2019

B.Sc. (Honours)

5th Semester Examination

PHYSICS

Paper - DSE-2T (TBD)

Full Marks : 60 Time : 3 Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

(NUCLEAR & PARTICLE PHYSICS)

1. Answer any *ten* questions from the following : 2×10=20

(a) Find the third component of isospin of Ξ^- in the following strong interaction.

$$\pi^+ + n \rightarrow \Xi^- + K^+ + K^+$$

(b) Calculate the packing fraction (f_B) for the α-particle (^4He).

(c) Under radioactive equilibrium, what do you mean "transient" and "secular" equilibrium ?

(d) $^7Li(Z=3)$ and $^7Be(Z=4)$ have the atomic masses 7.0160054 nad 7.0169294. Which of them shows β-activity and of what type ?

(e) In an experiment on the absorption of γ-rays in lead, the half-value thickness is found to be 112 kg/m^2. What is the mass absorbing coefficient of this radiation. ?

(f) Find the total angular momentum and parity for ground state of $^{33}_{11}S$ necleus, using the shell model.

(g) What is the advantages of cyclic accelerators over linear accelerators ?

(h) Calculate the Q-value of the following reaction.

$$^3_1H + ^2_1H \rightarrow ^4_2He + ^1_0n.$$

Given : $M\left({}_{1}^{3}H\right) = 3.0169982$,

$M\left({}_{1}^{2}H\right) = 2.0147361$,

$M\left({}_{2}^{4}He\right) = 4.0038727$,

$M\left({}_{0}^{1}n\right) = 1.0089832$.

(i) What is internal conversion ?

(j) What do you mean by "prompt" & "delayed" neutrons ?

(k) A nuclear power generating station has a capacity of 60,000 kW. If only 20% of the thermal energy generated is converted into electricity, and if 200 MeV energy is produced per fission, calculate the amount of U-235 spent per year.

[Turn Over]

(l) Indentify the type of the following interaction from the conservation laws $\Sigma^{o} \rightarrow \wedge^{o} + \gamma$ (life time $\leq 10^{-14}$ sec.)

(m) A μ^{-} meson decays into an electron e^{-} and a pair of neutrinos. Calculate the maximum available energy for the process and the average electron energy.

(n) A cyclotron in which the magnetic flux density is 1.4 Wb/m^2 is employed to accelerate protons. How rapidly should the electric field between the dees be reversed ?

Mass of proton = 1.67×10^{-27} kg. and the charge = 1.6×10^{-19} C.

(o) A betatron has a magnetic current supply frequency of 60Hz and the peak magnetic flux density at the orbit is 0.5 Wb/m^2. If the radius of the electron orbit is 0.75 m, calculate the energy of the electron.

2. Answer any *four* questions from the following : 5×4=20

(a) According to shell model, predict spins and parities for the ground states of ${}^{15}_{8}O$ and ${}_{8}O^{16}$, ${}_{17}Cl^{36}$. 1+2+2

(b) What is a neutrino ? Explain qualitatively how the hypothesis of a neutrin solves the apparent breakdown of conservation of momentum and energy in β-decay. 1+4

(c) Show that the Q-value of nuclear reactions is

$$Q = K_y\left(1+\frac{m_y}{M_Y}\right) - k_x\left(1-\frac{m_x}{M_Y}\right) - \frac{2}{M_Y}\sqrt{m_x m_y k_x k_y}\cos\theta$$

where m_x : mass of incident particle

m_y : mass of product particle

M_x : mass of target nucleus

M_y : mass of product nucleus.

other symbols have usual meanings.

[Turn Over]

(d) What do you mean "cerenkov" radiation ? Calculate the minimum kinetic energy of this radiation ? 2+3

(e) Explain the difference between ionisation chamber, proportional counter and Geiger Muller counter. How is quenching achieved in a GM-Counter ? 3+2

(f) (i) Check in the following reactions are allowed or forbidden

$$p + \bar{p} \rightarrow 2\pi^+ + 2\pi^- + 2\pi^0$$

(ii) Find the value of third component of isotropic spin of Ξ^- in the following strong interaction :

$$\pi^+ + n \rightarrow \Xi^- + K^+ + K^+$$ 3+2

3. Answer any *two* questions from the following : 10×2=20

(a) (i) A neutral pion is produced when a γ-ray photon strikes a stationary proton. Show that the threshold energy is

$$E_\gamma = m_\pi c^2 \left(1 + \frac{m_\pi}{2M_p}\right)$$

(ii) Deduce the expression for the maximum energy of an emerging proton beam in a cyclotron in terms of the radius of the dees and the magnetic field.

