mean by permafrost and why is it important? 2
- (e) What are the consequences of permafrost melting? 2
3. (a) Write down the principle of uniformitarianism. 2
- (b) Write down the difference between uniformitarianism, catastrophism and actualism. 3
- (c) State the principle of superposition used to interpret the geological history. 1
- (d) Why is Antarctica the place to go to, to understand the earth's present, past and future? 3
- (e) How can we know the age of the Earth? 3
4. (a) Write down the basic structure and properties of the Galaxy. 3+2
- (b) Define Cosmic ray shower. How it is originated? Write down the composition of primary and secondary cosmic ray. 2+2+3



5. (a) Write down the hypothesis about the origin of life of Earth. 2
- (b) Discuss chemosynthetic theory for origin of life. 4
- (c) Name the four gases present in the primitive atmosphere of the earth. 2
- (d) Where did life originate : in water or on land? 2
- (e) Define Palaeontology. 2
6. (a) What is Carbon Cycle? Explain with diagram. 1+2
- (b) Write down the importance of Carbon Cycle. 2
- (c) Define the term carbon sink and carbon sequestration. What are the types of carbon sequestration? 2+1
- (d) What are the causes of loss of biodiversity? 2
- (e) What is fresh water depletion? What causes it? 2
7. (a) What are the main causes of nuclear waste? 2
- (b) Write down the types of the nuclear waste. How can the nuclear waste affect the environment? 2+2
- (c) What do you mean by ocean current? What are the types of it? How it is affected by Coriolis force? 2+2+2
8. (a) Write down the origin of the Earth's magnetic field. 3
- (b) What are the basic components of Earth's magnetic field? Define each component. 1+3
- (c) Describe the internal structure of the earth. 4
- (d) Mention the uses of geothermal energy. 1

**Group-B**

**B. Answer any six of the following questions :**

**2×6=12**

- (i) What is the real shape of the Earth?
  - (ii) What is meant by Paleoclimate? Why do we study it?
  - (iii) Write down the difference between terrestrial and Jovian planets.
  - (iv) What do you mean by Dole effect?
  - (v) Define MOR.
  - (vi) Explain 'Earth's heat budget'.
  - (vii) What is wave erosion? What are the processes of wave erosion?
  - (viii) Who measures the global warming rate?
  - (ix) What is Tsunami?
  - (x) Distinguish between asteroids and comets.
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OR

[ ADVANCED MATHEMATICAL PHYSICS II ]

(Theory)

Group-A

A. Answer any *four* of the following questions : 12×4=48

1. (a) Define the terms functional and extremal. Using Euler's equation test for an extremum the functional  $\int_0^1 (xy + y^2 - 2y^2 y') dx$ ,  $y(0) = 1$ ,  $y(1) = 2$  2+3
- (b) Derive the Euler-Lagrange's equations of motion using the calculus of variations and hence obtain the Lagrange's equation of motion for a system of particles. 5+2
2. (a) What is meant by variational principle? Apply variational principle to show that the path of a projectile is parabola. 2+3
- (b) Show that the transformation  $Q = p + iaq$ ,  $P = \frac{p - iaq}{2ia}$  is canonical and find a generating function. 3
- (c) Show that the Poisson Bracket of any three dynamical functions  $F(q, p)$ ,  $G(q, p)$  and  $H(q, p)$  satisfy the Jacobi's identity  $[F, [G, H]] + [G, [H, F]] + [H, [F, G]] = 0$ . 4
3. (a) Discuss the motion of a freely rotating symmetric top. Calculate the value of its kinetic energy and angular momentum. 3+(2+2)
- (b) What is a gyroscope? Give its uses. 1+1
- (c) Prove that the sphere is the solid figure of revolution which, for a given surface area, has maximum volume. 3
4. (a) Show that the set  $\{1, -1, i, -i\}$  is an abelian finite group of order 4 under multiplication. 2