(iii) If U-236 nucleus is fissioned by a neutron, two fission fragments of mass numbers 96 and 138, and two neutrons are obtained. If the masses of the nuclei and neutron are 235.1175, 95.9385, 137.9487 and 1.00898 amu, calculate the amount of energy relased. 3+4+3

(b) (i) Describe Rutherford's experiment on the scattering of α-particles and state some of the important conclusions drawn from the experiment.

(ii) What is the parity of a p-election ? Is it the same as that of an α-particle with total angular momentum $j = 4$? (5+2)+3

[Turn Over]

(c) (i) Write a short note on "Radioactive dating".

(ii) Describe the Fermi's theory of allowed β-decay. 3+7

(d) (i) What are mirror nuclei ? Calculate the β-disintegration energy of mirror nuclei.

(ii) The mean kinetic energy of the nucleons in a nucleus at the temperature T is given by

$$\langle \epsilon \rangle = \langle \epsilon_0 \rangle \left\{ 1 + \frac{5\pi^2}{12} \left(\frac{KT}{\epsilon_{fo}} \right)^2 \right\}$$

where $\langle \epsilon_0 \rangle$ is the mean kinetic energy at the OK and ϵ_{fo} is the Fenni energy of the nucleus at OK. Show that the total excitation energy of the nucleus at the temparature T is equal to $11(KT)^2$ MeV.

(1+4)+5=10

(ASTRONOMY AND ASTROPHYSICS)

1. Answer any *ten* questions from the following : $2\times10=20$

(a) What is Astronomical distance ? How it is measured ? 2

(b) Describe the difference between stellar parallax and stellar abberration. 2

(c) Explain why the equitorial plane is chosen as a suitable reference plane ? What do you mean by 'equator of the celestial sphere' ? 2

(d) Find the azimuth of the Moon in Helsinki at the beginning of 1996. Provided : Right ascension $(\alpha)=2h$ 55 min 7s, Declination $(\delta)=14°42'$, the sidereal time $(\theta)=6h$ 19 min 26s and latitude $(\lambda)=60.16°$. 2

(e) What is the 'Pressure tensor' for a plasma ? What is the physical significance of the plasma frequency ? 2

[Turn Over]

(f) The distance between two distant stellar objects is 1.25". What will be the diameter of a telescope to resolve those objects ? 2

(g) Show that $u = \frac{4\pi}{c} I$, where u is the energy density and I is the intensity of radiation. 2

(h) The absolute magnitude of a star is $M = -5$ and the appartent magnitude is $m = 15$. What is the distance of the star ? 2

(i) Show that the ratio of orbital speeds of a planet at perihelion and apchelion is given by : $v_p / v_a = \frac{1+e}{1-e}$. where e is the eccentricity of the orbit. 2

(j) What do you mean by Fraunhofer lines in the optical solar spectrum ? Briefly discuss about it's origin. 2

(k) How many p-p reactions take place in the Sun per second ? The luminosity of sun is 3.9×10^{26} W. Mass of proton is 1.00728 a.m.u and that of an (α) alpha particle is 4.00151 a.m.u. 2

(l) What is a white dwarf ? How it is different from a red joint ? 2

(m) What is meant by Chandrasekhar limit ? 2

(n) What are binary stars ? 2

(o) Where does gravitational condensation occurs ? 2

2. Answer any *four* questions from the following. 4×5=20

(i) (a) What is spectroscopic parallax ? 2

(b) How would you determine the distance to a globular cluster using this method ? 3

(ii) (a) Briefly write about three types of *MHD* waves in a magnetized plasma. 3

(b) Write down the *MHD* equations of continuity, momentum conservation and energy conservation. 2

(iii) Briefly discuss the importance of Saha equation in stellar structure culculations. 5

[Turn Over]

(iv) (a) What do you mean by chromatic aberration ? How it is corrected in large optical telescopes ? 1+2