- (b) Define cyclic group. If  $G = \{a\}$  is a cyclic group of order 8, then find the quotient groups corresponding to the subgroups generated by  $a^2$  and  $a^4$ , respectively. 1+2
- (c) If  $R$  be the additive group of real numbers and  $R^+$  the multiplicative group of positive real numbers show that the following mapping are isomorphism.
- (i)  $f: R \rightarrow R^+$  such that  $f(x) = e^x, x \in R$
- (ii)  $f: R^+ \rightarrow R$  such that  $f(x) = \log x, x \in R^+$  3
- (d) If a group is defined as  $a * b = a + b - 1$  then find the inverse of the group. 2
- (e) If  $a$  is a fixed element of a group  $G$ , then prove that the set  $N(a) = \{x \in G; xa = ax\}$  is a subgroup of  $G$ . 2
5. (a) Define isomorphism of a group. Let  $f: (G, 0) \rightarrow (G^+, *)$  be an isomorphism. Then prove that  $G^+$  is commutative if and only if  $G$  is commutative. 2+3
- (b) Prove that "A finite group  $G$  of order  $n$  is isomorphic to a subgroup of  $S_n$ ". 4
- (c) Define Euler's angles. 3
6. (a) What is meant by 'principle of least square'? 2
- (b) Fit a straight line  $y = a + bx$  to the following data by the method of least squares :
- |     |   |   |   |   |   |   |
|-----|---|---|---|---|---|---|
| x : | 0 | 1 | 3 | 6 | 8 |   |
| y : | 1 | 3 | 2 | 5 | 4 | 3 |
- (c) Consider  $n$  boxes each containing  $P$  black ball and  $Q$  white balls.
- (i) Find the probability  $p$  of drawing a black ball from a given box and the probability  $q$  of drawing a white ball from a box. 2
- (ii) Show that the probability  $w_n(m)$  that in drawing one ball from each of the  $n$  boxes,  $m$  of them will be white, the remaining  $(n - m)$  balls will be black
- $$w_n(m) = \binom{n}{m} p^{n-m} q^m \quad 3$$
- (iii) Show that  $\sum_{m=0}^n w_n(m) = 1$  2

7. (a) In the context of probability explain with examples the terms : Sample space and non-uniform sample space. 2+2
- (b) A die is tossed thrice. A success is getting 1 or 6 on a toss. Find the mean and variance of the number of successes. 3
- (c)  $X$  is a continuous random variable with probability density function given by

$$f(x) = \begin{cases} kx & (0 \leq x < 2) \\ 2k & (2 \leq x < 4) \\ -kx + 6k & (4 \leq x < 6) \end{cases}$$

Find  $k$  and mean value of  $X$ .

- 3
- (d) If  $x$  be a random variable with probability generating function  $P_x(t)$ , find the probability generating function of  $x + 2$ . 2
8. The Gaussian Probability distribution is given by

$$P(x; \mu, \sigma) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right], \quad -\infty < x < \infty$$

- (a) What are the parameters  $\mu$  and  $\sigma$ ? Discuss their significance. 2+2
- (b) Draw the graph of  $P(x; \mu, \sigma)$  and hence show that it has two point of inflexion at  $x = \mu \pm \sigma$ . 1+2
- (c) What is the maximum value of  $P(x; \mu, \sigma)$ ? 1
- (d) What is the area under the curve? What does it signify? 1+1
- (e) Interpret  $p(x_1, x_2) = \int_{x_1}^{x_2} P(x; \mu, \sigma) dx$  2

### Group-B

**B. Answer any six of the following questions :** **2×6=12**

- (i) What is  $\Delta$ -variation? How it differs from  $\delta$ -variation?
- (ii) Define modified Hamilton's principle.
- (iii) Apply variational principle to find the equation of 1D harmonic oscillator.
- (iv) A cyclist is riding a bicycle without holding handle. He wishes to turn to one side. Explain how.

- (v) Define the terms : Precessional angular velocity and Precessional torque.
- (vi) What do you mean by semi-group?
- (vii) For any two elements  $a$  and  $b$  of a group  $G$ , show that  $G$  is abelian if  $(ab)^2 = a^2b^2$ .
- (viii) Define the term 'canonical homomorphism' of a group.
- (ix) Let  $P(E)$  denote the probability of the event  $E$ . Given,  $P(A)=1$ ,  $P(A)=\frac{1}{2}$ . Find the values of  $P\left(\frac{A}{B}\right)$  and  $P\left(\frac{B}{A}\right)$ .
- (x) Write down the conditions satisfied by probability density function of a continuous random variable.
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