(b) Discuss the advantages of radio telescopes over optical telescope. 2

(v) (a) Describe the Havard spectral classification scheme for stars. 3

(b) What are characteristic luminasities for main sequence star of each class ? 2

(vi) (a) Write down the four basic equations of stellar structure. 2

(b) Derive the equation of hydrostatic equilibrium in a star. 3

3. Answer any *two* questions from the following. 10×2=20

(i) (a) Describe the equitarial system of co-ordinates. How would you convert the equiterial co-ordinates to ecliptic co-ordinates ? 2+4

(b) A star is above the horizon for 8h 30m. What is the azimuth is sets, if the observer stands at a place of lattitude 38°05'16"N and longitude 68°25'40"W ? 4

(ii) (a) Describe the Hertzsprung-Russell diagram for a typical globular cluster in detail. 6

(b) How does the quantity B-V helps to determine a star's effective temperature ? 4

(iii) (a) Describe the internal structure of the sun with necessary diagram. 5

(b) Describe the role of Proton-Proton chain reactions in energy generation of a star. 5

(iv) (a) How are the gas and dust distributed in our Galaxy ? Why are they distributed differently from the stars ? 2½+2½

(b) How galaxy rotation curves are measured ? What evidence do galaxy rotation curves provide for dark matter ? 2+3

[Turn Over]

(PHYSICS OF EARTH)

1. Answer any *ten* questions from the following : 2×10=20

(a) Name various branches of Earth Sciences.

(b) How was Earth formed ?

(c) Where did Earth's water originate ?

(d) Where are we in the Milky way galaxy ?

(e) What is the real shape of Earth ?

(f) What is the most obvious difference between terrestrial and jovian planets ?

(g) What are the different types of volcanos present in the Earth ?

(h) What do you mean by Earth's heat budget ?

(i) What are mid oceanic ridges and trenches ?

(j) What is the difference between asterodis and meteoroids ?

(k) Mention two uses of geothermal energy.

(l) Name different members of the solar system.

(m) Write the name of four marine organisms.

(n) What is wave erosion process ?

(o) Mention consequences of lunar motion on tide formation.

2. Answer any *four* questions from the following : 5×4=20

(a) What is nuclear waste ? Mention the safety measures to be taken during nuclear waste disposal. 2+3

(b) Explain the term biodiversity. Mention the causes that are responsible for biodiversity loss from the Earth. Suggest some measures that can be taken to conserve biodiversity in the Earth. 1+2+2

(c) Explain the production of cosmic ray shower. What caused cosmic microwave background radiation ? What is the significance of it ?

[Turn Over]

3+1+1

(d) What do you mean by ocean current ? What are the two types of ocean current ? How ocean current is effected by coriolis force ? 1+2+2

(e) What is cryosphere ? Mention different types of glaciers present in the Earth with proper examples. 1+4

(f) Describe Indian monsoon system with suitable diagram. 3+2

3. Answer any *two* questions from the following : 10×2=20

(a) What do you mean by cosmic rays ? What is the composition of cosmic rays ? How the east-west effect, latitude effect and altitude effect changes the cosmic ray intensity in Earth ? 2+2+(2+2+2)

(b) Explain the process of Green house effect using suitable diagram. What are the consequences of this effect ? Name two Green house gases. What is El-nino ? 3+2+2+2+1

(c) What are the causes of earthquakes ? Mention the major earthquake belts around the world. What are the safety measures one should take during earthquake ? 4+3+3

(d) What do you mean by the biosphere ? What is the role of the nutrient cycles in maintaining a steady state biosphere ? Briefly explain the Nitrogen cycle.

(ADVANCED MATHEMATICAL PHYSICS - II)

1. Answer any *ten* questions from the following : 2×10=20

(a) What do you mean the term "functional" ? Write down the Euler-Lagrange equation.

(b) Show that the shortest distance between any two points in a plane is a straight line.

(c) State the Hamilton's principle with mathematical expressions.

(d) Explain what is meant by a 'geodesic' and a 'great circle'.

(e) Can the Hamilton's principle replace the Newton's laws for holomorphic systems ?

(f) Write down the properties of a group.

(g) Show that every cyclic group is abelian.

(h) Show that "in a monoid $(M, 0)$ if an element a be left invertible as well as right invertible then a is invertible.

(i) What do you mean "Non-Abelian group" ?

(j) Let $G = (Z, +)$, $G' = (2z, +)$ and a mapping $\phi : G \to G'$ be defined by $\phi(a) = 2a, a \in G$. Examine if ϕ is a homomorphism.

(k) Define permutation groups.

(l) A biased six-sided die has probabilities $\frac{p}{2}$, p, p, p, p, $2p$ of showing 1, 2, 3, 4, 5, 6 respectively calculate p.

(m) Find the probability of drawing two aces at random from a pack of cards, when the first card drawn is replaced at random into the pack before the second and is drawn.

(n) The independent random variables X and Y have the PDF, $g(x) = e^{-x}$ and $h(y) = 2e^{-2y}$ respectively. Calculate the probability that x lies in the interval $1 < X \leq 2$ and Y lies in the interval $0 < Y \leq 1$.

(o) The Moment generating functions (MGF) for the Gaussian distribution is given by

$$M_x(t) = \exp\left(\mu t + \frac{1}{2}\sigma^2 t^2\right).$$

Find the expectation and variance of this distribution.

2. Answer any *four* questions from the following : 5×4=20

(a) For the four-element Abelian group consisting of the set $\{1, i, -1, -i\}$ under ordinary multiplication, change the basis vector from $u = (1 \quad i)^T$ to $u_Q = (3-i \quad 2i-5)^T$. Find the real transformation matrix Q. Show that the transformed representative matrix for element i, $D_{QT}(i)$ is given by $D_{QT}(i) = \begin{pmatrix} 17 & -29 \\ 10 & -17 \end{pmatrix}$ and verify that $D_{QT}^T(i)u_Q = iu_Q$. 2+1½+1½

(b) Define "isomorphism". Let $\varphi : (G, 0) \to (G^1, *)$ be an isomorphism. Then proof that G' is commutative if and only if G is commutative. 2+3

(c) The time taken for a computer 'packet' to travel from Cambridge UK to Cambridge MA is Gaussian distributed. 6.8% of the packets take over 200 ms to make journey and 3.0% take under 140ms. Find the mean and standard deviation of the distribution. 5

(d) A random variable X is given by the number of trials needed to obtain a first success when the chance of success at each trial is constant and equal to p. Find the probability generating function for X and use it to determine the mean and variance of X. 2+3

(e) Determine the canonical transformations defined by the generating function

$G(q, Q, t) = \frac{1}{2} mwq^2 \cot Q$ and hence obtain an expression for the displacement of the harmonic oscillator. 4+1

[Turn Over]

(f) If X, Y, Z be any three dynamical variables, then proof that the Jacobi's identity.

$$[X,[Y,Z]]+[Y,[Z,X]]+[Z,[X,Y]]=0 \quad 5$$

3. Answer any *two* questions from the following : $10\times2=20$

(a) (i) Show that the path of shortest (brachistoss) time (chromos) of a particle is a cycloid.

(ii) Show that the extremal of the following functional $\int_{x_0}^{x_1}\frac{\sqrt{1+(y')^2}}{x}dx$ is a circle with its centre situated on the y-axis. 5+5

(b) (i) Show, by the use of Lagrange brackets, that the following transformation is canonical.

$Q=\ln\left(\frac{1}{2}\sin p\right)$; $P=q\cot p$ and hence find the function F. 3+2

(ii) Find the closed convex curve of length l that encloses the greatest possible area. 5

(c) (i) Proof that "A finite group G of order n is isomorphic to a subgroup of S_n". 5

(ii) Let $(G, \circ)$ and $(G', *)$ be two groups and $\varphi : G \to G'$ be a homomorphism. Then prove that.

$\langle\alpha\rangle$ $\varphi(e_G) = e_{G'}$ and

$\langle\beta\rangle$ $\varphi\left(G^{-1}\right) = \{\varphi(a)\}^{-1}$ for all $a \in G$.

2+3

(d) (i) The random variable X is distributed as $X \sim B$ in $\left(3, \frac{1}{2}\right)$. Evaluate the probability function $f(x)$ using the binomial recurrence formula. 5

(ii) Two types of e-mail arrive independently and at random : external e-mails at mean rate of one every five minutes and internal e-mails at a rate of two every five minutes. Calculate the probability of receiving two or more e-mails in any two-minute interval. 5
